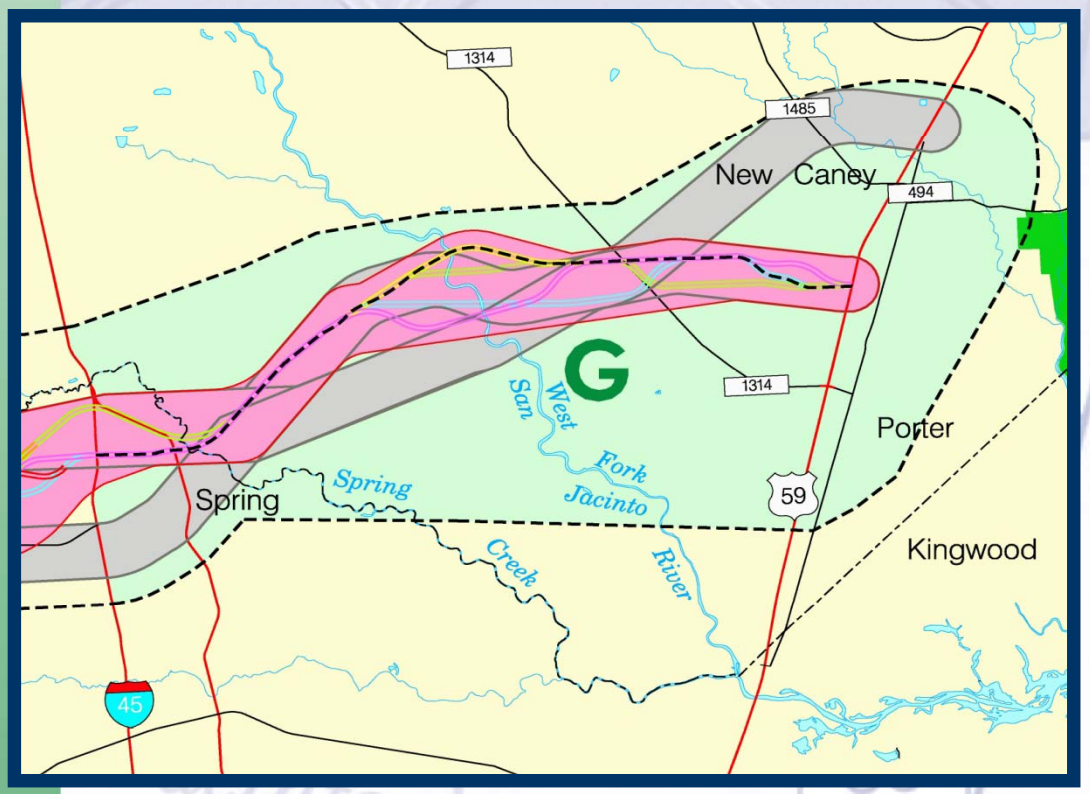
VOLUME II

From IH 45 to US 59
Harris County, Texas
Montgomery County, Texas

Final Environmental Impact Statement

Grand Parkway State Highway 99 Segment G



FHWA-TX-EIS-03-03-F

U.S. Department of Transportation
Federal Highway Administration

Texas Department of Transportation

U.S. Army Corps of Engineers
Cooperating Agency

January 2009

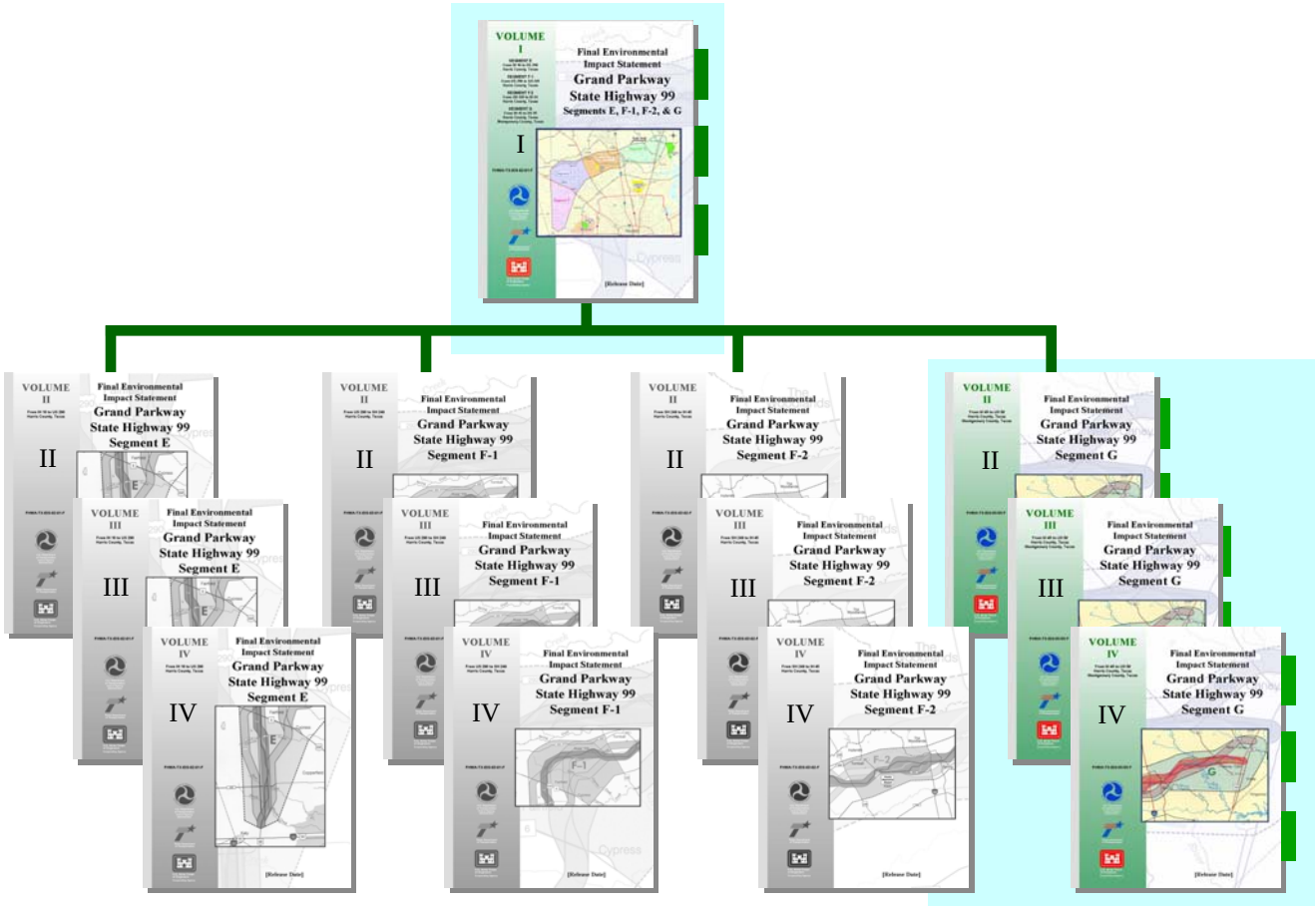
Document Organization

The Grand Parkway Segments E, F-1, F-2, and G study area is divided into four Segments of Independent Utility (SIUs) to facilitate planning, design, and construction because limited state and federal funding provides no assurance that all the Grand Parkway segments would be constructed. Each SIU would connect at least two existing major transportation corridors to ensure independent utility as well as independent significance as required by the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA) regulations (23 Code of Federal Regulations [CFR] 771.111[f]).

The Segment G Final Environmental Impact Statement (FEIS) is organized in a four-volume set in response to public and resource agency comments concerning potential cumulative effects of Segment G and the need to assess Segment G as a facility with independent utility and logical termini, as follows:

- Volume I presents analyses and results common to Segments E, F-1, F-2, and G, including project description, the need for and purpose of the project, alternatives considered, affected environment, indirect and cumulative effects, and agency and public coordination.
- Volume II provides a detailed assessment of Segment G relative to its specific project area. It includes issues, permits, and federal actions particular to Segment G, such as the need for and purpose of the project; alternatives considered; affected environment; environmental consequences; avoidance, minimization, and mitigation measures; indirect and cumulative effects; and agency and public coordination.
- Volume III contains exhibits and appendices referenced in Volumes I and II.
- Volume IV includes materials related to the Segment G Draft Environmental Impact Statement (DEIS) Public Hearing, comments submitted, and responses to the DEIS comments provided following the release of the Segment G DEIS in January 2007.

The volume covers and section tabs for Segment G are color coded (Volume I [Green, common to Segments E, F-1, F-2, and G] and Volume II/III/IV [Light Green, Segment G specific]) to help the reader navigate through the document. The following highlights how Segment G is structured in relation to the FEISs for Segments E, F-1, and F-2:



VOLUME II
TABLE OF CONTENTS

INTRODUCTION **1**

SECTION 1: PROJECT NEED AND PURPOSE **1-1**
1.1 NEED FOR AND PURPOSE OF THE PROPOSED PROJECT 1-1
1.2 DETAILED TRANSPORTATION NEEDS ANALYSIS 1-4
1.2.1 SYSTEM LINKAGE 1-4
1.2.2 EXPANDED CAPACITY 1-5
1.2.3 SAFETY 1-12
1.2.4 ECONOMIC DEVELOPMENT 1-14

SECTION 2: ALTERNATIVES ANALYSIS **2-1**
2.1 CORRIDOR STUDY 2-2
2.1.1 CORRIDOR A 2-3
2.1.2 CORRIDOR B 2-3
2.1.3 CORRIDOR C 2-3
2.1.4 CORRIDOR RESOURCE INVENTORY 2-3
2.1.5 AGENCY AND PUBLIC COORDINATION 2-4
2.1.6 CORRIDOR REVISIONS 2-8
2.1.7 PREFERRED ALTERNATIVE CORRIDOR RECOMMENDATION 2-9
2.2 TRANSPORTATION MODE STUDY 2-9
2.2.1 NO-BUILD ALTERNATIVE 2-10
2.2.2 BUILD ALTERNATIVE 2-15
2.2.3 ALTERNATIVE TRANSPORTATION MODES ELIMINATED FROM DETAILED STUDY 2-16
2.2.4 ALTERNATIVE TRANSPORTATION MODES ADVANCED FOR FURTHER STUDY 2-17
2.2.5 TRAFFIC AND TRANSPORTATION ANALYSIS 2-18
2.2.6 PREFERRED ALTERNATIVE TRANSPORTATION MODE 2-24
2.3 ALTERNATIVE ALIGNMENT STUDY 2-25
2.3.1 ALTERNATIVE ALIGNMENTS DEVELOPMENT 2-25
2.3.2 SCREENING PROCESS 2-27
2.3.3 ALTERNATIVES ANALYSIS RESULTS 2-31

SECTION 3: AFFECTED ENVIRONMENT **3-1**
3.1 LAND USE AND TRANSPORTATION PLANNING 3-1
3.1.1 HISTORICAL DEVELOPMENT PATTERNS 3-1
3.1.2 EXISTING LAND USE 3-2
3.1.3 LAND USE PLANNING 3-3
3.1.4 TRANSPORTATION PLANNING 3-4
3.1.5 JOINT DEVELOPMENT 3-4
3.2 GEOLOGY, SOILS, AND FARMLAND 3-5
3.2.1 GEOLOGY 3-5
3.2.2 SOILS 3-5
3.2.3 FARMLAND 3-6
3.3 SOCIAL CHARACTERISTICS 3-11
3.3.1 POPULATION CHARACTERISTICS 3-11
3.3.2 SOCIAL/COMMUNITY RESOURCES 3-14

3.3.3 PUBLIC LANDS 3-16
3.4 ECONOMICS 3-16
3.4.1 ECONOMIC CONDITIONS 3-16
3.5 PEDESTRIANS AND BICYCLISTS 3-20
3.6 AIR QUALITY 3-20
3.6.1 CRITERIA POLLUTANTS 3-20
3.6.2 MOBILE SOURCE AIR TOXICS (MSAT) 3-23
3.7 EXISTING NOISE ENVIRONMENT 3-27
3.7.1 EXISTING NOISE LEVELS 3-29
3.7.2 LAND USE ACTIVITY AREAS 3-30
3.8 WATER QUALITY 3-31
3.8.1 SURFACE WATER 3-31
3.8.2 GROUNDWATER 3-33
3.9 PERMITS 3-35
3.9.1 WATERS OF THE U.S., INCLUDING WETLANDS 3-35
3.9.2 NAVIGABLE WATERS OF THE U.S. 3-36
3.10 WETLANDS AND VEGETATIVE COMMUNITIES 3-36
3.10.1 WETLANDS 3-36
3.10.2 VEGETATIVE COMMUNITIES 3-39
3.10.3 NATURAL AREAS 3-42
3.11 WILDLIFE 3-42
3.11.2 AQUATIC HABITATS 3-45
3.12 FLOODPLAINS 3-47
3.12.1 HYDROLOGY AND DRAINAGE 3-47
3.12.2 FLOODWAYS AND FLOODPLAINS 3-47
3.13 WILD AND SCENIC RIVERS 3-49
3.14 COASTAL BARRIERS 3-49
3.15 COASTAL ZONE MANAGEMENT 3-50
3.16 ESSENTIAL FISH HABITAT (EFH) 3-50
3.17 THREATENED AND ENDANGERED SPECIES 3-50
3.18 CULTURAL RESOURCES 3-54
3.18.1 AREA OF POTENTIAL EFFECT (APE) 3-54
3.18.2 CULTURAL CHRONOLOGY 3-54
3.18.3 ARCHEOLOGICAL RESOURCES 3-57
3.18.4 NON-ARCHEOLOGICAL HISTORIC RESOURCES 3-61
3.19 HAZARDOUS MATERIALS 3-63
3.19.1 REGULATED HAZARDOUS MATERIAL SITES 3-65
3.19.2 OIL/GAS WELLS 3-67
3.19.3 PETROLEUM PIPELINES 3-68
3.20 VISUAL AND AESTHETIC QUALITIES 3-69

SECTION 4: ENVIRONMENTAL CONSEQUENCES 4-1
4.1 LAND USE 4-2
4.1.1 SUMMARY OF IMPACTS 4-4
4.1.2 INDIRECT IMPACTS 4-4
4.1.3 MITIGATION 4-7
4.2 GEOLOGY, SOILS, AND FARMLAND 4-7
4.2.1 PHYSIOGRAPHY, SOILS, AND GEOLOGY 4-7
4.2.2 FARMLAND.. 4-9
4.2.3 SUMMARY OF IMPACTS 4-11
4.2.4 INDIRECT IMPACTS 4-11

4.2.5 MITIGATION 4-11
4.3 SOCIAL 4-11
4.3.1 SOCIAL/COMMUNITY IMPACTS ANALYSIS 4-11
4.3.2 RELOCATIONS 4-22
4.3.3 SUMMARY OF IMPACTS 4-26
4.3.4 INDIRECT IMPACTS 4-27
4.3.5 MITIGATION 4-27
4.4 ECONOMICS 4-28
4.4.1 METHODOLOGY 4-28
4.4.2 CONSTRUCTION COSTS BY ALTERNATIVE 4-29
4.4.3 TOTAL OUTPUT AND VALUE ADDED IMPACTS 4-31
4.4.4 EMPLOYMENT IMPACTS 4-33
4.4.5 TAX IMPACTS 4-35
4.4.6 SUMMARY OF IMPACTS 4-36
4.4.7 INDIRECT IMPACTS 4-37
4.4.8 MITIGATION 4-37
4.5 PEDESTRIANS AND BICYCLISTS 4-38
4.5.1 SUMMARY OF IMPACTS 4-38
4.5.2 INDIRECT IMPACTS 4-39
4.5.3 MITIGATION 4-39
4.6 AIR QUALITY 4-39
4.6.1 CRITERIA POLLUTANTS 4-39
4.6.2 MICRO-SCALE CARBON MONOXIDE (CO) ANALYSIS 4-41
4.6.3 MOBILE SOURCE AIR TOXICS (MSAT) 4-42
4.6.4 CONGESTION MANAGEMENT SYSTEM (CMS)/CONGESTION REDUCTION STRATEGIES 4-59
4.6.5 SUMMARY OF IMPACTS 4-60
4.6.6 INDIRECT IMPACTS 4-61
4.6.7 AIR QUALITY CONSTRUCTION IMPACTS 4-61
4.7 TRAFFIC NOISE 4-62
4.7.1 TRAFFIC DATA FOR NOISE PREDICTION 4-62
4.7.2 IMPACTS TO NOISE RECEIVERS - ALTERNATIVE ALIGNMENTS A, B, C, AND D 4-63
4.7.3 IMPACTS TO NOISE RECEIVERS - PREFERRED ALTERNATIVE ALIGNMENT 4-71
4.7.4 TRAFFIC NOISE ABATEMENT MEASURES 4-77
4.7.5 NOISE IMPACT CONTOURS 4-81
4.7.6 SUMMARY OF IMPACTS 4-81
4.7.7 INDIRECT IMPACTS 4-82
4.7.8 MITIGATION 4-82
4.8 WATER QUALITY 4-82
4.8.1 SURFACE WATER 4-82
4.8.2 GROUNDWATER 4-83
4.8.3 SUMMARY OF IMPACTS 4-88
4.8.4 INDIRECT IMPACTS 4-89
4.8.5 MITIGATION 4-89
4.9 PERMITS 4-90
4.9.1 WATERS OF THE U.S., INCLUDING WETLANDS 4-90
4.9.3 NAVIGABLE WATERS OF THE U.S. 4-92
4.9.4 SUMMARY OF IMPACTS 4-92
4.9.5 INDIRECT IMPACTS 4-92
4.9.6 MITIGATION 4-92
4.10 WETLANDS AND VEGETATIVE COMMUNITIES 4-92

4.10.1 WETLANDS 4-92
4.10.2 VEGETATIVE COMMUNITIES 4-96
4.10.3 HABITAT MITIGATION 4-101
4.10.4 NATURAL AREAS 4-105
4.10.5 SUMMARY OF IMPACTS 4-105
4.10.6 INDIRECT IMPACTS 4-106
4.10.7 MITIGATION 4-107
4.11 WILDLIFE 4-107
4.11.1 TERRESTRIAL WILDLIFE 4-107
4.11.2 AQUATIC HABITAT 4-111
4.11.3 SUMMARY OF IMPACTS 4-113
4.11.4 INDIRECT IMPACTS 4-113
4.11.5 MITIGATION 4-114
4.12 WATERBODY MODIFICATIONS AND FLOODPLAINS 4-114
4.12.1 HYDROLOGY AND DRAINAGE 4-114
4.12.2 FLOODWAYS AND FLOODPLAINS 4-119
4.12.3 SUMMARY OF IMPACTS 4-126
4.12.4 INDIRECT IMPACTS 4-127
4.12.5 MITIGATION 4-127
4.13 WILD AND SCENIC RIVERS 4-128
4.14 COASTAL BARRIERS 4-128
4.15 COASTAL ZONE MANAGEMENT 4-128
4.16 ESSENTIAL FISH HABITAT (EFH) 4-128
4.17 THREATENED AND ENDANGERED SPECIES 4-128
4.17.1 SUMMARY OF IMPACTS 4-130
4.17.2 INDIRECT IMPACTS 4-131
4.17.3 MITIGATION 4-131
4.18 CULTURAL RESOURCES 4-131
4.18.1 ARCHEOLOGICAL RESOURCES 4-131
4.18.2 NON-ARCHEOLOGICAL HISTORIC PROPERTIES 4-132
4.18.3 SUMMARY OF IMPACTS 4-132
4.18.4 INDIRECT IMPACTS 4-133
4.18.5 MITIGATION 4-133
4.19 HAZARDOUS MATERIALS 4-133
4.19.1 REGULATED HAZARDOUS MATERIAL SITES 4-134
4.19.2 OIL/GAS WELL AND PIPELINE SITES 4-134
4.19.3 PETROLEUM PIPELINES 4-135
4.19.4 POTENTIAL IMPACTS FROM CONSTRUCTION ACTIVITIES 4-135
4.19.5 SUMMARY OF IMPACTS 4-136
4.19.6 INDIRECT IMPACTS 4-136
4.19.7 MITIGATION 4-137
4.20 VISUAL AND AESTHETIC QUALITIES 4-137
4.20.1 VIEWS OF THE PROPOSED ROADWAY 4-137
4.20.2 VIEWS FROM THE PROPOSED ROADWAY 4-138
4.20.3 REACH 8 4-138
4.20.4 REACH 9 4-139
4.20.5 REACH 10 4-139
4.20.6 REACH 11 4-139
4.20.7 REACH 12 4-139
4.20.6 SUMMARY OF IMPACTS 4-140
4.20.7 INDIRECT IMPACTS 4-140
4.20.8 MITIGATION 4-140

4.21 ENERGY....4-141
4.21.1 SUMMARY OF IMPACTS....4-142
4.21.2 MITIGATION....4-142
4.22 CONSTRUCTION IMPACTS....4-142
4.22.1 AIR QUALITY CONSTRUCTION IMPACTS....4-143
4.22.2 CONSTRUCTION NOISE....4-143
4.22.3 WATER QUALITY CONSTRUCTION IMPACTS....4-143
4.22.4 MAINTENANCE AND CONTROL OF TRAFFIC....4-144
4.22.5 HEALTH AND SAFETY....4-144
4.22.6 POLLUTION CONTROL....4-144
4.22.7 OTHER CONSTRUCTION IMPACTS....4-145
4.22.8 SUMMARY OF IMPACTS....4-145
4.22.9 INDIRECT IMPACTS....4-145
4.22.10 MITIGATION....4-145
4.23 RELATIONSHIP OF LOCAL SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY....4-146
4.24 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES....4-146
4.25 PREFERRED ALTERNATIVE ALIGNMENT....4-147
4.25.1 DESCRIPTION OF PREFERRED ALTERNATIVE ALIGNMENT....4-148
4.25.2 SUMMARY OF ENVIRONMENTAL CONSEQUENCES....4-149
4.26 MITIGATION MEASURES AND COMMITMENTS....4-157
4.26.1 LAND USE....4-158
4.26.2 GEOLOGY, SOILS, AND FARMLAND....4-158
4.26.3 SOCIAL....4-159
4.26.4 ECONOMICS....4-159
4.26.5 PEDESTRIANS AND BICYCLISTS....4-159
4.26.6 AIR QUALITY....4-159
4.26.7 NOISE IMPACTS....4-160
4.26.8 WATER QUALITY....4-160
4.26.9 PERMITS....4-161
4.26.10 WETLANDS AND VEGETATIVE COMMUNITIES....4-161
4.26.11 WILDLIFE....4-166
4.26.12 WATERBODY MODIFICATIONS AND FLOODPLAINS....4-166
4.26.13 WILD AND SCENIC RIVERS....4-167
4.26.14 COASTAL BARRIERS....4-167
4.26.15 COASTAL ZONE MANAGEMENT....4-167
4.26.16 ESSENTIAL FISH HABITAT....4-167
4.26.17 THREATENED AND ENDANGERED SPECIES....4-167
4.26.18 CULTURAL RESOURCES....4-167
4.26.19 HAZARDOUS MATERIALS....4-168
4.26.20 VISUAL AND AESTHETIC QUALITIES....4-168
4.26.21 ENERGY....4-169
4.26.22 CONSTRUCTION IMPACTS....4-169

SECTION 5: INDIRECT AND CUMULATIVE EFFECTS....5-1
5.1 AREA OF INFLUENCE (AOI)....5-1
5.2 LAND USE FORECASTING....5-2
5.2.1 ESTIMATING LAND USE IN 2025....5-2
5.2.2 USGS/NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) DRAFT 2001 NATIONAL LAND COVER DATABASE (NLCD)....5-5
5.3 INDIRECT EFFECTS....5-7
5.3.1 LAND USE....5-8
5.3.2 GEOLOGY, SOILS, AND FARMLAND....5-8

5.3.3 SOCIAL 5-9
5.3.4 ECONOMICS 5-10
5.3.5 PEDESTRIAN AND BICYCLISTS 5-10
5.3.6 AIR QUALITY 5-10
5.3.7 NOISE 5-10
5.3.8 WATER QUALITY 5-10
5.3.9 WETLANDS AND VEGETATIVE COMMUNITIES 5-11
5.3.10 WILDLIFE 5-11
5.3.11 WATERBODY MODIFICATIONS AND FLOODPLAINS 5-11
5.3.12 WILD AND SCENIC RIVERS 5-11
5.3.13 COASTAL BARRIERS 5-12
5.3.14 COASTAL ZONE MANAGEMENT 5-12
5.3.15 ESSENTIAL FISH HABITAT (EFH) 5-12
5.3.16 THREATENED AND ENDANGERED SPECIES 5-12
5.3.17 CULTURAL RESOURCES 5-12
5.3.18 HAZARDOUS MATERIALS 5-13
5.3.19 VISUAL AND AESTHETIC QUALITIES 5-13
5.4 CUMULATIVE EFFECTS 5-13
5.4.1 CUMULATIVE EFFECTS ANALYSIS (CEA) METHODS 5-14
5.4.2 CUMULATIVE EFFECTS ANALYSIS (CEA) 5-14
5.5 CONCLUSION 5-69

SECTION 6: AGENCY AND PUBLIC COORDINATION 6-1
6.1 NOTICE OF INTENT (NOI) 6-1
6.2 SCOPING AND CORRIDOR STUDY 6-2
6.2.1 PUBLIC INVOLVEMENT 6-2
6.2.2 LOCAL OFFICIAL INVOLVEMENT 6-3
6.2.3 RESOURCE AGENCY INVOLVEMENT 6-4
6.3 ALIGNMENT STUDY 6-7
6.3.1 PUBLIC INVOLVEMENT 6-8
6.3.2 LOCAL OFFICIAL INVOLVEMENT 6-10
6.3.3 RESOURCE AGENCY INVOLVEMENT 6-10
6.4 ADDITIONAL COORDINATION 6-12
6.4.1 EXPERT PANEL 6-12
6.4.2 COMMUNITY GROUPS 6-13
6.4.3 REGIONAL TRANSPORTATION PLAN (RTP) AND TRANSPORTATION IMPROVEMENT PROGRAM (TIP) 6-14
6.4.4 WEBSITE 6-14

SECTION 7: LIST OF PREPARERS 7-1

SECTION 8: DISTRIBUTION LIST 8-1

SECTION 9: REFERENCES CITED 9-1

SECTION 10: INDEX 10-1

LIST OF TABLES

TABLE 1-1 SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD ADT BY ROADWAY SEGMENT 1-7
TABLE 1-2 SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD LOM BY FACILITY TYPE 1-11
TABLE 1-3 LOCATIONS IN THE SEGMENT G TRAFFIC STUDY AREA WITH HIGH ACCIDENT RATES. 1-13
TABLE 2-1 CORRIDOR RESOURCES INVENTORY FOR SEGMENTS E, F-1, F-2, AND G 2-5
TABLE 2-2 SUMMARY OF COMMENTS RECEIVED FROM RESOURCE AGENCIES ON PRELIMINARY CORRIDORS 2-7
TABLE 2-3 SEGMENT G TRAFFIC STUDY AREA VHT 2-19
TABLE 2-4 SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD AND BUILD ADT BY ROADWAY SEGMENT 2-21
TABLE 2-5 SEGMENT G PERCENTAGE OF ROADWAY MILES OPERATING AT VARIOUS LOM BY FACILITY TYPE 2-23
TABLE 2-6 LOCATIONS IN THE SEGMENT G TRAFFIC STUDY AREA WITH HIGH ACCIDENT RATES 2-24
TABLE 2-7 SUMMARY OF IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G 2-29
TABLE 2-8 OCTOBER 2000 PUBLIC WORKSHOP ALIGNMENT SELECTION PREFERENCES 2-32
TABLE 2-9 POTENTIAL RELOCATIONS FROM THE 2007 DEIS FOR SEGMENT G BY ALTERNATIVE ALIGNMENT AND REACH 2-33
TABLE 2-10 SUMMARY OF ALTERNATIVE ALIGNMENT SCREENING RESULTS 2-34
TABLE 2-11 HIGHWAY CONSTRUCTION COST FOR SEGMENT G 2.36
TABLE 3-1 POPULATION AND ETHNICITY CHARACTERISTICS FOR THE SEGMENT G PROJECT AREA – 2000 CENSUS 3-13
TABLE 3-2 POPULATION / INCOME CHARACTERISTICS FOR THE SEGMENT G PROJECT AREA – 2000 CENSUS 3-14
TABLE 3-3 ECONOMIC CHARACTERISTICS OF REGIONAL POPULATION – 2000 3-17
TABLE 3-4 OCCUPATION AND CLASS OF WORKER – 2000 CENSUS 3-19
TABLE 3-5 TAX RATE AND NET TAXABLE VALUATION FOR MAJOR TAXING JURISDICTIONS IN THE SEGMENT G PROJECT AREA 3-20
TABLE 3-6 NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) 3-21
TABLE 3-7 LOCAL MONITOR DATA 3-25
TABLE 3-8 TOTAL MSAT EMISSIONS TONS/YEAR FOR THE SEGMENT G TRAFFIC STUDY AREA 3-27
TABLE 3-9 COMMON NOISES AND TYPICAL SOUND LEVELS 3-28
TABLE 3-10 FHWA NOISE ABATEMENT CRITERIA (NAC) 3-29
TABLE 3-11 AMBIENT NOISE LEVELS IN THE SEGMENT G PROJECT AREA 3-30
TABLE 3-12 SUMMARY OF WATER QUALITY CONCERNS FOR SEGMENT G 3-31
TABLE 3-13 TCEQ SURVEY STATIONS NEAR THE PROJECT AREA 3-32
TABLE 3-14 SEGMENT G PROJECT AREA VEGETATIVE COMMUNITIES 3-37
TABLE 3-15 SEGMENT G PROJECT AREA FLOODWAYS AND 100-YEAR FLOODPLAINS 3-49
TABLE 3-16 HABITAT DESCRIPTIONS FOR RARE, THREATENED, AND ENDANGERED SPECIES IN HARRIS AND MONTGOMERY COUNTIES, TEXAS 3-51
TABLE 3-17 SEGMENT G ARCHEOLOGICAL RESOURCE HIGH PROBABILITY AREAS BY MAP UNIT NUMBER 3-60
TABLE 3-18 RECORDED NON-ARCHEOLOGICAL HISTORIC RESOURCES IN AND AJACENT TO THE SEGMENT G PROJECT AREA 3-62
TABLE 4-1 LAND USE IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G 4-5
TABLE 4-2 PRIME AND STATEWIDE IMPORTANT FARMLAND SOILS IMPACTS FOR SEGMENT G 4-9
TABLE 4-3 COMMUNITY COHESION BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G 4-13
TABLE 4-4 POPULATION AND ETHNICITY CHARACTERISTICS FOR THE SEGMENT G PROJECT AREA CENSUS TRACTS – 2000 CENSUS 4-15

TABLE 4-5 POPULATION, INCOME, AND LANGUAGE CHARACTERISTICS FOR THE SEGMENT G PROJECT AREA CENSUS TRACTS – 2000 CENSUS....4-17
TABLE 4-6 POTENTIAL RELOCATIONS BY ALIGNMENT AND REACH FOR SEGMENT G....4-23
TABLE 4-7 HIGHWAY CONSTRUCTION COST FOR SEGMENT G....4-29
TABLE 4-8 DIRECT, INDIRECT, AND INDUCED IMPACTS TO TOTAL OUTPUT AND VALUE ADDED IN SEGMENT G....4-31
TABLE 4-9 DIRECT, INDIRECT, AND INDUCED IMPACTS TO EMPLOYMENT IN SEGMENT G (NUMBER OF PERSONS)....4-34
TABLE 4-10 DIRECT, INDIRECT, AND INDUCED IMPACTS TO INDIRECT BUSINESS TAX IN SEGMENT G....4-35
TABLE 4-11 CO EMISSION FACTORS (G/MI) AT 65 MPH....4-41
TABLE 4-12 PROJECT CO CONCENTRATIONS (SEGMENT G)....4-42
TABLE 4-13 SEGMENT G SENSITIVE RECEPTORS PROPERTY IMPACTS....4-43
TABLE 4-14 MSAT EMISSIONS BY ALTERNATIVE (TONS/YEAR) (ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)....4-45
TABLE 4-15 MSAT EMISSIONS BY ALTERNATIVE FOR SEGMENT G TRAFFIC STUDY AREA (TONS/YEAR)....4-47
TABLE 4-16 SEGMENT G MSAT EMISSIONS – GRAND PARKWAY ROADWAY LINKS ONLY (TONS/YEAR)....4-55
TABLE 4-17 SEGMENT G ADT ROADWAY....4-55
TABLE 4-18 PROJECTED 2025 TRAFFIC VOLUME DATA FOR SEGMENT G PROJECT AREA....4-62
TABLE 4-19 DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS....4-63
TABLE 4-20 TOTAL NOISE IMPACTS SUMMARY– DEIS ANALYSIS....4-70
TABLE 4-21 DETAILED NOISE ANALYSIS RESULTS – PREFERRED ALTERNATIVE ALIGNMENT....4-72
TABLE 4-22 TOTAL RECIEVERS IMPACTED BY THE PREFERRED ALTERNATIVE ALIGNMENT....4-77
TABLE 4-23 GRAND PARKWAY, SEGMENT G – NOISE BARRIER ANALYSIS FOR THE PREFERRED ALTERNATIVE ALIGNMENT....4-79
TABLE 4-24 NOISE IMPACT CONTOURS FOR THE SEGMENT G PREFERRED ALTERNATIVE ALIGNMENT....4-81
TABLE 4-25 POTENTIAL WATER SUPPLY WELL IMPACTS FOR SEGMENT G....4-84
TABLE 4-26 IDENTIFICATION OF POTENTIAL PUBLIC WATER SUPPLY WELL IMPACTS IN SEGMENT G....4-85
TABLE 4-27 WETLAND IMPACT SUMMARY BY ALTERNATIVE ALIGNMENT AND REACH IN SEGMENT G....4-95
TABLE 4-28 POTENTIAL VEGETATIVE COMMUNITY IMPACTS FOR THE SEGMENT G PROJECT AREA....4-99
TABLE 4-29 POTENTIAL RIPARIAN FOREST AND BOTTOMLAND HARDWOOD IMPACTS....4-100
TABLE 4-30 SUMMARY OF VEGETATIVE COMMUNITY IMPACTS IN THE SEGMENT G PROJECT AREA....4-106
TABLE 4-31 STREAM CROSSINGS BY ALTERNATIVE ALIGNMENT AND REACH....4-115
TABLE 4-32 FLOODWAYS AND FLOODPLAINS WITHIN ALTERNATIVE ALIGNMENT ROW....4-122
TABLE 4-33 FLOODPLAIN ENCROACHMENT SUMMARY FOR EACH PROJECT AREA WATERSHED....4-123
TABLE 4-34 OIL AND GAS WELLS WITHIN SEGMENT G PROJECT ALTERNATIVE ALIGNMENT ROW....4-134
TABLE 4-35 SUMMARY OF PETROLEUM PIPELINES WITHIN THE SEGMENT G PROJECT AREA....4-135
TABLE 4-36 ENERGY CONSUMPTION IN THE GRAND PARKWAY TRAFFIC STUDY AREA....4-141
TABLE 4-37 HIGHWAY CONSTRUCTION COST FOR SEGMENT G PREFERRED ALTERNATIVE ALIGNMENT....4-148
TABLE 4-38 SUMMARY OF IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G....4-171
TABLE 5-1 THE EXPERT PANEL....5-3
TABLE 5-2 LAND USE CATEGORIES DEFINED BY THE EXPERT PANEL....5-5
TABLE 5-3 USGS/NOAA DRAFT 2001 NLCD – THEMATIC CLASSES....5-6
TABLE 5-4 GUIDELINES FOR IDENTIFYING AND ASSESSING CUMULATIVE EFFECTS....5-14
TABLE 5-5 FORMAL AGENCY MEETINGS DURING THE SCOPING AND CORRIDOR STUDY....5-16
TABLE 5-6 RESOURCES/ISSUES CARRIED FORWARD FOR FURTHER CONSIDERATION IN THE CUMULATIVE EFFECTS ANALYSIS (CEA) FOR SEGMENTS E, F-1, F-2, AND G OF THE GRAND PARKWAY....5-17
TABLE 5-7 COMPOSITION OF LAND USE IN THE AOI BY YEAR....5-24
TABLE 5-8 USGS/NOAA DRAFT 2001 NLCD – LAND USE/LAND CLASSIFICATION OF THE AOI....5-26
TABLE 5-9 LOCAL MONITOR DATA....5-28

TABLE 5-10 BASE YEAR (2000) TOTAL MSAT EMISSIONS FOR THE ENTIRE TRAFFIC STUDY AREA (SEGMENTS E, F-1, F-2, AND G) 5-29
TABLE 5-11 USGS/NOAA DIRECT 2001 NLCD WETLANDS IN CUMULATIVE EFFECTS STUDY AREA....5-32
TABLE 5-12 DIRECT USGS/NOAA DRAFT 2001 NLCD LAND USE IMPACTS....5-36
TABLE 5-13 INDIRECT USGS/NOAA DRAFT 2001 NLCD LAND USE IMPACTS IN AOI 5-37
TABLE 5-14 GRAND PARKWAY SEGMENTS E, F-1, F-2, AND G LINKS ONLY - MSAT EMISSIONS (TONS/YEAR)....5-37
TABLE 5-15 DIRECT IMPACTS TO WATER-RELATED RESOURCES 5-40
TABLE 5-16 POTENTIAL DIRECT AND INDIRECT VEGETATIVE COMMUNITIES WETLAND AND KATY PRAIRIE IMPACTS IN AOI 5-41
TABLE 5-17 LOCAL OFFICIALS MEETING 5-42
TABLE 5-18 COMMUNITY GROUPS 5-43
TABLE 5-19 STATUS OF DEVELOPMENTS IN THE STUDY AREA 5-46
TABLE 5-20 COMPARISON OF PREDICTED CUMULATIVE AND INDIRECT EFFECTS TO 2025 LAND USE FOR THE NO-BUILD AND BUILD ALTERNATIVES 5-51
TABLE 5-21 COMPOUND ANNUAL HOUSEHOLD GROWTH RATE COMPARISON (2025) 5-53
TABLE 5-22 COMPARISON OF 2001 LAND USE AND PREDICTED 2025 LAND USE UNDER THE NO-BUILD AND BUILD ALTERNATIVES....5-54
TABLE 5-23 SUMMARY OF POTENTIAL CUMULATIVE WETLAND IMPACTS 5-56
TABLE 5-24 SUMMARY OF POTENTIAL CUMULATIVE KATY PRAIRIE IMPACTS....5-56
TABLE 5-25 MSAT EMISSIONS BY ALTERNATIVE (TONS/YEAR) (ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G) 5-61
TABLE 5-26 SEGMENT ADT ROADWAY BY YEAR....5-63
TABLE 5-27 SUMMARY OF CUMULATIVE EFFECTS 5-70
TABLE 6-1 LOCAL OFFICIALS MEETING, AUGUST 1999 AND OCTOBER 2000 FOR SEGMENT G....6-4
TABLE 6-2 FORMAL AGENCY MEETINGS DURING THE SCOPING AND CORRIDOR STUDY FOR SEGMENT G....6-6
TABLE 6-3 USACE PREFERRED ALTERNATIVE CORRIDOR AND RATIONALE FOR SEGMENT G....6-7
TABLE 6-4 USFWS PREFERRED ALTERNATIVE CORRIDOR AND RATIONALE FOR SEGMENT G....6-7
TABLE 6-5 FORMAL AGENCY MEETINGS DURING THE ALIGNMENT STUDY FOR SEGMENT G....6-10
TABLE 6-6 THE EXPERT PANEL 6-12

LIST OF FIGURES

FIGURE 1-1 EXPANDED CAPACITY – LOM/LOS....1-10
FIGURE 1-2 SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD LOM 1-12
FIGURE 3-1 VEHICLE MILES TRAVELED (VMT) VS. MOBILE SOURCE AIR TOXICS EMISSIONS, 2000-2020 3-23
FIGURE 4-1 PROJECTED CHANGES IN MSAT EMISSIONS BY ALTERNATIVE OVER TIME (ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)....4-46
FIGURE 4-2 PROJECTED CHANGES IN MSAT EMISSIONS BY ALTERNATIVE OVER TIME FOR SEGMENT G TRAFFIC STUDY AREA....4-48
FIGURE 4-3 TOTAL MSAT EMISSIONS OVER TIME, SEGMENT G TRAFFIC STUDY AREA....4-49
FIGURE 4-4 TOTAL VMT OVER TIME, SEGMENT G TRAFFIC STUDY AREA....4-50
FIGURE 4-5a COMPARISON OF ACETALDEHYDE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA....4-50
FIGURE 4-5b COMPARISON OF ACROLEIN BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA....4-51
FIGURE 4-5c COMPARISON OF BENZENE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA....4-51

FIGURE 4-5d COMPARISON OF 1,3 BUTADIENE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA 4-52
FIGURE 4-5e COMPARISON OF FORMALDEHYDE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA 4-52
FIGURE 4-5f COMPARISON OF DIESEL PARTICULATE MATTER BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA 4-53
FIGURE 5-1 CONCEPTUAL MODEL 5-15
FIGURE 5-2 TIME SCALE 5-23
FIGURE 5-3 PERCENT OF LAND USE OVER TIME 5-25
FIGURE 5-4 DIRECT AND INDIRECT MSAT EMISSIONS BY COMPOUND - 2025 5-38
FIGURE 5-5 CUMULATIVE EFFECTS OF MSAT BY COMPOUND - 2025 5-39
FIGURE 5-6 COMPARISON OF 2001 LAND USE AND PREDICTED 2025 LAND USE UNDER THE NO-BUILD AND BUILD ALTERNATIVES....5-55
FIGURE 5-7 COMPARISON OF THE GRAND PARKWAY SEGMENTS E, F-1, F-2, AND G TOTAL MSAT EMISSIONS AND VMT OVER TIME (ENTIRE TRAFFIC STUDY AREA) 5-57
FIGURE 5-5a COMPARISON OF ACETALDEHYDE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)....5-58
FIGURE 5-5b COMPARISON OF ACROLEIN BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)....5-58
FIGURE 5-5c COMPARISON OF BENZENE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)....5-59
FIGURE 5-5d COMPARISON OF 1,3 BUTADIENE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)....5-59
FIGURE 5-5e COMPARISON OF FORMALDEHYDE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)....5-60
FIGURE 5-5f COMPARISON OF DIESEL PARTICULATE MATTER BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA....5-60
FIGURE 5-9 PROJECTED CHANGES IN MSAT EMISSIONS BY ALTERNATIVE OVER TIME (ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)....5-62

INTRODUCTION

PROJECT DESCRIPTION

The proposed State Highway (SH) 99 (Grand Parkway) is planned as a 170-mile circumferential facility (a roadway loop such as Beltway 8) around the Houston metropolitan area. 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 proposed project would be a four-lane controlled access toll road with intermittent frontage roads located within a 400-foot right-of-way (ROW). The 400-foot ROW can accommodate one of the following typical roadway sections: four-lane section without frontage roads, four-lane section with frontage roads, four-lane section with exit and entrance ramps, and four-lane section with toll facilities and exit and entrance ramps. The entire proposed facility traverses Harris, Montgomery, Liberty, Chambers, Galveston, Brazoria, and Fort Bend Counties, provides access to radial highways (such as Interstate Highway [IH] 45 or United States Highway [US] 59), and would serve as a third loop around the Houston metropolitan area (see Exhibit G–1).

PROJECT HISTORY

The Grand Parkway was first proposed in 1961 by Harris County and the city of Houston Planning Commission following traffic studies that identified regional transportation deficiencies. The Grand Parkway corridor was placed on city maps in 1968, but funds were not available to advance the project. With the development of the Houston metropolitan area, the Katy area, and other residential and corporate facilities in West Houston, the need for additional transportation facilities increased. County officials and landowners mapped a proposed corridor for the Grand Parkway and submitted the plan to the Texas Transportation Commission.

In 1984, the Texas Legislature authorized the creation and organization of a nonprofit transportation corporation to act on behalf of the Texas Department of Transportation (TxDOT) in the development of public transportation facilities and systems within the state. The Grand Parkway Association (GPA), the first of these corporations created, was charged with assisting the Texas Transportation Commission in obtaining land and funding to meet the planning, legal, engineering, and ROW requirements of the Grand Parkway. Since its inception, the GPA has worked directly with landowners, local and state governmental agencies, elected officials, and the public to complete the Grand Parkway.

In August 1993, TxDOT and Federal Highway Administration (FHWA) filed a Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for Segment E. (An NOI is published in the *Federal Register* to notify the public that an agency is preparing an EIS.) In January 2000, an NOI was published for Segments F-1, F-2, and G. Formal public scoping meetings were held in September 1993 and February 2000 for Segment E and Segments F-1, F-2, and G, respectively (see Section 6 [Agency and Public Coordination] of this volume for a detailed discussion of agency and public involvement).

The April 2003 Texas Transportation Commission Minute Order 109226 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 and operating 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." The Houston-Galveston Area Council's (H-GAC) 2035 Regional Transportation Plan (RTP) identifies the addition of tolled facilities, including the Grand Parkway, as necessary to address current congestion and future growth in the Houston region (H-GAC, 2007a). H-GAC has been designated by the state of Texas as the metropolitan planning organization (MPO) charged with coordinating transportation planning for the eight-county area around Houston, including Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties (see also Glossary and Volume I, Section 3.1.3).

CURRENT STATUS

The current status of each segment of the Grand Parkway is shown in Table 1. Locations of these segments are illustrated in Exhibit G–2.

TABLE 1
GRAND PARKWAY PROPOSED SEGMENTS

Segment	Proposed Location	Approx. Length (mi)	Counties	Status
A	SH 146 west to IH 45	6.4	Galveston	Corridor Feasibility Study initiated (fall 2008)
B	IH 45 west to SH 288	20.5	Galveston, Brazoria	Release of Final EIS (FEIS) in fall 2009
C	SH 288 west to US 59	26.0	Brazoria, Fort Bend	Release of FEIS in summer 2009
D	US 59 north to IH 10	19.0	Fort Bend, Harris	Complete
E	IH 10 north to US 290	14.0	Harris	Record of Decision (ROD) issued in June 2008
F-1	US 290 east to SH 249	12.0	Harris	ROD issued in November 2008
F-2	SH 249 east to IH 45	12.0	Harris	Release of FEIS in August 2008
G	**IH 45 east to US 59**	**13.7**	**Harris, Montgomery**	**Release of FEIS in January 2009**
H	US 59 south to US 90	23.0	Montgomery, Harris	Release of Draft EIS (DEIS) in summer 2009
I-1	US 90 south to IH 10	12.5	Harris, Liberty, Chambers	Release of DEIS in summer 2009
I-2	IH 10 south to SH 146	12.5	Chambers, Harris	Complete

Note: Bold/Shaded text indicates the segment included in this study.
Source: GPA, 2009

Segment E is proposed to extend approximately 14.0 miles north from IH 10 and west to US 290. Approximately one mile of Segment E, from IH 10 to Franz Road, was already constructed with Segment D. Segment F-1 would extend northeast approximately 12.0 miles from US 290 to SH 249. Segment F-2 would extend east approximately 12.0 miles from SH 249 to IH 45. Finally, Segment G would continue east approximately 13.7 miles from IH 45 to US 59.

PROJECT INDEPENDENT UTILITY AND LOGICAL TERMINI

The Grand Parkway is divided into 11 segments to facilitate planning, design, and construction since limited state and federal funding provides no assurance that all of the Grand Parkway segments will be constructed (Table 1). Because of commercial and residential growth and the expansion of SH 249 as a major transportation corridor, Segment F was further divided into two segments, F-1 and F-2.

While Segments E, F-1, F-2, and G support the overall purpose of the Grand Parkway, they also support the same purpose relevant to transportation needs specific to northwest Harris County and southern Montgomery County. As expected by H-GAC, residential and commercial development continues to expand from Houston's current outer loop. Northwest Harris County and portions of southern Montgomery County will require improved and additional roadway facilities to accommodate the anticipated increase in traffic volume.

To this end, Segment G connects at least two existing major transportation corridors to ensure independent utility as well as independent significance as required by FHWA regulations (23 Code of Federal Regulations [CFR] 771.111[f]). Segment G has its logical termini at IH 45 and US 59, providing independent utility, even if implemented separately.

LEGISLATION

Segment G, as with all the segments of the Grand Parkway, is included in recent federal transportation legislation, including the 1995 National Highway System designation, established by the Intermodal Surface Transportation Efficiency Act (ISTEA), the North American Free Trade Agreement (NAFTA), the Transportation Equity Act for the 21st Century (TEA-21), and the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

At the state level, Segment G is included in the Statewide Transportation Improvement Program (STIP) Fiscal Year 2006 Revisions in Appendix D as a project currently undergoing environmental review that is scheduled for implementation beyond the three-year STIP time frame. The STIP allocates funds for all transportation and air quality projects necessary for addressing existing and projected statewide transportation needs. At the local level, Segment G is consistent with the city of Houston's Major Thoroughfare and Freeway Plan (MTFP), the 2025 RTP, and the Transportation Improvement Program (TIP), as detailed in the following paragraphs.

Segment G is included in the city of Houston's 2006 MTFP (Houston Planning Commission, 2006). The MTFP covers the city of Houston and unincorporated portions of Harris, Montgomery, Waller, Liberty, and Fort Bend Counties. Updated annually, the MTFP guides roadway and transit planning and development within the city of Houston and is supported by neighboring county and local governments in the Consolidated Metropolitan Statistical Area (CMSA).

Segment G was contained in H-GAC's 2025 RTP as a four-lane, controlled access toll facility that is necessary to address congestion and future growth in the region (H-GAC, 2005a). Since H-GAC has been designated by the state of Texas as the MPO charged with coordinating transportation planning for the eight-county area around Houston, H-GAC's Transportation Policy Council (TPC) approves the RTP and TIP.

The RTP is a long-range plan designed to:

- Identify the need for transportation improvement projects, including mass transit and other non-road projects;
- Satisfy future transportation demand; and
- Bring the Houston metropolitan area into conformance with regulatory emission limits and air quality standards.

In addition to traditional funding sources, the 2025 RTP identified other funding sources such as motor fuel taxes and toll roads that will play a strategic role in expanding the roadway system. The TPC provides regional coordination with various stakeholders, including cities and counties in the eight-county area, TxDOT, transportation agencies (such as transit, toll, and port authorities), and citizens of the region. The 2025 RTP conformed to emission limits set by the Texas Commission on Environmental Quality (TCEQ, formerly Texas Natural Resource Conservation Commission [TNRCC]) and approved by the U.S. Environmental Protection Agency (EPA).

The Grand Parkway Segment G is included in the H-GAC's 2035 RTP and fiscal year (FY) 2008-2011 TIP, as amended. On August 24, 2007, the H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. The U.S. Department of Transportation (FHWA and Federal Transit Administration [FTA]) found the 2035 RTP and 2008-2011 TIP to conform to the State Implementation Plan (SIP) on November 9, 2007.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional analysis is warranted before 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 modeled parameters can be found in the Administrative Record.

PROJECT DEVELOPMENT PROCESS AND DOCUMENT ORGANIZATION

The project development process implemented for Segments E, F-1, F-2, and G consisted of studies to determine the need for and purpose of the project, analyze various alternatives, determine the affected environment, and study indirect and cumulative effects. For each level of study in the project development process, Table 2 shows the alternatives

considered, the focus of study, the terms used by the Study Team (see also Glossary), and the result of the DEIS and FEIS. Throughout the study process (Table 3), workshops were held to solicit comments from the public and resource agency officials. Section 6 (Agency and Public Coordination) of this volume provides greater detail on coordination and outreach efforts for the corridor and alignment studies. The environmental studies and public input were used to develop a full range of alternative corridors and select a Preferred Alternative Corridor to carry forward in a more detailed process. The project development process is depicted graphically in Exhibit G–3.

The Grand Parkway Segments E, F-1, F-2, and G study area has been divided into four Segments of Independent Utility (SIUs) to facilitate planning, design, and construction because limited state and federal funding provides no assurance that all the Grand Parkway segments would be constructed. For Segment G, the FEIS is organized in a four-volume set in response to public and resource agency comments concerning potential cumulative effects of Segment G and the need to assess Segment G as a facility with independent utility and logical termini, as follows:

- Volume I presents analyses and results common to Segments E, F-1 F-2, and G, including project description, the need for and purpose of the project, alternatives considered, affected environment, indirect and cumulative effects, and agency and public coordination.
- Volume II provides a detailed assessment of Segment G relative to its project area. It includes issues, permits, and federal actions particular to Segment G, such as the need for and purpose of the project; alternatives considered; affected environment; environmental consequences; avoidance, minimization, and mitigation measures; indirect and cumulative effects; and agency and public coordination.
- Volume III contains exhibits and appendices referenced in Volumes I and II.
- Volume IV contains materials related to the Segment G DEIS Public Hearing, comments submitted, and responses to the DEIS comments provided following the release of the Segment G DEIS in January 2007.

The volume covers and section tabs for Segment G are color-coded (Volume I [Green, common to Segments E, F-1, F-2, and G] and Volume II/III/IV [Light Green, specific to Segment G]) to help the reader navigate through the document.

TABLE 2
ALTERNATIVES CONSIDERED AT EACH LEVEL OF STUDY

Alternative Considered			Focus of Study	Results of DEIS	Results of FEIS
Level of Study	**Examples**				
Volume I					
Corridor	Segment E	A, B, C, CB, and D	Study Area	Preferred Alternative Corridor	Preferred Alternative Corridor
	Segment F-1	A, B, C, CB, and D			
	Segment F-2	A, B, C, and D			
	Segment G	A, B, C, and D			
Transportation Mode	No-Build and Build Alternatives		Traffic Study Area	Recommended Alternative Transportation Mode	Preferred Alternative Transportation Mode
Volume II					
Alignment	Segment E	A, B, C, and NB	Preferred Alternative Corridor (Project Area)	Recommended Alternative Alignment	Preferred Alternative Alignment
	Segment F-1	A, B, C, and NB		Recommended Alternative Alignment	Preferred Alternative Alignment
	Segment F-2	A, B, C, D, E, F, and NB		Recommended Alternative Alignment	Preferred Alternative Alignment
	Segment G	A, B, C, D, and NB		Recommended Alternative Alignment	Preferred Alternative Alignment

Notes: NB = No-Build Alternative. Although the No-Build Alternative would not satisfy the need for and purpose of the project, it was retained as a basis for comparison per 40 CFR 1502.14(d).

Source: Study Team, 2007

TABLE 3
STEPS IN THE DEVELOPMENT PROCESS OF THE GRAND PARKWAY

Step	Scope	Purpose	Public Meeting/ Workshop*
Project Initiation and Early Scoping	Presentation of the project to the public, local officials, and state and federal resource agencies.	To include public and cooperating agencies early in the project development process and solicit public/agency comments.	Yes
Socioeconomic Study	Evaluation of past, present, and future forecasts of social and economic conditions of the study area and the region.	To determine project need and guide project design to meet the need.	No
Corridor Study	Develop broad environmental inventory mapping of the study area and develop preliminary corridors roughly 5,000 feet in width.	To develop preliminary corridors, determine environmental constraints on a broad scale, solicit public comments, and select the Preferred Alternative Corridor for detailed alignment specific analysis.	Yes
Indirect Development Analysis	Evaluate the difference in land use and corresponding environmental effects from: 1) Segments E, F-1, F-2, and G are not built; and 2) Segments E, F-1, F-2, and G are built.	To assess potential long term or geographically distant impacts from highway-induced development associated with the No-Build and Build Alternatives.	No
Traffic Study	Model future travel demand within the study area, based on future land use scenarios.	To continue to establish the need for and purpose of the project as well as guide preliminary alternative design to best serve the study area.	No
Affected Environment	Study natural, physical, and social resources that could be impacted by the proposed facility.	To identify the alignment that minimizes impacts to the natural, physical, and social environment that best fulfills the need for and purpose of the project.	No
Alignment Study	Study natural, physical, and social resources specific to preliminary alignments.	To identify project impacts, to refine preliminary alignments, and to develop an appropriate mitigation plan.	Yes
Mitigation Planning	Coordinate to develop a plan to resolve unavoidable impacts of the project on resource specific variables identified in the affected environment study.	To continue to develop a project that minimizes impacts.	No
Environmental Documentation	Produce a DEIS and FEIS that disclose the benefits and impacts of the proposed action.	To provide the public and agencies an opportunity to comment on the findings of the environmental studies and ultimately to reach a ROD.	Yes

Note: * The dates of meetings and workshops are discussed in Section 6 (Agency and Public Coordination) of this volume.
Source: Study Team, 2007

Environmental Resource Mapping

In order to efficiently collect, organize, analyze, and display large amounts of environmental data in the 300 square-mile study area, a Geographic Information System (GIS) was established for the study. Coverages (features or layers) include the roadway network; traffic and demographic information; census information; past, present, and forecasted land use; vegetative cover types; jurisdictional (adjacent) and isolated wetlands; floodplains; sensitive resource areas and protected species; political boundaries; streams and waterbodies; parks and recreation areas; historic properties and known or potential archeological sites; locations of potentially hazardous materials; and locations of study alternatives.

Continual coordination with local officials, business owners, and landowners has contributed to the identification of planned or platted housing developments, as well as properties purchased for expansion of schools. The residential acreage mapped and presented in the inventory includes any residential development planned for construction and completion within a three to five year period.

Representatives of the Texas Parks and Wildlife Department (TPWD), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Army Corps of Engineers (USACE) were particularly concerned with the identification and avoidance of wetlands; floodplains; rare, threatened, endangered, or otherwise protected species; and special habitat areas such as remnant prairie and bottomland hardwoods. Tools such as GIS were used to identify, map, and analyze the resource agencies' concerns.

This information was used to produce maps identifying environmental constraints to be considered for the proposed project. The objective of the GIS constraints mapping effort was to identify, avoid, and minimize impacts to sensitive resources while developing 5,000-foot wide alternative corridors within the study area. A corridor of this width was chosen to allow project planners to develop reasonable and distinct alternative alignments within the corridor, while providing maximum flexibility to avoid adverse impacts. The majority of the information compiled during the corridor study was available in state and local databases and other existing sources. Table 4 presents the environmental data categories and the source of these data for the corridor-level analysis. The data were overlaid on 1995 aerial photography (updated for 1999 housing and development). For the purpose of corridor-level analysis, the study area was divided into seven corridor reaches to facilitate the determination of the Preferred Alternative Corridor. A corridor reach is defined as a segment of the study area where two or three of the corridors overlap because of the density of environmental constraints in those areas. Reaches were used to examine "hybrid" combinations of the corridors. The seven corridor reaches allowed the Study Team to analyze and compare the potential impacts associated with various corridors or combinations of corridors.

TABLE 4
GIS DATA COVERAGES

Coverage	Source(s)
Cemeteries	U.S. Geological Survey (USGS) 7.5 minute series quadrangle maps, Harris (2000) and Montgomery (2000) County Key Maps
Churches	USGS 7.5 minute series quadrangle maps, Harris (2000) and Montgomery (2000) County Key Maps
Golf Courses	North and West Houston Association Development Maps, Aerial Photography
Recorded Archeological Sites	Texas Archeological Research Lab
Farmland Soils	Natural Resource Conservation Service (NRCS) Soil Surveys
Floodplain and Floodways	Federal Emergency Management Agency (FEMA)
Residential Development	Aerial photography, North and West Houston Association Maps, Harris (2000) and Montgomery (2000) County Key Maps, County Engineers, Developers
Hazardous Material Sites	Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), National Priority List (NPL), Resource Conservation and Recovery Act – Treatment Storage and Disposal (RCRA-TSD), RCRA Corrective Action Database (CORRACT), Resource Conservation and Recovery Act – Generators and Violators (RCRA-G), Emergency Response Notification System (ERNS), Texas State Superfund List (TXSSF), Texas Landfill Database (TXLF), Texas Leaking Underground Storage Tank Database (TXLUST), Texas Underground Storage Tank Database (TXUST), Texas Above Ground Storage Tank Database (TXAST), Texas Spills Incident Information System (TXSPILL)
Historic-Age Resources	USGS 7.5 min series quadrangle maps older than 50 years; TxDOT mapping
Area of Influence (AOI)	Expert Panel, Study Team
Wetlands	USFWS National Wetland Inventory Mapping, Aerial Photography
Oil and Gas Wells	Texas Railroad Commission and Banks Information Systems
State Historic Markers	Texas Historical Commission
Parks	Precincts 3 and 4 Recreation Maps
Prior Converted Wetlands	NRCS
High Probability Areas for Archeological Resources	TxDOT Environmental Affairs Division
Rare, Threatened, and Endangered Species	USFWS, TPWD
Schools	Aerial photography; contact with school districts

TABLE 4 (CONT.)
GIS DATA COVERAGES

Coverage	Source(s)
Streams	TxDOT, Study Team, USGS 7.5 min series quadrangle maps
Project Area	Study Team
Remnant Prairie Topography	USFWS, TPWD, Study Team
Forested Floodplains	USFWS, TPWD, Study Team
Water Wells	TCEQ

Source: Study Team, 2007

Once a Preferred Alternative Corridor was selected, 400-foot wide alternative alignments were identified within the selected corridor. At this level of study, the Preferred Alternative Corridor was defined as the project area. For the purposes of the alternative alignment-level of analysis, the project area (Preferred Alternative Corridor) was divided into 12 alignment reaches to facilitate the determination of a Recommended Alternative Alignment. These alignment reaches were segments of the project area where two, three, or more alternative alignments overlap because of the density of environmental constraints. The 12 alignment reaches allowed the Study Team to analyze and compare the potential impacts associated with various alternative alignments or combinations of alternative alignments (Section 2.3.1 [Alternative Alignments Development] of this volume).

The Segment G DEIS, published in January 2007, presented four alternative alignments and a hybrid alternative alignment defined as the Recommended Alternative Alignment. The Recommended Alternative Alignment was analyzed to the same level of detail as the other alternative alignments. This FEIS presents the original four alternative alignments and a selected Preferred Alternative Alignment. For the selection of the Preferred Alternative Alignment and the analyses presented in the FEIS, updated land use data were incorporated into the environmental resource mapping, and some resources have been analyzed beyond the level of detail presented in the DEIS in order to present a more thorough inventory of potential impacts that would result from the Preferred Alternative Alignment. These studies are detailed in Section 3 (Affected Environment) and Section 4 (Environmental Consequences) of this volume.

Updated land use data and analyses, as well as comments received after release of the DEIS, led to a slight shift to the Recommended Alternative Alignment. Thus, the Preferred Alternative Alignment is different from the Recommended Alternative Alignment presented in the Grand Parkway Segment G DEIS. These changes are detailed in Section 2 (Alternatives Analysis) of this volume.

Public Involvement

FHWA, TxDOT, and the GPA have engaged governmental agencies and the public in an extensive coordination effort to both inform others of progress in the planning process and solicit input from them. Through 2007, over 170 meetings have been held with homeowner associations, the media, and other community groups throughout the Segments E, F-1,

F-2, and G study areas. The GPA maintains a website (www.grandpky.com) to provide updates to the public on developments and issues concerning the Grand Parkway. The Grand Parkway project has been open to comments by any person and all views on the scope of the proposed project, alternative actions, environmental impacts, and any other matter concerning the proposed Grand Parkway. FHWA, TxDOT, and the GPA have considered all comments to date and will continue to consider all comments in its planning process into the future.

Initial public workshops were held in August 1999 to introduce the public to Segments E, F-1, F-2, and G, to solicit public comments regarding the proposed project, and to provide an explanation of the studies needed to further the project. The Preferred Alternative Corridor was identified after engineering and environmental studies, coordination with state and federal resource agencies, and public scoping meetings in February 2000. Subsequent public meetings in October 2000 were held to present preliminary alternative alignments within the Preferred Alternative Corridor. These meetings are detailed in Sections 6.2.1 and 6.2.3 of this volume.

Following the publication of the DEIS, a Public Hearing was held over two nights on March 7 and 8, 2007. The Public Hearing consisted of an exhibit viewing session, a formal presentation, and a public commenting session. Availability of the DEIS and announcement of the Public Hearing was published in the *Federal Register*, *Texas Register*, and area newspapers. Comments were submitted during both the Public Hearing and the following comment period. In accord with the Council on Environmental Quality (CEQ) regulations (40 CFR 1503.4), substantive comments, and responses to the comments are presented in the FEIS (see Volume IV).

After careful consideration of comments received on the DEIS and updates to the environmental resource mapping, inventory of potential direct impacts, and indirect and cumulative effects assessment, a Preferred Alternative Alignment was selected, as detailed in Section 2.3 (Alternative Alignment Study) of this volume. The selection of the Preferred Alternative Alignment complies with regulations issued by the CEQ (40 CFR 1500-1508), FHWA (23 CFR 771) and the state of Texas (43 TAC Section 2.43), as well as in accord with the FHWA Technical Advisory T 6640.8A. Segment G public involvement is further addressed in Section 6 (Agency and Public Coordination) of this volume.

SECTION 1: PROJECT NEED AND PURPOSE

Volume II addresses Grand Parkway Segment G. The Segment G study area is generally bounded by IH 45 to the west, US 59 to the east, Farm-to-Market Road (FM) 1960 to the south, and just beyond the proposed Grand Parkway to the north in Montgomery County (see Volume III, Exhibit G–2).

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

1.1 NEED FOR AND PURPOSE OF THE PROPOSED PROJECT

Transportation improvements are needed in the Segment G study area because there are inefficient connections between suburban communities and major radial roadways, the current and future transportation demand exceeds capacity, many roadways in the study area have a high accident rate, and there is an increasing strain on transportation infrastructure from population and economic growth. The local needs for Segment G 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 IH 45 and US 59:
  - This region experiences a high number of east-west traffic movements. The origin/destination study shows that of the approximately 1,672,900 trips generated to/from the Segment G traffic study area[1], approximately 36 percent (607,900) are engaged in circumferential movement and could benefit from Segment G.
  - The transportation system does not provide efficient connections between suburban communities, such as Spring, The Woodlands, Kingwood, Porter, and New Caney.
  - Only collector roadways connect IH 45 and US 59 within the study area. To accomplish circumferential trips, travelers either use radial roadways (such as IH 45, US 59, the Hardy Toll Road, or FM 1314) to reach circumferential roadways (such as FM 1960 and Beltway 8) or travel on collector roadways (such as Louetta Road, Spring-Cypress Road, Riley Fuzzel Road, Treaschwig, FM 1314, Cypresswood Drive, or Rayford Road).

[1] The area used for analyzing traffic data has been expanded beyond the project study area in order to include all major roadways potentially affected by the proposed new transportation facility. This area is referred to as the traffic 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 (such as Louetta Road, Spring-Cypress Road, Riley Fuzzel Road, Treaschwig, FM 1314, Cypresswood Drive, or Rayford Road) will not be able to meet future traffic demand.
  - The circumferential roadways that lie within the traffic study area (FM 1960, SH 242, and Beltway 8) are expected to increase in traffic an average of 127 percent by 2025. Beltway 8 is expected to have a 219 percent increase in traffic.
  - The major facilities in the Segment G traffic study area are expected to increase in traffic an average of 111 percent by 2025.
  - The Level of Mobility (LOM) of the major facilities in the area shows trends toward serious and severe conditions by 2025.
  - The total number of Vehicle Hours Traveled (VHT) for the Segment G traffic study area is expected to increase by 48 percent from 2000 to 2025 (H-GAC, 2005a), which can be related to the average commuter spending more time getting to and from work.
- Safety: Many roadways in Segment G, such as FM 1960 and Cypresswood Drive, have high accident rates. These roads are characterized by intersections, traffic signals, and/or stop signs, and multiple access points, all of which may contribute to stop-and-go conditions, increased crash rates, and congestion during peak travel times and emergency events:
  - The Houston region had a fatal and injury crash rate higher than both state and national averages. For example, 1,010 accidents occurred on roadways in the Segment G traffic study area of the Grand Parkway in the period from 1999 through 2001 (see Table 1-3), six of which resulted in fatalities, and 631 of which caused injuries or possible injuries (H-GAC, 2005c).
  - 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 two 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 (Little et al., 2006).
- Economic Development: The expected growth will continue to strain existing transportation infrastructure, creating a barrier to businesses, commuters, and economic development. For those areas outside the IH 610 Loop, H-GAC predicts an 83.4 percent growth in population and a 76.0 percent growth in employment from the year 2000 to 2025 (H-GAC, 2005a). Much of this growth would be concentrated in the study area. With this increasing population and corresponding increases in traffic and congestion, it could become progressively more difficult for businesses to function efficiently.

The purpose of the proposed transportation improvements in the Segment G 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 Segment G are further detailed in the following:

- System Linkage: The proposed project would improve system linkage, or connectivity, within the existing transportation network. The proposed project would provide circumferential linkage between IH 45 and US 59, the two major radial facilities in the Segment G study area, to provide linkage for traffic engaged in circumferential traffic movement.
- Expanded Capacity: The proposed project would address transportation demand, improve the LOM, reduce traffic congestion, and provide travel options.
- Safety: The proposed project would improve regional and local safety for the traveling public by minimizing conditions that contribute to stop-and-go conditions, increased crash rates, and congestion during peak travel times and emergency events:
  - The proposed project would divert traffic from parallel roadways with high accident rates, such as FM 1960 and Cypresswood Drive, thereby reducing accident rates.
  - The Grand Parkway would provide an additional hurricane and emergency evacuation route for the greater Houston area consistent with Minute Order No. 82325 signed October 25, 1984. The Grand Parkway could alleviate a portion of the congestion during mass evacuations thus creating safer and more efficient evacuation conditions.
- Economic Development: The proposed project would 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 FHWA's Technical Advisory T 6640.8A, *Guidance for Preparing and Processing Environmental and Section 4(f) Documents* (FHWA, 1987), FHWA's memorandum entitled, *Purpose and Need in Environmental Documents* (FHWA, 1990a), FHWA's and FTA's joint memorandum entitled, *Integration of Planning and NEPA [National Environmental Policy Act] Processes* (FHWA and FTA, 2005), and TxDOT's memorandum entitled, *Guidance on Purpose and Need* (TxDOT, 2001). FHWA (1990a) 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 area. Studies conducted for the proposed Grand Parkway included substantial interaction with project stakeholders, including the general public, local businesses and landowners, local officials and 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 Segment G study area shown in Exhibit G–2 because it includes all major roadways potentially affected by the proposed new transportation facility. The traffic study area for Segment G is generally bounded by IH 45 to the west, US 59 to the east, IH 610 to the south, and extends just beyond the proposed Grand Parkway to the north in Montgomery County.

The 2025 RTP was reviewed to document transportation forecasts and travel deficiencies. Several different years were analyzed to better understand the land use changes and consequential travel demand changes over time. Analyzing interim years allows planners to assess proposed transportation improvements that are planned for construction throughout the 20-year planning horizon. To fully understand the transportation issues, the traffic analysis included data from years 2000 (base year), 2010 (No-Build only), 2015, and 2025. The state has identified the need for Segment G by including it in TxDOT's Unified Transportation Program (UTP), a 10-year statewide plan for transportation project development (last updated October 27, 2005). The No-Build Alternative discussed herein is defined as a condition in which all planned and programmed improvements included in the 2025 RTP are in place except Grand Parkway Segments E, F-1, F-2, and G.

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 system. Information obtained from the public meetings (see Section 6 of this volume) indicated that citizens would use the proposed project as a link to the existing interstates or state highways for travel to areas outside Houston.

IH 45 and US 59 are two radial, or "spoke," highways connecting Houston to its suburbs and beyond. No reasonable freeway alternative connecting major radial facilities exists in the Segment G study area. There currently is no primary east-west thoroughfare in the Segment G study area, and travelers are forced to access SH 242, FM 1960, or Beltway 8 to move east-west in within the traffic study area. Secondary roads include Rayford Road, Northgate Crossing Boulevard, Riley Fuzzel Road, and FM 1314. The center portion of the study area is mostly undeveloped and lacks transportation infrastructure. The existing network of roads was developed along historic property boundaries, does not meet current design standards, and would not be able to efficiently accommodate projected future traffic.

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 (2000) and future (2025) traffic projections. Base year and future traffic were compared to determine the change in traffic volumes over time. 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.

The traffic analysis was conducted for the following facility types defined by FHWA:

- Interstate Highways/Freeways: These roadways are divided highways with two or more lanes designated for the exclusive use of traffic in each direction and 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 45.
- 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. They serve long distance travel demands such as statewide and interstate travel. 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, the Hardy Toll Road, and US 59. The proposed Grand Parkway is an example of a freeway[2] principal arterial.
  - Non-Freeway Principal Arterial: These principal arterials do not exhibit access control. At-grade intersections and impeded traffic flow are common. FM 1960 is an example of a non-freeway 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 SH 242.
- 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 Louetta Road, Spring-Cypress Road, Riley Fuzzel Road, Treaschwig, FM 1314, Cypresswood Drive, and Rayford Road.

[2] The term, "freeway" in this document is consistent with terminology in the TRB's Highway Capacity Manual (2000). Any divided arterial with complete access control and unimpeded traffic flow is designated a freeway, whether it is tolled or not.

- Smart Streets/Express Streets: Smart Street enhancement is a concept developed and introduced into the 2025 RTP as an additional tool to increase mobility and improve transit access and safety by providing operational improvements along strategic regional thoroughfares. Smart Street enhancements would improve mobility through a range of alternatives, such as synchronization of traffic signals; construction of roundabouts, medians, or turn bays (dedicated turn lanes); consolidation of duplicate driveways; and, as appropriate, partial grade separation of some traffic lanes at major intersections (H-GAC, 2007a). Smart Street improvements are scheduled for the year 2023 and would take place along collector roadways. Examples of future Smart Streets include FM 1960, Kingwood Drive, Treaschwig, FM 1314, and SH 242. Expected future benefits of Smart Streets include:
    - Reduced cut-through traffic in neighborhoods;
    - 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;
    - Enhanced regional evacuation routes; and
    - Improvements to transit and reliability of transit trip times resulting from the proposed Smart Street alignment with Metropolitan Transit Authority's (METRO) Signature Express bus line plans.

Table 1-1 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 2025 RTP are in place except the Grand Parkway Segments E, F-1, F-2, and G. All of the roadways within the traffic study area are expected to have increases in Average Daily Traffic (ADT) from the year 2000 to 2025. Overall, the major facilities in the Segment G traffic study area are expected to average an increase of 111 percent by 2025. Furthermore, some of the principal arterials would increase over 200 percent or more. This growth in traffic is consistent with the projected future population and employment growth.

In addition to traffic volumes, LOM calculations were used to assess roadway operating conditions. The LOM is a concept developed by H-GAC and introduced in the 2025 RTP to illustrate the degree of congestion on roadways within the region. The LOM is comparable to the Transportation Research Board (TRB) Highway Capacity Manual's "Level of Service" (LOS) methodology (TRB, 2000), but LOS is a more specific measure because it provides a greater number of categorizations of traffic flow.

TABLE 1-1
SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD ADT BY ROADWAY SEGMENT

Facility	From	To	2000 (Base Year) ADT	2010 No-Build		2015 No-Build		2025 No-Build	
				ADT	% Change (from 2000)	ADT	% Change (from 2000)	ADT	% Change (from 2000)
Interstates									
IH 610	IH 45	US 59	196,500	167,700	-15%	182,900	-7%	199,600	2%
IH 45	North of SH 99	SH 99	146,700	194,900	33%	233,200	59%	244,600	67%
	SH 99	FM 1960	127,300	144,400	13%	170,300	34%	177,400	39%
	FM 1960	Beltway 8	180,400	200,300	11%	219,400	22%	224,600	25%
	Beltway 8	IH 610	213,300	218,400	2%	231,400	8%	256,400	20%
Principal Arterials									
US 59	North of SH 99	SH 99	54,900	50,300	-8%	58,800	7%	66,100	20%
	SH 99	FM 1960	115,700	135,600	17%	145,400	26%	157,100	36%
	FM 1960	Beltway 8	141,100	159,600	13%	177,100	26%	202,400	43%
	Beltway 8	IH 610	185,000	175,300	-5%	189,400	2%	215,000	16%
FM 1960	IH 45	US 59	47,800	63,600	33%	69,900	46%	70,700	48%
Beltway 8	IH 45	US 59	39,400	77,700	97%	91,700	133%	125,600	219%
Hardy Toll Rd	IH 45	SH 99	26,500	35,200	33%	32,400	22%	41,000	55%
	SH 99	FM 1960	31,800	40,700	28%	38,100	20%	48,000	51%
	FM 1960	Beltway 8	37,200	40,400	9%	33,600	-10%	50,400	35%
	Beltway 8	IH 610	45,700	41,000	-10%	33,300	-27%	58,600	28%
Minor Arterials									
SH 242	IH 45	FM 1314	13,300	15,700	18%	17,100	29%	29,300	120%
	FM 1314	US 59	8,000	10,100	26%	10,900	36%	17,500	119%

TABLE 1-1 (CONT.)
SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD ADT BY ROADWAY SEGMENT

Facility	From	To	2000 (Base Year)	2010 No-Build		2015 No-Build		2025 No-Build	
			ADT	ADT	% Change (from 2000)	ADT	% Change (from 2000)	ADT	% Change (from 2000)
Collector Roadways									
Louetta Rd	IH 45	Hardy Toll Rd	6,300	12,600	100%	17,800	183%	28,100	346%
Spring-Cypress Rd	IH 45	Hardy Toll Rd	3,400	2,100	-38%	5,500	62%	4,300	26%
Cypresswood Dr	IH 45	Hardy Toll Rd	11,600	15,500	34%	19,600	69%	22,700	96%
	Hardy Toll Rd	FM 1960	3,800	5,800	53%	18,700	392%	20,500	439%
Spring Stuebner Rd	IH 45	Hardy Toll Rd	5,900	7,400	25%	11,400	93%	18,900	220%
FM 1314	SH 242	US 59	10,900	20,100	84%	21,700	99%	31,000	184%
FM 1485	SH 242	US 59	5,800	11,200	93%	19,900	243%	30,000	417%

Source: H-GAC, 2005a

LOS is a qualitative measure of the operating conditions of a traffic stream on a transportation facility. There are six LOSs (LOS A-F) defined for each type of facility. LOS A represents the free-flow or best operating conditions with no congestion and LOS F denotes the forced-flow or worst operating conditions with heavy congestion. LOS D is considered an acceptable LOS, especially for urban areas such as the Houston area.

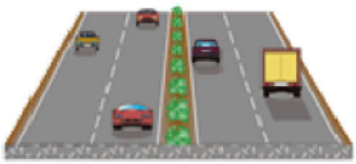
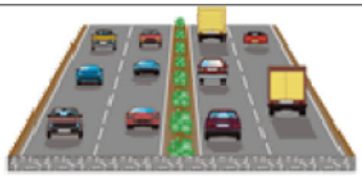
The Highway Capacity Manual provides LOS criteria based on maximum density, minimum speed, the ratio of flow rate known as volume to capacity (v/c), and maximum service flow rate. H-GAC provides LOM criteria based only on roadway v/c. The LOM incorporates local adjustments to account for facilities that have higher volumes than they were designed to carry. The LOM concept takes into account traffic demand, speed, roadway type, and number of lanes. An LOM of 0–0.85 represents a tolerable condition, 0.86–1.00 represents a moderate condition, 1.01–1.24 represents a serious condition, and 1.25 and higher represents a severe condition.

Figure 1-1 demonstrates how LOS uses six categories while LOM uses four categories to classify traffic flow conditions. This comparison shows that a tolerable LOM represents acceptable conditions; a moderate LOM is the point at which the volume of vehicles is approaching or has reached the capacity of the facility and the traffic flow is breaking down; and serious and severe LOMs relate to situations in which facility capacity has been reached or exceeded, causing considerable delays and lengthy traffic jams.

Figure 1-2 and Table 1-2 present base year and future No-Build LOM. Taking Grand Parkway out of the equation, planned and programmed transportation improvements alone will not be sufficient to accommodate the projected increase in congestion. Even with the improvements, congestion is expected to worsen through the year 2015, while in 2025, congestion decreases throughout the Segment G traffic study area. For example, in 2000, 8 percent of all roadway miles operate with serious and severe LOM conditions. In 2015, this increases to 15 percent, but in 2025, this percentage drops to 12 percent of roadways operating at serious and severe conditions. Thus, the year 2025 level of congestion is expected to be better than the base year (2000), even with an increase in traffic volumes.

The improvement in LOM in the year 2025, as stated above, is attributable to the implementation of the Smart Streets concept. Smart Streets, per the 2025 RTP, are scheduled to be open to traffic in the year 2023. Smart Streets allow for increased capacity and improved traffic or operational flow along arterial corridors without adding additional lanes. The effect of Smart Streets on the LOM in the year 2025 is explained in detail in Volume I, Section 1.2.2 (Expanded Capacity), particularly with the trend-line analysis presented in Figure 1-4 (Base Year and Future No-Build Projected LOM).

FIGURE 1-1
EXPANDED CAPACITY – LOM/LOS*

Level Of Mobility (LOM)	Volume to Capacity (V/C)		Technical Descriptions	Flow Conditions	Level Of Service (LOS)
	LOM	LOS			
Tolerable	0-0.85	0-0.27	Highest quality of service. Traffic flows freely with little or no restrictions on speed or maneuverability. No delays		A
		0.28-0.44	Traffic is stable and flows freely. The ability to maneuver in traffic is only slightly restricted. No delays		B
		0.45-0.64	Few restrictions on speed. Freedom to maneuver is restricted. Drivers must be more careful making lane changes. Minimal delays		C
		0.65-0.85	Speeds decline slightly and density increases. Freedom to maneuver is noticeably limited. Minimal delays		D
Moderate	0.86-1.00	0.86-1.00	Vehicles are closely spaced, with little room to maneuver. Driver comfort is poor. Significant delays		E
Serious	1.01-1.24	>1.00	Few restrictions on speed. Freedom to maneuver is restricted. Drivers must be more careful making lane changes.		F
Severe	>1.25	N/A	Considerable delays		

Note: *For further information in regards to LOM, LOS, and v/c, please refer to Section 1.2.2 (Expanded Capacity) of this volume.

Source: California Department of Transportation (Caltrans), 2003 and Study Team, 2007

TABLE 1-2
SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD LOM BY FACILITY TYPE

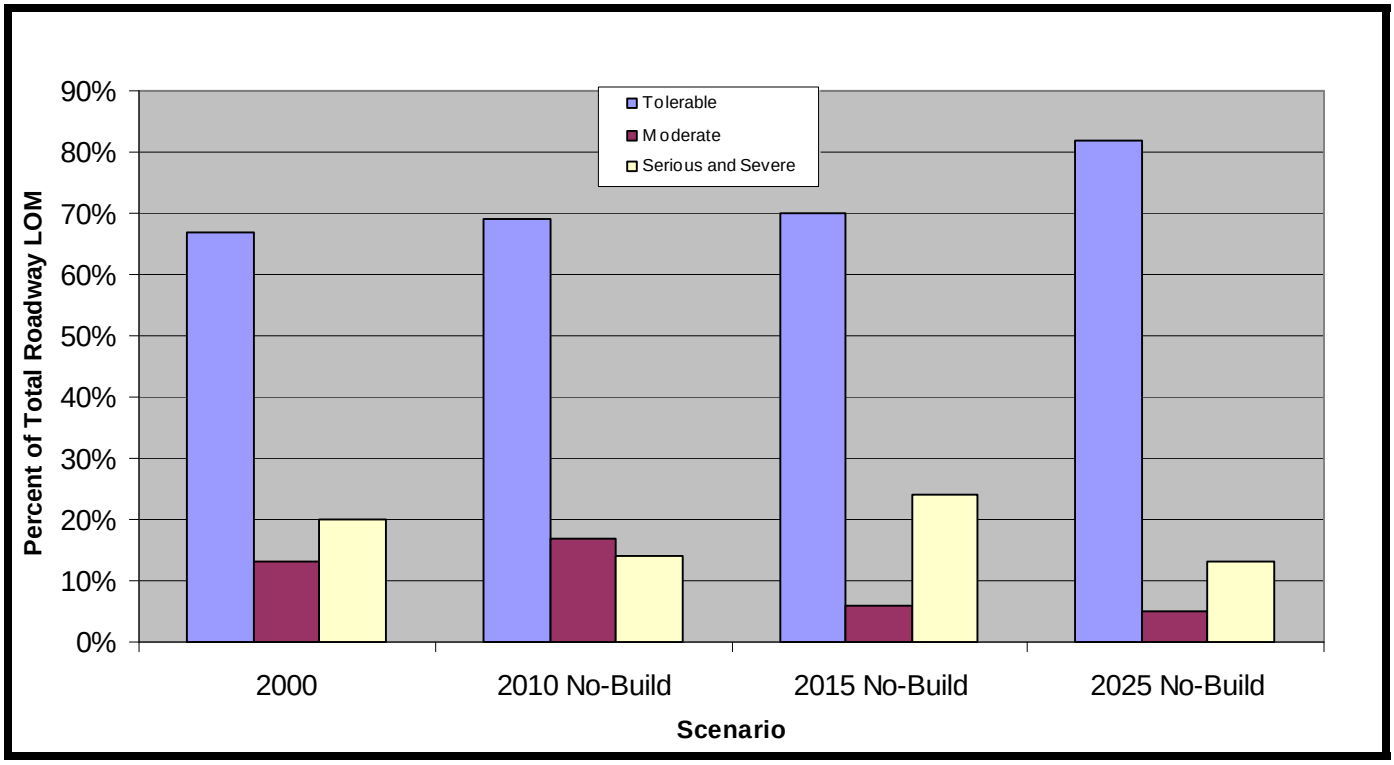
Condition	2000 (Base Year)	2010 No-Build	2015 No-Build	2025 No-Build[1]
Interstates				
Tolerable	81%	89%	71%	96%
Moderate	10%	9%	26%	3%
Serious	9%	2%	3%	1%
Severe	0%	0%	0%	0%
Principal Arterials				
Tolerable	91%	97%	90%	88%
Moderate	5%	2%	5%	9%
Serious	3%	1%	4%	3%
Severe	1%	0%	1%	0%
Minor Arterials				
Tolerable	39%	36%	31%	15%
Moderate	38%	35%	5%	30%
Serious	6%	8%	39%	35%
Severe	17%	21%	25%	20%
Collector Roadway/Smart Streets				
Tolerable	94%	78%	49%	70%
Moderate	2%	18%	20%	5%
Serious	1%	3%	8%	18%
Severe	3%	1%	23%	7%
Total Roadway Miles[2]				
Tolerable	82%	85%	74%	78%
Moderate	10%	10%	11%	10%
Serious	5%	2%	9%	9%
Severe	3%	3%	6%	3%

Notes: [1] By 2025, unless funding sources are identified for major projects in the 2025 RTP (such as Smart Streets), more roadways, particularly collector roadways/Smart Streets, would operate at less than tolerable conditions (i.e., with a Moderate, Serious, or Severe LOM). See Volume I, Section 1.2.2, particularly the trend-line analysis presented in Figure 1-4, for further explanation.

[2] Total roadway miles based on weighted average.

Source: H-GAC, 2005a and Study Team, 2005

FIGURE 1-2
SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD LOM



Note: By 2025, unless funding sources are identified for major projects in the 2025 RTP (such as Smart Streets), more roadways, particularly collector roadways/Smart Streets, would operate at less than tolerable conditions (i.e., with a Moderate, Serious, or Severe LOM). See Volume I, Section 1.2.2, particularly the trend-line analysis presented in Figure 1-4, for further explanation.

Source: H-GAC, 2005a and Study Team, 2005

1.2.3 Safety

For the three-year period of 1999-2001, the Houston region had a fatal and injury crash rate 2.48 times that of the U.S. and 1.36 times that of the state of Texas (H-GAC, 2006). Table 1-3 shows examples of frequent accident locations within the traffic study area.

An accident analysis was conducted to determine how travel safety would be affected by new circumferential freeway capacity. Nationally, freeways have lower accident rates per number of vehicles than lower classified roads because of the design of the freeways, fewer access points, fewer driver distractions, and less stop-and-go conditions. Therefore, diverting traffic from collector roadways to a limited access facility, such as the proposed project, would reduce the accident fatality rate.

Studies have also shown a correlation between accident rates and frequency of access points (Cirillo, 1968 and McGuirk, 1973). The proposed project would eliminate at-grade intersections and limit access points to specific, controlled locations.

TABLE 1-3
LOCATIONS IN THE SEGMENT G TRAFFIC STUDY AREA WITH HIGH ACCIDENT RATES

Roadway			Accident Type					
Facility	From	To	Fatalities	Incapacitating Injury	Non-Incapacitating Injury (Probable Injury Crashes)	Possible Injury	Non-Injuries (Serious Property Damage)	Total
FM 1960	IH 45	US 59	6	57	151	396	361	971
Cypresswood Dr	IH 45	FM 1960	0	2	7	18	12	39

Note: Represents years 1999 through 2001, the most recent dataset available.
Source: H-GAC, 2005c

The Texas Transportation Institute's (TTI) Center for Transportation Safety compared fatal crashes by roadway functional class for the years 2000 and 2001 (National Highway Traffic Safety Administration [NHTSA], 2001 and NHTSA, 2002). The study concluded that fatal crashes were the lowest on freeways and expressways. The highest number of fatal crashes was recorded on local roads and principal arterials. The distribution of fatal crashes in Texas for the year 2001 by roadway functional class was as follows: 25 percent on local roads; 21 percent on principal arterials other than interstates, freeways, and expressways; 18 percent for collector roadways; 13 percent on minor arterials; 9 percent on urban interstate principal arterials; 7 percent on rural interstate principal arterials; and 7 percent for principal arterials, such as the proposed project.

Local roads, collector facilities, and non-freeway principal arterials have much higher accident rates because of more frequent turns, stop-and-go conditions, roadway distractions, and lack of access control. As seen in Table 1-1, principal arterials and collector roadways within the Segment G traffic study area are expected to see a substantial increase in travel demand by the year 2025. It is anticipated that if a new circumferential, controlled access facility was constructed, accident rates may decrease because traffic would be diverted from non-freeway principal arterials, collector roadways, and local roads to a less congested, safer facility.

The Grand Parkway would also provide an additional hurricane and emergency evacuation route for the greater Houston area (Exhibit G–12) consistent with Minute Order No. 82325 signed October 25, 1984. The circumferential route connects to numerous radial facilities that are often congested during an evacuation. As an example, when as many as two 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 (Little et al., 2006). The Grand Parkway could alleviate a portion of the congestion during mass evacuations thus creating safer and more efficient evacuation conditions.

1.2.4 Economic Development

H-GAC predicts substantial population and economic growth for northern Harris County and southern Montgomery County through the year 2025. Segment G is within one of the fastest growing regions in the CMSA. 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. 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.

Segment G 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.

SECTION 2: ALTERNATIVES ANALYSIS

This section discusses the alternatives considered throughout the project planning process. This process included consideration of a full range of alternatives; the Study Team considered the No-Build Alternative, various transportation modes, alternative corridors, and alternative alignments. This section also presents a traffic and transportation analysis of the No-Build and Build Alternatives. Section 2.1 reviews the Corridor Study also presented in Volume I, Section 2.1; Section 2.2 reviews the Transportation Mode Study also presented in Volume I, Section 2.2; and Section 2.3 presents for the first time in this document, the Alternative Alignment Study, including the selection of the Preferred Alternative Alignment. Careful consideration was given to all comments received from the public and local, state, and federal resource agencies.

The environmental study process was a systematic, interdisciplinary effort that involved public outreach, environmental resource mapping, socioeconomic studies, and detailed analysis. Exhibit G–3 shows the multi-step study process, which allows the examination of a full range of alternatives at the corridor level, transportation mode level, and alignment levels, with increasing detail as the study has progressed. This process has enabled alternatives to be evaluated in several stages so that only the most practicable, those alternatives that met the need for and purpose of the project and those that had the potential to minimize adverse environmental impacts, were advanced to the next phase of study. The Preferred Alternative Corridor and the Preferred Alternative Alignment were selected based on their abilities to best fulfill the need for and purpose of the project while avoiding or minimizing environmental impacts.

A range of transportation alternatives were considered, including the alternative of building the Grand Parkway as a toll road (Build Alternative) and not building Segments E, F-1, F-2, and G of the Grand Parkway (No-Build Alternative). The No-Build Alternative is defined as the implementation of all committed improvements found in the 2025 RTP (H-GAC, 2005a) without the construction of Segments E, F-1, F-2, and G. These committed improvements include Transportation System Management (TSM), Travel Demand Management (TDM), and modal transportation improvements such as bus transit, high-occupancy vehicle (HOV) lanes, rail feasibility, and new planned roadway construction. Smart Street improvements, as defined and discussed in the 2025 RTP, are also included in the No-Build Alternative. Alternatives determined not to meet the need for and purpose of the project were eliminated from further consideration, while other reasonable alternatives were identified and carried forward for detailed study in this volume. The Build Alternative was selected because it is the only alternative that fulfills the need for and purpose of the project. Identification of the Preferred Alternative Alignment (Section 4.25) in this FEIS is consistent with FHWA and CEQ guidelines and regulations (23 CFR 771.125; 40 CFR 1502; and FHWA, 1987).

This study process also satisfies various regulatory and coordination requirements for projects integrating the NEPA and the Section 404 permit processes. The multi-step project approach allowed a thorough consideration of all alternatives developed with respect to potential impacts to “Waters of the U.S.,” including wetlands, as required under Section 404 of

the Clean Water Act (CWA). The required Section 404 (b)(1) alternatives analysis has been conducted during the corridor and alignment studies as the project has progressed. This approach first emphasized avoidance, and then minimization to ensure that the identified Preferred Alternative Corridor and ultimately, the Preferred Alternative Alignment minimize adverse impacts to the greatest extent possible.

2.1 CORRIDOR STUDY

The corridor study process implemented for Segments E, F-1, F-2, and G was a complex effort. *Working Paper #1: Socioeconomic and Corridor Study* was produced in April 2000 (Michael Baker Jr., Inc, 2000a) documenting the project initiation and early scoping outreach period, socioeconomic aspects of the need for and purpose of the project, environmental resource mapping, corridor alternatives and comparison, formal scoping and corridor outreach period, and corridor recommendation. This working paper is available on the Grand Parkway website, www.grandpky.com.

A multi-step process was utilized to determine the location of potential corridors:

1. The initial step of this process was to develop sensitive resource mapping (e.g., schools, churches, parks, cemeteries, wetlands, and residential commercial developments).
2. Following the creation of a GIS, approximately 5,000-foot wide bands, or linear “corridors,” were developed that minimized inclusion of identified environmental constraints (sensitive resources).
3. Each corridor was extensively examined to develop a refined environmental constraints inventory.
4. Results of these analyses were presented to the public and state and federal resource agencies at the public workshops held on August 18, 24, and 26, 2000.
5. Following these presentations and analysis of comments derived from them, a Preferred Alternative Corridor was identified that best served the need for and purpose of the project and that maximized the probability of being able to avoid the greatest number of sensitive resources during specific alignment development.

During Step 2 of the process, engineering control locations were identified throughout the project length in order to develop the corridors. These control locations included areas such as probable interchange locations (e.g., IH 10), areas free of sensitive resources, and acceptable river and floodplain crossing locations. Connections between these control locations were then arranged in a number of configurations that met engineering design criteria. This process resulted in the development of the three corridors: A, B, and C (Exhibit G–13). These corridors are described in the following paragraphs along with the analysis that led to the selection of a Preferred Alternative Corridor.

There are places where two or three corridors overlap because of the density of environmental constraints. The segments of corridors between these overlap areas were defined as "reaches." The corridor reaches were used as a tool for examining “hybrid” combinations of the three original corridors. The corridor reaches that overlap with Segment G of the Grand Parkway are Reach 5 (partially within Segment G) and Reaches 6 and 7 (completely within Segment G). In addition to Corridors A, B, and C, two corridor variations were added in response to comments received during the public

outreach program and new land use information: partial Corridor CB (in Reach 2) and Corridor D (a full length corridor), as detailed in Section 2.1.6 (see also Exhibits G–13 and G–14).

2.1.1 Corridor A

Corridor A (Exhibit G–13) begins one mile north of IH 10 and continues north for about five miles, then shifts slightly west and parallels Katy Hockley Road, and proceeds northward to US 290 and Becker Road. There, Corridor A turns northeast for about 7.5 miles crossing Cypress Rosehill Road before turning east, then parallels FM 2920 for 1.5 miles. Corridor A turns southeast crossing Willow Creek, then turns east crossing SH 249, and parallels Boudreaux Road to Stuebner-Airline Road. After crossing Stuebner-Airline Road, Corridor A turns east again crossing Kuykendahl and Gosling Roads before turning northeast (for a distance of 5.5 miles) crossing IH 45, Spring Creek, and the Harris/Montgomery County line. In Montgomery County, Corridor A continues northeast for nearly eight miles, crosses the San Jacinto River, and then trends east for about three miles to its terminus at US 59.

2.1.2 Corridor B

Corridor B (Exhibit G–13) begins north of IH 10 and travels about 12 miles due north to intersect with US 290 at Fairfield. Corridor B continues northward crossing Little Cypress Creek and joins Corridor A heading toward Mueschke Road. There, Corridor B turns due east for 5.5 miles, then northeast across SH 249. Corridor B then turns east for 6.5 miles crossing Hufsmith Kohrville Road, Willow Creek, and Stuebner-Airline Road before rejoining Corridor A. Corridors A and B continue eastward crossing Kuykendahl Road, Gosling Road, IH 45, the Hardy Toll Road, and Spring Creek. Corridor B turns northeast after crossing Spring Creek for 4.5 miles, then eastward crossing the San Jacinto River, and continues on crossing FM 1314. Corridor B proceeds northeast crossing FM 1485 and then turns eastward to an intersection with US 59 North.

2.1.3 Corridor C

Corridor C (Exhibit G–13) begins north of IH 10 and travels about five miles north, turns northeast crossing Cypress Creek, then proceeds north crossing US 290 near Mueschke Road. From there, Corridor C continues north to Little Cypress Creek, then northeast for a distance of eight miles intersecting and joining with Corridor A. Both corridors continue eastward crossing SH 249, Hufsmith Kohrville Road, FM 2920, and Kuykendahl Road. Corridor C turns southeast at Gosling Road generally following FM 2920 eastward for about four miles toward IH 45. Corridor C then turns northeast, crossing the Hardy Toll Road and Spring Creek. There, Corridor C rejoins Corridor A, continues northeast crossing the San Jacinto River, and then turns east crossing FM 1314 and proceeds on toward US 59.

2.1.4 Corridor Resource Inventory

The resource inventory for the three full-length corridors is included in Table 2-1. These data represent the sum total of all resources within each 5,000-foot wide corridor and were used as a guide to determine which corridor would provide the

best opportunity to develop alternatives that avoid or minimize adverse environmental effects within that corridor. The actual construction impacts of the highway within a 400-foot wide ROW would be substantially less than the inventory data presented for the 5,000-foot wide corridor. Environmental constraints within the corridors, as they existed at the time of this study, are presented graphically in Exhibit G–15a-e. This exhibit has five parts to cover the entire study area of Segments E, F-1, F-2, and G.

2.1.5 Agency and Public Coordination

Extensive coordination with the public, local officials, state and federal resource agencies, and landowners has been conducted to date. Throughout the Segments E, F-1, F-2, and G study areas, meetings were held with homeowner associations, the media, and other community groups during the corridor study (for details, see Volume I, Section 5.4.2). Six formal public workshops were held between August 1999 and February 2000. At these workshops, the corridors were presented to the public as well as federal, state, and local agencies using multi-media presentations. The public was asked for their response and feedback during the workshops.

Additional meetings were held with TPWD, USACE, and USFWS and comments were provided by the agencies (Table 2-2). The Study Team then met with officials of TxDOT and FHWA to discuss the process followed during the corridor study, issues considered, comments received, and the possibilities for corridor revisions.

Reports of the proceedings of the public workshops and all meeting minutes are on file at the GPA. Agency coordination and public involvement are detailed in Volume I, Section 5 (for Segments E, F-1, F-2, and G) and Section 6 of this volume (for Segment G only) of the FEIS.

Coordination with various agencies indicated that a number of issues needed to be addressed before identification of a Preferred Alternative Corridor, which included:

- Identification of remnant prairie elements (mima mounds) as potential habitat for the federally listed endangered Texas prairie dawn (*Hymenoxys texana*) and Texas windmill-grass (*Chloris texensis*);
- Distinction between regulated forested wetlands and forested floodplains;
- Identification of potential wetland mitigation sites;
- Location determination of state plant species of special concern; and
- Identification of extensive additional residential development as previously defined (three to five-year period).

These issues were addressed through photo-interpretation, coordination with resource agency representatives, and/or meetings with proposed land developers and city and county officials. The corridor resource inventory was then revised, recalculated, and reviewed with the TPWD, USACE, and USFWS (Table 2-1).

TABLE 2-1
CORRIDOR RESOURCES INVENTORY FOR SEGMENTS E, F-1, F-2, AND G

Reach[1]	Corridor[2]	Meets Need and Purpose	Length (mi)	Residential Area (acres)	School Properties	Churches	Cemeteries	Golf Courses	Parks	Natural Resources								Cultural Resources			Oil and Gas Wells	Potential Hazardous Material Sites	Water Wells	
										Special Resource Areas	Wetlands (acres)	Prior Converted Wetlands (acres)	Remnant Prairie (TPWD 2/2/2000)	Remnant Prairie Topography (c.1995) (acres)	Forested Floodplain (acres)	100-year Floodplain (acres)	Prime Farmland (acres)	Recorded Archeology Sites	Historic-Age Resources	High Probability Area (HPA) (acres)			Public	Private
No-Build		No	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
1	A	Yes	6.3	264	-	-	-	-	-	1	400	64	-	-	-	2,197	3,728	-	10	-	23	-	-	1
	B	Yes	6.3	721	-	-	-	-	-	1	171	128	-	-	-	1,815	3,733	-	14	-	35	-	4	3
	C	Yes	6.5	720	-	-	-	-	-	2	244	57	-	-	-	894	3,850	-	15	-	14	-	1	1
	D	Yes	6.4	753	-	-	-	-	-	2	191	122	-	-	-	1,348	3,763	-	12	-	21	-	3	3
2	A	Yes	13.1	34	-	-	-	-	-	2	960	507	-	112	116	1,709	7,809	-	18	91	2	1	-	7
	B	Yes	11.9	30	-	-	-	-	-	1	620	1,232	-	112	210	1,501	7,140	1	22	105	3	-	-	12
	C	Yes	9.7	1,809	-	1	2	2	1	2	373	1,254	-	12	198	1,469	5,858	2	27	59	38	-	-	5
	D	Yes	12.3	161	-	-	-	-	-	1	728	1,389	-	112	193	1,617	7,682	1	21	106	7	-	1	6
	CB	Yes	11.2	1,692	-	-	3	1	1	-	488	1,355	-	272	196	1,341	6,727	2	30	75	38	-	2	5
3	A	Yes	7.6	537	-	1	1	-	1	1	349	-	-	121	-	287	4,525	-	53	-	143	3	5	6
	B	Yes	6	241	-	-	-	-	-	-	215	-	-	338	-	932	3,556	-	14	-	68	-	2	1
	C	Yes	4.7	583	1	-	-	-	1	2	356	-	-	332	221	601	2,813	-	25	29	34	1	-	-
	D	Yes	6.4	349	1	-	-	-	-	-	256	-	-	339	-	1196	4,226	-	15	-	86	-	2	2
4	A	Yes	8	1,396	2	-	-	-	2	-	476	-	-	138	33	353	4,820	-	39	153	65	10	11	7
	B	Yes	8.1	168	1	-	1	1	2	-	437	-	-	138	93	654	4,671	-	36	214	152	14	12	10
	C	Yes	7.9	1,344	2	-	-	-	2	-	474	-	-	138	33	277	4,721	-	39	153	61	10	11	7
	D	Yes	80	1,396	2	-	-	-	2	-	475	-	-	138	33	341	4,769	-	38	153	64	10	11	7
5	A	Yes	8.2	1,190	1	1	1	-	2	-	358	-	-	37	234	964	4,008	-	111	1,707	70	7	7	6
	B	Yes	8.2	1,261	1	1	1	-	2	-	340	-	-	37	234	963	4,008	-	113	1,608	69	7	7	6
	C	Yes	8.8	1,224	3	8	1	-	2	-	377	-	-	110	142	444	4,284	-	80	636	30	18	29	15
	D	Yes	8.1	2,343	3	3	1	-	3	-	589	-	-	133	234	756	6,799	-	143	1,600	79	19	25	16
6	A	Yes	5.3	163	-	-	-	-	-	1	369	-	-	-	1,225	1,160	106	1	-	350	-	-	-	-
	B	Yes	5.9	181	-	-	-	-	-	1	602	-	-	-	1,503	1,383	176	-	7	960	2	-	-	1
	C	Yes	5.3	163	-	-	-	-	-	1	375	-	-	-	1,242	1,177	109	1	-	350	-	-	-	-
	D	Yes	5.9	182	-	-	-	-	-	1	671	-	-	-	1,512	787	265	-	7	831	2	-	-	1
7	A	Yes	4.1	570	2	-	-	-	-	-	329	-	-	-	-	399	799	-	2	366	1	-	-	3
	B	Yes	6.4	548	1	-	-	-	-	-	378	-	-	-	278	749	1,438	-	-	296	3	-	4	2
	C	Yes	4.1	570	2	-	-	-	-	-	329	-	-	-	-	399	799	-	2	366	1	-	-	3
	D	Yes	4.1	731	2	-	-	-	-	-	346	-	-	-	-	249	875	-	3	366	1	-	-	4

Notes: [1] The corridor reaches that overlap with Segment G of the Grand Parkway are Reach 5 (partially within Segment G) and Reaches 6 and 7 (completely within Segment G).
[2] Corridors are approximately 5,000 feet wide.
Source: Study Team, 2002

THIS PAGE IS INTENTIONALLY LEFT BLANK

TABLE 2-2
SUMMARY OF COMMENTS RECEIVED FROM RESOURCE AGENCIES ON PRELIMINARY CORRIDORS

Reach[1]	Corridor Preference (USACE)	Corridor Preference (USFWS)	Corridor Preference (TPWD)	Corridor Preference Study Team	Basis for Preference Study Team
1	C	B or C	C	B	Preferred by public; minimizes potential wetland impacts; consistent with local transportation plans; effect on current and future residential areas has been considered in development plans; avoids snow goose (*Chen caerulescens*) roosting sites.
2	C or B	B	C/B	B	Preferred by public; minimizes potential impact to existing residential areas; further inspection of this reach suggests a greater ability to minimize impacts to wetlands during alignment development in Corridor B.
3	C or B	None stated[2]	B	B	Preferred by public; avoids school property and existing residential areas in Corridor C; minimizes potential impacts to residential areas
4	A/C	None stated[2]	B, then A/C	A	Minimizes potential floodplain impact; avoids oil fields; avoids conservation easement in Corridor B; residential effect on Gleannloch Farms residential development has been planned for; public was undecided in this reach.
5	C	C	None stated[2]	ABC	None at this time; received a great deal of information at the public workshops about specific land developments that have recently occurred; need more information to make a corridor decision; public was undecided in this reach. Advantages of Corridor A/B include avoiding historic Spring area, minimizing potential impact to existing and planned residential areas, providing opportunity to follow Hardy Toll Road in this reach, incorporating the effect on residential areas in Northgate Development into plans, avoiding most floodplain areas through careful engineering. Advantages of Corridor C include minimizing potential floodplain impact.
6	B	No-Build[2]	B may be better	B	Preferred by the public; minimizes potential wetland impacts; provides better bridge crossing location of the San Jacinto River. Since Corridor B is more northern, it may involve fewer bottomland hardwoods; provides opportunity to follow a ridge and minimize effects on floodplains and bottomland; alignments within corridor can avoid roosting sites.
7	A/C	No-Build[2]	A/C	A/C	Preferred by the public, shorter by 2.3 miles, can avoid Lake Houston Park during future development of the Grand Parkway.

Notes: [1] The corridor reaches that overlap with Segment G of the Grand Parkway are Reach 5 (partially within Segment G) and Reaches 6 and 7 (completely within Segment G).
[2] Refer to March 16, 2000 USFWS letter, Appendix B.

Source: Study Team, 2002

2.1.6 Corridor Revisions

In response to comments received during the public outreach program, a partial corridor, Corridor CB, was developed to avoid remnant prairie topography that is potential habitat for the federally protected Texas prairie dawn. Corridor CB was also developed to avoid areas that are targeted for development over the next three to five years. A new full-length corridor, Corridor D, was developed. Corridor D consists of portions of Corridors A, B, and C as well as five areas where shifts were made to avoid or minimize potential impacts.

2.1.6.1 Partial Corridor CB

In Segments E and F-1, between Little Cypress Creek and Willow Creek, Corridor C crosses substantial land area identified for development in a three to five-year period, as well as areas identified as remnant prairie topography that is potential habitat for the protected species, Texas prairie dawn. At the suggestion of TPWD, USFWS, and the USACE, Corridor CB was developed for Segments E and F-1 only. Corridor CB turns north from Corridor C and connects back to Corridor B (Exhibit G–13). The resource inventory for Corridor CB is provided in the Reach 2 portion of Table 2-1.

2.1.6.2 Corridor D

The Study Team, using an interdisciplinary approach, developed Corridor D to avoid and/or minimize adverse environmental effects. Corridor D generally follows existing corridors A, B, or C (Exhibit G–14). However, deviations from A, B, or C were made in order to:

- Reduce potential floodplain area impacts;
- Reduce potential residential area impacts;
- Avoid potential remnant prairie impacts; and
- Expand the project area within Reach 5.

Five adjustments were made as follows:

- In Reaches 1 and 2, Corridor B was shifted slightly east in order to reduce floodplain encroachment.
- In Reach 2, just north of the US 290 crossing, Corridor B was widened to avoid an area of remnant prairie.
- In Reach 3, Corridor B was widened to the north near the crossing of Telge Road in order to avoid a residential area and remnant prairie.
- In Reach 5, because of numerous environmental constraints in Corridor A/B, it was widened to roughly 10,000 feet (about 5,000 feet south) for further study.
- In Reach 6, Corridor B was shifted slightly south to minimize possible impacts at the San Jacinto River crossing.

The resource inventory for Corridor D is provided in Table 2-1.

2.1.7 Preferred Alternative Corridor Recommendation

Results of the resource inventory analysis and public and agency coordination led to the selection of Corridor D as the Preferred Alternative Corridor (Exhibit G–14). Therefore, Corridor D was carried forward for the alignment study for Segments E, F-1, F-2, and G. Based on public comments and coordination during the environmental process for Segments F-2 and G, the Study Team analyzed an additional corridor, the FM 1488 – SH 242 (Northern Alignment) corridor, for Segments F-2 and G. The Northern Alignment is located in Harris and Montgomery Counties between SH 249 and US 59 and is approximately 30 miles in length. This corridor was evaluated to determine if a potentially reasonable and feasible alignment could be developed as an alternative to Segments F-2 and G. Based on the analysis presented in the environmental, engineering, and financial feasibility study, the evaluation concluded that:

- Based on the traffic analysis conducted for this effort, the alternative alignments and options developed for the feasibility study are serving a different traffic study area than Segments F-2 and G.
- As the Northern Alignment would serve a separate and distinct traffic study area from Segments F-2 and G, this alternative would not meet the identified need for transportation improvements in the study area for Segments F-2 or G.
- As the Grand Parkway is designated as a toll facility, the potential toll collection from the Northern Alignment can only partially fund the project and would not be a viable alternative. Segments F-2 and G are expected to generate higher revenue that would fund the implementation of these projects.
- The Northern Alignment would displace substantially more residences and businesses than the Recommended Alternative Alignments for Segments F-2 and G.
- The Northern Alignment would impact publicly owned parkland and would require a Section 4(f) evaluation to determine that there is no feasible and prudent alternative to the use of this property.

Based on the these findings, the Northern Alignment, as an alternative corridor for either Segments F-2 or G, was not carried forward for more detailed study (Michael Baker Jr. Inc., 2006).

2.2 TRANSPORTATION MODE STUDY

The No-Build and Build Alternatives were defined and evaluated with respect to meeting the need for and achieving the purpose of transportation improvements. The results of these evaluations and the reasons for elimination of transportation alternatives are presented in the following sections. Elimination of transportation alternatives from detailed study is consistent with 23 CFR 771.125.

As stated in 23 CFR 771.125, “The final EIS shall identify the preferred alternative and evaluate all reasonable alternatives considered.” This section (Section 2.2) presents different modes of transportation considered for satisfying the need for

and the reasoning behind the selection of the Build Alternative. Then, Section 2.3 presents different alignments considered for the Build Alternative and the reasoning behind the selection of the Preferred Alternative Alignment.

2.2.1 No-Build Alternative

The No-Build Alternative includes all committed improvements found in the 2025 RTP (H-GAC, 2005a) without the construction of Segments E, F-1, F-2, and G. These committed improvements include TSM, TDM, and modal transportation improvements such as bus transit, HOV lanes, rail feasibility, and new planned roadway construction. The No-Build Alternative also includes short-term, minor restoration activities such as resurfacing, bridge repairs, and minor road widening. These improvements are already a part of the ongoing plan for the continued operation of the existing roadway system. Smart Street improvements, as defined and discussed in the 2025 RTP, are also included in the No-Build Alternative. The TSM, TDM, modal transportation improvements, and Smart Street components of the No-Build Alternative are detailed in the following sections.

2.2.1.1 Transportation System Management (TSM)

The purpose of TSM is to make the existing transportation system as efficient as possible through the implementation of such measures as:

- Park-and-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 non-HOV use during peak traffic periods;
- 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; and
- Intersection Improvements – consist of additional turn lanes, added through lanes through restriping, and traffic signal optimization.

Although TSM measures are generally considered appropriate in urban areas where the existing facilities operate beyond their designed capacity limits (FHWA, 1987), based on currently approved TSM measures in the 2025 RTP, TSM measures by themselves would not be adequate to handle the rapid growth projected for northwestern Harris County over the next 18 years. For example, SH 6/FM 1960 does not serve regional traffic very effectively. It was not constructed as a complete circumferential controlled access highway. It is a partial circumferential principal arterial and currently serves local traffic desiring to make shorter trips. Its design (non-controlled access) is not conducive to the longer trips that the Grand Parkway Segments E, F-1, F-2, and G serve. Adjacent property can be or currently is developed with residential and commercial businesses. This type of adjacent development tends to impede the roadway's ability to serve longer

trips. Traffic interruptions occur causing motorist delays because of the existence of driveways and traffic signals. Segments E, F-1, F-2, and G would be constructed as a controlled access toll facility with no traffic signals or driveways.

As with SH 6/FM 1960, other circumferential roadways located within or in proximity to the study area are limited. No other roadway crosses all four segments. FM 2920 is located in portions of Segments F-1 and F-2 and is considered a major arterial.

The transportation model supplied by H-GAC includes all major TSM improvements currently in the 2025 RTP (Appendix C). Smaller TSM projects, such as traffic management systems, were included in the Congestion Mitigation Analysis (CMA) conducted for Segments E, F-1, F-2, and G (Appendix D). Some forms of TSM improvements also require additional ROW. On roadways where development is directly adjacent to the facility, the cost of ROW for the most effective TSM improvements, such as additional turning lanes, may outweigh the benefits of such improvements. Furthermore, as stated previously, many TSM improvements are most effective in areas of high-density residential development and employment. While Houston ranks as the sixth most populated metropolitan area in the country next to New York City, Los Angeles, and Chicago, Houston ranks 14th in terms of population density (with 3,000 people per square mile vs. 7,400 people per square mile in Los Angeles, CA). This pattern of development makes it difficult for many of the TSM strategies to be effective. Therefore, it is unlikely that TSM measures, additional to those already planned, would be adequate to handle the rapid growth projected for northwestern Harris County over the next 20 years.

A CMA was conducted for the parallel facilities that would be affected by the Grand Parkway (Appendix D). The CMA included all TSM and TDM improvements too small to be programmed into H-GAC's travel demand model. The study revealed that TSM and TDM improvements are not expected to substantially improve the LOM.

While the TSM improvements included in the 2025 RTP are expected to ease congestion and travel times for localized trips, these improvements do not adequately address system linkage, expanded capacity, safety, and economic development. The TSM improvements by themselves would not adequately meet the need for and purpose of the project.

2.2.1.2 Travel Demand Management (TDM)

TDM relies on commuters making voluntary behavioral changes to their travel habits that result in fewer vehicles during peak hours. TDM measures improve mobility and reduce congestion during the peak hours. Several examples of TDM measures include:

- Carpooling/Vanpooling – Combining multiple commuters into a single vehicle, resulting in fewer peak hour trips;
- 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;
- Compressed Work Weeks – Working full time in fewer days, resulting in some reduction in peak hour trips;

- Telecommuting – Working from home, resulting in few or no peak hour trips;
- Flex-Time – Working non-typical schedules resulting in a shift in commute trips from the peak hours to non-peak hours; and
- Employer Incentives – Incentives that encourage employees to carpool or vanpool.

The first two TDM measures previously described require modification to the behavioral patterns of individual commuters. The remaining TDM measures result from employers allowing employees to vary their typical work schedules. All of these options rely on voluntary behavioral changes that would not be reliable enough to solve the transportation increase in traffic volume predicted through 2025.

A CMA was conducted for the parallel facilities that would be affected by the Grand Parkway (Appendix D). The CMA included all TSM and TDM improvements too small to be programmed into H-GAC's travel demand model. The study revealed that TSM and TDM improvements are not expected to substantially improve the LOM.

The TDM component of the No-Build Alternative would not address system linkage, expanded capacity, safety, and economic development. Based on currently approved TDM measures in the 2025 RTP, TDM measures by themselves would not adequately meet the need for and purpose of the project.

2.2.1.3 Modal Transportation Improvements

Modal transportation improvements include bus transit, HOV lanes, and rail feasibility. The 2025 RTP recommends a major expansion of the public transit system in the region. The plan incorporates the 2025 METRO Solutions Plan and recommends some service expansions beyond the METRO service area based on increasing population densities.

<u>Bus Transit</u>

Four public transit agencies serve the Houston-Galveston Transportation Management Area (TMA): METRO, Brazos Transit District (BTD), Island Transit, and Connect Transportation. The study area counties are serviced by METRO and BTD. METRO's service area covers most of Harris County and small portions of Fort Bend and Montgomery Counties, and BTD provides park-and-ride service between southern Montgomery County and three main destinations in Houston (Greenway Plaza, Downtown, and the Medical Center). Although BTD utilizes IH 45, it does not provide circumferential service in the study area. System linkage to IH 45 may facilitate easier access to their services.

METRO is the largest public transit agency in the region. Its service area includes most of the study area; however, there are currently no fixed routes (north of FM 1960) within the study area. METRO expands service as demand increases. With projections for increased population, employment, and associated traffic congestion, the study area may be a candidate for future expansion of service. However, commuter use of radial bus transit in the greater Houston area could be facilitated by improved circumferential system linkage provided by the Grand Parkway.

The bus transit improvement component of the No-Build Alternative would not address system linkage, expanded capacity, safety, and economic development. Bus transit improvements by themselves would not adequately meet the need for and purpose of the project.

High-Occupancy Vehicle (HOV) Lane

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 ridesharers have common geographic trip origins and destinations within similar time frames. 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.

The HOV lane concept would not be appropriate because a congested circumferential freeway corridor does not exist within the study area. The HOV lane concept does not adequately address system linkage, expanded capacity, safety, and economic development. The HOV concept would not adequately meet the need for and purpose of the project.

Rail Transit

The rail transit concept is most effective where commuters have common geographic trip origins and destinations. A rail system offering circumferential travel between radial freeways would not have sufficient ridership to make such a plan financially feasible, and such a facility is not currently planned (H-GAC, 2005a).

Since its inception, METRO has been studying the need for and feasibility of rail services within its service area, which includes most of the study area. The 2025 METRO Solutions Plan, which is incorporated into the 2025 RTP, recommends a major expansion of the public transit system in the region, including rail. METRO is studying several major corridors for implementation of a comprehensive rail system. The vision of this proposed system includes both radial and circumferential corridors. However, the success of a rail system implemented in Houston would be based upon its ability to attract ridership from the residential areas to the major employment centers. METRO is currently operating a light rail system connecting Reliant Park to the Texas Medical Center and downtown Houston and is focusing its rail efforts along the existing radial highway corridors. Grand Parkway Segments E, F-1, F-2, and G would serve a different commuter and would provide a direct (circumferential) route between IH 10, US 290, SH 249, IH 45, and US 59 (all of which are radial routes) for residents of Harris and Montgomery Counties. The 2025 METRO Solutions Plan analyzed and tested commuter and rail services for potential ridership along the SH 249 and IH 45 North corridors. The feasibility of a METRO light rail extension along the IH 45 North corridor will be studied in more detail during future RTP updates. A portion of METRO's study area crosses the Grand Parkway near IH 45 and the Hardy Toll Road. If the preferred alternative were to cross the Grand Parkway, the Grand Parkway could be designed to accommodate increased ridership in the corridor. A Major Investment Study (MIS) has also been completed for the US 290 corridor. The locally preferred alternative transportation mode includes increased capacity, but also has proposed an advanced high capacity transit (light rail transit /bus rapid transit). The Grand Parkway could be designed to accommodate increased ridership in the US 290 corridor by

supporting park-and-ride facilities and providing access. In addition, METRO continues to evaluate the viability of rail transit in the IH 10 corridor. The 2025 METRO Solutions Plan notes that despite the addition of service lines, "increasing transit capacity alone is not sufficient enough to alter travel behavior to the point where motorists will, with little hesitation, decrease SOV [single-occupancy vehicle] mileage" (H-GAC, 2005a).

The rail transit concept does not adequately address system linkage, expanded capacity, safety, and economic development. However, potential rail transit projects listed in the 2025 RTP along the radial freeways that represent the project termini of the Grand Parkway may benefit from improvements to circumferential roadway travel. The Grand Parkway could facilitate commuter use of park-and-ride lots associated with future rail transit. The rail transit concept would not adequately meet the need for and purpose of the project.

2.2.1.4 Smart Street Alternatives

Smart Streets are a concept developed and introduced into the 2025 RTP as an additional tool to increase mobility, transit access, and safety by providing operational improvements along strategic regional thoroughfares. Smart Street enhancements would improve mobility through a range of alternatives such as synchronization of traffic signals; construction of roundabouts, medians, or turn bays (dedicated turn lanes); consolidation of duplicate driveways; and, as appropriate, partial grade separation of some traffic lanes at major intersections (H-GAC, 2007a). Some Smart Street enhancement alternatives may require the construction of an entirely new roadway or the acquisition of new ROW to accommodate additional lanes (capacity) or grade separations. Most Smart Street improvements are scheduled for the year 2023 and would take place along collector roadways. Examples of Smart Streets in the Segment G project area include FM 1960, Treaschwig, FM 1314, and SH 242.

The Smart Street component of the No-Build Alternative would provide operational improvements along collector roadways, including several within the traffic study area. Although these enhancements would add capacity and improve mobility at specific locations, the enhancements would provide minimal system linkage because none of the roadways are continuous and many begin or end between radial facilities. Smart Street enhancements would not provide additional circumferential capacity to handle the expected increase in traffic. As indicated in H-GAC's 2025 RTP, Smart Street enhancements do not address system linkage and would not promote economic development for the next 15 to 20 years. The impact to business and commerce from Smart Streets is not fully known; the implementation of Smart Streets could displace businesses as existing ROW is expanded to accommodate new lanes, grade separations, or new construction.

2.2.1.5 No-Build Alternative Summary

The No-Build Alternative includes all committed improvements found in the 2025 RTP (H-GAC, 2005a) without Segments E, F-1, F-2, and G and includes TSM, TDM, and modal transportation improvements such as bus transit, HOV lanes, rail, and Smart Streets. Based on an analysis of these components individually and collectively, the No-Build Alternative would improve traffic congestion, travel times, and safety, particularly after 2023 when the majority of Smart Streets are

scheduled to be implemented. However, the No-Build Alternative would not adequately address the current regional and/or local circumferential system linkage, expanded capacity, safety, and economic development. Although the No-Build Alternative would not satisfy the need for and purpose of the project, it was retained as a basis for comparison with the alternatives carried forward for detailed study as required by CEQ regulations (40 CFR 1502.14[d]).

2.2.2 Build Alternative

As conceived by TxDOT and the GPA, and as included in various regional planning documents, including the H-GAC 2025 RTP, the Build Alternative consists of a controlled access toll road constructed on a new location. The Build Alternative is being proposed in addition 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 roadway 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 2025 RTP (H-GAC, 2005a). 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 2025 RTP 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 2025 RTP states, "If the 2025 RTP did not include new roads financed by user tolls, congestion would grow by 26%." The implementation of a non-tolled Build Alternative would divert funds allocated for other projects identified in the 2025 RTP and TIP as necessary to meet regional and local transportation improvement objectives. The 2025 RTP recognizes that as the region's travel demand increases, federal and state revenues for building and maintaining freeways will need to be supplemented through the creation of toll facilities to expand the area transportation system. The 2025 RTP is consistent with 2001 Texas legislation Senate Joint Resolution (SJR) 16 that, upon voter approval, amended the Texas State Constitution to create the 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 HCTRA and the Fort Bend County Toll Road Authority (FBCTRA), H-GAC has included tolling as an integral part of its financial planning strategy and the Grand Parkway as a component of the 2025 RTP.

2.2.3 Alternative Transportation Modes Eliminated from Detailed Study

The alternatives study process enabled alternatives to be evaluated in several stages so that only the most practicable, those that met the need for and purpose of the project and those that had the potential to minimize adverse environmental impacts, were advanced to the next phase of study. The following alternatives were eliminated from detailed study:

- TSM Alternatives (Park-and-Ride Lots, Ridesharing, HOV facilities, traffic signal coordination, and intersection improvements): While TSM measures are generally considered appropriate in urban areas where the existing facilities operate beyond their designed capacity limits (FHWA, 1987), TSM measures by themselves, based on currently approved TSM measures in the 2025 RTP, would not be adequate to handle the rapid projected growth. Without providing added capacity to handle the expected increase in traffic, the TSM Alternatives would lead to the same congestion posed by the No-Build Alternative.
- TDM Alternatives (Carpooling, Employee Trip Reduction Programs, Compressed Work Weeks, Telecommuting, Flex-Time, and Employer Incentives): All TDM measures rely on behavioral or voluntary changes that would not be reliable enough to solve the large capacity problem expected for the project area. TDM measures would not address the regional and interstate and intrastate commerce needs of the project and would not address the need for improved system linkage.
- Bus Transit: Bus Transit Alternatives proposed in the 2025 RTP were included in the transportation modeling for the No-Build Alternative. The results of the analysis of the No-Build Alternative (see Section 1 of this volume [Project Need and Purpose]) concluded that a Bus Transit Alternative would not meet the need for and purpose of this project.
- HOV Lanes: HOV strategies are most effective on freeway type facilities that experience recurring congestion. No such facility currently exists in the Grand Parkway corridor. However, HOV strategies could be incorporated into the Grand Parkway as congestion warrants in future years.
- Rail Transit: Rail Transit Alternatives are most effective when oriented in a radial fashion to serve commuters during peak hours traveling into and out of the central business core of a city. A Rail Transit Alternative positioned in a circumferential orientation, as in the study corridor, is not expected to have enough ridership to satisfy the need for and purpose of the project.
- Smart Street Alternatives: The Smart Street component of the No-Build Alternative would provide minimal system linkage and expanded circumferential capacity. In addition, Smart Street enhancements would not promote economic development for the next 15 to 20 years, and their impact to business and commerce is not fully known. The implementation of Smart Streets could displace businesses as existing ROW is expanded to accommodate new lanes, grade separations, or new construction. Therefore, this alternative does not meet the need for and purpose of the project.

2.2.4 Alternative Transportation Modes Advanced for Further Study

2.2.4.1 No-Build Alternative

The No-Build Alternative does not include construction of Segment G of the Grand Parkway. This alternative transportation mode consists of a continuation of the existing transportation facilities and incorporates the execution of planned and/or committed roadway improvements, TSM, TDM, modal transportation improvements, and new roadway construction in the Segment G project area. Committed improvements are those projects included in the 2025 RTP (H-GAC, 2005a) excluding new construction of the Grand Parkway. The No-Build Alternative includes short-term, minor restoration activities such as resurfacing, bridge repairs, and minor road widening. These improvements are already a part of the ongoing plan for the continued operation of the existing roadway system.

The Segment G project area has and will continue to experience growth. The No-Build Alternative would result in high traffic volumes being confined to the existing roadway network leading to increased stop-and-go conditions (i.e., increased congestion). The lack of adequate improvements to system linkage and roadway capacity would result in the No-Build Alternative failing to satisfy the need for and purpose of the project.

As shown in Section 1 (Project Need and Purpose) of this volume, the No-Build Alternative would not reduce existing and future traffic volumes on roadways within the Segment G project area. Although the No-Build Alternative would not include the costs to construct the Grand Parkway, the No-Build Alternative would result in higher maintenance costs to existing roadways within the Segment G study area because of 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 existing roadways. These traffic disruptions on existing facilities for maintenance purposes would be more frequent with the No-Build Alternative and would contribute to higher levels of congestion.

Although the No-Build Alternative would not satisfy the need for and purpose of the project, it was retained as a basis for comparison with the alternative transportation modes carried forward for detailed study as required by CEQ regulations (40 CFR 1502.14[d]).

2.2.4.2 Build Alternative

The Build Alternative would be an approximately 13.63 to 13.74 miles long, four-lane controlled access toll road with intermittent frontage roads in a 400-foot ROW. Traversing parts of Harris and Montgomery Counties, the proposed new highway would provide access to IH 45 and US 59 (radial freeways). Typical sections of the Grand Parkway facility are shown in Exhibit G–42a-b. As described in Section 2.3 (Alternative Alignment Study), four alternative alignments were developed through public outreach and agency coordination and continuous avoidance and minimization of impacts to sensitive resources. The Build Alternative would also include a continuation of the existing transportation facilities, and

incorporate the execution of planned and/or committed roadway improvements. These improvements include TSM, TDM, modal transportation improvements, Smart Streets, and new roadway construction in the project area. Committed improvements are those projects included in the 2025 RTP (H-GAC, 2005a).

The Build Alternative would provide system linkage, expanded capacity to ease circumferential travel around Houston, improved roadway safety, and a relief from barriers to economic development. Thus, the Build Alternative fulfills the need for and purpose of the project and was advanced for further evaluation.

2.2.5 Traffic and Transportation Analysis

The traffic study area used for traffic analysis of Segment G is bounded by IH 45 to the west, US 59 to the east, IH 610 to the south, and just beyond the proposed Grand Parkway to the north. Currently, the transportation facilities in the Segment G traffic study area are characterized by a network of roads that are becoming overwhelmed with existing traffic demand and would not adequately serve traffic because of projected residential and commercial growth in the Segment G study area. IH 45 and US 59 are radial highways connecting the city of Houston to its suburbs and beyond. FM 1960 and Beltway 8 are the only circumferential roadways in the area and are located to the far south, forcing motorists to travel outside of the Segment G study area. As a result, these facilities absorb most of the east-west travel demand and associated congestion. Presently, residential development is heavy in the area between these roadways, serviced by a network of roads developed primarily along property boundaries. This current network of roads is not expected to efficiently serve continued development of residential communities and service industries.

In terms of transportation impact, the alternative alignments considered for Segment G of the Build Alternative would have very similar results. Therefore, these alternative alignments were treated and analyzed as one Build Alternative in the traffic and transportation analysis. The same traffic study area from Section 1.2 (Detailed Transportation Needs Analysis) of this volume is used in this section.

2.2.5.1 System Linkage

The current transportation system in the Segment G traffic study area consists of two radial freeways, IH 45 and US 59, connected by a network of congested circumferential arterials and collector facilities. To accomplish circumferential trips, travelers either use radial roadways (such as IH 45, US 59, or the Hardy Toll Road) to reach circumferential roadways (such as FM 1960 or SH 242) or they make trips that include Beltway 8, several miles south of FM 1960. In addition, the current transportation system does not provide efficient connections between suburban communities such as Porter, Oak Ridge, Humble, Spring, and The Woodlands.

Segment G of the Grand Parkway, if constructed independently from the other segments, is expected to carry up to 53,700 vehicles per day in 2025, clearly showing the need for additional circumferential freeway capacity within the traffic study area. An analysis was conducted to determine the total VHT in the traffic study area once Segment G is constructed. The projected 53,700 vehicles using the Grand Parkway would account for a projected 9,200 VHT each day in 2025. Consistent with personal travel behavior, the model developed by H-GAC distributes traffic to roadways based on the quickest route to their destination. When a facility with high capacity and high speeds becomes congested, trips are distributed to other facilities to save time over the congested roadways. Table 2-3 shows the results of the VHT analysis for the No-Build and Build Alternatives for 2000 (base year), 2010 (No-Build only), 2015, and 2025.

TABLE 2-3
SEGMENT G TRAFFIC STUDY AREA VEHICLE HOURS TRAVELED*

Facility	2000 (Base Year)	2010 No-Build	2015			2025		
			No-Build	Build	% Change	No-Build	Build	% Change
Interstates	75,000	85,200	97,900	89,700	-8%	97,200	93,100	-4%
Principal Arterials	81,500	93,200	104,700	102,000	-3%	130,200	131,400	1%
Proposed Grand Parkway	N/A	N/A	N/A	4,500	N/A	N/A	9,200	N/A
Minor Arterials	5,300	6,200	9,800	8,000	-18%	10,400	10,600	2%
Collector Roads	3,400	4,100	8,500	6,500	-24%	7,500	8,200	9%
Total	165,200	188,700	220,900	210,700	-5%	245,300	252,500	3%

Note: * VHT (Vehicle Hours Traveled) is the total of all hours driven by each car in the traffic study area in one day.
Source: H-GAC, 2005a and Study Team, 2005

As shown in Table 2-3, the VHT statistics vary greatly depending on the type of roadway being considered. A new circumferential roadway with capacity like that of the proposed Segment G would be used by travelers to access destinations within the outer suburbs and radial facilities such as IH 45 and US 59. In 2015, the Grand Parkway provides a greater benefit to minor arterials and collector roadways, which show the greatest decrease in VHT (18 percent and 24 percent) because of the improvement in travel time found on the proposed Grand Parkway.

2.2.5.2 Expanded Capacity

The H-GAC regional travel demand model for the Houston metropolitan area was used to determine the base year traffic and future traffic projections for the No-Build Alternative as well as future traffic projections for the Build Alternative. Future traffic projections were compared for the No-Build and Build Alternatives to determine the transportation impacts of constructing Segment G of the proposed Grand Parkway. H-GAC's model determined traffic volumes on roadway facilities based upon current and projected population and employment data as well as the transportation network available to travelers.

Table 2-4 presents No-Build and Build Alternative traffic volumes for Segment G of the Grand Parkway and other selected roadways in the Segment G traffic study area for 2000 (base year), 2010 (No-Build only), 2015, and 2025. The No-Build Alternative represents a condition in which all planned improvements in the 2025 RTP are in place excluding Segments E, F-1, F-2, and G of the Grand Parkway, which corresponds with the presentation of the No-Build Alternative in Volume I of this FEIS. The Build Alternative represents a condition in which all planned improvements in the 2025 RTP are in place, including the proposed Segment G and still excluding Segments E, F-1, and F-2 of the Grand Parkway. These exclusions and inclusions for the traffic analysis presented here in Volume II of the FEIS clarify the effect of Segment G. For the 2010 and 2015 analysis years, only projects expected to be complete by these years were included in the scenarios.

As shown in Table 2-4, many of the arterial and collector facilities are expected to see a decrease in traffic volumes in 2015 and 2025 once Segment G of the Grand Parkway is constructed and operational, as this portion of the freeway is expected to divert travelers from slower, more congested roadways. Collector roadways see the greatest impact (up to a 30 percent reduction in volume in 2025) because these facilities are close to or run parallel with Segment G.

Table 2-5 presents the percentage of roadway miles, broken down by facility type, operating at different conditions for 2000 (base year), 2010 (No-Build only), 2015, and 2025. The construction of the proposed Segment G of the Grand Parkway would increase the percentage of total roadway miles operating under "tolerable" conditions by 10 percent in 2015 and 3 percent in 2025 while decreasing the percentage of roadway miles operating at a "serious" condition.

Notably, the lower classified facilities receive the most benefit from the proposed Grand Parkway. In 2015, Segment G of the Grand Parkway would increase the percentage of collector facilities operating at a tolerable condition from 49 percent to 69 percent (20 percent improvement) In 2025, the percentage of collector roadway miles operating at a serious or severe condition would decrease by 2 percent.

TABLE 2-4
SEGMENT G TRAFFIC STUDY AREA BASE YEAR AND FUTURE NO-BUILD AND BUILD ADT BY ROADWAY SEGMENT

Facility	From	To	2000 (Base Year) ADT	2010 No-Build ADT	2015			2025		
					No-Build ADT	Build ADT	% Change from No-Build	No-Build ADT	Build ADT	% Change from No-Build
Interstates										
IH 610	IH 45	US 59	196,500	167,700	182,900	183,000	<1%	199,600	194,700	-2%
IH 45	North of SH 99	SH 99	146,700	194,900	233,200	211,000	-10%	244,600	232,600	-5%
	SH 99	FM 1960	127,300	144,400	170,300	154,800	-9%	177,400	161,200	-9%
	FM 1960	Beltway 8	180,400	200,300	219,400	205,400	-6%	224,600	202,400	-10%
	Beltway 8	IH 610	213,300	218,400	231,400	221,200	-4%	256,400	239,500	-7%
Principal Arterials										
US 59	North of SH 99	SH 99	54,900	50,300	58,800	59,400	1%	66,100	73,500	11%
	SH 99	FM 1960	115,700	135,600	145,400	131,300	-10%	157,100	146,000	-7%
	FM 1960	Beltway 8	141,100	159,600	177,100	167,900	-5%	202,400	190,300	-6%
	Beltway 8	IH 610	185,000	175,300	189,400	185,800	-2%	215,000	205,800	-4%
FM 1960	IH 45	US 59	47,800	63,600	69,900	58,900	-16%	70,700	74,200	5%
Beltway 8	IH 45	US 59	39,400	77,700	91,700	84,100	-8%	125,600	118,400	-6%
Hardy Toll Road	IH 45	SH 99	26,500	35,200	32,400	36,500	13%	41,000	55,300	35%
	SH 99	FM 1960	31,800	40,700	38,100	47,600	25%	48,000	72,800	52%
	FM 1960	Beltway 8	37,200	40,400	33,600	45,400	35%	50,400	70,400	40%
	Beltway 8	IH 610	45,700	41,000	33,300	48,400	45%	58,600	78,500	34%
Proposed Grand Parkway										
Proposed Grand Parkway	IH 45	US 59	N/A	N/A	N/A	25,800	N/A	N/A	53,700	N/A
Minor Arterials										
SH 242	IH 45	FM 1314	13,300	15,700	17,100	15,800	-8%	29,300	26,300	-10%
	FM 1314	US 59	8,000	10,100	10,900	9,700	-11%	17,500	18,100	3%
Collector Roadways										
Louetta	IH 45	Hardy Toll Rd	6,300	12,600	17,800	14,500	-19%	28,100	28,500	1%
Spring-Cypress Rd	IH 45	Hardy Toll Rd	3,400	2,100	5,500	4,700	-15%	4,300	8,400	95%
Cypresswood Dr	IH 45	Hardy Toll Rd	11,600	15,500	19,600	19,500	-1%	22,700	24,700	9%
	Hardy Toll Rd	FM 1960	3,800	5,800	18,700	14,300	-24%	20,500	16,900	-18%
Spring-Stuebner Rd	IH 45	Hardy Toll Rd	5,900	7,400	11,400	15,800	39%	18,900	13,300	-30%
FM 1314	SH 242	US 59	10,900	20,100	21,700	23,900	10%	31,000	31,700	2%
FM 1485	SH 242	US 59	5,800	11,200	19,900	20,300	2%	30,000	29,200	-3%

Source: H-GAC, 2005a

THIS PAGE IS INTENTIONALLY LEFT BLANK

TABLE 2-5
SEGMENT G PERCENTAGE OF ROADWAY MILES OPERATING AT VARIOUS LOM BY FACILITY TYPE

LOM	2000 (Base Year)		2010 (No-Build Only)		2015		2025[1]	
Interstates								
Tolerable	81%	N/A	87%	N/A	87%	96%	98%	87%
Moderate	10%	N/A	11%	N/A	11%	3%	2%	11%
Serious	9%	N/A	2%	N/A	2%	1%	0%	2%
Severe	0%	N/A	0%	N/A	0%	0%	0%	0%
Principal Arterials								
Tolerable	91%	N/A	97%	N/A	95%	88%	88%	97%
Moderate	5%	N/A	2%	N/A	3%	9%	7%	2%
Serious	3%	N/A	1%	N/A	1%	3%	5%	1%
Severe	1%	N/A	0%	N/A	1%	0%	0%	0%
Proposed Grand Parkway								
Tolerable	N/A	N/A	N/A	N/A	N/A	100%	N/A	100%
Moderate	N/A	N/A	N/A	N/A	N/A	0%	N/A	0%
Serious	N/A	N/A	N/A	N/A	N/A	0%	N/A	0%
Severe	N/A	N/A	N/A	N/A	N/A	0%	N/A	0%
Minor Arterials								
Tolerable	39%	N/A	36%	N/A	31%	34%	15%	15%
Moderate	38%	N/A	35%	N/A	5%	21%	30%	30%
Serious	6%	N/A	8%	N/A	39%	20%	35%	34%
Severe	17%	N/A	21%	N/A	25%	25%	20%	21%
Collector Roadways/Smart Streets								
Tolerable	94%	N/A	78%	N/A	49%	69%	70%	69%
Moderate	2%	N/A	18%	N/A	20%	2%	5%	6%
Serious	1%	N/A	3%	N/A	8%	9%	18%	16%
Severe	3%	N/A	1%	N/A	23%	20%	7%	9%
Total Roadway Miles[2]								
Tolerable	82%	N/A	85%	N/A	74%	84%	78%	81%
Moderate	10%	N/A	10%	N/A	11%	7%	10%	8%
Serious	5%	N/A	2%	N/A	9%	4%	9%	8%
Severe	3%	N/A	3%	N/A	6%	5%	3%	3%

Notes: Unshaded cells = No-Build; Shaded cells = Build

[1] By 2025, unless funding sources are identified for major projects in the 2025 RTP (such as Smart Streets), more roadways, particularly collector roadways/Smart Streets, would operate at less than tolerable conditions (i.e., with a Moderate, Serious, or Severe LOM). See Volume I, Section 1.2.2, particularly the trend-line analysis presented in Figure 1-4, for further explanation.

[2] Total roadway miles based on a weighted average.

Source: H-GAC, 2005a and Study Team, 2005

2.2.5.3 Safety

An accident analysis was conducted to determine how travel safety would be affected by new circumferential freeway capacity. Nationally, freeways have lower accident rates per number of vehicles than lower classified roads because of the design of the freeway, fewer access points, fewer driver distractions, and less stop-and-go conditions. Consequently, it can be determined that moving traffic from lower classified facilities, such as collector roadways, to higher classified roadways, such as freeways, including toll roads, would reduce the accident rate in the area. See the complete discussion of safety issues in Section 1.2.3 (Safety) of this volume. Table 2-6 shows examples of frequent accident locations within the Segment G traffic study area and the amount of traffic diverted by the proposed Grand Parkway.

TABLE 2-6
LOCATIONS IN THE SEGMENT G TRAFFIC STUDY AREA WITH HIGH ACCIDENT RATES

Roadway			Number of Crashes[1]	% Change in ADT as a Result of Building the Grand Parkway	
Facility	From	To		2015	2025
FM 1960	IH 45	US 59	971	-16%	5%
Cypresswood Dr	IH 45	FM 1960	39	-12%	-4%

Notes: [1] Represents years 1999 through 2001, the most recent dataset available.
Source: H-GAC, 2005c

As shown in Table 2-6, traffic on most of these roadways with high accident rates would be reduced in 2015 (by as much as 16 percent). These vehicles would not be eliminated from the overall transportation system, but funneled to other facilities with lower national average crash rates (e.g., the proposed Grand Parkway). Therefore, it is likely the crash rate in the Segment G traffic study area would decrease with the construction of Segment G.

2.2.6 Preferred Alternative Transportation Mode

The results of the Traffic and Transportation Analysis for the Segment G traffic study area yielded the following results:

- System Linkage: The Segment G traffic study area experiences a high number of east-west traffic movements between radial freeways, IH 45 and US 59. Currently, only congested arterial and collector facilities connect these major roadways in this area. The existing transportation system will not be sufficient to handle the expected growth in population and employment. Segment G of the Grand Parkway, if constructed independently from the other segments, is expected to carry up to 53,700 vehicles per day in 2025, showing the need for additional circumferential freeway capacity.

- Expanded Capacity: The existing roadway network is expected to become even more congested as population and employment rise. In the base year (2000), approximately 8 percent of all roadway miles operate with serious and severe LOMs, which are expected to increase to 15 percent by 2015. By 2025, unless funding sources are identified for major projects in the RTP (such as Smart Streets), this percentage is anticipated to increase even more. Construction of the proposed Segment G of the Grand Parkway would result in 84 percent of roadway miles operating with a tolerable condition by 2015 as opposed to 74 percent under the No-Build Alternative.
- Safety: Studies have shown that roadways with frequent turns, stop-and-go conditions, distractions, and lack of access control (driveways) tend to have more crashes than freeway facilities. In the Segment G traffic study area, most of the circumferential roadways are collector roadways, which characterize the conditions that cause frequent crashes. Segment G of the proposed Grand Parkway is expected to reduce the traffic on these high crash-rate facilities as travelers utilize the new facility instead of congested collectors and arterials. Consequently, the crash rate in the Segment G traffic study area is anticipated to decrease.

Given these results, the Build Alternative was selected as the Preferred Alternative Transportation Mode. Although the No-Build Alternative would not satisfy the need for and purpose of the project, it was retained as a basis for comparison with the Build Alternative throughout the analysis of environmental impacts as required by CEQ regulations (40 CFR 1502.14[d]).

The following section provides an analysis of the individual alignments developed for the Build Alternative within the Segment G project area.

2.3 ALTERNATIVE ALIGNMENT STUDY

The analysis detailed in the following sections presents the selection of the Preferred Alternative Alignment. The analysis first resulted in a Recommended Alternative Alignment which was presented in the DEIS, published in January of 2007. Although selection of a Recommended Alternative Alignment in the DEIS is not required by CEQ or FHWA regulations, presenting the status of the alternatives analysis with its selection of the Recommended Alternative Alignment in the DEIS allowed the public and agencies to comment on the alignment, and therefore, more effectively influence the decision of whether or not to select the alignment as the Preferred Alternative Alignment. As detailed below, the Preferred Alternative Alignment presented in this FEIS is nearly equivalent to the Recommended Alternative Alignment, with the exception of a shift designed in response to new development.

2.3.1 Alternative Alignments Development

Following the identification of a Preferred Alternative Corridor (Exhibit G–14), alternative alignments were developed within this corridor. The portion of the Preferred Alternative Corridor that is within Segment G is shown in Exhibit G–40 and is referred to as the “project area” for the remainder of this document.

Within the Segment G project area, four alternative alignments were developed for the analysis in the DEIS to fulfill the need for and purpose of the project and minimize potential environmental impacts: Alternative Alignment A, Alternative Alignment B, Alternative Alignment C, and Alternative Alignment D. All of the alternative alignments would be a four-lane controlled access toll road with intermittent frontage roads in a 400-foot ROW on a new location. The Study Team used the GIS-based resource inventory to develop the alternative alignments. The corridor-level data, supplemented with field-collected data, were used as a guide to determine the alignments that provide the best opportunity to avoid or minimize adverse environmental effects and still meet the need for and purpose of transportation improvements.

There are five sections within the Segment G project area where two or more of the alternative alignments overlap because of the density of environmental constraints. The segments of alternative alignments between these overlapped areas are defined as "reaches." The alignment reaches were used as a tool for examining "hybrid" combinations of the alternative alignments. It should be noted that the boundaries of corridor reaches and alternative alignment reaches differ. The delineation of alignment reaches and the four alternative alignments are shown in Exhibit G–40 and on U.S. Geological Survey (USGS) Topographic Maps shown in Exhibit G–41a-e. The alignment reaches that overlap with the Segment G project area are named Reach 8, Reach 9, Reach 10, Reach 11, and Reach 12.

2.3.1.1 Alternative Alignment A

Section 2.3.1 introduces the alternative alignments developed for the DEIS analysis within the Segment G project area: Alternative Alignment A is approximately 13.7 miles in length (Exhibit G–40). Alternative Alignment A begins at IH 45 approximately 2.9 miles north of FM 2920. Alternative Alignment A travels east approximately 2.5 miles, crossing the Hardy Toll Road and Spring Creek, before shifting to a northeasterly direction approximately 2.6 miles, paralleling Riley Fuzzel Road. Alternative Alignment A veers southeast 1.0 miles before traversing east approximately 2.0 miles, crossing the San Jacinto River. Alternative Alignment A heads to a northeasterly direction approximately 1.1 miles before veering east approximately 3.5 miles, crossing FM 1314 and White Oak Creek. Alternative Alignment A continues southeast approximately 1.0 miles before terminating at US 59. Alternative Alignment A would require approximately 745 acres of ROW (Exhibit G–40).

2.3.1.2 Alternative Alignment B

Alternative Alignment B is approximately 13.6 miles in length (Exhibit G–40). Alternative Alignment B begins at IH 45 approximately 0.2 miles south of IH 45 and the Hardy Toll Road interchange. Alternative Alignment B travels southeast along the Hardy Toll Road approximately 1.2 miles before shifting to an easterly direction approximately 1.3 miles, crossing Spring Creek. Alternative Alignment B traverses northeast with Alternative Alignment A for approximately 2.3 miles, paralleling Riley Fuzzel Road. Alternative Alignment B continues northeast approximately 1.4 miles before veering east approximately 3.6 miles, crossing the San Jacinto River. Alternative Alignment B then turns southeast approximately 0.5 miles, paralleling FM 1314. Alternative Alignment B proceeds east approximately 3.3 miles, crossing White Oak Creek and then terminating at US 59. All 13.6 miles of Alternative Alignment B would be on a new location. Alternative Alignment B would require approximately 713 acres of ROW (Exhibit G–40).

2.3.1.3 Alternative Alignment C

Alternative Alignment C is approximately 13.7 miles in length (Exhibit G–40). Alternative Alignment C begins at IH 45 approximately 2.9 miles north of FM 2920. Alternative Alignment C traverses east with Alternative Alignment A approximately 2.5 miles, crossing the Hardy Toll Road and Spring Creek. Shifting to a northeasterly direction approximately 2.6 miles, Alternative Alignment C parallels Riley Fuzzel Road and then heads in an easterly direction approximately 4.5 miles, crossing the San Jacinto River. Alternative Alignment C veers to the northeast approximately 1.0 miles, crossing FM 1314, before joining Alternative Alignment A in an easterly direction for approximately 1.3 miles. Alternative Alignment C traverses to the southeast approximately 0.8 miles before continuing east with Alternative Alignment B approximately 1.0 miles, crossing White Oak Creek and terminating at US 59. All 13.7 miles of Alternative Alignment C would be on a new location. Alternative Alignment C would require approximately 744 acres of ROW (Exhibit G–40).

2.3.1.4 Alternative Alignment D

Alternative Alignment D is approximately 13.7 miles in length (Exhibit G–40). Alternative Alignment D is the same as Alternative Alignment A in Reaches 8, 10, and 11, and the same as Alternative Alignment C in Reach 12. In Reach 9, Alternative Alignment D was developed after the other alignments because of high potential for natural resource impacts in that region. The new option was the result of continual coordination with resource agencies. Alternative Alignment D follows a more northerly course to cross the West Fork of the San Jacinto River.

Alternative Alignment D begins at IH 45 approximately 2.9 miles north of FM 2920. Alternative Alignment D travels east with Alternative Alignment A and Alternative Alignment C approximately 1.9 miles, crossing the Hardy Toll Road and Spring Creek. Shifting to a northeasterly direction approximately 1.8 miles, Alternative Alignment D parallels Riley Fuzzel Road and traverses approximately 3.6 miles in a northeasterly direction, crossing the San Jacinto River. Alternative Alignment D veers to the southeast approximately 1.4 miles and continues easterly 3.0 miles, crossing FM 1314. Alternative Alignment D traverses to the southeast approximately 1.3 miles before continuing east with Alternative Alignment B approximately 0.7 miles, crossing White Oak Creek and terminating at US 59. All 13.7 miles of Alternative Alignment D would be on a new location. Alternative Alignment D would require approximately 747 acres of ROW (Exhibit G–40).

2.3.2 Screening Process

As detailed in Section 2.3.1, there are five alignment reaches within Segment G (Reaches 8, 9, 10, 11, and 12) (Exhibit G–40). Although the four alternative alignments can stand alone, different combinations of alternative alignments within each of the five reaches were also analyzed for their potential independent and cumulative effects in order to select a Preferred Alternative Alignment.

Identification of the Preferred Alternative Alignment was based on public and agency outreach results and an analysis and comparison of the potential effects on the physical, biological, and human environments of each alternative alignment. Table 2-7 provides a summary of impacts for each of the alternative alignments within each alignment reach. Section 3 (Affected Environment) of the FEIS describes the affected environment of this project, and Section 4 (Environmental Consequences) provides detailed analysis of the potential impacts for all alternative alignments and the No-Build Alternative.

Analysis of certain resources were used as criteria for eliminating alternative alignments from further study in order to arrive at the selection of a Preferred Alternative Alignment. The analysis first resulted in the selection of a Recommended Alternative Alignment for presentation in the DEIS (January 2007) and solicitation of comment. Such a screening process is consistent with CEQ and FHWA regulations. Then, further analysis was used to finalize a Preferred Alternative Alignment to undergo preliminary design and further study as presented in the FEIS. The Preferred Alternative Alignment may still undergo changes after publication of the FEIS to best avoid and minimize impacts.

Particularly because Houston has a history of flooding, natural resources that affect floodwater control and retention were avoided to the extent feasible and practicable considering engineering and other constraints in the development of the alternative alignments. Nonetheless, different combinations of the alignments in the five reaches yield different resource impacts, and examination of these differences was used in the selection of a Preferred Alternative Alignment.

Avoidance of floodplain impacts was a primary criterion in the alternative alignment screening process. Unavoidable floodplain impacts would be mitigated and a detailed drainage study conducted for the selected alignment (as detailed in Section 4.12); however, avoidance and minimization precede mitigation for unavoidable impacts. Because wetlands serve the function of floodwater retention, avoidance of wetland impacts was also a principal criterion in the alternative alignment screening process. Again, although mitigation measures may be employed to offset unavoidable permanent impacts to wetland flood control function (as detailed in Section 4.10), avoidance and minimization of impact precede mitigation as mechanisms for preventing loss of this function.

Public outreach and the number of home and business relocations were also key factors in the determination of the Preferred Alternative Alignment for Segment G of the Grand Parkway. The following list summarizes the screening criteria used for the selection of a Preferred Alternative Alignment:

- Feedback from Public Workshops;
- Number of relocations;
- Potential to impact floodplains; and
- Potential to impact wetlands.

TABLE 2-7
SUMMARY OF IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Alternative Alignment	Reach	Length (miles)	Land Use		Changes in Community Cohesion	Environmental Justice (EJ) Issues	Air Quality Impacts	Traffic Noise Impacts[1]	Residence Displacements	Commercial Displacements	School Properties [2]	Churches	Cemeteries	Parks	Natural Resources														Cultural Resources				Oil and Gas Wells	Potential Hazardous Material Sites	Water Wells	
															Special Resource Areas					Aquatic Resources				Flood Zones											
			Visual and Potential Access Impacts	Separation of Farmland from Homestead											Threatened & Endangered Species	Species of Concern	Remnant Prairie Topography (acres)	Bottomland Hardwoods (acres) [3]	Riparian Forest (acres)[3]	Adjacent Wetlands (acres)[4]	Isolated Wetlands (acres)[4]	Total Wetlands (acres)[4]	Stream Crossings [5]	100-Year Floodplain (acres)	Floodway (acres)[5]	Prime Farmlands (acres)	Statewide Important Farmland Soils	Recorded Archeology Sites	Historic Properties	Century Farm Sites	High Probability Area (acres) [6]			Public [7]	Private
A	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.43	No	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	53.2	-	19.4	20.8	40.2	4	35.5	20.4	-	192.2	-	-	-	179	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	4	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.02	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	32.3	-	2.7	2.2	4.9	4	27.8	8.8	1.3	16.3	-	-	-	94	-	-	-	-
Total		13.70	-	-	-	-	-	141	109	0	0	0	0	0	0	0	0	109.4	0	36.0	48.0	84.0	14	95.1	64.4	64.1	315.6	0	0	0	538	1	1	16	1
B	8	4.96	Yes	No	Yes	No	No	134	38	1	1	-	-	-	-	-	-	19.2	-	4.3	2.1	6.4	5	32.2	33.5	18.1	32.1	-	-	-	231	-	1	9	-
	9	4.27	No	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	43.6	-	23.2	7.2	30.4	3	13.7	49.4	4.6	139.4	-	-	-	170	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	2.09	Yes	No	Yes	No	No	67	64	-	-	-	-	-	-	-	-	-	-	-	5.0	5.0	-	-	-	-	11.1	-	-	-	45	-	-	-	-
	12	1.92	Yes	No	Yes	No	No	14	3	-	-	-	-	-	-	-	-	20.8	-	3.1	3.3	6.4	3	15.6	5.9	1.3	14.5	-	-	-	100	-	-	-	-
Total		13.63	-	-	-	-	-	215	105	1	1	0	0	0	0	0	0	83.6	0	30.6	17.6	48.2	11	61.5	88.8	24.0	208.4	0	0	0	549	0	1	12	0
C	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.10	No	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	58.0	-	26.9	4.5	31.4	5	52.5	24.5	-	168.4	-	-	-	171	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1.5	17.7	-	-	-	19	-	-	1	-
	11	2.19	Yes	No	Yes	No	No	-	169	-	-	-	-	-	-	-	-	-	-	-	10.3	10.3	1	-	-	16.2	46.4	-	-	-	56	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		13.65	-	-	-	-	-	156	209	0	0	0	0	0	0	0	0	144.3	0	44.8	19.0	63.8	16	144.8	67.2	78.9	275.3	0	0	0	564	1	1	15	1
D	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.42	No	No	Yes	No	No	-	1	-	-	-	-	-	-	-	-	46.4	-	14.6	0.4	15.0	4	11.3	52.9	0.1	159.7	-	-	-	177	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	4	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		13.72	-	-	-	-	-	141	110	0	0	0	0	0	0	0	0	132.7	0	32.5	27.3	59.8	14	103.6	95.6	64.2	287.6	0	0	0	549	1	1	16	1
Recommended[8]	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.42	No	No	Yes	No	No	-	1	-	-	-	-	-	-	-	-	46.4	-	14.6	0.4	15.0	4	11.3	52.9	0.1	159.7	-	-	-	177	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	4	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		13.72	-	-	-	-	-	141	110	0	0	0	0	0	0	0	0	132.7	0	32.5	27.3	59.8	14	103.6	95.6	64.2	287.6	0	0	0	549	1	1	16	1

TABLE 2-7 (CONT.)
SUMMARY OF IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Alternative Alignment	Reach	Length (miles)	Land Use		Changes in Community Cohesion	Environmental Justice (EJ) Issues	Air Quality Impacts	Traffic Noise Impacts[1]	Residence Displacements	Commercial Displacements	School Properties[2]	Churches	Cemeteries	Parks	Natural Resources													Cultural Resources				Oil and Gas Wells	Potential Hazardous Material Sites	Water Wells	
															Special Resource Areas					Aquatic Resources				Flood Zones											
			Visual and Potential Access Impacts	Separation of Farmland from Homestead											Threatened & Endangered Species	Species of Concern	Remnant Prairie Topography (acres)	Bottomland Hardwoods (acres)[3]	Riparian Forest (acres)[3]	Adjacent Wetlands (acres)[4]	Isolated Wetlands (acres)[4]	Total Wetlands (acres)[4]	Stream Crossings[5]	100-Year Floodplain (acres)	Floodway (acres)[5]	Prime Farmlands (acres)	Statewide Important Farmland Soils	Recorded Archeology Sites	Historic Properties	Century Farm Sites	High Probability Area (acres)[6]			Public[7]	Private
Preferred	8	4.93	Yes	No	Yes	No	No	195	18	-	-	-	-	-	-	-	-	23.4	-	13.7	2.3	16.0	5	31.7	35.7	59.9	26.2	-	-	-	212	1	1	10	1
	9	4.43	No	No	Yes	No	No	26	1	-	-	-	-	-	-	-	-	44.0	-	19.4	0.5	19.9	4	10.7	52.2	0.1	158.6	-	-	-	177	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	43	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	16	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		13.74	-	-	-	-	-	280	110	0	0	0	0	0	0	0	0	129.8	0	37.1	27.4	64.5	14	102.9	95.4	64.2	290.7	0	0	0	550	1	1	16	1

Notes: Totals may not appear to equal sum of reaches because of rounding. [1] = Impacts account for traffic assuming construction of all four segments (E, F-1, F-2, and G) of the Grand Parkway (i.e., worst-case scenario with respect to noise impact). Preferred Alternative Alignment noise impacts are based on a revised analysis conducted for the FEIS; [2] = Impact in Alternative Alignment B is to undeveloped Spring ISD property; [3] = See definition of Bottomland Hardwoods and Riparian Forest in the Glossary; [4] = As with all land cover data, numbers for original alternative alignments reflect new land use calculations. Additionally, for the FEIS, a more detailed analysis of wetlands was conducted in the Preferred Alternative Alignment. See Section 4.10 for further explanation; [5] = Includes stream crossings, lakes, and ponds; [6] = Total of Map Units 1, 2, 2a, 3, and 3a; [7] = Wellhead Capture Zones; [8] = Recommended Alternative Alignment is the same as that presented in the DEIS, however, impact calculations account for updated land use; "-" = No resource located within reach

Source: Study Team, 2007

2.3.3 Alternatives Analysis Results

Identification of the Preferred Alternative Alignment was a complex process based on a combination of public and agency outreach results and an analysis and comparison of the potential effects on the physical, biological, and human environments of each alternative alignment. However, analysis of the four specific criteria listed above and detailed below played a particularly important role in the decision process. The analysis highlights how the selection of the Preferred Alternative Alignment is a process that has continually involved efforts to avoid and minimize environmental impacts while at the same time serving to fulfill the need for and purpose of the proposed project.

2.3.3.1 Feedback from Public Workshops

Public preference was tallied in a number of workshops held in October 2000. The preliminary alternative alignments (A, B, and C) were presented to the public on October 26 at Kingwood College (adjacent to the Segment G project area), as well as on October 23 at Langham Creek High School (adjacent to the Segment E project area) and October 25 at Tomball College (adjacent to the Segment F-1 and Segment F-2 project areas). Alternative Alignment D had not been developed by that time; the fourth alignment option was designed after further coordination with resource agencies as a means of reducing potential natural resource impacts in Reach 9.

Citizens were invited to comment on any of the four proposed Grand Parkway segments (E, F-1, F-2, or G) at any of these meetings. Therefore, comments were received pertaining to Segment G at the Langham Creek and Tomball meetings as well as at the Kingwood meeting. Two hundred eighty-seven citizens attended the three workshops, with 124 attendees completing questionnaires. Further details regarding these meetings are provided in Section 6 of this volume (Agency and Public Coordination).

Table 2-8 presents the preferences selected on workshop questionnaires by citizens attending the workshops. With consideration of results both from the Kingwood College meeting alone and from all public workshops tallied together, feedback showed the following: preference for Alternative Alignment A (which is the same as Alternative Alignment C) in Reach 8, no distinct preference indicated in Reaches 9 or 10, and preference for Alternative Alignment A again in Reaches 11 and 12.

Based on public feedback from the alignment study workshops, the Preferred Alternative Alignment would be Alternative Alignment A in Reach 8, any alternative alignment in Reaches 9 and 10, and Alternative Alignment A in Reaches 11 and 12. Again, it should be noted that Alternative Alignment D was not considered in these questionnaires, and that several of the alignments overlap for substantial portions of the project area (see Exhibit G–40).

TABLE 2-8
OCTOBER 2000 PUBLIC WORKSHOP ALIGNMENT SELECTION PREFERENCES

Alignment	Reach 8				Reach 9				Reach 10				Reach 11				Reach 12			
	A	B	C[4]	D[5]	A	B	C	D[5]	A	B	C	D[5]	A	B	C	D[5]	A	B	C	D[5]
Kingwood College Public Workshop Responses[1]	3	3	1	N/A	1	3	3	N/A	1	3	3	N/A	6	3	2	N/A	5	3	1	N/A
Percentage of Responders	43%	43%	14%	N/A	14%	43%	43%	N/A	14%	43%	43%	N/A	55%	27%	18%	N/A	56%	33%	11%	N/A
October 2000 Public Workshop Response Total[2]	26	12	7	N/A	10	11	10	N/A	10	12	9	N/A	20	9	6	N/A	19	11	4	N/A
Percentage of Responders[3]	58%	27%	16%	N/A	32%	35%	32%	N/A	32%	39%	29%	N/A	57%	26%	17%	N/A	56%	32%	12%	N/A

Notes: Shading indicates alternative preferred by the highest number of respondents.

[1] Not all workshop attendees responded, and not necessarily the same respondents nor the same number of respondents indicated a preference in each reach.

[2] Refers to the total results from all three workshops held in October 2000.

[3] Not all percentages total to 100 because of rounding.

[4] Alternative Alignment C is actually the same as Alternative Alignment A in Reach 8.

[5] Alternative Alignment D had not been developed at the time of the October 2000 workshops; however, it should be noted that Alternative Alignment D is the same as Alternative Alignment A in Reaches 8, 10, and 11, and the same as Alternative Alignment C in Reach 12. Alternative Alignment D was developed in order to reduce potential impacts to natural resources in Reach 9.

Source: Study Team, 2000

2.3.3.2 Relocations

Table 2-9 shows the differences between the alternative alignments in the five reaches with respect to total relocations (residences and businesses).

TABLE 2-9
POTENTIAL RELOCATIONS FROM THE 2007 DEIS
FOR SEGMENT G BY ALTERNATIVE ALIGNMENT AND REACH

Alternative Alignment	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12
A	17	0	0	69	22
B	38	0	0	64	3
C	17	0	0	169	22
D	17	1	0	69	22

Source: Study Team, 2007

In Reach 8, Alternative Alignments A, C, or D would require the fewest number of relocations. In Reaches 9 and 10, none of the alternative alignments would have more than one relocation. In Reach 11, Alternative Alignment B would require the fewest number of relocations (64), although Alternative Alignments A and D would only require five more relocations (69). In Reach 12, Alternative Alignment B would require the fewest number of relocations.

Based solely on the number of relocations, the selection of a Preferred Alternative Alignment would be any alignment but Alternative Alignment B in Reach 8, any alignment in Reaches 9 and 10, any alignment except Alternative Alignment C in Reach 11, and Alternative Alignment B in Reach 12.

2.3.3.3 Potential to Impact Floodplains

Table 2-7 shows the differences between the alternative alignments in the five reaches with respect to potential impacts to floodplains (regulatory floodways and 100-year floodplains combined). In Reach 8, all alternative alignments would have roughly the same amount of floodplain impact (between 66 and 67 acres). In Reach 9, Alternative Alignment A would have the smallest impact on this resource (56 acres, versus 63 acres with Alternative Alignment B, 77 acres with Alternative Alignment C, and 64 acres with Alternative Alignment D). In Reaches 10 and 11, none of the alignments would impact floodplains. In Reach 12, Alternative Alignment B would have the least amount of floodplain impact (22 acres, versus 37 acres with Alternative Alignment A, and 68 acres with Alternative C or Alternative Alignment D).

Based solely on the potential to impact floodplains, the Preferred Alternative Alignment would be any alternative alignment in Reach 8, Alternative Alignment A in Reach 9, any alternative alignment in Reach 10 and Reach 11, and Alternative Alignment B in Reach 12.

2.3.3.4 Potential to Impact Wetlands

Table 2-7 shows the differences between the alternative alignments in the five reaches with respect to potential wetland impacts. In Reach 8, Alternative Alignment B would impact the least amount of wetland acreage (6.3 acres, versus 16.2

acres with Alternative Alignments A, B, C, and D). In Reach 9, Alternative Alignment D would impact the least amount of wetland (15.0 acres, versus 40.2 acres with Alternative Alignment A, 30.4 acres with Alternative Alignment B, and 31.4 acres with Alternative Alignment C). In Reach 10, none of the alternative alignments would impact wetland. In Reach 11, Alternative Alignment B would impact the least amount of wetland (5.0 acres, versus 22.7 acres with Alternative Alignment A, 10.3 acres with Alternative Alignment C, and 22.7 acres with Alternative Alignment D). In Reach 12, Alternative Alignment A would impact the least amount of wetland (4.9 acres, versus 6.4 acres with Alternative Alignment B, and 5.8 acres with either Alternative Alignment C or Alternative Alignment D).

Based solely on the potential to impact wetlands, the Preferred Alternative Alignment would be Alternative Alignment B in Reach 8, Alternative Alignment D in Reach 9, any alternative alignment in Reach 10, Alternative Alignment B in Reach 11, and Alternative Alignment A in Reach 12.

2.3.3.5 Selection of Recommended Alternative Alignment for the DEIS

Table 2-10 summarizes the results after the analysis of these four screening criteria (public input, relocations, floodplain impact acreage, and wetland impact acreage).

TABLE 2-10
SUMMARY OF ALTERNATIVE ALIGNMENT SCREENING RESULTS

Criterion	Reach 8*	Reach 9	Reach 10	Reach 11	Reach 12
Public Response	A, C, or D	any	any	A	A
Relocations*	A, C, or D	any	any	B	B
Floodway/Floodplain Impact	any	A	any	any	B
Wetland Impact	B	D	any	B	A

Notes: * See Exhibit G–40 to note where alternative alignments overlap. In Reach 8, all alignments are the same except Alternative Alignment B; in Reach 10, all alignments are the same except Alternative Alignment C.

Source: Study Team, 2007

- In Reach 8, the screening results most strongly support the selection of the more southern route (Alternative Alignment A, C, or D). Additionally, with the more northern route, the merging of IH 45 and Hardy Toll Road traffic along the Grand Parkway posed engineering challenges that might have necessitated an increase in ROW width (see Exhibit G–40).
- In Reach 9, the screening supports the selection of either Alternative Alignment A or Alternative Alignment D. However, Alternative Alignment D was designed in Reach 9 in close coordination with resource agencies in order to best avoid impacts to natural resources. Therefore, Alternative Alignment D would be the best overall choice in Reach 9.
- In Reach 10, no alternative alignment stands out as the best choice from these screening criteria. Therefore, the more northern alignment (Alternative Alignment A, B, or D) was selected since Alternative Alignment C would not be possible with the selection of Alternative Alignment D in Reach 9. Additionally, the more northern route would have one less stream crossing and less farmland acreage impacted than the more southern alignment.

- In Reach 11, the screening supports the selection of Alternative Alignment B. However, Alternative Alignment A was selected in part for engineering considerations since it would provide for a more perpendicular crossing of FM 1314. Also, public support was strongly in favor of Alternative Alignment A (Table 2-8), and with the selection of Alternative Alignment C in Reach 12 (see next bulleted item), Alternative Alignment B would not be an option in Reach 11 (see Exhibit G–40).
- In Reach 12, the screening supports the selection of either Alternative Alignment A or Alternative Alignment B. The Study Team still strongly considered Alternative Alignment C because of the potential visual and noise impacts to the established residences in the Silver Trails subdivision associated with Alternative Alignment A. One of the reasons for lack of support for Alternative Alignment C in the 2000 workshops was that it passed through the Valley Ranch development. However, since 2000, coordination with developers of this growing community has allowed for reduced impacts to these new residences.

After consideration of the above, Alternative Alignment D (which is a composite of Alternative Alignment A/C in Reach 8, the added Alternative Alignment D in Reach 9, Alternative Alignment A/B in Reach 10, Alternative Alignment A in Reach 11, and Alternative Alignment C in Reach 12) was selected for presentation in the DEIS as the Recommended Alternative Alignment. Subsequent to publication of the DEIS, the selection of a Preferred Alternative Alignment continued as detailed in the following section.

2.3.3.6 Selection of Preferred Alternative Alignment for the FEIS

Continual updates to land use data and public and agency coordination have taken place since the publication of the DEIS in January 2007. Comments received on the DEIS, updated analyses, and coordination have led to the slight shifting of the Recommended Alternative Alignment in one area near a new subdivision named Creekside Village that has been planned for development at the end of Riley Fuzzel Road (at the junction of Reach 8 and Reach 9). The Grand Parkway alignment was shifted slightly to the south to avoid residential impacts in this subdivision. Other than the slight shift at Creekside Village, the Preferred Alternative Alignment is the Recommended Alternative Alignment as presented in the DEIS (see the previous sections for detail on how the Recommended Alternative Alignment was selected).

<u>Description of the Preferred Alternative Alignment</u>

The Preferred Alternative Alignment for the Grand Parkway Segment G is approximately 13.74 miles long. The facility is proposed as a four-lane, controlled access principal arterial, with intermittent frontage roads in a 400-foot ROW. The mainlanes of the Grand Parkway are designed to be above the water surface elevation generated by a 100-year (1 percent chance) storm event. Frontage roads, where present, are generally designed to be above the water surface elevation generated by a five or 10-year storm. The schematic design is shown in Exhibit G–42a-b. The preliminary design of the Preferred Alternative Alignment is shown in Exhibit G–55. As detailed in Section 2.2.5, the Build Alternative, including the Preferred Alternative Alignment, would satisfy the need for and purpose of the project through improved system linkage and expanded capacity, which would also allow for improved safety and accommodation of demographic and economic growth.

The Preferred Alternative Alignment begins at IH 45 approximately 2.9 miles north of FM 2920. It travels east for approximately 1.7 miles, crossing the Hardy Toll Road and Spring Creek. The Preferred Alternative Alignment turns to the northeast, paralleling Riley Fuzzel Road, and continuing in this direction for approximately 5.5 miles. After crossing the West Fork of the San Jacinto River, the Preferred Alternative Alignment turns to the southeast for approximately 1.5 miles. The alignment slightly turns to head easterly for approximately 3.1 miles, passing between the Cumberland and Winchester Place subdivisions and crossing FM 1314. After passing the Timberland Estates subdivision, the Preferred Alternative Alignment turns back toward the southeast for approximately 1.9 miles until its terminus at US 59. In this final stretch of the project area, the alignment parallels and then crosses the White Oak Creek floodplains and runs through the Valley Ranch community. All of the Preferred Alternative Alignment would be on a new location, and its ROW would require approximately 748.4 acres.

Estimated total construction cost for building the Preferred Alternative Alignment for Segment G is $476,687,000. Estimated construction costs for all alternative alignments are presented in Table 2-11. Costs include estimates for the following: construction cost, ROW cost, utilities cost, escalation cost and inflation cost for the targeted letting year. The total cost estimates also include construction of half the interchanges at the project termini; the estimates do not include the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment F-2 at IH 45 nor the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment H at US 59. Funding for the construction of the Grand Parkway will be via toll revenues generated by the facility and not by public funds.

Table 2-7 summarizes the potential impacts for the alternative alignments, including the Preferred Alternative Alignment. Section 3 (Affected Environment) of this volume of the FEIS describes the affected environment of this project. Section 4 (Environmental Consequences) of this volume provides detailed analysis of the potential impacts and mitigation for those impacts for all alternative alignments and the No-Build Alternative. Within Section 4, the final two sections provide a summary of direct impacts that would occur (Section 4.25) and mitigation measures and commitments that would be in place (Section 4.26) with the construction of the Preferred Alternative Alignment. Section 5 (Indirect and Cumulative Effects) presents the indirect and cumulative effects analysis conducted for the proposed Grand Parkway, Segment G in conjunction with the proposed Grand Parkway, Segments E, F-1, and F-2.

TABLE 2-11
HIGHWAY CONSTRUCTION COST FOR SEGMENT G

Alternative Alignment	Reach	Estimated Construction Cost
A	8	$170,691,000
	9	$153,692,000
	10	$13,530,000
	11	$67,305,000
	12	$70,081,000
Alternative Alignment A Total		$475,299,000

TABLE 2-11 (CONT.)
HIGHWAY CONSTRUCTION COST FOR SEGMENT G

Alternative Alignment	Reach	Estimated Construction Cost
B	8	$172,079,000
	9	$148,141,000
	10	$13530,000
	11	$72,509,000
	12	$66,611,000
Alternative Alignment B Total		$472,871,000
C	8	$170,691,000
	9	$142,243,000
	10	$13,530,000
	11	$75,979,000
	12	$71,121,000
Alternative Alignment C Total		$473,565,000
D	8	$170,691,000
	9	$153,345,000
	10	$13,530,000
	11	$67,305,000
	12	$71,121,000
Alternative Alignment D Total		$475,993,000
Recommended Alternative Alignment	8	$170,691,000
	9	$153,345,000
	10	$13,530,000
	11	$67,305,000
	12	$71,121,000
Recommended Alternative Alignment Total		$475,993,000
Preferred Alternative Alignment	8	$171,038,000
	9	$153,692,000
	10	$13,530,000
	11	$67,305,000
	12	$71,121,000
Preferred Alternative Alignment Total		$476,687,000

Note: The No-Build Alternative is not included in this table because it would be purely speculative on the part of the Study Team to estimate maintenance and construction costs on the existing and future roadway systems within the project area. The No-Build Alternative could result in higher maintenance, safety improvements, short-term restoration, and construction (new roads) costs for existing roadways because of increased traffic volumes on these facilities if the Grand Parkway were not constructed.

Costs include estimates for the following: construction cost, ROW cost, utilities cost, escalation cost and inflation cost for targeted letting year (2010). The total cost estimates also include construction of half the interchanges at the project termini; the estimates do not include the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment F-2 at IH 45 nor the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment H at US 59.

Totals may appear not to match the sum of the reaches because of rounding.

Source: Study Team, 2007

SECTION 3: AFFECTED ENVIRONMENT

This section presents baseline information for the existing affected environment in the Segment G project area. The Segment G project area is equivalent to the area bounded by the selected Preferred Alternative Corridor (Exhibit G–40), within which alternative alignments have been located.

Information is presented in technical and scientific disciplines with respect to the existing physical, biological, and human environments that may be affected by the Grand Parkway within Segment G, including the No-Build Alternative. These technical and scientific disciplines include: Land Use and Transportation Planning; Geology, Soils, and Farmland; Social Characteristics; Economics; Pedestrians and Bicyclists; Air Quality; Existing Noise Environment; Water Quality; Permits; Wetlands and Vegetative Communities; Wildlife; Floodplains; Wild and Scenic Rivers; Coastal Barriers; Coastal Zone Management; Essential Fish Habitat (EFH); Threatened and Endangered Species; Cultural Resources; Hazardous Materials; and Visual and Aesthetic Qualities.

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 both within the Segment G project area and within the broader context of the Segment G study area.

Existing land uses within the Segment G project area were identified from aerial photography, TxDOT county maps, and USGS topographic maps. The resulting land use map (Exhibit G–43) was verified with a number of field reconnaissance efforts conducted between 2000 and 2006. 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

General historical development patterns for the Segment G project area are discussed in Volume I, Section 3.1.1 (Historical Development Patterns) of this FEIS. The proposed project area falls within the Houston-Galveston-Brazoria CMSA, which is made up of three Primary Metropolitan Statistical Areas (PMSAs): Houston PMSA (Chambers, Fort Bend, Harris, Liberty, Montgomery, and Waller Counties), Galveston Texas City PMSA (Galveston County), and Brazoria PMSA (Brazoria County). The Segment G project area is located entirely within the Houston PMSA and within Harris and Montgomery Counties.

3.1.2 Existing Land Use

Located on the Gulf Coastal Plain, the Segment G project area covers 10,627 acres in northern Harris County and southern Montgomery County. The Segment G project area is characterized by a moderate degree of residential and commercial development with little development in Reach 9 and the bulk of the undeveloped land being forestland. Residential areas vary in density and composition, and these areas include single-family homesteads on ranches, master-planned subdivisions, and mobile home communities. Reflective of Houston's general growth pattern (described in Volume I, Section 3.3.1.1 [Rate of Growth]), recent development is occurring throughout the project area primarily in master planned communities, municipal utility districts, and commercial development along arterial roadways.

Within the Segment G project area, less than 1 percent of the land is considered farmland, 0 percent is rangeland, and 46 percent is forest. Approximately 41 percent is considered residential or commercial with no other urban usage, and 1 percent is parkland. Transportation and natural features like streams, canals, lakes, and wetlands comprise the remaining approximate 11 percent land cover of the proposed project area.

3.1.2.1 Urban Development

The primary type of development within the Segment G project area consists of residential subdivisions, mobile home communities, and strip commercial development along arterial roadways. The most intensive development within the Segment G project area is found in Reaches 8, 11, and 12, along the existing transportation network. Reach 9 is almost entirely undeveloped and Reach 10 contains a moderate degree of development. Subdivisions are currently under construction primarily along Riley Fuzzel Road and FM 1314. Subdivisions that are currently under construction or that are slated for future development are summarized in Section 5, Table 5-19 (Status of Developments in the Study Area) of this volume. Commercial growth has occurred mainly in and around the community of Spring and in the vicinity of IH 45 and US 59.

The residential and commercial pattern of recent developments contrasts sharply with the semi-rural nature of the area's traditional housing stock, where small clusters of homes or individual farm homesteads are located adjacent to FM roads. Residences in more rural settings typically include farm-related structures such as garages, barns, storage buildings, and other agricultural outbuildings.

3.1.2.2 Agricultural Land Use

Within the Segment G project area there are 15 acres of agricultural land (including farmland), which represents less than 1 percent of the Segment G project area. Agricultural land uses are discussed generally for Harris and Montgomery Counties in Volume I, Section 3.1.2 (Agricultural Land Use).

3.1.2.3 Transportation Land Use

The Segment G project area falls between two major thoroughfares: the western border is IH 45, which extends north from Houston toward the Woodlands, and the eastern border is US 59, which extends northeast from Houston toward

Porter and New Caney. On the western end of the Segment G project area, Spring Stuebner Road and Spring-Cypress Road offer limited east-west access within the Segment G project area; however, there is no primary east-west thoroughfare. The Hardy Toll Road provides a north-south access alternative to IH 45 through the community of Spring. Secondary roads include Rayford Road, Northgate Crossing Boulevard, Riley Fuzzel Road, and FM 1314. Riley Fuzzel Road provides access in a northeasterly direction from Spring Stuebner Road to the community of New Caney (on the west side of US 59). Riley Fuzzel Road is a two-lane, undivided paved road from the intersection of Spring Stuebner Road to a point just east of the Fox Run subdivision. From the point east of the Fox Run subdivision to the intersection with FM 1485 in New Caney, Riley Fuzzel Road is a dirt road. FM 1314 accommodates north-west/south-east travel through the eastern portion of the project area and provides connection to numerous major collector roads located in residential subdivisions.

The Union Pacific Railroad (UPRR) provides freight rail service for the greater Houston area. Within the Segment G project area, this railroad runs in a north-south direction within Reach 8. There are no public or private airport or landing strip facilities within the Segment G project area.

3.1.3 Land Use Planning

The western and far eastern portions (almost all of Reach 8, a very small portion of Reach 11, and almost all of Reach 12) of the Segment G project area are located within the city of Houston's Extra-Territorial Jurisdiction (ETJ). Only a small portion of the project area located near IH 45 (in and around the community of Spring) is located within Harris County, and the remainder of the project area is located in Montgomery County. The community of Spring is not an incorporated city and therefore does not exert land use control within the project area. No other incorporated cities have jurisdiction over any portion of the Segment G project area. Land development in areas of Harris County and the city of Houston's ETJ is regulated jointly by the city of Houston and Harris County, whereas both have adopted subdivision ordinances and review new subdivisions under a consolidated review process. Within areas that are located in Houston's ETJ and in Montgomery County, the city of Houston and Montgomery County subdivision ordinances apply, but new subdivisions are reviewed in separate review processes. There is no zoning ordinance in effect within the Segment G project area. No long-term or comprehensive plans have been adopted by the city of Houston, Harris County, or Montgomery County that would affect land use within the project area (Lambright, 2001). A general discussion of land development patterns for Segments E, F-1, F-2, and G is provided in Volume I, Section 3.1.1 (Historical Development Patterns).

The H-GAC, which is responsible for intergovernmental coordination and regional planning within the 13-County Gulf Coast Planning Region of Texas (including both Harris and Montgomery Counties), has adopted the "Goals For Tomorrow – A Comprehensive Planning Framework for the Houston-Galveston Area Council." This document is intended to be used as "an important tool to help H-GAC guide and integrate its existing planning programs" and also to "identify potential new programs, which would benefit the region and local governments." The H-GAC also intends this document to provide "a sound set of planning principles and best management practices that can be used by local governments throughout the region" (H-GAC, 1998). Contained within this plan are numerous "Goals for the Region," which are intended to be used in

making land use decisions and these are summarized in the following sections. This list of goals is not comprehensive, but is a summary of the most relevant goals from the plan (H-GAC, 1998).

3.1.3.1 General Goals for the Region:

- Coordinate development and infrastructure, so development does not overwhelm transportation and other systems;
- Include considerations for pedestrian/bicycle access and transit service, when appropriate, in developers' designs;
- Coordinate land use and transportation development;
- Conserve open space as a major component of local comprehensive plan and development policies;
- Employ collaborative public/private approaches to strategically acquire and set aside open land for public recreation, flood control, and habitat conservation programs; and
- Plan multi-jurisdictional planning for emergency preparedness and response.

3.1.3.2 Infrastructure/Transportation Goals for the Region:

- A multimodal transportation system;
- Coordinated land use and transportation development;
- Seamless connections;
- Efficient movement of people and goods;
- An environmentally responsible system;
- Active citizen involvement; and
- A cost effective and affordable transportation system.

3.1.4 Transportation Planning

A review of H-GAC's 2025 RTP, the 2006-2008 TIP, and the FY 2008-2011 TIP revealed roadway improvement projects within the Segment G project area that are either currently under construction or planned for future construction. Planned improvements include the widening of US 59 North to eight main lanes and two three-lane frontage roads from 1.0 mile north of Community Drive to 0.56 miles north of FM 1314 (H-GAC, 2005b), and south from 0.56 miles north of FM 1314 to 0.40 miles north of Northpark Drive as listed in the FY 2008-2011 TIP (H-GAC, 2007a).

3.1.5 Joint Development

Within the Segment G project area, there are no known joint development measures that would impact social, economic, environmental, or visual values within the area. It is likely that joint development measures have been a low priority because of the sparsely urbanized nature of the Segment G project area.

3.2 GEOLOGY, SOILS, AND FARMLAND

3.2.1 Geology

3.2.1.1 Physiography

The Segment G project area is located in the Gulf Coastal Plain physiographic province of Texas as described in Volume I, Section 3.2.1 (Geology). The project area is characterized as a smooth, nearly featureless depositional plain. The land surface within the Segment G project area is characterized as nearly level to gently sloping with natural drainage features and several manmade drainage features. The natural features include Spring Creek, Woodsons Gully, White Oak Creek, and West Fork San Jacinto River. These streams flow through shallow, incised valleys, which provide the most notable relief in topography. The natural ground surface of the project area slopes coastward and ranges in elevation from about 128 feet above mean sea level (MSL) near the western extent of the segment to about 100 feet above MSL near the eastern extent.

3.2.1.2 Stratigraphy and Structure

The geologic units recognized within the Segment G project area include the Lissie Formation and the overlying Beaumont Formation, Deweyville Formation, and Alluvium. Generally, each of these units is composed of sedimentary deposits of clay, silt, and sand with minor amounts of siliceous gravel.

Faulting is common in the Gulf Coast Province. Most faults are strike faults that appear to be related to gradual subsidence and tilting of the underlying strata and the resulting adjustment of the overlying sediment. According to the Geologic Atlas of Texas, Beaumont Sheet (Bureau of Economic Geology, 1977), there are no documented faults reported to cross the Preferred Alternative Corridor of Segment G.

3.2.1.3 Subsidence

Land-surface subsidence is another natural geologic process that is a function of the depositional environment of the Texas Coastal Plain. The natural rate of subsidence has been greatly accelerated because of the increased utilization of groundwater resources. Excessive groundwater withdrawal is the primary cause of land-surface subsidence. Land subsidence already experienced is irreversible according to studies performed by the Harris-Galveston and Fort Bend County subsidence districts; the land-surface in the project area has subsided approximately one to two feet between 1906 and 1995 (Exhibit G–19). The rate of subsidence of the Segment G project area from 1987-1995 is estimated to be slightly more than 0.25 feet.

3.2.2 Soils

Examination of the soil survey of Montgomery and Harris Counties, Texas (U.S. Department of Agriculture [USDA], 1972 and 1976) indicates that two general soil associations are mapped within the Segment G project area located in Harris County: the Wockley-Gessner and Segno-Hockley. These soils are formed from the parent material on the outcrops of

the Lissie and Willis Formations. Four general soil associations are mapped within Montgomery County: the Splendora-Boy-Segno, Sorter, Albany-Tuckerman, and Tuscumbia. These soils are formed from the Beaumont Formation, the Deweyville, or the Alluvium. Each of the three soil associations within the Segment G project area includes prime farmland soils and is described in the following section.

3.2.3 Farmland

Although only a small portion of the Segment G project area is farmed (15 acres), a substantial portion of the project area contains soils protected 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).

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 to 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 erodible by wind or water. Prime soils are not saturated for long periods, nor are they subject to frequent flooding during the growing season. Generally, prime farmland soils contain slopes 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.

Unique farmland is further defined as that whose value is derived from its particular advantages for growing specialty crops; however, at the current time, the state of Texas does not recognize unique farmland soils. Statewide and locally important farmlands are defined by the appropriate state or local agency as soils, other than those already designated as being prime or unique farmlands, that are important for the production of food, feed, fiber, and forage or oilseed crops. At the present time, there is no officially published list of local or statewide important farmlands, although they are identified by the state during the rating process. An effort is underway by the NRCS in Texas to publish such a list in the near future. 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.

Each of the four soil associations within the Segment G project area includes prime, statewide, and locally important farmland soils, which are shown in Exhibit G–44. All comprise nearly level, loamy prairie soils derived from twelve

different soil series. The following is a description of each of these series that underlie the project area, all of which are mapped soil units of Montgomery County.

3.2.3.1 Splendora-Boy-Segno Association

Splendora Fine Sandy Loam (Sp)

Splendora fine sandy loam is a nearly level, somewhat poorly drained loamy soil found on slopes of less than 1 percent. The surface layer is a dark grayish-brown fine sandy loam to about four inches, below which are several lower layers of sandy loam with varying colors of mottled yellowish-brown to light brownish-gray to strong brown sandy clay loam, respectively. Generally, Splendora soils have a moderate available water capacity and are mainly associated with pine timber; however, in cleared areas, crops of vegetables or improved pasture grasses are now grown.

Segno Fine Sandy Loam (Se)

Segno fine sandy loam is a nearly level to gently sloping loamy soil and moderately well drained. It contains mottled lower layers with plinthite. Segno soils typically include a surface layer five inches thick consisting of dark grayish-brown fine sandy loam, followed by a subsurface layer of pale-brown fine sandy loam down to nine inches. Lower layers contain yellowish-brown sandy clay loam to yellowish-brown sandy clay loam with reddish-yellow mottles. Segno fine sandy loam is frequently found occupying broad, low, convex ridges with slopes of between 0.5 to 2 percent. It is mainly used for pine timber and where cleared, row crops or improved pasture grasses dominate the landscape.

Sorter Silt Loam (So)

Sorter silt loam is found on nearly level and poorly drained soils with high silt content wherein soil particles are saturated with water periodically each year. The surface layer is a gray silt loam to approximately three inches, followed by a light brownish-gray silty loam subsurface layer. Below this layer is a brownish-gray silty loam followed by colors of light gray to yellow with brownish-yellow mottles at lower levels, respectively. Sorter silt loam is used chiefly to grow pine and hardwood timber and in some areas it is cleared for pasture.

Albany Fine Sand (Ab)

Albany fine sand is found on nearly level to gently sloping and poorly drained soils with deep sands reaching to depths of 40 to 60 inches. It is often found along stream terraces or convex ridges. The surface layer of Albany fine sand is typically dark grayish-brown fine sand to approximately six inches. The layer below this is brown fine sand to about 41 inches with some light-gray mottles. Following this layer and down to a depth of more than 72 inches is a light yellowish-brown fine sandy loam. Albany soils have a low water capacity and are mainly used for pine timber and cleared pasture.

Fuquay Loamy Fine Sand (Fs)

Fuquay loamy sand is found on nearly level to gently sloping well-drained soils down to depths of 20 to 38 inches. The surface layer consists of brown, loamy sand to four inches, followed by pale-brown loamy sand down to approximately 19 inches, followed by several layers of yellowish-brown sandy loam with mottles of yellow and red to about 67 inches. Fuquay loamy fine sands have typically been used for pine timber although many areas have been cleared for vegetable crops and pasture grasses.

Leefield Loamy Fine Sand (Le)

Leefield loamy fine sand is found on nearly level and poorly drained soils to a depth of between 20 and 40 inches. On the surface, Leefield loamy fine sand is gray in color down to about six inches where it is then underlain by a subsurface of very pale brown loamy fine sand to approximately 28 inches. There are two more layers below this one: the first is a yellowish-brown fine sandy loam mottled with strong brown, gray, and red colors; and the layer below is a mottled light gray with strong brown to red colors within a sandy clay loam texture. This soil is mainly utilized for pine timber, crops, and pasture.

Tuckerman Loam, Heavy Substratum (Tk)

Tuckerman loam, heavy substratum, consists of level and deep loamy soils along stream terraces that are poorly drained. The surface layer is a grayish-brown loam down to approximately 8 inches followed by a light brownish-gray loam down to 7 inches. Lower layers contain 22 inches of light brownish-gray loam followed by approximately 27 inches of light-gray clay that has a yellowish-red component, after which is 14 inches of light-gray clay with yellowish-brown mottles. This soil is used for growing native hardwood timber.

Waller Loam (Wa)

Waller loam consists of level poorly drained loamy soils with mottled lower layers. The surface contains grayish-brown loam to about four inches, followed by a subsurface layer of light-gray loam for another 30 inches. The lower layer is gray clay loam about 46 inches thick with strong-brown mottles. Waller loam is used mainly for hardwood and pine timber with some areas cleared for pasture.

3.2.3.2 Sorter Association

Splendora Fine Sandy Loam (Sp)

Splendora fine sandy loam is a nearly level, somewhat poorly drained loamy soil found on slopes of less than 1 percent. The surface layer is a dark grayish-brown fine sandy loam to about four inches, below which are several lower layers of sandy loam with varying colors of mottled yellowish-brown to light brownish-gray to strong brown sandy clay loam, respectively. Generally, Splendora soils have a moderate available water capacity and are mainly associated with pine timber; however, in cleared areas, crops of vegetables or improved pasture grasses are now grown.

Fuquay Loamy Fine Sand (Fs)

Fuquay loamy sand is found on nearly level to gently sloping well-drained soils down to depths of 20 to 38 inches. The surface layer consists of brown, loamy sand to four inches, followed by pale-brown loamy sand down to approximately 19 inches, followed by several layers of yellowish-brown sandy loam with mottles of yellow and red to about 67 inches. Fuquay loamy fine sands have typically been used for pine timber, although many areas have been cleared for vegetable crops and pasture grasses.

Leefield Loamy Fine Sand (Le)

Leefield loamy fine sand is found on nearly level and poorly drained soils to a depth of between 20 and 40 inches. On the surface, Leefield loamy fine sand is gray in color down to about six inches where it is then underlain by a subsurface of very pale brown loamy fine sand to approximately 28 inches. Below this layer are two more layers: the first is a yellowish-brown fine sandy loam mottled with strong brown, gray, and red colors; and the layer below, which is colored by a mottled light gray with strong brown to red colors within a sandy clay loam texture. This soil is mainly utilized for pine timber, crops, and pasture.

Waller Loam (Wa)

Waller loam consists of level poorly drained loamy soils with mottled lower layers. The surface contains grayish-brown loam to about four inches, followed by a subsurface layer of light-gray loam for another 30 inches. The lower layer is gray clay loam about 46 inches thick with strong-brown mottles. Waller loam is used mainly for hardwood and pine timber with some areas cleared for pasture.

Segno Fine Sandy Loam (Se)

Segno fine sandy loam is a nearly level to gently sloping loamy soil and moderately well drained. It contains mottled lower layers with plinthite. Segno soils typically include a surface layer five inches thick consisting of dark grayish-brown fine sandy loam, followed by a subsurface layer of pale-brown fine sandy loam down to nine inches. Lower layers contain yellowish-brown sandy clay loam to yellowish-brown sandy clay loam with reddish-yellow mottles. Segno fine sandy loam is frequently found occupying broad, low, convex ridges with slopes of between 0.5 to 2 percent. It is mainly used for pine timber and where cleared, row crops or improved pasture grasses dominate the landscape.

Fuquay Loamy Fine Sand, Terrace (Ft)

Fuquay loamy fine sand, terrace, consists of nearly level to gently sloping and deep well-drained soils occupying low stream terraces with slopes of less than 1 percent. The surface layer is pale-brown loamy sand to a depth of 25 inches followed by a subsurface of layer of brownish-yellow sandy clay loam. Lower layers are sandy clay loams in texture mottled in shades of gray, red, yellow, and brown and containing 10 to 20 percent plinthite. This soil is primarily used for pine timber, and in a few areas, crops and pasture grasses are grown.

3.2.3.3 Albany Tuckerman Association

Albany Fine Sand (Ab)

Albany fine sand is found on nearly level to gently sloping and poorly drained soils with deep sands reaching to depths of 40 to 60 inches. It is often found along stream terraces or convex ridges. The surface layer of Albany fine sand is typically dark grayish-brown fine sand to approximately six inches. The layer below this is brown fine sand to about 41 inches with some light-gray mottles. Following this layer and down to a depth of more than 72 inches is a light yellowish-brown fine sandy loam. Albany soils have a low water capacity and are mainly used for pine timber and cleared pasture.

Tuckerman Loam, Heavy Substratum (Tk)

Tuckerman loam, heavy substratum, consists of level and deep loamy soils along stream terraces that are poorly drained. The surface layer is a grayish-brown loam down to approximately 8 inches followed by a light brownish-gray loam down to 7 inches. Lower layers contain 22 inches of light brownish-gray loam followed by approximately 27 inches of light-gray clay that has a yellowish-red component, after which is 14 inches of light-gray clay with yellowish-brown mottles. This soil is used for growing native hardwood timber.

Sorter Silt Loam (So)

Sorter silt loam is found on nearly level and poorly drained soils with high silt content wherein soil particles are saturated with water periodically each year. The surface layer is a gray silt loam to approximately three inches, followed by a light brownish-gray silty loam subsurface layer. Below this layer is a brownish-gray silty loam followed by colors of light gray to yellow with brownish-yellow mottles at lower levels, respectively. Sorter silt loam is used chiefly to grow pine and hardwood timber and in some areas it is cleared for pasture.

Chipley Fine Sand (Chi)

Chipley fine sand is found on gently sloping stream terraces and isolated stream bottoms within floodplains and where slopes can range from 0 to 8 percent. The surface layer of this soil is grayish-brown fine sand down to approximately five inches, followed by 10 inches of pale brown fine sand, 44 inches of very pale brown fine sand, to 21 inches of light brownish-gray fine sand in the lower layers, respectively. Chipley fine sand is utilized primarily for pine timber, and where cleared areas exist, pastures are managed for improved grasses.

Crowley Fine Sandy Loam (Cw)

Crowley fine sandy loam consists of nearly level somewhat poorly drained, loamy soils along ancient stream terraces. The surface layer is grayish-brown fine sandy loam down to approximately five inches, followed by a 10-inch thick subsurface layer that is light brownish-gray fine sandy loam. Sequentially, the next layers include 17 inches of light brownish-gray clay with yellowish-red mottles, followed by 11 inches of light brownish-gray clay that contains olive-brown

mottles, 12 inches of light-gray clay with yellowish-brown mottles, and 12 inches of light-gray sandy clay, which composes the lowest layer.

Leefield Loamy Fine Sand (Le)

Leefield loamy fine sand is found on nearly level and poorly drained soils to a depth of between 20 and 40 inches. On the surface, Leefield loamy fine sand is gray in color down to about six inches where it is then underlain by a subsurface of very pale brown loamy fine sand to approximately 28 inches. Below are two more layers: the first a yellowish-brown fine sandy loam mottled with strong brown, gray, and red colors; and the layer below is a mottled light gray with strong brown to red colors within a sandy clay loam texture. This soil is mainly utilized for pine timber, crops, and pasture.

Garner Clay (Ga)

Garner clay is found on nearly level to gently sloping poorly drained clay soils of stream terraces with slopes of 0.5 to 1.5 percent, but can range up to 3 percent in some areas. The surface layer is a dark-gray clay to a depth of five inches, followed by 60 inches of gray clay in the lower layers containing brownish-yellow mottles in the lowest portions. This soil is used for growing crops, pasture grasses, and native timber.

3.2.3.4 Tuscumbia Association

Susquehanna Fine Sandy Loam, 1 to 5 Percent Slope (SuC)

Susquehanna fine sandy loam, 1 to 5 percent slope, occupies gently sloping to rolling terrain on poorly drained inter-stream divides. The surface layer is a dark grayish-brown fine sandy loam approximately four inches thick, followed by a subsurface layer that is pale brown within a 5-inch layer. The lower layers include 8 inches of mottled red, light-gray, and brownish-yellow clay followed by nine inches of mottled light-gray, red, and brownish-yellow clay. This layer is followed by 12 inches of light-gray clay with red mottles and by 10 inches of light-gray sandy clay with red mottles. Below this layer is 36 inches of mottled light gray and red stratified clay loam followed by 16 inches of mottled light-gray and red fine sandy loam and loamy fine sand. This soil is mainly used for timber and cropland.

3.3 SOCIAL CHARACTERISTICS

3.3.1 Population Characteristics

General population characteristics for the Segment E, F-1, F-2, and G study area are provided in Volume I, Section 3.3.1 (Population). Only the Census tracts that overlap either partially or fully within the Segment G project area are discussed in this section. Exhibit G–45 shows the location of the Segment G project area in relation to the 2000 Census tracts.

The population and ethnicity characteristics (U.S. Census Bureau, 2000) for the Segment G project area Census tracts are presented in Table 3-1. The data provide a social and economic representation of area population. The proportion of white persons living within the project area Census tracts (80.8 percent) is substantially greater than that of Harris County

(42.0 percent) and the state of Texas (52.4 percent) but slightly less than that of Montgomery County (81.2 percent). The proportion of Hispanics/Latinos living within the project area (13.1 percent) is substantially less than that of both Harris County (33.0 percent) and the state of Texas (32.0 percent) but slightly greater than that of Montgomery County (12.6 percent). The proportion of African-Americans living within the project area Census tracts (3.3 percent) is substantially less than that of Harris County (18.2 percent) and the state of Texas (11.3 percent) and only slightly less than that of Montgomery County (3.4 percent). The percentage of American Indians and the Alaskan Native population living within the project area Census tracts (0.7 percent) is slightly greater than that of Harris County (0.2 percent), Montgomery County (0.5 percent), or the state of Texas (0.3 percent). The percentage of Asians living within the project area Census tracts (0.8 percent) is less than that of Harris County (5.0 percent), Montgomery County (1.0 percent), or the state of Texas (2.6 percent), while the percentage of the "Other Race" population living within the project area Census tracts (1.2 percent) is lower than in Harris County (1.5 percent) and the state of Texas (1.3 percent) but similar to Montgomery County (1.2 percent).

For purposes of this analysis, "Other Race" is the total number of "Some Other Race Alone" and "Two or More Races," as defined by the U.S. Census Bureau (2000). "Some Other Race Alone" is defined as a single race alone that is not identified on the long or short Census forms (e.g., Indian). "Two or More Races" is a combination of two or more races (e.g., a combination of Asian and White).

Table 3-2 shows the 2000 income characteristics by Census tracts in the Segment G project area. According to the most recent available data, median household incomes of the project area Census tracts range from $35,313 to $65,833 (U.S. Census Bureau, 2000). The 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 guideline. The poverty guideline for a family of four in 1999 was $17,030. This level is based on the 1999 US Census Bureau poverty threshold (rounded to the nearest $10), which is the best available indicator of populations meeting the HHS poverty guideline referenced in the USDOT definition of environmental justice populations (HHS, 2008a). None of the Census tracts within the project area have a median household income less than the current HHS threshold or 1999 poverty threshold. In addition, none of the Census tracts within the project area have a median household income less than the current HHS poverty threshold, which is $21,200 (HHS, 2008b).

The percentage of poverty status persons living within the Segment G project area Census tracts (8.4 percent) is below that of Harris County (14.8 percent), the state of Texas (15.0 percent), and Montgomery County (9.3 percent).

TABLE 3-1
POPULATION AND ETHNICITY CHARACTERISTICS FOR THE SEGMENT G PROJECT AREA – 2000 CENSUS

Census Tract	Population	% White	% African American	% American Indian & Alaska Native	% Hispanic or Latino	% Asian	% Native Hawaiian & Other Pacific Islander	% Other Race*
6920	7,128	82.6%	5.4%	0.0%	10.4%	1.0%	0.0%	0.5%
6923	7,556	74.6%	2.2%	<0.1%	20.2%	2.1%	0.0%	0.8%
6925	6,894	83.5%	2.9%	0.6%	11.1%	0.4%	0.1%	1.4%
6926	10,804	81.1%	0.7%	1.3%	14.4%	0.0%	0.0%	2.6%
2413	3,396	78.5%	11.5%	0.8%	8.1%	1.0%	0.0%	0.0%
2414	5,248	85.0%	2.2%	1.7%	9.8%	0.6%	0.0%	0.7%
Total	**41,026**	**80.8%**	**3.3%**	**0.7%**	**13.1%**	**0.8%**	**<0.1%**	**1.2%**
Harris County	3,400,578	42.0%	18.2%	0.2%	33.0%	5.0%	<0.1%	1.5%
Montgomery County	293,768	81.2%	3.4%	0.5%	12.6%	1.0%	0.1%	1.2%
Texas	20,851,820	52.4%	11.3%	0.3%	32.0%	2.6%	<0.1%	1.3%

Note: *"Other Race" combines two U.S. Census Bureau data categories: "Two or More Races" and "Some Other Race Alone."

Source: U.S. Census Bureau, 2000; Tables P1 and P7

TABLE 3-2
POPULATION / INCOME CHARACTERISTICS FOR THE SEGMENT G PROJECT AREA – 2000 CENSUS

Census Tract	Population	Median Household Income	Number Below Poverty*	Percent Below Poverty
6920	7,128	$59,877	327	4.6%
6923	7,556	$42,358	590	7.8%
6925	6,894	$35,313	916	13.3%
6926	10,804	$39,184	1,434	13.3%
2413	3,396	$58,148	72	2.1%
2414	5,248	$65,833	120	2.3%
Total/Weighted Average	**41,026**	**$47,692**	**3,459**	**8.4%**
Harris County	3,400,578	$42,598	503,234	14.8%
Montgomery County	293,768	$50,864	27,376	9.3%
State of Texas	20,851,820	$39,927	3,117,609	15.0%

*Note: Population for whom poverty status is determined.
Source: U.S. Census Bureau, 2000; Tables P1, P53, and P87

3.3.2 Social/Community Resources

Sensitive social and community facilities (e.g., schools, churches, and cemeteries) and 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. Exhibit G–46 shows the locations of community resources in the Segment G project area.

3.3.2.1 Schools

The Segment G project area includes portions of three school districts, the Spring Independent School District (ISD), the New Caney ISD, and the Conroe ISD. The Spring ISD serves approximately 57 square miles, including the community of Spring and other areas of unincorporated Harris County east and west of IH 45. This ISD has two high schools, five middle schools, and 17 elementary schools, serving approximately 28,000 students. Spring ISD has a few existing schools that are in the study area, but are far from the project area. The Northgate Crossing subdivision is the only residential area that Spring ISD serves that is located in the project area. The Spring ISD owns a 42-acre tract for a planned elementary school and a middle school. This site is located immediately southwest of the intersection of Northgate Crossing and the Hardy Toll Road. The elementary school is to be completed by fall of 2008, and the middle school is planned for completion in either 2011 or 2012.

The New Caney ISD serves approximately 90 square miles of eastern Montgomery County, including the far eastern portion of the Segment G study area, including the communities of Porter and New Caney. This ISD includes five elementary schools, two middle schools, one high school, and an alternative education center and serves approximately 7,000 students. New Caney ISD schools that are in the project area include the Robert L. Crippen Elementary School and New Caney High School. Robert L. Crippen Elementary is located in the Cumberland subdivision and is southwest of FM 1314 in the western-most portion of Reach 11. Access to this school is via FM 1314 and from within the Cumberland subdivision which the school serves. The New Caney High School is located east of US 59 and west of FM 494 in Reach 12 of the project area. Access to this school is via FM 494 and Legion Road.

The Conroe ISD serves approximately 348 square miles of Montgomery County, including the community of Conroe and the Woodlands. This ISD includes 24 elementary schools, eight intermediate schools, six junior high schools, six high schools, and two academy high schools and one alternative high school. A few of the Conroe ISD schools are located within the Segment G study area; however, none of them are close to the project area, and none of them serve students in subdivisions that are located within the project area.

3.3.2.2 Churches and Cemeteries

There are two churches, two cemeteries, and one funeral home located within the Segment G project area (Exhibit G–46):

- The True-Holiness Church of God in Christ is located on Nelson Street, in the Southwell neighborhood, and near the W. M. Southwell Park.
- The Grand Parkway Church is located on the east side of FM 1314, adjacent to the Wood Hollow subdivision.
- The Rosewood Funeral Home and Cemetery are located on the east side of US 59, south of Community Road.
- The Spring Peaceful Rest Cemetery is located on the east side of East Hardy Road, just south of the Hardy Toll Road.

3.3.2.3 Parks and Recreation

A search of the TPWD, Texas Outdoor Recreation Inventory (TORI) database, field reconnaissance, and internet research, revealed the locations of parks and recreation areas within the Segment G project area as follows: W. M. Southwell Park is owned and maintained by Harris County and is the only public park within the project area (the northern portion of the park is within the project area). This park is located within Reach 8 of the project area at the intersection of Nelson Street and Liddell Street. This 5-acre park consists of lighted basketball courts, a playground, a barbeque pavilion, picnic tables, a community center, volleyball courts, and a parking lot. Access to this park is via Nelson Street.

Other parks that are located in the project area are privately owned and include the YMCA Camp Pine Tree, the Northwood Pines Community Park, and the Park at Northgate. The YMCA Camp Pine Tree facility is located east of the Hardy Toll Road and west of Spring Creek within Reach 8. This 47.9-acre facility is accessed via Riley Fuzzel Road and includes cabins and other facilities to support horseback riding, canoeing, swimming, archery, fishing, and other outdoor activities. The Northwood Pines Community Park and the Park at Northgate are located within the Northwood Pines subdivision and are used primarily by Northwood Pines residents. Other small neighborhood parks that are located within subdivisions were not considered in this park inventory.

3.3.2.4 Fire Departments

The Segment G project area is served by three fire departments: the Spring Volunteer Fire Department (VFD), the Porter VFD, and the New Caney VFD. The Spring VFD has a total of five fire stations, and four proposed new fire stations covering approximately 94 square miles within the community of Spring and other unincorporated areas of Harris and Montgomery Counties (Spring VFD, 2001). The Porter VFD has three fire stations located in the community of Porter and surrounding areas (unincorporated Montgomery County) and covers approximately 92 square miles. This VFD responds to emergencies for all residences with a Porter or New Caney address and will assist other VFDs outside their primary response area when requested. The New Caney VFD covers approximately 52 square miles in unincorporated areas of Montgomery County, including the community of New Caney and the Wood Branch and Roman Forest subdivisions. This VFD has three fire stations, with a fourth station planned within five years. The New Caney VFD primary response area only includes a small portion of the Segment G project area in the southern-most portion of the Silver Trails subdivision. This VFD periodically will assist with emergencies within the community of Porter, including the project area, as requested.

3.3.3 Public Lands

As shown in Exhibit G–46 and described in this section, there is a limited amount of public land within the Segment G project area. The Crippen Elementary School, the New Caney High School, and W. M. Southwell Park are the only public properties within the project area. These properties are described in more detail in Section 3.3.2.1 (Schools), and Section 3.3.2.3 (Parks and Recreation). The school properties are public entities, but access to these properties is restricted.

3.4 ECONOMICS

3.4.1 Economic Conditions

General economic characteristics were examined for the CMSA, Harris County, and Montgomery County, for a region-wide portrayal of the Segment G project area's economic environment (Volume I, Section 3.4 [Economics]). Within this section, U.S. Census Bureau data are provided for Census tracts that lie either partially or fully within the project area. Exhibit G–45 shows the location of the Segment G project area in relation to the 2000 Census tracts.

3.4.1.1 Economic Characteristics of Area Population

Work Location

Within the CMSA and in Harris County, 81.6 percent and 93.5 percent of the workforce are employed in the same county as their residence (Table 3-3). Montgomery County has a much smaller percentage of the workforce employed in the same county where they live, with 51.3 percent. Similarly, in the Segment G project area Census tracts, only 49.6 percent of the workforce is employed in the same county as residence.

TABLE 3-3
ECONOMIC CHARACTERISTICS OF REGIONAL POPULATION – 2000 CENSUS

Work Location/ Other Parameter	CMSA		Harris County		Montgomery County		Segment G Project Area Census Tracts	
	#	%	#	%[1]	#	%[1]	#	%[1]
Same County as Residence	1,698,933	81.6	1,417,166	93.5	68,788	51.3	9,342	49.6
Different County	368,206	17.7	88,815	5.9	63,910	47.7	9,379	49.8
Work at Home	51,644	2.5	36,195	2.4	4,369	3.3	564	3.0
Mean Travel Time to Work (minutes)	28.8	N/A	28.1	N/A	32.9	N/A	31.2[2]	N/A
Median Household Income	$44,761	N/A	$42,598	N/A	$50,864	N/A	$47,692[3]	N/A
Poverty Status	628,385	13.5	503,234	14.8	27,376	9.3	3,459	8.4

Notes: [1] Percentages of work location total to more than 100 because many individuals work more than one job.
[2] Average of mean travel time to work from Census tracts overlapping the project area (2413 and 2414 of Harris County and 6920, 6923, 6924, and 6925 of Montgomery County).
[3] Weighted average of median household income from Census tracts overlapping the project area.
Source: U.S. Census Bureau, 2000; Tables P26, P31, P53, P87, and QT-P23 and Study Team, 2007

Mean Travel Time to Work

The Harris County workforce has the shortest mean travel time to work (28.1 minutes) among the groups examined in Table 3-3, which most likely reflects the large number of workers that have relatively short travel times to work within the more urban setting of the county. Within the Segment G project area, the average mean travel time to work is 31.2 minutes, which is longer than that of the CMSA (28.8 minutes) and Harris County (32.9) but shorter than that of Montgomery County (32.9 minutes).

Median Household Income

According to the 2000 Census, median household income for the CMSA was $44,761. This figure is slightly higher than that of Harris County, which was $42,598 and less than that of Montgomery County, which was $50,864 in 1999 (Table 3-3). The average median household income of the Census tracts within the Segment G project area is $47,692, which is higher than that of the CMSA and Harris County, but less than Montgomery County.

Poverty Status

The CMSA and Harris County both exhibited relatively high proportions of poverty-level residents according to the 2000 Census, at 13.5 percent and 14.8 percent, respectively (Table 3-3). These percentages are not consistent with the relatively high median household income figures and suggest wide income disparities within the Houston metropolitan area. Montgomery County recorded a lower percentage of poverty level residents at 9.3 percent. The Segment G project area had a slightly lower proportion (8.4 percent) of the population living below the poverty level than the CMSA, Harris County, or Montgomery County.

Occupation and Class of Worker

Occupation and class of worker data are shown in Table 3-4 for the CMSA, Harris County, and Montgomery County. In the CMSA, the greatest number of workers is employed as managerial and professional workers (35.2 percent) and as sales and office workers (27.3 percent). These occupational categories are followed by service workers (13.6 percent); production, transportation, and materials moving workers (12.5 percent); construction, extraction, and maintenance workers (11.1 percent); and farming, fishing, and forestry workers (0.2 percent). Similarly, Harris County is led by managerial and professional workers (34.8 percent) and sales and office workers (27.7 percent). These occupational categories are followed by service workers (13.8 percent); production, transportation, and materials moving workers (12.6 percent); construction, extraction, and maintenance workers (10.9 percent); and farming, fishing, and forestry workers (0.1 percent). In Montgomery County, the greatest number of workers is employed as managerial and professional workers (33.9 percent) and as sales and office workers (28.1 percent). These occupational categories are followed by service workers (12.7 percent); construction, extraction, and maintenance workers (12.5 percent); production, transportation, and materials moving workers (12.4 percent); and farming, fishing, and forestry workers (0.3 percent).

With regard to class of worker, the greatest percentage of workers in both the CMSA and Harris County work for private, for profit employers (76.1 and 77.3 percent, respectively), which is followed by self-employed workers (6.2 percent and 6.0 percent, respectively), local government workers (6.2 percent and 5.8 percent, respectively), private, not-for-profit workers (5.2 and 5.3 percent, respectively), state government workers (4.2 and 3.6 percent, respectively), federal government workers (1.8 percent in both cases), and unpaid family workers (0.3 and 0.5 percent, respectively). Similarly, in Montgomery County, private for profit workers make up a large majority of workers (76.5 percent). Other worker categories represent a much smaller percentage of the workforce. Self-employed workers are the next most abundant (7.4 percent), followed by local government workers (6.4 percent), and private not-for-profit workers (4.4 percent).

TABLE 3-4
OCCUPATION AND CLASS OF WORKER – 2000 CENSUS

Characteristic	CMSA		Harris County		Montgomery County	
	#	%	#	%	#	%
Occupation						
Managerial and Professional	746,560	35.2	538,143	34.8	46,376	33.9
Sales and Office	580,083	27.3	428,185	27.7	38,367	28.1
Service	289,480	13.6	214,052	13.8	17,388	12.7
Farming, Forestry, Fishing	4,462	0.2	1,959	0.1	426	0.3
Construction, Extraction, and Maintenance	235,483	11.1	168,840	10.9	17,092	12.5
Production, Transportation, and Materials Moving	265,547	12.5	194,754	12.6	16,969	12.4
Class of Workers						
Private, for Profit	1,615,519	76.1	1,194,859	77.3	104,581	76.5
Private, Not-for-Profit	111,068	5.2	81,333	5.3	5,964	4.4
Local Government	130,623	6.2	89,912	5.8	8,753	6.4
State Government	89,575	4.2	55,655	3.6	4,737	3.5
Federal Government	38,018	1.8	27,354	1.8	1,900	1.4
Self-Employed	130,937	6.2	93,025	6.0	10,173	7.4
Unpaid Family Workers	5,875	0.3	7,547	0.5	510	0.4

Source: U.S. Census Bureau, 2000

Summary

Compared to the population in the CMSA, the population in the Segment G project area Census tracts in 2000 had substantially less of a tendency to work in their county of residence, slightly longer commute times to work, slightly higher median household incomes, and a smaller portion of the population living below the poverty line. Compared to the population in Harris County, the Segment G project area population in 2000 had substantially less of a tendency to work in their county of residence, slightly longer commute times to work, higher median household incomes, and a smaller portion of the population living below the poverty line. Compared to the population in Montgomery County, the Segment G project area population in 2000 had slightly less of a tendency to work in the same county as residence, slightly shorter commute times to work, slightly lower median household incomes, and a slightly smaller portion of the population living below the poverty line.

3.4.1.2 Tax Base

Table 3-5 shows tax rate and net taxable valuation information for the major taxing jurisdictions, which collect property taxes within the Segment G project area. Several tax jurisdiction offices within the CMSA were contacted to determine which jurisdictions apply within the project area.

TABLE 3-5
TAX RATE AND NET TAXABLE VALUATION FOR MAJOR TAXING JURISDICTIONS IN THE SEGMENT G PROJECT AREA

Jurisdiction	2007 Tax Rate*	2006 Net Taxable Valuation**
Harris County	0.39239	$223,329,196,120
Montgomery County	0.4888	$184,912,366,980
Montgomery Co. Hospital District	0.0777	$123,989,336,135
Spring ISD	1.44000	$7,156,077,428
New Caney ISD	1.64000**	$1,393,851,806
Conroe ISD	1.2400	$14,718,446,372

Notes: *Expressed as dollars per $100 of taxable value. **2007 rate not available; 2006 rate shown.
Source: Harris County Appraisal District, 2008; Montgomery County Tax Office, 2008; Altinger, 2007; Burton, 2007; Moore, 2007; and Smith, 2007.

3.5 PEDESTRIANS AND BICYCLISTS

There is no existing bicycle or pedestrian facilities in the Segment G project area, although in 2003, Montgomery County Commissioners installed "Share the Road" signage along many county roads. Review of H-GAC's 2035 Regional Bikeway Plan identified several proposed bicycle facilities within the Segment G project area (H-GAC, 2007a). The plan includes "Proposed Bicycle Lanes" for the following areas: along Spring Creek (throughout its length within the project area), along Spring-Cypress Road from IH 45 to Old Town Spring (intersection of E. Hardy Road), and along Riley Fuzzel Road from East Hardy Road to Spring Creek.

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 (CO_2), particulate matter (PM) and a class of compounds called Mobile Source Air Toxics (MSAT).

3.6.1 Criteria Pollutants

The NEPA of 1969 and the Clean Air Act of 1970 (CAA), as amended, resulted in federal requirements for USDOT to consider the impact proposed highways, such as the Grand Parkway, may have on the local air quality. Under the CAA, the EPA sets national ambient air quality standards (NAAQS) for six criteria air pollutants to protect public health and the environment, with an adequate margin of safety. NAAQS exist for: CO, ozone (O_3), nitrogen dioxide (NO_2), SO_2, PM for both 10 and 2.5 microns and less (PM_{10} and $PM_{2.5}$), and lead (Pb). The air standards shown in Table 3-6 represent levels of these pollutants and exposure periods that the EPA has determined pose no substantial threat to human health or

welfare. 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. The EPA classified the Houston-Galveston area, which includes Harris County and Montgomery County, as a moderate O_3 non-attainment area (EPA, 2006a). Currently, the Houston area exceeds the national O_3 standard for about 40 days per year. The Houston area is in attainment for all other NAAQS.

TABLE 3-6
NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Pollutant	Primary Standard (Public Health)			Secondary Standard (Public Welfare)		
	Level	Averaging Time	Form	Level	Averaging Time	Form
Ozone (O_3)	0.08 ppm	8 hours	3-year average of annual 4th highest daily maximum	Same as Primary Standard		
Particulate Matter 10 microns or smaller (PM_{10})	150 μg/m³	24 hours	3-year average of annual 99th percentiles	Same as Primary Standard		
Particulate Matter 2.5 microns or smaller ($PM_{2.5}$)	35 μg/m³	24 hours	3-year average of annual averages	Same as Primary Standard		
	15 μg/m³	Annual	3-year average of 98th percentile	Same as Primary Standard		
Carbon Monoxide (CO)	35 ppm	1 hour	More than once per year	No Secondary Standard		
	9 ppm	8 hours				
Sulfur Dioxide (SO_2)	0.14 ppm	24 hours	24 hour standard	0.50 ppm	3-hour	More than once per year
	0.03 ppm	Annual	Annual arithmetic mean			
Nitrogen Dioxide (NO_2)	0.053 ppm	Annual	Not to be exceeded	Same as primary standard		
Lead (Pb)	1.5 μg/m³	Quarterly	Not to be exceeded	Same as primary standard		

Notes: All standards with averaging times of 24 hours or less are not to be exceeded more than once per year.
ppm = parts per million; μg/m3 = micro grams per cubic meter
Source: EPA, 2006b (40 CFR 50)

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 are created inside the combustion chambers of motor vehicles when, under high heat and pressure, nitrogen molecules in the air are split into reactive nitrogen atoms, which then combine with oxygen. NO_X also react with oxygen and VOCs 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. NO_X emissions per mile increase as vehicles go either slower or faster, so simply increasing or decreasing average traffic speed can increase NO_X emission.

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 ten microns (about one-seventh the width of a human hair) and for particles smaller than 2.5 microns.

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; therefore CO is a local problem where it occurs. In order to evaluate local air quality changes, a localized analysis of CO has been performed (Section 4.6 of this volume [Air Quality]) in accordance with TxDOT's *Air Quality Guidelines* (2006a) and FHWA's Technical Advisory T 6640.8A.

VOCs from motor vehicles, industry, and other sources can combine with NO_X in a series of photochemical reactions under certain conditions to form O_3. These reactions take place over a period of several hours and can result in high concentrations of O_3 that are often far downwind from the precursor sources. 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).

The EPA has determined that Harris County and the seven other counties (including Montgomery County) that comprise the Houston-Galveston Area are in attainment for all of the NAAQS pollutants except the 8-hour O_3 air quality standards. EPA regulations require that a non-attainment area demonstrate that its RTP and TIP conform to the intent of the SIP by showing that the emissions under the plan are less than the emission budget set in the SIP. Under the regulations, added capacity projects, such as the Grand Parkway, may advance to construction only if they are part of the RTP and TIP that have been determined to conform to the SIP by the MPO and USDOT.

The Grand Parkway Segment G was included in H-GAC's 2025 RTP, and was included in the 2006-2008 TIP, Appendix D, as project undergoing environmental review and scheduled for implementation beyond the three-year TIP time frame. The 2025 RTP and 2006-2008 TIP were adopted by H-GAC in April 2005 and found to conform to the SIP by USDOT (FHWA and FTA) on June 3, 2005 and October 31, 2005, respectively.

The Grand Parkway Segment G is included in H-GAC's 2035 RTP and FY 2008-2011 TIP, as amended. On August 24, 2007, H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. USDOT (FHWA and FTA) found the 2035 RTP and 2008-2011 TIP to conform to the SIP on November 9, 2007.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional analysis is warranted before 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 modeled parameters can be found in the Administrative Record.

3.6.2 Mobile Source Air Toxics (MSAT)

In addition to the criteria air pollutants for which there are NAAQS, the EPA also regulates toxic air pollutants. Most toxic air pollutants originate from man-made sources, including on-road mobile sources (e.g., cars, light trucks, motorcycles, and 18-wheelers), non-road mobile sources (e.g., airplanes), area sources (e.g., dry cleaners and gas stations), and stationary sources (e.g., electric utilities, petrochemical refining, and factories).

MSAT are a subset of the 188 toxic air pollutants defined by the CAA. MSAT are compounds emitted from highway vehicles and non-road equipment. Some toxic compounds are present in fuel and are emitted into the air when the fuel evaporates or passes through the engine unburned, for example benzene. Other toxics are emitted from the incomplete combustion of fuels or as secondary combustion products. Metal air toxics also result from engine wear or from impurities in oil or gasoline (EPA, 2000a). In a 2001 rulemaking, EPA identified six priority MSAT: acetaldehyde, acrolein, benzene, 1,3-butadiene, diesel exhaust (including diesel PM and organic gases), and formaldehyde (EPA, 2001a, 66 FR 17230).

The EPA is the lead federal agency for administering the CAA and has some responsibilities on the health effects of MSAT. In 2001, the EPA issued a final rule on controlling emissions of hazardous air pollutants from mobile sources (66 CFR 17229, March 29, 2001). This rule was issued under the authority in Section 202 of the CAA. In its rule, the EPA examines the impacts of current and newly promulgated mobile source control programs, including its reformulated gasoline program, national low-emission vehicle standards, Tier 2 motor vehicle emissions standards and gasoline sulfur control requirements, and heavy-duty engine and vehicle standards and on-highway diesel fuel sulfur control requirements. Between 2000 and 2020, despite a 64 percent increase in Vehicle Miles Traveled (VMT), the mobile source control programs will reduce on-highway emissions of benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and acrolein by 57 percent to 65 percent, and will reduce on-highway diesel PM emissions by 87 percent, as shown in Figure 3-1.

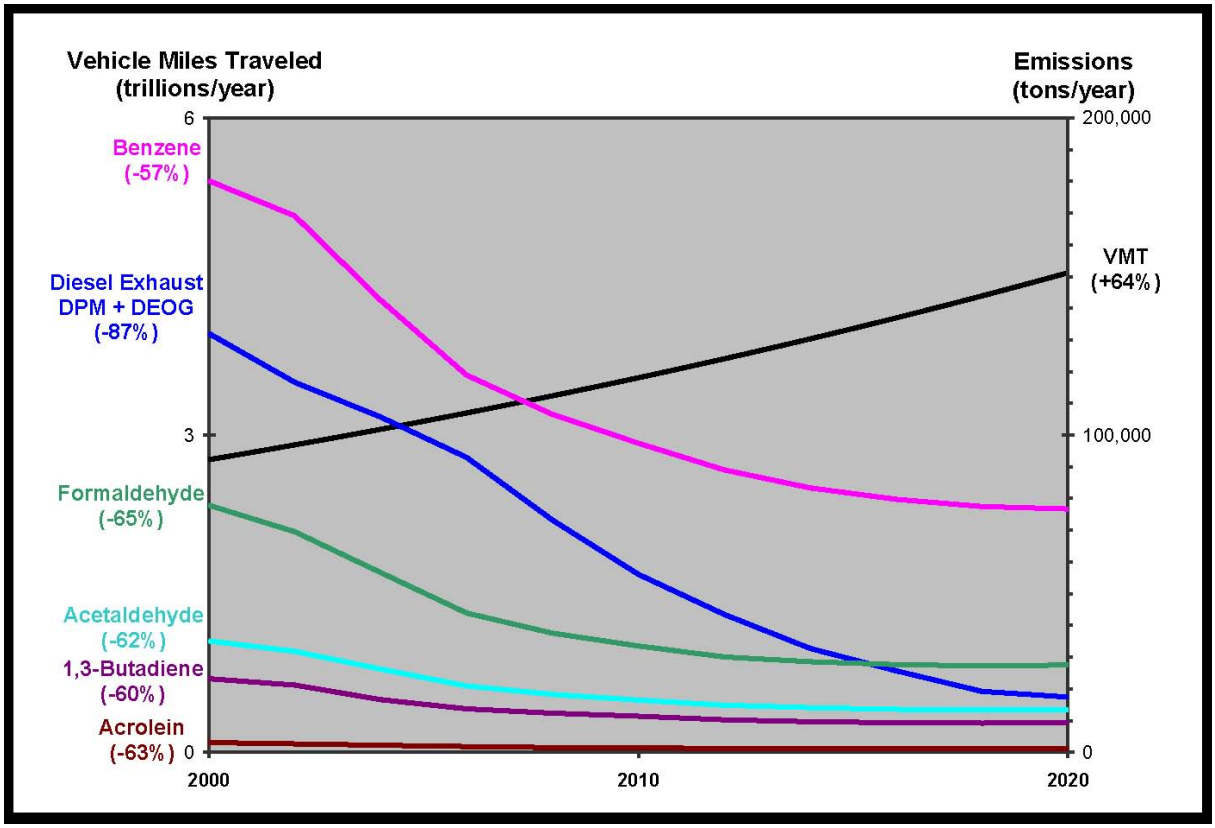
In an ongoing review of MSAT, the EPA finalized additional rules under the authority of CAA Section 202(l) to further reduce MSAT emissions to even a greater extent than is reflected in Figure 3-1. The EPA issued a set of final rules on Control of Hazardous Air Pollutants from Mobile Sources (72 FR 8427, February 26, 2007) under 40 CFR 59, 80, 85, and 86. The rule changes were effective on April 27, 2007. Because of this review, the EPA adopted the following new requirements to substantially lower emissions of benzene and other MSAT by: 1) lowering the benzene content in gasoline; 2) reducing evaporative emissions that permeate through portable fuel containers; and 3) reducing non-methane hydrocarbon (NMHC) exhaust emissions from passenger vehicles operated at cold temperatures (under 75 degrees Fahrenheit) (EPA, 2007a).

Beginning in 2011, petroleum refiners must meet an annual average gasoline benzene content standard of 0.62 percent by volume for both reformulated and conventional gasolines, nationwide, which would be a 38 percent reduction from 2007. The EPA standards to reduce NMHC exhaust emissions from new gasoline-fueled passenger vehicles will become effective in phases. Standards for light-duty vehicles and trucks (≤ 6000 pounds [lbs]) become effective during the period

of 2010 to 2013, and standards for heavy light-duty trucks (6,000 to 8,000 lbs) and medium-duty passenger vehicles (up to 10,000 lbs) become effective during the period of 2012 to 2015. Evaporative requirements for portable gas containers become effective with containers manufactured in 2009. Evaporative emissions must be limited to 0.3 grams of hydrocarbons per gallon per day (EPA, 2007a).

The EPA has also adopted more stringent evaporative emission standards (equivalent to current California standards) for new passenger vehicles. The new standards become effective in 2009 for light vehicles and in 2010 for heavy vehicles. In addition to the reductions from the 2001 rule, the new rules will substantially reduce annual national MSAT emissions. The EPA estimates that emissions in the year 2030, when compared to emissions in the base year prior to the rule, will show a reduction of 330,000 tons of MSAT (including 61,000 tons of benzene), more than one million tons of VOCs, and more than 19,000 tons of $PM_{2.5}$ (EPA, 2007a).

FIGURE 3-1
VEHICLE MILES TRAVELED (VMT) VS. MOBILE SOURCE AIR TOXICS EMISSIONS, 2000-2020



Notes: For on-road mobile sources, emissions factors were generated using MOBILE6.2, which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a). MTBE proportion of market for oxygenates is held constant, at 50%. Gasoline RVP and oxygenate content are held constant. VMT: Highway Statistics 2000, Table VM-2 for 2000, analysis assumes annual growth rate of 2.5%. "DPM + DEOG" is based on MOBILE6.2-generated factors for elemental carbon, organic carbon and SO4 from diesel-powered vehicles, with the particle size cutoff set at 10.0 microns.
Source: FHWA, 2006

3.6.2.1 Existing Environment / TCEQ Monitor Data

TCEQ and other local entities operate air quality monitors in the Houston area. In the Houston area, there are 57 active monitors. This network of monitors measures the air quality and determines the levels of the various pollutants in the air. Consequently, the following paragraphs discuss the monitors nearest to the project (Table 3-7), as well as ambient monitors that have detected levels of MSAT.

The closest air quality monitors to Segment G are 3.9 miles (CAMS 557), 5.6 miles (CAMS 309), and 6.0 miles (CAMS 555) away (Table 3-7). The closest $PM_{2.5}$ monitor used for compliance with the $PM_{2.5}$ NAAQS is about 27.4 miles from Segment G; although CAMS 309 (5.6 miles from Segment G) also monitors $PM_{2.5}$, it is not a regulatory monitor. The official monitor data are found on EPA's national air quality monitor web site (www.epa.gov/air/data). As can be seen in Table 3-7, not all monitors sample for the same pollutants, and not all monitors have one year of complete data to compile an annual average for any given pollutant.

The Mayor of Houston has recently organized a task force to help reduce air quality health risks in Houston. The main focus of this task force is to "…review and summarize the available evidence on the health risks associated with air pollution in the Houston region, recommend areas of research needed to allow regional leaders to make the best decisions on strategies for reducing pollution, within established legal timetables, and to provide guidance to the City on strategies for reducing health risks."

TABLE 3-7
LOCAL MONITOR DATA

Air Monitor	Activation Date	Average Ozone 2006	Annual Average $PM_{2.5}$ 2006	Average Benzene 2006**	Average 1,3 Butadiene 2006**	Distance from Segment G
CAMS 26	April 1997	0.0445 ppm (Standard is a 3-year average which must be 0.080 ppm or below)	N/A	9.48 ug/m^3	0.17 ug/m^3	14.4 miles
CAMS 555	April 2004	N/A	N/A	N/A	N/A	6.0 miles
CAMS 309	February 2001	N/A	11.59 ug/m^3*	N/A	N/A	5.6 miles
CAMS 557	February 2004	N/A	N/A	N/A	N/A	3.9 miles
CAMS 554	January 2004	N/A	N/A	N/A	N/A	20.6 miles
CAMS 148	August 1998	N/A	10.25 ug/m^3 (Standard is a 3- year annual average below 15 ug/m^3)	10.41 ug/m^3	0.69 ug/m^3	27.4 miles

Notes: EPA disclaimer regarding these 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 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."

* Not a regulatory monitor for $PM_{2.5}$, these monitors do not use the same collection and analysis methods for measuring $PM_{2.5}$ data and therefore are not used for compliance monitoring.

** Currently, no NAAQS have been established for any of the priority MSAT. The EPA is in the process of assessing the risks of exposure to these pollutants. For more information see the MSAT Technical Report (Appendix F) or http://www.epa.gov/iris for potential human health effects that may result from exposure to various MSAT.

Source: EPA, 2007b

3.6.2.2 Existing Environment/Proximity to Roadways and the Potential to Impact Health

Recent studies have been reported to show that proximity to roadways is related to negative health outcomes, particularly respiratory problems (South Coast Air Quality Management District, 2000; Sierra Club, 2004; Environmental Law Institute, 2005). On February 26, 2007, the EPA issued a final rule on the "Control of Hazardous Air Pollutants from Mobile Sources." In the preamble to this final rule, the EPA summarized recent studies by stating, "Significant scientific uncertainties remain in our understanding of the relationship between adverse health effects and near-road exposure, including the exposures of greatest concern, the importance of chronic versus acute exposures, the role of fuel type (e.g., diesel or gasoline) and composition (e.g., % aromatic), relevant traffic patterns, the role of co-stressors including noise and socioeconomic status, and the role of differential susceptibility within the 'exposed' populations" (EPA, 2007a).

The lack of professional consensus on concentration levels needed to impact health is evident. What can be determined fairly consistently amid the research is the tendency for pollutant levels to drop off substantially as the distance from the roadway increases. Pollutant concentration starts to decline most rapidly at approximately 328 feet (100 meters) from the roadway. By 1,640 feet (500 meters), most studies reviewed have found difficulty distinguishing between background levels of a given pollutant and detectable levels that may have been found directly adjacent to the roadway. Finally, wind direction and speed, vehicle traffic levels, and roadway design can further increase or decrease the distance at which detectable levels of any given pollutant can be distinguished as directly associated with a roadway, as opposed to simply a background concentration of the pollutant.

Sensitive receptors were mapped and entered to the project GIS. Exhibit G–25a-e depicts sensitive receptors that were considered within and adjacent to the Segment G project area; these receptors include all public and private schools, hospitals, senior citizen care facilities, and licensed daycare facilities.

3.6.2.3 Existing MSAT Levels

A basic quantitative analysis of the total mass of MSAT emissions from the traffic study area of Segment G was completed. The traffic study area used for this analysis includes all major roadways potentially affected by the proposed new transportation facility. The traffic study area is generally bounded by US 290 to the west, SH 249 to the east, IH 610 to the south, and just beyond the proposed Grand Parkway to the north. This area appears graphically in Exhibit G–26.

A discussion of how total MSAT levels were estimated and some of the limitations and cautions regarding these estimations is contained in Section 4.6 of this volume and in Appendix F. A summary of these emissions for the base year is shown in Table 3-8.

TABLE 3-8
TOTAL MSAT EMISSIONS TONS/YEAR FOR THE SEGMENT G TRAFFIC STUDY AREA

Compound	2000 Base Year
Acetaldehyde	23
Acrolein	3
Benzene	133
Butadiene	20
Formaldehyde	77
Diesel Particulate Matter	196
Total MSAT – Segment G	**452**

Source: EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology); Study Team, 2007

3.6.2.4 MSAT Summary

MSAT modeled for the Grand Parkway Segment G was found to be substantially lower in the future years (2015 and 2025) than the base year (2000). MSAT will continue to improve over time because of dramatic improvements in vehicle technology and fuels and traffic flow improvements realized over time.

3.7 EXISTING NOISE ENVIRONMENT

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 "dBA." In addition, since traffic sound levels are never constant because of the changing number, type, and speed of vehicles, a single value expressed as "Leq" is used to represent the average or equivalent sound level. Table 3-9 illustrates some common sound/noise levels in dBA.

TABLE 3-9
COMMON NOISES AND TYPICAL SOUND LEVELS

Common Outdoor Noise Levels	Noise Level (dBA)	Common Indoor Noise Levels
Pneumatic Hammer	100	Subway Train
Gas Lawn Mower at 1 meter (~3 ft)		
	90	Food Blender at 1 meter (~3 ft)
Downtown (Large City)	80	Garbage Disposal at 1 meter (~3 ft)
Lawn Mower at 30 meters (~100 ft)	70	Vacuum Cleaner at 3 meters (~10 ft)
		Normal Speech at 1 meter (~3 ft)
Air Conditioning Unit	60	Clothes Dryer at 1 meter (~3 ft)
Babbling Brook		Large Business Office
Quiet Urban (Daytime)	50	Dishwasher (Next Room)
Quiet Urban (Nighttime)	40	Library

Source: TxDOT, 2005

The traffic noise analysis typically includes the following elements:

- Identification of land use activity areas that might be affected by traffic noise;
- Determination of existing noise levels;
- Prediction of future noise levels;
- Identification of possible noise impacts; and
- Consideration and evaluation of measures to reduce noise impacts.

The FHWA has established Noise Abatement Criteria (NAC) for various land use activity areas that are used as one of two means to determine when a traffic noise impact would occur (Table 3-10). A noise impact occurs when either the absolute or relative criterion is met:

- Absolute Criterion: The predicted noise level at a receiver that approaches, equals, or exceeds the NAC is considered an absolute criterion noise impact. "Approach" is defined as one dBA below the NAC. For example, a noise impact would occur at a Category B residence if the noise level were predicted to be 66 dBA or above.
- Relative Criterion: The predicted noise level that substantially exceeds the existing noise level at a receiver even though the predicted noise level does not approach, equal, or exceed the NAC is considered a relative criterion noise impact. “Substantially exceeds” is defined as more than 10 dBA. For example, a noise impact would occur at a Category B residence if the existing level were 54 dBA and the predicted level were 65 dBA (11 dBA increase).

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.

TABLE 3-10
FHWA NOISE ABATEMENT CRITERIA (NAC)

Activity Category	dBA Leq	Description of Land Use Activity Areas
A	57 (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 were to continue to serve its intended purpose
B	67 (exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals
C	72 (exterior)	Developed lands, properties, or activities not included in Categories A or B above
D	--	Undeveloped lands
E	52 (interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums

Note: Primary consideration is given to exterior areas (Category A, B, or C) where frequent human activity occurs. However, interior areas (Category E) are used if exterior areas were physically shielded from the roadway or if there were little or no human activity in exterior areas adjacent to the roadway.

Source: FHWA, 2001 (23 CFR 772)

3.7.1 Existing Noise Levels

To assess the ambient (existing) noise conditions within the Segment G project area, a noise measurement program was conducted between September 5 and September 11, 2007. This monitoring program was conducted in accordance with FHWA guidelines (FHWA-DP-45-1R), *Sound Procedures for Measuring Highway Noise: Final Report*. Short-term noise measurements of 15 minutes duration each were conducted at the selected monitoring sites using a Metrosonics db-3080 Sound-Level Meter and Analyzer. The approximate location of these sites is shown in Exhibit G–47. These ambient noise level monitoring sites were chosen to be representative of the noise sensitive land uses adjacent to the Preferred Alternative Alignment and characteristic of the existing background noise levels within the project area. Simultaneous traffic counts were also recorded for nearby roadways as applicable. Table 3-11 lists the existing noise level samples within the Segment G project area.

Ambient noises levels were originally taken in 2000 at representative locations for the alternative alignments and used in the DEIS for Segment G dated January 2007. Updated ambient noise measurements were necessary to provide baseline noise levels for new developments, to reflect changing land use and traffic levels, and to provide locations adjacent to the Preferred Alternative Alignment. Because of changing conditions, noise levels decreased by a maximum of two dBA at some locations and increased a maximum of eight dBA in new developments.

TABLE 3-11
AMBIENT NOISE LEVELS IN SEGMENT G PROJECT AREA

Site Number	Site Location	Description	Noise Level (dBA Leq)
MG-A	Residential area in Northgate Crossing on Westgate Village Drive located north of proposed Segment G approximately 1,500 ft east of IH 45.	Residential Home	50
MG-B	Residential area in Northgate Crossing on Merrimac Ridge Lane located north of proposed Segment G approximately 3,800 ft east of IH 45.	Residential Home	50
MG-C	Residential area in Northgate Crossing on North Bridge Terrace Court located south of proposed Segment G approximately 2,500 ft east of IH 45.	Residential Home	49
MG-D	Residential area in Northgate Crossing on North Bridge Terrace Lane located south of proposed Segment G approximately 3,500 ft east of IH 45.	Residential Home	49
MG-E	Residential area in Spring Trails on Ryansbrook Lane located south of proposed Segment G approximately 575 ft southeast of Riley Fuzzel Road.	Residential Home	46
MG-F	Adjacent to residential area in Misty Cliff Lane located south of proposed Segment G approximately 400 ft southeast of Riley Fuzzel Road.	Residential Home	51
MG-G	Residential area in Lockeridge Farms on Lockeridge Bend located south of proposed Segment G approximately 125 ft southeast of Riley Fuzzel Road.	Residential Home	52
MG-H	Residential area in Legends Ranch on Fuller Bluff Drive located north of proposed Segment G approximately 1,300 ft northwest of Riley Fuzzel Road.	Residential Home	48
MG-I	Residential area in Benders Landing on East Benders Landing Boulevard located south of proposed Segment G approximately 210 ft southeast of Riley Fuzzel Road.	Residential Home	47
MG-J	Residential area in Creekside Village on Little River Court located north of proposed Segment G approximately 125 ft northwest of Riley Fuzzel Road.	Residential Home	51
MG-K	Residential area in Cumberland Crossing on Hammer Lane located south of proposed Segment G approximately 650 ft east of FM 1314.	Residential	52
MG-L	Residential area in Timberland Estates at the intersection of Timberland Boulevard and Alyssa Drive.	Residential	51
MG-M	Residential area in Timberland Estates on Hallie Lane.	Residential	50
MG-N	Residential area in Valley Ranch at the intersection of Dave Canyon and Dove Haven Court approximately 3,400 ft west of US 59.	Residential	49

Source: Study Team, 2007

3.7.2 Land Use Activity Areas

Land use within the Segment G project area can be characterized as residential developments along major roadways and large tracts of undeveloped forest. Commercial developments are scattered throughout the Segment G project area, primarily along the major roadways (see Section 3.1, Land Use and Transportation Planning).

3.8 WATER QUALITY

3.8.1 Surface Water

The TCEQ Permanent Rules Chapter 307, Texas Surface Water Quality Standards (TSWQS) Subsections 307.1 – 307.10, dated August 17, 2000, presents surface water quality standards that apply to all surface waters in the state. The major surface waters of the state are classified in the TSWQS as "segments" for the purposes of water quality management and designation of site-specific standards.

There are four major streams within the Segment G project area: Spring Creek, West Fork San Jacinto River, Woodsons Gully, and White Oak Creek. Woodsons Gully and White Oak Creek do not have a segment classification since they are tributaries and not major bodies of water. Spring Creek is classified as Segment 1008 and the West Fork San Jacinto River is classified as Segment 1004. All four streams are located within the San Jacinto River Basin. The San Jacinto River Basin has a drainage area of over 3,400 square miles. The state of Texas Water Quality Inventory states that the water quality for the streams, rivers, and bayous within the San Jacinto River Basin varies widely depending on the land use within the sub-basins (TNRCC, 1998).

Chapter 26.023 of the Texas Water Code gives authority to the TCEQ to establish water quality standards for all state waters. Each designated stream or river segment has specific desired water uses and numerical criteria developed by the TCEQ. Waterbodies that do not support their water quality standards, and for which existing controls are not adequate, are placed on the 303(d) List of Impaired Waterbodies (as required under the CWA, Section 303[d]). The 2006 303(d) List (TCEQ, 2007), the most recent data available, indicates water quality concerns for both of the segments that traverse the project area (Spring Creek and West Fork San Jacinto River). Table 3-12 presents the specific water quality concerns for these segments.

TABLE 3-12
SUMMARY OF WATER QUALITY CONCERNS FOR SEGMENT G

TSWQS Segment	Stream	Assessment Unit*	ALU Designation**	Water Quality Concerns
1004	West Fork San Jacinto	1004_02	High	Water quality concern based on screening levels for nitrate. Non-supporting of water uses because of *E. coli* bacteria from non-point sources including urban runoff/storm sewers.
1008	Spring Creek	1008_04	High	Non-supporting of water uses because of *E. coli* bacteria from non-point sources including urban runoff/storm sewers and on-site treatment systems and from sanitary sewer overflow point sources.

*The specific portion of the stream segment that overlaps or is close to the project area and for which specific water quality concerns are presented.

**ALU=Aquatic Life Use

Source: TCEQ, 2007

3.8.1.1 Spring Creek (Segment 1008)

Spring Creek has a drainage area of approximately 284 square miles. It forms the boundary between Montgomery and Harris Counties. The northeastern portion of the watershed is urbanized (The Woodlands), but the remainder of the watershed is a mix of forested, agricultural, and semi-urban areas. The portion in the Segment G project area is suitable for recreation except in periods of very dry weather.

Spring Creek has been on the 303(d) List since 1996. The designated uses of Spring Creek are contact recreation, aquatic life, general use, fish consumption, and public water supply use. Depressed dissolved oxygen was identified as a water quality concern for a portion of Spring Creek, but a TMDL cannot be scheduled until more data are available. In the 2006 303(d) List, Spring Creek assessment units are listed under Category 5a for bacteria, meaning that a TMDL can be scheduled immediately (TCEQ, 2007). A study prepared for the TCEQ on the stream segments upstream of Lake Houston (James Miertschin & Associates, Inc., 2007), reported that 14 of the 36 samples taken along Assessment Unit 1008_04 (the portion of Spring Creek that passes through the Grand Parkway project area) exceeded the criterion for designation as impaired. The geometric mean for *E. coli* in those Spring Creek samples was 309 org/ml (above the criterion of 126 org/ml). Survey stations are listed in Table 3-13.

Wastewater treatment plants have potential to contribute substantial bacteria loads if complete disinfection were not achieved. Wet weather may result in greater loads; however, in low flow conditions, the loading from the wastewater treatment plants may be more noticeable. The 2007 TCEQ study (James Miertschin & Associates, Inc., 2007) found wastewater treatment plant flows to account for 100 percent of the Spring Creek flow at low flow conditions and 39 percent of the flow at median flow conditions.

TABLE 3-13
TCEQ SURVEY STATIONS NEAR THE PROJECT AREA

Station	Location
11313	Spring Creek Bridge at IH 45
11312	Spring Creek at Riley Fuzzel Road
11239	West Fork San Jacinto River at River Ridge Estates Subdivision upstream of confluence with Spring Creek
11240	West Fork San Jacinto River at Old Houston Road

Source: TCEQ, 2007

3.8.1.2 West Fork San Jacinto River

West Fork San Jacinto River begins in Walker County, is dammed in Montgomery County, creating Lake Conroe, and merges with the East Fork in the headwaters of Lake Houston, from which the San Jacinto River flows ultimately to

Galveston Bay. Recreational usage of the West Fork San Jacinto River depends upon rainfall to increase the volume of water. West Fork San Jacinto River is approximately 50 miles in length, and its drainage area is approximately 1,750 square miles. The major cities within proximity to the river are Spring, Tomball, Conroe, The Woodlands, and Houston.

West Fork San Jacinto River has been on the 303(d) List since 1996. In the 2006 303(d) List, Assessment Unit 1004_02 (the portion of West Fork San Jacinto that passes through the Grand Parkway project area) is listed under Category 5a for bacteria, meaning that a TMDL can be scheduled immediately (TCEQ, 2007). A study prepared for the TCEQ on the stream segments upstream of Lake Houston (James Miertschin & Associates, Inc., 2007), reported that 10 of the 38 samples taken along Assessment Unit 1004_02 exceeded the criterion for designation as impaired. Table 3-12 presents the specific water quality concerns for this assessment unit. The geometric mean for *E. coli* in this portion of West Fork San Jacinto River was 167 org/ml (which is above the criterion of 126 org/ml). Survey stations are listed in Table 3-13.

Wastewater treatment plants have potential to contribute substantial bacteria loads if complete disinfection were not achieved. Wet weather may result in greater loads; however, in low flow conditions, the loading from the wastewater treatment plants may be more noticeable. The 2007 TCEQ study (James Miertschin & Associates, Inc., 2007) found wastewater treatment plant flows to account for 100 percent of the West Fork San Jacinto River flow at low flow conditions and 17 percent of the flow at median flow conditions.

3.8.1.3 Other Segment G Streams

Woodsons Gully and White Oak Creek are tributaries to the West Fork San Jacinto River. Woodsons Gully enters the West Fork San Jacinto River upstream from the confluence of Spring Creek and the West Fork San Jacinto River and therefore does not have a segment classification. White Oak Creek drains into the West Fork San Jacinto River below the confluence of Spring Creek and the West Fork San Jacinto River and is considered to be a part of Segment 1004.

3.8.2 Groundwater

The Gulf Coast Aquifer forms a wide belt along the Gulf of Mexico from Florida to Mexico (Exhibit G–27). In Texas, the aquifer is responsible for providing water to all or portions of 54 counties from the Louisiana-Texas border southwestward to the Rio Grande. All of Harris and Montgomery Counties, and thus Segment G, are part of the Gulf Coast Aquifer.

The Texas Water Development Board (TWDB) has identified and defined nine major and 20 minor aquifers in the state of Texas based on the quantity of water supplied by each. A major aquifer is typically defined as supplying large quantities of water in large areas of the state, while a minor aquifer usually supplies large quantities of water in small areas or relatively small quantities in large areas (Ashworth and Hopkins, 1995). The Gulf Coast Aquifer is considered a major aquifer.

The Gulf Coast Aquifer is made up of complex interbedded clays, silts, sands, and gravels of the Cenozoic age that are hydrologically connected to form a large, leaky artesian aquifer system. This system is recognized as containing four major aquifers in the Segment G project area that contain fresh water (i.e., water not having more than 1,000 mg/l Total Dissolved Solids [TDS]), including the Catahoula, Jasper, Evangeline, and Chicot Aquifers (Exhibit G–27) (Baker, 1979). The Catahoula is the deepest aquifer and contains groundwater near the outcrop (i.e., surface extent) in relatively restricted sand layers. Above the Catahoula is the Jasper Aquifer. This aquifer is primarily contained within the Oakville Sandstone. Between the Jasper Aquifer and the Evangeline Aquifer is a confining layer known as Burkeville. The Evangeline Aquifer is contained within the Goliad and Fleming sands. The Chicot Aquifer is the shallowest major aquifer of the Gulf Coast Aquifer system. The Chicot Aquifer is associated with the Lissie, Willis, Bentley, Montgomery, and Beaumont Formations and overlying alluvial deposits. The greatest total sand thickness ranges from 700 feet in the south to 1,300 feet in the northern limits (Baker, 1979). In Texas, this portion of the Gulf Coast Aquifer system is not designated a sole source aquifer by the EPA under Section 1424(e) of the Safe Drinking Water Act.

The 2007 State Water Plan published by the TWDB, states that "the transition from groundwater to surface water, necessitated by subsidence, is an ongoing challenge [to Region H, which includes the Gulf Coast Aquifer], requiring development of new supplies to replace lost groundwater production" (TWDB, 2006a). Municipal and irrigation users account for 90 percent of the total pumpage from the Gulf Coast Aquifer. Because of this dependence, the Harris-Galveston Coastal Subsidence District (HGCSD) was created in 1975 in response to concern over subsidence, which exacerbates hurricane storm surge flooding in coastal areas and riverine flooding in other areas. The HGCSD regulates the withdrawal of groundwater within Harris and Galveston Counties. Restrictions on the use of the Gulf Coast Aquifer have been instituted to combat subsidence. Groundwater quality of the Gulf Coast Aquifer is generally good to the northeast of the San Antonio River but declines to the southwest because of increased chloride concentrations and saltwater encroachment near the coast (TWDB, 2006b).

3.8.2.1 Water Well Review

Public well records from TCEQ and private water well records and drillers' reports from TWDB were reviewed for the project area. Both agencies maintain a listing of water wells existing in the area. However, the databases only include wells that have been reported to the TCEQ and TWDB and may not include all water wells in the Segment G project area. The results of the water well review indicate that there are a total of 27 water wells within the project area (TCEQ, 2006; TWDB, 2006c). Of this total, 12 are public water supply wells. The remaining 15 wells are private, which are not presently afforded protection by any regulations. Private wells are utilized for domestic, livestock, industrial, or irrigation purposes.

All public water supply systems are eligible to participate in the Source Water Protection Program. The Source Water Protection Program is a voluntary pollution prevention program created by the 1996 Safe Drinking Water Act

Amendments. 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.

Under the program, a wellhead protection area is established around each public supply well. This area is a protective buffer zone of a diameter specific to each well (based upon the hydrogeology of the area) within which certain development is excluded to prevent possible contamination of the groundwater. TCEQ has established these "capture zones" for most public supply wells inside and adjacent to the project area. For wells that do not have designated capture zones, a default zone of a quarter mile radius (1,320 feet) surrounding the well was utilized for project resource mapping. The Segment G project area overlaps 39 public water supply well capture zones (TCEQ, 2006).

3.9 PERMITS

3.9.1 Waters of the U.S., Including Wetlands

Section 404 of the CWA (Clean Water Act) 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. The Segment G project area is mostly upland; however, several wetlands and intermittent and perennial streams (Waters of the U.S.) have been identified within the Segment G project area and may be jurisdictional under Section 404 of the CWA. Placement of dredged or 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 results of the Section 404 field evaluations and potential impacts are discussed in Section 3.10 (Wetlands and Vegetative Communities) and Section 4.10 (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 a TPDES permit is required in Texas for construction activity that disturbs five or more acres, provided an NOI is filed with the TCEQ and EPA (40 CFR 122); even though the TCEQ has assumed authority for the storm water program from the EPA as part of TPDES authorization.

The TPDES permit requires the completion of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP requirements are designed to allow maximum flexibility when selecting Best Management Practices (BMPs) at the construction site. As part of the SWPPP, 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 storm water runoff.

Summary reports of these inspections must be written and retained as part of the SWPPP. Once construction has been completed, a Notice of Termination must be filed per permit requirements. Additional coordination with Harris and Montgomery County local government relative to storm water runoff 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 Sections 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. No navigable waterways occur within the Segment G project area, and therefore the need for a Section 9 permit from the USCG or a Section 10 permit from the USACE is not anticipated.

3.10 WETLANDS AND VEGETATIVE COMMUNITIES

3.10.1 Wetlands

Wetlands within the Segment G project area can be divided into two general categories: non-forested and forested, which typically correspond to the Cowardin Classification System's Palustrine Emergent (PEM), Palustrine Scrub-Shrub (PSS), and Palustrine Forested (PFO) wetland categories (Cowardin et al., 1979). The wetland vegetation present in the Segment G project area is typical of these wetland classes within southeast Texas, and is described in Volume I, Section 3.10.1 (Wetlands) of this document. Please refer to Exhibit G–48 for the locations of wetlands relative to the alternative alignments.

Based on field investigations and aerial photo interpretation, the Segment G project area contains approximately 375 acres of non-forested wetlands and 601 acres of forested wetlands (Table 3-14). (Vegetative communities shown in Table 3-14 and following sections do not represent residential [38 percent] or commercial [3 percent] land use in the Segment G project area. These categories represent 41 percent of the total land use in the Segment G project area.) Typical Segment G project area non-forested wetlands include PEM and PSS wetlands. Many of these non-forested wetlands occur within pasture and agricultural areas and may include portions of artificial impoundments and moist-soil units. Typical Segment G project area forested wetlands occur along the floodplains of Spring Creek, the West Fork of the San Jacinto River and their tributaries. Many of these forested wetlands consist of riparian and bottomland hardwood communities. Additionally, several forested wetlands dominated by the invasive exotic Chinese tallow-tree (*Sapium sebiferum*) occur in isolated depressions outside the riparian and bottomland hardwood communities.

TABLE 3-14
SEGMENT G PROJECT AREA VEGETATIVE COMMUNITIES

Vegetative Community	Acres (Approximate)	Percentage of Total
Farmland	15	<1%
Rangeland	0	0%
Forest	4,883	46%
Non-Forested Wetlands	375	4%
Forested Wetlands	601	6%
Total	**5,874**	**55% ***

Note: * The remaining 45 percent is comprised of residential, commercial, streams and lakes, and land cover. The entire project area is 10,627 acres.
Source: Study Team, 2007

3.10.1.1 Wetland Functions and Values

Wetlands provide a variety of ecological functions and values to the natural ecosystem and to humans, which include wildlife and aquatic habitat, removal of sediments and toxicants, removal or transformation of nutrients, flood control, erosion control/stabilization, groundwater recharge and discharge, production export, threatened and endangered species habitat, recreation, educational/scientific research, aesthetics, and potential unique heritage or scientific values (Mitsch and Gosselink, 1986; USACE, 1999). Wetlands within the Segment G project area provide many of these functions and values at varying levels and degrees. These functions and values are described in greater detail in Volume I, Section 3.10.1.1 (Wetland Functions and Values).

The following paragraphs provide a more detailed discussion describing how the wetland functions and values relate to the various types of wetlands and open-water areas (emergent vegetation wetlands, artificial impoundments, scrub-shrub wetlands, and forested wetlands) found within the Segment G project area. Wetland functions and values described follow those outlined in the USACE *New England District's Wetlands Functions and Values – A Descriptive Approach* (USACE, 1999).

Non-Forested Wetlands

Non-forested wetlands within the Segment G project area are typically associated with floodplain corridors of Spring Creek and the West Fork San Jacinto River and land development. Non-forested wetlands within the Segment G project area include herbaceous wetlands, scrub-shrub wetlands, and open water impoundments along drainages, many of which are considered early successional communities. These habitats offer a variety of wetland functions and values.

Herbaceous wetlands, both within agricultural and non-agricultural areas, provide important wildlife habitat, especially for waterfowl. Wetlands associated with the Pineywoods region and the San Jacinto River floodplain provide important waterfowl habitat within the upper Texas Gulf Coast. In addition, herbaceous wetlands provide consumptive and non-consumptive recreational opportunities such as hunting and bird watching. Although not formally quantified, revenues generated by hunting within the project area may substantially contribute to local economies (Gore, 1994).

Primary functions and values of herbaceous wetland areas within the Segment G project area include wildlife habitat, flood flow storage, desynchronization, sediment/toxicant retention, and nutrient removal/retention/transformation. Secondary functions and values provided by these herbaceous wetlands include groundwater recharge, and uniqueness/heritage. These depressional areas hold surface water runoff from farming and ranching operations following rainfall events for extended periods, allowing sediments, agricultural runoff, and excess nutrients to settle out and be removed. Herbaceous wetlands may also contribute to groundwater recharge, especially those that are not under cultivation.

Non-forested scrub-shrub wetlands occur to a limited extent within the Segment G project area. These wetlands result from historically emergent wetlands, including prairie potholes that were once cultivated or grazed, then invaded by woody species such as Drummond's rattlebush (*Sesbania drummondii*), eastern baccharis (*Baccharis halimifolia*), wax myrtle (*Myrica cerifiera*), and Chinese tallow-tree saplings. Primary functions and values of these scrub-shrub wetlands include flood flow storage, sediment/toxicant retention, nutrient removal/retention/transformation, wildlife habitat, limited production export (food for wildlife), and limited groundwater recharge. These wetlands provide little, if any, other functions and values such as fish/shellfish habitat, sediment/shoreline stabilization, educational/scientific value, uniqueness/heritage value, aesthetic value, or endangered species habitat. As agricultural practices increased, artificial impoundments, such as stock ponds and irrigation reservoirs, developed within the Segment G project area. Primary functions and values of these mainly open-water areas include wildlife habitat and consumptive and non-consumptive recreation (i.e., waterfowl hunting and bird watching). Secondary functions and values include production export (food for waterfowl) and fish habitat. Impoundments that receive surface runoff may provide sediment/toxicant retention and nutrient removal/retention/transformation. Abandoned borrow pits from construction activity and floodwater retention ponds created in conjunction with development offer similar habitat functions and values within the Segment G project area.

Forested Wetlands

Forested wetlands within the Segment G project area are typically associated with riparian corridors adjacent to Spring Creek, the West Fork of the San Jacinto River, and their tributaries. Primary functions and values of these riparian forest and bottomland hardwood areas include wildlife habitat, sediment/toxicant retention, nutrient removal/retention/ transformation, flood flow storage, desynchronization, production export (food for wildlife), and groundwater recharge.

The limited amount of forested wetlands within the Segment G project area that occur outside riparian corridors are often dominated by the Chinese tallow-tree – an invasive exotic tree species native to southeast Asia that forms monotypical stands of trees and saplings, especially in overgrazed rangelands and old fields released from cultivation (Frasier, 1994). Other than the primary functions listed in this section, these forested wetlands provide very limited additional functions and values. Compared to other wetlands within the Segment G project area, these monocultural "tallow flats" offer limited wildlife habitat because of the lack of vegetative species diversity. Opportunities for both consumptive and non-consumptive recreation, groundwater recharge/discharge, production export, sediment/toxicant/pathogen retention and

nutrient removal/retention/transformation may occur on a very limited scale, especially in relation to more diverse wetlands within the Segment G project area.

3.10.2 Vegetative Communities

The Segment G project area is situated entirely within the Pineywoods vegetational area (Hatch et al., 1990). The Pineywoods area is characterized by nearly level to gently undulating and locally hilly topography with precipitation averaging 48 inches per year. Elevations within the Pineywoods range from 200 to 700 feet above MSL with little topographic relief (Hatch et al., 1990). Mean annual temperature is typically 70° F (Hatch et al., 1990).

The original vegetation types of the Pineywoods vegetational area consists of mixed pine/hardwood forest in uplands and mixed hardwood forest in bottomlands. A wide variety of hardwoods grows in mixed stands with the pines in most upland areas, but hardwoods are dominant in the low-lying areas of the floodplain. Typical species in mixed pine/hardwood upland forest include loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), southern red oak (*Quercus falcata*, var. *falcata*), Chinese tallow-tree (*Sapium sebiferum*), wax-myrtle, yaupon (*Ilex vomitoria*), American beauty-berry (*Calicarpa americana*), dewberry (*Rubus* spp.), narrowleaf woodoats (*Chasmanthium sessiliflorum*) and poison ivy (*Toxicodendron radicans*). Typical species in mixed bottomland hardwood forest include water oak, willow oak, sweetgum, cherrybark oak (*Quercus falcata* var. *pagodifolia*), Chinese tallow-tree, red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), wax-myrtle, deciduous holly (*Ilex decidua*), dwarf palmetto (*Sabal minor*), Cherokee sedge (*Carex cherokeensis*), giant cane (*Arundinaria gigantea*) and longtom (*Paspalum lividum*). Many species of shrubs, vines, forbs, and grasses occupy the forest floor, and grasses and forbs dominate openings in the forest canopy.

The majority of the Segment G project area is forested with the exception of isolated blocks of land previously cleared and currently used for urban development and, to a lesser degree, farming and ranching. Urban development is concentrated in the western and eastern portions of the project area along the IH 45 and US 59 corridors, respectively. Where there had been disturbance or alterations to the forests, such as silviculture, farming, ranching, and urbanization, various shrubs, exotic trees, and undesirable herbaceous species have invaded.

The vegetative communities within the Segment G project area can be divided into four categories: farmland/rangeland, forest, non-forested wetlands, and forested wetlands. These categories correspond with Anderson Land Use Level 1 and 2 Classification Codes (Anderson et. al., 1976). An additional source of land cover/land use mapping includes the vegetation types of Texas as described by McMahan et al. (1984) (see Volume I, Section 3.10.2 [Vegetative Communities]).

Volume I of the FEIS provides a general description of the vegetation categories. Details specific to the Segment G project area are provided in the following sections. A breakdown of vegetative communities within Segment G by acreage and percentage is provided in Table 3-14.

3.10.2.1 Farmland/Rangeland

Farmland and rangeland comprise 15 acres (less than 1 percent) of the Segment G project area. Farmland within the project area is limited due in part to the poor soils, which prevail within the Pineywoods. Some cattle grazing and other agriculture practices do persist, though limited. The majority of the current farmland was developed from clearing the historically forested areas.

3.10.2.2 Forest

Forested vegetative cover accounts for approximately 4,883 acres (46 percent) of the Segment G project area. Forested communities within the Segment G project area are mainly associated with the riparian and bottomland hardwood forests along the floodplains of Spring Creek and the West Fork of the San Jacinto River (see Volume I, Section 3.10.2.3 [Forest]) for definitions). Exhibit G–49 shows locations of riparian and bottomland hardwood forests in Segment G. Scattered forested communities also occur within abandoned farm areas and along fencerows and windbreaks throughout the Segment G project area. In addition, patches of second growth forested areas still persist within the Segment G project area surrounding urbanized areas.

Based on field observations, typical overstory trees are approximately 20 to 50 feet tall with an average diameter at breast height (dbh) ranging between eight and 20 inches. Canopy coverage ranges between 60 and 80 percent. These forested communities closely correspond with McMahan et al.'s (1984) vegetation types 41 (Young Forest/Grassland) and 42 (Pine-Hardwood Forest). Typical overstory vegetation species within non-wetland forested communities include loblolly pine, long-leaf pine (*Pinus palustris*), and shortleaf pine (*Pinus echinata*) with few intermixed hardwoods of sweetgum, white oak (*Quercus alba*), and southern red oak. Other overstory vegetation species found with forested communities include red maple, American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), southern red oak, water oak, red mulberry (*Morus rubra*), eastern redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), southern magnolia (*Magnolia grandiflora*), eastern red cedar (*Juniperus virginiana)*, American sycamore (*Platanus occidentalis*), bald cypress (*Taxodium distichum*), black gum (*Nyssa* sylyatica), and Chinese tallow-tree. Understory and shrub species include American beautyberry, wax-myrtle (*Myrica cerifera*), Chinese privet (*Ligustrum sinense*), and Chinese tallow-tree saplings. Common vine species include common greenbriar, laurel greenbriar (*Smilax laurifolia*), southern dewberry, Japanese honeysuckle (*Lonicera japonica*), poison ivy, and Alabama supplejack (*Berchemia scandens*). The herbaceous layer within these areas is typically composed of narrowleaf woodoats, blackseed needlegrass (*Piptochaetiom avenaceum*), bahiagrass, and Virginia wildrye (*Elymus virginicus*). Forested wetlands, as described in Section 3.10.2.4 (Forested Wetlands), are typically located within isolated depressions and within riparian corridors and floodplains of the major drainages.

3.10.2.3 Non-Forested Wetlands

Non-forested wetlands include PEM and PSS (Cowardin et al., 1979) wetland habitats. These wetland habitats occur throughout the Segment G project area as isolated depressions and within the floodplains of major drainages. Many of

the non-forested wetlands observed appear to be early successional communities experiencing secondary succession. This vegetative community accounts for approximately 375 acres (4 percent) of the Segment G project area.

Typical vegetation in these communities includes swamp smartweed (*Polygonum hydropiperoides*), green flatsedge, jointed flatsedge (*Cyperus articulatus*), soft rush (*Juncus effusus*), slender rush (*Juncus tenuis*), rough button-weed (*Diodia teres*), ovate false-fiddle-leaf (*Hydrolea ovata*), sedge (*Carex* spp.), yellow-eyed-grass (*Xyris* spp.), sand spikerush (*Eleocharis montevidensis*), smooth water primrose (*Ludwigia peploides*), curly dock, sawtooth frog-fruit (*Phyla incisa),* hairy hydrolea (*Hydrolea ovata*), arrowhead (*Sagittaria* spp.), Cherokee sedge, maidencane (*Panicum hemitomon*), bushy bluestem (*Andropogon glomeratus*), longtom, morning glory (*Ipomoea coccinea*), Drummond's rattlebush, eastern baccharis, wax-myrtle and Chinese tallow-tree saplings.

3.10.2.4 Forested Wetlands

Forested wetlands, or PFO (Cowardin et al., 1979), in the Segment G project area account for approximately 601 acres or 6 percent of the Segment G project area. They occur in isolated depressions and within riparian corridors and floodplains of the major drainages. Forested wetland communities within the Segment G project area closely correspond with McMahan et al.'s (1984) vegetation types 31 (Willow Oak-Water Oak-Blackgum Forest) and 36 (Water Oak-Elm-Hackberry Forest).

The majority of the forested wetlands within the Pineywoods are considered early to late successional forested wetland communities. Forested wetlands within the bottomland hardwood and riparian forests of the Segment G project area contain overstory trees typically between 40 and 60 feet tall, with average dbh ranging from eight to 12 inches. Typical canopy coverage ranges between 60 and 80 percent. Vegetation within these areas typically includes willow oak, water oak, cherrybark oak, southern red oak, Chinese tallow-tree, green ash, black willow (*Salix nigra*), sugarberry, sweetgum, American elm (*Ulmus americana*), eastern cottonwood (*Populus deltoides*), dwarf palmetto, Cherokee sedge, maidencane, longtom, Virginia wildrye, and narrowleaf woodoats.

Many forested wetlands located throughout the Segment G project area, especially those located within isolated depressions, appear to be early successional, formerly herbaceous wetlands being converted to forested wetlands by invasive woody species. Chinese tallow-tree, green ash, and black willow trees that range in height from 20 to 30 feet typically dominate these wetlands. The average dbh ranges from four to eight inches and the canopy coverage typically ranges from 50 to 60 percent.

Chinese tallow-tree is an invasive exotic tree species native to Southeast Asia that forms monotypical stands of trees and saplings, especially in overgrazed rangelands and old fields released from cultivation (Frasier, 1994). Removal and management of this species presents one of the greatest obstacles to wetland and upland habitat improvement projects within the Pineywoods ecological region.

3.10.3 Natural Areas

Natural areas are ecologically sensitive areas, including portions of certain important habitats such as bottomland hardwood forest, wetlands, and native tall grass prairie. The Segment G project area traverses the southernmost portion of the Big Thicket ecological region. Much of the original Big Thicket region within the Segment G project area has been cleared. The forested areas present at this time are typical of second growth forests.

Currently, fragmented remnants of undisturbed forest exist in remote locations and narrow corridors typically associated with Big Thicket National Preserve, adjacent conservation easements, and areas that are otherwise protected, difficult to access, or difficult to develop. These remnant areas are thought to total 300,000 to 500,000 acres (NPS, 2006b). Efforts to preserve or recognize the unique habitat found within the Big Thicket include the National Park Services' Big Thicket National Preserve, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Man and Biosphere Program in 1981, and the American Bird Conservancy's designation of the Big Thicket National Preserve as a Globally Important Bird Area in 2001. The preserve is largely buffered by surrounding land owned and managed by timber companies, but between 2000 and 2004, more than two million acres of timber company land were sold or put up for sale (NPCA, 2005). Much of the land adjacent to the preserve is still in timber holdings or under conservation easements (NPS, 2006b).

Historically and as early as 2002, Segment G crossed a largely unfragmented expanse of mixed upland and bottomland hardwood forest between Spring Creek and the West Fork of the San Jacinto River within the region historically defined as the Big Thicket. This area has been identified in correspondence with USFWS as an area of special concern (USFWS, 2000a, 2000b, and 2000c).

Currently, the Segment G project area consists of a fragmented land use pattern with mixed upland and bottomland hardwood forest between Spring Creek and the West Fork of the San Jacinto River. The mixed upland forest areas are currently under intense residential development pressures. Additionally, three large residential development projects (Spring Trails, Benders Landing, and Legends) are rapidly expanding in the project area. Bottomland forest between Spring Creek and the West Fork of the San Jacinto River located in the low lying floodplains and floodways of Spring Creek, Cypress Creek, and the San Jacinto River support a wide variety of native bottomland fauna and flora in an area that has experienced relatively little impact from development. Although this area has experienced impacts due to silvicultural practices and sand/gravel mining operations in recent years, it is still considered high quality wildlife habitat by natural resource agency personnel.

3.11 WILDLIFE

The entire Segment G project area occurs within the Austroriparian Biotic Province (Blair, 1950). Extensive pine and hardwood forests, swamps, marshes, and other hydric communities characterize the Austroriparian Biotic Province. The range of the Austroriparian Biotic Province extends from eastern Texas to the Atlantic coastal plain and as far north as the Dismal Swamp of southeast Virginia (Dice, 1943). The western boundary of the Austroriparian Biotic Province is the

western boundary of the pine and hardwood forest of the Eastern Gulf Coastal Plain. The ecological associations of the Austroriparian Biotic Province extend westward beyond this boundary, in local areas, wherever soil conditions are favorable. At least 47 mammal species, 29 snake species, 10 lizard species, two land turtle species, 17 anuran species, and 18 urodele species are known to have occurred in the Austroriparian Biotic Province in recent times (Blair, 1950).

Vertebrate fauna in the Segment G project area is typical of that found over most of the Austroriparian Biotic Province to the east. With respect to the 10 vegetation regions of the state described by Hatch et al. (1990), the Segment G project area is located within the Pineywoods ecological region. The wildlife habitats within the Segment G project area correspond to this vegetative type. Vegetative communities are described in Volume I, Section 3.10.2 (Vegetative Communities).

The Segment G project area can be divided into four major wildlife habitat types, which coincide with the major vegetative communities present within the Segment G project area. The major wildlife habitat divisions are defined as farmland/rangeland, forest, non-forested wetlands, and forested wetlands. The distribution of habitat types in the Segment G project area and the activity patterns of many wildlife species result in some overlap of faunal communities. Forest-dwelling species may occasionally occur in open areas around forest stands, and species particular to non-forested 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.

3.11.1.1 Farmland/Rangeland

The farmland/rangeland habitat occupies less than 1 percent of the Segment G project area (Table 3-14). This community type is primarily used to raise cattle but also contains abandoned fields. The farmland habitat is located within Segment G is not considered to be part of the Katy Prairie. The clearing of trees to facilitate cattle and crop production created these non-forested areas. The small amount of farmland habitat available within the Segment G project area could provide a food source for some species of wildlife, but because of the limited amount of habitat available, few species wholly exist within the farmland habitat. Wildlife species associated with farmland habitat are most likely associated with adjacent forested areas.

3.11.1.2 Forest

Forested habitat occupies approximately 46 percent of the Segment G project area (Table 3-14). Upland forests in the Segment G project area are primarily large tracks of second growth mature forests with bands of early to mid successional forested communities occurring along fence rows, abandoned farm areas, timbered areas, and riparian corridors. This habitat type is widespread throughout the Segment G project area and forms a transitional zone between other habitat types providing stratified cover and edge habitat for a variety of wildlife.

The early to mid successional tree stands, fence rows, and riparian corridors provide protective cover and additional food sources to wildlife in other habitats. Wildlife movement patterns are variable because of the amount of food, cover, and water provided in a particular area.

Amphibian and Reptile Species

Amphibians likely to occur within the Segment G project area in forested areas include the northern cricket frog (*Acris crepitans crepitans*), upland chorus frog (*Pseudacris triseriata feriarum*), bull frog (*Rana catesbeiana*), bronze frog (*Rana clamitans clamitans*), green tree frog (*Hyla cinerea*), southern leopard frog (*Rana utricularia*), northern spring peeper (*Pseudacris crucifer*), Cope's gray tree frog (*Hyla chrysoscelis*), and gray tree frog (*Hyla versicolor*). Some of the more common turtle species are most likely to be associated with aquatic habitat in forested areas and include the red-eared slider (*Trachemys scripta elegans*), common snapping turtle (*Chelydra serpentina serpentina*), and the Midland smooth softshell (*Trionyx muticus muticus*). One terrestrial species of turtle that may occur in the Segment G project area's forest habitat includes the three-toed box turtle (*Terrapene carolina triunguis*). Common lizard species that may occur throughout the Segment G project area include the five-lined skink (*Eumeces fasciatus*) and the northern fence lizard (*Sceloporus undulates hyacinthinus*). Snake species that may occur in the Segment G project area include the eastern hognose snake (*Heterodon platirhinos*), the rough earth snake, and diamondback water snake (*Nerodia rhombifer*). Venomous species of snakes that may occur within the Segment G project area include the Texas coral snake (*Micrurus fulvius*), western pigmy rattlesnake (*Sistrurus miliarius streckeri*), and western cottonmouth.

Avian and Mammal Species

Avian species likely to occur in these forested areas include the cedar waxwing (*Bombycilla cedrorum*), American goldfinch (*Carduelis tristis*), white-eyed vireo (*Vireo griseus*), and eastern screech owl (*Otus asio*). Mammal species that may occur throughout the upland forest include the following: southern short-tailed shrew (*Blarina carolinensis)*, swamp rabbit (*Sylvilagus aquaticus*), marsh rice rat (*Oryzomys palustris*), eastern harvest mouse (*Reithrodontomays humulis*), eastern fox squirrel (*Sciurus niger*), eastern gray squirrel (*Sciurus carolinensis*), and eastern red bat (*Lasiurus borealis*).

3.11.1.3 Non-Forested Wetlands

Non-forested wetland habitat occupies approximately 4 percent of the Segment G project area (Table 3-14). Many of these scattered wetlands are the result of wetlands being cleared for agriculture, land development, or timber production. Many of the wildlife species likely to occur in this habitat type are the same as those found in aquatic areas mentioned in the farmland and forest habitat discussions (Sections 3.11.1.1 and 3.11.1.2) such as the nutria, American beaver, and western cottonmouth.

3.11.1.4 Forested Wetlands

Forested wetland habitat occupies 6 percent of the Segment G project area (Table 3-14). These wetlands appear to be early to late successional forested wetlands. Many of the wildlife species likely to occur in this habitat type are the same

as those found in aquatic areas mentioned in the previous farmland and forest habitat discussions (Sections 3.11.1.1 and 3.11.1.2) such as the Cope's gray tree frog, western cottonmouth, eastern fox squirrel, eastern gray squirrel, and eastern red bat.

3.11.2 Aquatic Habitats

Aquatic habitats within the Segment G project area support a diverse assemblage of biotic communities, including perennial and intermittent streams/creeks, emergent and forested wetlands, and several impoundments and drainages. The Segment G project area contains the West Fork of the San Jacinto River, one perennial creek, Spring Creek, and two intermittent creeks, Woodsons Gully and White Oak Creek. The Segment G project area also contains several intermittent natural and artificial tributaries to these perennial/intermittent creeks. Typical aquatic habitat features along these creeks and streams include woody debris, overhanging vegetation, undercut banks, gravel, and artificial cover (i.e., broken cement, tires, and culverts). Creeks and wetlands in the Segment G project area are subject to changing hydrology because of the frequency and duration of rainfall events, resulting in typically slow moving, pooled, or saturated conditions punctuated by short periods of faster moving water in channels and across the landscape (sheet flow).

Consequently, organisms typically occurring in these habitats have a high tolerance for a number of physical and chemical variables. Along with these high tolerances, these organisms generally exhibit adaptations that include dormant or resistant life-history stages, mechanisms for rapid dispersal, high reproduction potential, or behavioral adaptations allowing exploitation of these habitats during favorable conditions. Species that are adapted to rapid colonization of disturbed habitats may include many algal and zooplankton species, aquatic insects with winged adult stages, and numerous small fish species that migrate into intermittent tributaries from perennial stream habitats to spawn. Impoundments located in the Segment G project area exhibit variability with respect to size, depth, substrate, age, use, drainage, and fertilization history. Unlike naturally occurring streams and wetlands in the Segment G project area, impoundments are almost always exposed to full sunlight and do not typically experience large fluctuations in water level and flow associated with heavy precipitation.

Physical and chemical components are responsible for supporting the lowest trophic levels within an aquatic system. These lower trophic levels are composed of microscopic plants (phytoplankton) and microscopic animals (zooplankton) that support the food chain for all other larger organisms.

Phytoplankton, the algae suspended in the water column, are usually a major component of the aquatic food chain in a non-flowing impoundment and greatly contribute to organic inputs. In flowing waters, phytoplankton have more difficulty maintaining substantial populations. Consequently, in riverine systems the source of organic input is predominantly allochthonous material as opposed to resident plankton. Under eutrophic conditions, reservoir phytoplankton can adversely affect water quality by forming slime or scum, producing unpleasant tastes and odors, and increasing the organic load sinking into the deep hypolimnion during stratification periods. Algal blooms are frequently due to blue-green algae (Cyanobacteria), although numerous other forms can reach nuisance levels. Phytoplankton populations in Segment

G project area streams are generally of low density because of flushing during periods of high rain. During low-flow periods, high plankton population densities are encountered in isolated pools, where light and nutrient conditions are suitable for development. Species composition and densities are highly variable among adjacent isolated pools in the same stream channel.

Zooplankton form an important part of the food chain in reservoirs and other slow-flowing waters within the Segment G project area. Zooplankton primarily feed on phytoplankton, detrital particles, bacteria, protozoa, and other zooplankton, and in turn are preyed upon by macroinvertebrates and numerous fish species. Different types of zooplankton communities occupy different types of aquatic systems. Within large rivers and streams, rotifers are generally the dominant zooplankton, while in a lacustrine environment, cladocerans and copepods are usually the dominant zooplankton. The zooplankton communities within the Segment G project area streams are most likely dominated by rotifers.

The benthic macroinvertebrates of freshwater systems form a highly diverse group of organisms with a wide variety of functions in the aquatic community. In addition to serving as a major food source for vertebrate predators such as fish, macroinvertebrates have important roles as herbivores, detritivores, and carnivores. The Orders that comprise the majority of macroinvertebrate samples in the Segment G project area include Insecta (particularly immature forms), Mollusca (mussels and snails), Oligochaeta (aquatic earthworms), and Crustacea (crawfishes and shrimp).

Macroinvertebrate composition in Segment G project area flowing waters is greatly influenced by substratum type. Clinging and hiding forms occur in gravelly areas of larger particle size, while burrowing forms are more common in sandy, silt-covered, and muddy bottoms. The greatest diversity generally occurs on gravelly substrates. Many species require a current to satisfy food and respiratory needs and cannot survive in a standing-water environment. The unionid mussels (Unionidae), crawfishes (Cambaidae), prosobranch snails (Gastropoda), and the larvae of dragonflies (Odonata), caddisflies (Trichoptera), and midgeflies (Chironomidae) usually reach maximum development in running waters.

A comparison of Hubbs (1957, 1982), Hubbs et al. (1991), and Lee et al. (1980) indicates that the geographic range of approximately 100 species of freshwater fish are included within the Segment G project area. Based on the size and degree of variation in the waterbodies, it is anticipated that the range of habitat does not occur to support all of these species. The larger creeks of the Segment G project area contain a more diverse fish community and support larger species, such as game and rough fish. Important game fish species include largemouth bass (*Micropterus salmoides*), blue catfish (*Ictalurus furcatus*), bluegill (*Lepomis macrochirus*), and white crappie (*Pomoxis annularis*). Gizzard shad (*Dorosoma cepedianum*), sunfishes (*Lepomis* spp.), and several species of minnows (*Cyprinidae*) are important forage species. Important rough fish species include the smallmouth buffalo (*Ictiobus bubalus*), spotted gar (*Lepisosteus oculatus*), common carp (*Cyprinus carpio*), and river carpsucker (*Carpiodes carpio*). Many of the stream segments that are intermittent or size limiting to gamefish may contain minnows (*Notropis* spp.), western mosquitofish (*Gambusia affinis*), topminnows (*Fundulus* spp.), and darters (*Etheostoma* spp). Pooled areas tend to be heavily dominated by sunfish that are widely distributed in area streams when sufficient water is present.

The fish communities of impoundments are primarily dependent upon stocking efforts. Several species of sunfish, largemouth bass, and channel catfish are the most common species stocked for recreational fishing in these ponds.

3.12 FLOODPLAINS

3.12.1 Hydrology and Drainage

The Segment G project area is located within the San Jacinto River Basin in Harris and Montgomery Counties, Texas. This basin is located in the southeastern portion of the state and is bordered by the Trinity River Basin on the east and the Brazos River Basin on the west. The San Jacinto Basin has a drainage area of over 3,400 square miles. Data from the Southern Regional Climate Center show that the average annual precipitation for the Houston area (Intercontinental Airport) (1971 to 2000) is 47.84 inches (SRCC, 2006). The Segment G project area is located within the coastal plain, where the grades of the streams are low, resulting in slow water velocities. The overland slopes in the Segment G project area are approximately four feet/mile (0.08 percent). Development in the Segment G project area is characterized by a moderate degree of residential development concentrated in Reaches 8 and 12, with the bulk of the area being forested. Residential areas vary in density and composition, and these include single-family homesteads, individual homes on large lots, trailer parks, and master-planned subdivisions. Master-planned subdivisions dominate recent development. Planned residential developments that lie within the Segment G project area include Northgate Crossing, Fox Run, Canyon Lakes at Legends Ranch, Legends Ranch, Legends Run, Estates of Legends Ranch, Lockeridge Farms, Spring Trails, Benders Landing, Creekside Village, Benders Landing Estates, Riverwalk (Northern Section), Cumberland Crossing, Winchester Place, Timbergrove, Timberland Estates, Valley Ranch Forest Colony, Legends Trace, and Spring Bridge Trails.

The proposed alternative alignments for Segment G begin at IH 45 northwest of the community of Spring and run in an easterly direction for about 14 miles, then end at US 59 north of the community of Porter. The proposed alternative alignments cross or are adjacent to two major streams, one minor stream, one minor tributary, and numerous irrigation channels. The major streams are Spring Creek and West Fork San Jacinto River. The minor stream is the White Oak Creek.

3.12.2 Floodways and Floodplains

3.12.2.1 Principle Characteristics of the Project Area

The Segment G project area includes mostly suburban areas north 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. In addition, the floodplains have been subject to increasing residential development (e.g., Creekside Village, and Valley Ranch). Each of the major streams within the Segment G project area has regulatory floodways and floodplains, as identified by FEMA (see Exhibit G–48).

3.12.2.2 Community Status in the National Flood Insurance Program (NFIP)

The 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 (SFHAs). 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 mapping 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 (FIRM) and in the majority of 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 (FHBM) showing only approximate base floodplain boundaries.

According to FEMA, Harris and Montgomery Counties participate in the Regular Program of the NFIP. FIRMs were obtained for all of Harris and Montgomery Counties showing the base floodplain and regulatory floodways for the major rivers and streams. Additionally, updated data have been obtained from the Tropical Storm Allison Recovery Project (TSARP), which produced Digital Flood Insurance Rate Maps (DFIRMs) for Harris County. These maps have undergone the necessary regulatory review process, were finalized in December 2006, and have become effective as of June 18, 2007 (TSARP, 2007).

The floodways and floodplains from the Preliminary 2006 DFIRMs were transferred onto the project mapping in the GIS (Exhibit G–48). A comparative analysis of the preliminary 2006 flood boundaries represented herein and the June 18, 2007 effective flood boundaries indicate no substantive differences within the Grand Parkway Segment G project area.

3.12.2.3 Segment G Project Area Floodways and Floodplains

The Segment G project area is located within the San Jacinto River Basin between the Trinity River Basin on the east and the Brazos River Basin on the west. Each of the major streams within and adjacent to the Segment G project area has regulatory floodways and floodplains, as identified by FEMA (Exhibit G–48). The regulatory floodplains and floodways were transferred to project mapping for the analysis.

Table 3-15 presents the amount of floodway and 100-year floodplain associated with each major stream found within the Segment G project area. Data are based on the 2000 FIRM maps for Montgomery County and the Preliminary 2006 DFIRMs for Harris County. FEMA has identified many of the base floodplains in the project area as Flood Hazard Zones. Flood Hazard Zones are areas where flooding is not considered to impose a high risk.

TABLE 3-15
SEGMENT G PROJECT AREA FLOODWAYS AND 100-YEAR FLOODPLAINS

Stream	Floodways within the Project Area (acres)	100-Year Floodplains within the Project Area (acres)	Total Floodways and 100-Year Floodplains within the Project Area (acres)
Spring Creek	434.1	346.8	780.9
West Fork San Jacinto River	815.2	577.7	1,392.9
White Oak Creek	149.6	248.6	398.2
Woodsons Gully	205.2	295.6	500.8
Total	**1,604.1**	**1,468.7**	**3,072.8**

Source: TSARP, 2006 and Montgomery County 2000 FIRMs

3.12.2.4 Historical Flooding

The project area of Segment G is in the West Fork San Jacinto River watershed. The watershed is in a region of Texas with the potential for high rainfall events ranging from 11 inches to 13 inches for a 100-year, 24-hour storm. The watershed has been subjected to more extreme events in historical times, such as the Tropical Storm Allison event in 2001 with 24 inches in 24 hours, and the 1994 event in Montgomery County, which in some areas, may have been a 500-year event. Flooding is a major problem any place in the watershed where development has encroached into the floodplains. The greatest number of vulnerable structures is in the highly developed and urbanized Harris County, southern Montgomery County, and Houston watersheds. However, areas of older development in the suburbs, such as portions of Spring Creek, Woodsons Gully, and White Oak Creek also have a number of vulnerable structures.

Extreme rainfall events have occurred in most, if not all, watersheds resulting in flooding. Not all flooding is due to riverine flooding along the main channels. Because of the flat terrain and high rainfall potentials, many areas are vulnerable to sheet flow and local flooding, which is normally a result of the local drainage infrastructure being incapable of conveying the runoff from extreme events to the outfall channels. The Grand Parkway Segment G is not proposed to cross any major streams.

3.13 WILD AND SCENIC RIVERS

The proposed action and the Segment G project area are not situated in the vicinity of any river segment on the National Inventory of River Segments included in the National Wild and Scenic River System list (NPS, 2007) or on the Nationwide Rivers Inventory list (NPS, 2004).

3.14 COASTAL BARRIERS

The proposed action and Segment G project area are wholly outside any coastal barrier systems.

3.15 COASTAL ZONE MANAGEMENT

The Texas Coastal Management Program (CMP) was approved by the National Oceanic and Atmospheric Administration (NOAA) on December 23, 1996, as published in the *Federal Register* (Volume 62, Number 7) on January 10, 1997. The CMP boundary delineates the coastal zone in accordance with the requirements of the Coastal Zone Management Act (CZMA) of 1972, federal program development and approval regulations, and the Texas Coastal Coordination Act. The southern portion of Harris County is included in the CMP boundary. At its closest point, the Segment G project area boundary is approximately 19 miles north of the CMP boundary. None of the alternative alignments are within the CMP boundary. The location of the Segment G project area relative to the delineated coastal zone is depicted in Exhibit G–28. None of the alternative alignments are within the CMP boundary; therefore the proposed action complies with CZMA.

3.16 ESSENTIAL FISH HABITAT (EFH)

The Magnuson-Stevens Fishery Conservation and Management Act, as amended on October 11, 1996, directs that all federal agencies whose actions will impact 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

Please refer to Volume I of the FEIS for a complete listing, status, and habitat requirements of all state and federally listed threatened and endangered species, as well as non-listed rare species, that could be found within the Grand Parkway Segments E, F-1, F-2, and G project areas. Table 3-16 lists state and federal rare, threatened, and endangered species found in Harris and Montgomery Counties and the potential occurrence of each species' habitat within the Segment G project area. The findings reported in Table 3.17 are made based on literature reviews and general habitat descriptions and may differ from the findings presented in Section 4.17 of this volume that are provided subsequent to field studies.

State and federally listed threatened and endangered species whose ranges or migratory routes may extend specifically into the Segment G project area include the American peregrine falcon (*Falco peregrinus anatum*), Arctic peregrine falcon (*Falco peregrinus tundrius*), bald eagle (*Haliaeetus leucocephalus*), piping plover (*Charadrius melodus*), white-faced ibis, Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), alligator snapping turtle (*Macroclemys temminckii*), timber/canebreak rattlesnake (*Crotalus horridus*), and Texas prairie dawn (*Hymenoxys texana*).

Rare species' habitats with potential or known presence in the Segment G project area include mountain plover (*Charadrius montanus*), snowy plover (*Charadrius alexandrinus*), southeastern snowy plover (*Charadrius alexandrinus tenuirostris*), plains spotted skunk (*Spilogale putorius interrupta*), southeastern myotis bat (*Myotis austroriparius*), little spectaclecase (*Villosa lienosa*), Louisiana pigtoe (*Pleurobema riddellii*), sandbank pocketbook (*Lampsilis satura*), Texas

pigtoe (*Fusconaia askewi*), Wabash pigtoe (*Fusconaia flava*), Houston daisy (*Rayjacksonia aurea*), and Texas meadow-rue (*Thalictrum texanum*).

TABLE 3-16
HABITAT DESCRIPTIONS FOR STATE AND FEDERAL THREATENED, ENDANGERED, AND RARE SPECIES IN HARRIS AND MONTGOMERY COUNTIES, TEXAS

Species	Habitat	Habitat Present* within Project Area
Amphibians		
Houston toad	All known populations occur within two separate bands of geologic formations, including the Sparta Sand, Weches Formation, Queen City Sand, Recklaw Formation, and Carrizo Sand	No
Birds		
American peregrine falcon	Winters along the entire Gulf Coast and occurs statewide during migration	Migrant
Arctic peregrine falcon	Winters along the entire Gulf Coast and occurs statewide during migration	Migrant
Bald eagle**	Coastal areas and around large bodies of water such as reservoirs, lakes, and rivers and tall trees	Yes
Black rail	Brackish and freshwater marshes, pond borders, wet meadows, and grassy swamps	No
Brown pelican	Primarily found along the lower and middle coast, but occasional sightings are reported on the upper coast and inland to central, north-central, and eastern Texas, usually on large fresh water lakes	No
Henslow's sparrow	Weedy fields or cut-over areas where lots of bunch grasses occur along with vines and brambles	No
Mountain plover	Nests on high plains or shortgrass prairie, shallow depressions on ground, plowed fields	Migrant
Piping Plover	Potential migrant	Migrant
Red-cockaded woodpecker	Mature pine forests of the southeastern U.S. and nests almost exclusively in old living pines infected with red heart disease	No
Snowy plover	Wintering migrant through most of the state	Migrant
Southeastern snowy plover	Wintering migrant through most of the state	Migrant
White-faced ibis	Fresh water marshes, sloughs, and irrigated rice fields, and also the occasional brackish and saltwater habitat	Yes
White-tailed hawk	Savannah-like, grassland habitats	No
Whooping crane	Winters in the prairies, salt marshes, and bays along the Texas coast	No
Wood stork	Central and upper coastal prairies and a regular visitor of lakes and reservoirs in central and East Texas	No
Fishes		
American eel	Coastal waterways, most aquatic habitats with access to ocean	No
Creek chubsucker	Sand and gravel bottom pools of clear headwaters, creeks, small rivers, and (occasionally) lakes, often near vegetation	No
Paddlefish	Large, free-flowing rivers	No

TABLE 3-16 (CONT.)
HABITAT DESCRIPTIONS FOR STATE AND FEDERAL THREATENED, ENDANGERED, AND RARE SPECIES IN HARRIS AND MONTGOMERY COUNTIES, TEXAS

Species	Habitat	Habitat Present* within Project Area
Mammals		
Louisiana black bear	Bottomland hardwoods and large tracts of undisturbed forest	No
Plains spotted skunk	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands	Yes
Rafinesque's big-eared bat	Roosts most frequently in buildings, wells, and hollow trees in bottomland hardwood forest	Yes
Red wolf	Brushy and forested areas, as well as the coastal prairies	No
Southeastern myotis bat	Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures	Yes
Mollusks		
Creeper (squawfoot)	Small to large streams, prefers gravel or gravel and mud in flowing water; Colorado, Guadalupe, San Antonio, Neches (historic), and Trinity (historic) River basins	No
Little spectaclecase	Creeks, rivers, and reservoirs, sandy substrates in slight to moderate current, usually along the banks in slower currents; East Texas, Cypress through San Jacinto River basins	Yes
Louisiana pigtoe	Streams and moderate size rivers, usually flowing water on substrates of mud, sand, and gravel	Yes
Pistolgrip	Stable substrate, rock, hard mud, silt, and soft bottoms, often buried deeply; East Texas, Red through San Antonio River basins	No
Rock-pocketbook	Mud, sand, and gravel substrates of medium to large rivers; East Texas, Red through Guadalupe River basins	No
Sandbank pocketbook	Small to large rivers with moderate flows and swift current on gravel and sand bottoms; East Texas, Big Cypress though San Jacinto River basins	Yes
Texas pigtoe	Rivers with mud, sand, and fine gravel in protected areas; East Texas river basins, Sabine though Trinity Rivers; San Jacinto	Yes
Wabash pigtoe	Creeks to large rivers on mud, sand, and gravel, all habitats	Yes
Reptiles		
Alligator snapping turtle	Deep rivers, lakes, and large streams with muddy bottoms	Yes
Louisiana Pine Snake	Sandy, longleaf piney woods	No
Sea turtles	Gulf of Mexico and may utilize the beaches along the coast as nesting grounds	No
Smooth green snake	Mesic shortgrass prairies	No
Texas horned lizard	Flat, open terrain, scattered vegetation, and sandy or loamy soils	No
Timber/Canebrake rattlesnake	Dense thickets and brushy areas along extensive floodplains of major creeks and rivers	Yes

TABLE 3-16 (CONT.)
HABITAT DESCRIPTIONS FOR STATE AND FEDERAL THREATENED, ENDANGERED, AND RARE SPECIES IN HARRIS AND MONTGOMERY COUNTIES, TEXAS

Species	Habitat	Habitat Present* within Project Area
Plants		
Coastal gay-feather	Black clay soils of prairie remnants, flowering in fall	No
Giant sharpstem umbrella sedge	Remnant coastal prairies in poorly drained sites	No
Houston daisy	Seasonally wet, saline soils and undeveloped areas, around the base of mima mounds in coastal prairies, pastures, roadsides	Yes
Texas meadow-rue	Messic woodlands or forests, including wet ditches on partially shaded roadsides	Yes
Texas prairie dawn	Poorly drained depressions or base of mima mounds in open grasslands or almost undeveloped areas or saline soils	Yes
Texas windmill-grass	Sandy to loam soils in open to sometimes undeveloped areas in prairies and grasslands, ditches and roadsides	No
Threeflower broomweed	Black clay soils of remnant grasslands, tidal flats	No

Note: *Assessments made after initial investigations using aerial photographs and limited field work. More detailed assessments were made for the Preferred Alternative Alignment, as described in Section 4.17 of this volume.

**The bald eagle was delisted by the USFWS on August 8, 2007 and is no longer a federal threatened species; however, it will be monitored closely for at least the next five years and is still afforded protection under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act.

Source: USFWS, 2007a; TPWD, 2007a, 2007b, 2007c

As part of initial scoping activities, coordination with state and federal resource agencies was conducted. A search of TPWD's Texas Natural Diversity Database (TXNDD) was conducted (TPWD, 2007c). According to the TXNDD, there are no known specific locations (e.g., nest sites, colonies, etc.) of protected species within the Segment G project area (TPWD, 2007c).

Although the TXNDD did not indicate any known specific locations of protected avian species within the Segment G project area itself, two species have been recorded in the vicinity. The red-cockaded woodpecker (*Picoides borealis*) has been recorded south of the project area, and a bald eagle nesting territory extends into the western portion of the project area (TPWD, 2007c). Correspondence with TPWD confirmed that the bald eagle nest site is located approximately five miles north of the project area (TPWD, 2007d). It was last monitored in 2005; however, the TPWD indicates that residents in the area have spotted an eagle in 2007.

Avian species are primarily likely to occur in the Segment G project area during foraging and roosting activities and during spring and fall migrations. Bald eagles and wood storks have been noted foraging and roosting near reservoirs and other waterbodies in recent years, per field surveys and informal discussions with USFWS and TPWD staff during project coordination meetings.

No other documented or even anecdotal reports of species listed in Table 3-16 are known within the Segment G project area (TPWD, 2007c).

3.18 CULTURAL RESOURCES

Segment G of the Grand Parkway is located in southeastern Montgomery County and northern Harris County, in the Southeast Texas Archeological Region. Segment G project area is dominated by woods and blackland prairies. A review of the 1920 (USGS, 1920) topographic quadrangle maps and Montgomery and Harris County general highway maps (TxDOT, 1936, 1941, 1947, 1948, 1952, and 1957), indicates the area was largely rural well into the mid-twentieth century.

3.18.1 Area of Potential Effect (APE)

For prehistoric archeological resources, the APE was defined by the ROW limits of the transportation project. In the case of non-archeological historic resources, the APE was developed between the State Historic Preservation Officer (SHPO) and TxDOT. For Grand Parkway Segment G, it was determined that the APE for the proposed project extends 1,300 feet on either side of the proposed ROW. This APE was examined for all alternatives including the selected Preferred Alternative Alignment.

3.18.2 Cultural Chronology

The cultural framework for the Segment G project area is based on divisions proposed by Story et al. (1990) for the Southeast Texas Gulf Coastal Plain, including the San Jacinto River Basin. An overview of the prehistoric, protohistoric, and historic eras can be found in Volume I, Section 3.18 (Cultural Resources). A detailed discussion of these eras in relation to the Segment G project area is presented in the following sections.

3.18.2.1 Prehistoric Era

Paleoindian (9500 to 7000 B.C.)

This period is characterized by mobile groups of people exploiting a wide variety of resources on the lower Texas coastal plain. Several types of well-made, lanceolate, parallel-flaked projectile points diagnostic of this period, including Scottsbluff, Clovis, Plainview, San Patrice, and Angostura, have been recovered from archeological contexts in Harris and Montgomery Counties. Nearby sites yielding this information include 41HR5, 41HR7 (Wheat, 1953), 41HR61, 41HR73 (Story et al., 1990), 41HR85 (Aten et al., 1976), 41HR89, 41HR182, 41HR194, 41HR273, 41HR282, 41HR285, 41HR315, 41HR525, 41HR571, 41MQ41, 41WA83, and 41SJ160 (Story et al., 1990).

Archaic Cultures (7000 B.C. to A.D. 100)

This period is characterized by the replacement of widespread point styles of the Paleoindian period by more area-specific styles, most likely because of a change in resource exploitation. Evidence of Early Archaic cultures is scarce in the

vicinity of Segment G, while Late Archaic cultures are better represented. Nearby sites yielding information for this broad period include 41HR315, 41MQ4, 41MQ6, 41MQ41, and 41SJ160 (Story et al., 1990). Archaic cemetery and midden sites along the western Galveston Bay margin, 41HR80 and 41HR85, and along the Brazos River drainage, 41AU36, suggest increased population densities in nearby areas during this period.

Early Ceramic (A.D. 100 to A.D. 900)

The artifacts of the Early Ceramic period resemble those of the Late Archaic cultures with the addition of pottery. Story et al. (1990) suggest the Clear Lake Period (A.D. 100 to 425) of the Mossy Grove Tradition as the beginning date for sandy paste pottery associated with Kent and Gary points in this vicinity. Early ceramic sites in Harris and Montgomery Counties yielding this information include 41HR1, 41HR5, 41HR7, 41HR61, 41HR80, 41HR82, 41HR85, 41MQ4, 41MQ5, 41MQ6, 41SJ160 (Story et al., 1990), and 41HR436 (Kotter and Fields, 1983).

Late Ceramic (ca. A.D. 900 to A.D. 1528)

The bow and arrow, small drills, and grog and bone tempered pottery are indicators of this period. Pottery from the north is well represented for this period, suggesting interaction with, or occupation by, northern groups in this vicinity (Story et al., 1990). Sites indicative of this period in Harris and Montgomery Counties include 41HR1, 41HR5, 41HR7, 41MQ6, 41MQ121 (Story et al., 1990), and 41HR436 (Kotter and Fields, 1983).

3.18.2.2 Protohistoric Era

Much of what is known from this period has been learned via the study of early maps, diaries, and oral histories. Coordination of archeological data with this documentary evidence has been rare. It is believed Cabeza de Vaca and three crewmembers from the Narvaez expedition landed at the mouth of Oyster Creek in nearby Brazoria County (Wharton, 1939). Cabeza de Vaca may have traveled up the San Jacinto River through northern Harris County on a quest to find the Spanish Colonies of Mexico (Hensen, 1999). Although primarily occupied by Native Americans, the Spanish loosely controlled this area for most of the next three centuries, establishing a few missionary and military outposts. In 1821, Mexico established its claim to the region. While the potential for discovery of archeological sites from this period is fairly remote, the potential for site discovery increases with the subsequent settlement by Anglo-American and other European immigrants beginning in the early 19th century.

3.18.2.3 Historic Era

Anglo-American and European Settlements and Communities

The earliest Anglo-American families arrived in the San Jacinto River Basin as participants in a colonization effort led by Stephen F. Austin, who acted first as a Spanish empressario and later as a Mexican empressario. The colonists received grants of land in proportion to their family status and time of arrival in the colony. Spring became one of the earliest settlements in the Segment G area with a trading post operated by William Pierpont in 1838 (American Association of University Women, 1977).

Continued European immigration into southern Montgomery County and northern Harris County was especially substantial in the 1840s, 1850s, and 1870s. During this period, Germans constituted the largest percentage of the influx to this area, followed by settlers from the southern states (Severance, 1999). While many of the region's immigrants settled on individual farmsteads that were sometimes distant, others settled in less isolated locales to be nearer those of the same ethnicity or place of origin. Some of these locales developed over time into viable communities and towns that served as cultural, religious, and educational centers for the surrounding farm families. These early communities were often located along primary transportation routes through the area, such as the old Atascosita Road. As the area continued to be settled through the middle and latter 19th century, some of the older roads were abandoned and a network of newer roads and trails developed (USGS, 1920).

Prior to the Civil War, Montgomery County exhibited a large slave-based plantation economy very similar to other southern states. By 1860, almost half of the population worked as bondsmen or indentured servants. Local communities gradually recovered from the Civil War during Reconstruction, but Montgomery County, in general, experienced a severe economic depression. It took the construction of several railroads and the accompanying timber boom to spark a period of expansion. The arrival of rail transportation greatly improved means of marketing agricultural produce and timber products. It also enhanced the development of towns and communities located along the railroad's route. The Houston and Great Northern Railroad was built through Spring in 1871. Like many towns that were positively influenced by the arrival of the railroad, Spring included a central street grid focused along the route of the railroad. Beyond this, the community also included widely dispersed farms and ranches that extended into the surrounding countryside (USGS, 1920). In 1872, Charles Bender, a German immigrant, initiated timber and milling businesses that would eventually cover parts of Harris, Montgomery, Liberty, and Polk Counties. The first post office in the area was established at Spring in 1873, followed by New Caney in 1882, and Porters in 1892 (Wheat, 2000). By 1880, Spring had two steam saw and gristmills, two cotton gins, three churches, and several schools (Severence, 1999). Its location along the railway system ensured its survival into the 20th and 21st centuries, where other towns not so well positioned were abandoned and forgotten (USGS, 1920).

With the advent of the railroads also came increased support for Texas' publicly funded school system. As a result, many of the smaller rural schools that served only a few farm families were combined and relocated to more substantial towns like Spring often located along the railroads (USGS, 1920). By 1902, the Wunsche family capitalized on this reorganization and expanded their businesses to include the Wunsche Brothers Saloon and Hotel (listed on the National Register of Historic Places [NRHP] in 1984). The International-Great Northern Railroad connected Spring with Fort Worth by 1903; and the Trinity and Brazos Valley Railway was constructed through Montgomery and Harris Counties ca. 1907 (Severance, 1999; TxDOT, 1936). Spring became a major railroad center with a roundhouse, switchyard, 14 track yards, and 200 rail workers (Severence, 1999).

Many farms and ranches in the Segment G project area benefited from the discovery and exploitation of local oil and gas discoveries in the early part of the 20th century. Moonshine Hill, located east of Humble in northeastern Harris County was one of the first oilfield discoveries in the area in 1904 (Kleiner, 1999). Other oil and gas fields were developed near Conroe, Humble, Magnolia, Pinehurst, and Fostoria in the late 1930s and early 1940s (TxDOT, 1936 and 1941). Income from mineral and timber operations often supplemented or even replaced agricultural production (Dennis and Upchurch, 1999).

Agriculture and Timber Industry

Historically, agriculture and timber production have been the economic mainstays in the Segment G vicinity, where the coastal prairie and the southern evergreen forest converge. Water from abundant natural springs along Spring Creek and rich blackland prairie soils enabled farmers to subsist by raising livestock and growing corn, sugar cane, sweet potatoes, potatoes, sweet sorghum, peanuts, and hay. Cotton served as one of the primary cash crops from the early 19th century until the early 20th century (Geib et al., 1928).

Timber-related industries strongly influenced the local economy, particularly in the late 19th and early 20th century periods when railroad transportation dramatically expanded. Substantial stands of timber occurred in better-drained areas and along streams extending across the coastal prairies. Although the primary timber cut for lumber production was loblolly pine (Geib et al., 1928: 1904-1905; and 1908), forest growth ca. 1900 included oak, sweet gum, ash, sycamore, pecan, hackberry, live oak, elm, ironwood, magnolia, hickory, bay, and cypress (American Association of University Women, 1977). There were sawmills operating in Spring and New Caney as early as the 1880s (Severance, 1999), and a total of 45 steam sawmills were operating throughout Montgomery County. During the first half of the 20th century sawmills were also recorded at Thoms, Splendora, and Porter.

3.18.3 Archeological Resources

3.18.3.1 Previous Archeological Investigations

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, 1932). With the exception of excavation at the Caplen Site, a prehistoric cemetery in nearby Galveston County, little of his investigations in the region was ever published (Campbell, 1957). Since then, numerous cultural resource management studies have been conducted in the region, but few of these have occurred in the Segment G project area until recently. Regional reviews of previous research along the upper Texas Gulf Coast have been presented by Aten (1983), Fields et al. (1983), and Stokes (1985). In addition, Moore et al. (1989), Story et al. (1990), and Patterson (1995) have compiled extensive bibliographies for the archeology of this region.

River Basin Surveys

The first major investigation in the vicinity of the Segment G project area was conducted by the Austin, Texas office of River Basin Surveys, a unit of the Bureau of American Ethnology at the Smithsonian Institution. In the 1940s, Joe Ben Wheat investigated the Addicks Reservoir area and several other locations within the San Jacinto River Basin in Harris County. Subsequent surveys and excavations conducted by the Houston Archeological Society (HAS) have contributed to the understanding of prehistoric settlement patterns, cultural chronology, and technological change in this area (Patterson, 1972; 1973a; 1973b; 1974; 1975; 1976; 1977; 1980a; and 1980b).

In 1958, the Texas Archeological Salvage Project (TASP) from the University of Texas replaced the Office of River Basin Surveys (Story et al., 1990) and went on to conduct investigations in the area. In 1965 and 1967, the TASP excavated sites 41MQ4, 41MQ5, 41MQ6, and 41MQ14 at Lake Conroe. Materials recovered at these sites expanded the knowledge of the area and pointed to evidence of culture contact with Late Prehistoric groups in the Caddoan area to the north and the Galveston Bay area to the south (Story et al., 1990).

Other Work

In 1971, James Malone from the THC carried out surveying, testing, and excavation at the Kirbee Kiln site (41MQ38) along Juggery Creek (Story et al., 1990). This site consisted of several piles of decomposing and cracked brick and stoneware sherds. A historic kiln was thought to have operated at this location from 1840 to the time the Kirbee family went off to the Civil War (Malone et al., 1979).

From 1967 to 1986, the Texas Parks and Wildlife Department sponsored archeological research in state parks, state recreation areas, and state historic sites throughout southeast Texas. This work included a 1982 survey at Lake Houston State Park that found no prehistoric or historic sites along the proposed Mont Belvieu-Conroe Pipeline.

In the 1970s and early 1980s, Texas A&M University conducted survey and testing in Sam Houston National Forest. These efforts recovered early and middle lithic period components that may represent the oldest cultural remains yet recovered from the Lake Conroe district (Shafer and Baxter, 1975). In 1980, the Texas Department of Water Resources conducted a survey for the city of Conroe and revisited an undisturbed Archaic site at Camp Martha Foster Madeley, originally located by the Girls Scouts of America in 1974.

More recently, TxDOT, USACE, and various development corporations have conducted highway, utility, and site-specific surveys in Montgomery County. These surveys have identified few sites that have warranted further testing.

3.18.3.2 Known Prehistoric and Historic Sites

Known site locations were researched using the THC online Texas Archeological Sites Atlas, which revealed more than 985 previously recorded archeological sites in Harris County. Of these sites, 242 are listed on the NRHP, and 87 are identified as State Archeological Landmark (SAL) properties. The Sites Atlas lists 196 previously recorded archeological

sites in Montgomery County. Of these sites, two are listed on the NRHP, and none are identified as SAL properties. Because of the official archeological records review, no previously recorded sites were identified within the Segment G project area.

3.18.3.3 Archeological High Probability Areas (HPAs)

As part of the corridor selection process within Segment G, efforts were made to identify areas with a high probability for containing cultural resources. HPAs for prehistoric and historic cultural resource sites were predicted for this project using a TxDOT GIS model called the Houston Potential Archeological Liability Map (Houston-PALM) of the Houston District (Exhibit G–29). While the Houston-PALM has been shown to illustrate the potential for prehistoric sites in the area, it is not intended to predict the location of historic archeological sites. Historical cultural resource sites were further predicted based on the review of historical maps of Harris and Montgomery Counties, local historical literature, and agricultural publications.

The primary criteria used in developing the Houston-PALM (Abbott, 2001) included landform types, soil types, and evidence of historic and recent land use. These mapping criteria were integrated with broad environmental determinations (upland, coastal, riverine, and water) from the Geologic Atlas of Texas (Bureau of Economic Geology, 1982) and field reconnaissance of the Houston area. Based on the results of this work, an initial matrix was used to construct a set of mapping criteria in consultation with the Texas SHPO and independent reviewers. These criteria were then used to map geoarcheological potential in the Houston District of TxDOT.

Seven basic map units were defined in constructing the Houston-PALM, and each was assigned a particular set of recommendations for archeological survey and/or testing. These units and recommendations are as follows:

- Map Unit 0 – Waterbodies, No Survey Required;
- Map Unit 1 – Surface Survey Recommended, Deep Reconnaissance Recommended if Deep Impacts are Anticipated;
- Map Unit 2 – Surface Survey Recommended, No Deep Reconnaissance Recommended;
- Map Unit 2a – Surface Survey of Mounds Only; No Deep Reconnaissance Recommended;
- Map Unit 3 – No Surface Survey Recommended, Deep Reconnaissance Recommended if Deep Impacts are Anticipated;
- Map Unit 3a – No Surface Survey Recommended, Deep Reconnaissance Recommended only if Severe Deep Impacts are Anticipated; and
- Map Unit 4 – No Survey Recommended.

Based on the assumptions set forth in the Houston-PALM, Map Units 1, 2, 2a, 3, and 3a represent areas of high probability for prehistoric and historic archeological resources. In order to fully assess the potential for cultural resources

in the selection of the Preferred Alternative Alignment within the Segment G project area, a summary matrix of HPAs was developed for comparison (Table 3-17). The actual number of archeological sites will not be known until archeological field surveys have been completed. The description of the survey will be available in the FEIS.

TABLE 3-17
SEGMENT G ARCHEOLOGICAL RESOURCE HIGH PROBABILITY AREAS BY MAP UNIT NUMBER

Alternative Alignment	Reach	Map Unit 1	Map Unit 2	Map Unit 2a	Map Unit 3	Map Unit 3a	Total Probability Area (acres)
A	8	50.7	140.1	-	20.5	-	211.3
	9	27.8	145.1	-	6.1	-	179.0
	10	-	3.2	-	-	-	3.2
	11	-	51.4	-	-	-	51.4
	12	12.3	81.6	-	-	-	93.9
Alt. Alignment A Total		**90.8**	**421.4**	**0**	**26.6**	**0**	**538.8**
B	8	108.1	122.4	-	-	-	230.5
	9	62.0	89.5	-	18.8	-	170.3
	10	-	3.2	-	-	-	3.2
	11	-	44.8	-	-	-	44.8
	12	22.3	78.1	-	-	-	100.4
Alt. Alignment B Total		**192.4**	**338.0**	**0**	**18.8**	**0**	**549.2**
C	8	50.7	140.0	-	20.5	-	211.2
	9	81.0	85.4	-	4.9	-	171.3
	10	-	19.2	-	-	-	19.2
	11	-	56.0	-	-	-	56.0
	12	55.9	50.8	-	-	-	106.7
Alt. Alignment C Total		**187.6**	**351.4**	**0**	**25.4**	**0**	**564.4**
D	8	50.7	140.0	-	20.5	-	211.2
	9	69.1	94.3	-	13.2	-	176.6
	10	-	3.2	-	-	-	3.2
	11	-	51.4	-	-	-	51.4
	12	55.9	50.8	-	-	-	106.7
Alt. Alignment D Total		**175.7**	**339.7**	**0**	**33.7**	**0**	**549.1**
Recommended	8	50.7	140.0	-	20.5	-	211.2
	9	69.1	94.3	-	13.2	-	176.6
	10	-	3.2	-	-	-	3.2
	11	-	51.4	-	-	-	51.4
	12	55.9	50.8	-	-	-	106.7
Rec. Alignment Total		**175.7**	**339.7**	**0**	**33.7**	**0**	**549.1**

TABLE 3-17 (CONT.)
SEGMENT G ARCHEOLOGICAL RESOURCE HIGH PROBABILITY AREAS BY MAP UNIT NUMBER

Alternative Alignment	Reach	Map Unit 1	Map Unit 2	Map Unit 2a	Map Unit 3	Map Unit 3a	Total Probability Area (acres)
Preferred	8	50.7	141.0	-	20.5	-	212.2
	9	68.6	93.9	-	13.7	-	176.2
	10	-	3.2	-	-	-	3.2
	11	-	51.4	-	-	-	51.4
	12	55.9	50.8	-	-	-	106.7
Pref. Alignment Total		**175.2**	**340.3**	**0**	**34.2**	**0**	**549.7**

Source: Study Team, 2007

3.18.4 Non-Archeological Historic Resources

Non-archeological historic-age resources, primarily consisting of residential and agricultural buildings observed in the Segment G project area represent patterns of rural agricultural and community development that were typical across rural Texas and Harris and Montgomery Counties in the early to mid-twentieth century. Few resources from the pre-1900 period remain within the Segment G project area, partly as a consequence of the 1900 and 1915 hurricanes that destroyed many of the 19th century buildings and structures on the open prairies and along the waterways of Harris and Montgomery Counties (THC, 1978). The subsequent pattern of historical development is typically limited to a few popular house types, ranging from early 20th century bungalows to mid-20th century ranch houses, and their associated utilitarian farm buildings and structures. The APE was reviewed for the presence of NRHP-listed or eligible properties as well as for any Recorded Texas Historic Landmarks, SALs (non-archeological), or Official State Historical Markers.

3.18.4.1 Survey of Non-Archeological Historic Resources

To identify non-archeological historic resources eligible for NRHP listing, research was conducted using historical maps of Harris and Montgomery Counties, TxDOT's historic bridges database, local historical literature, and agricultural publications. Informants and landowners were also contacted in the area. Sites were then examined in the field from publicly accessible property and roadways to locate resources dating to ca. 1957 or earlier. Visible resource locations within or near the APE of each alternative alignment were photographed and recorded on project maps (Exhibit G–50). Brief descriptive information about each recorded resource was entered into a non-archeological historic resources database for use in planning and evaluating route alternatives. Using maps, photographs, and historical information for each recorded resource, NRHP eligibility assessments were made by TxDOT with SHPO concurrence (Appendix H). Table 3-18 presents brief information about each of these recorded resources, and Exhibit G–50 shows the locations of these resources.

TABLE 3-18
RECORDED NON-ARCHEOLOGICAL HISTORIC RESOURCES IN AND ADJACENT TO THE SEGMENT G PROJECT AREA

Resource No.	Location	Property Type	Description	Comments	NRHP Assessment*	Proximity to Alternative Alignment Route
G-1	IH 45	Residential: Dwelling	1-story wooden framed residence	Ca. 1950	Not Eligible	Outside APE
G-2	E. Hardy	Residential: Dwelling	1-story, bungalow; replacement porch supports	Ca. 1920; adjacent to railroad tracks	Not Eligible	In ROW of Alternative Alignments A/C/D
G-3	E. Hardy	Residential: Dwelling	1-story, front gabled, bungalow, corner porch	Ca. 1930	Not Eligible	Outside APE
G-4	E. Hardy	Cemetery	Fenced on 4 sides, fair maintenance; some old style markers	Ca. 1918	Not Eligible	In ROW of Alternative Alignment B; ROW across corner
G-5	E. Hardy	Recreation	Ball field w/ chain link back stop and bleachers	Ca. 1950	Not Eligible	200 ft north of Alternative Alignments A /C/D
G-6	E. Hardy	Residential: Dwelling	1-story, -end-gabled bungalow , partial front porch	Ca. 1930	Not Eligible	1,000 ft south of Alternative Alignments A /C/D
G-7	E. Hardy	Residential: Dwelling	1-story wood gabled bungalow	Ca. 1930	Not Eligible	Outside APE
G-8	Riley Fuzzel & Hardy Toll Rd	Residential: Dwelling	1-story, hipped-roof, bungalow, sheltered front porch	Ca. 1920	Not Eligible	Outside APE
G-9	Riley Fuzzel	Residential: Dwelling	1-story, end-gabled, bungalow	Ca. 1945	Not Eligible	Outside APE
G-10	Riley Fuzzel	Agricultural: Farmstead	1-story, end-gabled, residence; Full width front porch	Ca. 1910	Not Eligible	1,300 ft south of Alternative Alignments A /C/D
G-11	Riley Fuzzel	Residential: Dwelling	1-1/2 story bungalow, clipped front gable and front porch.	Ca. 1920	Not Eligible	1,300 ft south of Alternative Alignments A /C/D
G-12	Riley Fuzzel	Residential: Dwelling	1-1/2 story residence; set behind entry road lined with trees	1945	Not Eligible	1,300 ft south of Alternative Alignments A /C/D
G-13	Riley Fuzzel & San Jacinto River	Transportation: Bridge	Concrete bridge	Ca. 1965; have BRINSAP; not pre-1957	Not Eligible	600 ft south of Alternative Alignments A /C/D
G-14	Riley Fuzzel	Agricultural: Farmstead	1-story, end-gabled, bungalow, partial width porch	Ca. 1920	Not Eligible	In ROW of Alternative Alignments A/C/D ; ROW extends across farm tract; 300 ft south of Alternative Alignment B
G-15	Riley Fuzzel	Agricultural: Farmstead	1 story, side-gabled residence; Shed porches on either side of central gable front	May not be historic-age	Not Eligible	100 ft north of Alternative Alignments A/B/C/D

TABLE 3-18 (CONT.)
RECORDED NON-ARCHEOLOGICAL HISTORIC RESOURCES IN AND ADJACENT TO THE SEGMENT G PROJECT AREA

Site No.	Location	Property Type	Description	Comments	NRHP Assessment*	Proximity to Alternative Alignment Route
G-17	Riley Fuzzel	Commercial	1-room residence w/ corrugated metal roof	Ca. 1965; was office for previous owners named Herron. May also have been a weigh station house	Not Eligible	100 ft south of Alternative Alignments A/B/C/D
G-18	Riley Fuzzel	Agricultural: Farmstead	1-story, end gabled bungalow, full-width porch with gable infill	Ca. 1930	Not Eligible	In ROW of Alternative Alignments A/B/C/D; ROW extends across farm tract
G-20	Lyndall	Residential: Dwelling	1-story, end-gabled bungalow, clipped-gable porch, supports replaced	Ca. 1920	Not Eligible	700 ft north of Alternative Alignments A/D
G-21	Hillcrest	Residential: Dwelling	1-story, end gabled, residence, replacement windows	Ca. 1955	Not Eligible	400 ft south of Alternative Alignment B
G-24	FM 1314	Dwelling	1-story, end gable shotgun	Ca. 1940	Not Eligible	1,100 ft south of Alternative Alignment C
G-25	E. Hardy	Residential: Dwelling	1-story front gable, residence; inset porch, replacement siding	Ca. 1920 with additions	Not Eligible	400-800 ft south of Alternative Alignments A/C/D
G-26	Riley Fuzzel	Recreation: Camp	Multiple 1-story frame and rock buildings, replacement windows, modern structures	Ca. 1920	Not Eligible	In ROW of Alternative Alignments A/C/D; 700 ft south of Alternative Alignment B

Note: * Effects determination letters with SHPO concurrence can be found in Appendix H.
Source: Study Team, 2007

3.18.4.2 NRHP-Listed or Eligible Non-Archeological Historic Properties

Official records and site listings of the THC indicate no NRHP-listed or eligible non-archeological historic properties are recorded in or adjacent to the Preferred Alternative Alignment or other alternative alignments being considered within the Segment G project area. Nor were any Recorded Texas Historic Landmarks, SALs (non-archeological), or Official State Historical Markers identified in the project vicinity. A survey for non-archeological historic resources identified 22 historic resources. The TxDOT Environmental Affairs Division architectural historians initiated and completed coordination with the SHPO on these sites in the Segment G project area during 2002 (Appendix H). All 22 resources were recommended "not eligible" for the NRHP.

3.19 HAZARDOUS MATERIALS

A search of publicly available records for hazardous material sites (Appendix I) was conducted for the Segment G project area. The following list of TCEQ and EPA databases were reviewed for this study:

- Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) – CERCLIS is the official repository for site and non-site specific Superfund data in support of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and contains information on hazardous waste site assessments and remediation from 1983 to the present.
- National Priority List (NPL) – The NPL is a priority subset of the CERCLIS list that lists priority sites that the EPA has determined to pose a threat to human health and/or the environment and where remedial action is required.
- No Further Remedial Action Planned (NFRAP) – The NFRAP database lists of a CERCLIS site that has been designated as "no further remedial action planned."
- Resource Conservation and Recovery Information System (RCRIS) – Treatment, Storage, or Disposal (TSD) Database - RCRIS, under the Resource Conservation and Recovery Act (RCRA) that identifies registered hazardous waste generators, transporters, treatment, storage, and disposal facilities, provides information to state environmental agencies/EPA concerning facility activities. The RCRIS-TSD database is a subset of the RCRIS list, which tracks facilities that generate, transport, treat, store, and/or dispose of hazardous waste.
- RCRIS Corrective Action (CORRACT) Database – The CORRACT database lists sites that are currently or in the past have had corrective action.
- RCRIS Generators (RCRIS-G) Database – The RCRIS-G database, under the RCRA, tracks facilities that generate or transport hazardous waste. A conditionally exempt small quantity generator (CESQG) is a facility that produces less than 100 kilograms per month of hazardous waste, a small quantity generator (SQG) produces at least 100 kilograms per month but less than 1,000 kilograms per month of hazardous waste, and a large quantity generator (LQG) produces more than 1,000 kilograms per month of hazardous waste.
- Emergency Response Notification System (ERNS) – The ERNS database supports the release notification requirements of Section 103 of the CERCLA, as amended; Section 311 of the CWA; and Sections 300.51 and 300.65 of the National Oil and Hazardous Substances Contingency Plan. Additionally, ERNS serves as a mechanism to document and verify incident location information as initially reported and is utilized as a direct source of easily accessible data needed for analyzing oil and hazardous substance spills.
- Texas Voluntary Cleanup Program (TXVCP) – The TXVCP was established in 1995 to provide administrative, technical, and legal incentives to encourage the cleanup of contaminated sites in Texas.
- Texas State Superfund (TXSSF) List – The TXSSF database is a list of sites that the state of Texas has identified for investigation or remediation.
- Texas Landfill (TXLF) Database – This database is a listing of solid waste facilities registered and tracked by the TCEQ Solid Waste Division. The TCEQ requires municipalities and counties to report active and inactive landfills. The facilities tracked include solid waste disposal sites as well as transfer and processing stations.

- Unauthorized and Unpermitted Landfills (LFUN) Database – The LFUN database is compiled by Southwest Texas University under contract with TCEQ and includes sites that have no permit and are considered abandoned.
- Leaking Underground Storage Tank (LUST) Database – The LUST database is a list of facilities with known underground storage tank releases maintained by the TCEQ.
- Registered Storage Tank Database – The Registered Storage Tank database is a list of facilities with permitted underground storage tanks (USTs) and/or above ground storage tanks (ASTs).
- Texas Innocent Owner/Operator Program (TXIOP) – The TXIOP database is maintained by the TCEQ and tracts properties impacted by adjacent properties. These properties enrolled in the TXIOP do so after the property has changed hands if an undetected source of off-site contamination were discovered.
- Brownfields Database (BRNFD) – The BRNFD database consists of properties that have a historical use that may have resulted in the presence of hazardous substances or pollutants. This database is maintained by the TCEQ.
- Dry Cleaner Database (DRYC) – The DRYC database is maintained by the TCEQ and tracts dry cleaning drop stations and dry cleaning facilities.
- Indian Reservation Underground Storage Tanks (IRUST) – The IRUST database is maintained by the EPA and tracts permitted underground storage tanks on Indian Land.
- Texas Spills Incident Information System (TXSPILL) – The TXSPILL database tracks cases where emergency response is needed for cleanup of toxic substances.

3.19.1 Regulated Hazardous Material Sites

According to the regulatory agency database report and the site reconnaissance, there are 14 facilities registered with state and/or federal agencies identified within the Segment G project area. Two of the sites are listed on multiple databases and may reflect a change in ownership. According to regulatory database searches, the following sites are located within the project area:

- One (1) CERCLIS site;
- One (1) NFRAP site; and
- One (1) RCRIS – G site;
- One (1) ERNS site;
- Six (6) LFUN sites;
- One (1) TXLF site;
- Two (2) LUST sites;
- Two (2) UST sites; and
- One (1) TXSPILL site.

No NPL, RCRIS CORRACT, TXVCP, TXIOP, BRNFD, DRYC, IRUST, and TXSSF sites were located within the project area. The following provides a summary of the results of the regulatory agency database information search.

3.19.1.1 Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)

According to the regulatory review, one CERCLIS facility is located within the project area:

- Bull Oil and Chemical Transporters (Site ID No. 17) located at 28528 Hardy Street, Spring, Texas, 77373.

3.19.1.2 No Further Remedial Action Planned (NFRAP)

According to the regulatory review, one NFRAP facility is located within the project area:

- Hardy Road Drum Site (a.k.a Bull Oil and Chemical Transporters) (Site ID No. 18) is located at 28528 Hardy Street, Spring, Texas, 77373.

3.19.1.3 Resource Conservation and Recovery Information System – Generator (RCRIS-G)

According to the regulatory review, one RCRIS-G facility is located within the project area:

- Home Depot USA Inc. (Site ID No. 13) is located at 22820 IH 45 North, Bldg A, Spring, Texas, 77373.

3.19.1.4 Emergency Response Notification System (ERNS)

According to the database, there is one reported spill within the project area. The spill involved a release from a tanker trunk that struck a stationary train. An unknown quantity of vinyl acetate was released into the rock ballast of the railroad. The location of the release identified within the project area is:

- Enterprise Transportation (Site ID No. 5) is located at the frontage road of IH 45 at the Spring Stuebner Road, Houston, Texas.

3.19.1.5 Unauthorized/Unpermitted Landfill (LFUN)

The LFUN database is compiled by Texas State University under contract with TCEQ. These sites may include properties that have had either a reported incident of unauthorized dumping or dumpsite with no permit that are considered abandoned. According to the database, there are six unauthorized dumpsites reported within the project area. Three of the sites (Sites 6, 17, and 21) are reported to contain demolition materials, while three (Sites 4, 16, and 23) are reported to contain household waste. The regulatory report did not indicate the nature of the waste material in the Johnny Jelks Landfill. The LFUN sites identified within the project area during the database search are:

- Bull Oil and Chemical Transporters (Site ID No. 17) is located at 28528 Hardy Road, Harris County.
- City of Spring Abandoned Dump (Site ID No. 23) is located near 27830 Hardy Road, Harris County.
- Doc Pruitt & Leo Carter Dumps (Site ID No. 16) is located near 27800 Block of Hardy Road, Harris County.
- Johnny Jelks Landfill (Site ID No. 4) is located west of the 28000 Block of Hardy Road, Harris County.

- B&W Sand Co. (Site ID No. 6) is located two miles north of Spring on Riley Fuzzel Road, Montgomery, Texas.
- Averie Bass Landfill (Site ID No. 21) is located two miles north of Spring, Texas on Riley Fuzzel Road, Montgomery County, Texas.

3.19.1.6 Solid Waste Facilities (TXLF)

The TCEQ solid waste division registers and tracks solid waste disposal facilities as well as transfer stations and processing stations. According to the database, there is one solid waste processing facility within the project area:

- Spring Sand Solid Waste Processing Facility (Site ID No. 7) is located at 2107 Riley Fuzzel Road, Montgomery County, Texas.

3.19.1.7 Leaking Underground Storage Tank (LUST) Sites

The LUST database is a list maintained by TCEQ of facilities where a known UST release has occurred. According to the database, two sites within the project area are listed as the location of a LUST. One release resulted in a soil contamination while the other reported no groundwater impact. The TCEQ has issued a final concurrence in each incident and both cases are closed. The LUST facilities identified within the project area during the database search are:

- Northgate Outdoor Power and Tractor (Site ID No. 14) is located at 22820 N IH 45, Spring, Texas, 77373.
- Stop-N-Go 1694 (Site ID No. 19) is located at 28727 N Highway 75, Spring, Texas, 77358.

3.19.1.8 Registered Storage Tanks Sites

The underground storage tank database (TXUST) and above ground storage tank database (TXAST) are maintained by TCEQ to track permitted petroleum storage tank sites. According to the database, two facilities have operated a total of six underground storage tanks within the project area. All six of the registered USTs are listed as removed from the ground. The UST facilities identified within the project area during the database search are:

- Northgate Outdoor Power and Tractor (Site ID No. 14) is located at 22820 N IH 45, Spring, Texas, 77373.
- Sutherland Lumber Co. (Site ID No. 11) is located at 22411 Highway 75 North, Spring, Texas, 77389.

3.19.1.9 Texas SPILLS

According to the database, one site within the project area is listed as the location of a cleanup of a toxic substance. The reported “material spilled” was a total of 14 abandoned drums. The cleanup status is reported to be complete. The TXSPILL facility identified within the project area during the database search is:

- Bull Oil and Chemical Transporters (Site ID No. 18) is located at 28528 East Hardy, Spring, Texas, 77373.

3.19.2 Oil/Gas Wells

A search of publicly available records for oil/gas well sites and petroleum pipelines was conducted for the Segment G project area. The Railroad Commission of Texas (RRC) Well Bore database was reviewed for this study. 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.

A total of 14 oil and/or gas well sites were identified within the Segment G project area. The database indicates that all of those reported are vertical wells and include the following types/status:

- One is listed as an active observation well;
- One is listed as a plugged gas well;
- One well site is listed as a cancelled/abandoned location; and
- Eleven are listed as dry holes.

The nature of the observation well is unknown; however, it appears to be active. No well is reported to be located at the cancelled/abandoned location. Exhibit G–51 shows the observation well and dry holes in the project area.

3.19.3 Petroleum Pipelines

A search of publicly available records for the petroleum pipeline systems was conducted for the project area. The following RRC records were reviewed for this study: the RRC Oil and Gas Division Petroleum Pipeline Database (the RRC issues permits for the installation and operation of petroleum pipelines within the state of Texas). Permitted pipelines are plotted on various RRC maps and listed in a pipeline database maintained by the RRC.

A total of seven petroleum pipeline systems were identified within the Segment G project area. The database indicates that each of the pipelines crosses at least one of the alternative alignments.

- Six of the permitted pipelines are listed as active and one is listed as inactive;
- Two are permitted to transport natural gas;
- Three are permitted to transport crude oil; and
- Two are permitted to transport refined product.

The pipelines range from six to 30 inches in diameter. Locations of the permitted pipelines identified by the RRC are shown in Exhibit G–51.

3.20 VISUAL AND AESTHETIC QUALITIES

The visual experience and aesthetic quality of an area depends upon the pattern of land or topography, the pattern of waterbodies, vegetation patterns, and the patterns of human development (FHWA, 1990b). More specifically, factors used to assess a person's visual experience and the aesthetic quality of an area may include:

- 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 the elements in the scene;
- Number of potential viewers;
- Duration of the view; and
- Amount of disturbance to the landscape.

The Segment G project area between IH 45 and US 59 crosses through the Pineywoods ecological region (Gould, 1975). The Pineywoods are characterized by nearly level to gently undulating and locally hilly topography with precipitation averaging 48 inches per year. Elevations within the Segment G project area range from 128 feet above MSL near the western extent of the segment to about 100 feet above MSL near the eastern extent (Hatch et al., 1990). The natural features include Spring Creek, Woodsons Gully, West Fork San Jacinto River, and White Oak Creek. These streams flow through shallow, incised valleys, which provide the most notable relief in topography. The vegetation types consist of mixed pine/hardwood forest in uplands and mixed hardwood forest in bottomlands. A wide variety of hardwoods grows in mixed stands with the pines in most upland areas, but hardwoods are dominant in the low-lying areas with more water. The vegetative communities within the Segment G project area consist of forest, farmlands/rangeland, non-forested wetlands, and forested wetlands. A breakdown of vegetative communities within Segment G by acreage and percentage is provided in Table 3-14.

The Segment G project area is characterized by a moderate degree of commercial and residential development (with most development concentrated in Reaches 8 and 12) with the bulk of the land being forested. Residential areas vary in density and composition, and these include single-family homesteads on ranches, master-planned subdivisions, individual homes on large lots, and trailer parks. Master-planned subdivisions dominate recent development. Reflective of Houston's general growth pattern, much of the development within the project area is primarily along arterial roadways.

An inventory of visual resources within the Segment G project area was performed through a review of published documents, aerial photography, and field surveys. A vast majority of the project area is forested or residential (approximately 84 percent); the extreme east and west ends of the project area are undergoing rapid conversion to suburban and/or agricultural land uses. Human disturbance and manipulation of the land is evident throughout most of the Segment G project area.

There are two groups potentially affected visually by the proposed action: those who use the roadway for travel, and those who live and work in proximity to the roadway. Highly scenic, sensitive views are generally not present within Segment G. The adjacent lands are topographically flat, pine-hardwood forest typically with thick undergrowth, residential and commercial developments, and isolated bottomland hardwood forest vegetation along the waterways. Potential visual scenic resources within the project area include forested areas, streams, forested and non-forested wetlands, farmland, and scattered residential areas and farmhouses.

SECTION 4: ENVIRONMENTAL CONSEQUENCES

This section presents the environmental impacts and consequences of the proposed alternative alignments within the Segment G project area of the Grand Parkway. Information is presented in technical and scientific disciplines with respect to the existing physical, biological, and human environments that may be affected by the construction and operation of each alternative alignment within the Segment G project area, including the No-Build Alternative.

The Segment G DEIS, published in January 2007, presented Alternative Alignment D (which is a composite of Alternative Alignment A/C in Reach 8, Alternative Alignment D in Reach 9, Alternative Alignment A/B in Reach 10, Alternative Alignment A in Reach 11, and Alternative Alignment C in Reach 12) as the Recommended Alternative Alignment. Since publication of the DEIS, updated analyses and continual coordination with the public have led to the slight shifting of the Recommended Alternative Alignment in one area. Near the junction of Reach 8 and Reach 9, a new subdivision named Creekside Village has been planned for development at the end of Riley Fuzzel Road. The Grand Parkway Segment G alignment was shifted slightly to the south to avoid residential impacts in this subdivision. Therefore, the Preferred Alternative Alignment detailed in the FEIS differs from the Recommended Alternative Alignment presented in the DEIS. For further discussion of the Preferred Alternative Alignment selection, see Section 2 (Alternatives Analysis) of this volume.

The FEIS presents the original four alternative alignments (A, B, C, and D) and the selected Preferred Alternative Alignment. In addition, for ease of comparison, the Recommended Alternative Alignment is included in impact tables presented in the following individual environmental resource sections. However, the reader should take care to examine table notes, where it is explained when a different level of analysis was conducted for the Preferred Alternative Alignment.

For all alternative alignments, analyses presented in the FEIS have utilized updated land use data (e.g., new residential developments). Additionally, some issues, such as noise, have been analyzed beyond the level of detail presented in the DEIS in order to exhibit a more thorough inventory of potential impacts that would result from the Preferred Alternative Alignment. These studies are detailed in the following individual environmental resource sections.

The alternative alignments start and end at common points beginning at IH 45 and ending at US 59. Alternative Alignments A, B, C, and D have lengths of 13.70, 13.63, 13.65, and 13.72 miles, respectively. The Preferred Alternative Alignment is 13.74 miles long. Exhibit G–40 presents the five alternative alignments, which overlap and diverge at several locations. To identify the Preferred Alternative Alignment, environmental inventory data were divided into reaches (Reach 8, Reach 9, Reach 10, Reach 11, and Reach 12), making it possible to analyze various combinations of alternatives. Table 4-38 summarizes the impacts within the 400-foot ROW for each alternative alignment.

A summary of construction impacts, the relationship of short-term uses of the environment to the maintenance and enhancement of long-term productivity, and irreversible and irretrievable commitment of resources is presented in Sections 4.22 to 4.24. Section 4.25 provides a summary of the Preferred Alternative Alignment, and Section 4.26 provides a summary of mitigation measures and commitments that would apply with the selection of the Preferred Alternative Alignment.

4.1 LAND USE

Numerous criteria were used to evaluate potential land use impacts for each of the alternative alignments, the No-Build Alternative, and the Preferred Alternative Alignment within Reaches 8, 9, 10, 11, and 12 of the Segment G project area. Primary considerations included: proximity of the project to habitable structures, compatibility of adjacent land uses, current development trends, municipal and state land use plans and policies, the amount of displaced land use, land cover changes, and land use conversion. Other primary considerations, including protected species, wildlife habitat, vegetation, and wetlands/waters, are discussed in their respective section of the document. Possible impacts include the direct loss of agricultural land, loss of access to land across the Segment G project area, the disruption of the physical fabric of neighborhoods and farm properties, and changes in land use due to localized pressure for business development in the vicinity of interchanges, sections of frontage roads, and entrance/exit ramps.

The majority of the ROW required for all four alternative alignments and the Preferred Alternative Alignment consists of non-urban land uses. Construction of any alternative alignment would result in reduced forestland and other undeveloped land acreage. This land conversion process would be a change in the appearance of the area from semi-forested and semi-rural in character to a more urbanized landscape.

There are a number of residential areas within proximity to the alternative alignments (Exhibit G–43). In Segment G, these residential areas are mostly located within Reaches 8, 9, 11, and 12, with almost no development of any kind occurring within Reach 10. There are three large subdivisions along Riley Fuzzel Road, and within Reach 8, residential development is underway or planned (Legends Run, Spring Trails, and Bender's Landing). All three of these subdivisions were platted to accommodate Alternative Alignments A, B, C, D, or the Preferred Alternative Alignment and in such a way that no residential structures would be displaced. The Valley Ranch subdivision, located east of the Freeway Oaks subdivision, south of the Silver Trails subdivision, and west of US 59, is under development. Planned development of this subdivision would fill in areas surrounded by all of the alternative alignments within Reach 12. This subdivision was platted such that Alternative Alignments B, C, D, and the Preferred Alternative Alignment would not directly impact any planned lots, and Alternative Alignment A would impact planned lots within the northern portion of this subdivision. (Please see Section 5, Table 5-19 [Status of Developments in the Study Area] of this volume for a listing of subdivisions within the Segment G project area that are constructed, under construction, or planned for construction.)

Portions of the Timberland Estates subdivision located east of FM 1314, and mostly within Reach 11, are currently under construction with approximately 50 percent built-out as of the date of this report. This subdivision, which consists mostly of manufactured homes and some (permanent) single-family homes, was platted before alternative alignments were developed, so Alternative Alignments A, B, C, D, and the Preferred Alternative Alignment would directly impact this subdivision. Alternative Alignment B lies in the southern portion of Timberland Estates and is adjacent to the Wood Hollow and Freeway Oaks subdivisions to the south. Alternative Alignment B would result in the displacement of several existing homes and platted homes. Alternative Alignments A, C, D, and the Preferred Alternative Alignment lie in the northern portion of this subdivision and would result in the displacement of several existing and platted homes. (See Section 4.3.2 [Relocations] for a detailed discussion on the number of structures displaced.)

Potential impacts to project area neighborhoods include noise (Section 4.7 [Traffic Noise]), visual effects (Section 4.20 [Visual and Aesthetic Qualities]) and changes in access. These areas would also be affected by highway construction, which is discussed in Section 4.22 (Construction Impacts). Because of the nature of the current land use in the area, forestland and other undeveloped land would be disrupted to a greater degree than neighborhoods.

Property values could increase near proposed interchanges and grade separated intersections as land becomes more desirable for commercial development. Commercial development and associated increased property values 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. Previous studies on this issue vary in their results depending on factors such as facility type, accessibility, presence of transit, and grade (Boarnet and Chalermpong, 2001; Gaegler et al., 1979; Gorney, 1999; Langley, 1976). Most studies agree that property values tend to be depressed during the construction phase and immediately afterward, but they also tend to recover quickly once the facility is operational. There are other instances where individual home or businesses would be displaced by specific alternative alignments. These relocations are discussed in Section 4.3.2 (Relocations).

All four alternative alignments and the Preferred Alternative Alignment intersect existing local roadways and transportation routes. While it is evident that Segment G of the Grand Parkway would generally increase accessibility in the region, the potential termination of local roads could adversely affect access to specific local destinations, as access across the highway would be limited. Typically, such impacts are avoided by the use of bridges or access ramps. Access across the highway would be limited to those areas where interchanges and bridges are incorporated into the highway design. Table 4-1 summarizes the potentially affected land uses by alternative alignment and reach.

4.1.1 Summary of Impacts

All four of the alternative alignments and the Preferred Alternative Alignment are consistent with state and local government plans and policies on land use and growth that is relevant within the project area. The No-Build Alternative is not consistent with state and local government plans.

All of the alternative alignments and the Preferred Alternative Alignment would result in the reduction of forestland and other undeveloped land, would cross the active UPRR rail line within Reach 8, and would cause temporary visual and noise effects and temporary traffic delays during project construction. All of the alternative alignments and the Preferred Alternative Alignment would require relocations of homes. In Reach 8, Alternative Alignment B would have the greatest impact on residential land uses; in Reaches 9 and 10 few impacts would occur to residential land uses with any of the alternative alignments; in Reach 11, Alternative Alignment C would have the greatest impact on residential land uses; and in Reach 12, all alternative alignments would impact the Valley Ranch community, with Alternative Alignment B having the least number of home relocations. In addition, all of the alternative alignments would intersect existing arterial roadways (within specific reaches). However, all major arterial roadways would be accommodated through grade separations, allowing for free flow of traffic across the corridor.

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 forestland and other undeveloped land and disruption of the semi-rural nature of the proposed Segment G project area. Commercial development would likely occur along existing arterial roadways that run through the Segment G project area. Existing arterial roadways through the Segment G 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 would not occur under the No-Build Alternative, as none of the roads within the Segment G 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.

4.1.2 Indirect Impacts

The proposed Grand Parkway would likely induce indirect development in the Segment G project area regardless of the alternative alignment 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 a variety of land uses such as 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.

TABLE 4-1
LAND USE IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Land Use Impacts	Alternative Alignment A					Alternative Alignment B					Alternative Alignment C					Alternative Alignment D					Recommended Alignment					Preferred Alignment				
	Reaches																													
	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12
Visual and potential access-related impacts to existing residences and communities	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Separation of farmland from farm homestead	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Decrease in forestland and undeveloped land acreages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Conversion of undeveloped/agricultural land to commercial land use at highway interchanges	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes
Potential termination of local and/or residential roadways	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Segment crosses an active rail line	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Increase in regional access to and through the Segment G project area	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Decrease in local access across the highway	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Segment cuts through or divides a residential subdivision	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes

Source: Study Team, 2007

THIS PAGE IS INTENTIONALLY LEFT BLANK

Nodes of indirect development are expected to occur at highway interchanges (IH 45, Hardy Toll Road, and US 59), along frontage roads, and at grade-separated intersections where entrance/exit ramps to the proposed Grand Parkway would be constructed. Frontage roads would be located on both sides of the Segment G corridor in the following locations: 1) extending from IH 45 to on-ramps; 2) from 0.7 miles east of the Hardy Toll Road extending north-eastward along Riley Fuzzel Road for approximately 2.7 miles; and 3) from US 59 west to Valley Ranch Thoroughfare (new roadway under construction). For the Preferred Alternative Alignment, which has preliminary design, grade-separated intersections with entrance and exit ramps are planned at the following roadways: IH 45 frontage roads, Hardy Toll Road, Riley Fuzzel Road near Spring Trails, Rayford Road, Birnam Woods Drive (future), Townsen Road (future), FM 1314, Valley Ranch Thoroughfare (future), and US 59 frontage roads. If allowed, other grade separations currently without entrance and exit ramps, such as Northgate Crossing Boulevard, would likely experience some indirect development in approximately 10 to 15 years after the proposed Grand Parkway is built. These nodes of indirect development would likely result in a further decrease of forestland and/or undeveloped land acreages since forestland and undeveloped land represent substantial land uses in the area.

4.1.3 Mitigation

Avoidance and minimization of impacts to land use were used as techniques in the selection of a Preferred Alternative Corridor, the development of alternative alignments, and the selection of the Preferred Alternative Alignment. Grade separations would be provided for all major arterial roadways that cross the selected alignment to avoid termination of through-travel, and intermittent frontage roads have been provided when required to provide adjacent property access and connectivity to major highways. Additionally, opportunities to reduce the amount of ROW would be identified during the final design stage.

4.2 GEOLOGY, SOILS, AND FARMLAND

4.2.1 Physiography, Soils, and Geology

No substantial impacts to the project area's topography, soils, or geologic resources are anticipated because of the proposed project. All four alternative alignments cross similar topography, soils, and geologic features consisting of broad, flat plains on clayey and sandy substrate of the Lissie, Beaumont, and Deweyville Formations. Therefore, other than the localized cut and fill areas that would be required by these alternative alignments, no further impacts are expected.

Most soil groups traversed by the alternative alignments are characterized by the NRCS as having a low shrink-swell potential, which is a measure of the potential volume change of a soil from 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. If the shrink-swell potential were rated moderate to high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special consideration would be given to the selection of materials for fill and the design of the roadbed.

Most of the soil groups traversed by the alternative alignments are characterized by the NRCS as having a moderate to high risk of corrosion to uncoated steel. Corrosion potential is a measure of the potential of soil-induced chemical reaction that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle size distribution, total acidity, and electrical conductivity of the soil material. The rating for corrosivity to concrete is based mainly on the sulfate content, soil texture, and acidity. Protective measures for steel and more resistive concrete help to avoid or minimize damage resulting from corrosion.

Construction of a roadway involves compaction of soils and removal of vegetation that can increase the amount of erosion and subsequent sedimentation. Slope, soil texture, and precipitation during construction determine the soil loss potential. Erosion and sediment control measures would effectively minimize erosion and soil loss during construction. Long-term impacts to area soils can be reduced by implementing appropriate BMPs to minimize erosion during ancillary development.

To the maximum extent possible where required, material excavated from the road cuts would be used as fill material. If suitable soils could not be 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 would be conducted during final design of the Preferred Alternative Alignment.

Impacts to the project from the natural environment are limited to the effects of land-surface subsidence and fault reactivation, particularly in response to heavy withdrawal of groundwater. The principal effects of subsidence are activation of surface faults, loss of ground elevation in critical low-lying areas already prone to flooding, and alteration of natural slope and drainage patterns (Fisher et al., 1972). In areas of present or projected subsidence, special attention would be given to problems caused by loss of ground elevation and activation of surface faults.

Data from the Harris-Galveston Counties Subsidence District (HGCSD) suggest that the project area has experienced between one and two feet of land surface subsidence from 1906 to 1995. Amounts of future subsidence will greatly depend on groundwater withdrawals in the immediate vicinity of the project. The HGCSD has proposed a regulatory plan designed to minimize groundwater withdrawals by converting to surface water use. The projected subsidence by the year 2030 for the project area without groundwater restrictions is approximately two to four feet. If the groundwater restrictions identified in the regulatory plan are effective, subsidence by the year 2030 is projected to be limited to one foot or less.

There were no surface faults identified within the Segment G project area. However, faulting in the region is common and the potential for future surface expressions of any nearby subsurface faults does exist. These subsurface faults do not appear to pose an immediate need for concern. Engineering design may be required to accommodate the potential rates of differential movement along active fault planes as they occur.

4.2.2 Farmland

The impacts to farmland soils protected under the FPPA does not include non-FPPA protected soils that are in existing agricultural use or any soil already converted for, or platted to, any development project. Bisection of farms would not only convert existing farmland or prime farmland soils (potential farmland) to transportation land use, but also would result in the disruption of some operations. The proposed project may result in positive impacts to local farming operations as well. Segment G of the Grand Parkway would increase efficiency of accessibility to FM roads. An improved transportation system in Harris and Montgomery Counties would improve highway safety for the transport of farm products and equipment. Exhibit G–44 shows the general location of prime and statewide important farmland soils in relation to the Segment G alternative alignments.

Project-related impacts to farmland soils in Montgomery County have been determined to be minimal according to a final land evaluation and site assessment scoring conducted by the NRCS using Form CPA-106, Part VII (see Table 4-2 and Appendix J). The NRCS scores on farmland are based upon a possible 260 points, meaning that the farmland requires the maximum possible protection. Those alignments (sites) receiving scores totaling less than 160 points are afforded a minimal level of consideration for protection. All four of the alternative alignments (A, B, C, and D) received a score totaling less than 160 points during a formal evaluation conducted by the NRCS on May 18, 2005.

Prime farmland soils would be avoided where practicable; however, because of the large acreage of this resource in Montgomery County, each alternative alignment would have an unavoidable effect on some prime farmland soils. The Preferred Alternative Alignment would be placed along and close to existing property lines where possible to minimize the splitting or fragmentation of farms.

Table 4-2 presents the direct impacts to farmland soils for each of the four alternative alignments by reach. Appendix J provides documentation of coordination with the NRCS and Form CPA-106 (Farmland Conversion Form for Corridor Type Projects). Benefits of the No-Build Alternative (avoidance of these potential farmland impacts) would decrease over time as farmland and potential farmland is converted to residential and commercial land uses, a trend that is already underway.

TABLE 4-2
PRIME AND STATEWIDE IMPORTANT FARMLAND SOILS IMPACTS FOR SEGMENT G

Alternative Alignment	Reach	Prime Farmland Soils (acres)	Statewide Important Farmland Soils (acres)	Total
A	8	59.9	22.0	81.9
	9	0.0	192.2	192.2
	10	0.0	11.3	11.3
	11	2.9	73.8	76.7
	12	1.3	16.3	17.6
Alternative Alignment A Total		**64.1**	**315.6**	**379.7**

TABLE 4-2 (CONT.)
PRIME AND STATEWIDE IMPORTANT FARMLAND SOILS IMPACTS FOR SEGMENT G

Alternative Alignment	Reach	Prime Farmland Soils (acres)	Statewide Important Farmland Soils (acres)	Total
B	8	18.1	32.1	50.2
	9	4.6	139.4	144.0
	10	0.0	11.3	11.3
	11	0.0	11.1	11.1
	12	1.3	14.5	15.8
Alternative Alignment B Total		**24.0**	**208.4**	**232.4**
C	8	59.9	22.0	81.9
	9	0.0	168.4	168.4
	10	1.5	17.7	19.2
	11	16.2	46.4	62.6
	12	1.3	20.8	22.1
Alternative Alignment C Total		**78.9**	**275.3**	**354.2**
D	8	59.9	22.0	81.9
	9	0.1	159.7	159.8
	10	0.0	11.3	11.3
	11	2.9	73.8	76.7
	12	1.3	20.8	22.1
Alternative Alignment D Total		**64.2**	**287.6**	**351.8**
Recommended Alternative Alignment	8	59.9	22.0	81.9
	9	0.1	159.7	159.8
	10	0.0	11.3	11.3
	11	2.9	73.8	76.7
	12	1.3	20.8	22.1
Recommended Alternative Alignment Total		**64.2**	**287.6**	**351.8**
Preferred Alternative Alignment	8	59.9	26.2	86.1
	9	0.1	158.6	158.7
	10	0.0	11.3	11.3
	11	2.9	73.8	76.7
	12	1.3	20.8	22.1
Preferred Alternative Alignment Total		**64.2**	**290.7**	**354.9**

Note: These potential impacts are calculated for the entire 400-foot ROW. Actual impacts would be less, as vegetation within the ROW would remain in place to the extent feasible and practicable in order to minimize impacts to soils and reduce erosion.

Source: Study Team, 2007

4.2.3 Summary of Impacts

All proposed alternative alignments cross soils and geology similar in nature, including some portions of prime farmland soils. While these impacts (i.e., removal of topsoil, compaction, and removal of vegetation) do cause temporary to permanent loss to these resources, they are considered minor as rated and scored by the NRCS. Mitigation measures to be implemented during and after construction are considered prudent and positive in helping to restore a portion of these same resources. Under the No-Build Alternative, no new ground disturbance 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 would occur because of induced development, although these impacts are expected to be minimal. Potential for indirect impacts to farmland soils within the project area because of the construction of the project have been determined to be minimal by the formal scoring by the NRCS on May 18, 2005 (Appendix J).

4.2.5 Mitigation

Potential impacts presented in Table 4-2 are calculated for the entire 400-foot ROW. Actual impacts would be less, as vegetation within the ROW would remain in place to the extent feasible and practicable in order to minimize impacts to soils and reduce erosion. The use of silt fences and other erosion control measures 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 corridors would prevent future erosion after construction and thereby would increase the success rate of any and all revegetation efforts. The need for mitigation of geologic resources is not anticipated. Mitigation for prime farmland is not required, as per NRCS ranking.

4.3 SOCIAL

Segment G of the Grand Parkway passes through a predominately semi-rural landscape consisting of a mix of forestlands, undeveloped land, and scattered residential and commercial development along the existing network of area roadways. This area is rapidly becoming more developed with several new residential subdivisions that are either planned or under construction. The Segment G project area (Preferred Alternative Corridor) was specifically located to minimize community, residential, and business impacts.

4.3.1 Social/Community Impacts Analysis

4.3.1.1 Community Cohesion

As defined in the FHWA Technical Advisory T 6640.8A, changes in community cohesion because of highway construction and improvements may be beneficial or adverse. Changes in community cohesion may include splitting neighborhoods,

isolating a minority group or a portion of a neighborhood, generating new development, changing property values, affecting residential roads, and separating residents from community facilities.

During construction of the proposed facility, short-term impacts would occur because of the movement of workers and materials through the area. Construction noise and dust as well as temporary disruption of traffic on local roads may also temporarily affect residents and businesses in the vicinity of the project. Construction activities may be allowed at night to minimize the effects of daytime traffic on existing facilities. Coordination between TxDOT and landowners regarding construction scheduling and access to the construction site and ROW would help to minimize such temporary disruptions.

There are a number of individual homes and several residential subdivisions within proximity to the alternative alignments and the Preferred Alternative Alignment (Exhibit G–43 [Land Use]). Potential impacts to these residential areas include noise (Section 4.7 [Traffic Noise]), visual effects (Section 4.20 [Visual and Aesthetic Qualities]), and a change in access across the facility. Potential temporary impacts to these areas are those created by highway construction, including dust, noise, and traffic from trucks and heavy equipment (Section 4.22 [Construction Impacts]). Table 4-3 describes specific community cohesion impacts by alternative alignment and reach.

The Grand Parkway project has included an open process for agency and public comments in the development of the Preferred Alternative Corridor and the selection of the Preferred Alternative Alignment. The public has been directly involved throughout the entire project through public workshops and questionnaires. Additional information regarding the public comment process for the Grand Parkway is addressed in Section 6 (Agency and Public Coordination) of this volume and Volume IV.

4.3.1.2 Environmental Justice (EJ)

This document complies with Executive Order (EO) 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” which requires the determination of whether a proposed project would have adverse impacts on minority or low-income populations. EO 12898, signed on February 11, 1994, requires all federal agencies to address the impact of their programs with respect to EJ. EO 12898 requires that federal agencies identify and appropriately address disproportionately high and adverse human health and environmental effects to minority and low-income populations and requires that minority or low-income populations who could be affected by the proposed project be involved in the community participation and public involvement process.

TABLE 4-3
COMMUNITY COHESION BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Impact	Alternative Alignment A					Alternative Alignment B					Alternative Alignment C					Alternative Alignment D					Recommended Alternative					Preferred Alternative				
	Reaches																													
	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12
Short-term construction impacts, including noise dust and rerouting of local traffic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Potential increase in value of properties adjacent to project especially at entrance/exit ramp access points and interchanges	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Potential degradation of aesthetics and community character to the Northgate Crossing subdivision located south of the Hardy Toll Road and east of IH 45	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character to the Southwell neighborhood located south of Riley Fuzzel Road and southwest of the Hardy Toll Rd	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Relocation of residential structures for neighborhood located west of the YMCA Camp Pine Tree and east of the UPRR	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character for several large-lot residential properties located on the north side of Riley Fuzzel Rd. and southwest of the Fox Run subdivision	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character for the Fox Run subdivision located on the north side of Riley Fuzzel Road and east of the Hardy Toll Road	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character for the Spring Trails subdivision located south of Riley Fuzzel Road	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character for the Legends Run subdivision located north of Riley Fuzzel Road	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character for the Benders Landing subdivision located south of Riley Fuzzel Road	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential degradation of aesthetics and community character for Cumberland subdivision located southwest of FM 1314	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No
Potential degradation of aesthetics and community character for Cumberland Crossing subdivision located on north of FM 1314	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No
Potential degradation of aesthetics and community character to the Winchester Place subdivision located northeast of FM 1314	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	No	Yes	No

TABLE 4-3 (CONT.)
COMMUNITY COHESION BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Impact	Alternative Alignment A					Alternative Alignment B					Alternative Alignment C					Alternative Alignment D					Recommended Alternative					Preferred Alternative				
	Reaches																													
	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12	8	9	10	11	12
Relocation of mobile homes and some single-family homes within the Timberland Estates subdivision located east of FM 1314 and south of Winchester Place subdivision	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Degradation of aesthetics and community character to the Wood Hollow subdivision located south of the Timberland Estates subdivision	No	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential degradation of aesthetics and community character to the Freeway Oaks subdivision located southeast of the Timberland Estates subdivision	No	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential degradation of aesthetics, and community character to the Timberland Estates subdivision located east of FM 1314 and south of Winchester Place subdivision	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Degradation of aesthetics and community character to the Silver Trails subdivision located northeast of the Timberland Estates subdivision	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Degradation of aesthetics and community character to the Valley Ranch subdivision located east of the Freeway Oaks subdivision and west of US 59	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes
Potential adverse effects for Robert L. Crippen Elementary	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for W. M. Southwell Park	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for Spring Peaceful Rest Cemetery	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for Legends Ranch	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for Spring Bridge Ranch and Lockeridge Farms	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential adverse effects for Lakewood Colony	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for AV Salinas Park	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for White Oak Middle School	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Potential adverse effects for True-Holiness Church of God in Christ	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Potential adverse effects for Creekside Village	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No

Source: Study Team, 2007

Methodology

Two analysis methods were used in the assessment of whether minority and/or low-income populations would receive disproportionately high and adverse effects due to relocations and neighborhood disruption caused by project alternatives, including the Preferred Alternative Alignment. The first method is Census tract analysis for project area Census tracts that are traversed by project alternatives. In this method, the population characteristics (ethnicity and income characteristics) of project area Census tracts (from the 2000 Census) are reviewed to determine whether or not there are minority or low-income persons living within the project area. The second measure is the EJ Index Methodology, which was developed by the EPA (EPA, 2003). The EJ Index Methodology provides an index for determining the potential for disproportionate effects to minority or low-income populations within the project area. The EJ Index Methodology is very similar to the Census tract analysis, and is used simply to confirm the results of the Census tract analysis. Appendix K provides a detailed description of the EJ Index Methodology and the EJ Index Maps that form the basis for this methodology.

Data used for the Census tract analysis to determine the potential for disproportionate impacts to minority and/or low-income populations are provided for Census tracts that overlap either partially or fully within the geographic boundaries of the Segment G project area (Table 4-4). As defined by the CEQ, a minority population is a population where either: (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate geographical analysis. The population is considered to be a low-income population if the median household income were below the HHS poverty guideline. 2000 Census data were used to determine the percent of the population below poverty in 1999. At that time, the HHS poverty guideline for a family of four was $17,030. The HHS poverty guideline for 2008 is $21,200 (HHS, 2008b).

TABLE 4-4
POPULATION AND ETHNICITY CHARACTERISTICS
FOR THE SEGMENT G PROJECT AREA CENSUS TRACTS – 2000 CENSUS

Census Tract	Population	% White	% African-American	% American Indian & Alaska Native	% Hispanic or Latino Origin	% Asian	% Native Hawaiian & Other Pacific Islander	% Other Race*
6920	7,128	82.6%	5.4%	0.0%	10.4%	1.0%	0.0%	0.5%
6923	7,556	74.6%	2.2%	<0.1%	20.2%	2.1%	0.0%	0.8%
6925	6,894	83.5%	2.9%	0.6%	11.1%	0.4%	0.1%	1.4%
6926	10,804	81.1%	0.7%	1.3%	14.4%	0.0%	0.0%	2.6%
2413	3,396	78.5%	11.5%	0.8%	8.1%	1.0%	0.0%	0.0%
2414	5,248	85.0%	2.2%	1.7%	9.8%	0.6%	0.0%	0.7%

TABLE 4-4 (CONT.)
POPULATION AND ETHNICITY CHARACTERISTICS
FOR THE SEGMENT G PROJECT AREA CENSUS TRACTS – 2000 CENSUS

Census Tract	Population	% White	% African-American	% American Indian & Alaska Native	% Hispanic or Latino Origin	% Asian	% Native Hawaiian & Other Pacific Islander	% Other Race*
Project Area Census Tracts	**41,026**	**80.8%**	**3.3%**	**0.7%**	**13.1%**	**0.8%**	**<0.1%**	1.2%
Harris County	3,400,578	42.0%	18.2%	0.2%	33.0%	5.0%	<0.1%	1.5%
Montgomery County	293,768	81.2%	3.4%	0.5%	12.6%	1.0%	0.1%	1.2%
State of Texas	20,851,820	52.4%	11.3%	0.3%	32.0%	2.6%	<0.1%	1.3%

Note: *"Other Race" combines two U.S. Census Bureau data categories: "Two or More Races" and "Some Other Race Alone."
Source: U.S. Census Bureau, 2000

Results

As shown in Table 4-4, the project area Census tracts are generally characterized by much smaller percentages of minority populations than those of Harris County or the state of Texas and slightly smaller percentages than Montgomery County. The percentage of African-Americans within the project area Census tracts (3.3 percent) is substantially lower than that of Harris County (18.2 percent) and the state of Texas (11.3 percent), and slightly lower than Montgomery County (3.4 percent). The percentage of Hispanics or Latinos within the project area (13.1 percent) is also substantially lower than that of Harris County (33.0 percent) and the state of Texas (32.0 percent) and slightly higher than Montgomery County (12.6 percent). There were no individual Census tracts identified within the Segment G project area that had a minority population 50 percent or greater and none was identified as a minority population.

Table 4-5 shows the 2000 Census population, income, and language characteristics for the project area. No individual Census tracts had a median household income below the HHS poverty threshold (either the 1999 level of $17,030 or the 2008 level of $21,200). The percentage of people living below poverty within the Segment G project area Census tracts (8.4 percent) is lower than that of Harris County (14.8 percent), the state of Texas (15.0 percent), and Montgomery County (9.3 percent). Although two Montgomery County Census tracts identified within the project area (tracts 6925 and 6926) had a higher percentage of poverty status persons than that of Montgomery County as a whole, the proportions of poverty status persons living within these Census tracts are not substantially greater than the proportion in Montgomery County.

TABLE 4-5
POPULATION, INCOME, AND LANGUAGE CHARACTERISTICS
FOR THE SEGMENT G PROJECT AREA CENSUS TRACTS – 2000 CENSUS

Census Tracts	Population	Median Household Income	Number Below Poverty	Percent Below Poverty	Number Speak English "Not Well" or "Not at All"	Percent Speak English "Not Well" or "Not at All"
6920	7,128	$59,877	327	4.6%	89	1.2%
6923	7,556	$42,358	590	7.8%	369	4.9%
6925	6,894	$35,313	916	13.3%	201	2.9%
6926	10,804	$39,184	1,434	13.3%	291	2.7%
2413	3,396	$58,148	72	2.1%	29	0.9%
2414	5,248	$65,833	120	2.3%	53	1.0%
Project Area Total/Average	**41,026**	**$47,692**	**3,459**	**8.4%**	**1,032**	**2.5%**
Harris County	3,400,578	$42,598	503,234	14.8%	330,874	9.7%
Montgomery County	293,768	$50,864	27,376	9.3%	9,821	3.3%
Texas	20,851,820	$39,927	3,117,609	15.0%	1,428,512	6.7%

Source: U.S. Census Bureau, 2000

The second analysis measure is the EJ Index Methodology. The potential for disproportionate project impacts to low-income and minority populations in the Segment G project area are shown in EJ maps that are provided in Appendix K. This appendix contains reports and maps that were obtained from the EPA, Region 6 office. The information is based on 2000 Census block level data for ethnicity (PL 94-171) and block group level (Summary Tape File 3A) for income data. Appendix K also provides a more detailed description of the EJ Index Methodology.

Current EPA computer-assisted environmental assessments are limited to a radial analysis. In order to better analyze the EJ issues for this document, radial analysis was performed from two points, one at the western terminus (IH 45) and the other at the eastern terminus (US 59) of the Segment G project area (this is represented by the a and b extension on the name of each map). Although a one-square mile buffer is presented (the inner most circle) on each exhibit, only the 50-square mile analysis is included in the discussion. It is noteworthy that the two 50-square mile circles cover an area that is substantially larger than the Segment G project area and therefore do not fully capture only Census data representing the population living within the Segment G project area. Consequently, the EJ Index Methodology is not as accurate as the Census tract analysis and should be used only as a starting point. Based on the findings of the test of disproportionate effects, it has been determined that no disproportionate impacts are expected. However, the results of the Census tract analysis should be used to determine whether there is potential within the Segment G project area for disproportionate effects to minority or low-income populations.

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 they provide to persons with limited English proficiency (LEP) and identify any need for services to those with LEP. (LEP is defined in the Elementary and Secondary Education Act of 1965 as amended by the Improving America's Schools Act of 1994.) This EO requires federal agencies to work to ensure that recipients of federal financial assistance provide meaningful access to the LEP applicants and beneficiaries.

The average percentage of people with LEP status within the project area Census tracts (2.5 percent) is lower than that of Harris County (9.7 percent), Montgomery County (3.3 percent), and the state of Texas (6.7 percent). There was no individual Census tract identified within the project area as having a considerable percentage of persons with LEP status. However, to better assure the distribution of information on the project, the Notice of Availability of the DEIS and announcements for the Public Hearings were published in *El Diá/La Subasta* twice during the month prior to the DEIS hearing. This newspaper is circulated within the Spanish-speaking communities in greater Houston. Both the project website (www.grandpky.com) and mailers include a statement indicating that Spanish-speaking interpreters were available upon request, although none were requested.

Conclusions

The results from the EJ Index Methodology (Appendix K) show a low to moderate EJ Index ranking for the Segment G project area, indicating that the potential for disproportionate effects by the proposed project to minorities or low-income populations may be low to moderate. However, the EJ Index ranking is only a starting point in the disproportionate effects test. Consideration must next be given to the Census tract analysis. The Census tract analysis shows there are no project area Census tracts that would be considered a minority or low-income population. Based on the findings of the test of disproportionate effects, it has been determined that no disproportionate impacts are expected.

The analysis of environmental justice impacts for the alternatives indicates that the percentage of minority and/or low-income populations within the project area is low. In addition, 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.

This project would be funded by toll revenue and users of the road would have to pay a toll. Therefore, the impacts to minority and low-income populations were assessed. There would be no difference in the alignment between a non-toll road and the toll road option, and therefore no difference in terms of which neighborhoods or residences would be affected. These impacts to neighborhoods are not disproportionate in terms of impact to any particular minority or low-income population. Therefore, the toll road option would not cause any potential impacts to minority populations within the project area. However, the toll road option may cause potential impacts to low-income populations within the project area.

Some possible impacts that may occur with the toll road 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 would use the toll road, benefits would include increased access to job markets and services, and decreased travel time to destinations. Local residents that choose not to use the toll road may benefit by reduced traffic on local roadways thereby decreasing their commuting times.

Mitigation for low-income populations within Segment G 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 population; and/or
- Buses may be allowed to use the toll road for free to allow those low-income populations toll road access.

4.3.1.3 Community Services and Facilities

The alternative alignments were selected in order to avoid and minimize the impacts to sensitive community facilities. Exhibit G–46 shows the locations of sensitive community facilities, such as schools, churches, cemeteries, parks, and recreation areas relative to the alternative alignments. Access to one church and one cemetery would be potentially affected by various alternative alignments of Segment G. No alternative alignments would affect access to any public parks. Grade separations with entrance/exit ramps and sections of frontage roads would maintain facility access.

Schools

No alternative alignment would displace a school. With any of the alternative alignments, some schools may experience indirect effects due to increased or decreased traffic, or changes in traffic patterns.

One Spring ISD school is located within the project area: Northgate Crossing Elementary. In Reach 8, Alternative Alignment B would cross over the edge of the Northgate Crossing Elementary School property; the alignment's ROW would be approximately 150 feet from the closest school building, but access and bus routes would not be affected because the alignment would be on structure through this area (Exhibit G–46). Alternative Alignments A, C, and the Preferred Alternative Alignment would pass through the Northgate Crossing subdivision, but bus routes would not be affected because of the proposed grade separation at Northgate Crossing Boulevard. In addition, Alternative Alignment B would pass to the north of this subdivision and would not cause a potential access problem.

The Conroe ISD would be unaffected by any of the alternative alignments because its schools are located away from the project area, and it does not serve school children living in subdivisions adjacent to the Segment G project area (Conroe

ISD, 2001). The New Caney ISD serves most of the urbanized portion of the eastern Segment G project area and is the only school district that has schools in the project area. Alternative Alignments B and C are located in relative proximity to the Robert L. Crippen Elementary School, which is located in the Cumberland subdivision adjacent to FM 1314. Alternative Alignment C would pass immediately along the southern edge of this school property, but would not directly impact any portion of the school property. This alignment ROW would be approximately 520 feet from the main elementary school building and would also intersect FM 1314. The Alternative Alignment B ROW would be approximately 840 feet to the northeast of this elementary school building and would intersect FM 1314. The Grand Parkway would be grade separated where Alternative Alignments A, B, C, D, and the Preferred Alternative Alignment would intersect FM 1314; therefore there would be no effect on school bus access to this elementary school. The New Caney High School is located between US 59 and Loop 494 and immediately north of the proposed Grand Parkway frontage roads that would connect US 59 to Loop 494. These frontage roads, within Reach 12, would not affect access to this school. Other schools in New Caney ISD would not be affected.

Current bus routes may require alteration to accommodate roadway system changes. Travel time along current routes may decrease because of reduced congestion on local roads, higher speeds, and more direct access provided by any of the proposed Segment G alternative alignments. If school bus routes would pass near the intersections of existing roads and the Grand Parkway, they may experience increased congestion in these areas, as they are likely to undergo increased development. However, generally, safety along existing school bus routes ought to improve as traffic is drawn from arterial roadways to the new facility. Potential mitigation measures to reduce the impacts to schools include the use of signalized intersections with pedestrian controls at the interchange ramps. Any school districts wishing to take advantage of the time savings afforded by use of the Grand Parkway along bus routes would be impacted by the cost of the of tolls.

Churches and Cemeteries

There are two churches, two cemeteries, and one funeral home within the Segment G project area. Alternative Alignments A, C, D, and the Preferred Alternative Alignment within Reach 8 would pass to the north of the True-Holiness Church of God in Christ that is located within the Southwell neighborhood and near the W. M. Southwell Park. Access to the True-Holiness Church of God in Christ could be affected by these alignments. Alternative Alignments B, C, and D would pass to the north of the Grand Parkway Church that is located on the east side of FM 1314, adjacent to the Wood Hollow subdivision. Access to the Grand Parkway Church would be unaffected by these alternative alignments.

In addition, Alternative Alignment B within Reach 8, would pass to the northeast of the Spring Peaceful Rest Cemetery that is located along East Hardy Road, southwest of the Hardy Toll Road. Access to this cemetery could be affected by the termination of East Hardy Road. All alternative alignments would intersect US 59 north of the Rosewood Funeral Home and Cemetery. Access to these facilities would not be affected. There are no direct impacts to the project area

churches, cemeteries, and funeral home within any of the Segment G alternative alignments that require the taking of land. However, temporary construction effects such as noise, dust, movement of construction vehicles through the area, and some traffic delays would occur within the vicinity of all of these church, cemetery, and funeral home facilities. Long-term effects to these facilities would include noise and aesthetics.

Parks and Recreation

None of the alternative alignments within the Segment G project area contain public park property. The YMCA Camp Pine Tree (private recreation area) is the only park or recreational area that would be directly affected by any alternative alignment. This 47.9-acre recreational property would be directly affected by Alternative Alignments A, C, D and the Preferred Alternative Alignment (which share the same alignment) within Reach 8. The Alternative Alignments A, C, D, and the Preferred Alternative Alignment would take 7.5 acres of the northern portion of this YMCA property. Access to this property via Riley Fuzzel Road would be unaffected by these alternative alignments. The W. M. Southwell Park (public park owned by Harris County) is located within the project area, in Reach 8, at the intersection of Nelson and Lindell Streets. Alternative Alignments A, C, D, and the Preferred Alternative Alignment would run north of this park and would not affect access to this park. The Northwood Pines Community Park and the Park at Northgate are both privately owned parks that are located within the Northwood Pines subdivision and access to these parks would be unaffected by the alternative alignments. The only other parks within the project area are small subdivision parks, and these are somewhat buffered from the alternative alignments because of their location within the interior of subdivisions. However, temporary construction effects such as noise, dust, movement of construction vehicles through the area, and some traffic delays would occur within the vicinity of all of these park facilities. Long-term effects to these facilities would include noise and aesthetics.

4.3.1.4 Public Lands

A discussion of project effects to schools and parks is provided in Section 4.3.1.3. The publicly owned properties within the Segment G project area include the Northgate Crossing Elementary School, the W. M. Southwell Park, the Robert L. Crippen Elementary School, and the New Caney High School. Alternative Alignment B would cross immediately adjacent to or over the edge of the Northgate Crossing Elementary School property. Otherwise, there would be no direct impacts by any of the alternative alignments to publicly owned properties. There would be no Section 4(f) or Section 6(f) impacts to public lands by any of the alternative alignments. For an assessment of Section 4(f) issues relative to cultural resources, see Section 4.18 (Cultural Resources).

4.3.1.5 Public Safety

The proposed project would have a beneficial impact on public safety in the Segment G project area. This improvement is attributable to the diversion of drivers from local roads since many people are likely to prefer the greater convenience, efficiency, and reduced travel times associated with the proposed Grand Parkway. It is likely that the proposed toll road

facility would reduce congestion and improve response time for police, fire protection, and emergency and medical services. It is also likely that Segment G of the Grand Parkway would ease commutes through the area.

No fire stations would be displaced by any of the alternative alignments. Generally, the proposed Grand Parkway is expected to improve fire department response times in the Segment G project area as travel on this controlled-access highway would be faster and more direct than on existing area roadways. An increase in the number of emergencies within the Segment G project area is anticipated to accompany the region's projected increase in development. Adequate movement for fire trucks and emergency vehicles across the highway corridor along arterial roads and entrance/exit ramp access to the proposed Grand Parkway is necessary to provide quick response times for emergencies.

The tolled nature of the proposed facility would not cause any additional potential impacts to public safety within the project area. Police, fire protection, and emergency and medical services would likely use TxTags or EZ Tags to access the toll road quickly during an emergency. As a tolled facility, the proposed Grand Parkway would likely have the effect of reducing the emergency response time because the toll road main lanes would allow for more efficient and faster travel through the project area than existing roads. Additionally, preliminary design of the Preferred Alternative Alignment includes the bridging of all public roads crossed by the proposed facility; therefore emergency response not utilizing the new facility would not be impeded.

4.3.2 Relocations

The Segment G project area is mostly undeveloped with about 38 percent residential development and 3 percent commercial development. The proposed alternative alignments were carefully selected to minimize the taking of structures. Potential relocation impacts are detailed in the following section and summarized in Table 4-6.

4.3.2.1 Relocation Segment Analysis

The data used in the following analysis was determined through aerial photo interpretation, field visits, and review of county tax records for 2005 and 2006. The displacements reported below include existing and platted properties.

Reach 8

Alternative Alignments A, C, and D and the Preferred Alternative Alignment would not result in any commercial displacements. Alternative Alignment B would result in the displacement of one commercial establishment (D&D Collision Specialist).

Alternative Alignments A, C, and D and the Preferred Alternative Alignment would result in the displacement and potential relocation of 18 residential properties, including five mobile homes. Alternative Alignment B would result in the displacement and potential relocation of 38 residential properties, including three mobile homes.

Reach 9

None of the alternative alignments would result in commercial displacements. Alternative Alignments A, B, and C would result in no displacements. Alternative Alignment D and the Preferred Alternative Alignment would result in the displacement and potential relocation of one residential structure. The assessed value was not determined.

Reach 10

No displacements would occur in Reach 10.

Reach 11

None of the alternative alignments would result in commercial displacements. Alternative Alignments A and D and the Preferred Alternative Alignment would result in the displacement and potential relocation of 69 residential properties, all of which are mobile homes. Alternative Alignment B would result in the displacement and potential relocation of 64 residential properties, 52 of which are mobile homes. Alternative Alignment C would result in the displacement and potential relocation of 169 residential properties, 168 of which are mobile homes.

Reach 12

None of the alternative alignments would result in commercial displacements. Alternative Alignments A, C, and D and the Preferred Alternative Alignment would result in the displacement and potential relocation of 22 residential properties, all of which are mobile homes. Alternative Alignment B would result in the displacement and potential relocation of three residential properties, all of which are mobile homes.

TABLE 4-6
POTENTIAL RELOCATIONS BY ALIGNMENT AND REACH FOR SEGMENT G

Alternative Alignment	Reach	Residential Relocations	Commercial Relocations	Total Relocations
A	8	18	0	18
	9	0	0	0
	10	0	0	0
	11	69	0	69
	12	22	0	22
Alternative Alignment A Total		**109**	**0**	**109**
B	8	38	1	39
	9	0	0	0
	10	0	0	0
	11	64	0	64
	12	3	0	3
Alternative Alignment B Total		**105**	**1**	**106**

TABLE 4-6 (CONT.)
POTENTIAL RELOCATIONS BY ALIGNMENT AND REACH FOR SEGMENT G

Alternative Alignment	Reach	Residential Relocations	Commercial Relocations	Total Relocations
C	8	18	0	18
	9	0	0	0
	10	0	0	0
	11	169	0	169
	12	22	0	22
Alternative Alignment C Total		**209**	**0**	**209**
D	8	18	0	18
	9	1	0	1
	10	0	0	0
	11	69	0	69
	12	22	0	22
Alternative Alignment D Total		**110**	**0**	**110**
Recommended Alternative Alignment	8	18	0	18
	9	1	0	1
	10	0	0	0
	11	69	0	69
	12	22	0	22
Recommended Alternative Alignment Total		**110**	**0**	**110**
Preferred Alternative Alignment	8	18	0	18
	9	1	0	1
	10	0	0	0
	11	69	0	69
	12	22	0	22
Preferred Alternative Alignment Total		**110**	**0**	**110**

Source: Study Team, 2007

4.3.2.2 Availability of Comparable Housing

For purposes of assessing availability of replacement housing for the structures being taken for construction, a search of the Multiple Listings of the Houston Association of Realtors was performed. The search was limited to properties in the general vicinity of the subject properties and in specific ranges of property values. The multiple listings are constantly updated as properties enter the market. This search simply represents properties that are available at the time this document is being prepared. Other properties may become available in the future.

The Houston Association of Realtors Multiple Listing indicates that over 800 single-family homes in the northwest Harris County area and over 250 single-family homes in the southeastern Montgomery County area currently listed for sale. In the Harris County listings, six properties listed under $50,000, 47 homes in the $50,000-$80,000 price range, 225 homes listed between $80,000 and $100,000, 379 homes between $100,000 and $150,000, 118 homes between $150,000 and $200,000, and 41 homes over $200,000. Approximately 21 percent of the homes listed in the less than $50,000 price range are mobile homes. In the Montgomery County listings, 20 properties listed under $50,000, 50 homes between $50,000 and $80,000, 40 homes listed between $80,000 and $100,000, 62 homes between $100,000 and $150,000, 25 homes between $150,000 and $200,000, and 47 homes over $200,000. Approximately one-third of the homes listed less than $50,000 are mobile homes.

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.

4.3.2.3 Relocation Assistance by the Texas Department of Transportation (TxDOT)

TxDOT offers relocation counseling and financial assistance to residences and businesses that are displaced by the acquisition of highway ROW in accordance with the Federal Uniform Relocation and Real Property Acquisition Policies Act of 1970 (PL 91-646). Once it has been determined that a structure must be acquired in order to construct the highway, the property owner and/or tenant is contacted by a relocation counselor who provides information on exactly what benefits for which the owner/tenant is eligible and who assists the owner/tenant in applying for those benefits. In general, the relocation counselor will provide listings of comparable housing, transportation to inspect the housing (especially for elderly and handicapped persons), and referrals to other agencies that provide assistance for relocated persons.

When a relocatee is contacted by a relocation counselor, the counselor provides a listing of comparable housing, which is currently available. This listing is as close as possible to the dwelling being taken in terms of number of rooms, living space, location, and square footage. The properties are currently available on the market and within the financial means of the occupant. The replacement housing has to meet all minimum standards established by the state (decent, safe, and sanitary) and conform to all local building codes.

In the case of the Segment G project area, property values are rapidly rising. Newly constructed housing in the area is considerably more expensive than the assessed valuations of the older housing stock. Market values for older housing stock in the Houston Realtors Association Combined Listings are also higher than the assessed valuations for these properties. Depending on the difference in prices of properties that are comparable in all other criteria, financial assistance in the form of a purchase supplement, rental assistance payments, or a down payment on a loan may be offered to the relocatee. In any case, a potentially displaced person will not be forced to move until at least one comparable replacement dwelling is presented.

In addition to residential relocation assistance, TxDOT also provides assistance to relocated businesses, farms, and nonprofit organizations. These benefits may be in the form of reimbursements for reasonable moving expenses and reestablishment expenses.

4.3.3 Summary of Impacts

An evaluation of EPA environmental index maps as well as race and income data for the Segment G project area has shown that the population living within the Segment G project area is generally less racially diverse, and of higher income than the majority in Harris County and is similar in racial diversity and income to that of Montgomery County. Following a methodology that is consistent and compliant with the EO 12898, it was demonstrated that there is no potential for disproportionate or adverse effects to minority or low-income populations within the Segment G project area.

Alternative Alignment C would have the greatest number of relocations, with a total of 209. Alternative Alignments A, B, and D would have similar relocation impacts with 109, 106, and 110 total displacements, respectively. The Preferred Alternative Alignment would have 110 displacements.

Alternative Alignments A, C, and D and the Preferred Alternative Alignment within Reach 8 would have the greatest adverse effect on community cohesion and could affect access to a church. Alternative Alignment B would potentially affect access to the Spring Peaceful Rest Cemetery within Reach 8. Alternative Alignments A, C, and D and the Preferred Alternative Alignment would affect approximately 7.5 acres of the YMCA Camp Pine Tree (a private recreation area) within Reach 8. Within Reaches 11 and 12, all alternative alignments would divide the Timberland Estates subdivision.

All the alternative alignments would likely have a beneficial effect on public safety, reduce traffic congestion, improve school bus transportation, and improve response times overall for police, fire protection, and medical services in the Segment G project area. No fire stations would be displaced by any alternative. Response times and transportation routes for the following fire departments would be affected by all of the alternative alignments: the Spring VFD, the Porter VFD, and the New Caney VFD. Generally, all of the alternatives are anticipated to increase property values in the Segment G project area, particularly in areas adjacent to entrance/exit ramps, interchanges, and the short sections of frontage road.

Under the No-Build Alternative, community cohesion impacts from the proposed project would not occur. However, anticipated future development in the Segment G 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 G 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 alternative 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 responsibilities may increase, and forest, farmland, and/or undeveloped land may be converted to additional residential areas or 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, 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, offices, and some housing for residents of the Segment G project area, but would not have any disproportionate effects to 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 also provide the congestion relief afforded by the Build Alternative.

4.3.5 Mitigation

Every effort has been made in the selection of alternative alignments and the Preferred Alternative Alignment 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 4.22 [Construction Impacts]). Traffic delays would be minimized through coordination between 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 maintenance of access to residences, farms, businesses, and community facilities where practicable. Grade separations would be incorporated into the design of all of the alternative alignments, allowing for adequate movement of school buses and emergency vehicles across the proposed Segment G project area.

There would be no potential for disproportionate effects (associated with any of the alternatives) to minorities or low-income populations within the Segment G project area; therefore no mitigation related to EJ would be necessary.

Furthermore, additional public meetings would be held during the final design process to discuss specific community and landowner concerns prior to construction of the highway.

4.4 ECONOMICS

The following sections address potential economic impacts from the construction of Alternative Alignments A, B, C, D, the Preferred Alternative Alignment, and the No-Build Alternative for Segment G of the Grand Parkway. Section 4.4.1 (Methodology) defines the methodology used for determining economic impacts. Section 4.4.2 (Construction Costs by Alternative) provides the estimated construction cost for this project. Sections 4.4.3 (Total Output and Value Added Impacts), Section 4.4.4 (Employment Impacts), and Section 4.4.5 (Tax Impacts) provide impacts to total output and value added, employment, and indirect business taxes, respectively. Section 4.4.6 (Summary of Impacts) provides a summary comparison of economic impacts for each of the alternatives.

4.4.1 Methodology

The economic analysis presented in this section discusses potential direct, indirect, and induced impacts that would occur because of this project. The analysis utilized a computer-based modeling program called Implan Professional (Version 2.0) (Minnesota Implan Group, 2000). Through the model, construction cost data were input to calculate direct, indirect, induced, and total impacts, which translate to gross revenues attributable to specific industry sectors (specified by Standard Industrial Classification code). In order to run the input-output model, the construction cost was applied to Implan Sector 39 Highway, Street, Bridge, and Tunnel Construction. The input-output model predicted the effects that highway construction would have on the Harris and Montgomery counties economies as money flows into the Highway, Street, Bridge, and Tunnel Construction industry, then is spent and re-spent within each county. All values are presented in 2010 dollars.

As these dollars are spent and re-spent within each county economy, this translates into direct, indirect, and induced impacts to value added, total output, employment, and indirect business taxes. Indirect and induced impacts occur as goods and services are provided to the sectors that provide the goods and services directly for the construction of the highway. The results of the input-output models were queried to determine the top 10 industries most affected by highway construction within the categories of total output, value added, employment, and indirect business taxes. Value added is a measurement of the value added to intermediate goods and services. It is equal to the total of employee compensation, proprietor income, other property income, and indirect business taxes. Total Output is a measure of the total value of purchases by intermediate and final consumers or by intermediate outlays plus value-added. Employment impacts show the number of new jobs that would be created as a result of the project as dollars are spent directly within the highway construction industry and as dollars are re-spent within the economy and new jobs are created in other industries within the two counties. Indirect business tax impacts measure the amount of local (county, city, and other local taxing entities) and state sales taxes (combined) that would occur because of highway construction.

In designing this economic impact analysis, it was assumed that all economic impacts from highway construction would occur in Harris and Montgomery Counties, Texas. This analysis does not account for leakage, as some dollars spent on highway construction within Harris and Montgomery Counties are re-spent in other counties. The amount of leakage in this case is considered negligible and further analysis of this subject is considered beyond the scope of this project.

Also, a limitation of this study is that the Implan Pro input-output model predicts economic impacts at the county level only. This study simply predicts the total output, value added, employment, and indirect business tax impacts that would occur on a countywide basis as dollars are spent and re-spent within the two counties. This study does not predict indirect or cumulative effects on land use that would occur because of project construction. These subjects are discussed in Section 5 (Indirect and Cumulative Effects) of this volume. Finally, this study does not attempt to address economic impacts from highway maintenance activities that would occur after the project is built. These operational impacts are not addressed because the cost for operation is not known at this time.

4.4.2 Construction Costs by Alternative

Estimated total construction cost estimates for building Alternative Alignments A, B, C, or D, or the Preferred Alternative Alignment, within Segment G are provided in Table 4-7. These estimates were used as inputs into the Implan Pro input-output model. These estimates do not include maintenance costs after highway construction is complete because these costs are unknown at this time. Costs include estimates for the following: construction cost, ROW cost, utilities cost, escalation cost and inflation cost for the targeted letting year. The total cost estimates also include construction of half the interchanges at the project termini; the estimates do not include the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment F-2 at IH 45 nor the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment H at US 59.

TABLE 4-7
HIGHWAY CONSTRUCTION COST FOR SEGMENT G

Alternative Alignment	Reach	Estimated Construction Cost
A	8	$170,691,000
	9	$153,692,000
	10	$13,530,000
	11	$67,305,000
	12	$70,081,000
Alternative Alignment A Total		**$475,299,000**
B	8	$172,079,000
	9	$148,141,000
	10	$13530,000
	11	$72,509,000
	12	$66,611,000
Alternative Alignment B Total		**$472,871,000**

TABLE 4-7 (CONT.)
HIGHWAY CONSTRUCTION COST FOR SEGMENT G

Alternative Alignment	Reach	Estimated Construction Cost
C	8	$170,691,000
	9	$142,243,000
	10	$13,530,000
	11	$75,979,000
	12	$71,121,000
Alternative Alignment C Total		**$473,565,000**
D	8	$170,691,000
	9	$153,345,000
	10	$13,530,000
	11	$67,305,000
	12	$71,121,000
Alternative Alignment D Total		**$475,993,000**
Recommended Alternative Alignment	8	$170,691,000
	9	$153,345,000
	10	$13,530,000
	11	$67,305,000
	12	$71,121,000
Recommended Alternative Alignment Total		**$475,993,000**
Preferred Alternative Alignment	8	$171,038,000
	9	$153,692,000
	10	$13,530,000
	11	$67,305,000
	12	$71,121,000
Preferred Alternative Alignment Total		**$476,687,000**

Note: The No-Build Alternative is not included in this table because it would be purely speculative on the part of the Study Team to estimate maintenance and construction cost on the existing and future roadway systems within the project area. The No-Build Alternative could result in higher maintenance, safety improvements, short-term restoration, and construction (new roads) cost for existing roadways because of increased traffic volumes on these facilities if the Grand Parkway were not constructed.

Costs include estimates for the following: construction cost, ROW cost, utilities cost, escalation cost and inflation cost for targeted letting year (2010). The total cost estimates also include construction of half the interchanges at the project termini; the estimates do not include the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment F-2 at IH 45 nor the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment H at US 59.

Totals may not appear to equal the sum of reaches because of rounding.

Source: Study Team, 2007

4.4.3 Total Output and Value Added Impacts

Table 4-8 shows the direct, indirect, induced, and total impacts to total output and value-added impacts that would occur within Harris and Montgomery Counties, Texas, because of each alternative alignment's construction. Total output and value-added impacts to the top 10 industries that are most affected by the Build Alternative are provided in Appendix L.

TABLE 4-8
DIRECT, INDIRECT, AND INDUCED IMPACTS TO TOTAL OUTPUT AND VALUE ADDED IN SEGMENT G

Impact Category		Direct Impact	Indirect Impact	Induced Impact	Total Impact
Alternative Alignment	Reach				
Total Output*					
A	8	$233,482,000	$85,064,000	$65,316,000	$383,862,000
	9	$210,229,000	$76,592,000	$58,811,000	$345,632,000
	10	$18,508,000	$6,743,000	$5,177,000	$30,428,000
	11	$92,064,000	$33,541,000	$25,755,000	$151,360,000
	12	$95,861,000	$34,925,000	$26,817,000	$157,602,000
Alternative Alignment A Total		**$650,143,000**	**$236,865,000**	**$181,876,000**	**$1,068,884,000**
B	8	$235,380,000	$85,755,000	$65,847,000	$386,983,000
	9	$202,636,000	$73,826,000	$56,687,000	$333,148,000
	10	$18,508,000	$6,743,000	$5,177,000	$30,428,000
	11	$99,182,000	$36,135,000	$27,746,000	$163,063,000
	12	$91,115,000	$33,196,000	$25,489,000	$149,800,000
Alternative Alignment B Total		**$646,821,000**	**$235,654,000**	**$180,946,000**	**$1,063,422,000**
C	8	$233,482,000	$85,064,000	$65,316,000	$386,862,000
	9	$194,568,000	$70,886,000	$54,430,000	$319,885,000
	10	$18,508,000	$6,743,000	$5,177,000	$30,428,000
	11	$103,928,000	$37,864,000	$29,074,000	$170,865,000
	12	$97,284,000	$35,443,000	$27,215,000	$159,942,000
Alternative Alignment C Total		**$647,770,000**	**$236,000,000**	**$181,212,000**	**$1,064,982,000**
D	8	$233,482,000	$85,064,000	$65,316,000	$383,863,000
	9	$209,754,000	$76,419,000	$58,678,000	$344,851,000
	10	$18,508,000	$6,743,000	$5,177,000	$30,428,000
	11	$92,064,000	$33,541,000	$25,755,000	$151,360,000
	12	$97,284,000	$35,443,000	$27,215,000	$159,942,000
Alternative Alignment D Total		**$651,092,000**	**$237,210,000**	**$182,141,000**	**$1,070,444,000**

TABLE 4-8 (CONT.)
DIRECT, INDIRECT, AND INDUCED IMPACTS TO TOTAL OUTPUT AND VALUE ADDED IN SEGMENT G

Impact Category		Direct Impact	Indirect Impact	Induced Impact	Total Impact
Alternative Alignment	**Reach**				
Recommended Alternative Alignment	8	$233,482,000	$85,064,000	$65,316,000	$383,863,000
	9	$209,754,000	$76,419,000	$58,678,000	$344,851,000
	10	$18,508,000	$6,743,000	$5,177,000	$30,428,000
	11	$92,064,000	$33,541,000	$25,755,000	$151,360,000
	12	$97,284,000	$35,443,000	$27,215,000	$159,942,000
Recommended Alternative Alignment Total		**$651,092,000**	**$237,210,000**	**$182,141,000**	**$1,070,444,000**
Preferred Alternative Alignment	8	$233,957,000	$85,237,000	$65,449,000	$384,642,000
	9	$210,229,000	$76,592,000	$58,811,000	$345,632,000
	10	$18,508,000	$6,743,000	$5,177,000	$30,428,000
	11	$92,064,000	$33,541,000	$25,755,000	$151,360,000
	12	$97,284,000	$35,443,000	$27,215,000	$159,942,000
Preferred Alternative Alignment Total		**$652,042,000**	**$237,556,000**	**$182,407,000**	**$1,072,004,000**
Value Added*					
A	8	$100,412,000	$49,785,000	$43,942,000	$194,140,000
	9	$90,412,000	$44,827,000	$39,566,000	$174,805,000
	10	$7,960,000	$3,946,000	$3,483,000	$15,389,000
	11	$39,593,000	$19,631,000	$17,327,000	$76,551,000
	12	$41,226,000	$20,440,000	$18,041,000	$79,708,000
Alternative Alignment A Total		**$279,604,000**	**$138,629,000**	**$122,359,000**	**$540,592,000**
B	8	$101,229,000	$50,190,000	$44,299,000	$195,718,000
	9	$87,147,000	$43,208,000	$38,137,000	$168,491,000
	10	$7,960,000	$3,946,000	$3,483,000	$15,389,000
	11	$42,655,000	$21,149,000	$18,667,000	$82,470,000
	12	$39,185,000	$19,428,000	$17,148,000	$75,762,000
Alternative Alignment B Total		**$278,175,000**	**$137,921,000**	**$121,734,000**	**$537,830,000**
C	8	$100,412,000	$49,785,000	$43,942,000	$194,140,000
	9	$83,672,000	$41,488,000	$36,619,000	$161,779,000
	10	$7,960,000	$3,946,000	$3,483,000	$15,389,000
	11	$44,696,000	$22,160,000	$19,560,000	$86,416,000
	12	$41,838,000	$20,744,000	$18,309,000	$80,892,000
Alternative Alignment C Total		**$278,578,000**	**$138,123,000**	**$121,913,000**	**$538,614,000**

TABLE 4-8 (CONT.)
DIRECT, INDIRECT, AND INDUCED IMPACTS TO TOTAL OUTPUT AND VALUE ADDED IN SEGMENT G

Impact Category		Direct Impact	Indirect Impact	Induced Impact	Total Impact
Alternative Alignment	**Reach**				
D	8	$100,412,000	$49,785,000	$43,942,000	$194,140,000
	9	$90,208,000	$44,726,000	$39,477,000	$174,410,000
	10	$7,960,000	$3,946,000	$3,483,000	$15,389,000
	11	$39,593,000	$19,631,000	$17,327,000	$76,551,000
	12	$41,838,000	$20,744,000	$18,309,000	$80,892,000
Alternative Alignment D Total		**$280,012,000**	**$138,831,000**	**$122,538,000**	**$541,381,000**
Recommended Alternative Alignment	8	$100,412,000	$49,785,000	$43,942,000	$194,140,000
	9	$90,208,000	$44,726,000	$39,477,000	$174,410,000
	10	$7,960,000	$3,946,000	$3,483,000	$15,389,000
	11	$39,593,000	$19,631,000	$17,327,000	$76,551,000
	12	$41,838,000	$20,744,000	$18,309,000	$80,892,000
Recommended Alternative Alignment Total		**$280,012,000**	**$138,831,000**	**$122,538,000**	**$541,381,000**
Preferred Alternative Alignment	8	$100,616,000	$49,886,000	$44,032,000	$194,534,000
	9	$90,412,000	$44,827,000	$39,566,000	$174,805,000
	10	$7,960,000	$3,946,000	$3,483,000	$15,389,000
	11	$39,593,000	$19,631,000	$17,327,000	$76,551,000
	12	$41,838,000	$20,744,000	$18,309,000	$80,892,000
Preferred Alternative Alignment Total		**$280,420,000**	**$139,034,000**	**$122,717,000**	**$542,170,000**

Note: Economic impacts are rounded to the nearest $1,000; totals may not appear to equal sum of reaches because of rounding.
* Definitions of Total Output and Value-Added are found in Section 4.4.1.
Source: Minnesota Implan Group, 2007

4.4.4 Employment Impacts

Table 4-9 shows the direct, indirect, induced, and total impacts to employment that would occur within Harris and Montgomery Counties, as a result of each alternative alignment's construction. Appendix L provides employment impacts broken down by the top 10 industries most affected by the construction of the highway.

TABLE 4-9
DIRECT, INDIRECT, AND INDUCED IMPACTS TO EMPLOYMENT IN SEGMENT G (NUMBER OF PERSONS)

Alternative Alignment	Reach	Direct Impact	Indirect Impact	Induced Impact	Total Impact
A	8	1,530	600	610	2,730
	9	1,370	540	550	2,460
	10	120	50	50	220
	11	600	240	240	1,080
	12	630	240	250	1,120
Alternative Alignment A Total		**4,250**	**1,660**	**1,690**	**7,600**
B	8	1,540	600	610	2,750
	9	1,330	520	530	2,370
	10	120	50	50	220
	11	650	250	260	1,160
	12	600	230	240	1,070
Alternative Alignment B Total		**4,230**	**1,650**	**1,680**	**7,560**
C	8	1,530	600	610	2,730
	9	1,270	500	500	2,270
	10	120	50	50	220
	11	680	270	270	1,210
	12	640	250	250	1,140
Alternative Alignment C Total		**4,240**	**1,660**	**1,680**	**7,570**
D	8	1,530	600	610	2,730
	9	1,370	540	540	2,450
	10	120	50	50	220
	11	600	240	240	1,080
	12	640	250	250	1,140
Alternative Alignment D Total		**4,260**	**1,680**	**1,690**	**7,630**
Recommended Alternative Alignment	8	1,530	600	610	2,730
	9	1,370	540	540	2,450
	10	120	50	50	220
	11	600	240	240	1,080
	12	640	250	250	1,140
Recommended Alternative Alignment Total		**4,260**	**1,680**	**1,690**	**7,630**
Preferred Alternative Alignment	8	1,530	600	610	2,730
	9	1,370	540	550	2,460
	10	120	50	50	220
	11	600	240	240	1,080
	12	640	250	250	1,140
Preferred Alternative Alignment Total		**4,260**	**1,670**	**1,700**	**7,620**

Note: Employment impacts are rounded to the nearest 10; totals may not appear to equal sum of reaches because of rounding.

Source: Minnesota Implan Group, 2007

The industry that would be most affected by employment is the Highway, Street, Bridge and Tunnel Construction industry (Appendix L). Construction is a large and fast growing industry (with respect to number of jobs) within Harris and Montgomery Counties. The number of construction jobs in Harris County increased by 1.3 percent between 2000 and 2006, and in Montgomery County the number of construction jobs increased by 3.41 percent during this time period (Texas Workforce Commission, 2007). 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. It is likely that at least some of the construction workforce would come from Fort Bend and Brazoria Counties.

4.4.5 Tax Impacts

Table 4-10 shows the direct, indirect, induced, and total impacts to indirect business taxes due to and during the period of highway construction. Indirect business tax impacts to the top 10 affected industries in Harris and Montgomery Counties are shown in Appendix L. These indirect business taxes consist of excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses. These taxes occur during the normal operation of businesses but do not include taxes on profit or income. These taxes include both state and major local taxing jurisdictions (county and city taxes). Indirect business tax numbers are derived from U.S. Bureau of Economic Analysis Gross State Product data.

In the longer term, land purchased for the ROW would be removed from local tax rolls, thus, potentially decreasing property tax revenues. However, it is likely that remaining lands along the ROW would be converted to more urbanized uses, particularly commercial uses, thus, increasing the revenue potential from property taxes from these properties. In addition, 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.

TABLE 4-10
DIRECT, INDIRECT, AND INDUCED IMPACTS TO INDIRECT BUSINESS TAX IN SEGMENT G

Alternative Alignment	Reach	Direct Impact	Indirect Impact	Induced Impact	Total Impact
A	8	$2,251,000	$3,228,000	$4,636,000	$10,115,000
	9	$2,027,000	$2,907,000	$4,174,000	$9,108,000
	10	$178,000	$256,000	$367,000	$802,000
	11	$888,000	$1,273,000	$1,828,000	$3,989,000
	12	$924,000	$1,325,000	$1,903,000	$4,153,000
Alternative Alignment A Total		**$6,268,000**	**$8,990,000**	**$12,908,000**	**$28,166,000**
B	8	$2,269,000	$3,255,000	$4,674,000	$10,198,000
	9	$1,950,000	$2,802,000	$4,024,000	$8,776,000
	10	$178,000	$256,000	$367,000	$802,000
	11	$956,000	$1,371,000	$1,969,000	$4,297,000
	12	$878,000	$1,260,000	$1,809,000	$3,947,000
Alternative Alignment B Total		**$6,231,000**	**$8,944,000**	**$12,844,000**	**$28,018,000**

TABLE 4-10 (CONT.)
DIRECT, INDIRECT, AND INDUCED IMPACTS TO INDIRECT BUSINESS TAX IN SEGMENT G

Alternative Alignment	Reach	Direct Impact	Indirect Impact	Induced Impact	Total Impact
C	8	$2,251,000	$3,228,000	$4,636,000	$10,115,000
	9	$1,876,00	$2,690,000	$3,863,000	$6,553,000
	10	$178,000	$256,000	$367,000	$802,000
	11	$1,002,000	$1,437,000	$2,064,000	$4,503,000
	12	$938,000	$1,345,000	$1,932,000	$4,215,000
Alternative Alignment C Total		**$4,369,000**	**$8,957,000**	**$12,862,000**	**$26,187,000**
D	8	$2,251,000	$3,228,000	$4,636,000	$10,115,000
	9	$2,022,000	$2,900,000	$4,165,000	$9,087,000
	10	$178,000	$256,000	$367,000	$802,000
	11	$888,000	$1,273,000	$1,828,000	$3,989,000
	12	$938,000	$1,345,000	$1,932,000	$4,215,000
Alternative Alignment D Total		**$6,277,000**	**$9,003,000**	**$12,928,000**	**$28,208,000**
Recommended Alternative Alignment	8	$2,251,000	$3,228,000	$4,636,000	$10,115,000
	9	$2,022,000	$2,900,000	$4,165,000	$9,087,000
	10	$178,000	$256,000	$367,000	$802,000
	11	$888,000	$1,273,000	$1,828,000	$3,989,000
	12	$938,000	$1,345,000	$1,932,000	$4,215,000
Recommended Alternative Alignment Total		**$6,277,000**	**$9,003,000**	**$12,928,000**	**$28,208,000**
Preferred Alternative Alignment	8	$2,255,000	$3,235,000	$4,646,000	$10,136,000
	9	$2,030,000	$2,907,000	$4,174,000	$9,111,000
	10	$178,000	$256,000	$367,000	$802,000
	11	$888,000	$1,273,000	$1,828,000	$3,989,000
	12	$938,000	$1,345,000	$1,932,000	$4,215,000
Preferred Alternative Alignment Total		**$6,289,000**	**$9,016,000**	**$12,947,000**	**$28,252,000**

Note: Impacts are for the period during construction. Numbers are rounded to the nearest $1,000; totals may not appear to equal sum of reaches because of rounding.

Source: Minnesota Implan Group, 2007

4.4.6 Summary of Impacts

Economic impacts related to the development of the Grand Parkway Segment G include a temporary increase in construction-related employment, an increase in other employment areas, a reduction in travel costs, and additional local and regional income generation from sources such as transportation related taxes. An input-output model (Implan Pro) was used to predict economic effects resulting from development of the proposed project alternative alignments based on highway construction cost estimates. Construction costs were as follows: 1) Alternative Alignment A, $475.3 million; 2) Alternative Alignment B, $472.9 million; 3) Alternative Alignment C, $473.6 million; 4) Alternative Alignment D, $476.0

million; and the Preferred Alternative Alignment, $476.7. Output impacts were as follows: 1) Alternative Alignment A, $1.07 billion; 2) Alternative Alignment B, $1.06 billion; 3) Alternative Alignment C, $1.06 billion; 4) Alternative Alignment D, $1.07 billion; and the Preferred Alternative Alignment, $1.07 billion. Value-added impacts were as follows: 1) Alternative Alignment A, $540.6 million; 2) Alternative Alignment B, $537.8 million; 3) Alternative Alignment C, $538.6 million; 4) Alternative Alignment D, $541.4 million; and the Preferred Alternative Alignment, $542.2 million. The total employment impacts would be as follows: 1) Alternative Alignment A, 7,600 employees; 2) Alternative Alignment B, 7,560 employees; 3) Alternative Alignment C, 7,570 employees; 4) Alternative Alignment D, 7,630 employees; and the Preferred Alternative Alignment, 7,620 employees. The indirect business tax impacts in Harris and Montgomery counties would be as follows: 1) Alternative Alignment A, $28.2 million; 2) Alternative Alignment B, $28.0 million; 3) Alternative Alignment C, $26.2 million; 4) Alternative Alignment D, $28.2 million; and the Preferred Alternative Alignment, $28.3 million.

Under the No-Build Alternative, the Segment G project area is expected to become increasingly urbanized over time. Land in the Segment G project area is expected to be converted over time from forestland and undeveloped land to residential subdivisions, offices, apartments, and commercial development. As development occurs over time, employment in the area is likely to grow. As the Segment G project area's economy diversifies and adds new jobs as a result of urbanization, total economic output and value-added impacts will increase. New commercial and residential development that would occur in the Segment G project area would likely increase the property tax base of the area. Newly built commercial businesses would add a boost to sales taxes collected in the area. With the No-Build Alternative, the Segment G project area's economy would not benefit from construction spending associated with the proposed project and therefore would not benefit from additional increases in total output, value-added, employment, and indirect business taxes associated with the proposed project.

4.4.7 Indirect Impacts

Indirect economic impacts would be tied to potential indirect development. The economic impacts of that development are summarized as follows:

- Provide improved access to IH 45 and US 59 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; and
- 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.

4.4.8 Mitigation

Economic effects related to proposed project alternative alignments are considered beneficial; therefore no mitigation would be necessary.

4.5 PEDESTRIANS AND BICYCLISTS

Segment G of the Grand Parkway would not impact any existing bicycle or pedestrian facilities. The 2035 RTP includes a Regional Bikeway Plan update that contains a listing of current and proposed bicycle facilities for the Houston area. The Grand Parkway is not a corridor identified in the plan to receive a future bicycle facility. All alternative alignments in Reach 8 would cross "Proposed Bicycle Lanes" along Spring Creek and Riley Fuzzel Road as identified in the Regional Bikeway Plan (H-GAC, 2007a). The Grand Parkway project as proposed would accommodate existing and 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. 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. As currently designed, it is not anticipated that bicycle traffic would be accommodated on the outside lanes of the toll-way main lanes or intermittent frontage roads. In the future, should H-GAC's RTP include a proposed bikeway corridor along the Grand Parkway, appropriate supplemental studies will be initiated.

The ease of pedestrian and bicyclist movement would be impacted at points along existing roadways where entrance and exit ramps would be constructed for the proposed Grand Parkway. The proposed 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). As currently proposed, frontage roads proposed in association with Segment G would not have sidewalks.

Under the No-Build Alternative, future urbanization within the Segment G project area is expected to lead to greater traffic volumes on arterial roadways. These greater traffic volumes would likely make these arterial roadways less safe for pedestrians and bicyclists unless substantial efforts are made to accommodate pedestrian and bicycle safety in roadway improvement design. The proposed bicycle routes (identified by H-GAC) could be accommodated as long as development within the project area does not encroach upon the areas where the lanes would be built.

4.5.1 Summary of Impacts

Within Reach 8, all alternative alignments would cross "Proposed Bicycle Lanes" along Spring Creek and Riley Fuzzel Road as identified in H-GAC's 2035 Regional Bikeway Plan. The Grand Parkway project as proposed would accommodate existing and 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. 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. The flow of bicycle and pedestrian traffic would be affected by the Grand Parkway at grade separations with access ramps, and by the No-Build Alternative because of higher traffic volumes.

4.5.2 Indirect Impacts

Pedestrians and bicyclists could benefit from the indirect development of residential and commercial streets, in conjunction with this project because of the congestion relief the Grand Parkway would provide and the increased availability of community resources such as shopping. Benefits will be greater if pedestrian walkways and bicycle facilities could be 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 Grand Parkway and induced development anticipated at these locations.

4.5.3 Mitigation

The proposed 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

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 VOCs, NOx, CO, CO_2, PM, and MSAT.

4.6.1 Criteria Pollutants

The EPA establishes limits on atmospheric pollutant concentrations through enactment of the national ambient air quality standards (NAAQS) for six principal “criteria” pollutants. The EPA designated Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties in the Houston metropolitan area as “moderate non-attainment” for the 8-hour ozone standard in accordance with the NAAQS. The Houston region (including Chambers County) is currently in “attainment” for all criteria pollutants, with the exception of ozone. VOCs and NOx can react in the air in sunlight to form ground-level ozone. Because the reactions take place over several hours, maximum concentrations of ozone are often far downwind of the precursor sources. Thus, ozone is a regional problem and not a local condition and is addressed through the SIP.

The Grand Parkway Segment G was included in H-GAC’s 2025 RTP and was included in the FY 2006-2008 TIP, Appendix D, as project undergoing environmental review and scheduled for implementation beyond the three-year TIP time frame. The 2025 RTP and 2006-2008 TIP were adopted by H-GAC in April 2005 and found to conform to the SIP by USDOT (FHWA/FTA) on June 3, 2005 and October 31, 2005, respectively.

The Grand Parkway Segment G is included in H-GAC's 2035 RTP and FY 2008-2011 TIP, as amended. On August 24, 2007, H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. USDOT (FHWA/FTA) found the 2035 RTP and 2008-2011 TIP to conform to the SIP on November 9, 2007.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional analysis is warranted before 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 modeled parameters can be found in the Administrative Record.

Of the criteria pollutants, CO is readily modeled for highway projects and is required by FHWA Technical Advisory T 6640.8A (1987). A Traffic Air Quality Analysis (TAQA-CO) for CO was prepared in accordance with TxDOT's 2006 *Air Quality Guidelines*. EPA's MOBILE6.2 mobile emission factor model and CALINE3 were used to estimate CO levels at the year of completion (2012) and the design year (2025). CALINE3 is a line source dispersion model specifically designed for the prediction of pollutant concentrations in the vicinity of highways.

Appropriate vehicle emission values from MOBILE6.2 for the years 2012 and 2025 were input into CALINE3. It should be noted that MOBILE6.2 does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a). MOBILE6.2 input factors include parameters for tampering rates, vehicle speeds, vehicle registration by vehicle type and age, percentage of vehicles in cold start mode, atmospheric temperature, humidity, and type of vehicle inspection/maintenance program. Projected CO concentrations were then calculated using inputs expected to be reflective of the highest CO concentrations, including meteorological conditions, vehicle fleet operating characteristics, traffic, and local terrain.

The EPA's highway vehicle emission factor model, MOBILE6.2 is a FORTRAN program that provides average in-use fleet emission factors for criteria pollutants (CO and NOx) and also provides emission factors for VOCs. These emission factors can be estimated for any year between 1952 and 2050 and under various conditions that affect in-use emission levels (e.g., ambient temperature, humidity, average traffic speeds, and gasoline volatility). The output from the model is in the form of emissions factors expressed as grams of pollutant per vehicle mile traveled (g/mi). Because newer cars with better pollution-control devices are replacing older cars, emissions continue to decrease despite the increase in overall VMT. The Air Quality Analysis section of the TxDOT Environmental Affairs Division in Austin, Texas provided the MOBILE6.2 CO data used in this study, as shown in Table 4-11. TxDOT's 2006 *Air Quality Guidelines*, updated with CO emission factor tables for all TxDOT districts (TxDOT, 2006a), includes CO emission factors for 2006-2030. (However, as noted above, MOBILE6.2 does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* [EPA, 2007a].) The CO emission

factors were calculated using toll build-out traffic conditions, assuming all segments of the corridor would be completed (E, F-1, F-2, and G conditions). This traffic condition represents the worst-case of emissions for the Grand Parkway.

TABLE 4-11
CO EMISSION FACTORS (G/MI) AT 65 MPH

Year*	Grams/Mile CO
2012	6.718
2025	5.389

Notes: *Traffic volume projections are found in Volume I, Table 2-4. Year 2012 traffic volumes are extrapolated from 2015 traffic data using a compound annual growth rate at approximately 2.8 percent

Source: H-GAC, 2005a; TxDOT, 2006a; and Study Team, 2007

CALINE3 is a line source dispersion model that estimates CO concentrations along a roadway. CALINE3 will estimate CO values for modeled receptors along the ROW line. CALINE3 is one of the suggested models for use by the TxDOT's 2006 *Air Quality Guidelines*. Inputs for CALINE3 include wind speed, wind angle, stability class, mixing height, VMT, signal timing, and background concentrations for CO. Background concentration or ambient level is a summation of all CO concentrations that are from other than project mobile sources. Included are natural sources, point sources, non-project mobile sources, residential and industrial heating, and other industrial sources. The background concentration is intended to represent a conservative constant that is used homogeneously throughout the project area. It is added to the predicted values to be compared to the NAAQS for a more accurate picture of the project's effect on the area. Model calculations included TxDOT's recommended background concentrations for Houston, which are 4.5 ppm for the 1-hour and 2.8 ppm for the 8-hour.

CALINE3 produces a 1-hour CO concentration value that is then converted to 8-hour concentrations and compared with the 8-hour CO NAAQS. The NAAQS for 1-hour CO is 35 ppm and the 8-hour standard is 9 ppm. Once the 1-hour and 8-hour CO concentrations are calculated, the results are converted to a percentage of the 1-hour and 8-hour CO NAAQS, respectively (TxDOT, 2006a).

4.6.2 Micro-Scale Carbon Monoxide (CO) Analysis

The projected year of completion (2012) and the design year (2025) concentration for 1-hour and 8-hour CO and the percentage of the NAAQS for the Build Alternative are presented in Table 4-12. CO levels are not expected to exceed national standards for any of the analysis years.

TABLE 4-12
PROJECT CO CONCENTRATIONS (SEGMENT G)

Year	Segment	1 Hr CO (ppm) Standard 35 ppm	1 Hr % NAAQS	8 Hr CO (ppm) Standard 9 ppm	8 Hr % NAAQS
2012 (completion)*	G	4.80	13.71%	2.92	32.44%
2025 (design year)	G	5.30	15.14%	3.28	36.44%

Notes: NAAQS for CO is 35 ppm for 1 hour and 9 ppm for 8 hours. Analysis includes a 1-hour background concentration of 4.5 ppm and an 8-hour background concentration of 2.8 ppm.

*2012 traffic volumes are extrapolated from 2015 traffic data using a compound annual growth rate at approximately 2.8 percent.

Source: Study Team, 2007

4.6.2.1 Summary

The topography and meteorology of each of the alternative alignments are nearly identical and none of the alignments would alter the topography or seriously restrict the dispersion of air pollutants; therefore each of the alternative alignments will be treated as one for purposes of CO modeling. The modeling indicates that local concentrations of CO are not expected to exceed national standards at any time along Segment G, and that local CO concentrations are not expected to exceed national standards should the four contiguous segments (E, F-1, F-2, and G) be built.

4.6.3 Mobile Source Air Toxics (MSAT)

4.6.3.1 Sensitive Receptor Assessment

There may be localized areas where ambient concentrations of MSAT are slightly higher for the Build Alternative than for the No-Build Alternative. Dispersion studies have shown that the "roadway" air toxics start to drop off at about 100 meters. By 500 meters, most studies have found it very difficult to distinguish the roadway from background toxic concentrations in any given area. An assessment of sensitive receptors (facilities most likely to contain large concentrations of the more sensitive populations including hospitals, schools, licensed daycares, and elderly care facilities) was completed. Table 4-13 indicates the number of sensitive receptors within 328 feet (100 meters) and within 1,640 feet (500 meters) of each alternative alignment.

Only Alternative Alignments B and C have a sensitive receptor within 328 feet (100 meters) of the ROW. All of the alternative alignments have four or five sensitive receptors within 1,640 feet (500 meters) of the ROW. Sensitive receptor locations are depicted in Exhibit G–25a-e. For a detailed description of the sensitive receptors, see Appendix F, Table 4.

TABLE 4-13
SEGMENT G SENSITIVE RECEPTORS PROPERTY IMPACTS

Alternative	Reach	328 ft (100 meters)				1,640 ft (500 meters)			
		Count	Dist from ROW (ft)	Receptor Type	Receptor Name	Count	Dist from R/W (ft)	Receptor Type	Receptor Name
A	8	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-
	11	-	-	-	-	1	1,560	School	Robert L. Crippen Elementary School
	12	-	-	-	-	3	-	-	-
							1,580	Daycare	Jungle Learning Center
							950	Daycare	New Caney High School Child Development
							950	School	New Caney High School
Total		**0**				**4**			
B	8	1	0	School	Northgate Crossing Elementary	1	0	School	Northgate Crossing Elementary
	9	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-
	11	-	-	-	-	1	630	School	Robert L. Crippen Elementary
	12	-	-	-	-	3	-	-	-
							1,580	Daycare	Jungle Learning Center
							950	Daycare	New Caney High School Child Development
							950	School	New Caney High School
	Total	**1**				**5**			
C	8	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-
	11	1	170	School	Robert L. Crippen Elementary	1	170	School	Robert L. Crippen Elementary
	12	-	-	-	-	3	-	-	-
							1,580	Daycare	Jungle Learning Center
							950	Daycare	New Caney High School Child Development
							950	School	New Caney High School
Total		**1**				**4**			

TABLE 4-13 (CONT.)
SEGMENT G SENSITIVE RECEPTORS PROPERTY IMPACTS

Alternative	Reach	328 ft (100 meters)				1,640 ft (500 meters)			
		Count	Dist from ROW (ft)	Receptor Type	Receptor Name	Count	Dist from R/W (ft)	Receptor Type	Receptor Name
	8	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-
	11	-	-	-	-	1	1,560	School	Robert L. Crippen Elementary
	12	-	-	-	-	3	-	-	-
							1,580	Daycare	Jungle Learning Center
							950	Daycare	New Caney High School Child Development
							950	School	New Caney High School
Total		**0**				**4**			
Recommended	8	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-
	11	-	-	-	-	1	1,560	School	Robert L. Crippen Elementary
	12	-	-	-	-	3	-	-	-
							1,560	Daycare	Jungle Learning Center
							950	Daycare	New Caney High School Child Development
							950	School	New Caney High School
Total		**0**				**4**			
Preferred	8	-	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-
	11	-	-	-	-	1	1,560	School	Robert L. Crippen Elementary
	12	-	-	-	-	3	-	-	-
							1,560	Daycare	Jungle Learning Center
							950	Daycare	New Caney High School Child Development
							950	School	New Caney High School
	Total	**0**				**4**			

Notes: DC = Daycare; all measurements are approximate (rounded to nearest 10) and are taken from the edge of the property to the edge of the ROW for each alternative alignment; a measurement of 0 feet indicates that the alternative alignment ROW either passes through the property or is immediately adjacent to the property.

Source: Study Team, 2007

4.6.3.2 MSAT Emissions by Alternative

The MSAT analysis was prepared in accordance with TxDOT's *2006 Air Quality Guidelines* for the six priority MSAT, acetaldehyde, acrolein, benzene, butadiene, formaldehyde, and diesel particulate matter (DPM). The resulting emission inventory for the six priority MSAT was compiled for the entire Grand Parkway traffic study area, Segments E, F-1, F-2, and G, as shown in Exhibit G–26 (see green wedge for Segment G), and as summarized in Table 4-14 and Figure 4-1. The Grand Parkway Segment G traffic study area's relative amount of total MSAT emissions (approximately 30 percent of the four segments combined) is provided in Table 4-15 and Figure 4-2.

TABLE 4-14
MSAT EMISSIONS BY ALTERNATIVE (TONS/YEAR)
(ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)

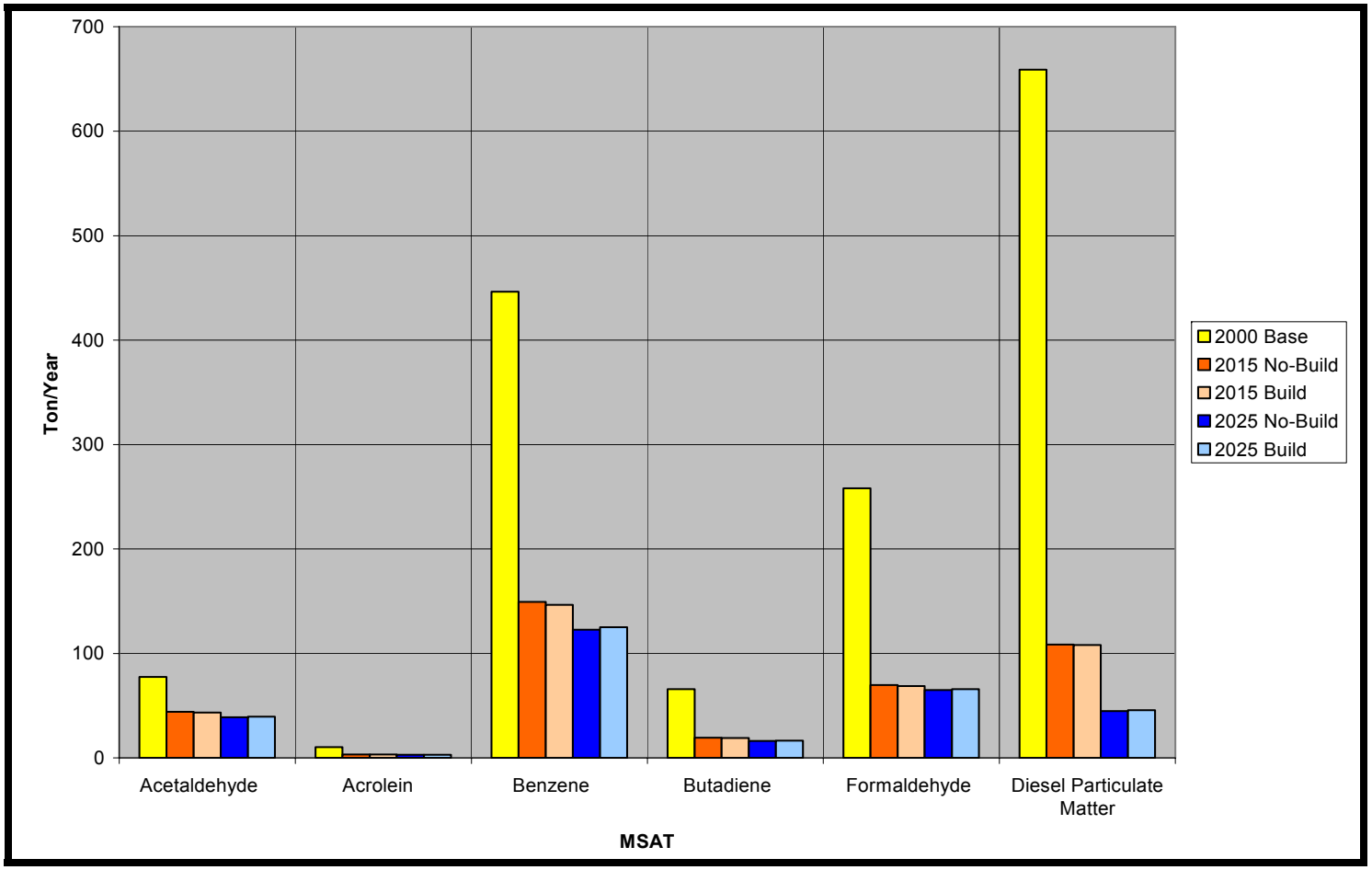
Compound	Year / Alternative				
	2000 (Base Year)	2015*		2025	
		No-Build	Build	No-Build	Build
Acetaldehyde	77	44	43	39	40
Acrolein	10	3	3	3	3
Benzene	446	149	147	123	125
Butadiene	66	19	19	16	17
Formaldehyde	258	70	69	65	66
Diesel PM (DPM)	659	108	108	45	46
Total MSAT	**1,516**	**393**	**389**	**291**	**297**

Note: * 2015 No-Build Alternative is higher because of more traffic congestion on local roadway links without the proposed Grand Parkway.

Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

FIGURE 4-1
PROJECTED CHANGES IN MSAT EMISSIONS BY ALTERNATIVE OVER TIME
(ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

TABLE 4-15
MSAT EMISSIONS BY ALTERNATIVE FOR SEGMENT G TRAFFIC STUDY AREA (TONS/YEAR)

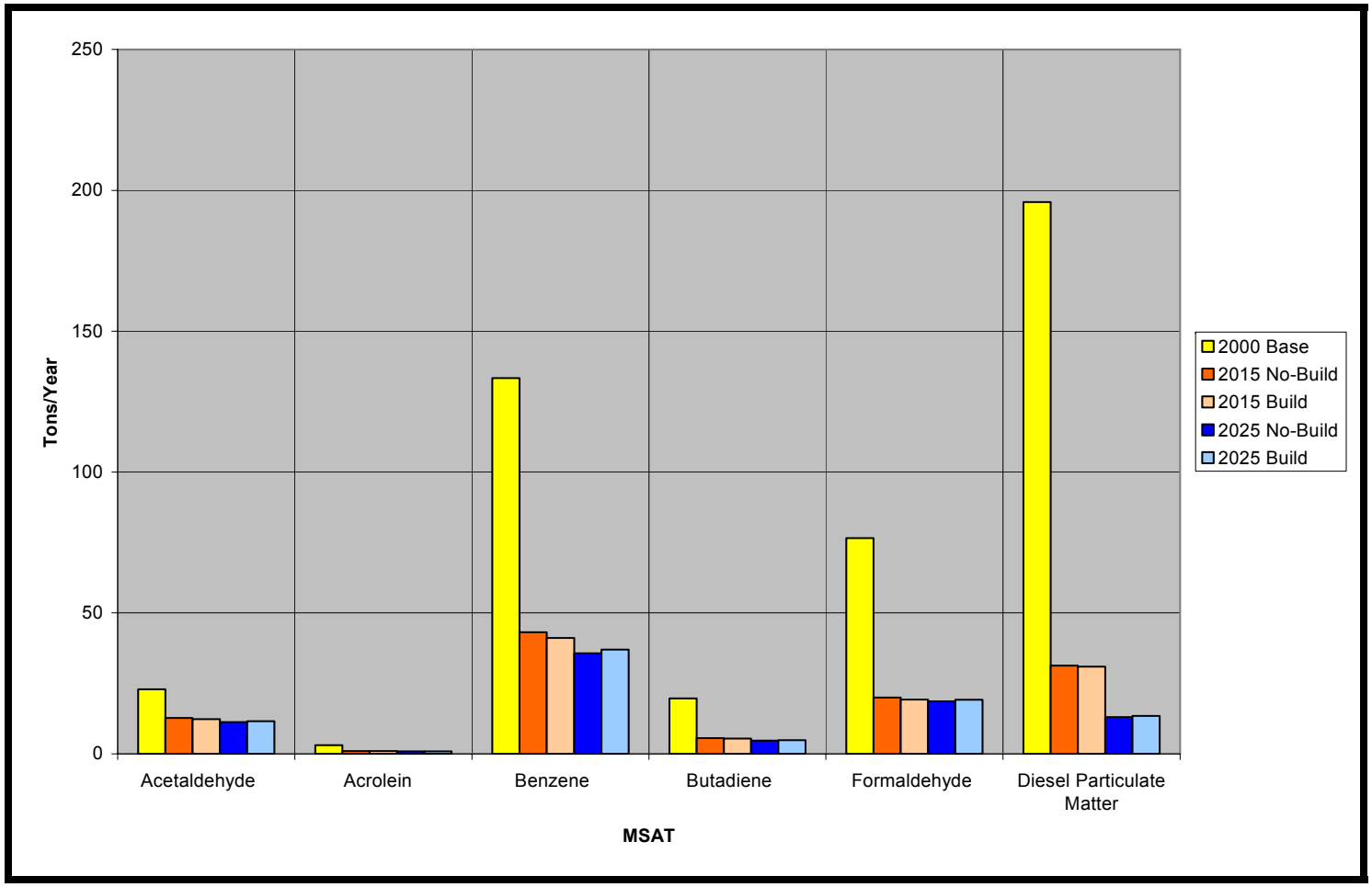
Compound	Year / Alternative				
	2000 (Base Year)	2015*		2025	
		No-Build	Build	No-Build	Build
Acetaldehyde	23	13	12	11	12
Acrolein	3	1	1	1	1
Benzene	133	43	41	36	37
Butadiene	20	6	5	5	5
Formaldehyde	77	20	19	19	19
DPM	196	31	31	13	13
Totals – Segment G	**452**	**114**	**109**	**85**	**87**

Note: * 2015 No-Build Alternative is higher because of more traffic congestion on local roadway links without the proposed Grand Parkway.

Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

FIGURE 4-2
PROJECTED CHANGES IN MSAT EMISSIONS BY ALTERNATIVE OVER TIME FOR SEGMENT G TRAFFIC STUDY AREA



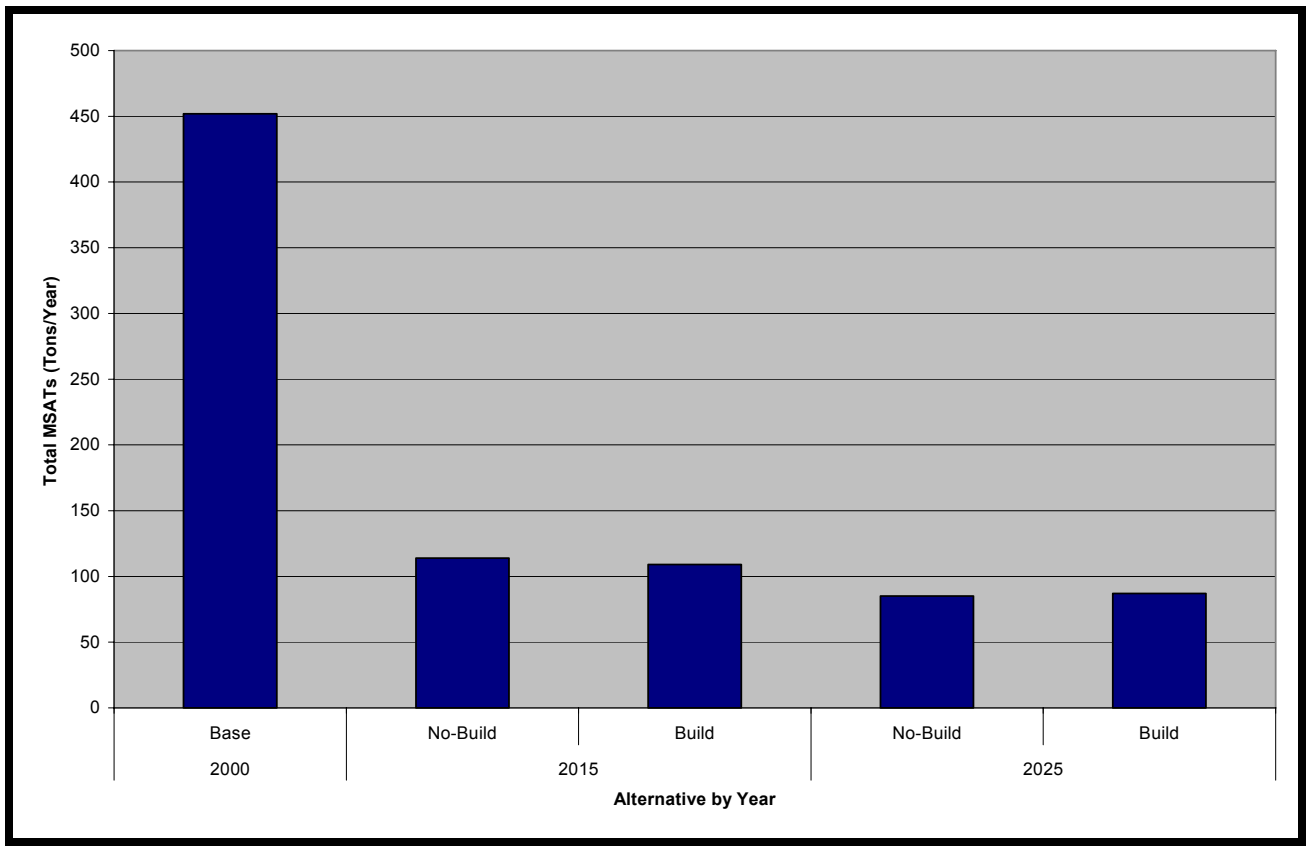
Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

The analysis indicates that a substantial decrease in MSAT emissions can be expected for both the Build and No-Build future cases (2015 and 2025) versus the base year (2000) for Segment G. Emissions of total MSAT are expected to decrease by approximately 81 percent by 2025 compared with 2000 levels for Segment G. If emissions are plotted over time, a substantially decreasing level of MSAT can be seen (Figure 4-3); however, overall VMT continues to rise (Figure 4-4).

Of the six priority MSAT compounds, benzene, and DPM contribute the most to the emissions total for Segment G (Table 4-15 and Figure 4-5a-f). The amount of DPM emitted in 2000 was higher than the amount of benzene emitted (196 tons/year for DPM and 133 tons/year for benzene). In future years, a substantial decline in benzene is anticipated (about a 73 percent reduction from 2000 to 2025, No-Build), and an even larger reduction in DPM emissions is expected (about a 93 percent decrease from 2000 to 2025, No-Build). Figures 4-3, 4-4, and 4-5a-f used the EPA Mobile Emission Factor Model with Grand Parkway specific inputs (see Appendix F, Mobile Air Source Toxics Technical Report for details).

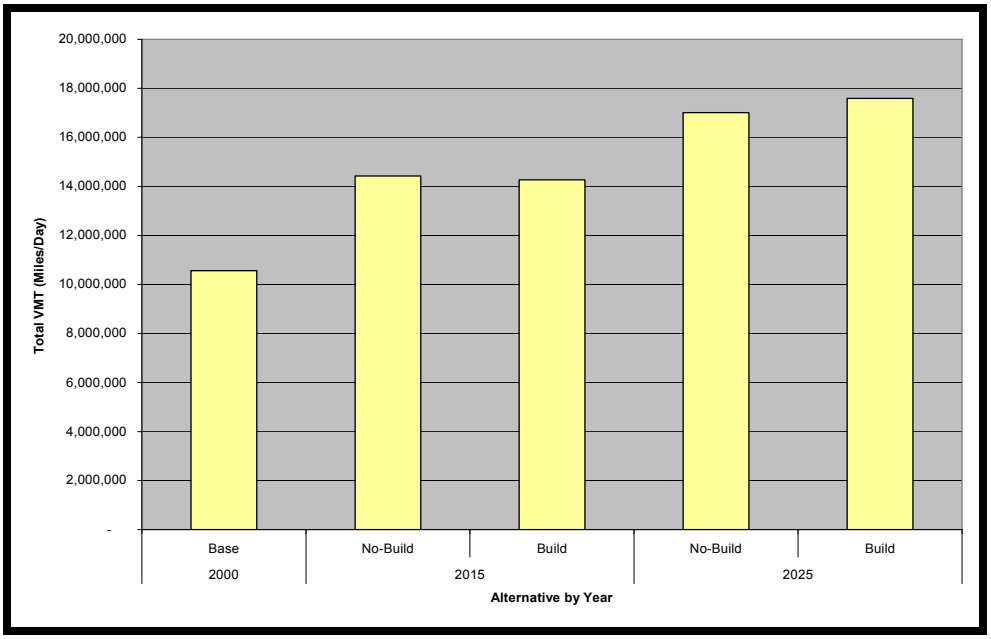
FIGURE 4-3
TOTAL MSAT EMISSIONS OVER TIME, SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

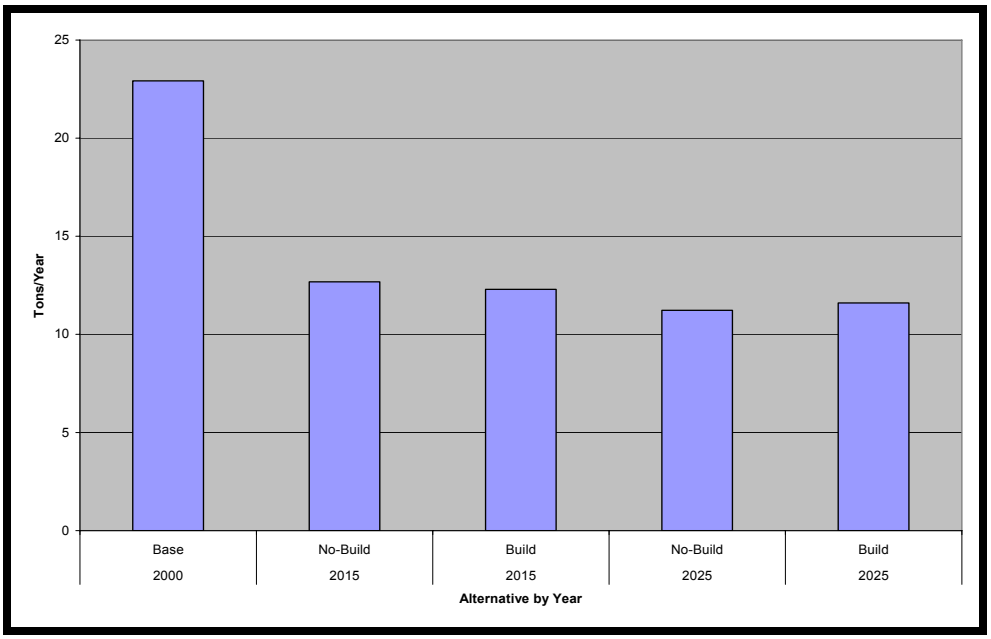
FIGURE 4-4
TOTAL VMT OVER TIME, SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

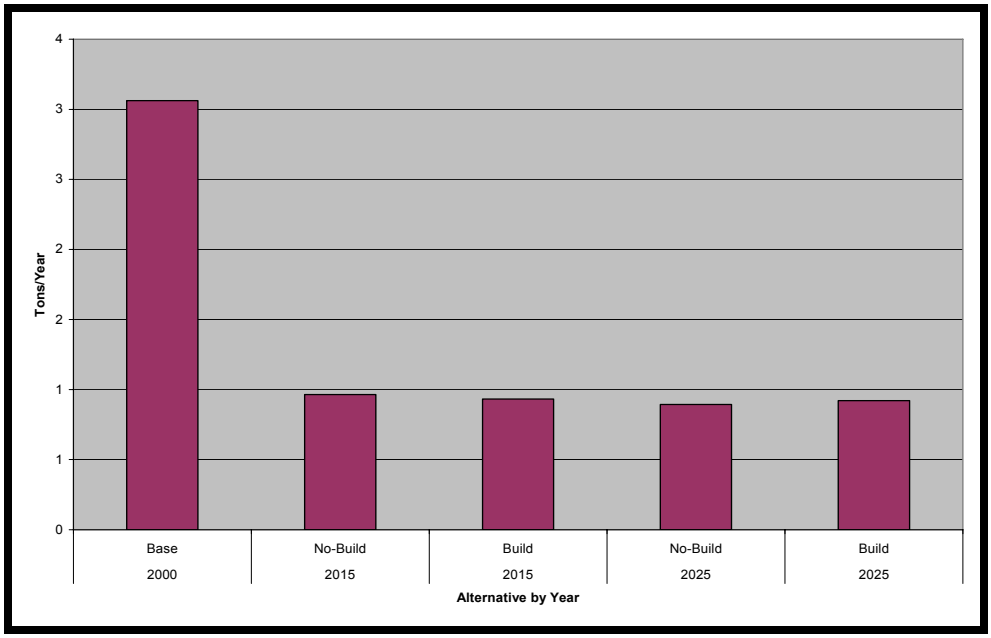
FIGURE 4-5a
COMPARISON OF ACETALDEHYDE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

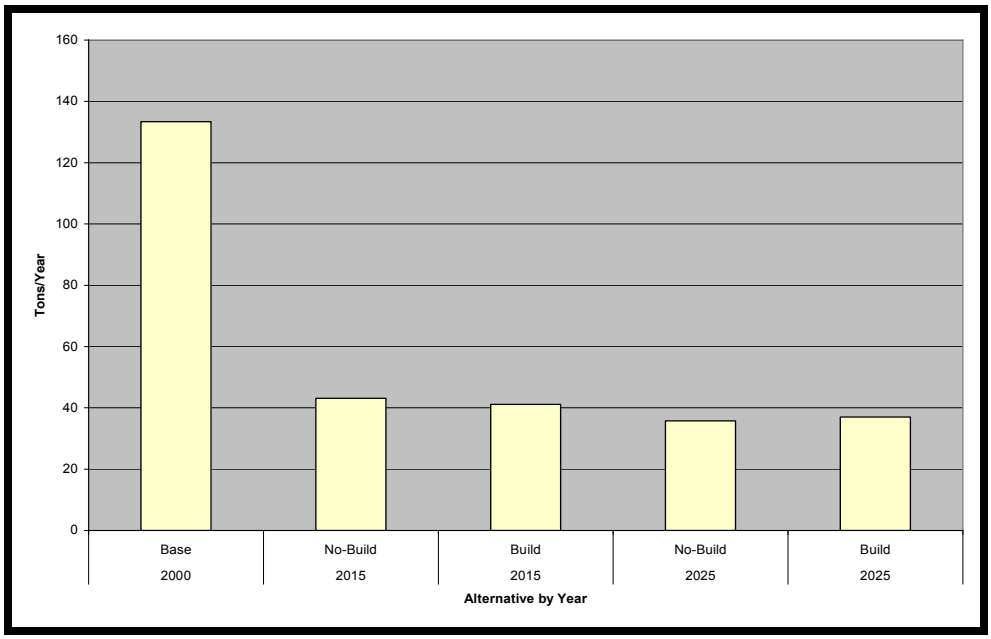
FIGURE 4-5b
COMPARISON OF ACROLEIN BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

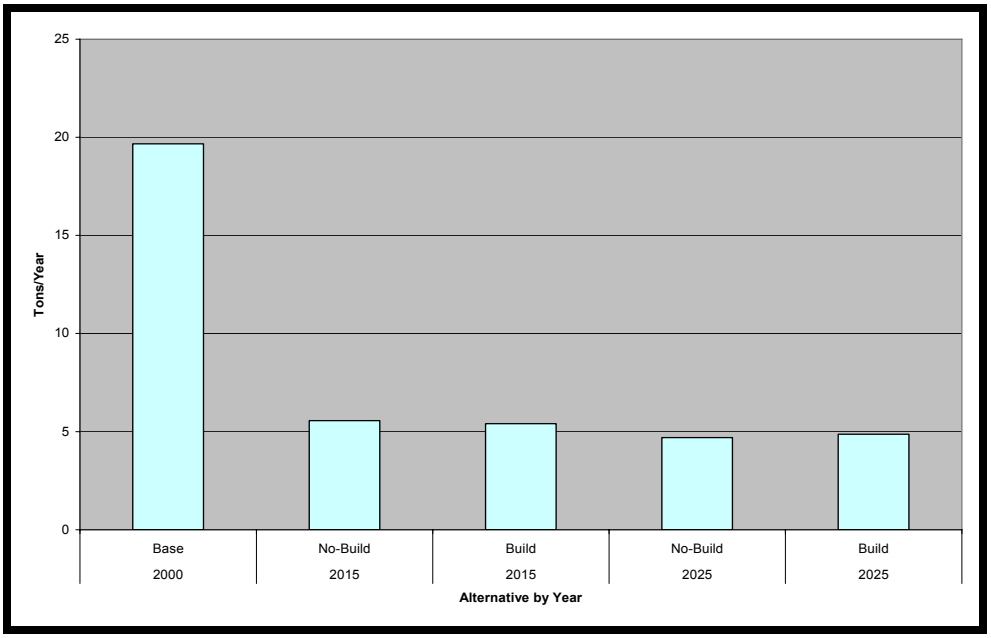
FIGURE 4-5c
COMPARISON OF BENZENE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

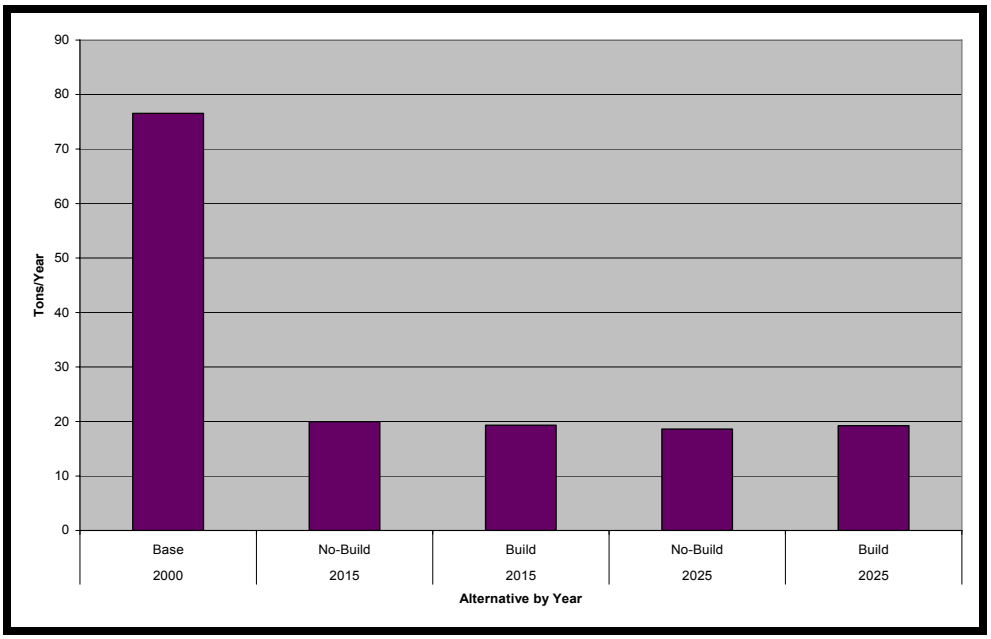
FIGURE 4-5d
COMPARISON OF BUTADIENE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

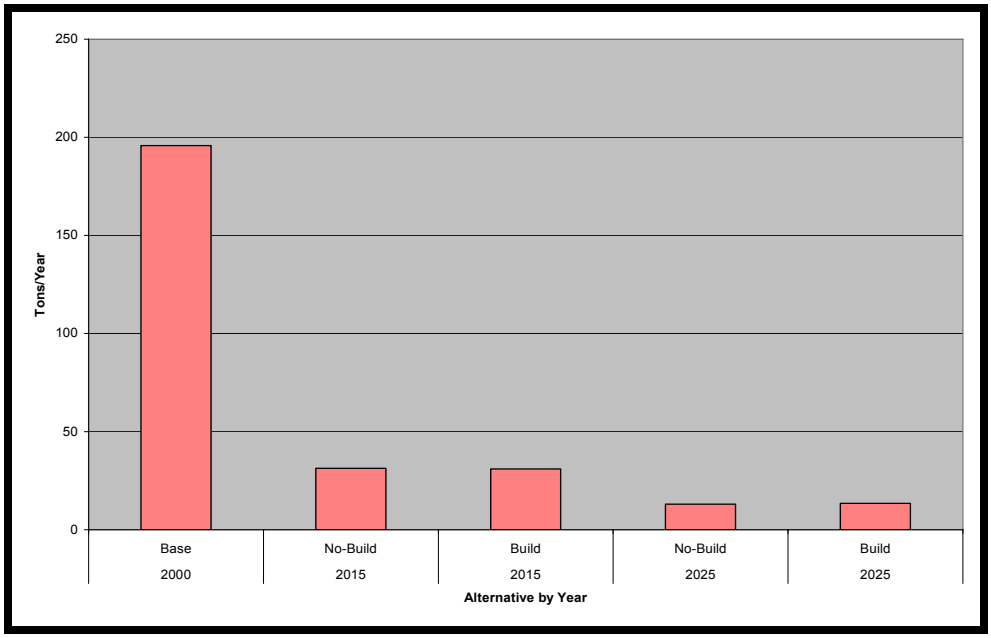
FIGURE 4-5e
COMPARISON OF FORMALDEHYDE BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

FIGURE 4-5f
COMPARISON OF DIESEL PARTICULATE MATTER BY ALTERNATIVE IN SEGMENT G TRAFFIC STUDY AREA



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).

Source: Study Team, 2007

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 that both light-duty and heavy-duty on-highway motor vehicles must meet. Diesel exhaust emissions have been falling since the early 1990s with the passage of the CAAA (Clean Air Act Amendments). The CAAA provided for improvement in diesel fuel through reductions in sulfur and other diesel fuel improvements. 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 (Tier 2, light-duty vehicle standard, Heavy-Duty Diesel Vehicle [HDDV] and HDDV standards and low sulfur diesel fuel, and EPA's proposed Off-Road Diesel Engine and Fuel Standard). These projected air emissions reductions will be realized even with the predicted continued growth in VMT. See EPA's Tier 2 regulatory impact analysis (RIA) and EPA's HDDV RIA (EPA, 1999b; 2000c; and TNRCC, 1997).

Growth in the Houston area is expected to remain strong through 2025. Population is expected to increase 64.1 percent and employment growth is expected to increase by 56.2 percent from 2000 through 2025 (Volume I, Section 3.3.1.1). This FEIS reviews several ways to address this anticipated growth and consequential increase in traffic within the greater Houston area.

Increased roadway usage, which will occur with either the No-Build Alternative or any of the Build Alternatives, will not necessarily lead to increases in harmful emissions (MSAT, PM, NOx, and VOCs [and therefore ozone]). Such emissions from vehicles are expected to continue the current dramatic pattern of decrease, even with continuing increases in VMT. Technology is improving at a pace that exceeds the effect of increased VMT.

Automotive design technology continues to improve and older, more polluting vehicles continue to be retired and replaced with newer, cleaner vehicles. Newer technology vehicles are getting cleaner with each subsequent model year. See EPA's Tier 2/gasoline sulfur regulations and EPA's heavy-duty on-highway/diesel fuel regulations. Fuels are improving and continue to improve (EPA, 1999b). EPA's 2004 non-road diesel sulfur rules will bring non-road diesel sulfur levels down to 15 ppm by 2015. Reformulated gasoline (RFG), in use in the Houston area since 1995, has produced reductions in MSAT, and continues to provide substantial MSAT reductions. Low sulfur gasoline enables better emission controls, and can lead to further emission reductions from current catalyst-equipped fleet (EPA, 1999b), and low sulfur diesel will enable new diesel emission reduction technology (EPA, 2000c).

During the period 2007-2010, the EPA's light-duty Tier 2 emission and fuel standards will be fully implemented. VMT increases were modeled by the EPA for light-duty vehicles from 2007 through 2030 (1999b). The EPA further estimated increases in heavy-duty diesel VMT of almost 50 percent between 2000 and 2030 (EPA, 2000b). Emissions estimates by EPA for similar years in the future argue that emissions will continue to fall.

The EPA has evaluated the following gaseous MSAT from heavy-duty on-highway vehicles: benzene, formaldehyde, acetaldehyde, 1,3 butadiene, acrolein, and dioxin. The EPA has also evaluated PM from these vehicles. The EPA modeled various urban areas including the Houston area, and concluded that as a result of their heavy-duty on-highway regulations, MSAT will be substantially reduced (EPA, 2000c). PM emissions reductions continue, because of the reduction of sulfur in diesel fuel down to 15 ppm. Changes in the fuel mix are estimated by the EPA to reduce DPM emissions by 90 percent in 2030 from the base (2000) emission levels. This 90 percent reduction in DPM was reflected in the MSAT modeling done for the Grand Parkway.

Light-duty vehicle emissions will show steady decreases in NOx emissions from a 10 percent reduction in 2004 to a 75 percent reduction by 2030 (EPA, 1999a, Table III.A-3). The EPA has concluded that NOx can be a precursor to fine PM. The same RIA indicates a reduction of light duty PM_{10} emission starting with a 36 percent reduction in 2004 to an 80 percent reduction by 2030 (EPA, 1999a, Table III.A-15).

This same RIA modeled ambient levels of MSAT (benzene, 1,3 butadiene, formaldehyde, acetaldehyde, and DPM) in several large cities including Houston. This analysis concluded that toxic air emissions from light-duty vehicles will continue the downward trend. This downward trend was also reflected in the MSAT analysis completed for the Grand Parkway, Segment G.

With the proposed Segment G roadway of the proposed Grand Parkway, MSAT emissions are estimated to emit 2.9 tons/year in 2015 and 3.9 tons/year in 2025 (Table 4-16). Currently no NAAQS have been established for any of the priority MSAT. The EPA is in the process of assessing the risks of exposure to these compounds and potential human health risks.

TABLE 4-16
SEGMENT G MSAT EMISSIONS PER YEAR – GRAND PARKWAY ROADWAY LINKS ONLY (TONS/YEAR)

Year	2015	2025
Amount of MSAT emissions per year Grand Parkway - Segment G Links Only	5,842 lbs. or 2.9 tons	7,884 lbs. or 3.9 tons

Note: This is the total MSAT for just the Grand Parkway roadway links for Segment G, not the entire roadways in the traffic study area. Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a).
Source: Study Team, 2007

The TXDOT's 2006 *Air Quality Guidelines* state that an MSAT analysis is required for road projects that have or are expected to have more than 140,000 ADT. Segment G does not reach the 140,000 ADT threshold, as can be seen in Table 4-17. However, IH 45 and US 59 are expected to exceed 140,000 ADT at the crossing of the Grand Parkway, Segment G.

TABLE 4-17
SEGMENT G ADT ROADWAY

Segment	2000*	2015	2025
G	N/A	43,400	64,500

Note: * The year 2000 is the base year and excludes the Grand Parkway.
Source: H-GAC, 2005a and Study Team, 2007

4.6.3.3 MSAT Conclusions

Research has found that the ability to discern differences in MSAT emissions among transportation alternatives is very 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 EPA's new motor vehicle emission control standards. Substantial decreases in MSAT emissions will be realized from the base year (2000) through an estimated time of completion and its design year some 25 years in the future for Segment G. Even accounting for anticipated increases in VMT and varying degrees of efficiency of vehicle operation, total MSAT emissions in Segment G were expected to decline approximately 81 percent from 2000 to 2025. While benzene emissions were expected to decline about 73 percent, emissions of DPM were expected to decline even more (93 percent).

MSAT are not expected to increase above the base year (2000). The major air toxics from mobile sources especially benzene have dropped dramatically since 1995 and are expected to continue dropping, as demonstrated by the

quantitative analysis presented here. 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 MSAT. 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. EPA also has called for dramatic reductions in NOx emissions, and particulate emissions from on-road and off-road diesel engines.

MSAT were modeled and were found to be substantially lower in the future (2015 and 2025) than the existing conditions (2000). MSAT will continue to improve over time because of dramatic improvements in vehicle technology and fuels, and traffic flow improvements realized over time. Other potential air quality impacts could occur with the continued existence of industrial complexes in the area. Generally, industrial facilities that emit air pollutants will be governed and permitted through TCEQ. MSAT due to a proposed Grand Parkway are not expected to increase overall air toxics in the Houston area in the future years investigated.

4.6.3.4 Unavailable Information for Project Specific MSAT Impact Analysis

This document includes a basic analysis of the likely MSAT emission impacts of this project. However, available technical tools do not enable us to predict the project-specific health impacts of the emission changes associated with the alternatives in this document. Because of these limitations, the following discussion is included in accordance with CEQ regulations (40 CFR § 1502.22(b)) regarding incomplete or unavailable information:

Information that is Unavailable or Incomplete

Evaluating the environmental and health impacts from MSAT on a proposed highway project would involve several elements, including emissions modeling, dispersion modeling to estimate ambient concentrations from the estimated emissions, exposure modeling to estimate human exposure to the estimated concentrations, and determination of health impacts based on the estimated exposure. Each of these steps is encumbered by technical shortcomings or uncertain science that prevents a more complete determination of the MSAT health impacts of this project.

- **Emissions -** The EPA tools to estimate MSAT emissions from motor vehicles are not sensitive to key variables of emissions of MSAT in the context of highway projects. While MOBILE6.2 is used to predict emissions at a regional level, it has limited applicability at the project level. MOBILE6.2 is a trip-based model. Emission factors are projected based on a typical trip of 7.5 miles and on average speeds for this typical trip, which means that MOBILE6.2 does not have the ability to predict emission factors for a specific vehicle operating condition at a specific location at a specific time. Because of this limitation, MOBILE6.2 can only approximate the operating speeds and levels of congestion likely to be present on the largest-scale projects, and cannot adequately capture emissions effects of smaller projects. For PM, the model results are not sensitive to average trip speed, although the other MSAT emission rates do change with changes in trip speed. In addition, the emission rates used in MOBILE6.2 for both PM and MSAT are based on a limited number of tests of mostly older technology vehicles, and the model does not include the emission reductions

associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the *Federal Register* (EPA, 2007a). Lastly, in its discussions of PM under the conformity rule, EPA has identified problems with MOBILE6.2 as an obstacle to quantitative analysis.

- These deficiencies compromise the capability of MOBILE6.2 to estimate MSAT emissions. MOBILE6.2 is an adequate tool for projecting emissions trends, and performing relative analyses between alternatives for very large projects, but it is not sensitive enough to capture the effects of travel changes tied to smaller projects or to predict emissions near specific roadside locations. However, MOBILE6.2 is currently the only available tool for use by the FHWA and TxDOT and may function adequately for larger-scale projects for comparison of alternatives.
- **Dispersion -** The tools to predict how MSAT disperse are also limited. The EPA's current regulatory models, CALINE 3 and CAL3QHC, were developed and validated more than a decade ago to predict episodic concentrations of CO to determine compliance with the NAAQS. Dispersion models are more accurate for predicting maximum concentrations that can occur at some time at some location within a geographic area. This limit makes it difficult to predict accurate exposure patterns at specific times at specific highway project locations across an urban area to assess potential health risk. The National Cooperative Highway Research Program is conducting research on best practices in applying models and other technical methods in the analysis of MSAT. This work will also focus on identifying appropriate methods of documenting and communicating MSAT impacts in an environmental impact assessment to the public. Along with these general limits of dispersion models, the FHWA is also faced with a lack of monitoring data in most areas for establishing project-specific MSAT background concentrations.
- **Exposure Levels and Health Effects -** Finally, even if emission levels and concentrations of MSAT could be accurately predicted, shortcomings in current techniques for exposure assessment and risk analysis preclude one from reaching meaningful conclusions about project-specific health impacts. Exposure assessments are complicated, which is because it is difficult to accurately calculate annual concentrations of MSAT near roadways and to determine the period of time that people are exposed to those concentrations at a specific location. These difficulties are magnified for 70-year cancer assessments, particularly because unsupportable assumptions would have to be made about changes in travel patterns and vehicle technology (which affect emissions rates) over 70 years. There is also considerable uncertainty with current estimates of toxicity of MSAT, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population. Because of these shortcomings, any calculated difference in health impacts between alternatives is likely to be much smaller than the uncertainty of the calculated impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against other project impacts that are better suited for quantitative analysis.

Summary of Existing Credible Scientific Evidence Relevant to Evaluating the Impacts of MSAT

Research into the health impacts of MSAT is ongoing. For different emission types, many studies show that MSAT are either statistically associated with adverse health outcomes through epidemiological studies (frequently based on emission levels found in occupational settings) or that animals demonstrate adverse health outcomes when exposed to large doses.

Exposure to toxics has been a focus of several EPA efforts. The agency conducted the National Air Toxics Assessment (NATA) in 1996 to evaluate modeled estimates of human exposure at the county level. While not intended for use as a measure or benchmark of local exposure, the modeled estimates in the NATA database best illustrate the levels of various toxics when aggregated to a national or state level. The EPA's current evaluation of the potential hazards and toxicity of the six priority MSAT is listed by chemical in Section 3.6.2 of this volume, and can be found at http://www.epa.gov/iris. For several of the MSAT, carcinogenicity either cannot be determined or is listed as probable.

There is currently a broad lack of consensus among both the scientific community and the regulatory community on the level at which MSAT may cause a negative health impact. This lack of consensus prevents any meaningful conclusion about the level of MSAT that must be experienced by a population before a health effect is found. Such limits make the study of MSAT concentrations, exposures, and health impacts difficult and uncertain. Thus, accurate and reliable estimates of actual human health or environmental impacts from transportation projects and MSAT are not scientifically possible at this time. This lack of consensus further prevents decisions from being made about alignments, grade elevations, and even selection of the No-Build Alternative versus the Build Alternative based solely on estimated MSAT levels.

Therefore, the analysis of MSAT presented here is provided as background information on the current levels of MSAT, anticipated future levels of MSAT, and assumptions on what effect the Grand Parkway Segment G project may have on MSAT. The Health Effects Institute, a non-profit organization funded by EPA, FHWA, and industry, has undertaken a major series of studies to research MSAT hot spots near roadways, the health implications of the entire mix of mobile source pollutants, and other topics. The final summary of the series is not expected for several years.

Some recent studies have reported that proximity to roadways is related to adverse health outcomes, particularly respiratory problems.[1] Much of this research is not specific to MSAT, instead surveying the full spectrum of both criteria and other pollutants. The FHWA cannot evaluate the validity of these studies, but more importantly, they do not provide

[1] *Multiple Air Toxic Exposure Study-II (MATES II)*, South Coast Air Quality Management District (2000); *Highway Health Hazards*, The Sierra Club (2004), summarizing 24 studies on the relationship between health and air quality; *NEPA's Uncertainty in the Federal Legal Scheme Controlling Air Pollution from Motor Vehicles*, Environmental Law Institute (2005), with health studies cited therein; the US 95 Nevada Study and associated case law; and *Recent Research Findings: Health Effects of Particulate Matter and Ozone Air Pollution*, California Environmental Protection Agency - Air Resources Board and American Lung Association of California (2004).

information that would be useful to alleviate the uncertainties listed above and enable the agency to perform a more comprehensive evaluation of the health impacts specific to this project. In addition, as mentioned previously, EPA has not developed health-based standards for MSAT, and instead has focused on regulations to substantially reduce on-road and non-road MSAT emissions.

On February 26, 2007, the EPA issued a final rule on the "Control of Hazardous Air Pollutants from Mobile Sources." In the preamble to this final rule, the EPA summarized recent studies by stating, "Significant scientific uncertainties remain in our understanding of the relationship between adverse health effects and near-road exposure, including the exposures of greatest concern, the importance of chronic versus acute exposures, the role of fuel type (e.g., diesel or gasoline) and composition (e.g., % aromatic), relevant traffic patterns, the role of co-stressors including noise and socioeconomic status, and the role of differential susceptibility within the 'exposed' populations" (EPA, 2007a).

Use of Available Information

Because of the uncertainties outlined above, an assessment of the effects of MSAT emissions impacts on human health cannot be made at the project level. Because available tools do allow one to predict relative MSAT emissions changes between alternatives for a proposed project of this magnitude, the amount of MSAT emissions from each of the Segment G project alternatives (Build Alternative and No-Build Alternative) are presented here (Table 4-15) for consideration of alternatives and for disclosure purposes, but are not intended for estimating potential human exposure or health impacts. Therefore, the relevance of the unavailable or incomplete information is that it is not possible to determine whether or not any of the alternatives would have "significant adverse impacts on human health" as related to MSAT emissions.

4.6.4 Congestion Management System (CMS)/Congestion Reduction Strategies

CMS is a systematic process for managing traffic congestion. The CMS provides information on transportation system performance, alternative strategies for alleviating congestion, and enhancing the mobility of people and goods to levels that meet state and local needs. The Grand Parkway project Segments E, F-1, F-2, and G were developed from the H-GAC operational CMS, which meets all requirements of CFR 500.109. The CMS was adopted by H-GAC in October 1997 and has been revised in December 1997, May 1998, and June 2005 (H-GAC, 2007b).

Operational improvements and travel demand reduction strategies are commitments made by the region at two levels: program level and project level implementation. Program level commitments are inventoried in the regional CMS, which was adopted by H-GAC. They are included in H-GAC's RTP, and future resources are reserved for their implementation.

The CMS element of the plan carries an inventory of all project commitments (including those resulting from major investment studies) detailing type of strategy, implementing responsibilities, schedules, and expected costs. At the project programming stage, travel demand reduction strategies and commitments will be added to the regional TIP or included in the construction plans. The regional TIP provides for programming of these projects at the appropriate time with respect to the SOV facility implementation and project specific elements.

In an effort to reduce congestion and the need for SOV lanes in the region, TxDOT and H-GAC will continue to promote appropriate congestion reduction strategies through the Congestion Management Air Quality Program (CMAQ) program, the CMS, and the RTP. According to H-GAC, the congestion reduction strategies considered for this project would help alleviate congestion in the SOV study boundary but will not eliminate it. Therefore, the proposed Segment G of the Grand Parkway is justified. The CMS analysis for added SOV capacity projects in the transportation management area (Segment G) and included in the 2025 RTP was conducted to improve the interchange at Jones Road and FM 1960 (between US 290 and SH 249) by constructing a grade-separated interchange including access management and intelligent management system and install an arterial management system along FM 2920 between US 290 and SH 249 to be implemented by 2023. For more information on the CMS analysis for the Grand Parkway, see Appendix D.

4.6.5 Summary of Impacts

Pollutants required to be evaluated include 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. Segment G will not contribute to additional violations nor prolong attaining the NAAQS for O_3. Segment G conforms to the emissions budget established for the approved 1-hour standard for ozone, but an 8-hour emissions budget has not been approved for the Houston area.

As identified in Section 4.6.1, the Grand Parkway Segment G was included in H-GAC's 2025 RTP, and was included in the FY 2006-2008 TIP, Appendix D, as project undergoing environmental review and scheduled for implementation beyond the three-year TIP time frame. The 2025 RTP and 2006-2008 TIP were adopted by H-GAC in April 2005 and found to conform to the SIP by USDOT (FHWA/FTA) on June 3, 2005 and October 31, 2005, respectively.

The Grand Parkway Segment G is included in H-GAC's 2035 RTP and FY 2008-2011 TIP, as amended. On August 24, 2007, H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. USDOT (FHWA/FTA) found the 2035 RTP and 2008-2011 TIP to conform to the SIP on November 9, 2007.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional analysis is warranted before 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 modeled parameters can be found in the Administrative Record.

MSAT were modeled and were found to be substantially lower in the future (2015 and 2025) than the existing conditions (2000). MSAT will continue to improve over time because of dramatic improvements in vehicle technology and fuels and traffic flow improvements. The major MSAT, especially benzene, have dropped dramatically since 1995 and are expected to continue dropping, as demonstrated by the quantitative analysis presented in this section. It should be noted that this analysis does not include the latest regulatory changes that will further reduce MSAT emissions.

Other potential air quality impacts could occur with the continued existence of industrial complexes in the area. Generally, industrial facilities that emit air pollutants will be governed and permitted through TCEQ. MSAT because of a proposed Grand Parkway are not expected to increase overall MSAT in the Houston area in the future years investigated. Under the No-Build Alternative, MSAT are expected to decline at nearly the same rate as the Build Alternative with no direct effect to air quality in Houston area.

4.6.6 Indirect Impacts

The network of future roadways and subdivision streets within the AOI (Area of Influence) are expected to contribute to further traffic improvements from the base year (2000). 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 (2000) and the future year of 2025, which is expected to be the case for both the criteria pollutants, including CO and MSAT.

Besides undergoing a conformity analysis to assure 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 on-going improvements in air quality as older technology vehicles are retired and newer cleaner vehicles replace them.

4.6.7 Air Quality Construction Impacts

Emissions from diesel powered and other construction equipment would occur under the Build Alternative for Segment G. 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 (TxLED) program started on October 31, 2005 and the federal low sulfur diesel program, which took effect at retailers 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 emissions can be undertaken. However, project construction would be conducted in accordance with all federal, state, and local regulations that govern construction activities and emissions. In addition to tailpipe emissions, fugitive dust may be generated during project construction. Specific dust suppression mitigation measures that can be utilized would be identified in a dust control plan prepared prior to project construction.

4.7 TRAFFIC NOISE

A preliminary noise analysis was performed to determine the anticipated (model predicted) impacts from future traffic-generated noise levels at representative receiver locations along each of the alternative alignments within Segment G of the Grand Parkway project. Since the selection of the Preferred Alternative Alignment, a subsequent detailed analysis was performed for representative receiver locations along the Preferred Alternative Alignment in September 2007 (Exhibit G–52). Both analyses were accomplished in accordance with TxDOT's (FHWA approved) *Guidelines for Analysis and Abatement of Highway Traffic Noise*. Existing noise levels were determined through a noise measurement program (Section 3.7.1 of this volume) and predicted (future) noise levels were determined through modeling with the FHWA approved Traffic Noise Model (TNM). 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.

4.7.1 Traffic Data for Noise Prediction

Traffic data used in the noise analysis included 24-hour ADT volumes and vehicle speeds for the project modeled roadways. As required by FHWA and TxDOT noise assessment guidelines, the traffic noise analysis was performed for the peak-hour (loudest) of the ADT. Design year (2025) ADT and peak-hour volumes for the Segment G project area are presented in Table 4-18. Typically, LOS C traffic volumes are considered to be the loudest operating condition for automobiles, because of the combination of relatively high volumes and constant speeds. With guidance from H-GAC, the traffic volumes selected to represent the peak-hour for the project-modeled roadways were 10.4 percent of their respective 24-hour ADT volumes, which is considered to be a close approximation to LOS C conditions. Vehicle speeds on the project roadway mainline were modeled as a toll facility at 65 mph and frontage roads at 50 mph.

TABLE 4-18
PROJECTED 2025 TRAFFIC VOLUME DATA FOR SEGMENT G PROJECT AREA

Location	Design Year ADT	Peak Hour Volume
IH 45 to Hardy Toll Road	43,888	4,564
Hardy Toll Road to Riley Fuzzel	64,173	6,673
Riley Fuzzel to Rayford Sawdust	64,511	6,709
Rayford Sawdust to Benders Landing Blvd.	61,112	6,355
Benders Landing Blvd. to FM 1314	61,564	6,402
FM 1314 to US 59	45,657	4,748

Note: Peak Hour = loudest hour of the day
Source: H-GAC, 2005a

Potentially impacted sensitive receivers were predicted using toll build-out traffic conditions, assuming all segments of the corridor would be completed (E, F-1, F-2, and G). This traffic condition represents the worst-case traffic noise conditions for the Grand Parkway. The projected design year vehicle mix percentages used in the noise modeling analysis consisted of 95 percent automobiles (including vans, pickups, etc.), 2 percent medium trucks (two axles and six tires), and 3 percent heavy trucks (three or more axles).

4.7.2 Impacts to Noise Receivers – Alternative Alignments A, B, C, and D

Table 4-19 (detailed results) and Table 4-20 (summarized results) present the noise impacts predicted to occur along Alternative Alignments A, B, C, and D as presented in the DEIS (January, 2007).

TABLE 4-19
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
A	8	1. Commercial	C	72	67	67	0	No	No	0
		2. Commercial	C	72	68	68	0	No	No	0
		3. Commercial	C	72	67	67	0	No	No	0
		4. Residential	B	67	66	66	0	Yes	No	15
		5. Residential	B	67	63	63	0	No	No	0
		6. Residential	B	67	61	61	0	No	No	0
		7. Residential	B	67	61	61	0	No	No	0
		8. Residential	B	67	61	61	0	No	No	0
		9. Residential	B	67	61	61	0	No	No	0
		10. Residential	B	67	61	61	0	No	No	0
		11. Residential	B	67	51	59	8	No	No	0
		12. Residential	B	67	53	53	0	No	No	0
		13. Church	B	67	61	61	0	No	No	0
		14. Residential	B	67	41	41	0	No	No	0
		15. Residential	B	67	41	59	18	No	Yes	5
		16. Residential	B	67	44	61	17	No	Yes	42
		17. Residential	B	67	44	55	11	No	Yes	60
		18. Residential	B	67	44	52	8	No	No	0
		19. Residential	B	67	40	60	20	No	Yes	7
		20. Residential	B	67	40	53	13	No	Yes	2
		21. Residential	B	67	42	62	20	No	Yes	4
		22. Commercial	C	72	44	63	19	No	Yes	2

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
A (Cont.)	9	None	---	---	---	---	---	---	---	---
	10	1. Residential	B	67	50	60	10	No	No	0
		2. Residential	B	67	50	52	2	No	No	0
		3. Residential	B	67	47	49	2	No	No	0
		4. Residential	B	67	47	49	2	No	No	0
		5. Residential	B	67	56	58	2	No	No	0
	11	1. Residential	B	67	45	61	16	No	Yes	4
		2. Residential	B	67	45	50	5	No	No	0
		3. Residential	B	67	45	50	5	No	No	0
		4. Residential	B	67	48	48	0	No	No	0
		5. Residential	B	67	47	47	0	No	No	0
		6. Residential	B	67	46	46	0	No	No	0
		7. Residential	B	67	47	47	0	No	No	0
		8. Residential	B	67	47	47	0	No	No	0
		9. Residential	B	67	46	50	4	No	No	0
		10. Residential	B	67	55	55	0	No	No	0
	12	1. Residential	B	67	48	48	0	No	No	0
		2. Residential	B	67	47	47	0	No	No	0
		3. Residential	B	67	46	47	1	No	No	0
		4. Residential	B	67	53	57	4	No	No	0
		5. Residential	B	67	53	53	0	No	No	0
		6. Residential	B	67	58	58	0	No	No	0
		7. Residential	B	67	58	58	0	No	No	0
		8. Residential	B	67	58	58	0	No	No	0
		9. Commercial	C	72	62	62	0	No	No	0
B	8	1. Commercial	C	72	67	67	0	No	No	0
		2. Commercial	C	72	68	68	0	No	No	0
		3. Commercial	C	72	67	67	0	No	No	0
		4. Residential	B	67	66	66	0	Yes	No	15
		5. Residential	B	67	63	63	0	No	No	0
		6. Residential	B	67	61	61	0	No	No	0
		7. Residential	B	67	61	61	0	No	No	0
		8. Residential	B	67	61	61	0	No	No	0
		9. Residential	B	67	61	61	0	No	No	0

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
B (Cont.)	8 (Cont.)	10. Residential	B	67	61	61	0	No	No	0
		11. Residential	B	67	51	51	0	No	No	0
		12. Residential	B	67	53	53	0	No	No	0
		13. Church	B	67	61	61	0	No	No	0
		14. Residential	B	67	41	57	16	No	Yes	2
		15. Residential	B	67	41	41	0	No	No	0
		16. Residential	B	67	44	61	17	No	Yes	42
		17. Residential	B	67	44	55	11	No	Yes	60
		18. Residential	B	67	44	52	8	No	No	0
		19. Residential	B	67	40	61	21	No	Yes	7
		20. Residential	B	67	40	55	15	No	Yes	2
		21. Residential	B	67	42	62	20	No	Yes	4
		22. Commercial	C	72	44	60	16	No	Yes	2
	9	None	---	---	---	---	---	---	---	---
	10	1. Residential	B	67	50	60	10	No	No	0
		2. Residential	B	67	50	52	2	No	No	0
		3. Residential	B	67	47	49	2	No	No	0
		4. Residential	B	67	47	49	2	No	No	0
		5. Residential	B	67	56	58	2	No	No	0
	11	1. Residential	B	67	45	48	3	No	No	0
		2. Residential	B	67	45	48	3	No	No	0
		3. Residential	B	67	45	48	3	No	No	0
		4. Residential	B	67	48	60	12	No	Yes	18
		5. Residential	B	67	47	53	6	No	No	0
		6. Residential	B	67	46	57	11	No	Yes	35
		7. Residential	B	67	47	68	21	Yes	Yes	9
		8. Residential	B	67	47	61	14	No	Yes	5
		9. Residential	B	67	46	56	10	No	No	0
		10. Residential	B	67	55	55	0	No	No	0
	12	1. Residential	B	67	48	60	12	No	Yes	14
		2. Residential	B	67	47	53	6	No	No	0
		3. Residential	B	67	46	51	5	No	No	0
		4. Residential	B	67	53	58	5	No	No	0
		5. Residential	B	67	53	58	5	No	No	0

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
B (Cont.)	12 (Cont.)	6. Residential	B	67	58	58	0	No	No	0
		7. Residential	B	67	58	58	0	No	No	0
		8. Residential	B	67	58	58	0	No	No	0
		9. Commercial	C	72	62	62	0	No	No	0
C	8	1. Commercial	C	72	67	67	0	No	No	0
		2. Commercial	C	72	68	68	0	No	No	0
		3. Commercial	C	72	67	67	0	No	No	0
		4. Residential	B	67	66	66	0	Yes	No	15
		5. Residential	B	67	63	63	0	No	No	0
		6. Residential	B	67	61	61	0	No	No	0
		7. Residential	B	67	61	61	0	No	No	0
		8. Residential	B	67	61	61	0	No	No	0
		9. Residential	B	67	61	61	0	No	No	0
		10. Residential	B	67	61	61	0	No	No	0
		11. Residential	B	67	51	59	8	No	No	0
		12. Residential	B	67	53	53	0	No	No	0
		13. Church	B	67	61	61	0	No	No	0
		14. Residential	B	67	41	41	0	No	No	0
		15. Residential	B	67	41	59	18	No	Yes	5
		16. Residential	B	67	44	61	17	No	Yes	42
		17. Residential	B	67	44	55	11	No	Yes	60
		18. Residential	B	67	44	52	8	No	No	0
		19. Residential	B	67	40	60	20	No	Yes	7
		20. Residential	B	67	40	53	13	No	Yes	2
		21. Residential	B	67	42	62	20	No	Yes	4
		22. Commercial	C	72	44	63	19	No	Yes	2
	9	None	---	---	---	---	---	---	---	---
	10	1. Residential	B	67	50	50	0	No	No	0
		2. Residential	B	67	50	50	0	No	No	0
		3. Residential	B	67	47	58	11	No	Yes	19
		4. Residential	B	67	47	52	5	No	No	0
		5. Residential	B	67	56	56	0	No	No	0
	11	1. Residential	B	67	45	51	6	No	No	0
		2. Residential	B	67	45	48	3	No	No	0
		3. Residential	B	67	45	48	3	No	No	0

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
C (Cont.)	11 (Cont.)	4. Residential	B	67	48	48	0	No	No	0
		5. Residential	B	67	47	48	1	No	No	0
		6. Residential	B	67	46	46	0	No	No	0
		7. Residential	B	67	47	48	1	No	No	0
		8. Residential	B	67	47	51	4	No	No	0
		9. Residential	B	67	46	51	5	No	No	0
		10. Residential	B	67	55	55	0	No	No	0
	12	1. Residential	B	67	48	51	3	No	No	0
		2. Residential	B	67	47	48	1	No	No	0
		3. Residential	B	67	46	48	2	No	No	0
		4. Residential	B	67	53	53	0	No	No	0
		5. Residential	B	67	53	53	0	No	No	0
		6. Residential	B	67	58	58	0	No	No	0
		7. Residential	B	67	58	58	0	No	No	0
		8. Residential	B	67	58	58	0	No	No	0
		9. Commercial	C	72	62	62	0	No	No	0
D	8	1. Commercial	C	72	67	67	0	No	No	0
		2. Commercial	C	72	68	68	0	No	No	0
		3. Commercial	C	72	67	67	0	No	No	0
		4. Residential	B	67	66	66	0	Yes	No	15
		5. Residential	B	67	63	63	0	No	No	0
		6. Residential	B	67	61	61	0	No	No	0
		7. Residential	B	67	61	61	0	No	No	0
		8. Residential	B	67	61	61	0	No	No	0
		9. Residential	B	67	61	61	0	No	No	0
		10. Residential	B	67	61	61	0	No	No	0
		11. Residential	B	67	51	51	0	No	No	0
		12. Residential	B	67	53	53	0	No	No	0
		13. Church	B	67	61	61	0	No	No	0
		14. Residential	B	67	41	41	0	No	No	0
		15. Residential	B	67	41	59	18	No	Yes	5
		16. Residential	B	67	44	61	17	No	Yes	42
		17. Residential	B	67	44	55	11	No	Yes	60
		18. Residential	B	67	44	52	8	No	No	0

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
D (Cont.)	8 (Cont.)	19. Residential	B	67	40	61	21	No	Yes	7
		20. Residential	B	67	40	55	15	No	Yes	2
		21. Residential	B	67	42	62	20	No	Yes	4
		22. Commercial	C	72	44	60	16	No	Yes	2
	9	None	---	---	---	---	---	---	---	---
	10	1. Residential	B	67	50	60	10	No	No	0
		2. Residential	B	67	50	52	2	No	No	0
		3. Residential	B	67	47	49	2	No	No	0
		4. Residential	B	67	47	49	2	No	No	0
		5. Residential	B	67	56	58	2	No	No	0
	11	1. Residential	B	67	45	61	16	No	Yes	4
		2. Residential	B	67	45	50	5	No	No	0
		3. Residential	B	67	45	50	5	No	No	0
		4. Residential	B	67	48	48	0	No	No	0
		5. Residential	B	67	47	47	0	No	No	0
		6. Residential	B	67	46	46	0	No	No	0
		7. Residential	B	67	47	47	0	No	No	0
		8. Residential	B	67	47	47	0	No	No	0
		9. Residential	B	67	46	50	4	No	No	0
		10. Residential	B	67	55	55	0	No	No	0
	12	1. Residential	B	67	48	48	0	No	No	0
		2. Residential	B	67	47	47	0	No	No	0
		3. Residential	B	67	46	47	1	No	No	0
		4. Residential	B	67	53	57	4	No	No	0
		5. Residential	B	67	53	53	0	No	No	0
		6. Residential	B	67	58	58	0	No	No	0
		7. Residential	B	67	58	58	0	No	No	0
		8. Residential	B	67	58	58	0	No	No	0
		9. Commercial	C	72	62	62	0	No	No	0
Recommended Alternative Alignment	8	1. Commercial	C	72	67	67	0	No	No	0
		2. Commercial	C	72	68	68	0	No	No	0
		3. Commercial	C	72	67	67	0	No	No	0
		4. Residential	B	67	66	66	0	Yes	No	15
		5. Residential	B	67	63	63	0	No	No	0

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
Recommended Alternative Alignment (Cont.)	8 (Cont.)	6. Residential	B	67	61	61	0	No	No	0
		7. Residential	B	67	61	61	0	No	No	0
		8. Residential	B	67	61	61	0	No	No	0
		9. Residential	B	67	61	61	0	No	No	0
		10. Residential	B	67	61	61	0	No	No	0
		11. Residential	B	67	51	51	0	No	No	0
		12. Residential	B	67	53	53	0	No	No	0
		13. Church	B	67	61	61	0	No	No	0
		14. Residential	B	67	41	41	0	No	No	0
		15. Residential	B	67	41	59	18	No	Yes	5
		16. Residential	B	67	44	61	17	No	Yes	42
		17. Residential	B	67	44	55	11	No	Yes	60
		18. Residential	B	67	44	52	8	No	No	0
		19. Residential	B	67	40	61	21	No	Yes	7
		20. Residential	B	67	40	55	15	No	Yes	2
		21. Residential	B	67	42	62	20	No	Yes	4
		22. Commercial	C	72	44	60	16	No	Yes	2
	9	None	---	---	---	---	---	---	---	---
	10	1. Residential	B	67	50	60	10	No	No	0
		2. Residential	B	67	50	52	2	No	No	0
		3. Residential	B	67	47	49	2	No	No	0
		4. Residential	B	67	47	49	2	No	No	0
		5. Residential	B	67	56	58	2	No	No	0
	11	1. Residential	B	67	45	61	16	No	Yes	4
		2. Residential	B	67	45	50	5	No	No	0
		3. Residential	B	67	45	50	5	No	No	0
		4. Residential	B	67	48	48	0	No	No	0
		5. Residential	B	67	47	47	0	No	No	0
		6. Residential	B	67	46	46	0	No	No	0
		7. Residential	B	67	47	47	0	No	No	0
		8. Residential	B	67	47	47	0	No	No	0
		9. Residential	B	67	46	50	4	No	No	0
		10. Residential	B	67	55	55	0	No	No	0

TABLE 4-19 (CONT.)
DETAILED NOISE ANALYSIS RESULTS – DEIS ANALYSIS

Alternative Alignment	Reach	Representative Receiver Number and Description	NAC Category	NAC Level (dBA)	Existing 2000 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
Recommended Alternative Alignment (Cont.)	12	1. Residential	B	67	48	48	0	No	No	0
		2. Residential	B	67	47	47	0	No	No	0
		3. Residential	B	67	46	47	1	No	No	0
		4. Residential	B	67	53	57	4	No	No	0
		5. Residential	B	67	53	53	0	No	No	0
		6. Residential	B	67	58	58	0	No	No	0
		7. Residential	B	67	58	58	0	No	No	0
		8. Residential	B	67	58	58	0	No	No	0
		9. Commercial	C	72	62	62	0	No	No	0

Notes: *Absolute and Relative Criteria are defined in Section 3.7 of this volume.

This table was retained from the DEIS analysis to show impacts to Alternative Alignments A, B, and C. See Table 4-21 for the results from the separate analysis conducted for the Preferred Alternative Alignment.

NAC = Noise Abatement Criteria

Source: Study Team, 2007

TABLE 4-20
TOTAL NOISE IMPACTS SUMMARY – DEIS ANALYSIS

Alignment	Reach	Impacts			Subdivisions Affected
		Residential Receivers	Commercial Receivers	Total	
A	8	135	2	**137**	Fox Run, Spring Trails (planned), & Bender Landing (planned)
	9	0	0	**0**	-
	10	0	0	**0**	-
	11	4	0	**4**	Winchester Place
	12	0	0	**0**	-
Alternative Alignment A Total		**139**	**2**	**141**	**-**
B	8	132	2	**134**	Fox Run, Spring Trails (planned), & Bender Landing (planned)
	9	0	0	**0**	-
	10	0	0	**0**	-
	11	67	0	**67**	Timberland Estates
	12	14	0	**14**	Timberland Estates
Alternative Alignment B Total		**213**	**2**	**215**	**-**

TABLE 4-20 (CONT.)
TOTAL NOISE IMPACTS SUMMARY – DEIS ANALYSIS

Alignment	Reach	Impacts			Subdivisions Affected
		Residential Receivers	Commercial Receivers	Total	
C	8	135	2	**137**	Fox Run, Spring Trails (planned), & Bender Landing (planned)
	9	0	0	**0**	-
	10	19	0	**19**	Cumberland
	11	0	0	**0**	-
	12	0	0	**0**	-
Alternative Alignment C Total		**154**	**2**	**156**	**-**
D	8	135	2	**137**	Fox Run, Spring Trails (planned), & Bender Landing (planned)
	9	0	0	**0**	-
	10	0	0	**0**	-
	11	4	0	**4**	Winchester Place
	12	0	0	**0**	-
Alternative Alignment D Total		**139**	**2**	**141**	**-**

Notes: See Table 4-22 for results from the separate analysis conducted for the Preferred Alternative Alignment.
Source: Study Team, 2007

As indicated in the analysis conducted for the DEIS, Alternative Alignment B would impact the most receivers (215), and Alternative Alignments A or D would impact the fewest receivers (141 receivers). Additionally, since the DEIS analysis was conducted, a new school has been opened immediately adjacent to the Alternative Alignment B ROW in Reach 8. It would most likely experience a noise impact at outdoor activity areas.

4.7.3 Impacts to Noise Receivers – Preferred Alternative Alignment

Potentially impacted sensitive receivers were predicted using toll build-out traffic conditions, assuming all segments of the corridor would be completed (E, F-1, F-2, and G). This traffic condition represents the worst-case traffic noise conditions for the Grand Parkway. Representative receivers were selected to represent the range of land use activity areas adjacent to the Segment G Preferred Alternative Alignment (Exhibit G–52). The representative receivers were located nearest the proposed ROW and therefore were most likely to be impacted by traffic noise. Table 4-21 shows the results of the analysis at each of the representative receivers and shows how many receivers (e.g., houses) are represented. Table 4-22 presents the total number of receivers impacted (as calculated from the right hand column of Table 4-21).

TABLE 4-21
DETAILED NOISE ANALYSIS RESULTS - PREFERRED ALTERNATIVE ALIGNMENT

Site Description	NAC Category	NAC Level (dBA)	Existing 2007 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
1. Residential	B	67	50	61	+11	No	Yes	3
2. Residential	B	67	50	56	+6	No	No	0
3. Residential	B	67	50	55	+5	No	No	0
4. Residential	B	67	50	60	+10	No	No	0
5. Residential	B	67	50	61	+11	No	Yes	4
6. Residential	B	67	50	60	+10	No	No	0
7. Residential	B	67	50	56	+6	No	No	0
8. Residential	B	67	50	57	+7	No	No	0
9. Residential	B	67	50	58	+8	No	No	0
10. Residential	B	67	50	58	+8	No	No	0
11. Residential	B	67	50	59	+9	No	No	0
12. Residential	B	67	50	56	+6	No	No	0
13. Residential	B	67	50	57	+7	No	No	0
14. Residential	B	67	50	65	+15	No	Yes	1
15. Residential	B	67	49	64	+15	No	Yes	3
16. Residential	B	67	49	64	+15	No	Yes	3
17. Residential	B	67	49	56	+7	No	No	0
18. Residential	B	67	49	64	+15	No	Yes	3
19. Residential	B	67	49	64	+15	No	Yes	3
20. Residential	B	67	49	55	+6	No	No	0
21. Residential	B	67	49	63	+14	No	Yes	3
22. Residential	B	67	49	57	+8	No	No	0
23. Residential	B	67	49	61	+12	No	Yes	3
24. Residential	B	67	49	61	+12	No	Yes	3
25. Residential	B	67	49	62	+13	No	Yes	3
26. Residential	B	67	49	60	+11	No	Yes	1
27. Residential	B	67	49	55	+6	No	No	0
28. Recreation	B	67	49	59	+10	No	No	0
29. Residential	B	67	46	64	+18	No	Yes	1
30. Residential	B	67	46	60	+14	No	Yes	1
31. Residential	B	67	46	63	+17	No	Yes	9
32. Residential	B	67	46	67	+21	Yes	Yes	3
33. Residential	B	67	46	68	+22	Yes	Yes	3
34. Residential	B	67	46	57	+11	No	Yes	7

TABLE 4-21 (CONT.)
DETAILED NOISE ANALYSIS RESULTS - PREFERRED ALTERNATIVE ALIGNMENT

Site Description	NAC Category	NAC Level (dBA)	Existing 2007 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
35. Residential	B	67	46	57	+11	No	Yes	7
36. Residential	B	67	46	58	+12	No	Yes	20
37. Residential	B	67	46	58	+12	No	Yes	12
38. Residential	B	67	46	67	+21	Yes	Yes	3
39. Residential	B	67	46	67	+21	Yes	Yes	3
40. Residential	B	67	46	66	+20	Yes	Yes	3
41. Residential	B	67	46	66	+20	Yes	Yes	3
42. Residential	B	67	46	66	+20	Yes	Yes	3
43. Residential	B	67	51	66	+15	Yes	Yes	3
44. Residential	B	67	51	66	+15	Yes	Yes	3
45. Residential	B	67	51	67	+16	Yes	Yes	3
46. Residential	B	67	51	66	+15	Yes	Yes	3
47. Residential	B	67	51	67	+16	Yes	Yes	3
48. Residential	B	67	51	66	+15	Yes	Yes	3
49. Residential	B	67	51	66	+15	Yes	Yes	3
50. Residential	B	67	51	67	+16	Yes	Yes	3
51. Residential	B	67	51	62	+11	No	Yes	3
52. Residential	B	67	51	66	+15	Yes	Yes	4
53. Residential	B	67	51	61	+10	No	No	0
54. Residential	B	67	51	59	+8	No	No	0
55. Residential	B	67	51	65	+14	No	Yes	3
56. Residential	B	67	51	60	+9	No	No	0
57. Residential	B	67	51	65	+14	No	Yes	3
58. Residential	B	67	51	64	+13	No	Yes	5
59. Residential	B	67	51	61	+10	No	No	0
60. Residential	B	67	51	62	+11	No	Yes	3
61. Residential	B	67	51	63	+12	No	Yes	3
62. Residential	B	67	51	60	+9	No	No	0
63. Residential	B	67	51	58	+7	No	No	0
64. Residential	B	67	51	66	+15	Yes	Yes	3
65. Residential	B	67	52	66	+14	Yes	Yes	5
66. Residential	B	67	52	66	+14	Yes	Yes	5
67. Residential	B	67	52	64	+12	No	Yes	3
68. Residential	B	67	52	64	+12	No	Yes	3

TABLE 4-21 (CONT.)
DETAILED NOISE ANALYSIS RESULTS - PREFERRED ALTERNATIVE ALIGNMENT

Site Description	NAC Category	NAC Level (dBA)	Existing 2007 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
69. Residential	B	67	52	61	+9	No	No	0
70. Residential	B	67	48	54	+6	No	No	0
71. Residential	B	67	48	54	+6	No	No	0
72. Residential	B	67	48	55	+7	No	No	0
73. Residential	B	67	48	55	+7	No	No	0
74. Residential	B	67	48	55	+7	No	No	0
75. Residential	B	67	48	55	+7	No	No	0
76. Residential	B	67	48	53	+5	No	No	0
77. Residential	B	67	48	51	+3	No	No	0
78. Residential	B	67	48	55	+7	No	No	0
79. Residential	B	67	48	54	+6	No	No	0
80. Residential	B	67	48	56	+8	No	No	0
81. Residential	B	67	48	56	+8	No	No	0
82. Residential	B	67	48	56	+8	No	No	0
83. Residential	B	67	48	54	+6	No	No	0
84. Residential	B	67	48	53	+5	No	No	0
85. Residential	B	67	48	52	+4	No	No	0
86. Residential	B	67	47	61	+14	No	Yes	2
87. Residential	B	67	47	63	+16	No	Yes	2
88. Residential	B	67	47	61	+14	No	Yes	2
89. Residential	B	67	47	58	+11	No	Yes	2
90. Residential	B	67	47	60	+13	No	Yes	2
91. Residential	B	67	47	59	+12	No	Yes	2
92. Residential	B	67	47	59	+12	No	Yes	2
93. Residential	B	67	47	58	+11	No	Yes	3
94. Residential	B	67	47	57	+10	No	No	0
95. Residential	B	67	47	55	+8	No	No	0
96. Residential	B	67	47	55	+8	No	No	0
97. Residential	B	67	47	54	+7	No	No	0
98. Residential	B	67	51	66	+15	Yes	Yes	3
99. Residential	B	67	51	65	+14	No	Yes	6
100. Residential	B	67	51	65	+14	No	Yes	4
101. Residential	B	67	51	59	+8	No	No	0
102. Residential	B	67	51	59	+8	No	No	0

TABLE 4-21 (CONT.)
DETAILED NOISE ANALYSIS RESULTS - PREFERRED ALTERNATIVE ALIGNMENT

Site Description	NAC Category	NAC Level (dBA)	Existing 2007 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
103 Residential	B	67	51	65	+14	No	Yes	4
104. Residential	B	67	51	66	+15	Yes	Yes	3
105. Residential	B	67	51	64	+13	No	Yes	5
106. Residential	B	67	51	66	+15	Yes	Yes	1
107. Residential	B	67	51	57	+6	No	No	0
108. Residential	B	67	51	57	+6	No	No	0
109. Residential	B	67	52	55	+3	No	No	0
110. Residential	B	67	52	54	+2	No	No	0
111. Residential	B	67	52	52	+0	No	No	0
112. Residential	B	67	52	56	+4	No	No	0
113. Residential	B	67	52	54	+2	No	No	0
114. Residential	B	67	52	58	+6	No	No	0
115. Residential	B	67	52	56	+4	No	No	0
116. Residential	B	67	52	60	+8	No	No	0
117. Residential	B	67	52	62	+10	No	No	0
118. Residential	B	67	52	59	+7	No	No	0
119. Residential	B	67	52	57	+5	No	No	0
120. Residential	B	67	52	62	+10	No	No	0
121. Residential	B	67	52	65	+13	No	Yes	1
122. Residential	B	67	52	66	+14	Yes	Yes	2
123. Residential	B	67	52	57	+5	No	No	0
124. Residential	B	67	52	65	+13	No	Yes	1
125. Residential	B	67	52	61	+9	No	No	0
126. Residential	B	67	52	58	+6	No	No	0
127. Residential	B	67	52	64	+12	No	Yes	8
128. Residential	B	67	52	65	+13	No	Yes	3
129. Residential	B	67	52	65	+13	No	Yes	4
130. Residential	B	67	52	65	+13	No	Yes	5
131. Residential	B	67	52	65	+13	No	Yes	4
132. Residential	B	67	52	60	+8	No	No	0
133. Residential	B	67	52	57	+5	No	No	0
134. Residential	B	67	51	51	+0	No	No	0
135. Residential	B	67	51	51	+0	No	No	0
136. Residential	B	67	51	51	+0	No	No	0

TABLE 4-21 (CONT.)
DETAILED NOISE ANALYSIS RESULTS - PREFERRED ALTERNATIVE ALIGNMENT

Site Description	NAC Category	NAC Level (dBA)	Existing 2007 (dBA)	Predicted 2025 (dBA)	Change (+/-) (dBA)	Absolute Impact*	Relative Impact*	Number of Receivers Impacted
137. Residential	B	67	51	51	+0	No	No	0
138. Residential	B	67	51	53	+2	No	No	0
139. Residential	B	67	51	54	+3	No	No	0
140. Residential	B	67	51	65	+14	No	Yes	3
141. Residential	B	67	51	65	+14	No	Yes	3
142. Residential	B	67	51	65	+14	No	Yes	3
143. Residential	B	67	51	58	+7	No	No	0
144. Residential	B	67	51	53	+2	No	No	0
145. Residential	B	67	51	66	+15	Yes	Yes	3
146. Residential	B	67	51	66	+15	Yes	Yes	3
147. Residential	B	67	48	59	+11	No	Yes	3
148. Residential	B	67	48	60	+12	No	Yes	3
149. Residential	B	67	48	64	+16	No	Yes	2
150. Residential	B	67	48	57	+9	No	No	0
151. Residential	B	67	48	53	+5	No	No	0
152. Residential	B	67	48	48	+0	No	No	0
153. Residential	B	67	48	64	+16	No	Yes	4
154. Residential	B	67	48	62	+14	No	Yes	4
155. Residential	B	67	48	58	+10	No	No	0
156. Residential	B	67	48	58	+10	No	No	0
157. Residential	B	67	48	54	+6	No	No	0
158. Residential	B	67	48	53	+5	No	No	0
159. Residential	B	67	48	51	+3	No	No	0
160 Residential	B	67	48	52	+4	No	No	0
161. Residential	B	67	48	50	+2	No	No	0
162. Residential	B	67	48	49	+1	No	No	0
163. Residential	B	67	48	52	+4	No	No	0
164. Residential	B	67	48	54	+6	No	No	0
165. School	E	52	40	40	+0	No	No	0

Note: * Absolute and Relative Criteria are defined in Section 3.7 of this volume.

Source: Study Team, 2008

TABLE 4-22
TOTAL RECEIVERS IMPACTED BY THE PREFERRED ALTERNATIVE ALIGNMENT

Reach	Receivers*	Subdivisions Affected
8	195	Northgate Crossing, Spring Trails, Fox Run, Lockeridge Farms, Bender's Landing
9	26	Creekside Village
10	0	None
11	43	Cumberland Crossing, Winchester Place, Timberland Estates
12	16	Timberland Estates
Total	**280**	**-**

Notes: * All of the impacts would be to residential locations. See Exhibit G–46 for locations of all referenced subdivisions.
Source: Study Team, 2008

4.7.4 Traffic Noise Abatement Measures

In accordance with TxDOT's Noise Guidelines, noise abatement measures must be considered for all impacted receivers. Abatement consideration is comprised of two components: feasibility and reasonableness, both of which are required. Feasibility deals primarily with elements such as topography, access points, drainage, safety, maintenance requirements, and other noise sources and whether a noise abatement measure would reduce the sound levels by a minimum of five dBA. Reasonable determinations are based primarily on cost effectiveness ($25,000 or less/benefited receiver).

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. Noise abatement measures include traffic management, noise barriers (berms and walls), the alternation of horizontal and/or vertical alignments, and acquisition of property to act as buffer zones.

4.7.4.1 Traffic Management

Traffic management measures include the prohibition and/or the time use restrictions for certain vehicle classes (heavy truck restrictions), reduction in speed limits, and traffic control devices. The lowering of highway speed limits has only minimal effects on reducing traffic noise and is not considered an effective abatement measure. A substantial decrease in speed would be needed to provide any noticeable noise level reduction. A 10 mph speed reduction would result in only a two dBA Leq decrease in noise levels. Other measures such as time or use restrictions for certain vehicle classes are prohibited on state highways.

4.7.4.2 Noise Barriers

Among the most common noise barriers are earth berms and free-standing walls. Earth berms have a very natural appearance and are usually considered more aesthetically pleasing than noise barriers. However, because they are normally graded to achieve a natural form that blends in with the surrounding topography, the use of earth berms can require a substantial amount of land. Free-standing walls take far less space and are the most commonly used in the Houston area. The optimum situation for the use of free-standing noise barriers results when a dense concentration of impacted sites lies directly adjacent to and parallel with the highway ROW.

Noise barriers were evaluated at each of the representative receivers determined to be impacted by the Preferred Alternative Alignment, as indicated in Table 4-21. The results are presented in Table 4-23 and depicted graphically in Exhibit G–53.

4.7.4.3 Alteration of Horizontal and/or Vertical Highway Alignments

Increasing the distance between the receiver and the highway can reduce traffic noise levels. Doubling the distance from a noise source can reduce sound levels at a receiver by as much as 4.5 dBA Leq. For highway projects on new location, the consideration of design modifications to the horizontal alignment as a mechanism to minimize noise impacts should be made in the final alignment decision. These changes would be weighed against other environmental impacts, engineering constraints, and additional cost considerations. Depressing a roadway often requires the taking of additional property for required slope, or added treatment costs for absorptive retaining walls, and in this case may involve hydrologic or flooding issues. Elevating a roadway would allow the traffic noise to propagate farther into the surrounding communities at higher levels.

4.7.4.4 Noise Buffer Zones

Noise buffer zones require the acquisition of adjacent undeveloped or unimproved tracts of land along the highway, in addition to the normal ROW. This form of abatement is typically used as a control of future development that could be impacted by highway traffic noise, rather than to actually provide noise abatement. A large amount of land is often required to provide an effective noise buffer. The costs and acquisition process can be extremely expensive and lengthy.

4.7.4.5 Highway Construction Noise

Noise associated with the construction of the project is difficult to predict. Heavy machinery (a 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 longer duration; therefore any extended disruption of normal activities is not expected. Provisions will 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.

TABLE 4-23
GRAND PARKWAY, SEGMENT G – NOISE BARRIER ANALYSIS FOR THE PREFERRED ALTERNATIVE ALIGNMENT

Barrier	Impacted Representative Receivers	Feasible	Preliminary Dimensions		Total Cost*	# Benefiting Receivers	$/Benefiting Receiver	Reasonable	Proposed (Yes, No)*
			Length	Height					
Northgate Crossing									
1	1,4,5,14,15,16,18,19,21, 23,24,25	Yes	5,547	16	$1,331,280	34	$18,438	Yes	Yes**
Spring Trails									
2	32,33,34,35,36,37,38,39, 40,41,42,43,44,45,46,47, 48	Yes	3,322	16	$797,280	39	$20,443	Yes	Yes
Fox Run									
3	49,50,51,52,55,57,58,60, 61,64	Yes	2,482	16	$595,680	31	$21,617	Yes	Yes
Lockeridge Farms									
4	65,66,67,68	Yes	1,166	16	$279,840	12	$23,320	Yes	Yes
Bender's Landing									
5	86,87,88,89,90,91,92,93	No	N/A	N/A	N/A	N/A	N/A	N/A	No
Creekside Village									
6	98,99,100,103,104,105, 106	Yes	1,970	16	$472,800	21	$22,514	Yes	Yes
Winchester Place									
7	121,122,124	No	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE 4-23 (CONT.)
GRAND PARKWAY, SEGMENT F-2 – NOISE BARRIER ANALYSIS FOR THE PREFERRED ALTERNATIVE ALIGNMENT

Barrier	Impacted Representative Receivers	Feasible	Preliminary Dimensions		Total Cost*	# Benefiting Receivers	$/Benefiting Receiver	Reasonable	Proposed (Yes, No)*
			Length	Height					
Cumberland Crossing									
8	127,128,129,130,131	Yes	2,079	16	$498,960	26	$19,191	Yes	Yes
Timberland Estates									
9	140,141,142,145,146, 147,148,149,153,154	Yes	3,014	10	$452,100	19	$23,795	Yes	Yes

Note: Any subsequent project design changes may require a reevaluation of this proposal. The final decision to construct the proposed noise barrier will be made upon completion of the project design, utility evaluation, and polling of adjacent property owners.

* Based on estimated construction cost of $15 dollars per square foot.

** Barrier is feasible, but contingent upon agreement by electric utility.

Source: Study Team 2008

4.7.5 Noise Impact Contours

Traffic noise impact contours are used for projects that have a substantial amount of undeveloped land (Category D) adjacent to the highway. There is no NAC for Category D lands; however, to avoid noise impacts that may result from future development of properties adjacent to the project, local officials responsible for land use 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 4-24).

TABLE 4-24
NOISE IMPACT CONTOURS FOR THE SEGMENT G
PREFERRED ALTERNATIVE ALIGNMENT

Undeveloped Areas	Land Use	Impact Contour	Approximate Distance from ROW
IH 45 to Hardy Toll Road	Residential	66 dBA	20 ft
	Commercial	71 dBA	Within ROW
Hardy Toll Road to Riley Fuzzel Road	Residential	66 dBA	20 ft
	Commercial	71 dBA	Within ROW
Riley Fuzzel Road to Rayford-Sawdust Road	Residential	66 dBA	20 ft
	Commercial	71 dBA	Within ROW
Rayford-Sawdust Road to Bender's Landing Blvd.	Residential	66 dBA	20 ft
	Commercial	71 dBA	Within ROW
Bender's Landing Blvd to FM 1314	Residential	66 dBA	60 ft
	Commercial	71 dBA	Within ROW
FM 1314 to US 59	Residential	66 dBA	50 ft
	Commercial	71 dBA	Within ROW

Source: Study Team, 2008

4.7.6 Summary of Impacts

Results of the traffic noise analysis for the Preferred Alternative Alignment indicated that 79 representative receivers, representing a total of 280 residences, would be impacted by traffic noise. Noise abatement measures were evaluated for each of the impacted representative receivers (see Section 4.7.8).

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 this projected growth.

4.7.7 Indirect Impacts

Future increases in ambient noise levels associated with projected development are anticipated, especially in proximity to the Segment G 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.

4.7.8 Mitigation

Noise abatement measures were analyzed for receiver locations impacted by the Preferred Alternative Alignment. 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 several locations and therefore are proposed for incorporation into the project subject to the completion of the project design, utility evaluation, and polling of adjacent property owners. These locations are shown in Exhibit G–53.

4.8 WATER QUALITY

4.8.1 Surface Water

Effects to surface water quality can be divided into two broad categories, one directly from construction of the roadway, and one from the long-term operation of the roadway. The effects of the alternative alignments on surface water quality are discussed in this section.

Since the proposed alternative alignments would disturb more than one acre of land, TxDOT would be required to comply with the TCEQ TPDES General Permit for Construction Storm Water Runoff, which requires development of a SWPPP in order to avoid adverse impacts potentially resulting from storm water runoff discharges. In addition, because the project would disturb more than five acres of land, TxDOT would issue an NOI prior to construction stating that the SWPPP has been developed and filed with TCEQ. To minimize impacts to water quality during construction, the proposed project will utilize both temporary and permanent erosion control practices from TxDOT's manual, *1993 Standard Specifications for Construction of Highways, Streets, and Bridges* (TxDOT, 1993). These practices will be in place prior to and during the construction period and will be maintained throughout the construction of the proposed project.

Construction in the immediate area of stream crossings can be assumed to generate additional sediment loads to the streams if bare earth were exposed for an extended period of time and not controlled using erosion control facilities. Erosion control facilities would be used during construction. The following sections describe the probable effects of the proposed highway on the local and regional water quality and the measures that would be taken to prevent short and long-term water quality degradation.

4.8.1.1 Water Quality Impacts during Construction Activities

A SWPPP would be prepared prior to construction and followed throughout the construction phase to minimize the discharge of sediment-laden storm water to the project area streams. The project SWPPP would be prepared pursuant to the TxDOT manual, *Storm Water Management Guidelines for Construction Activities* (TxDOT, 2000). The SWPPP includes an erosion control plan and any specifications to prevent/minimize sediment-laden runoff from entering the project area streams. The erosion control plan may include, but is not limited to, the use of silt fence, inlet protection barriers, hay bales, sediment traps and/or basins, and seeding or sodding of excavated soil. Exposure of the soil surface would be minimized during any clearing activities in order to maintain soil integrity. At the completion of construction, the TxDOT specifications, *Seeding for Erosion Control* (TxDOT, 2004a) will be followed to restore and reseed all disturbed areas.

4.8.1.2 Water Quality Impacts from Long-Term Highway Operations

Surface waters can be affected in numerous ways by the long-term operations of a highway. As the highway is constructed, the land would be converted from mostly farmland, prairie, and woodlands to paved surface for the width of the roadway, and the vegetation may be cleared out to the project's ROW boundary. This change in land use typically results in accelerated storm water runoff to the streams. Depending on the amount of land that was converted from a natural condition to a paved or compacted surface within the drainage area of a stream, the stream may experience increased water velocities that result in streambed and bank erosion and degradation, sediment and pollutant loading, and other morphological changes.

Construction of the proposed highway alternative in Segment G would produce changes in the quantity and quality of the runoff from the paved roadway. The proposed alternative alignments within the Segment G project area would each cross several perennial and intermittent streams (see Section 4.12.1 [Hydrology and Drainage]). With the implementation of mitigation measures detailed in Section 4.8.5, any changes in the quantity and quality of the runoff are expected to have a minimal impact on the surface waters.

4.8.2 Groundwater

Potential adverse impacts to groundwater could occur because of a spill of hazardous or toxic material during transport on the completed highway facility. During construction, spills would be mainly limited to fuels (i.e., petrochemicals) and lubricants used for construction equipment. Such potential spills and their subsequent adverse impacts can be controlled through the proper application and management of these materials and equipment maintenance and by prompt response and cleanup of leaks and spills. In either case, impacts to the groundwater quality because of surface spills would be greatly minimized by the characteristically low permeability of the clayey soils and clay substrate. Following project construction, no substantial new pathways would be created for the highway storm water runoff to the regional aquifers. An appropriate spill response action plan will ensure potential impacts are localized and remediated.

Potential impacts to water supply wells were assessed using data gathered from the TCEQ and TWDB databases (see Section 3.8.2.1 [Water Well Review] of this volume). Table 4-25 summarizes the potential impacts to public and private water supply wells by each of the proposed alternative alignments. For private wells, potential impacts account for wellheads located within the alternative alignment ROWs. For public wells, potential impacts account for all capture zones that would be crossed by the ROW for each alternative alignment. If a capture zone would be overlapped, pollution prevention measures will not necessarily have to occur, and more detailed impact assessments would be conducted prior to construction (Rogers, 2006). Therefore, although Table 4-25 presents total overlapped capture zones as a means of comparing the alternative alignments, actual impacts to public water supply wells for each of the alternative alignments would likely be different. Table 4-26 shows detailed information for each public water supply well capture zone potentially impacted.

TABLE 4-25
POTENTIAL WATER SUPPLY WELL IMPACTS FOR SEGMENT G

Alternative Alignment	Reach*	Private Water Supply Wells	Public Water Supply Well Capture Zones
A	8	1	10
	9	0	1
	10	0	2
	11	0	3
	12	0	0
Alternative Alignment A Total		**1**	**16**
B	8	0	9
	9	0	1
	10	0	2
	11	0	0
	12	0	0
Alternative Alignment B Total		**0**	**12**
C	8	1	10
	9	0	1
	10	0	1
	11	0	3
	12	0	0
Alternative Alignment C Total		**1**	**15**
D	8	1	10
	9	0	1
	10	0	2
	11	0	3
	12	0	0
Alternative Alignment D Total		**1**	**16**

TABLE 4-25 (CONT.)
POTENTIAL WATER SUPPLY WELL IMPACTS FOR SEGMENT G

Alternative Alignment	Reach*	Private Water Supply Wells	Public Water Supply Well Capture Zones
Recommended	8	1	10
	9	0	1
	10	0	2
	11	0	3
	12	0	0
Recommended Alternative Alignment Total		**1**	**16**
Preferred	8	1	10
	9	0	1
	10	0	2
	11	0	3
	12	0	0
Preferred Alternative Alignment Total		**1**	**16**

Notes: *Public Water Supply Well Capture Zones that occur in more than one reach are only counted in the westernmost reach (e.g., if a zone overlaps an alignment in Reach 8 and Reach 9, it is only counted for Reach 8 impacts). Table 4-26 details, which reaches are crossed by each zone. Additionally, all capture zones overlapped will not necessarily require groundwater pollution prevention measures as more detailed impact assessments would need to occur (Rogers, 2006).

Source: TCEQ, 2006; TWDB, 2006c

TABLE 4-26
IDENTIFICATION OF POTENTIAL PUBLIC WATER SUPPLY WELL IMPACTS IN SEGMENT G

Public Well Capture Zone ID No.	Reach(es)	Well Owner	Aquifer	Well Depth (ft)	Approximate Distance of Well from ROW (ft)
Alternative Alignment A					
1010124C	8	Harris County WCID 92	Chicot	1,020	7,314
1010212A	8	Bayer Water System	Chicot	185	3,382
1010212D	8	Bayer Water System	Chicot	190	3,524
1011503A	8	Spring Creek Trails	Evangeline	390	335
1011533B	8	Camp Pine Tree YMCA	Chicot	310	930
1013077A	8	Northgate Crossing MUD 1	Evangeline	1,200	5,265

TABLE 4-26 (CONT.)
IDENTIFICATION OF POTENTIAL PUBLIC WATER SUPPLY WELL IMPACTS IN SEGMENT G

Public Well Capture Zone ID No.	Reach(es)	Well Owner	Aquifer	Well Depth (ft)	Approximate Distance of Well from ROW (ft)
1013078A	8	N/L	Evangeline	1,100	2,494
1700133A	8	Spring Creek Utility District	Chicot	520	3,738
1700678A	8	Benders Landing Water Plant 1	Chicot	355	4,691
1700717A	8 / 9	Montgomery County MUD 89	Evangeline	1,070	4,021
1700604A	9 / 10 / 11	Riverwalk Subdivision	Chicot	285	6,873
1700068D	10 / 11	Porter SUD	Evangeline	560	1,382
1700489A	10 / 11	Montgomery County MUD 56	Evangeline	571	2,070
1700612A	11	Timberland Estates	Evangeline	514	909
1700612B	11	Timberland Estates	Evangeline	513	880
1700612C	11	Timberland Estates	Evangeline	513	884
Alternative Alignment B					
1010124C	8	Harris County WCID 92	Chicot	1,020	7,718
1010212A	8	Bayer Water System	Chicot	185	4,766
1010212D	8	Bayer Water System	Chicot	190	4,778
1011533B	8	Camp Pine Tree YMCA	Chicot	310	2,096
1013077A	8	Northgate Crossing MUD 1	Evangeline	1,200	1,949
1700073B	8	N/L	N/L	N/L	N/L
1700133A	8	Spring Creek Utility District	Chicot	520	3,738
1700678A	8	Benders Landing Water Plant 1	Chicot	355	4,691
1700717A	8 / 9	Montgomery County MUD 89	Evangeline	1,070	4,021
1700604A	9 / 10 / 11	Riverwalk Subdivision	Chicot	285	3,089

TABLE 4-26 (CONT.)
IDENTIFICATION OF POTENTIAL PUBLIC WATER SUPPLY WELL IMPACTS IN SEGMENT G

Public Well Capture Zone ID No.	Reach(es)	Well Owner	Aquifer	Well Depth (ft)	Approximate Distance of Well from ROW (ft)
1700068D	10 / 11	Porter SUD	Evangeline	560	1,390
1700489A	10 / 11	Montgomery County MUD 56	Evangeline	571	1,739
Alternative Alignment C					
1010124C	8	Harris County WCID 92	Chicot	1,020	7,451
1010212A	8	Bayer Water System	Chicot	185	3,382
1010212D	8	Bayer Water System	Chicot	190	3,524
1011503A	8	Spring Creek Trails	Evangeline	390	335
1011533B	8	Camp Pine Tree YMCA	Chicot	310	930
1013077A	8	Northgate Crossing MUD 1	Evangeline	1,200	5,265
1013078A	8	N/L	Evangeline	1,100	2,494
1700133A	8	Spring Creek Utility District	Chicot	520	3,738
1700678A	8	Benders Landing Water Plant 1	Chicot	355	4,691
1700717A	8 / 9	Montgomery County MUD 89	Evangeline	1,070	4,021
1700604A	9 / 10 / 11	Riverwalk Subdivision	Chicot	285	2,898
1700489A	10 / 11	Montgomery County MUD 56	Evangeline	571	813
1700612A	11	Timberland Estates	Evangeline	514	830
1700612B	11	Timberland Estates	Evangeline	513	838
1700612C	11	Timberland Estates	Evangeline	513	857
Alternative Alignment D					
1010124C	8	Harris County WCID 92	Chicot	1,020	7,451
1010212A	8	Bayer Water System	Chicot	185	3,382

TABLE 4-26 (CONT.)
IDENTIFICATION OF POTENTIAL PUBLIC WATER SUPPLY WELL IMPACTS IN SEGMENT G

Public Well Capture Zone ID No.	Reach(es)	Well Owner	Aquifer	Well Depth (ft)	Approximate Distance of Well from ROW (ft)
1010212D	8	Bayer Water System	Chicot	190	3,524
1011503A	8	Spring Creek Trails	Evangeline	390	335
1011533B	8	Camp Pine Tree YMCA	Chicot	310	930
1013077A	8	Northgate Crossing MUD 1	Evangeline	1,200	5,265
1013078A	8	N/L	Evangeline	1,100	2,494
1700133A	8	Spring Creek Utility District	Chicot	520	3,738
1700678A	8	Benders Landing Water Plant 1	Chicot	355	4,691
1700717A	8 / 9	Montgomery County MUD 89	Evangeline	1,070	4,021
1700604A	9 / 10 / 11	Riverwalk Subdivision	Chicot	285	6,873
1700068D	10 / 11	Porter SUD	Evangeline	560	1,382
1700489A	10 / 11	Montgomery County MUD 56	Evangeline	571	2,070
1700612A	11	Timberland Estates	Evangeline	514	909
1700612B	11	Timberland Estates	Evangeline	513	880
1700612C	11	Timberland Estates	Evangeline	513	884

Note: N/L = Not Listed.
Source: TCEQ, 2006; TWDB, 2006c

4.8.3 Summary of Impacts

Effects to surface water runoff and groundwater from the alternative alignments would be minimal. Quality and quantity of storm water runoff would be altered by the alternative alignments in two ways: 1) direct effects from construction, and 2) effects from long-term operation of the roadway. Well records indicated that groundwater pollution prevention measures might be required for 16 public wells with Alternative Alignments A, Alternative Alignment D or the Preferred Alternative Alignment; 15 public wells with Alternative Alignment C; and 12 public wells with Alternative Alignment B. Furthermore,

Alternative Alignment B would not impact any known private water supply wells, and all other alternative alignments would impact a single private water supply well. Under the No-Build Alternative, no direct effect to surface water or groundwater resources would occur.

4.8.4 Indirect Impacts

Future increases in storm water runoff levels and effects to groundwater associated with projected regional and local development are anticipated, especially in proximity to the Segment G 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 within the watershed near the highway may result in additional impacts to private and public water wells; however, an estimate cannot be determined.

4.8.5 Mitigation

4.8.5.1 Surface Water

A SWPPP will be prepared prior to construction and followed throughout the construction phases to minimize the discharge of sediment laden storm water to the Segment G project area streams. The project SWPPP 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 chances 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 specifications *Seeding for Erosion Control* (TxDOT, 2004a) would be followed to restore and reseed all disturbed areas.

Additionally, in accord with Clean Water Act Section 402, where storm water 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. See Section 4.9.1 for further discussion of permitting for storm water discharge.

4.8.5.2 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 Alignment and would be performed during final design of the project. Measures would include minor alignment shifts to minimize the impact to source water protection areas and/or avoid direct impacts 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 TDLR.

A storm water management plan would be developed according to FHWA and TxDOT criteria to reduce the risk of contaminating local aquifers. The storm water 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 storm water runoff from entering the aquifer at wellheads.

An emergency spill control pollution prevention plan would be developed and coordinated with local officials for the Preferred Alternative Alignment. Special storm water management measures would be designed 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

Based on field surveys and review of aerial photography, impacts to jurisdictional Waters of the U.S., including wetlands, associated with construction of Segment G appear unavoidable. Each of the alternative alignments, regardless of reach, will result in some level of impact to Waters of the U.S. (refer to Section 4.10.1 [Wetlands] for discussion and locations of potential adverse impacts). A CWA Section 404 permit will be required by the USACE.

A January 9, 2001 Supreme Court decision (*Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Eng'rs,* 531 U.S. 159 [2001]) ruled that intrastate waters, including isolated wetlands, which could affect interstate commerce solely by virtue of their use by migratory birds, are no longer Waters of the U.S. and are not subject to Section 404 of the CWA (SWANCC v. USACE, 2001). Based on this ruling, many isolated wetlands that were formerly considered jurisdictional no longer fall under the jurisdiction of the USACE. Therefore, project wetland impacts have been evaluated as either "isolated" or "adjacent."

Currently, the USACE Galveston District provides guidance on jurisdictional determinations on whether an area is adjacent or isolated in the context of the USACE Regulatory Program (Appendix M). The USACE Galveston District interprets "isolated" Waters of the U.S. to be any waterbody not located within the 100-year floodplain or otherwise connected to the surface tributary system, surface water connections, continuous wetland system, ditch, or water course

that carries water from a waterbody to navigable waters, or waters that are part of a surface tributary system during normal expected flows or predictable flood events. Based on this approach, the USACE Galveston District will make permit decisions on direct impacts to jurisdictional wetlands based on their Section 404 authority and the regulatory definitions of a wetland, with consideration given to indirect impacts and to other natural resources.

Coordination with the USACE and various other state and federal agencies (including USFWS, TPWD, TCEQ, and EPA) relative to wetland impact avoidance (both isolated and adjacent), minimization, and mitigation during multiple meetings occurred throughout development of the proposed alternative alignments. Information regarding these meetings is provided in Section 6.2.3 (Resource Agency Involvement) of this volume.

A Section 404 permit application may be submitted to the USACE concurrently with the ROD for this project. The application and mitigation plan takes into account recommendations and suggestions made during the agency coordination meetings. Prior to issuance of the FEIS and Section 404 permit, all practicable measures were taken to avoid and minimize wetland and waterbody impacts to the extent reasonable and feasible. Those impacts that cannot be avoided or further minimized will be appropriately mitigated per coordination with the USACE and other appropriate state and federal agencies and in accordance with the Section 404 permit requirements. Please refer to Section 4.10.7 (Mitigation) for wetland mitigation recommendations.

Since the project would disturb more than one acre of land, TxDOT would be required to comply with the TCEQ TPDES General Permit for Construction Storm Water Runoff, which requires development of a SWPPP in order to avoid adverse impacts potentially resulting from construction storm water runoff discharges. In addition, because the project would disturb more than five acres of land, TxDOT would issue an NOI prior to construction stating that the SWPPP 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 storm water discharge permit as per Section 402 of the CWA. Additionally, in accord with CWA Section 402, where storm water 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.

TxDOT has its own storm water management guidelines and BMPs for construction activities (TxDOT, 2000) that will be used in the development of the SWPPP. As part of the SWPPP, 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 storm water runoff through a drainage system. Summary reports of these inspections will be written and retained as part of the SWPPP. 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 that disturbs more than three acres of Waters of the U.S. is subject to individual review by the TCEQ as Tier 2 project impacts.

4.9.2 Navigable Waters of the U.S.

The General Bridge Act of 1946 and Sections 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 USCG and the USACE, respectively. No navigable Waters of the U.S. occur within the Segment G project area. Therefore, the need for a Section 9 permit from the USCG or a Section 10 permit from the USACE is not required.

4.9.3 Summary of Impacts

Implementation of any of the alternative alignments would require a Section 404 permit, Section 401 water quality certification, and an appropriate mitigation plan. The proposed project would also require a TPDES construction storm water discharge permit and completion of a SWPPP and an NOI. No navigable waters occur within the Segment G project area; neither a Section 9 permit from the USCG nor a Section 10 permit from USACE is required. Under the No-Build Alternative, no permits would be required.

4.9.4 Indirect Impacts

Wetlands requiring a Section 404 permit for the proposed project are discussed in Section 4.10.6 (Indirect Impacts [Wetlands]), and the indirect impacts requiring the TPDES permit are presented in Section 4.8.4 (Indirect Impacts [Water Quality]).

4.9.5 Mitigation

Mitigation options associated with the wetland impacts requiring the Section 404 permit are discussed in Section 4.10.7 (Mitigation [Wetlands]), and the mitigation discussion for the activities requiring the TPDES permit are presented in Section 4.8.5 (Mitigation [Water Quality]). The Section 404 permit and TPDES permit will be obtained prior to construction.

4.10 WETLANDS AND VEGETATIVE COMMUNITIES

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." The FHWA 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 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.

Section 3.10.1.1 (Wetland Functions and Values) of this volume provides a discussion on the quality and function of the wetlands that exist within the Segment G project area. A discussion on avoidance, minimization, and mitigation associated with wetlands that exist within the Segment G project area is provided in Section 4.10.3.1 (Regulatory) and Section 4.10.3.2 (Non-Regulatory).

Proposed construction activities associated with Segment G would impact wetlands and aquatic systems to varying degrees. Land clearing during construction activities would remove vegetative cover. These activities may increase surface runoff during storm events and could lead to erosion. If runoff were allowed to flow into streams without erosion and sediment control measures, increased turbidity and sedimentation may modify water chemistry because of elevated levels of sediments, nutrients and pollutants, which would also diminish suitable habitat for aquatic species, including littoral zone plants. To aid in minimizing such impacts, placement and monitoring of erosion control measures at the start of, during, and after construction would be incorporated into project plans according to TxDOT SWPPP guidelines. Revegetation along the ROW will adhere to TxDOT revegetation guidelines.

The effects of roadway construction activities primarily fall into two categories: 1) the immediate and short-term impacts during the construction phase; and, 2) the long-term impacts 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 have on the environment depends largely on construction methodologies and on the design of highway and bridge structures. Conservative construction practices can reduce the effects on the physical environment.

Short-term impacts to wetland functions and values (described in Section 3.10.1.1 [Wetland Functions and Values] of this volume) would most likely include temporary water quality degradation, wildlife habitat loss, and a decrease in some recreational uses. Construction activities that fill wetlands would permanently destroy the ecological and hydrologic values and functions of those wetlands. The clearing of vegetation and the filling of wetlands would result in a permanent loss of wetland wildlife habitat. Borrow areas and any other project specific locations (PSLs) would be identified during the preparation of the Section 404 permit application and final design.

Long-term impacts are less predictable than the immediate impacts of construction on wetland habitats, as changes to the wetland/aquatic system can take place over a longer period of time. As previously described, removal of existing wetlands could result in increased sediment and nutrient runoff that could impact nearby wetlands and receiving waters over time. In addition, long-term impacts resulting from wetland removal could include decreased flood control capacity. However, impacts to the flood control function would be avoided and mitigated by design measures (e.g., detention facilities) as dictated by TxDOT, which would prevent increased runoff and flooding potential downstream that could result from wetland loss in the Segment G project area.

Various mitigation measures may be employed to offset unavoidable permanent impacts to wetland functions and values. Short-term and long-term impacts would be mitigated by the replacement of the impacted wetlands and their function and value. Wetland mitigation measures are described in Section 4.10.3 (Habitat Mitigation). Formal mitigation measures will be discussed and developed to ensure wetland function and value are not permanently lost by the proposed project.

Three major levels of investigation were employed to identify wetlands within the Segment G project area, as defined by the USACE 1987 Wetland Delineation Manual (USACE, 1987), allowing the project team to avoid wetland impacts where possible and minimize those impacts that were unavoidable.

The first level of investigation included review of color infrared aerial photographs, National Wetland Inventory (NWI) maps, and published soil survey maps. All potential wetland areas were delineated on these maps, transferred to an aerial background image managed with a GIS, and classified as either forested or non-forested wetlands. Aerial photograph interpretation is a common and accepted planning tool when accessing potential wetland impacts. The accuracy of wetland "signatures" depicted on aerial photographs versus actual field investigations can vary depending on various environmental conditions, including the amount of rain and ground disturbance any one area receives the year of or prior to the photograph. While there is inherent error in using aerial photography, the error is common throughout all of the alternatives.

The second level of investigation involved a helicopter survey of the proposed alternative alignments. During the flight, all the potential wetlands identified from the aerial photos were qualified as either forested or non-forested, and their boundaries were confirmed and corrected as necessary by the project team. The boundaries of the wetlands were not verified by the USACE and therefore were considered to represent potential jurisdictional wetlands.

The third level of investigation consisted of a ground survey of all properties within the alternative alignments to which the field team was given access by the property owner. During the ground survey, all areas that met the three criteria outlined in the USACE 1987 Wetlands Delineation Manual (i.e., dominated by hydrophytic vegetation, contained indicators of hydrology, and had hydric soils) were mapped as potential jurisdictional wetlands. Where access was permitted for on-site investigations, the boundaries of the potential wetland areas were flagged and mapped with real-time, differentially corrected Digital Global Positioning Satellite (DGPS) system equipment. Properties without access required evaluation of aerial photographs and digital area calculations to determine acreage.

An additional level of investigation will be completed for the Preferred Alternative Alignment prior to completion of the Section 404 permit. This fourth level of investigation consists of a formal wetland delineation, which began in the fall of 2007. The delineation is being conducted within the Preferred Alternative Alignment in accordance with the USACE 1987 Wetlands Delineation Manual. As of the completion of this FEIS, right-of-entry has not been obtained for approximately 60 percent of the total ROW along the Segment G Preferred Alternative Alignment. Results of this investigation are awaiting additional property owner access and will require verification by the USACE Galveston District.

Currently, the USACE and the EPA are conducting interagency coordination to establish jurisdiction over wetlands using an approved jurisdictional form developed jointly by USACE headquarters in consultation with EPA. The basis for determining jurisdiction with this form, following the U.S. Supreme Court's Decision in *Rapanos v. United States* and *Carabell v. United States* (2006), is to establish whether a substantial nexus exists between a wetland and traditional navigable water.

Table 4-27 presents the results of the first three levels of analysis conducted on all alternative alignments. Results for Alternative Alignments A, B, C, and D differ slightly from those presented in the DEIS because of the incorporation of new land use data (e.g., residential developments) in the Segment G project area since publication of the DEIS.

Appendix N provides a more detailed listing of the potential wetlands, wetland types, and acreages identified. Acreage calculations have been separated into total area of the individual wetland and actual area of the individual wetland potentially impacted (i.e., inside an alignment) by the proposed project. Exhibit G–48 shows the locations of wetlands potentially impacted by the proposed alternative alignments.

TABLE 4-27
WETLAND IMPACT SUMMARY BY ALTERNATIVE ALIGNMENT AND REACH IN SEGMENT G

Alternative Alignment	Reach	Non-Forested Wetland (acres)		Forested Wetland (acres)		Total Wetland (acres)		
		Adjacent	Isolated	Adjacent	Isolated	Adjacent	Isolated	Overall
A	8	9.92	1.51	3.96	0.82	13.88	2.33	16.21
	9	8.55	2.25	10.81	18.57	19.36	20.82	40.18
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.78	0.00	21.94	0.00	22.72	22.72
	12	0.00	2.20	2.72	0.00	2.72	2.20	4.92
Alternative Alignment A Total*		**18.47**	**6.74**	**17.49**	**41.33**	**35.96**	**48.07**	**84.03**
B	8	2.66	1.44	1.59	0.65	4.25	2.09	6.34
	9	2.27	5.73	20.94	1.43	23.21	7.16	30.37
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	3.56	0.00	1.47	0.00	5.03	5.03
	12	0.00	0.81	3.13	2.50	3.13	3.31	6.44
Alternative Alignment B Total*		**4.93**	**11.54**	**25.66**	**6.05**	**30.59**	**17.59**	**48.18**
C	8	9.92	1.51	3.96	0.82	13.88	2.33	16.21
	9	20.70	3.88	6.21	0.65	26.91	4.53	31.44
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	3.52	0.00	6.78	0.00	10.30	10.30
	12	0.00	1.85	3.96	0.00	3.96	1.85	5.81
Alternative Alignment C Total*		**30.62**	**10.76**	**14.13**	**8.25**	**44.75**	**19.01**	**63.76**

TABLE 4-27 (CONT.)
WETLAND IMPACT SUMMARY BY ALTERNATIVE ALIGNMENT AND REACH IN SEGMENT G

Alternative Alignment	Reach	Non-Forested Wetland (acres)		Forested Wetland (acres)		Total Wetland (acres)		
		Adjacent	Isolated	Adjacent	Isolated	Adjacent	Isolated	Overall
D	8	9.92	1.51	3.96	0.82	13.88	2.33	16.21
	9	4.28	0.40	10.28	0.00	14.56	0.40	14.96
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.78	0.00	21.94	0.00	22.72	22.72
	12	0.00	1.85	3.96	0.00	3.96	1.85	5.81
Alternative Alignment D Total*		**14.20**	**4.54**	**18.20**	**22.76**	**32.40**	**27.30**	**59.70**
Recommended	8	9.92	1.51	3.96	0.82	13.88	2.33	16.21
	9	4.28	0.40	10.28	0.00	14.56	0.40	14.96
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.78	0.00	21.94	0.00	22.72	22.72
	12	0.00	1.85	3.96	0.00	3.96	1.85	5.81
Recommended Alternative Alignment Total*		**14.20**	**4.54**	**18.20**	**22.76**	**32.40**	**27.30**	**59.70**
Preferred	8	9.77	1.51	3.96	0.82	13.73	2.33	16.06
	9	9.89	0.50	9.48	0.00	19.37	0.50	19.87
	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	0.00	0.78	0.00	21.94	0.00	22.72	22.72
	12	0.00	1.85	3.96	0.00	3.96	1.85	5.81
Preferred Alternative Alignment Total*		**19.66**	**4.64**	**17.40**	**22.76**	**37.06**	**27.40**	**64.46**

* Totals may not appear to equal sum of reaches because of rounding.
Source: Study Team, 2007

4.10.2 Vegetative Communities

The primary impact to vegetation resulting from site preparation and construction of the proposed highway project is the removal of existing vegetation from the ROW and any construction staging areas. The proposed alternative alignments would potentially impact five general vegetative community types: farmland (including prime farmland), rangeland, forest (including riparian forest), non-forested wetland, and forested wetland. Although each of these communities would be potentially impacted, only the adjacent wetland and prime farmland communities are regulated by state and federal resource agencies. Table 4-28 lists the community types and accompanying potential impacts by alternative alignment and reach.

For each of the proposed alternative alignments, impacts will be direct and indirect, temporary and permanent. In general, impacts will be avoided, minimized, and mitigated where practical. Unavoidable impacts to wetlands and other habitats,

such as bottomland hardwood forest, that cannot be further minimized would be mitigated as described in Section 4.10.3 (Habitat Mitigation). Direct impacts would entail the alteration of the vegetation, soils, and hydrology. Vegetation may be mowed and/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 characteristics. 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. Unpaved disturbed areas within the ROW and staging areas would be revegetated. BMPs may call for seeding or sodding of disturbed areas.

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 within the Segment G project area are 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 are interrelated at various scales of both time and space.

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 proposed alternative alignments would be directly impacted by construction-related activities. The potential fragmentation of habitat and riparian 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, the 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 may suffer impacts associated with habitat fragmentation and displacement into adjacent habitats. However, these impacts are not likely to adversely affect or jeopardize the continued existence of any species. Please refer to Section 4.11 (Wildlife) for further discussion regarding wildlife impacts.

The following discussion for the non-wetland vegetation community types is relative to the ROW. 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 (USACE, 1987) and differentially corrected Global Positioning System (GPS) data or by review of color infrared aerial photographs and digital area calculations (for properties with no ground access). Wetland impact acreages were generated using a GIS and overlaying with the potential ROW of the proposed alternative alignments. Wetland

community impacts are discussed in detail in Section 4.10.1 (Wetlands) and presented in Table 4-27. Section 4.11.1.1 (Terrestrial Wildlife Impacts by Alternative Alignment) provides a comparative discussion of vegetation community impacts by alternative alignment within each reach relative to terrestrial wildlife habitat.

4.10.2.1 Farmland/Rangeland

Farmland and rangeland are the least common community types found within the Segment G project area. Farmland and rangeland would not be affected within the Segment G project area. These impacts are separate and distinct from the impacts to prime farmland soils, which are shown in Table 4-2. Descriptions of and impacts to prime farmland soils can be found in Section 3.2.3 (Farmland) of this volume and Section 4.2.2 (Farmland), respectively.

4.10.2.2 Forest

Forest habitat is the largest community type found within the Segment G project area; consequently, it is the vegetative community most impacted by all alternative alignments. Forest impacts vary from a low of 245.7 acres in Alternative Alignment B to a high of 357.3 acres in Alternative Alignment D (Table 4-28). The Preferred Alternative Alignment would impact 352.8 acres of forest.

Table 4-29 shows the amount of upland forest impacts that are specifically composed of riparian forest and bottomland hardwood forest impacts. None of the alternative alignments would impact riparian forest. Potential impacts to bottomland hardwood forest would occur with any of the alternative alignments. Alternative Alignment B would impact the least amount of bottomland hardwood forest (83.6 acres), and Alternative Alignment C would impact the most (144.3 acres). With its slight shifts in Reaches 8 and 9, the Preferred Alternative Alignment ROW encompasses slightly less bottomland hardwood acreage than the Recommended Alternative Alignment (129.8 acres versus 132.7 acres). Since some of these acres lie adjacent to stream crossings planned for bridging, actual impacts would be less than the ROW totals represented in Table 4-29. Refer to Exhibit G–49 for the location of alternative alignments relative to bottomland hardwood forest and riparian forest in the Segment G project area.

The Spring Creek Greenway Project, sponsored by Harris and Montgomery Counties with the assistance of Legacy Land Trust, aims to connect and protect approximately 12,000 acres of forest along over 30 miles of riparian corridor on both sides of the creek. The project will restore and preserve tracts of such habitats as baldcypress (*Taxodium distichum*) swamps and bottomland hardwood. Portions of the project would be within the Segment G project area; however, there will not be impacts from the Grand Parkway because of continual coordination between the GPA and the Spring Creek Greenway Project. Both Montgomery and Harris County plan to preserve the lands for the Spring Creek Greenway Project through non-development deed restrictions and conservation easements. For additional information on the Spring Creek Greenway Project and its associated in-lieu fee program, see the following website: www.springcreekgreenway.org.

TABLE 4-28
POTENTIAL VEGETATIVE COMMUNITY IMPACTS IN THE SEGMENT G PROJECT AREA

Alternative Alignment	Reach	Farmland (acres)	Rangeland (acres)	Forest (acres)	Non-Forested Wetland (acres)	Forested Wetland (acres)
A	8	0.0	0.0	83.2	11.4	4.8
	9	0.0	0.0	172.2	10.8	29.4
	10	0.0	0.0	11.3	0.0	0.0
	11	0.0	0.0	54.0	0.8	21.9
	12	0.0	0.0	13.7	2.2	2.7
Alternative Alignment A Total*		**0.0**	**0.0**	**334.4**	**25.2**	**58.8**
B	8	0.0	0.0	57.3	4.1	2.2
	9	0.0	0.0	152.2	8.0	22.4
	10	0.0	0.0	11.3	0.0	0.0
	11	0.0	0.0	9.6	3.6	1.5
	12	0.0	0.0	15.2	0.8	5.6
Alternative Alignment B Total*		**0.0**	**0.0**	**245.7**	**16.5**	**31.7**
C	8	0.0	0.0	83.2	11.4	4.8
	9	0.0	0.0	164.7	24.6	6.9
	10	0.0	0.0	19.2	0.0	0.0
	11	0.0	0.0	52.3	3.5	6.8
	12	0.0	0.0	19.4	1.9	4.0
Alternative Alignment C Total*		**0.0**	**0.0**	**338.9**	**41.4**	**22.4**
D	8	0.0	0.0	83.2	11.4	4.8
	9	0.0	0.0	189.4	4.7	10.3
	10	0.0	0.0	11.3	0.0	0.0
	11	0.0	0.0	54.0	0.8	21.9
	12	0.0	0.0	19.4	1.9	4.0
Alternative Alignment D Total*		**0.0**	**0.0**	**357.3**	**18.7**	**41.0**
Recommended	8	0.0	0.0	83.2	11.4	4.8
	9	0.0	0.0	189.4	4.7	10.3
	10	0.0	0.0	11.3	0.0	0.0
	11	0.0	0.0	54.0	0.8	21.9
	12	0.0	0.0	19.4	1.9	4.0
Recommended Alternative Alignment Total*		**0.0**	**0.0**	**357.3**	**18.7**	**41.0**

TABLE 4-28 (CONT.)
POTENTIAL VEGETATIVE COMMUNITY IMPACTS IN THE SEGMENT G PROJECT AREA

Alternative Alignment	Reach	Farmland (acres)	Rangeland (acres)	Forest (acres)	Non-Forested Wetland (acres)	Forested Wetland (acres)
Preferred	8	0.0	0.0	87.5	11.3	4.8
	9	0.0	0.0	180.7	10.4	9.5
	10	0.0	0.0	11.3	0.0	0.0
	11	0.0	0.0	54.0	0.8	21.9
	12	0.0	0.0	19.4	1.9	4.0
Preferred Alternative Alignment Total*		**0.0**	**0.0**	**352.8**	**24.3**	**40.2**

Note: These impacts do not include impacts to residential, commercial, industrial, transportation, streams and canals, lakes or other areas that are not included in the five vegetation types.

* Totals may not appear to equal sum of parts because of rounding.

Source: Study Team, 2007

TABLE 4-29
POTENTIAL RIPARIAN FOREST AND BOTTOMLAND HARDWOOD IMPACTS

Alternative Alignment	Reach	Riparian Forest	Bottomland Hardwood
A	8	0	23.9
	9	0	53.2
	10	0	0
	11	0	0
	12	0	32.3
Alternative Alignment A Total		**0**	**109.4**
B	8	0	19.2
	9	0	43.6
	10	0	0
	11	0	0
	12	0	20.8
Alternative Alignment B Total		**0**	**83.6**
C	8	0	23.9
	9	0	58.0
	10	0	0
	11	0	0
	12	0	62.4
Alternative Alignment C Total		**0**	**144.3**

TABLE 4-29 (CONT.)
POTENTIAL RIPARIAN FOREST AND BOTTOMLAND HARDWOOD IMPACTS

Alternative Alignment	Reach	Riparian Forest	Bottomland Hardwood
D	8	0	23.9
	9	0	46.4
	10	0	0
	11	0	0
	12	0	62.4
Alternative Alignment D Total		**0**	**132.7**
Recommended	8	0	23.9
	9	0	46.4
	10	0	0
	11	0	0
	12	0	62.4
Recommended Alternative Alignment Total		**0**	**132.7**
Preferred	8	0	23.4
	9	0	44.0
	10	0	0
	11	0	0
	12	0	62.4
Preferred Alternative Alignment Total		**0**	**129.8**

Note: Totals include all acreage within the alternative alignment ROWs. Final design will include bridging of perennial streams and portions of adjacent bottomland hardwood forest.
Source: Study Team, 2007

4.10.3 Habitat Mitigation

4.10.3.1 Regulatory

Mitigation includes measures, which avoid, minimize, and/or compensate for unavoidable losses to resources that cannot be further minimized. The assessment of mitigation measures (avoidance, minimization, and compensation) is an integral part of the NEPA/Section 404 process. The preferred means of mitigation is avoidance, which is inherent in impact evaluation analysis and alternative development/assessment. For those adverse impacts that cannot be avoided, other mitigation efforts must be considered. These efforts include minimization of potentially adverse impacts and compensation for those remaining adverse impacts that cannot be further reduced.

Initial mitigation measures in the planning or alignment of highway projects such as Segment G of the Grand Parkway minimize the probable occurrence of habitat (vegetation communities) and wetland impacts (both adjacent and isolated) 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 roadway design (use of bridge crossings instead of filled embankment); the use of retention basins and revegetated swales to minimize runoff, sedimentation, turbidity, leaching of soil nutrients, and leaching of chemicals from petroleum products, pavement, and waste material; and maintaining flow patterns to ensure wetland hydrology in spite of roadway design requirements.

The fact that some degree of impact is often unavoidable, regardless of the care applied during the planning, design, and construction of a highway, requires a plan for compensatory mitigation to replace functions, values, and features or habitat that may be disturbed. Replacement of values for unregulated habitat (habitat not under USACE jurisdiction where compensation can be required) within transportation corridors and highway ROW may not always be practical, feasible, or safe (refer to Section 4.10.3.2 [Non-Regulatory]). On occasion, on-site restoration of degraded wetland habitat or creation of wetland habitat within the highway ROW through creative use of detention basins, borrow pit areas, or drainage runoff channels may be appropriate. Where such measures may not effectively restore resource functions and values, 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, values, and type as the pre-existing site. Off-site mitigation would be conducted in the same geographic vicinity or in proximity, and most likely within the same watershed as the project, particularly for wetlands. Wetland mitigation may include expanding existing wetlands, restoration with hydrophytic species, or regulating water levels in impoundments or streams. Mitigation that involves wetland creation and/or enhancement would include post-project monitoring of mitigation sites to ensure success.

Natural resource agencies (including TPWD, USFWS, USACE, EPA, and TCEQ) will be involved in decisions regarding appropriate mitigation ratios and the location, size, and character of the mitigation. A compensatory mitigation plan will be submitted to the USACE as part of the Section 404 permit review process. The mitigation plan will include a discussion of the avoidance and minimization measures used in the routing and design of the roadway. The plan will provide mitigation for unavoidable impacts to both adjacent and isolated wetlands, regardless of current USACE regulatory status (refer to Section 4.9.1 [Waters of the U.S., Including Wetlands]). In addition, the plan will include specifications for accomplishing the proposed compensatory mitigation measures. It is anticipated that a monitoring program would be included in the mitigation plan to ensure the successful implementation of the compensatory mitigation measures. The approved mitigation plan will be a condition of the USACE Section 404 permit for the Grand Parkway Segment G project. The approved mitigation plan will provide a detailed discussion of mitigation commitments, including those that must be implemented during construction. Mitigation measures for site-specific activities will be identified, to the extent practicable, throughout project development as additional information becomes available.

Every effort has been made to avoid and minimize wetland impacts, both adjacent and isolated, to the extent practicable during the planning process (Corridor and Alignment selection). This effort will continue up to construction of the proposed Grand Parkway Segment G. Preliminary design of the Preferred Alternative Alignment includes bridging perennial stream crossings with portions of the adjacent wetlands and bottomland hardwood forest. Further minimization of impact through bridging would be considered during final design.

For impacts that cannot be avoided or further minimized, preliminary mitigation options have been discussed with the GPA, TPWD, USFWS, and the USACE during project team meetings and in agency correspondence. Summaries of these meetings and copies of agency correspondence are provided in Section 6 (Agency and Public Coordination) of this volume and Appendix B. Preliminary mitigation options include on-site mitigation and off-site mitigation. On-site mitigation may include creation or enhancement of wetlands within the final Segment G ROW, which 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.

It should be noted that on-site mitigation is being considered only as an option at this time. Per correspondence with USFWS (August 30, 1993, Appendix B), on-site mitigation for highway projects may not be considered adequate for replacement of all lost wetland functions and values. On-site (i.e., immediately adjacent to the new highway) mitigation will not be considered as the only source of wetland mitigation for impacts associated with this project. On-site mitigation may be considered as a supplement to additional off-site mitigation. Further coordination with USFWS, TPWD, and the USACE may eliminate the use of on-site mitigation as an option for this project, especially in light of better off-site mitigation options that adequately compensate for impacts to wetland functions and values.

Potential off-site areas considered for enhancement, restoration, and/or preservation include tracts of land within and adjacent to the Spring Creek-San Jacinto River floodplain that may be placed under conservation easement or purchased and placed under perpetual deed restriction. Other options may include use of the Katy-Cypress Mitigation Bank, wetland creation, and/or enhancement on property owned and/or managed by the Katy Prairie Conservancy, wetland creation on property currently owned by Harris County Precinct 3, and wetland creation at the Westside Airport site and forested wetland preservation, creation, and/or enhancement at the Bahr Woods Mitigation Area located adjacent to the San Jacinto River in Montgomery County. Off-site wetland mitigation options will likely include surrounding upland prairie restoration and/or efforts to ensure sufficient hydrology for any constructed or acquired wetland habitat per USFWS recommendations (March 16, 2000, Appendix B).

In summary, several viable wetland mitigation alternatives will be investigated and evaluated in the mitigation plan. The plan will also address mitigation for “isolated” wetlands, regardless of current regulatory status under Section 404 of the CWA. The technical and regulatory merit of these mitigation recommendations will be evaluated and further discussed with resource agency staff and ultimately presented to the public prior to construction.

4.10.3.2 Non-Regulatory

Non-regulated resources (e.g., isolated wetlands, remnant prairie topography, or riparian habitat) identified as environmentally sensitive, socially desirable, or ecologically valuable have been avoided to the extent practicable. Non-regulated resources are often included as part of a wetland mitigation plan, on a case-by-case basis. As discussed above, the compensatory mitigation plan will address mitigation for isolated wetlands, regardless of current regulatory status under Section 404 of the CWA. In addition, it is anticipated that a non-wetland component would be incorporated into the mitigation plan to compensate for unavoidable impacts to non-regulated natural resources per the provisions outlined in TxDOT's Memorandum of Agreement (MOA) with TPWD and USFWS recommendations (March 16, 2000, Appendix B).

In accordance with Provision (4) (A) (ii) of the TxDOT's Memorandum of Understanding (MOU) with TPWD signed in 1998 and at the TxDOT district's discretion, habitats given consideration for non-regulatory mitigation during project planning include:

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 TPWD designations) that also locally provide habitat for a state-listed species.
3. All vegetation communities listed as S1 or S2, regardless of whether or not the series in question provides habitat for a state-listed species.
4. Bottomland hardwoods, native prairies, and riparian sites.
5. Any other habitat feature considered to be locally important that the TxDOT district chooses to consider.

As discussed in Volume I, Section 3.17 (Threatened and Endangered Species), only one federal candidate species, the Louisiana pine snake, may occur within the Grand Parkway Segments E, F-1, F-2, and G project areas. Although unlikely to occur within the Segment G project area, suitable habitat for the Louisiana pine snake (i.e., sandy areas of longleaf pine and hardwood communities as described in Volume I, Section 3.17.1 [State and Federally Listed Threatened and Endangered Species]) would primarily be found northeast of the Segment G project area. Given the location and extent of this species' preferred habitat relative to the Segment G project area, mitigation for impacts to any potential Louisiana pine snake habitat within the Segment G project area would be unlikely to assist in the prevention of the listing of this species.

No rare vegetation series are known or expected to occur within the Segment G project area (TPWD, 2007c). Impacts to riparian forest have been avoided in the development of the proposed alternative alignments based on current information. However, compensation for bottomland hardwood forest impacts (described in Volume I, Section 3.10.2.3 [Forest]) will be considered and addressed in the mitigation plan to be submitted for agency review and approved prior to construction. As suggested by USFWS (March 16, 2000, Appendix B), such compensation may include a contribution to the acquisition of flood easements containing riparian forest remnants within Segment G project area watersheds.

Additional non-regulatory mitigation may be considered by TxDOT Houston District as appropriate. The GPA will continue to coordinate with the federal and state natural resource agencies and project stakeholders to develop a final compensatory mitigation plan that protects, enhances, and preserves the integrity of the natural environment. In accordance with the Executive Memorandum of August 10, 1995, all agencies shall comply with NEPA as it relates to vegetation management and landscape practices for all federally assisted projects. The Executive Memorandum directs that where cost-effective and to the extent practicable, agencies will 1) use regionally native plants for landscaping; 2) design, use, or promote construction practices that minimize adverse effects on the natural habitat; 3) seed to prevent pollution by, among other things, reducing fertilizer and pesticide use; 4) implement water-efficient and runoff reduction practices; and 5) create demonstration projects employing these practices. Landscaping included with this project would comply with the Executive Memorandum and the guidelines for environmentally and economically beneficial landscape practices.

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.

4.10.4 Natural Areas

No officially designated natural areas were identified within the Segment G project area. However, the Segment G project area is partially located within a region historically known as the Big Thicket (http://www.nps.gov/bith/). It should be noted that The Big Thicket National Preserve is not in the project area of the Preferred Alternative Alignment of the Grand Parkway, Segment G.

Within the Segment G project area the Spring Creek Greenway Project (http://springcreekgreenway.org/) is a collaborative project that will connect, preserve, restore, and protect up to 12,000 acres of forest on both sides of Spring Creek. Furthermore, this project will educate the public about an ecological gem, a biologically diverse ecosystem that provides important habitat for many wildlife species and aims to create an ecotourism mecca and a peaceful respite from busy urban lives for Houston residents or travelers nationwide.

4.10.5 Summary of Impacts

Vegetative community impacts are summarized in Table 4-30. None of the alternative alignments would impact farmland or rangeland. With respect to forest impacts, Alternative Alignment D would have the most impact, with the Preferred Alternative Alignment having nearly the same amount. Alternative Alignment B would have the least amount of forest impact.

Alternative Alignment A would have the greatest impact to wetlands, including the most specifically to forested wetland. Alternative Alignment C would impact the fewest forested wetlands, but Alternative Alignment B would have the least impact to wetlands overall, including the least specifically to non-forested wetlands. The Preferred Alternative Alignment would impact an intermediate amount of wetlands relative to the other alternative alignments.

TABLE 4-30
SUMMARY OF VEGETATIVE COMMUNITY IMPACTS IN THE SEGMENT G PROJECT AREA

Alternative Alignment	Farmland (acres)	Rangeland (acres)	Forest (acres)	Non-Forested Wetland (acres)	Forested Wetland (acres)
A	0.0	0.0	334.4	25.2	58.8
B	0.0	0.0	245.7	16.5	31.7
C	0.0	0.0	338.9	41.4	22.4
D	0.0	0.0	357.3	18.7	41.0
Recommended	0.0	0.0	357.3	18.7	41.0
Preferred	0.0	0.0	352.8	24.3	40.2

Notes: These impacts do not include impacts to residential, commercial, industrial, transportation, streams and canals, lakes or other areas that are not included in the five vegetation types. All acreages account for updated land use since publication of the DEIS (January 2007).

Source: Study Team, 2007

The No-Build Alternative would avoid impacts to larger wetlands (forested and non-forested), 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.

4.10.6 Indirect Impacts

Indirect impacts to wetlands and vegetative communities resulting from the construction of Segment G are considered likely based on the existing land use of the Segment G 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 non-forested 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 G 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.

4.10.7 Mitigation

Preliminary mitigation options for impacts to wetlands that cannot be avoided or further minimized include on-site mitigation and off-site mitigation. On-site mitigation may include creation or enhancement of wetlands within the Segment G 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 Spring Creek-San Jacinto River floodplain that may be placed under conservation easement or purchased and placed under perpetual deed restriction. Other options may include use of the Katy-Cypress Mitigation Bank, wetland creation, and/or enhancement on property owned and/or managed by the Katy Prairie Conservancy, wetland creation on property currently owned by Harris County Precinct 3, and wetland creation at the Westside Airport site, and forested wetland preservation, creation, and/or enhancement at the Bahr Woods Mitigation Area located adjacent to the San Jacinto River in Montgomery County. Additional options may include use of property currently owned by Harris County Precinct 4, Montgomery County Precinct 3, and Montgomery County Precinct 4. Properties in these County Precincts include but are not limited to, Spring Creek Greenway Project, Cypress Creek Greenway Project, and forested wetland preservation, creation, and/or enhancement at the Bahr Woods Mitigation Area located adjacent to the San Jacinto River in Montgomery County.

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 permit review process. It is anticipated that a non-wetland component would be incorporated, at the discretion of the TxDOT Houston District, into the mitigation plan to compensate for unavoidable impacts to non-regulated natural resources (riparian habitat, upland forest, etc.). Please refer to Section 4.10.3 (Habitat Mitigation) for a discussion of the regulatory and non-regulatory measures of habitat mitigation.

4.11 WILDLIFE

4.11.1 Terrestrial Wildlife

Potential impacts to wildlife 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 path of the highway alignment. The heavy machinery may remove some small, low-mobility forms, which include several species of amphibians, reptiles, and mammals and, if construction would occur during the breeding season, the young of many species, including nestling and fledgling birds. Fossorial animals (i.e., those that live underground) such as mice and shrews may be negatively impacted because of soil compaction caused by heavy machinery. Larger, more-mobile species such as birds, deer, foxes, and squirrels may avoid the initial clearing and construction activities and move into adjacent areas outside the corridor. Wildlife in the immediate area

would experience a loss of browse or forage material within the construction easement; however, the prevalence of similar habitats in adjacent areas should minimize the effects of this loss. The highway could act as a barrier to dispersal of small mammals, thus, fragmenting the populations and modifying their home range (Natural Resources Defense Council [NRDC], 2000). In addition, roadways often bisect the home range or foraging habitat from breeding or roosting habitat (Forman and Deblinger, 2000), such as between forage communities in farmland or rangeland and breeding or roosting areas in wetlands or waterbodies.

In addition to the removal of habitat and these previously mentioned impacts, individual terrestrial wildlife mortality may be associated with automobile collisions. According to Findlay and Bourdages (2000), evidence is accumulating that road construction may result in a loss of biodiversity at both the local and regional scales because of restricted movement of species between local populations.

The increased noise and activity levels associated with the project could potentially disturb breeding or other activities of species inhabiting the areas adjacent to the ROW. Within the avian community, traffic noise rather than visual disturbance, air pollutants, or predators along roads is the primary cause for changes associated with highway development (Forman and Deblinger, 2000). The normal behavior of many wildlife species would be temporarily disturbed during construction; however, once the road is in operation, traffic noise would have only a slight impact on wildlife. Wildlife would likely move far enough away from the noise to achieve a comfort level. Overall, it is expected that the normal behavior of many wildlife species would be temporarily disturbed during construction; however, little long-term damage to the populations of such organisms would result from increased noise levels.

Potential impacts to wildlife are expected to result from the removal of forests, wetland habitats, and farmland. Forests, in particular, are relatively static environments that require greater regenerative times compared to pastureland, cropland, grassland, or emergent wetlands. Although tributaries would be bridged or culverted, wetland areas occurring within the footprint of the highway would be filled, thus, reducing foraging, breeding, and roosting habitat for some wildlife species.

Recent studies indicate that forest fragmentation has a detrimental effect on some avian species that show a marked preference for large undisturbed forest tracts (Faaborg et al., 1992). Several studies have demonstrated that individual species are not randomly distributed with regard to habitat size. Contiguous unfragmented forested tracts 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; Terborgh, 1989; Faaborg et al., 1992). 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). 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., the Midwest) relative to regions dominated by a forested landscape (e.g., the Northeast) (Robinson et al., 1995; Rosenberg et al., 1986). Research shows that the incidence of nest parasitism by the brown-headed cowbird (*Molothrus ater*) and nest predation, especially by blue jays and American crow, typically increases when forest fragment size decreases (Robinson et al., 1995).

The carrying capacity of habitat for any particular species is dependent on the availability of limiting resources such as food, shelter, water, territory, and nesting sites (Dempster, 1975). For the purpose of impact analysis, available habitats are assumed to be at their carrying capacity for the species that occur there. Since highway construction would likely displace individuals in the vicinity of the ROW, they could be forced into competition with residents of adjacent habitat for 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 species adapt to different habitats over time. 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. Although these impacts to the carrying capacity of wildlife populations in the Segment G project area will occur, their extent is impossible to predict.

Once construction is completed and the vegetation has recovered, some wildlife species may move back into vegetated portions of the 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 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 improves the habitat for ecotonal or edge species, such as the eastern cottontail, white-tailed deer, indigo bunting (*Passerina cyanea*), Virginia opossum, and grassland species, particularly the white-footed mouse (*Peromyscus leucopus*), hispid cotton rat, and eastern harvest mouse (*Reithrodontomys humulis*) (Adams and Geis, 1983). Although mortality of birds, 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 (Leedy, 1977; Adams and Geis, 1983).

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 spill

and erosion control methods. Measures used to minimize water quality impacts are discussed in Section 4.8 (Water Quality); air quality impacts are discussed in Section 4.6 (Air Quality).

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; Bogemans et al., 1989; and Banerjee et al., 1983). Organisms (especially those contained in the soil) may suffer mortality or be displaced because of chemical exposure (Muskett and Jones, 1981; Gunter and Wilke, 1983; Krzusztofiak, 1991). Growth and vitality (including resistance to pathogens) of many plants can be depressed (Petersen et al., 1982; Flueckiger et al., 1984; Moritz and Breitenstein, 1985; Fleck et al., 1988; Northover, 1987). Plants and animals may accumulate toxins at levels that pose health hazards, which may be passed on to humans that consume contaminated organisms (Graham and Kalman, 1974; Nasralla and Ali, 1985; Dickinson et al., 1987; and Guttormsen, 1993). Also, increased concentrations of some pollutants, particularly salts used in de-icing, may attract large mammals, putting them at risk of being killed by vehicles (Fraser and Thomas, 1982), though use of salts for de-icing in the project area is not expected to occur frequently because of 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 because of increased spread of exotic and/or noxious species (such as non-native grass, shrub, and tree species planted in the ROW) into previously undisturbed portions of the Segment G project 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. However, the Segment G project area has already been subjected to extensive human access and alteration resulting from silviculture operations and urbanization practices.

It should be noted that roadway construction can have positive effects on many generalist wildlife species. The mowed zone adjacent to the highway will not be particularly productive as wildlife habitat, but will provide a feeding area for some birds such as the American robin, 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 will provide feeding and nesting areas for some bird species and cover for a variety of wildlife (Leedy, 1977; Adams and Geis, 1983). 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.

Migratory Birds

The MBTA (1918) protects migratory birds, active nests, eggs, and/or young. Please note 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.

4.11.1.1 Terrestrial Wildlife Impacts by Alternative Alignment

Considering potential impacts to wildlife discussed previously, the primary concerns are impacts caused by habitat fragmentation, especially relative to riparian forest corridors and wetland habitats. Forests, particularly, are relatively static environments that require greater regenerative time after clearing compared to farmland or non-forested wetlands. Acreage impacts to vegetative communities that occur within the Segment G project area provide a method of quantifying and comparing terrestrial wildlife habitat impacts, including habitat fragmentation, potentially incurred by construction of Segment G. Section 4.10.2 (Vegetative Communities) summarizes the potential impacts to vegetative communities. The impacts resulting from each of the proposed alternative alignments within each reach are listed in Table 4-28 and are summarized by alternative alignment in Table 4-30 (see also Section 4.11.3).

4.11.2 Aquatic Habitat

The project streams are designated as warm freshwater fisheries. Tidal influence or cold water fishery streams do not exist in the Segment G project area under normal circumstances. Three categories of impacts to aquatic habitats and fisheries were evaluated. First, the aquatic habitats, including streams and waterbodies, may be directly impacted as a result of construction activities. Second, the construction activities may indirectly impact a stream's aquatic habitat by increasing sedimentation and turbidity. Third, the water quality may be impacted because of increased vehicular traffic and nonpoint source runoff or point source toxic spills draining into the aquatic habitats.

Physical alteration can occur when the existing channel is relocated or a culvert is installed. 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. Permanent channel relocations may also incorporate natural channel design principles to provide a more natural habitat.

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 would occur, a beneficial provision of habitat will be available for aquatic life during dry periods. Depressing culverts into the substrate will aid in maintaining adequate water depths and providing a rough bottom to simulate a rock/gravel substrate. The use of properly designed culverts and low-flow augmentation will enhance fish passage.

Typical short-term construction impacts include increased 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). High turbidity is tolerated either by many species or temporarily displaces the fish until acceptable levels of turbidity are restored. However, high levels of turbidity can create situations that clog the gills of fish and reduce their ability to extract oxygen from the water. Turbidity and sedimentation may also affect food supplies and the ability of a fish to locate prey. While fish normally recover quickly from stress, such circumstances during spawning seasons may reduce reproductive success.

Sedimentation can bury the food supplies of benthic (bottom) feeders, which is of limited concern in segments of streams with mud or silt bottoms. If the degree of siltation would be 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 rapid.

Oil and grease products wash into streams from roadways. These chemicals accumulate on the roads during dry periods and are rinsed off when it rains. The most toxic fraction of these petroleum products, the volatiles, is rarely included in the oil and grease washed into a stream because they evaporate rapidly. Since flows are generally high after a rain, the oil and grease are often diluted and dispersed. Greater details of potential water quality impacts are included in Section 4.8 (Water Quality) of this document.

In summary, the physical alterations to the waterway will be limited by the construction of adequately sized and designed drainage structures. Hydraulic structures designed in accordance with TxDOT standards will ensure that adequate fish passage is maintained during periods of low-flow. In addition, stream channels will experience limited siltation during construction. Proper planning and execution of the construction should ensure only short-term, minor impacts to the aquatic habitat.

No negative long-term impacts to aquatic species in the Segment G project area are expected as a result of highway construction and usage. Adverse impacts to aquatic species are expected to be slight, with minimal habitat conversion and some individual mortality associated with construction when species are present at creek crossings. Mitigation for impacts listed previously 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. These practices will 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.

4.11.3 Summary of Impacts

The use of any alternative alignment would result in varying degrees of impact to forest and wetland habitats with no outstanding alternative alignment having considerably less overall wildlife habitat impact within each reach. Alternative Alignment A would have the greatest impact to forested wetlands (58.8 acres). Alternative Alignment C would have the greatest impact to non-forested wetlands (41.4 acres). With respect to wetlands, overall, Alternative Alignment A would have the most impact (84.0 acres). The Preferred Alternative Alignment would impact 64.5 acres of wetland habitat, with 40.2 acres being forested wetland. Alternative Alignment D would have the most impact on forest habitat (357.3 acres), while the Preferred Alternative Alignment would have a similar impact on forest (352.8 acres).

The potential impacts to the aquatic environment caused by the proposed alternative alignments would 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 proposed alignments. All alternative alignments would cross four major streams: Spring Creek, Woodsons Gully, West Fork San Jacinto River, and White Oak Creek. Preliminary design of the Preferred Alternative Alignment includes bridging these major 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.

4.11.4 Indirect Impacts

Indirect impacts to wildlife resulting from the construction of Segment G are considered likely based on the existing land use of the Segment G 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.

The most visible effect of roads on wildlife is animal mortality resulting from collisions with motor vehicles. For most wildlife species, the death of a few individuals does not directly impact the overall survival of the species throughout its range. In general, most wildlife species found within the project area are broadly distributed across southeastern Texas. It is unlikely that highway mortality would pose a serious threat to the continued existence of any of these species. Several highway-related wildlife mortality studies have concluded that roads appeared to act in a density-dependent manner. Species killed in greatest numbers were those with high population densities attracted to ROW habitat, such as edge associated birds and small/medium sized mammals (Adams and Geis, 1983).

4.11.5 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 non-regulated natural resources, such as isolated wetlands. Please refer to Section 4.10.3 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.

4.12 WATERBODY MODIFICATIONS AND FLOODPLAINS

Section 4.12.1 provides a description of potential stream impacts by each of the alternative alignments. Impacts to floodways and floodplains are addressed in Section 4.12.2. Impacts to vegetative communities and wetlands, including Palustrine Open Water (POW) wetlands, also affect hydrology and drainage, and are addressed in Section 4.10 of this volume.

4.12.1 Hydrology and Drainage

The proposed Grand Parkway is not anticipated to 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 would not be considered substantial because of the required drainage (mitigation) facilities that would be incorporated into the project designs (see Section 4.12.5.1 for mitigation of impacts to hydrology and drainage).

Major streams that flow through the Segment G project area and are crossed by all alternative alignments include Spring Creek, Woodsons Gully, West Fork San Jacinto River, and White Oak Creek. Each alternative alignment also crosses either Black Branch or Black Slough, named drainages in the Woodsons Gully and West Fork San Jacinto River watersheds, respectively. Each alternative alignment also crosses several intermittent tributaries to the major drainages.

All of the project area streams are located within the San Jacinto River Basin, which has a drainage area of over 3,400 square miles. The watersheds within the Segment G project area are comprised of residential and commercial development and undeveloped acreage, such as farmlands and wooded areas.

The project area streams generally flow in a northwest–to-southeast direction. The proposed project alternative alignments run in a western direction to the terminus at US 59. Crossings of streams were kept perpendicular to the extent feasible and practicable in light of other environmental and engineering constraints. No stream relocations are anticipated for Segment G. Stream crossings are detailed in Table 4-31 for each proposed highway alternative.

TABLE 4-31
STREAM CROSSINGS BY ALTERNATIVE ALIGNMENT AND REACH

Alternative Alignment	Reach	Major Stream Crossings	Major Stream Name	Minor Stream Crossings	Minor Stream Name	Total Stream Crossings
A	8	2	Spring Creek (J100-00-00)	3	Trib to Spring Creek	5
			Woodsons Gully		Trib to Spring Creek	
			–		Trib to Woodsons Gully	
	9	1	West Fork San Jacinto River	3	Black Slough	4
			–		Trib to West Fork San Jacinto River	
			–		Trib to West Fork San Jacinto River	
	10	0	–	0	–	0
	11	0	–	1	Trib to White Oak Creek	1
	12	1	White Oak Creek	3	Trib to White Oak Creek	4
			–		Trib to White Oak Creek	
			–		Trib to White Oak Creek	
Total		**4**	–	**10**	–	**14**

TABLE 4-31 (CONT.)
STREAM CROSSINGS BY ALTERNATIVE ALIGNMENT AND REACH

Alternative Alignment	Reach	Major Stream Crossings	Major Stream Name	Minor Stream Crossings	Minor Stream Name	Total Stream Crossings
B	8	2	Spring Creek (J100-00-00)	3	Trib to Spring Creek	5
			Woodsons Gully		Trib to Spring Creek	
			–		Trib to Woodsons Gully	
	9	1	West Fork San Jacinto River	2	Trib to West Fork San Jacinto River	3
			–		Black Branch	
	10	0	–	0	–	0
	11	0	–	0	–	0
	12	1	White Oak Creek	2	Trib to White Oak Creek	3
			–		Trib to White Oak Creek	
Total		**4**	–	**7**	–	**11**
C	8	2	Spring Creek (J100-00-00)	3	Trib to Spring Creek	5
			Woodsons Gully		Trib to Spring Creek	
			–		Trib to Woodsons Gully	
	9	1	West Fork San Jacinto River	4	Trib to Black Branch	5
			–		Trib to West Fork San Jacinto River	
			–		Trib to West Fork San Jacinto River	
			–		Black Slough	
	10	0	–	1	Trib to West Fork San Jacinto River	1
	11	0	–	1	Trib to White Oak Creek	1
	12	1	White Oak Creek	3	Trib to White Oak Creek	4
			–		Trib to White Oak Creek	
			–		Trib to White Oak Creek	
Total		**4**	–	**12**	–	**16**

TABLE 4-31 (CONT.)
STREAM CROSSINGS BY ALTERNATIVE ALIGNMENT AND REACH

Alternative Alignment	Reach	Major Stream Crossings	Major Stream Name	Minor Stream Crossings	Minor Stream Name	Total Stream Crossings
D	8	2	Spring Creek (J100-00-00)	3	Trib to Spring Creek	5
			Woodsons Gully		Trib to Spring Creek	
			–		Trib to Woodsons Gully	
	9	1	West Fork San Jacinto River	3	Trib to West Fork San Jacinto River	4
			–		Trib to West Fork San Jacinto River	
			–		Black Branch	
	10	0	–	0	–	0
	11	0	–	1	Trib to White Oak Creek	1
	12	1	White Oak Creek	3	Trib to White Oak Creek	4
			–		Trib to White Oak Creek	
			–		Trib to White Oak Creek	
Total		**4**	–	**10**	–	**14**
Recommended	8	2	Spring Creek (J100-00-00)	3	Trib to Spring Creek	5
			Woodsons Gully		Trib to Spring Creek	
			–		Trib to Woodsons Gully	
	9	1	West Fork San Jacinto River	3	Trib to West Fork San Jacinto River	4
			–		Trib to West Fork San Jacinto River	
			–		Black Branch	
	10	0	–	0	–	0
	11	0	–	1	Trib to White Oak Creek	1
	12	1	White Oak Creek	3	Trib to White Oak Creek	4
			–		Trib to White Oak Creek	
			–		Trib to White Oak Creek	
Total		**4**	–	**10**	–	**14**

TABLE 4-31 (CONT.)
STREAM CROSSINGS BY ALTERNATIVE ALIGNMENT AND REACH

Alternative Alignment	Reach	Major Stream Crossings	Major Stream Name	Minor Stream Crossings	Minor Stream Name	Total Stream Crossings
Preferred	8	2	Spring Creek (J100-00-00)	3	Trib to Spring Creek	5
			Woodsons Gully		Trib to Spring Creek	
			–		Trib to Woodsons Gully	
	9	1	West Fork San Jacinto River	3	Trib to West Fork San Jacinto River	4
			–		Trib to West Fork San Jacinto River	
			–		Black Branch	
	10	0	–	0	–	0
	11	0	–	1	Trib to White Oak Creek	1
	12	1	White Oak Creek	3	Trib to White Oak Creek	4
			–		Trib to White Oak Creek	
			–		Trib to White Oak Creek	
Total		**4**	–	**10**	–	**14**

Source: Study Team, 2007

Alternative Alignment C would have the most stream crossings, with 16. Alternative Alignment B would have the least stream crossings with 11. The remaining alternative alignments, including the Preferred Alternative Alignment, would have 14 stream crossings. Preliminary design of the Preferred Alternative Alignment includes long bridges over Spring Creek and the West Fork San Jacinto River and the bridging of Woodsons Gully, White Oak Creek, and a perennial tributary to Woodsons Gully. Other stream crossings would be culverted, although further bridging would be considered in final design. Bridges and culverts of a tributary to Spring Creek, the tributary to Woodsons Gully, Woodsons Gully, and a tributary to White Oak Creek would involve frontage roads as well as the main lane Grand Parkway.

Particularly because of the lack of natural drainage features and the flat topography in the area, each of the proposed alternative alignments has the potential to impact overland sheet flow patterns. Sheet flow patterns will be considered when designing cross drainage structures. Final drainage and mitigation analyses would be conducted during final project design.

4.12.2 Floodways and Floodplains

4.12.2.1 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, FHPM 6-7-3-2, *Location and Hydraulic Design of Encroachments on Floodplains*, and USDOT's EO 5650.2, *Floodplain Management and Protection*.

FHPM 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 performed 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 floodplain; 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.

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 one foot at any point within the community" (44 CFR 60.3(c)(10)). Section 60.3(d) 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)).

DFIRMs and FIRMs were obtained for all of Harris County and Montgomery County, respectively, showing the regulatory floodways and base floodplains. During the corridor study, year 2000 FIRMs were obtained for the corridor study. Since the corridor study, TSARP produced DFIRMs for Harris County. These maps have undergone the necessary regulation review process, were finalized in December 2006, and have become effective as of June 18, 2007 (TSARP, 2007). The floodplains and floodways from the Harris County Preliminary 2006 DFIRMs and Montgomery County 2000 FIRMs were

transferred onto the project mapping in the GIS. A comparative analysis of the Harris County Preliminary 2006 flood boundaries represented herein and the June 18, 2007 effective flood boundaries indicate no substantive differences within the Grand Parkway Segment G.

The GIS was used to calculate the amount of floodway and floodplain acreage within the Segment G project area and the amount of floodway and floodplain encroachment associated with each alternative alignment. Project area floodways and floodplains are shown in Exhibit G–48. Table 4-32 identifies the floodway and floodplain acreage for each watershed within the ROW for each alternative alignment and reach.

Additionally, to assess the potential risk of flooding associated with each alternative alignment, each potential encroachment was identified as one of three categories:

- Longitudinal encroachments occur when the proposed alignment falls within the floodplain parallel to the stream;
- Transverse encroachments occur when the proposed alignment will cross the stream and its associated floodplain perpendicularly, or nearly so; and
- Complex encroachments are a combination of longitudinal and transverse encroachments.

4.12.2.2 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.

4.12.2.3 Natural and Beneficial Floodplain Values

Floodplains provide several natural and beneficial values. Floodplains provide floodwater detention, water quality maintenance, and groundwater recharge. 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 sub-surface storage, which contributes to the reduction of downstream flood flows. Floodplain encroachments increase the water flow velocity, thus, reducing groundwater infiltration/recharge rates.

4.12.2.4 Alternatives Analysis of Floodplain Avoidance

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 G project area's watercourses and associated floodplains. The No-Build Alternative would not result in direct impacts to floodways or floodplains. Table 4-32 shows the amount of both floodway and 100-year floodplain within the ROW of each alternative alignment by reach. For each floodplain crossing, the type of encroachment (see Section 4.12.2.1 above) is listed in Table 4-32 as well. The totals in Table 4-32 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 4-33 presents a worst-case scenario for 100-year floodplain encroachments within each watershed by showing the total amount of 100-year floodplain encroachment if no bridging occurred in the final design. Table 4-33 also provides two comparisons to regional floodplains: the total amount of each individual floodplain in the project area, and the total amount of all floodplains in the project area.

TABLE 4-32
FLOODWAYS AND FLOODPLAINS WITHIN THE ALTERNATIVE ALIGNMENT ROW

Alternative Alignment	Reach	Stream Name	Floodway within ROW (acres)	100-yr Floodplain within ROW (acres)	Type of Encroachment*
A	8	Spring Creek	20.87	25.80	T
		Woodsons Gully	14.31	6.00	T
	9	West Fork San Jacinto River	20.38	35.47	T
	10	None	-	-	-
	11	None	-	-	-
	12	White Oak Creek	8.83	27.80	T
Alternative Alignment A Total			**64.39**	**95.07**	
B	8	Spring Creek	19.15	26.16	C
		Woodsons Gully	14.31	6.00	T
	9	West Fork San Jacinto River	49.41	13.69	T
	10	None	-	-	-
	11	None	-	-	-
	12	White Oak Creek	5.87	15.60	T
Alternative Alignment B Total			**88.74**	**61.45**	
C	8	Spring Creek	20.87	25.80	T
		Woodsons Gully	14.31	6.00	T
	9	West Fork San Jacinto River	24.46	52.50	T
	10	None	-	-	-
	11	None	-	-	-
	12	White Oak Creek	7.49	60.52	C
Alternative Alignment C Total			**67.13**	**144.82**	
D	8	Spring Creek	20.87	25.80	C
		Woodsons Gully	14.31	6.00	T
	9	West Fork San Jacinto River	52.87	11.27	T
	10	None	-	-	-
	11	None	-	-	-
	12	White Oak Creek	7.49	60.52	C
Alternative Alignment D Total			**95.54**	**103.59**	
Recommended	8	Spring Creek	20.87	25.80	C
		Woodsons Gully	14.31	6.00	T
	9	West Fork San Jacinto River	52.87	11.27	T
	10	None	-	-	-
	11	None	-	-	-
	12	White Oak Creek	7.49	60.52	C
Recommended Alternative Alignment Total			**95.54**	**103.59**	

TABLE 4-32 (CONT.)
FLOODWAYS AND FLOODPLAINS WITHIN ALTERNATIVE ALIGNMENT ROW

Alternative Alignment	Reach	Stream Name	Floodway within ROW (acres)	100-yr Floodplain within ROW (acres)	Type of Encroachment*
Preferred	8	Spring Creek	20.86	25.80	C
		Woodsons Gully	14.86	5.94	T
	9	West Fork San Jacinto River	52.21	10.74	T
	10	None	-	-	-
	11	None	-	-	-
	12	White Oak Creek	7.49	60.52	C
Preferred Alternative Alignment Total			**95.42**	**103.00**	

Notes: Totals for each stream include floodways/floodplains for tributaries to the major streams that are crossed by the alternative alignments. Acreages represent total amount in ROW and do not represent impacts. 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 of the selected Preferred Alternative Alignment.

*Encroachment Types: T = Transverse, C = Complex (Combination of Transverse and Longitudinal), see Section 4.12.2.1 for definitions.

Source: TSARP, 2006; FEMA Digital Q3 Data, 2000; Study Team, 2007

TABLE 4-33
FLOODPLAIN ENCROACHMENT SUMMARY FOR EACH PROJECT AREA WATERSHED

Alternative Alignment	Stream Watershed	100-yr Floodplain Encroachment* (acres)	Encroachment as Percent of Stream's 100-yr Floodplain* within the Project Area	Encroachment as Percent of Total 100-yr Floodplain within the Project Area
A	Spring Creek	25.80	7.44%	1.76%
	Woodsons Gully	6.00	2.03%	0.41%
	West Fork San Jacinto River	35.47	6.14%	2.42%
	White Oak Creek	27.80	11.18%	1.89%
Alternative Alignment A Total**		**95.07**	**N/A**	**6.47%**
B	Spring Creek	26.16	7.54%	1.78%
	Woodsons Gully	6.00	2.03%	0.41%
	West Fork San Jacinto River	13.69	2.37%	0.93%
	White Oak Creek	15.60	6.27%	1.06%
Alternative Alignment B Total**		**61.45**	**N/A**	**4.18%**
C	Spring Creek	25.80	7.44%	1.76%
	Woodsons Gully	6.00	2.03%	0.41%
	West Fork San Jacinto River	52.50	9.09%	3.57%
	White Oak Creek	60.52	24.34%	4.12%
Alternative Alignment C Total**		**144.82**	**N/A**	**9.86%**

TABLE 4-33 (CONT.)
FLOODPLAIN ENCROACHMENT SUMMARY FOR EACH PROJECT AREA WATERSHED

Alternative Alignment	Stream Watershed	100-yr Floodplain Encroachment* (acres)	Encroachment as Percent of Stream's 100-yr Floodplain* within the Project Area	Encroachment as Percent of Total 100-yr Floodplain within the Project Area
D	Spring Creek	25.80	7.44%	1.76%
	Woodsons Gully	6.00	2.03%	0.41%
	West Fork San Jacinto River	11.27	1.95%	0.77%
	White Oak Creek	60.52	24.34%	4.12%
Alternative Alignment D Total**		**103.59**	**N/A**	**7.05%**
Recommended	Spring Creek	25.80	7.44%	1.76%
	Woodsons Gully	6.00	2.03%	0.41%
	West Fork San Jacinto River	11.27	1.95%	0.77%
	White Oak Creek	60.52	24.34%	4.12%
Recommended Alternative Alignment Total**		**103.59**	**N/A**	**7.05%**
Preferred	Spring Creek	25.80	7.44%	1.76%
	Woodsons Gully	5.94	2.01%	0.40%
	West Fork San Jacinto River	10.74	1.86%	0.73%
	White Oak Creek	60.52	24.34%	4.12%
Preferred Alternative Alignment Total**		**103.00**	**N/A**	**7.01%**

Notes: * Includes tributaries. ** Totals may not appear to equal sum of parts because of rounding.

Acreages represent total amount in ROW and do not represent impacts. 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 of the selected Preferred Alternative Alignment.

Source: TSARP, 2006, FEMA Digital Q3 Data, 2000; Study Team, 2007

4.12.2.5 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 G project area, where the risk of flooding is generally high.

The majority of highways constructed in the Houston area are very near to at-grade facilities. Highways are typically elevated on one to three (plus) 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, it is likely that the construction technique would be consistent with the existing highways in the region.

An at-grade highway facility in Segment G would not result in substantial increases in flooding to the Segment G project area. Mitigation measures would be used to allow passage of the base flood without increasing the established FEMA base flood levels more than one foot.

4.12.2.6 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 with the possible exception of a portion of floodway adjacent to Woodsons Gully. For floodplain crossings that are not bridged, the alternative alignment ROW would represent a 400-foot wide band through the broad floodplains, with the actual proposed roadway footprint covering just a portion of that width. Table 4-33 shows the percentage of each stream's floodplains within the project area that would be crossed, either with a bridge or not, by each of the alternative alignments. These percentages represent just a portion of the total floodplains for the entire watersheds. Without bridging, the Preferred Alternative Alignment would encroach upon 7.0 percent of all 100-year floodplains in the project area. The bridging developed in final design may reduce this percentage. The small percentage of anticipated floodplain impacts in conjunction with the implementation of mitigation measures would result in unsubstantial impacts to the natural and beneficial values of the Segment G project area floodplains.

4.12.2.7 Support of Incompatible Development within the Floodplain

For all alternative alignments, diamond 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.

4.12.2.8 Measures Taken to Minimize Floodplain Impacts

The alternative alignments were designed to avoid impacts to floodplains to the maximum extent feasible and practicable. All four alignments were located to minimize encroachment on regulatory floodways and floodplains and maintain a transverse encroachment to the extent possible. Each of the alignments was shifted to the north or south to avoid wetlands and longitudinal encroachments. Preliminary design of the Preferred Alternative Alignment includes bridging or culverting all of the regulatory floodways with the possible exception of a portion of the floodway adjacent to Woodsons Gully. 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.

4.12.2.9 Measures 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 detailed 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 SWPPP to protect water quality;
- Implementation of a storm water 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.

4.12.3 Summary of Impacts

4.12.3.1 Hydrology and Drainage

All of the alternative alignments would cross intermittent tributaries. Alternative Alignment C would have the most stream crossings with 16. Alternative Alignment B would have the least streams crossings with 11. The remaining alternative alignments, including the Preferred Alternative Alignment, would have 14 stream crossings. Preliminary design of the Preferred Alternative Alignment includes long bridges over Spring Creek and the West Fork San Jacinto River and the bridging of Woodsons Gully, White Oak Creek, and a perennial tributary to Woodsons Gully. 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 4.12.5.1). The No-Build Alternative would not impact hydrology and drainage.

4.12.3.2 Floodways and Floodplains

Of the 10,627 acres within the Segment G project area, 29 percent, or 3,072.8 acres, are within floodways or floodplains (see Volume I, Section 3.12.2, Table 3-15). Avoidance of this resource during the development of the alternative alignments was carefully balanced with avoidance of other sensitive resources in the project area. All of the alternative alignments would encroach on the following streams and their associated regulatory floodways and floodplains: Spring Creek, Woodsons Gully, West Fork San Jacinto River, and White Oak Creek. The proposed project would have little to no impact to regulatory floodways, as these would be bridged, with the possible exception of a portion of floodway adjacent to Woodsons Gully.

With respect to floodplains, Alternative Alignment C would have the greatest potential encroachment (9.86 percent of project area floodplains), while Alternative Alignment B would have the least potential encroachment (4.18 percent of project area floodplains) (Table 4-33). The Preferred Alternative Alignment would potentially encroach upon 7.01 percent of the floodplains in the project 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 4.12.5.2 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 floodways and floodplains.

4.12.4 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 Harris and Montgomery County floodplain administrator. Access points to the Grand Parkway have been located outside of the floodplains to the greatest extent practicable to minimize potential for future floodplain development.

4.12.5 Mitigation

4.12.5.1 Hydrology and Drainage

Because of flat topography and the low number of natural drainage features within the project 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.

4.12.5.2 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 Harris and Montgomery County "floodplain program." Any proposed construction or development in a SFHA (special flood hazard area) would be coordinated with the Harris and Montgomery County floodplain administrator to receive a development permit.

The proposed alternative alignments were designed to avoid impacts to floodplains to the maximum extent feasible and practicable. All alignments were located to minimize encroachment on regulatory floodways and floodplains and maintain a transverse encroachment to the extent possible. Each of the alignments was shifted to the north or south to avoid wetlands and longitudinal encroachments. 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 4.12.2.9 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.

4.13 WILD AND SCENIC RIVERS

The proposed action is not situated in the vicinity of any river segment on the National Inventory of River Segments included in the National Wild and Scenic River System list (NPS, 2007) or on the Nationwide Rivers Inventory list (NPS, 2004); no impacts to Wild and Scenic Rivers would occur. The No-Build Alternative would also not impact these resources.

4.14 COASTAL BARRIERS

The Segment G project area is wholly outside any coastal barrier systems; the proposed project would not have any impacts to coastal barrier resources. The No-Build Alternative would also not impact these resources.

4.15 COASTAL ZONE MANAGEMENT

The Segment G project area is not within the CMP boundary and, therefore, is in compliance with the CZMA. Coordination with the Coastal Coordination Council (CCC) would not be required with either the Build Alternative or the No-Build Alternative.

4.16 ESSENTIAL FISH HABITAT (EFH)

The proposed project does not intersect tidally influenced coastal waters and would have no impact on EFH. Coordination with NMFS would not be required for either the Build Alternative or the No-Build Alternative.

4.17 THREATENED AND ENDANGERED SPECIES

A list of all state and federally listed rare, threatened, or endangered species for Harris County and Montgomery County and the potential existence of their habitat in the project area are found in Section 3.17 (Threatened and Endangered

Species), Table 3-16 of this volume. The findings reported in Table 3.16 were made based on literature reviews and general habitat descriptions.

Initial field investigations of the Segment G project area in 2000 and 2001, including a review of aerial photography, a helicopter survey, and the TPWD's natural heritage database files (TPWD, 1999), determined that no suitable habitat for any threatened or endangered species existed within the Segment G project area.

Further review of the TXNDD took place in July 2007, and habitat evaluations for protected species are currently being made concurrently with the field investigations for waters of the U.S. along the Preferred Alternative Alignment. Field surveys have been performed where landowner access was granted to confirm the desktop and file reviews. At the time of this FEIS, approximately 40 percent of the ROW had been surveyed; therefore only desktop analyses and literature reviews can be used to support the preliminary findings of the remaining 60 percent of ROW. As right-of-entry is granted and additional field studies can be performed, any changes to the findings will be updated.

As detailed in Section 3.17, results of the literature review and agency coordination indicated the nesting territory of a bald eagle extends into the project area (TPWD, 2007d). 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 five years, and the eagle could be reclassified after the five-year monitoring period. The bald eagle is still listed as threatened by TPWD. Additionally, the bald eagle is protected by the MBTA and the Bald and Golden Eagle Protection Act. 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, 2007c)." The Bald and Golden Eagle Protection 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 Bald and Golden Eagle Protection Act was recently defined by a final rule published in the *Federal Register* 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, 2007c).

No confirmed sightings of bald eagles or nests are known within the project area according to the USFWS; however, the bald eagle could nest along the riparian corridor of Spring Creek or the West Fork San Jacinto River. Increases in traffic and construction noise may elevate stress levels in any potential breeding eagles, possibly causing the birds to flee or fail at breeding attempts. Construction outside of the breeding season may be considered to reduce stress levels on any eagles that might occur in the area. Since eagles are not known to occur in the project area, the project will not likely affect the bald eagle. However, if the project changes or if additional information on the distribution of eagles becomes

available, the project would be reanalyzed for effects not previously considered, and the appropriate construction buffers established by the National Bald Eagle Guidelines (USFWS, 2007d) would be applied to the proposed project.

Several other threatened, endangered, or rare bird species may potentially occur within the proposed Segment G project area at various times throughout the year (please refer to Section 3.17 [Threatened and Endangered Species] of this volume). None of the state or federally listed species have any known documented nest sites within the Segment G project area (TPWD, 2007c). Threatened or endangered bird species would likely only occur within the Segment G project area to forage, roost, or migrate through the region. In order to minimize potential impacts to these species, the alternative alignments avoid major waterbodies within the Segment G project area.

Most of the Segment G project area occurs within forested habitat, which can directly or indirectly provide a rich food source for many birds, including those listed in Section 3.17, Table 3-16 of this volume. Indirect impacts to these bird species resulting from a decrease in farmland within the Segment G project area are not expected to occur because of the abundance of farmland throughout the Gulf Coast Region. Most protected bird species, in general, are highly mobile, exhibit lower tolerances for disturbance, and will likely avoid the project area. Direct mortality impacts are not anticipated to any threatened, endangered, or rare bird species and no designated suitable habitat will be directly affected.

Adverse impacts to other species listed in Section 3.17 (Threatened and Endangered Species) are not expected to occur because of the relative lack of recorded occurrences within the Segment G project area (TPWD, 2007c). Water quality data (i.e., elevated turbidity levels) within the Spring Creek and the West Fork San Jacinto River watersheds do not suggest presence of preferred habitat (i.e., clear headwaters, creeks, rivers, etc.) for the creek chubsucker within the Segment G project area. Please refer to Section 3.8 (Water Quality) for additional information regarding water quality.

Potential habitat for listed species may be present in the Segment G project area; however, because of lack of access granted by private property owners in the Segment G project area (San Jacinto River Crossing), additional surveys are needed to determine whether listed species are present or absent.

4.17.1 Summary of Impacts

No known locations of threatened or endangered species, nest sites, discrete populations, or suitable habitats are known to occur within the Segment G project area (based on TXNDD reviews, coordination with USFWS and TPWD, and field surveys). Suitable habitats required by threatened or endangered species do not occur within the surveyed portion of the Preferred Alternative Alignment. Potential habitat for listed species may be present in the Segment G project area; however, because of lack of access granted by private property owners in the Segment G project area (San Jacinto River Crossing), additional surveys are needed to determine whether listed species are present. As ROW is acquired on lands that have not been surveyed because of lack of access, additional coordination (if required) will be initiated with the USFWS and TPWD in full compliance with the ESA. The No-Build Alternative would have no direct effect on the Segment G project area relative to threatened and endangered species.

4.17.2 Indirect Impacts

No indirect impacts to threatened and endangered species are expected to occur from the construction of Segment G.

4.17.3 Mitigation

As ROW is acquired on lands that have not been surveyed because of lack of access, TxDOT will follow all requirements of the ESA, including additional coordination (if required) will be initiated with the USFWS and TPWD. TxDOT would continue to coordinate as necessary with USFWS and TPWD in order to determine whether additional protected species investigations or consultation under Section 7 of the ESA are required. No mitigation for threatened and endangered species is anticipated to be required for the proposed project.

4.18 CULTURAL RESOURCES

4.18.1 Archeological Resources

A TxDOT archeologist evaluated the potential for the proposed undertaking to affect archeological historic properties (36 CFR 800.16(l)) or State Archeological Landmarks (13 TAC 26.12) in the APE. The APE comprises the ROW limits of the proposed project. The APE does not extend below the surface, with the exception that pilings for bridge columns may be placed as deep as 50 feet below the modern ground surface. Section 106 review and consultation proceeded in accordance with the "First Amended Programmatic Agreement among the Federal Highway Administration, the Texas Department of Transportation, the Texas State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding the Implementation of Transportation Undertakings" (PA-TU), as well as the MOU between the THC and TxDOT. The following documentation presents TxDOT's findings and explains the basis for those findings.

An initial archeological records review found no previously recorded sites within the Segment G project area. An intensive survey of selected, accessible portions of the area of potential effects (APE) was performed by PBS&J under Texas Antiquities Permit No. 2769. TxDOT completed its review of the surveyed portions of the APE in August of 2005.

Section 106 consultation with federally recognized Native American tribes with a demonstrated historic interest in the area was initiated on July 29, 2002 (Appendix B). No objections or expressions of concern were received within the comment period.

As a result of archeological field surveys of accessible portions of the Preferred Alternative Alignment, three archeological sites were identified: 41MQ197, 41MQ198, and 41MQ199. Site 41MQ199 has been determined ineligible for the NRHP, and sites 41MQ197 and 41MQ198 have been recommended as needing further investigation to determine eligibility for the NRHP (see letter dated August 2, 2005, Appendix H). However, site 41MQ198 was later determined to be outside the ROW. If site 41MQ197 is determined to be eligible by the THC and would be affected by the proposed project, appropriate consultation would occur to resolve potential adverse effects. The unsurveyed portions of the APE will be surveyed once access is obtained (see letter dated August 2, 2005, Appendix H). If unanticipated archeological deposits

would be encountered during construction, work in the immediate area will cease, and TxDOT archeological staff will be contacted to initiate post-review discovery procedures under the provisions of the PA and MOU.

4.18.2 Non-Archeological Historic Properties

As noted in Section 3.18.4 (Non-Archeological Historic Resources) of this volume, official records and site listings of the THC indicate no NRHP-listed or eligible non-archeological historic properties have been recorded in or adjacent to the alternative alignments being considered within Segment G. Furthermore, no Recorded Texas Historic Landmarks, SALs (non-archeological), or Official State Historical Markers are present in the APE for the Segment G project. Survey methodology and NRHP determinations of non-archeological historic resources were also noted in Section 3.18.4. SHPO concurred with the determination that none of the 22 resources located within the APE of Segment G alternative alignments are NRHP-eligible (Appendix H). No further consideration of impacts is required under Section 106 of the National Historic Preservation Act of 1966, as amended, or under Section 4(f) of the Department of Transportation Act.

4.18.3 Summary of Impacts

4.18.3.1 Archeological Resources

HPAs were identified for areas that may contain archeological resources, based on the assumptions set forth in the Houston-PALM (see Exhibit G–29) and the review of historical literature. While the Houston-PALM has been shown to illustrate the potential for prehistoric sites in the area, it is not intended to predict the location of historic archeological sites. One archeological historic property (36 CFR 800.16(l)) was identified within the surveyed portions of the APE. Site 41MQ197 will require additional investigations to determine if it is potentially eligible for nomination to the NRHP. The total number of archeological sites within a Preferred Alternative Alignment will not be known until the completion of the archeological field survey for this segment. If archeological sites could be identified within the Preferred Alternative Alignment, additional investigations may be necessary to determine if they are eligible for nomination to the NRHP.

4.18.3.2 Non-Archeological Historic Properties

In accordance with the Programmatic Agreement between FHWA, THC, the Advisory Council on Historic Preservation (ACHP), and TxDOT, and with the MOU between TxDOT and THC, TxDOT consulted with the SHPO regarding the project's potential to affect non-archeological historic properties. The results of the Section 106 coordination have been utilized in the selection of the Preferred Alternative Alignment that avoids or minimizes to the greatest extent possible any potentially adverse effects from the project on non-archeological historic properties.

In 2003, TxDOT Environmental Affairs Division completed coordination with SHPO concerning the NRHP status of 22 non-archeological historic resources located within the APE of Segment G alignments. It has been determined that no non-archeological historic properties occur in or adjacent to the alternative alignments. In addition, none of the alternative

alignments for the Segment G project would impact any Recorded Texas Historic Landmarks, SALs (non-archeological), or Official State Historical Markers. No further consideration of impacts is required under Section 106 of the National Historic Preservation Act of 1966, as amended, or under Section 4(f) of the Department of Transportation Act.

4.18.3.3 No-Build Alternative

The No-Build Alternative could result in future cultural resource impacts associated with widening and passing lane construction activities along existing roads due to the population growth in the area. The extent of these impacts is not known at this time as detailed designs for these proposed projects are not known. Current levels of looting, vandalism, and non-scientific collecting would likely continue on known and discovered sites.

4.18.4 Indirect Impacts

4.18.4.1 Archeological Resources

Indirect impacts to archeological resources would likely be in the form of construction and land disturbing activities outside the ROW. All construction borrow or fill dirt would be procured from areas that have been surveyed and given archeological clearance by the THC.

4.18.4.2 Non-Archeological Historic Properties

Official records and site listings of the THC indicate no NRHP-listed or eligible non-archeological historic resources occur in or adjacent to the alternative alignments being considered within the APE of the Segment G Preferred Alternative Alignment. No indirect effect to non-archeological historic resources is anticipated.

4.18.5 Mitigation

If any site identified by archeological field survey within the Preferred Alternative Alignment, including Site 41MQ197, 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 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 non-adverse 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 (see letter dated August 2, 2005, Appendix H).

4.19 HAZARDOUS MATERIALS

The proposed construction of Segment G poses little risk of hazardous material impacts to the environment. Hazardous material impacts associated with the proposed project would more likely be associated with currently operating sites and

facilities or historical sites and facilities that have already impacted the existing environment or have the potential to impact the existing environment. Facilities such as these that are located within the selected Preferred Alternative Alignment would be acquired by the project owner through ROW acquisition. The acquisition of hazardous material sites and facilities presents a liability risk to the project owner. Therefore, prior to ROW acquisition, a Phase I Environmental Site Assessment (in accordance with the most current American Society for Testing and Materials [ASTM] Standards) would be conducted at each site and/or facility that has known or the potential for hazardous material impacts to the existing environment. Based on the results of the Phase I Environmental Site Assessment, sampling and analysis activities and possibly remedial activities may be warranted at certain sites or facilities. Mitigation of hazardous materials (e.g., asbestos and lead paint) associated with the relocation of residential and commercial buildings within the proposed ROW, is discussed briefly in Section 4.3.2 (Relocations). The proposed project may include the demolition and/or relocation of building structures. The buildings may contain asbestos containing materials and/or lead paint. Asbestos and lead paint inspections, specifications, notification, license, accreditation, abatement, and disposal, as applicable, would comply with federal and state regulations. Issues related to asbestos and lead paint would be addressed during the ROW process prior to construction.

4.19.1 Regulated Hazardous Material Sites

According to the regulatory database search (Appendix I), 14 hazardous material sites registered with state and/or federal agencies were identified within the Segment G project area. Exhibit G–51 depicts the location of each site.

One of the 14 sites is reportedly located within the proposed ROW of any alternative alignment: Site ID No. 21, owned by Averie Bass. This site is reported as an unauthorized landfill (LFUN) containing demolition materials and brush. The two-acre site is a reclaimed sand pit that was reportedly first used in 1979. According to a recent site reconnaissance, the facility is actively excavating aggregate and receiving brush and debris. A portion of the site is reported to be located in the floodplain of a tributary to Woodsons Gully, two miles north of Spring, Texas on Riley Fuzzel Road, Montgomery County, Texas. The site is in a location where all of the proposed alternative alignments are the same.

4.19.2 Oil/Gas Well and Pipeline Sites

Fourteen oil/gas well sites lie within the Segment G project area. Based on the RRC records, one observation well is located within the ROW of the alternative alignments. A summary of the oil/gas wells identified within the ROW of the alternative alignments is presented in Table 4-34 and Exhibit G–51.

TABLE 4-34
OIL AND GAS WELLS WITHIN SEGMENT G PROJECT ALTERNATIVE ALIGNMENT ROW

Map ID	Well Status	Well Type	Well ID	API Well	Lease Name	Lease	Alternative Alignment(s)	Reach
2751	Active	Observation	N/A	33930714	N/A	N/A	A, C, & D	8

Source: Texas Railroad Commission of Texas (RRC), 2005

The potential impacts typically associated with the production of oil and gas includes surface soil contamination and Naturally Occurring Radioactive Material (NORM) issues. Elevated NORM issues may be an environmental concern in oil fields, especially where water injection has been used as a secondary recovery technique, or water disposal has occurred. The concern would likely be limited to the current producing wells. However, if the wells within the ROW were plugged and abandoned as per regulations stipulated in the RRC Statewide Rule 14, NORM hazards should not impact the proposed project. However, based on the absence of any producing wells there appears to be a nominal risk of NORM issues within Segment G.

4.19.3 Petroleum Pipelines

Seven petroleum pipelines have been identified within the project area of Segment G. Each of these pipelines crosses at least one of the alternative alignments. 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 G 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. A summary of the petroleum pipelines identified within the project area is presented in Table 4-35.

TABLE 4-35
SUMMARY OF PETROLEUM PIPELINES WITHIN THE SEGMENT G PROJECT AREA

Map ID	Operator	System	Status	T4 Permit	Diameter	Fluids
1	Trunkline Gas Co.	Trunkline Gas-Mainline Sys.	Active	262	24”	Natural Gas
4	Natural Pipeline Co of Amer.	Gulf Coast Mainline	Active	399	30”	Natural Gas
7	Explorer Pipeline Company	Houston to Greenville	Active	18	28”	Refined Product
6	Sun Pipeline Co.	Conroe to Humble Trunk Line	Active	582	6.63”	Crude Oil
5	Koch Pipeline Company, L.P.	Koch Crude	Inactive	140	0	Crude Oil
3	Magellan Pipeline Company, L.P.	Orion Products	Active	5754	16”	Refined Product
2	Arco Pipe Line Company	400-Seaway/ARCO	Active	5162	20"	Crude Oil

Source: RRC, 2005

4.19.4 Potential Impacts from Construction Activities

The impacts from hazardous material handling and use and during Segment G construction activities pose a minimal risk of impact to the environment. Temporary ASTs and equipment, vehicles, and machinery that contain oil and diesel fuel are typically utilized during major construction projects. Temporary ASTs are regulated and their use would require spill

containment and control strategies such as secondary containment. Typical impacts include leaking valves, hoses, or small spills that occur during refueling activities or small leaks that may occur from equipment, vehicles, and/or machinery. However, these impacts would be minimal and typically do not pose a substantial risk to the environment. All activities related to hazardous materials use and storage during highway construction would conform to TxDOT standards and include appropriate spill containment and control strategies.

4.19.5 Summary of Impacts

The potential for impacts to the project related to hazardous material sites is negligible. The proposed construction of the project poses very little risk of hazardous material impacts to the environment. Hazardous material impacts associated with the proposed project would more likely be associated with currently operating sites and facilities or historical sites and facilities that have already impacted the existing environment or have the potential to impact the existing environment. One registered hazardous material site was identified within the ROW of the all the alternative alignments. The facilities that are located within the final design ROW of the Preferred Alternative Alignment would be acquired by the project owner. A Phase I Environmental Site Assessment would be conducted at each site to assess the potential for hazardous material impacts to the existing environment. Based on the results of the assessment, sampling and analysis activities and possible remedial activity may be warranted at certain sites.

RRC records indicate that one observation well site is located within the ROW of Alternative Alignments A, C, and D, and the Preferred Alternative Alignment (none are located within the ROW of Alternative Alignment B). A total of seven petroleum pipelines have been identified within the project area of Segment G. Each of these pipelines cross at least one of the alternative alignments. Impacts related to buried petroleum pipelines are negligible.

Under the No-Build Alternative, development within the Segment G 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 the most common of hazardous material sites, retail gasoline outlets (i.e., UST facilities).

4.19.6 Indirect Impacts

Potential indirect impacts to hazardous materials locations could occur as a result of land disturbing activities from potential development, infrastructure, or utility improvements. This risk could be minimized or avoided by conducting a Phase I Environmental Site Assessment to identify potential hazardous materials prior to property acquisition and development.

4.19.7 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 Texas Administrative Code, Title 16, Part I, 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 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 right-of-way process prior to construction.

4.20 VISUAL AND AESTHETIC QUALITIES

The Segment G project area exhibits a medium degree of aesthetic quality, with few unique or spectacular views. Because of the relatively large overall size of the project, the proposed highway would have some effect on the existing aesthetic quality of the surrounding area. Segment G is almost evenly split between forestland and residential (only a small percentage is commercial or parkland). Much of the residential populations are found in master-planned subdivisions, but single-family homesteads on ranches, individual homes on large lots, and trailer parks are also in this segment.

Visual impacts would take two forms: views of the proposed highway from various points along the alignments and views from the proposed highway of the surrounding landscape. All alternative alignments, including the Preferred Alternative Alignment, would have similar visual impacts. The roadway would be designed to create an aesthetically and visually pleasing experience for the user and adjacent landowners to the extent feasible and practical.

4.20.1 Views of the Proposed Roadway

The proposed highway would alter the appearance of the forested and semi-rural/suburban setting of the project area. The visual impact would vary with location. As the highway would approach existing development and/or communities,

more residents would have a view of the facility, but the highway would have less effect on the overall viewshed. Conversely, as the highway moves farther away from these developed areas, the result may be a greater change in the overall visual setting, but would be observed by fewer individuals. As the viewer's distance from the new roadway increases, the relatively flat terrain and forest vegetation would limit most views of the highway to the elevated grade separations. Preliminary design of the Preferred Alternative Alignment includes stretches of frontage roads and grade separations with and without access to the Grand Parkway, as detailed for each reach in Sections 4.20.3 to 4.20.7.

The main lane toll plaza and entrance and exit ramps would present additional visual and aesthetic impacts. Both the toll plaza and all entrance and exit ramps would be lighted; therefore 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. Collection facilities would be located at the main lane toll plaza and at certain exit ramps to be determined in final design, which would include Automatic Vehicle Identification (AVI) lanes (TxTag and EZ Tag) and Automatic Collection Machine (ACM) lanes; no manned tollbooths would be present at these locations. Within Segment G, a main lane toll plaza would be located most likely in Reach 9 or Reach 10. Where residential areas are located near the collection facilities and ramps, the additional light and the site of the facilities could be considered a negative impact.

4.20.2 Views from the Proposed Roadway

Viewshed opportunities may be enhanced at elevated grade separations that would allow motorists expanded views of forests, wetlands, rivers, and rural and suburban communities. These views would be short in duration, as the viewer would be traveling at highway speeds.

4.20.3 Reach 8

Alternative Alignments A, C, D, and the Preferred Alternative Alignment share a common alignment in this reach from IH 45 to 0.7 miles east of Hardy Toll Road; these alignments would create a new roadway in the suburban landscape. Alternative Alignment B would follow the existing Hardy Toll Road from IH 45 to Riley Fuzzel Road, causing no visual effects. East of Hardy Toll Road, Alternative Alignments A, B, C, D, and the Preferred Alternative Alignment follow a common alignment along Riley Fuzzel Road for 2.7 miles to the end of Reach 8, where the proposed roadway would consist of four travel lanes, two in each direction, and four frontage road lanes, two in each direction.

The viewshed from a number of suburban single-family homes (especially in the area of the Northgate Crossing, Spring Trails, Fox Run, and Benders Landing subdivisions) would be affected by construction and operation of the Grand Parkway in this reach. Some visual resources would be affected with the construction of elevated interchange structures at IH 45 and Hardy Toll Road. Preliminary design of the Preferred Alternative Alignment includes additional grade separations at Northgate Crossing Boulevard, Riley Fuzzel Road near Spring Trails, Rayford Road, Birnam Woods Drive (future), Woodsons Gully, and a perennial tributary to Woodsons Gully.

4.20.4 Reach 9

All alternative alignments are similar in their effect on visual resources in Reach 9; they would all create a new roadway in a forested landscape in this reach and a new bridge would be constructed across the West Fork San Jacinto River. An additional grade separation would be located at Townsen Road (future), east of Creekside Village. Preliminary design of the Preferred Alternative Alignment includes a main lane toll plaza in either Reach 9 or 10, so additional lights associated with these facilities could have visual and aesthetic impact in this reach. The new Creekside Village subdivision would have its viewshed affected by all of the alternative alignments. Affording views from the new bridge over the West Fork San Jacinto River could be considered a beneficial impact of any of the alternative alignments.

4.20.5 Reach 10

All alternative alignments are similar in their effect on visual resources in Reach 10; they would primarily create a new roadway in a forested landscape. Preliminary design of the Preferred Alternative Alignment includes a main lane toll plaza in either Reach 9 or 10, so additional lights associated with these facilities could have visual and aesthetic impact in this reach. All alternative alignments would include a grade separation with entrance and exit ramps at FM 1314. All alternative alignments would affect the viewshed from a few rural and suburban single-family homes and the Cumberland subdivision.

4.20.6 Reach 11

All alternative alignments in this reach would create a new roadway in the existing landscape. Alternative alignments A and D and the Preferred Alternative Alignment pass along the southern side of the Winchester Place subdivision through a forested area and along the north side and through the northern extension of Timberland Estates, a subdivision consisting of mobile homes. Alternative Alignment B passes along the western end and southern side of Timberland Estates, primarily through previously disturbed areas. Alternative Alignment C passes along the western end of the Timberland Estates, and along the north side and through the northern extension of Timberland Estates. Preliminary design of the Preferred Alternative Alignment includes a small grade separation within Timberland Estates. The viewshed from several homes in Timberland Estates would be affected by construction and operation of the Grand Parkway in this reach.

4.20.7 Reach 12

All alternative alignments are similar in their effect on visual resources; they would all create a new roadway in a forested landscape in this reach and include a grade separated interchange at US 59. Preliminary design of the Preferred Alternative Alignment includes an additional grade separation at Valley Ranch Thoroughfare (future). All alternative alignments would affect the viewshed of the Valley Ranch development, which consists of mobile homes, and Alternative Alignment A would additionally impact the viewshed from the southern portion of the Silver Trails subdivision.

4.20.8 Summary of Impacts

Construction of any of the alignment alternatives would have a visual impact on adjacent areas, and the impact would be similar for all alternative alignments. 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 utilizing the existing arterial system.

The proposed Grand Parkway would be constructed predominately at grade with vegetated shoulders, ROW, and medians. The relatively flat terrain and forest vegetation would limit the visible portions of the highway to the elevated grade separations. 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.

4.20.9 Indirect Impacts

It is likely that commercial and/or residential development resulting from the Grand Parkway 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.

4.20.10 Mitigation

Where reasonable and feasible, visual mitigation measures could include naturally vegetated medians, minimization of ROW clearing, incorporation of design specifications to blend into the landscape, and promotion of roadside native wildflower planting programs. For roadside revegetation, landscape planting, and revegetation of natural areas impacted by construction, native plants will be considered to improve the visual aesthetics and to control the introduction of invasive species. Where reasonable and feasible, existing trees within the proposed ROW, but not within the defined safety clear zone, could be retained in the proposed landscaping to block the view of the roadway from adjacent properties. As currently proposed, the roadway lighting system would be restricted to those areas where entrance/exit ramps and a main lane toll facility are located and would consist of low impact, downward directional lighting.

4.21 ENERGY

All alternative alignments, including the Preferred Alternative Alignment, would require short-term energy consumption during construction activity. Construction related energy consumption would be generally based on the construction cost of the alternative. The amount of energy required for the production and placement of materials (asphalt, structures, cut, fill, etc.) during construction would be a fixed one-time cost. Construction-related energy consumption would be short term in nature and could be offset by operational energy efficiencies gained through the use of an improved transportation facility over many decades. Energy impacts are a function of several variables including average running speed, vehicle-miles of travel, and the mix of vehicle types in the system.

The Grand Parkway could improve fuel efficiencies as traffic moves from the existing roadway network to the new facility improving traffic mobility (uniform speeds, less congestion) across the traffic study area. Consequently, the operating efficiency could improve on existing traffic study area roadways, reducing travel times between destinations, and in turn, reducing overall fuel consumption.

VMTs are a factor in determining demand for transportation related energy needs. Energy consumption was estimated for the Grand Parkway traffic study area for both the No-Build Alternative and Build Alternative. For the purposes of this analysis, the Build Alternative includes the entire Grand Parkway (Segments E, F-1, F-2, and G). Segments E, F-1, F-2, and G combined served as the maximum energy consumption scenario for the Build Alternative. Energy calculations used an energy intensity of 5,623 British thermal units (Btu) per VMT, (*Transportation Energy Data Book – Edition 24-2004*). Results of this analysis are shown in Table 4-36.

Based on this analysis, the Build Alternative could result in approximately 1,805,000 fewer miles traveled per day in the traffic study area in 2025, which would equate to a savings of roughly 90,000 gallons of fuel per day or nearly 33 million gallons of fuel per year, based on a vehicle fuel efficiency of 20 MPG. While energy would be expended in the construction of the project, these annual energy savings suggest that the project has substantial net benefits to energy use.

TABLE 4-36
ENERGY CONSUMPTION IN THE GRAND PARKWAY TRAFFIC STUDY AREA

Year	Vehicle Miles Traveled (VMT/day)		Btus (million/day)*	
	Build	No-Build	Build	No-Build
2000	N/A	121,831,000	N/A	685,100
2015	157,288,000	159,697,000	884,400	898,000
2025	174,534,000	176,339,000	981,400	991,600

TABLE 4-36 (CONT.)
ENERGY CONSUMPTION IN THE GRAND PARKWAY TRAFFIC STUDY AREA

Year	Vehicle Miles Traveled (VMT/day)		Gallons (per day)*	
	Build	No-Build	Build	No-Build
2000	N/A	121,831,000	N/A	6,092,000
2015	157,288,000	159,697,000	7,864,000	7,985,000
2025	174,534,000	176,339,000	8,727,000	8,817,000

Note: *British thermal units (Btu) calculated using an energy intensity of 5,623 Btus per VMT; gallons calculated using a fuel efficiency of 20 miles per gallon (MPG).
Source: Study Team, 2007

4.21.1 Summary of Impacts

The Build Alternative would require short-term energy consumption during construction activity. A worst-case estimate of operational energy consumption was calculated based on traffic conditions predicted with the construction of Segments E, F-1, F-2, and G of the Grand Parkway. Based on this analysis, the future expected energy consumption is less than, though similar to, that of the No-Build Alternative. 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.

4.21.2 Mitigation

The construction of the Grand Parkway 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) of this volume, this facility would be designed to:

- Help complete or expedite the implementation of several major thoroughfare plans;
- Provide major roadway linkages between major freeways and highways; and
- Provide an alternative route to bypass the central city.

In addition, the construction of the Grand Parkway would result in the implementation of CMS commitments for managing traffic congestion. These congestion reduction strategies would also result in the reduction of energy consumption and are discussed in greater detail in Section 4.6 (Air Quality).

4.22 CONSTRUCTION IMPACTS

All of the alternative alignments for Segment G would result in construction impacts. These impacts can include:

- The temporary degradation of air, noise, and water quality;
- The temporary disruption of traffic for residents, businesses, and travelers, including maintenance, control and safety concerns;

- Public health and safety;
- The stockpiling and disposal of construction materials and waste;
- The use of borrow areas and the construction and use of haul roads; and
- The temporary disruption of utilities.

Construction activities would affect the residents of the Segment G project area and those traveling in the vicinity. However, the construction impacts discussed in the following sections would be temporary in nature. A conservative estimate of construction time for Segment G would be two to four years; however, a more exact length of construction time will be established during the final design phase. Up to date project status and construction schedule postings would be available on the Grand Parkway project website at http://www.grandpky.com/home.

4.22.1 Air Quality Construction Impacts

Construction activities associated with the facility could have a short-term impact on local air quality during periods of site preparation. PM, also known as fugitive dust, has the greatest impact during construction activities. This impact can occur in association with excavation and earth moving; cement, asphalt, and aggregate handling; heavy equipment operation; the use of haul roads; and wind erosion of exposed areas and material storage piles. Any effects from fugitive dust would be temporary and would vary in scale depending on local weather conditions, the degree of construction activity, and the nature of the construction activity.

During construction, this effect would be minimized by requiring the contractor to adhere strictly to dust control measures as outlined in current TxDOT guidelines. Where fugitive dust is likely to be a problem, effective dust control measures would be implemented following standard roadway construction procedures. Debris from all removed vegetation would be mulched, and that which is not suitable for mulching would be disposed of in a landfill. Open burning would not be used to dispose of vegetative debris.

4.22.2 Construction Noise

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 the 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 will 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 systems.

4.22.3 Water Quality Construction Impacts

Water quality impacts are discussed in detail in Section 4.8 (Water Quality). Effects to water quality resulting from erosion and sedimentation, as well as from pollutants such as chemicals, fuels, lubricants, bitumins, raw sewage, and other

harmful waste, would be strictly controlled in accordance with TxDOT's *Seeding for Erosion Control* Manual (TxDOT, 2004a). The contractor would exercise every reasonable precaution during construction to prevent pollution of rivers, streams, or impoundments.

4.22.4 Maintenance and Control of Traffic

Maintenance of the current flow of traffic on the existing roadway network will be planned and scheduled to minimize adverse impacts to the traveling public. Within construction areas, traffic control measures using standard practices would be used, as outlined in TxDOT guidelines. In addition to using these standards, news releases of construction activities and schedules would be made available to the public.

Construction of the proposed highway would disrupt the daily use of the existing roadways being upgraded. Since Segment G would be constructed on a new alignment, maintenance of traffic for its construction would mostly impact the existing roadway network where it crosses existing roads. Disturbances would be relatively short with respect to length of road affected. The number of disturbances within a single geographic area would be limited to protect communities or geographical areas from being inundated with construction zones. Since these disturbances are limited, most work would use flagging operations or the temporary widening of existing roads.

4.22.5 Health and Safety

During the course of construction, the contractor would comply with all federal, state, and local laws governing safety, health, and sanitation. All reasonable safety considerations and safeguards necessary to protect the life and health of employees on the job, the safety of the public, and the protection of property in connection with roadway construction would be taken.

4.22.6 Pollution Control

Project construction would consist of roadways and bridges requiring excavation of unsuitable materials, placement of embankments, and use of materials such as aggregates, asphalt, and cement. The stockpiling and disposal of the construction and excavation materials may be visually displeasing to some of the residents along the construction corridor. However, this would be a temporary condition and would pose no permanent problems with the use of the required temporary erosion control features. The contractor would be responsible for methods of placing the necessary features of pollution control on haul roads, borrow and other material pits, areas used for the disposal of waste materials, and other potential pollutants associated with the construction of the project. Temporary erosion control features would consist of berms, dikes, temporary seeding, sediment traps, fiber mats, silt fences, slope drains, mulches, crushed stone, and others as specified in TxDOT guidelines.

Existing conditions that pose challenges to the constructability of the facility, such as stream crossings and relocations would be handled individually during final design. The final alignment would be placed in the most practical location to

avoid construction problem areas and sensitive natural resource areas. In-depth geotechnical research, reconnaissance, and core borings would be used to support and defend sound engineering judgments in solving difficult construction problems as they arise.

4.22.7 Other Construction Impacts

Utilities in the project area include water, sewer, gas and oil pipelines, telephone, and electrical transmission lines. The contractor will contact the appropriate local officials to coordinate a work schedule that will avoid and minimize any disruption of utility services during construction.

The stockpiling and/or disposal of construction materials generated from clearing, grubbing, and other phases of construction would be conducted in accordance with local and state regulatory agencies permitting the construction operation. The use of borrow areas and construction of haul roads would also be coordinated with the appropriate local, state, or federal regulatory agencies as necessary. Borrow areas and any other PSLs would be identified during the preparation of the Section 404 permit application prior to construction. If borrow pits could be identified within the 400-foot project ROW, TxDOT would have to obtain the necessary permits and clearances (such as the Section 404 permit and a SWPPP). If PSLs could be identified outside the project ROW, construction contractors would need to obtain the necessary permits and clearances (TxDOT, 2004b).

4.22.8 Summary of Impacts

Temporary construction impacts would result from construction activities associated with any of the alternative alignments. These impacts are likely to include the temporary degradation of air, noise, and water quality; the temporary impedance to the maintenance and control of traffic; safety concerns because of changes in traffic patterns; the stockpiling and disposal of construction materials; and the use of borrow areas. Construction activities would affect residents in the immediate area and those traveling in the vicinity.

4.22.9 Indirect Impacts

Construction related indirect impacts are expected to be limited to water quality. Construction activities such as clearing, grading, stockpiling, and disposal of construction materials may result in slight increases in turbidity downstream of construction sites. These impacts would be avoided or minimized through the use of proper storm water pollution prevention measures such as silt barriers or other engineering controls.

4.22.10 Mitigation

Requiring the construction contractor to adhere strictly to mitigation procedures would minimize construction impacts. To minimize effects to air quality, dust control measures would be implemented and open burning would not be used to dispose of vegetative debris. In order to control construction noise impacts, construction timing would be limited to “noise

tolerant periods." Minimization of the effects to water quality from erosion and sedimentation would be accomplished by preparing a SWPPP pursuant to the TxDOT guidelines. The SWPPP may include, but not be limited to, silt fences, inlet protection barriers, hay bales, and seeding or sodding of excavated soil. Exposure of the soil surface would be minimized during any clearing activities in order to maintain soil integrity. To minimize the disturbances to maintenance and control of traffic construction within a single geographic area would be limited to protect communities or geographical areas from being inundated with construction zones. All reasonable safety considerations to protect the life and health of construction workers, the public, and property would be exercised. The construction contractor would be responsible for pollution control on haul roads, borrow and other material pits, waste material disposal areas, and any other potential pollutants, which could be accomplished with erosion control features such as berms, dikes, temporary seeding, sediment traps, fiber mats, silt fences, slope drains, mulches, crushed stone, and others as specified by TxDOT guidelines (TxDOT, 2000).

4.23 RELATIONSHIP OF LOCAL SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

The construction of Segment G would cause short-term effects on the environment. The short-term uses of the environment associated with the proposed alternative alignments are typical of those associated with highway construction. These short-term environmental concerns include air quality impacts, construction-related noise, visual impacts, and water quality impacts.

Adverse effects have been evaluated in detail and mitigation measures identified. In addition, careful attention would be given to the problems identified during design. Proposed mitigation measures, some temporary and some permanent, would minimize adverse short-term effects and avoid any substantial long-term damage.

In comparison to these short-term impacts, the most evident long-term benefit of the proposed alternative alignments is the improved local and regional system linkage and decreased congestion and delay. Tax revenue within the immediate vicinity of the project area would ultimately increase because of the development of the surrounding area as a result of the increased accessibility provided by the highway. Construction related employment would also offset short-term loss of employment due to displacements and relocations. These benefits offered by the long-term productivity of this project would offset the short-term inconvenience and short-term adverse effects on the natural, physical, and human environment.

4.24 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction of Segment G would involve a commitment of irreversible and irretrievable resources. These include a range of natural, physical, human, and fiscal resources. The commitment of land to the project ROW would require between 713 acres and 748 acres depending on which of the alternative alignments is constructed. This land includes residential and business properties, farmland, and natural and forested landscapes. Land used in the construction of the proposed highway is considered an irreversible commitment during the period that the land is used for a highway facility. However,

if a greater need would arise for use of the land, or if the highway facility would be no longer needed, the land can be converted to another use. At present, there is no reason to believe such a conversion would be necessary or desirable.

The natural resources required for construction include asphalt, sand, aggregate, cement, and iron ore for steel products. Once used for construction, these resources cannot be replaced as natural resources. These resources are not in short supply, and their use would not have an adverse effect upon the continued availability of these resources. Each alternative would also require an expenditure of fossil fuel for the construction of the highway. Although this is an irretrievable resource, the amount expended toward construction would be offset by the reduced fuel consumption of the vehicles using the facility. The construction of the highway would also require a substantial one-time expenditure of both state and federal funds. These funds, combined with the labor required to construct this highway, represent monetary commitments and, as such, are irretrievable.

The commitment of these resources is based on the concept that residents in the immediate area, state, and region would benefit by the improved quality of the transportation system. These benefits would consist of improved accessibility and safety, savings in time, fuel savings, and greater availability of quality services that are anticipated to outweigh the commitment of these resources.

4.25 PREFERRED ALTERNATIVE ALIGNMENT

Identification of the Preferred Alternative Alignment was based on public and agency outreach results and an analysis and comparison of the potential effects on the physical, biological, and human environments of each alternative alignment. The combinations of alternative alignments within each of the five reaches of Segment G were analyzed for their potential independent and cumulative effects. This analysis is detailed in Section 2.3 (Alternative Alignment Analysis) of this volume. The Segment G DEIS, published in January 2007, presented Alternative Alignment D (which is a composite of Alternative Alignment A/C in Reach 8, Alternative Alignment D in Reach 9, Alternative Alignment A/B in Reach 10, Alternative Alignment A in Reach 11, and Alternative Alignment C in Reach 12) as the Recommended Alternative Alignment

After consideration of the agency and public comments received on the DEIS as well as updated environmental data, the GPA, in coordination with TxDOT and FHWA, selected a Preferred Alternative Alignment. Since publication of the DEIS, updated analyses and continual coordination with the public have led to the slight shifting of the Recommended Alternative Alignment in one area. Near the junction of Reach 8 and Reach 9, a new subdivision named Creekside Village has been planned for development at the end of Riley Fuzzel Road. The Grand Parkway Segment G alignment was shifted slightly to the south to avoid residential impacts in this subdivision. Therefore, the Preferred Alternative Alignment detailed in the FEIS differs from the Recommended Alternative Alignment presented in the DEIS (Exhibit G–55).

4.25.1 Description of Preferred Alternative Alignment

The Preferred Alternative Alignment for Segment G is approximately 13.74 miles long, beginning at IH 45 and ending at US 59. The preliminary design is shown in (Exhibit G–55). There would be a fully elevated, directional interchange between SH 99 and IH 45. From IH 45 to Riley Fuzzel Road, 1.9 miles, SH 99 consists of four travel lanes, two in each direction, with frontage roads only extending to the on-ramps. Just east of IH 45, there will be an eastbound entrance ramp and a westbound exit ramp. There would be a main lane overpass, with no interchange at Northgate Crossing Boulevard. There would be directional interchanges with the Hardy Toll Road in the following directions: northbound Hardy Toll Road to westbound SH 99, northbound Hardy Toll Road to eastbound SH 99, eastbound SH 99 to southbound Hardy Toll Road, and westbound SH 99 to southbound Hardy Toll Road. From Riley Fuzzel Road, 0.7 miles east of Hardy Toll Road, SH 99 will generally follow the alignment of proposed Riley Fuzzel Road for 2.7 miles. In this section, SH 99 will consist of four travel lanes, two in each direction, and four frontage road lanes, two in each direction. Approximately 1.1 miles east of Hardy Toll Road, there is an eastbound exit ramp and a westbound entrance ramp. There is a frontage road intersection with Rayford Road and a frontage road intersection with Birnam Wood Boulevard. The frontage road section ends 3.4 miles east of Hardy Toll Road with an eastbound entrance ramp and a westbound exit ramp. From the end of the frontage roads, SH 99 continues for 9.4 miles to US 59. In this portion of the proposed project, there would be a bridge over the floodplains of the West Fork San Jacinto River, diamond interchanges at FM 1314, and a short section of frontage roads from Valley Ranch Thoroughfare (new roadway under construction) to US 59. The main lanes of SH 99 end 0.5 miles west of US 59 with an eastbound exit ramp and a northbound entrance ramp. There would be a frontage road intersection with the US 59 frontage roads. There would be directional connectors at US 59 in the following directions: northbound US 59 to westbound SH 99, southbound US 59 to west bound SH 99, eastbound SH 99 to northbound US 59 and eastbound SH 99 to southbound US 59. Estimated total construction cost for building the Preferred Alternative Alignment for Segment G is $476,687,000 (Table 4-37).

TABLE 4-37
HIGHWAY CONSTRUCTION COST FOR
SEGMENT G PREFERRED ALTERNATIVE ALIGNMENT

Reach	Estimated Construction Cost
8	$171,038,000
9	$153,692,000
10	$13,530,000
11	$67,305,000
12	$71,121,000
Total	**$476,687,000**

Note: Cost includes estimates for the following: construction cost, ROW cost, utilities cost, escalation cost and inflation cost for targeted letting year (2010). The total cost estimate also includes construction of half the interchanges at the project termini; the estimate does not include the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment F-2 at IH 45 nor the half of the interchange that is proposed (in a separate document) within the Grand Parkway Segment H at US 59.

Source: Study Team, 2007

4.25.2 Summary of Environmental Consequences

Table 4-38 summarizes the potential impacts for the four alternative alignments and the Preferred Alternative Alignment. The following sections provide a synopsis of the potential impacts that would result from just the Preferred Alternative Alignment with respect to each of the resources discussed in this Section 4. Mitigation for these impacts is discussed in Section 4.26 (Mitigation Measures and Commitments). Indirect and cumulative impacts are detailed in Section 5 (Indirect and Cumulative Effects Analysis) of this volume.

4.25.2.1 Land Use

The Preferred Alternative Alignment is consistent with state and local government plans and policies on land use and growth that is relevant within the project area. The Preferred Alternative Alignment would be approximately 13.74 miles in length and have an approximate ROW of 748.4 acres. The Preferred Alternative Alignment would result in the reduction of land available for development or greenspace, and would cause temporary visual and noise effects and temporary traffic delays in neighborhoods during project construction. The Preferred Alternative Alignment would likely cause community cohesion effects in the Northgate Crossing, Timberland Estates, and Valley Ranch subdivisions.

Indirect development would likely result from the Preferred Alternative Alignment in the Segment G project area. Nodes of indirect development are expected to occur at highway interchanges (i.e., IH 45 and US 59), along frontage roads, and at grade separations where entrance/exit ramps to the proposed Preferred Alternative Alignment are present. Preliminary design of the Preferred Alternative Alignment includes frontage roads in the following locations: 1) extending from IH 45 to on-ramps; 2) from 0.7 miles east of the Hardy Toll Road extending north-eastward along Riley Fuzzel Road for approximately 2.7 miles; and 3) from US 59 west to Valley Ranch Thoroughfare (new roadway under construction). Grade separated intersections with entrance and exit ramps would be built at junctions with the following roads: IH 45 frontage roads, Hardy Toll Road, Riley Fuzzel Road near Spring Trails, Rayford Road, Birnam Woods Drive (future), Townsen Road (future), FM 1314, Valley Ranch Thoroughfare (future), and US 59 frontage roads. Grade separations without on and off ramps, such as at Northgate Crossing Boulevard, would not likely experience indirect development until on and off ramps are built some time in the future.

The actual extent and type of indirect development is influenced greatly by many variables including the size of and distance to nearby communities as well as the existing local services offered. This indirect development would likely include a variety of land uses such as convenience stores, gas stations, retail shopping centers, restaurants, office buildings, and residences, including apartments. Residential development may result because of community growth and improved access to nearby job markets. More detail regarding indirect and cumulative effects of the Preferred Alternative Alignment on land use patterns are addressed in Section 5 (Indirect and Cumulative Effects) of this volume.

4.25.2.2 Geology, Soils, and Farmlands

The Preferred Alternative Alignment crosses soils and geology similar in nature to the original alternative alignments. The proposed ROW includes 355 acres of prime and statewide important farmland soils. While these impacts, such as removal of topsoil, compaction, and removal of vegetation, cause a degree of temporary to permanent loss to these resources, they are considered minor as rated and scored by the NRCS. Mitigation measures to be implemented during and after construction are considered prudent and positive in helping to restore a portion of these resources.

4.25.2.3 Social Characteristics

An evaluation of EPA environmental index maps and race and poverty data for the Segment G project area has shown that the population living within the Segment G project area is generally less racially diverse and of higher income than the majority of Harris County and is similar in ethnic diversity and income to that of Montgomery County. Following a methodology that is consistent and compliant with EO 12898, it was demonstrated that there is no potential for disproportionate or adverse effects to minority or low-income populations within the Segment G project area. Additionally, analysis showed there were no individual Census tracts identified within the project area that have a considerable percentage of persons with LEP.

Many potential social impacts have been mitigated by the incorporation of grade separations to the design of the Preferred Alternative Alignment at all public road crossings. Travel times could be lengthened across the facility at the intersections; however, travel throughout the project area in general would improve because of the relief in congestion afforded by the new facility. Because of the congestion relief and quicker, safer travel afforded by the Grand Parkway, the Preferred Alternative Alignment would likely have an overall beneficial effect on public safety. Emergency responders (police, fire protection, and emergency medical services) would likely use the toll road quickly during an emergency thereby improving response times through the project area. No fire stations, police stations, or health care facilities would be displaced by the Preferred Alternative Alignment.

Direct impacts to school bus routes would likely be improved travel times overall due to the new facility. Travel that can incorporate use of the new facility would improve. Local school districts choosing to use the toll facility could experience quicker school bus routes; however, they would have to absorb the increased cost due to the toll. If local school districts would not choose to use the new facility, routes may be slower at intersections with the Grand Parkway; however, routes would not be impacted by issues of access, and congestion overall in the project area would improve with the new facility. School bus routing may experience impacts due to increased traffic in the areas of increased development or changes in traffic patterns.

Community impacts expected as a result of the Preferred Alternative Alignment include potential increase in property values adjacent to the project, particularly at nodes of access to the facility; potential degradation of aesthetics and community character for individual single-family homes and the residential developments adjacent to the facility; and temporary construction impacts. Additionally, the Preferred Alternative Alignment would affect approximately 7.5 acres of

the YMCA Camp Pine Tree (a private recreation area) within Reach 8, and access to the True-Holiness Church of God in Christ. The Preferred Alternative Alignment would cause the displacement of 110 residences. No businesses, schools, churches, cemeteries, or parks are located within the Preferred Alternative Alignment ROW.

4.25.2.4 Economics

The economic effects from the Preferred Alternative Alignment were based on the total construction cost of $476.69 million for the proposed toll road project. The total output impact of the proposed toll road project is estimated to be $1.072 billion, and the total value added impact is estimated to be $542.17 million. The proposed toll road project would have an impact on the temporary employment of 7,620 employees that are in construction-related jobs. The total indirect business tax impacts are estimated to be $28.25 million.

4.25.2.5 Pedestrians and Bicyclists

Pedestrian and bicycle access within the Segment G project area would not be impacted by the Preferred Alternative Alignment. No existing bicycle lanes would be affected. New pedestrian and bicycle facilities as planned in H-GAC's Bikeway Plan would be accommodated by the Grand Parkway construction. The flow of bicycle traffic may be affected by the Grand Parkway at grade separations with entrance and exit ramps.

4.25.2.6 Air Quality

Pollutants required to be evaluated include CO and O_3. EPA's MOBILE6.2 mobile emission factor model and CALINE3 were used to estimate CO levels at the year of completion (2012) and the design year (2025). The Houston area is in attainment for all the criteria pollutants except for 8-hour O_3. Segment G will not contribute to additional violations nor prolong attaining the NAAQS for O_3. Segment G conforms to the emissions budget established for the approved 1-hour standard for ozone, but an 8-hour emissions budget has not been approved for the Houston area. The modeling indicates that local concentrations of CO are not expected to exceed national standards at any time along Segment G, and that local CO concentrations are not expected to exceed national standards should the four contiguous segments (E, F-1, F-2, and G) be built.

The Grand Parkway Segment G was included in H-GAC's 2025 RTP and was included in the FY 2006-2008 TIP, Appendix D, as project undergoing environmental review and scheduled for implementation beyond the three-year TIP time frame. The 2025 RTP and 2006-2008 TIP were adopted by H-GAC in April 2005 and found to conform to the SIP by USDOT (FHWA/FTA) on June 3, 2005 and October 31, 2005, respectively.

The Grand Parkway Segment G is included in H-GAC's 2035 RTP and FY 2008-2011 TIP, as amended. On August 24, 2007, H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. USDOT (FHWA/FTA) found the 2035 RTP and 2008-2011 TIP to conform to the SIP on November 9, 2007.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional

analysis is warranted before 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 modeled parameters can be found in the Administrative Record.

MSAT were modeled and were found to be substantially lower in the future (2015 and 2025) than the existing conditions (2000). MSAT will continue to improve over time because of dramatic improvements in vehicle technology and fuels and traffic flow improvements. Even accounting for anticipated increases in VMT, total MSAT emissions in Segment G are expected to decline approximately 81 percent from 2000 to 2025 with the Build Alternative.

Emissions from diesel powered and other construction equipment would occur under the Build Alternative for Segment G. These construction emissions would be temporary in nature. In addition to tailpipe emissions, fugitive dust may be generated during project construction. See Section 4.26.6 for mitigation measures for these impacts.

4.25.2.7 Noise Environment

Future noise levels at representative receivers along the Segment G Preferred Alternative Alignment were predicted using build-out conditions assuming all four segments (E, F-1, F-2, and G) of the Grand Parkway would be constructed. This traffic condition represents the worst-case traffic noise conditions, as more vehicles would use Segment G if all four segments would be constructed. A detailed traffic noise analysis (impact and abatement) was conducted for the Preferred Alternative Alignment. Results of the traffic noise analysis indicated that 79 representative receivers, representing a total of 280 residences and no commercial receivers, would be impacted by traffic noise. Noise abatement measures were evaluated for each of the impacted representative receivers (see Section 4.26.7).

4.25.2.8 Water Quality

Quality and quantity of storm water runoff would be altered by the Preferred Alternative Alignment; however, with the implementation of mitigation measures detailed in Section 4.26.8, any changes in the runoff are expected to have a minimal impact on the surface waters. The potential impacts on surface water quality would occur in two ways: 1) direct effects from construction, and 2) effects from long-term operation of the roadway. The Preferred Alternative Alignment would cross the following surface waters: Spring Creek, Woodsons Gully, West Fork San Jacinto River, White Oak Creek, and ten tributaries to these streams. With construction of the Preferred Alternative Alignment, groundwater pollution prevention measures might be required for 16 public water supply wells. Additionally, one private water supply well is within the Preferred Alternative Alignment.

4.25.2.9 Permits

The proposed project would require a Section 404 permit, a Section 401 water quality certification, and an appropriate mitigation plan. The proposed project would also require a TPDES construction storm water discharge permit and completion of a SWPPP and an NOI. Neither a Section 9 permit from the USGS nor a Section 10 permit from the USACE would be required for construction of the Preferred Alternative Alignment.

4.25.2.10 Wetlands and Vegetative Communities

Wetlands

The Preferred Alternative Alignment would potentially impact 64.5 acres of wetland, including 24.3 acres of non-forested wetland and 40.2 acres of forested wetland. Impact calculations do not account for bridging, which would likely reduce the wetland acreage impact particularly in the vicinity of West Fork San Jacinto River.

Additional investigation will be completed for the Preferred Alternative Alignment prior to completion of the Section 404 permit. This additional investigation consists of a formal wetland delineation, which began in the fall of 2007. The delineation is being conducted within the Preferred Alternative Alignment in accordance with the USACE 1987 Wetlands Delineation Manual. As of the completion of this FEIS, right-of-entry has not been obtained for approximately 60 percent of the total ROW along the Segment G Preferred Alternative Alignment. Results of this investigation are awaiting additional property owner access and will require verification by the USACE Galveston District.

Vegetative Communities

The Preferred Alternative Alignment encompasses 748.4 acres. Approximately 56 percent (or 417.28 acres) of the Preferred Alternative Alignment has designated vegetative land covers. This acreage has the following break down by vegetative community type: no acres of farmland or rangeland, 352.84 acres of forest, 24.30 acres of non-forested wetland, and 40.16 acres of forested wetland. Of the forested land cover, 129.76 acres are bottomland hardwood forest. Preliminary design of the Preferred Alternative Alignment includes bridging substantial portions of the bottomland hardwood forest along with floodplains of Spring Creek and West Fork San Jacinto River. No officially designated natural areas were identified within the Segment G project area.

4.25.2.11 Wildlife

Assessing acreage impacts to vegetative communities that occur within the Preferred Alternative Alignment provides a method of quantifying and comparing terrestrial wildlife habitat impacts, including habitat fragmentation, potentially incurred by construction of Segment G. Acreage of impact to vegetative communities is provided in the previous section (Section 4.25.2.10 [Vegetative Communities]). Other than direct conversion of land use from forest etc., other impacts to remaining wildlife habitat is summarized below.

Several potential impacts of nonpoint source pollution on terrestrial plant and animal life from construction and use of the roadway may occur with the proposed project. In addition, terrestrial wildlife impacts may occur because of increased spread of exotic and/or noxious species (such as non-native grass, shrub, and tree species planted in the ROW) into previously undisturbed portions of the Segment G project 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. However, the Segment G project area has already been subjected to extensive human access and alteration resulting from increasing development. Since forest habitat is a major component of the area surrounding the Preferred Alternative

Alignment, forest fragmentation effects are a concern. The project will be implemented in full compliance with all provisions and regulations outlined in and pursuant to the MBTA (16 USC 703-711).

The proposed project would impact aquatic habitat. The Preferred Alternative Alignment would cross several major streams in the project area, as well as perennial and intermittent tributaries to these streams. All of the major stream crossings (Spring Creek, Woodsons Gully, West Fork San Jacinto River, and White Oak Creek) would be bridged by the Preferred Alternative Alignment, while others would be bridged or culverted. BMPs will be followed before, during and after construction activities; therefore no negative long-term impacts to aquatic species in the Segment G project area are expected because of project construction and usage. On small waterways, pipe and box culverts would be used to allow the passage of water, and relocations would incorporate natural channel design principles to provide a more natural habitat. Some individual mortality is anticipated to occur during construction when species are present at creek crossings.

4.25.2.12 Waterbody Modifications and Floodplains

Hydrology and Drainage

The Preferred Alternative Alignment would cross the four major streams flowing through the project area: Spring Creek, Woodsons Gully, West Fork San Jacinto River, and White Oak Creek. The alignment would also cross two tributaries to Spring Creek, a perennial tributary to Woodsons Gully, three tributaries to West Fork San Jacinto River (including Black Branch), and three tributaries to White Oak Creek. These crossings are almost all transverse, reducing the length of impact along the stream corridor. All of the major streams listed above would be bridged by the proposed facility, and the remaining streams would be bridged or culverted.

The proposed project would increase the amount of impervious area within the watersheds, resulting in increased surface runoff and impacted overland flow patterns. However, these impacts would be substantially reduced with the design of drainage (mitigation) facilities that consider sheet flow patterns. Final drainage and mitigation analyses would be conducted during final project design (see Section 4.26.12.1 for more detail).

Floodways and Floodplains

The Preferred Alternative Alignment ROW includes 95.42 acres of regulatory floodway and 103.00 acres of 100-year floodplain. All of the floodway would be bridged with the possible exception of a portion of the floodway adjacent to Woodsons Gully. Further avoidance and minimization of floodplain encroachments would be considered during final design.

Rainfall runoff rates would be expected to increase slightly because of an increase in impervious pavement surface area with construction of the Preferred Alternative Alignment. However, natural and beneficial floodplain values would not be altered because of implementation of mitigation measures determined from final drainage and mitigation analyses conducted during final project design (see Section 4.26.12.2 for more detail). Cross drainage and mitigation facilities associated with the proposed roadway and drainage improvements would be designed to handle a 100-year flood event.

Review of the drainage and mitigation analyses by regulatory agencies would confirm that adequate measures are being taken to ensure that the project's floodplain encroachment would not increase the risk of flooding to adjacent property.

4.25.2.13 Wild and Scenic Rivers

The Preferred Alternative Alignment would not impact Wild and Scenic Rivers.

4.25.2.14 Coastal Barriers

The Preferred Alternative Alignment would not impact coastal barriers.

4.25.2.15 Coastal Zone Management

The Preferred Alternative Alignment is not within the CMP boundary and would not require coordination with the CCC.

4.25.2.16 Essential Fish Habitat

The Preferred Alternative Alignment would not impact EFH.

4.25.2.17 Threatened and Endangered Species

The Preferred Alternative Alignment is not known to include any unique or suitable habitats or any known populations or nest sites of listed species (based on TXNDD file reviews [TPWD, 2007c], coordination with TPWD and USFWS, and limited field surveys). As ROW is acquired on lands that have not been surveyed because of lack of access (San Jacinto River Crossing), additional coordination (if required) will be initiated with the USFWS and TPWD in full compliance with the ESA. The Preferred Alternative Alignment may affect, but is not likely to adversely affect threatened and endangered species.

4.25.2.18 Cultural Resources

Archeological Resources

HPAs were identified to assess the potential for prehistoric sites in the Preferred Alternative Alignment, and a total of 550 acres of HPAs were identified. The Map Units for these HPAs (Map Unit 2 and Map Unit 2a) do not recommend deep reconnaissance. As a result of archeological field surveys of accessible portions of the Preferred Alternative Alignment and coordination with the SHPO, one archeological historic property (36 CFR 800.16(l)) was identified within the surveyed portions of the APE. Site 41MQ197 will require additional investigations to determine if it would be potentially eligible for nomination to the NRHP. The total number of archeological sites within the Preferred Alternative Alignment will not be known until the completion of the archeological field survey for this segment. If archeological sites could be identified within the Preferred Alternative Alignment, additional investigations may be necessary to determine if they would be eligible for nomination to the NRHP.

Non-Archeological Historic Properties

It has been determined that no NRHP-listed non-archeological historic properties occur in or adjacent to the Preferred Alternative Alignment. In addition, the Preferred Alternative Alignment would not impact any Recorded Texas Historic Landmarks, SALs (non-archeological), or Official State Historical Markers. Thus, the Preferred Alternative Alignment will not directly impact any non-archeological historic properties. No further consideration of impacts is required under Section 106 of the National Historic Preservation Act of 1966, as amended, or under Section 4(f) of the Department of Transportation Act.

4.25.2.19 Hazardous Materials

Overall, the proposed construction of the project poses very little risk of hazardous material impacts to the environment. The review of regulatory agency databases indicates the presence of one registered facility within the ROW of the Preferred Alternative Alignment, Site ID No. 21, owned by Averie Bass. This site is reported as an unauthorized landfill (LFUN) containing demolition materials and brush. The two-acre site is a reclaimed sand pit that was reportedly first used in 1979. According to a recent site reconnaissance, the facility is actively excavating aggregate and receiving brush and debris. The facilities that are located within the final design ROW of the Preferred Alternative Alignment would be acquired by the project owner. A Phase I Environmental Site Assessment would be conducted to assess the potential for hazardous material impacts to the existing environment. Based on the results of the assessment, sampling and analysis activities and possible remedial activity may be warranted.

RRC records indicate that one observation well site and six is located within the ROW of the Preferred Alternative Alignment. Elevated NORM issues may be an environmental concern in oil fields, especially where water injection has been used as a secondary recovery technique, or water disposal has occurred. The concern would likely be limited to the current producing wells, of which there are none in the proposed project ROW. 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 Preferred Alternative Alignment crosses seven petroleum pipelines (six active and one inactive). The relocation of existing pipelines does not appear necessary. However, the pipelines may be required to be reinstalled at a greater depth prior to roadway construction. The depths of the pipelines and their locations would be clearly marked prior to construction to prevent an accidental rupture.

4.25.2.20 Visual and Aesthetic Qualities

Because of the relatively large overall size of the project and the rural setting of the project area, the Preferred Alternative Alignment would have some effect on the existing aesthetic quality of the surrounding area. The visual impact would vary with location. Views both from and of the facility would be greatest at grade separations, which would be at the following locations: IH 45, Hardy Toll Road, Northgate Crossing Boulevard, Riley Fuzzel Road near Spring Trails, Rayford Road,

Birnam Woods Drive (future), Townsen Road (future), FM 1314, Valley Ranch Thoroughfare (future), and US 59. Preliminary design of the Preferred Alternative Alignment also includes long bridges over Spring Creek and the West Fork San Jacinto River, and the bridging of Woodsons Gully, White Oak Creek, and a perennial tributary to Woodsons Gully. As the highway approaches existing development and communities, more residents have a view of the facility, but the highway would have less effect on the overall rural viewshed. Conversely, as the highway moves farther away from these developed areas, the result may be a greater change in the overall rural visual setting, but would be observed by fewer individuals. Outside grade separations, potential views of the highway would be limited because of the relatively flat nature of the project area. The toll facilities and all entrance and exit ramps would be lighted, which could be considered additional negative visual and aesthetic impacts, especially where residential areas are located near the main lane toll plazas and exit ramps with collection facilities.

4.25.2.21 Energy

The Preferred Alternative Alignment would require short-term energy consumption during construction activity. A worst-case estimate of operational energy consumption was calculated based on expected traffic conditions with the construction of Segments E, F-1, F-2, and G of the Grand Parkway. Based on this analysis, the future expected energy consumption is less than, though similar to, that of the No-Build Alternative. 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.

4.25.2.22 Construction Impacts

The Preferred Alternative Alignment would have temporary construction impacts likely to include the temporary degradation of air, noise, and water quality; the temporary impedance to the maintenance and control of traffic; safety concerns because of changes in traffic patterns; the stockpiling and disposal of construction materials; and the use of borrow areas. Construction activities would affect residents in the immediate area and those traveling in the vicinity.

4.26 MITIGATION MEASURES AND COMMITMENTS

Throughout the process of developing transportation projects, one of the chief considerations is to reduce adverse impacts to the environment. One of the methods used to reduce overall impacts is referred to as “mitigation.” Federal policy on mitigation is specified in the CEQ regulations implementing NEPA. Federal agencies shall to the fullest extent possible “use all practicable means consistent with the Act [NEPA] and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions on the quality of the human environment” (40 CFR 1500.2(f)).

Mitigation of impacts and enhancement of resources must be considered for all impacts, whether or not the impacts are substantial. All relevant, reasonable mitigation measures that could improve the project are to be identified and included in the project. The CEQ regulations (40 CFR 1508.20) define mitigation to include:

- Avoiding the impact altogether by not taking a certain action or parts of an action;
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- Compensating for the impact by replacing or providing substitute resources or environments.

This ordered approach to considering possible methods of mitigating impacts is known as "mitigation sequencing" and involves understanding the affected environment and assessing the transportation project's potential impacts throughout the development of the project. It is FHWA's policy that measures necessary to mitigate adverse impacts be incorporated into the proposed action. This policy emphasizes the identification and implementation of measures to rehabilitate, restore, or replace impacted resources.

The mitigation recommendations presented herein are appropriate for the Grand Parkway Segment G based on experience developing other transportation projects and on general recommendations made by various local, state, and federal agencies in response to preliminary discussions and correspondence concerning the proposed action. The FHWA/TxDOT/GPA will continue coordination efforts with other agencies through project final design and during refinements of the mitigation and enhancement measures on this project.

4.26.1 Land Use

Avoidance and minimization of impacts to land use were used as techniques in the selection of a Preferred Alternative Corridor, the development of alternative alignments, and the selection of the Preferred Alternative Alignment. Grade separations would be provided for all major arterial roadways that cross the selected alignment to avoid termination of through-travel, and intermittent frontage roads have been provided when required to provide adjacent property access and connectivity to major highways (IH 45, Hardy Toll Road, and US 59). Additionally, opportunities to reduce the amount of ROW would be identified during the final design stage.

4.26.2 Geology, Soils, and Farmland

Potential impacts presented in Section 4.2 are calculated for the entire 400-foot ROW. Actual impacts would be less, as vegetation within the ROW would remain in place to the extent feasible and practicable in order to minimize impacts to soils and reduce erosion. The use of silt fences and other erosion control measures 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 corridors would prevent future erosion after construction and thereby increase the success rate of any and all revegetation efforts. The need for mitigation of geologic resources is not anticipated. Mitigation for prime farmland is not required, as per NRCS ranking.

4.26.3 Social

Every effort has been made in selection of alternative alignments and the Preferred Alternative Alignment 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 4.26.22 [Construction Impacts]). Traffic delays would be minimized through coordination between 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 maintenance of access to residences, farms, businesses, and community facilities where practicable. Grade separations would be incorporated into the design of all of the alternatives, allowing for adequate movement of school buses and emergency vehicles across the proposed Segment G project area.

There would be no potential (associated with any of the alternatives) for disproportionate effects to minorities or low-income populations within the Segment G project area; therefore no mitigation related to EJ would be necessary. Furthermore, additional public meetings would be held during the final design process to discuss specific community and landowner concerns prior to construction of the highway.

4.26.4 Economics

Economic effects related to proposed project alternatives are considered beneficial; therefore no mitigation would be necessary.

4.26.5 Pedestrians and Bicyclists

The proposed 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.

4.26.6 Air Quality

Emissions from diesel powered and other construction equipment would occur under the Build Alternative for Segment G. 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 by both the Texas Low Emission Diesel (TxLED) program started in 2005 and the federal low sulfur diesel program, which took effect at retailers in Texas on October 15, 2006. 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 emissions can be undertaken. However, project construction would be

conducted in accordance with all federal, state, and local regulations that govern construction activities and emissions. In addition to tailpipe emissions, fugitive dust may be generated during project construction. Specific dust suppression mitigation measures that can be utilized would be identified in a dust control plan prepared prior to project construction.

4.26.7 Noise Impacts

Noise abatement measures were analyzed for receiver locations impacted by the Preferred Alternative Alignment. 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 several locations and therefore are proposed for incorporation into the project subject to the completion of the project design, utility evaluation, and polling of adjacent property owners. These locations are shown in Exhibit G–53.

4.26.8 Water Quality

4.26.8.1 Surface Water

A SWPPP will be prepared prior to construction and followed throughout the construction phases to minimize the discharge of sediment laden storm water to the Segment G project area streams. The project SWPPP 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 chances 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 specifications *Seeding for Erosion Control* (TxDOT, 2004a) would be followed to restore and reseed all disturbed areas.

Additionally, in accord with Clean Water Act Section 402, where storm water 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. See Section 4.9.1 for further discussion of permitting for storm water discharge.

4.26.8.2 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 Alignment and would be performed during final design of the project. Measures would include minor alignment shifts to minimize the impact to source water protection areas and/or avoid direct impacts 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 or private 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 TDLR.

A storm water management plan would be developed according to FHWA and TxDOT criteria to reduce the risk of contaminating local aquifers. The storm water 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 storm water runoff from entering the aquifer at wellheads.

An emergency spill control pollution prevention plan would be developed and coordinated with local officials for the Preferred Alternative Alignment. Special storm water management measures would be designed 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 Preferred Alternative Alignment.

4.26.9 Permits

Mitigation options associated with the wetland impacts requiring the Section 404 permit are discussed in Section 4.26.10 (Wetlands and Vegetative Communities), and the mitigation discussion for the activities requiring the TPDES permit are presented in Section 4.26.8 (Water Quality). The Section 404 permit and TPDES permit will be obtained prior to construction.

4.26.10 Wetlands and Vegetative Communities

4.26.10.1 Habitat Mitigation

Regulatory

Mitigation includes measures, which avoid, minimize, and/or compensate for unavoidable losses to resources that cannot be further minimized. The assessment of mitigation measures (avoidance, minimization, and compensation) is an integral part of the NEPA/Section 404 process. The preferred means of mitigation is avoidance, which is inherent in impact evaluation analysis and alternative development/assessment. For those adverse impacts that cannot be avoided, other mitigation efforts must be considered. These efforts include minimization of potentially adverse impacts and compensation for those remaining adverse impacts that cannot be further reduced.

Initial mitigation measures in the planning or alignment of highway projects such as Segment G of the Grand Parkway minimize the probable occurrence of habitat (vegetation communities) and wetland impacts (both adjacent and isolated) 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 roadway design (use of bridge crossings instead of filled embankment); the use of retention basins and revegetated swales to minimize runoff, sedimentation, turbidity, leaching of soil nutrients, and leaching of chemicals from petroleum products, pavement, and waste material; and maintaining flow patterns to ensure wetland hydrology in spite of roadway design requirements.

The fact that some degree of impact is often unavoidable, regardless of the care applied during the planning, design, and construction of a highway, requires a plan for compensatory mitigation to replace functions, values, and features or habitat that may be disturbed. Replacement of values for unregulated habitat (habitat not under USACE jurisdiction where compensation can be required) within transportation corridors and highway ROW may not always be practical, feasible, or safe (refer to the following section [Non-Regulatory]). On occasion, on-site restoration of degraded wetland habitat or creation of wetland habitat within the highway ROW through creative use of detention basins, borrow pit areas, or drainage runoff channels may be appropriate. Where such measures may not effectively restore resource functions and values, 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, values, and type as the pre-existing site. Off-site mitigation would be conducted in the same geographic vicinity or in proximity, and most likely within the same watershed as the project, particularly for wetlands. Wetland mitigation may include expanding existing wetlands, restoration with hydrophytic species, or regulating water levels in impoundments or streams. Mitigation that involves wetland creation and/or enhancement would include post-project monitoring of mitigation sites to ensure success.

Natural resource agencies (including TPWD, USFWS, USACE, EPA, and TCEQ) will be involved in decisions regarding appropriate mitigation ratios and the location, size, and character of the mitigation. A compensatory mitigation plan will be submitted to the USACE as part of the Section 404 permit review process. The mitigation plan will include a discussion of the avoidance and minimization measures used in the routing and design of the roadway. The plan will provide mitigation for unavoidable impacts to both adjacent and isolated wetlands, regardless of current USACE regulatory status. In addition, the plan will include specifications for accomplishing the proposed compensatory mitigation measures. It is anticipated that a monitoring program would be included in the mitigation plan to ensure the successful implementation of the compensatory mitigation measures. The approved mitigation plan will be a condition of the USACE Section 404 permit for the Grand Parkway Segment G project. The approved mitigation plan will provide a detailed discussion of mitigation commitments, including those that must be implemented during construction. Mitigation measures for site-

specific activities will be identified, to the extent practicable, throughout project development as additional information becomes available.

Every effort has been made to avoid and minimize wetland impacts, both adjacent and isolated, to the extent practicable during the planning process (Corridor and Alignment selection). This effort will continue up to construction of the proposed Grand Parkway Segment G. Preliminary design of the Preferred Alternative Alignment includes bridging perennial stream crossings with portions of the adjacent wetlands and bottomland hardwood forest. Further minimization of impact through bridging would be considered during final design.

For impacts that cannot be avoided or further minimized, preliminary mitigation options have been discussed with the GPA, TPWD, USFWS, and the USACE during project team meetings and in agency correspondence. Summaries of these meetings and copies of agency correspondence are provided in Section 6 (Agency and Public Coordination) of this volume and Appendix B. Preliminary mitigation options include on-site mitigation and off-site mitigation. On-site mitigation may include creation or enhancement of wetlands within the final Segment G ROW, which 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.

It should be noted that on-site mitigation is being considered only as an option at this time. Per correspondence with USFWS (August 30, 1993, Appendix B), on-site mitigation for highway projects may not be considered adequate for replacement of all lost wetland functions and values. On-site (i.e., immediately adjacent to the new highway) mitigation will not be considered as the only source of wetland mitigation for impacts associated with this project. On-site mitigation may be considered as a supplement to additional off-site mitigation. Further coordination with USFWS, TPWD, and the USACE may eliminate the use of on-site mitigation as an option for this project, especially in light of better off-site mitigation options that adequately compensate for impacts to wetland functions and values.

Potential off-site areas considered for enhancement, restoration, and/or preservation include tracts of land within and adjacent to the Spring Creek-San Jacinto River floodplain that may be placed under conservation easement or purchased and placed under perpetual deed restriction. Other options may include use of the Katy-Cypress Mitigation Bank, wetland creation, and/or enhancement on property owned and/or managed by the Katy Prairie Conservancy, wetland creation on property currently owned by Harris County Precinct 3, and wetland creation at the Westside Airport site and forested wetland preservation, creation, and/or enhancement at the Bahr Woods Mitigation Area located adjacent to the San Jacinto River in Montgomery County. Off-site wetland mitigation options will likely include surrounding upland prairie restoration and/or efforts to ensure sufficient hydrology for any constructed or acquired wetland habitat per USFWS recommendations (March 16, 2000, Appendix B).

In summary, several viable wetland mitigation alternatives will be investigated and evaluated in the mitigation plan. The plan will also address mitigation for “isolated” wetlands, regardless of current regulatory status under Section 404 of the

CWA. The technical and regulatory merit of these mitigation recommendations will be evaluated and further discussed with resource agency staff and ultimately presented to the public prior to construction.

Non-Regulatory

Non-regulated resources (e.g., isolated wetlands, remnant prairie topography, or riparian habitat) identified as environmentally sensitive, socially desirable, or ecologically valuable have been avoided to the extent practicable. Non-regulated resources are often included as part of a wetland mitigation plan, on a case-by-case basis. As discussed above, the compensatory mitigation plan will address mitigation for isolated wetlands, regardless of current regulatory status under Section 404 of the CWA. In addition, it is anticipated that a non-wetland component would be incorporated into the mitigation plan to compensate for unavoidable impacts to non-regulated natural resources per the provisions outlined in TxDOT's MOA with TPWD and USFWS recommendations (March 16, 2000, Appendix B).

In accordance with Provision (4) (A) (ii) of the TxDOT's MOU with TPWD signed in 1998 and at the TxDOT district's discretion, habitats given consideration for non-regulatory mitigation during project planning include:

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 TPWD designations) that also locally provide habitat for a state-listed species.
3. All vegetation communities listed as S1 or S2, regardless of whether or not the series in question provides habitat for a state-listed species.
4. Bottomland hardwoods, native prairies, and riparian sites.
5. Any other habitat feature considered to be locally important that the TxDOT district chooses to consider.

As discussed in Volume I, Section 3.17 (Threatened and Endangered Species), only one federal candidate species, the Louisiana pine snake, may occur within the Grand Parkway Segments E, F-1, F-2, and G project areas. Although unlikely to occur within the Segment G project area, suitable habitat for the Louisiana pine snake (i.e., sandy areas of longleaf pine and hardwood communities as described in Volume I, Section 3.17.1 [State and Federally Listed Threatened and Endangered Species]) would primarily be found northeast of the Segment G project area. Given the location and extent of this species' preferred habitat relative to the Segment G project area, mitigation for impacts to any potential Louisiana pine snake habitat within the Segment G project area would be unlikely to assist in the prevention of the listing of this species.

No rare vegetation series are known or expected to occur within the Segment G project area (TPWD, 2007c). Impacts to riparian forest have been avoided in the development and selection of the Preferred Alternative Alignment based on current information. However, compensation for bottomland hardwood forest impacts (described in Volume I, Section 3.10.2.3 [Forest]) will be considered and addressed in the mitigation plan to be submitted for agency review and approved prior to construction. As suggested by USFWS (March 16, 2000, Appendix B), such compensation may include a

contribution to the acquisition of flood easements containing riparian forest remnants within Segment G project area watersheds.

Additional non-regulatory mitigation may be considered by TxDOT Houston District as appropriate. The GPA will continue to coordinate with the federal and state natural resource agencies and project stakeholders to develop a final compensatory mitigation plan that protects, enhances, and preserves the integrity of the natural environment. In accordance with the Executive Memorandum of August 10, 1995, all agencies shall comply with NEPA as it relates to vegetation management and landscape practices for all federally assisted projects. The Executive Memorandum directs that where cost-effective and to the extent practicable, agencies will 1) use regionally native plants for landscaping; 2) design, use, or promote construction practices that minimize adverse effects on the natural habitat; 3) seed to prevent pollution by, among other things, reducing fertilizer and pesticide use; 4) implement water-efficient and runoff reduction practices; and 5) create demonstration projects employing these practices. Landscaping included with this project would comply with the Executive Memorandum and the guidelines for environmentally and economically beneficial landscape practices.

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.

4.26.10.2 Wetlands and Vegetative Communities

Preliminary mitigation options for impacts to wetlands that cannot be avoided or further minimized include on-site mitigation and off-site mitigation. On-site mitigation may include creation or enhancement of wetlands within the Segment G 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 Spring Creek-San Jacinto River floodplain that may be placed under conservation easement or purchased and placed under perpetual deed restriction. Other options may include use of the Katy-Cypress Mitigation Bank, wetland creation, and/or enhancement on property owned and/or managed by the Katy Prairie Conservancy, wetland creation on property currently owned by Harris County Precinct 3, and wetland creation at the Westside Airport site, and forested wetland preservation, creation, and/or enhancement at the Bahr Woods Mitigation Area located adjacent to the San Jacinto River in Montgomery County. Additional options may include use of property currently owned by Harris County Precinct 4, Montgomery County Precinct 3, and Montgomery County Precinct 4. Properties in these County Precincts include but are not limited to, Spring Creek Greenway Project, Cypress Creek Greenway Project, and forested wetland preservation, creation, and/or enhancement at the Bahr Woods Mitigation Area located adjacent to the San Jacinto River in Montgomery County.

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 permit review process. It is anticipated that a non-wetland component would be incorporated, at the discretion of the TxDOT Houston District, into the mitigation plan to compensate for unavoidable impacts to non-regulated natural resources (riparian habitat, upland forests, etc.). Please refer to Section 4.26.10.1 (Habitat Mitigation) for a discussion of the regulatory and non-regulatory measures of habitat mitigation.

4.26.11 Wildlife

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 Preferred Alternative Alignment 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 non-regulated natural resources, such as isolated wetlands. Please refer to Section 4.26.10.1 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.

4.26.12 Waterbody Modifications and Floodplains

4.26.12.1 Hydrology and Drainage

Because of the flat topography and the low number of natural drainage features within the project 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 remain 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.

4.26.12.2 Floodways and Floodplains

During final design of the highway, final drainage and mitigation analyses would be performed. The studies would provide detailed hydraulic information necessary to determine the use of mitigation measures 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 could be identified, design criteria may be more restrictive than those specified in county orders. The project will comply with the Harris and Montgomery County "floodplain program." Any proposed construction or development in an SFHA would be coordinated with the Harris and Montgomery County floodplain administrator to receive a development permit.

BMPs would be incorporated into 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, after any approved revisions to floodway mapping. 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.

4.26.13 Wild and Scenic Rivers

No impacts to Wild and Scenic Rivers would occur; therefore no mitigation would be necessary.

4.26.14 Coastal Barriers

No impacts to coastal barrier resources would occur; therefore no mitigation would be necessary.

4.26.15 Coastal Zone Management

The Segment G project area is not within the CMP boundary and, therefore, is in compliance with the CZMA. Coordination with the CCC is not required.

4.26.16 Essential Fish Habitat

The Segment G project area does not intersect tidally influenced coastal waters and would have no impact on EFH. Coordination with NMFS is not required.

4.26.17 Threatened and Endangered Species

As ROW is acquired on lands that have not been surveyed because of lack of access, TxDOT will follow all requirements of the ESA, including additional coordination (if required) will be initiated with the USFWS and TPWD. TxDOT would continue to coordinate with USFWS and TPWD, as necessary, in order to determine whether additional protected species investigations or consultation under Section 7 of the ESA are required. No mitigation for threatened and endangered species is anticipated to be required for the proposed project.

4.26.18 Cultural Resources

If any site identified by archeological field survey within the Preferred Alternative Alignment, including Site 41MQ197, is found to be eligible to the NRHP, actions and consultation would be initiated to avoid, minimize, or mitigate adverse effects to that site. If an NRHP-eligible site could 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 non-adverse 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 (see letter dated August 2, 2005, Appendix H).

4.26.19 Hazardous Materials

Mitigation of impacts may come in the form of remediation of impacted sites or compensation to relocate oil or gas wells or install petroleum pipelines at a greater depth. Mitigation of hazardous material impacts associated with the proposed project would more likely be associated with existing and historical sites that either have the potential or have already impacted the environment. A Phase I Environmental Site Assessment would be conducted at each site to assess the need for mitigation. Based on the results of the assessment, sampling and analysis activities and possible remedial activity (i.e., mitigation) may be warranted at certain sites. Any unanticipated hazardous materials and/or petroleum contamination encountered during construction would be handled according to applicable state and federal regulations and TxDOT Standard Specifications and Guidelines for handling emergency discovery of hazardous materials.

The proposed project may include the demolition and/or relocation of building structures. The buildings may contain asbestos containing materials and/or lead paint. Asbestos and lead paint inspections, specifications, notification, license, accreditation, abatement, and disposal, as applicable, would comply with federal and state regulations. Issues related to asbestos and lead paint would be addressed during the ROW process prior to construction.

If active wells are later located within the ROW of the selected alternative alignment, the wells will 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 Texas Administrative Code, Title 16, Part I, 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 locations of the abandoned dry holes within the Preferred Alternative Alignment will be flagged to avoid accidental disturbance.

4.26.20 Visual and Aesthetic Qualities

Where reasonable and feasible, visual mitigation measures could include naturally vegetated medians, minimization of ROW clearing, incorporation of design specifications to blend into the landscape, and promotion of roadside native wildflower planting programs. For roadside revegetation, landscape planting, and revegetation of natural areas impacted by construction, native plants will be considered to improve the visual aesthetics and to control the introduction of invasive

species. Where reasonable and feasible, existing trees within the proposed ROW, but not within the defined clear zone, could be retained in the proposed landscaping to block the view of the roadway from adjacent properties. As currently proposed, the roadway lighting system would be restricted to those areas where entrance/exit ramps and a main lane toll facility are located and would consist of low impact, downward directional lighting.

4.26.21 Energy

The construction of the Grand Parkway 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) of this volume, this facility would be designed to:

- Help complete or expedite the implementation of several major thoroughfare plans;
- Provide major roadway linkages between major freeways and highways; and
- Provide an alternative route to bypass the central city.

In addition, the construction of the Grand Parkway will result in the implementation of CMS commitments for managing traffic congestion. These congestion reduction strategies will also result in the reduction of energy consumption and are discussed in greater detail in Section 4.6.4.

4.26.22 Construction Impacts

Requiring the construction contractor to adhere strictly to the mitigation procedures would minimize construction impacts. To minimize effects to air quality, dust control measures would be implemented and open burning would not be used to dispose of vegetative debris. In order to control construction noise impacts, construction timing would be limited to “noise tolerant periods.” Minimization of the effects to water quality from erosion and sedimentation would be accomplished by preparing a SWPPP pursuant to TxDOT guidelines. The SWPPP may include, but not be limited to, silt fences, inlet protection barriers, hay bales, and seeding or sodding of excavated soil. Exposure of the soil surface would be minimized during any clearing activities in order to maintain soil integrity. To minimize the disturbances to maintenance and control of traffic during construction within a single geographic area would be limited to protect communities or geographical areas from being inundated with construction zones. All reasonable safety considerations to protect the life and health of the construction workers, the public, and property would be exercised. The construction contractor would be responsible for pollution control on haul roads, borrow and other material pits, waste material disposal areas, and other potential pollutants, which could be accomplished with erosion control features such as berms, dikes, temporary seeding, sediment traps, fiber mats, silt fences, slope drains, mulches, crushed stone, and others as specified by TxDOT guidelines (TxDOT, 2000).

THIS PAGE IS INTENTIONALLY LEFT BLANK

TABLE 4-38
SUMMARY OF IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Alternative Alignment	Reach	Length (miles)	Land Use		Changes in Community Cohesion	Environmental Justice (EJ) Issues	Air Quality Impacts	Traffic Noise Impacts[1]	Residence Displacements	Commercial Displacements	School Properties [2]	Churches	Cemeteries	Parks	Natural Resources													Cultural Resources						Water Wells	
															Special Resource Areas					Aquatic Resources				Flood Zones											
			Visual and Potential Access Impacts	Separation of Farmland from Homestead											Threatened & Endangered Species	Species of Concern	Remnant Prairie Topography (acres)	Bottomland Hardwoods (acres) [3]	Riparian Forest (acres)[3]	Adjacent Wetlands (acres)[4]	Isolated Wetlands (acres)[4]	Total Wetlands (acres)[4]	Stream Crossings [5]	100-Year Floodplain (acres)	Floodway (acres)[5]	Prime Farmlands (acres)	Statewide Important Farmland Soils	Recorded Archeology Sites	Historic Properties	Century Farm Sites	High Probability Area (acres) [6]	Oil and Gas Wells	Potential Hazardous Material Sites	Public [7]	Private
A	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.43	No	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	53.2	-	19.4	20.8	40.2	4	35.5	20.4	-	192.2	-	-	-	179	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	4	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.02	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	32.3	-	2.7	2.2	4.9	4	27.8	8.8	1.3	16.3	-	-	-	94	-	-	-	-
Total		**13.70**	**-**	**-**	**-**	**-**	**-**	**141**	**109**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**109.4**	**0**	**36.0**	**48.0**	**84.0**	**14**	**95.1**	**64.4**	**64.1**	**315.6**	**0**	**0**	**0**	**538**	**1**	**1**	**16**	**1**
B	8	4.96	Yes	No	Yes	No	No	134	38	1	1	-	-	-	-	-	-	19.2	-	4.3	2.1	6.4	5	32.2	33.5	18.1	32.1	-	-	-	231	-	1	9	-
	9	4.27	No	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	43.6	-	23.2	7.2	30.4	3	13.7	49.4	4.6	139.4	-	-	-	170	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	2.09	Yes	No	Yes	No	No	67	64	-	-	-	-	-	-	-	-	-	-	-	5.0	5.0	-	-	-	-	11.1	-	-	-	45	-	-	-	-
	12	1.92	Yes	No	Yes	No	No	14	3	-	-	-	-	-	-	-	-	20.8	-	3.1	3.3	6.4	3	15.6	5.9	1.3	14.5	-	-	-	100	-	-	-	-
Total		**13.63**	**-**	**-**	**-**	**-**	**-**	**215**	**105**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**83.6**	**0**	**30.6**	**17.6**	**48.2**	**11**	**61.5**	**88.8**	**24.0**	**208.4**	**0**	**0**	**0**	**549**	**0**	**1**	**12**	**0**
C	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.10	No	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	58.0	-	26.9	4.5	31.4	5	52.5	24.5	-	168.4	-	-	-	171	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1.5	17.7	-	-	-	19	-	-	1	-
	11	2.19	Yes	No	Yes	No	No	-	169	-	-	-	-	-	-	-	-	-	-	-	10.3	10.3	1	-	-	16.2	46.4	-	-	-	56	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		**13.65**	**-**	**-**	**-**	**-**	**-**	**156**	**209**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**144.3**	**0**	**44.8**	**19.0**	**63.8**	**16**	**144.8**	**67.2**	**78.9**	**275.3**	**0**	**0**	**0**	**564**	**1**	**1**	**15**	**1**
D	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.42	No	No	Yes	No	No	-	1	-	-	-	-	-	-	-	-	46.4	-	14.6	0.4	15.0	4	11.3	52.9	0.1	159.7	-	-	-	177	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	4	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		**13.72**	**-**	**-**	**-**	**-**	**-**	**141**	**110**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**132.7**	**0**	**32.5**	**27.3**	**59.8**	**14**	**103.6**	**95.6**	**64.2**	**287.6**	**0**	**0**	**0**	**549**	**1**	**1**	**16**	**1**
Recommended[8]	8	4.92	Yes	No	Yes	No	No	137	18	-	-	-	-	-	-	-	-	23.9	-	13.9	2.3	16.2	5	31.8	35.2	59.9	22.0	-	-	-	211	1	1	10	1
	9	4.42	No	No	Yes	No	No	-	1	-	-	-	-	-	-	-	-	46.4	-	14.6	0.4	15.0	4	11.3	52.9	0.1	159.7	-	-	-	177	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	4	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	-	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		**13.72**	**-**	**-**	**-**	**-**	**-**	**141**	**110**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**132.7**	**0**	**32.5**	**27.3**	**59.8**	**14**	**103.6**	**95.6**	**64.2**	**287.6**	**0**	**0**	**0**	**549**	**1**	**1**	**16**	**1**

TABLE 4-38 (CONT.)
SUMMARY OF IMPACTS BY ALTERNATIVE ALIGNMENT AND REACH FOR SEGMENT G

Alternative Alignment	Reach	Length (miles)	Land Use		Changes in Community Cohesion	Environmental Justice (EJ) Issues	Air Quality Impacts	Traffic Noise Impacts[1]	Residence Displacements	Commercial Displacements	School Properties[2]	Churches	Cemeteries	Parks	Natural Resources													Cultural Resources				Oil and Gas Wells	Potential Hazardous Material Sites	Water Wells	
															Special Resource Areas					Aquatic Resources				Flood Zones											
			Visual and Potential Access Impacts	Separation of Farmland from Homestead											Threatened & Endangered Species	Species of Concern	Remnant Prairie Topography (acres)	Bottomland Hardwoods (acres)[3]	Riparian Forest (acres)[3]	Adjacent Wetlands (acres)[4]	Isolated Wetlands (acres)[4]	Total Wetlands (acres)[4]	Stream Crossings[5]	100-Year Floodplain (acres)	Floodway (acres)[5]	Prime Farmlands (acres)	Statewide Important Farmland Soils	Recorded Archeology Sites	Historic Properties	Century Farm Sites	High Probability Area (acres)[6]			Public[7]	Private
Preferred	8	4.93	Yes	No	Yes	No	No	195	18	-	-	-	-	-	-	-	-	23.4	-	13.7	2.3	16.0	5	31.7	35.7	59.9	26.2	-	-	-	212	1	1	10	1
	9	4.43	No	No	Yes	No	No	26	1	-	-	-	-	-	-	-	-	44.0	-	19.4	0.5	19.9	4	10.7	52.2	0.1	158.6	-	-	-	177	-	-	1	-
	10	0.39	Yes	No	Yes	No	No	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	-	-	-	3	-	-	2	-
	11	1.94	Yes	No	Yes	No	No	43	69	-	-	-	-	-	-	-	-	-	-	-	22.7	22.7	1	-	-	2.9	73.8	-	-	-	51	-	-	3	-
	12	2.05	Yes	No	Yes	No	No	16	22	-	-	-	-	-	-	-	-	62.4	-	4.0	1.9	5.9	4	60.5	7.5	1.3	20.8	-	-	-	107	-	-	-	-
Total		**13.74**	**-**	**-**	**-**	**-**	**-**	**280**	**110**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**129.8**	**0**	**37.1**	**27.4**	**64.5**	**14**	**102.9**	**95.4**	**64.2**	**290.7**	**0**	**0**	**0**	**550**	**1**	**1**	**16**	**1**

Notes: Totals may not appear to equal sum of reaches because of rounding. [1] = Impacts account for traffic assuming construction of all four segments (E, F-1, F-2, and G) of the Grand Parkway (i.e., worst-case scenario with respect to noise impact). Preferred Alternative Alignment noise impacts are based on a revised analysis conducted for the FEIS; [2] = Impact in Alternative Alignment B is to undeveloped Spring ISD property; [3] = See definition of Bottomland Hardwoods and Riparian Forest in the Glossary; [4] = As with all land cover data, numbers for original alternative alignments reflect new land use calculations. Additionally, for the FEIS, a more detailed analysis of wetlands was conducted in the Preferred Alternative Alignment. See Section 4.10 for further explanation; [5] = Includes stream crossings, lakes, and ponds; [6] = Total of Map Units 1, 2, 2a, 3, and 3a; [7] = Wellhead Capture Zones; [8] = Recommended Alternative Alignment is the same as that presented in the DEIS, however, impact calculations account for updated land use; "-" = No resource located within reach

Source: Study Team, 2007

SECTION 5: INDIRECT AND CUMULATIVE EFFECTS

This section describes the Indirect and Cumulative Effects Analysis (CEA) conducted for the proposed Grand Parkway project, Segments E, F-1, F-2, and G. This analysis follows the requirements and processes outlined in 23 CFR 771, the FHWA Technical Advisory T 6640.8A (1987), CEQ's handbook, *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ, 1997), *Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process* (FHWA, 2003), CEQ's memorandum *Guidance on the Consideration of Past Actions in Cumulative Effects Analysis* (CEQ, 2005), and TxDOT's *Guidance on Preparing Indirect and Cumulative Impact Analyses* (TxDOT, 2006b). NOTE: This section is an exact duplication of Volume I, Section 4 (Indirect and Cumulative Effects). The FEIS includes this repetition in order to reduce the reader's need to open another volume of the document (see the Document Organization chart at the front of this volume, also found in Summary, Figure S-1).

5.1 AREA OF INFLUENCE (AOI)

For this analysis, the Study Team defined the geographic boundary within which possible indirect development and potential cumulative effects could occur as the AOI (Exhibit G–30). The AOI is an irregularly shaped study area for land use in the northwest Houston metropolitan area, over 600,000 acres (approximately 945 square miles) in size encompassing the communities of Katy, Copperfield, Tomball, The Woodlands, Spring, and Kingwood. The Study Team developed the AOI using traffic data from H-GAC. Fifteen, 30, and 45-minute trips outward from the proposed Grand Parkway corridor were calculated along each radial roadway and the end points of each time interval were connected to produce travel contours (Exhibit G–30). The travel contours were then overlaid with the regional Traffic Analysis Zones (TAZ) used by the H-GAC in their travel forecast program. By comparing the geographic extent of each travel contour with typical commutes for the Houston area, the Study Team (along with the Expert Panel - see Table 5-1) determined that only part of the typical commute trip would use the Grand Parkway with the remainder of the trip using other roadways. For example, for a typical 45-minute commute, 15 minutes could be spent traveling to the Grand Parkway, 15 minutes traveling on the Grand Parkway, and the remaining 15 minutes traveling on other roadways to the final destination. Using this assumption, the 15-minute contour was selected and then adjusted to coincide with the nearest H-GAC zone to form the outer boundary of the AOI. The inner boundary of the AOI (also shown in Exhibit G–30) was set by existing dense development that roughly parallels SH 6 and FM 1960. These efforts are described in detail in *Working Paper #2: Secondary Development Analysis* (Michael Baker Jr., Inc., 2000b), available on the Grand Parkway website, www.grandpky.com.

Please note that the study area (Exhibit G–14) is approximately 300 square miles, while the AOI (Exhibit G–30) is approximately 945 square miles. The study area is the area within which alternative corridor locations were developed and direct effects were assessed. The AOI is the geographic boundary within which possible indirect and cumulative development and potential cumulative effects could occur.

5.2 LAND USE FORECASTING

The Study Team recognized the need to conduct a detailed land use forecasting model involving knowledgeable members of the community with first hand experience in planning or development in the government, education, and private sectors. Drawing from a large group of transportation and planning professionals, an Expert Panel was assembled to assist the Study Team with this effort (Table 5-1). The Expert Panel and the Study Team collaborated to develop reasonable and potential scenarios of future land use maps and associated demographics for Segments E, F-1, F-2, and G for the No-Build and Build Alternatives. These efforts are described in detail in *Working Paper #2: Secondary Development Analysis* (Michael Baker Jr., Inc., 2000b). Although the Expert Panel initially convened in 2000 to address the land use issues, members of the Study Team have continued to coordinate with members of the panel or the organizations they represent to regularly update information. The responsibilities of the Expert Panel were to:

- Comment and agree on general study methods;
- Review and comment on work products throughout the study;
- Provide guidance on analytical tools employed and assumptions made as the study progressed; and
- Ensure that predictions matched actual Houston results.

The Study Team and the Expert Panel classified the land use into three land classes: Residential Development, Other Development, and Undeveloped land. Land classes 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 (levels of stress beyond which the desired condition degrades); and their current status (baseline condition). The land use component was selected due to the potential for indirect and cumulative effects related to the Grand Parkway Segments E, F-1, F-2, and G Build Alternative. More detailed discussions of the Affected Environment are included in Volumes I and II, Section 3.

5.2.1 Estimating Land Use in 2025

The proposed action's potential for facilitating land development opportunities may have an indirect and cumulative effect beyond that of the No-Build Alternative. 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. Development effects, both beneficial and adverse, would continue under the No-Build Alternative regardless of when or if the Grand Parkway is constructed, but the Build Alternative will compliment and reinforce the development pattern and effects. Land use is seen as the most influential cumulative effect for all resources, both human and natural, in the AOI.

TABLE 5-1
THE EXPERT PANEL

Expert Panel Member	Position or Affiliation
John Chiang	Member of Houston Planning Commission; Grand Parkway Board Member – Involved in apartment development
Alan Clark	Executive Director of the H-GAC – Oversees regional transportation planning for the eight-county Houston metropolitan area, including demographic forecasts and traffic modeling
Kim Coleman	Cy-Fair Independent School District – Cy-Fair is a suburban school district within the project area that has devoted considerable effort in acquiring property to meet projected growth
Charles Dean	Harris County Planning and Development
John deBessonet	Harris County Engineering Department, Park Planning – Parks are important to the quality of life for many people; appropriate expertise in this topic was necessary
Richard DeBose	H-GAC – Travel Modeling
John Fourqurean	Director of Planning, Research, and Evaluation; Cy-Fair Independent School District
Reeves Gilmore	Harris County Public Infrastructure Department – Oversees all plat applications and planning documents and coordinates with the city of Houston
Paul Hawkins, P.E.	Assistant Precinct Engineer, Harris County Precinct 3 – The Grand Parkway would intersect or parallel several precinct roads. This precinct is undergoing substantial development pressure
Robert Heineman	Vice President, Woodlands Operating Company – The Woodlands is Houston's largest master planned community, with development activities since the 1970s
Mike Inselmann	President, American Metro Study – Studied Houston's housing and development market and that of many other U.S. cities
John Jackson	City of Houston Planning and Development
Eric Lambe	City of Houston, Long Range Planning Group
Ray Laughter	North Harris Montgomery Community College District, Vice Chancellor, Center for Business and Economic Development
Madan Mangal	City of Houston Planning and Development
Mark Mooney, P.E.	Montgomery County Engineer – Montgomery County makes up nearly 25% of the project area and is undergoing current development pressures
Pamela Muhammad	H-GAC – Planning
Andy Mullins	Oversees the travel demand modeling effort for H-GAC; understands the relationship between households, income, and employment to traffic demand
Chris Olavson	Former Director of Transportation Planning, Houston District – TxDOT; currently in private consulting; brings years of experience in planning for the Houston area and working closely with H-GAC
Pamela Rocchi	Harris County Precinct 4 Engineering
Max Samfield	GIS Data Services Manager for H-GAC – Coordinated and analyzes geographic data between the demographers and the traffic engineers
David Schuelke	Tomball Independent School District

TABLE 5-1 (CONT.)
THE EXPERT PANEL

Expert Panel Member	Position or Affiliation
Ed Shackleford, P.E.	Precinct Engineer, Harris County Precinct 4 – The Grand Parkway would intersect or parallel several precinct roads; this precinct is undergoing substantial development pressure
Barton Smith, Ph.D.	University of Houston, Professor and Director, Center for Public Policy – Brings years of Houston-specific experience in real estate development, growth, and the economy
Jeff Taebel	H-GAC – Planning
Anthony Tangwa	City of Houston Planning
Ralph Taylor	Harris County Flood Control District – Flooding and runoff issues are critical in most of the project area; specific expertise was needed in this subject
Chris Van Slyke	H-GAC – Travel Modeling

Source: Expert Panel Sign-In Sheets, 2000

5.2.1.1 The Land Use Forecast Process: Assumptions and Methods

Regional demographic and travel forecasting typically starts with growth rates determined by H-GAC for population and employment in a given area. The growth rates are calculated based on the most recent data available. The resulting population and employment (people, households, and jobs) are then allocated to smaller geographic regions of the Houston metropolitan area.

The forecast presented here began from a different perspective to provide a more detailed look at land use. The Study Team and Expert Panel agreed that the land use categories would be drawn onto maps and the population and employment figures would then be generated from the land use maps. The No-Build and Build Alternative maps predict future development for each alternative. From these maps, the Study Team estimated the total number of households and jobs (employment) for the year 2025, with concurrence from the H-GAC and the city of Houston Planning Commission.

The Expert Panel was presented with the historic land use maps, which present snapshots of residential and other development from 1970, 1980, and 1995 (Exhibits G–24a through G–24c). These maps summarized land development (rates, patterns, and extent) over the past 30 years. The Expert Panel was also presented with a year 2000 base map (Exhibit G–24d) that contained existing residential and commercial development, parks and mitigation areas, wetlands, and floodplains, as well as development with plat approval.

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 Alternatives. From this, the Study Team could then determine what growth and hence what indirect and cumulative impacts could be attributed to the development of the Grand Parkway (Build Alternative). The Expert Panel convened

four times between January and June of 2000. 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. Remaining land, free of these constraints, was then analyzed for development potential and land uses were allocated under both the No-Build and Build Alternatives. The land use categories developed by the Expert Panel are described in Table 5-2.

TABLE 5-2
LAND USE CATEGORIES DEFINED BY THE EXPERT PANEL

Land-Use Category[1]	Definition
Residential	Characterized by degree of density
R1	High density single family
R2	Low density single family
R3	Multi-family
Master Planned Community	A suburban plan that includes homes and commercial, work, educational and community facilities
Commercial	Characterized by type: retail, office, or industrial
Undeveloped/Constrained	Would remain undeveloped due to a form of an environmental constraint (e.g., parks, wetlands, and floodplains)
Undeveloped [2]	Would remain undeveloped due to a lack of demand

Notes: [1] The land use categories are those that the Expert Panel agreed were most reasonable and do not represent land use controls or regulations.
[2] Undeveloped land was defined as land with no visible buildings or infrastructure.
Source: Study Team and Expert Panel, 2000

5.2.2 USGS/National Oceanic and Atmospheric Administration (NOAA) Draft 2001 National Land Cover Database (NLCD)

In addition to the land use forecasting by the Study Team and the Expert Panel, the Study Team utilized USGS/NOAA Draft NLCD (2001) information to determine the vegetative composition of undeveloped land in the AOI. The NLCD 2001 Landsat data were acquired from the Coastal Change Analysis Program (C-CAP) data center of the NOAA. The dates of the images were chosen by the National Land Cover Characterization 2001 project, which is conducting a land use study to update the 1992 NLCD study. The 2001 NLCD data are a grid-based file with each 30-meter cell containing one of 21 possible land use categories (Table 5-3). The Landsat data are classified through computer software processes; however, other ancillary data sources were used to augment the final land classification. These sources include census, urban boundaries, NWI wetlands, and aerial photography. The use of these ancillary data adds to the overall accuracy of the final land cover classification.

TABLE 5-3
USGS/NOAA DRAFT 2001 NLCD – THEMATIC CLASSES

Class	Sub-class
10 Water	11 - Open Water 12 - Perennial Ice/Snow
20 Development	21 - Developed, Open Space 22 - Developed, Low Intensity 23 - Developed, Medium Intensity 24 - Developed, High Intensity
30 Barren	31 - Barren Land 32 - Unconsolidated Shore
40 Forested Upland	41 - Deciduous Forest 42 - Evergreen Forest 43 - Mixed Forest
50 Shrubland	52 - Scrub/Shrub
60 Non-Natural Woody	61 - Orchards/Vineyards/Other
70 Herbaceous Upland Natural/Semi-Natural Vegetation	72 - Grassland/Herbaceous
80 Herbaceous Planted/Cultivated	81 - Pasture/Hay 82 - Cultivated Crops
90 Wetlands	90 - Woody Wetlands 91 - Palustrine Forested Wetland 92 - Palustrine Scrub/Shrub 93 - Estuarine Forested Wetlands 94 - Estuarine Scrub/Shrub 95 - Emergent Herbaceous Wetland 96 - Palustrine Emergent Wetland (Persistent) 97 - Palustrine Emergent Wetland 98 - Palustrine Aquatic Bed

Source: EPA, 2001b

5.2.2.1 Landsat Imagery

The proposed land use analysis can be better understood through a more thorough discussion of Landsat imagery. The satellites of the Landsat program capture information though various spectral bands, each of which is sensitive to a small range of wavelength of light. When analyzed alone or in combination, these wavelength values produce unique arrays of data, which describe object properties such as the greenness of a plant or the reflectiveness of a surface. Features on the earth, whether natural or manmade, undergo changes in their properties becoming hot or cold, wet or dry at different times throughout the day, through the seasons, and year-to-year. The Landsat satellites acquire data over the same area every sixteen days along a path approximately 607 feet (185 meters) wide; two such paths comprise the AOI. For each

path, one scene is captured over the AOI leading to the possibility of two homogeneous scenes of the same day conditions. Even so, weather patterns and temperature differences can vary greatly. Cloud cover often renders scenes unusable and forces the selection of a scene at an opposing seasonal time period. Issues such as these often cause localized discrepancies; therefore careful consideration should be given when analyzing trends in land use change. For more information on Landsat imagery and its uses, please visit http://landsat.gsfc.nasa.gov/.

5.2.2.2 The USGS/NOAA Draft 2001 NLCD Limitations

Landsat imagery has a base scale of 1:100,000 for mapping applications. Maps of 1:100,000 scale and smaller (covering a larger area), are typically used for regional analyses, but are not appropriate for identifying individual species, or for permitting-type applications. The 1:100,000 scale maps are more suited to land cover and change analysis on a regional scale and zoning and planning applications. The data should not be evaluated at the single pixel level, which is below the minimum mapping unit of four pixels. The data are appropriate for capturing regional trends and changes even if single pixels are wrong. **The data in subsequent tables that utilize USGS/NOAA Draft 2001 NLCD are used for the indirect and cumulative analysis only and are meant to facilitate discussions of potential cumulative impacts to land use in the AOI resulting from the development of the Grand Parkway and not to replace the actual direct impacts analysis in Section 4 (Environmental Consequences) of this volume. Direct and indirect impacts in this volume focus specifically on independent segments of the Grand Parkway and on specific alignment alternatives developed in each segment.**

5.3 INDIRECT EFFECTS

Indirect effects are defined as those "…which are caused by an 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 land 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 were assessed based on guidance described in the TRB's National Cooperative Highway Research Program (NCHRP) *Report 466: Desk Reference for Estimating the Indirect Effect of Proposed Transportation Projects* (TRB, 2002).

Examples of indirect effects could include the following:

- Development and land use changes due to improved access;
- Runoff increases due to changes in land use and increased development on land surrounding the proposed facility;
- Increased sedimentation of wetlands and streams and decreased water quality due to future development of land adjacent to the new facility;
- Loss of wildlife habitat and decreased habitat value in areas of increased land development spurred by the proposed project;

- Impact to cultural resource sites from development projects on private property that do not require cultural resource investigation because public funds or permits are not required;
- Increased use of parks and recreational areas due to more convenient access provided by the new facility; and
- Stimulation of the local economy from the circulation of construction spending; improved access to employment opportunities, markets, goods, or services such as health and education; an increased work force related to construction; and development stemming from the new facility.

Potential indirect development would be similar for all alignments of the Build Alternative. Resource specific indirect impacts were evaluated within the AOI and are discussed in the following sections. Where possible, the Study Team quantitatively determined the induced or indirect growth effect of the Build Alternative compared to the No-Build Alternative based on mapping developed by the Expert Panel (see Section 5.2). 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.

5.3.1 Land Use

The Study Team determined that land use impacts would occur under both the Build and No-Build Alternatives. Under the Build Alternative, the Expert Panel determined that the Grand Parkway would likely induce indirect development in the AOI regardless of the alternative alignment selected. The Study Team's land use analysis determined that the Build Alternative would indirectly impact 11,373 acres (2 percent of the AOI) above that expected for the No-Build Alternative. Of this acreage, 10,651 acres were converted from undeveloped to developed land. The remaining 722 acres of developed land would convert from one type of development to another. This indirect development would likely include a variety of land use intensities such as convenience stores, gas stations, retail strip malls, restaurants, office buildings, and residential, including apartments. With the Build Alternative, land use around highway interchanges, along frontage roads, and at grade separations with entrance/exit ramps to the proposed Grand Parkway would likely have new commercial development or convert from residential to commercial land use. Under the No-Build Alternative, land development would still occur in these interchange areas, but would likely be residential in nature. Under either scenario, undeveloped land would continue to be converted to commercial and residential uses throughout the AOI.

5.3.2 Geology, Soils, and Farmland

Construction of the proposed Grand Parkway and associated indirect development would result in a direct loss of some soils because of soils being removed from 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 one or more acres are required to obtain authorization under the TPDES storm water construction general permit, these impacts would be minimized through the requirement to prepare and obtain a TCEQ TPDES permit and associated SWPPP.

The construction of the proposed Grand Parkway would result in effects to prime farmland soils. Some prime farmland soils would be converted directly to a ROW use. Additionally, farmland soils could be impacted by indirect development outside of the project ROW. However, indirect impacts due to the construction of the project have been determined to be minimal by a formal scoring by the NRCS on June 9, 2005.

5.3.3 Social

Indirect development would occur because of the proposed Grand Parkway and could affect the daily lives of residents of the AOI. Potential indirect development would be similar for all alignments. 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 (i.e., conversion of undeveloped land to single-family residences, or conversion of undeveloped or single-family residences to multi-family residences), 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 life style.

All of the proposed project alternatives would provide an opportunity for alteration of land use patterns at or near entrance/exit ramps and highway interchanges and adjacent to frontage roads. This 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, offices, and some housing for residents of the AOI, but would not have any disproportionate effects on minorities or low-income persons. 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 where local communities, planners, developers, and service providers have provided the basic infrastructure (utilities and roads) conducive to residential/commercial development.

Indirect development and potential community change can be perceived as positive or negative. To some, this change is unwanted and development is undesirable as land is converted to residential and commercial uses and area populations increase. For others, new development often means potential new jobs, increased economic utility, reduced travel times for users of the facility, and potentially reduced travel time for users on the current roadway network in the AOI because of reduced congestion.

5.3.4 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, but local governments could in turn use these tax dollars to increase and improve community services, maintain and improve local roadways, and improve and provide public recreational opportunities. Growth in residential/commercial development would increase the demand for consumer services, including, but not limited to, retail, banking, medical, and recreational.

5.3.5 Pedestrian and Bicyclists

Pedestrians and bicyclists could benefit from the indirect development of residential and commercial streets, in conjunction with this project. This benefit could be further realized if pedestrian walkways and bicycle facilities are incorporated into transportation plans within the AOI. Proposed pedestrian walkways and bicycle facilities will be considered for incorporation to the proposed Grand Parkway where determined safe, reasonable, and feasible. All existing and planned facilities would be accommodated by the proposed project.

5.3.6 Air Quality

The network of future roadways and subdivision streets within the AOI are expected to contribute to further traffic improvements from the base year (2000). The Study Team's land use analysis determined that the Build Alternative would indirectly influence 11,373 acres (2 percent of the AOI) above that expected for the No-Build Alternative. Developing this area under the Build Alternative would indirectly contribute 6.7 tons of MSAT per year in 2025. If compared to the total 2025 Build Alternative MSAT in the entire AOI, the indirect MSAT account for approximately 2.25 percent of the AOI. Other potential indirect impacts of air quality could occur with increased industrial development in the AOI spurred by the proposed Grand Parkway. Generally, industrial facilities that emit air pollutants would be governed and permitted through the TCEQ.

5.3.7 Noise

Future increases in ambient noise levels associated with projected development are anticipated, especially in proximity to the proposed Grand Parkway. 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.

5.3.8 Water Quality

Future increases in storm water runoff levels, non-point source pollution, and effects to groundwater associated with projected regional and local development are anticipated with the No-Build and Build Alternatives. The network of future roadways and subdivision streets, in conjunction with the proposed project, would contribute to increased runoff as

impermeable surface area increases. The density and type of future development within the AOI would contribute to the overall changes in runoff. The TPDES program will minimize the amount of pollutants flowing into nearby streams and reduce the impact to the streams' water quality. Appreciable differences in water quality are not anticipated between the No-Build and Build Alternatives with the implementation of the TPDES program.

5.3.9 Wetlands and Vegetative Communities

The Expert Panel determined that land use impacts, which include impacts to wetlands and vegetative communities, would occur under both the No-Build and Build Alternatives within the AOI. Based on USGS/NOAA Draft 2001 NLCD data, the Build Alternative could indirectly impact 823 acres of wetland (approximately 1 percent of the 66,098 acres of total wetlands within the AOI) above that expected for the No-Build Alternative. In addition, the Build Alternative could indirectly impact 2,829 acres of the Katy Prairie (approximately 2 percent of the 148,198 acres of Katy Prairie within the AOI) above that expected for the No-Build Alternative. The general public, resource agencies, and Study Team's technical experts identified impacts to wetlands and unique habitat, including the Katy Prairie, as key concerns during project development. Filling and dredging activities of wetlands are regulated under Section 404 of the CWA by the USACE and other permitting agencies.

5.3.10 Wildlife

The Expert Panel determined that land use impacts, which include impacts to wildlife habitat, would occur under both the No-Build and Build Alternatives within the AOI. The land use analysis determined that the Build Alternative would indirectly impact approximately 10,651 acres of undeveloped land or potential wildlife habitat (3 percent of the approximate 371,219 acres of undeveloped land in the AOI) above that expected for the No-Build Alternative. Removal or fragmentation of habitat due to the development of farmlands, forests, wetlands, and other habitat could impact the foraging, breeding, and roosting activities of many terrestrial wildlife species. Indirect development could impact aquatic species by increasing sedimentation in streams, wetlands, and other natural waterbodies and by decreasing water quality due to increased roadway runoff, other nonpoint source runoff, or point source toxic spills flowing into aquatic habitats.

5.3.11 Waterbody Modifications and Floodplains

Based on assumptions made by the Expert Panel, indirect project impacts would not be located within the AOI floodplains. Executive Order 11988 restricts development in the floodplains. Additionally, county and local ordinances regulate development in floodplains.

5.3.12 Wild and Scenic Rivers

The proposed project is not situated in the vicinity of any river either on the National Inventory of River Segments included in the National Wild and Scenic River System list (NPS, 2007) or on the Nationwide Rivers Inventory list (NPS, 2004); no direct or indirect impacts to Wild and Scenic Rivers would occur.

5.3.13 Coastal Barriers

The proposed project is wholly outside any coastal barrier systems and would not directly or indirectly impact coastal barrier resources.

5.3.14 Coastal Zone Management

The proposed project is not within the CMP boundary and therefore complies with the CZMA. Coordination with the CZMA is not required.

5.3.15 Essential Fish Habitat (EFH)

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.

5.3.16 Threatened and Endangered Species

No direct or indirect impacts to threatened and endangered species are expected to occur from the construction of the proposed project.

5.3.17 Cultural Resources

5.3.17.1 Non-Archeological Historic Resources

Potential indirect impacts to non-archeological historic resources may include visual, noise, atmospheric, or other types of effects at distances well removed from the area of project construction. Increased development could increase incidences of looting, vandalism, and non-scientific collecting to non-archeological historic resources. Regardless whether the No-Build or Build Alternative is selected for this project, patterns of development in the project area will likely continue in the future and will likely have an indirect impact on non-archeological historic resources.

5.3.17.2 Archeological Resources

Potential indirect impacts to archeological resources may include visual, noise, atmospheric, or other types of effect at distances well removed from the area of project construction. However, based on assumptions made by the Expert Panel, indirect project impacts would not be located within the AOI floodplains, which have a high probability for archeological resources. Increased development could also increase incidences of looting, vandalism, and non-scientific collecting to archeological resources. Regardless whether the No-Build or Build Alternative is selected for this project, patterns of development in the project area will likely continue in the future and will likely have an indirect impact on archeological resources.

5.3.18 Hazardous Materials

Potential indirect impacts to hazardous materials locations could occur because of land disturbing activities from potential development, infrastructure, or utility improvements. This risk could be minimized or avoided by conducting a Phase I Environmental Site Assessment to identify potential hazardous materials prior to property acquisition and development.

5.3.19 Visual and Aesthetic Qualities

The proposed Grand Parkway facility would alter the suburban 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 Grand Parkway of the surrounding landscape. Indirect development would also affect visual quality of the areas in which a facility is constructed. 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.

5.4 CUMULATIVE EFFECTS

This section describes the CEA developed to address future land development, both with and without Grand Parkway, Segments E, F-1, F-2, and G, and to assess cumulative effects that are "caused" by the facilities' construction on resources, ecosystems, and human communities. This analysis follows the requirements and processes outlined in 23 CFR 771, the FHWA Technical Advisory T 6640.8A (1987), the CEQ's handbook, *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ, 1997), *Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process*, FHWA 2003, CEQ's memorandum, *Guidance on the Consideration of Past Actions in Cumulative Effects Analysis* (CEQ, 2005), the California Department of Transportation (Caltrans) *Guidance for Preparers of Indirect and Cumulative Impact Assessments* (2005), and TxDOT's *Guidance on Preparing Indirect and Cumulative Impact Analyses* (TxDOT, 2006b). Figure 5-1 shows a conceptual model of the CEA and how it relates to land use.

While FHWA position papers and technical guidance require that cumulative effects be evaluated, the agency recognizes that 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, define its AOI, and fully understand the current social and economic conditions and transportation infrastructure of the area.

The objective of this CEA is to evaluate land development and the corresponding environmental effects for two scenarios: the Build Alternative where Segments E, F-1, F-2, and G of the Grand Parkway are fully constructed and the No-Build Alternative where the facility is not constructed.

5.4.1 Cumulative Effects Analysis (CEA) Methods

The Study Team followed an 8-step approach to evaluate cumulative effects based on TxDOT (2006b) *Guidance on Preparing Indirect and Cumulative Impact Analyses* (Table 5-4). Steps 1 through 3 identify the study area, history, and health of each resource considered in the analysis. Steps 4 through 7 involve identifying and analyzing direct, indirect, and potential cumulative effects, and Step 8 involves assessing and discussing mitigating adverse effects and developing mitigation strategies as appropriate.

TABLE 5-4
GUIDELINES FOR IDENTIFYING AND ASSESSING CUMULATIVE EFFECTS

1	Identify the resources to consider in the analysis
2	Define the study area for each affected resource
3	Describe the current health and historical context for each resource
4	Identify direct and indirect impacts that may contribute to a cumulative effect
5	Identify other reasonably foreseeable actions that may affect resources
6	Assess potential cumulative effects to each resource
7	Report the results
8	Assess and discuss mitigation issues for all adverse impacts

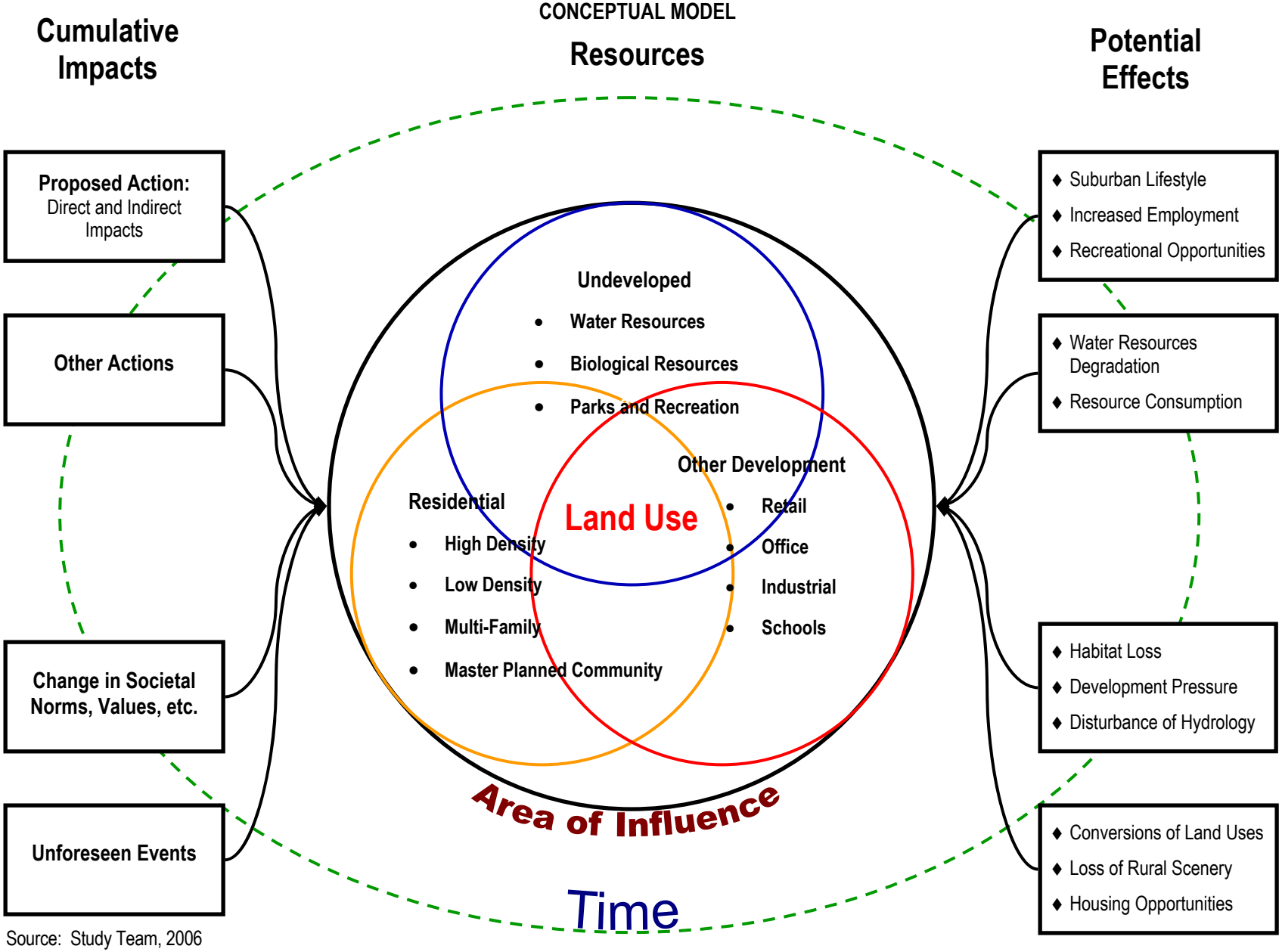
Source: TxDOT, 2006b

5.4.2 Cumulative Effects Analysis (CEA)

5.4.2.1 Step 1: Identify Resources to Consider

Step 1 requires the identification of cumulative effects issues associated with the project and the definition of assessment goals. Scoping with federal, state, local, regional, and local agencies (Table 5-5) was conducted to gather input on substantial issues in the proposed project area. In addition, numerous public meetings and workshops were conducted throughout the study area to solicit input on the proposed project and issues of concern. The Study Team used this information to evaluate the cumulative effects to all project resources and issues (Table 5-6). TxDOT (2006b) guidance (page 7) states, "If a project will not cause direct or indirect impacts on a resource, it will not contribute to a cumulative impact on that resource." The Study Team determined that if the Grand Parkway did not have a direct or indirect impact on a resource, then that resource would not be carried forward for detailed CEA. Furthermore, the AOI, as defined, delineates the area outside of which the Grand Parkway would not cause indirect (or direct) impacts to any resources. Therefore, all cumulative effects discussed are within the defined AOI.

FIGURE 5-1
CONCEPTUAL MODEL



Source: Study Team, 2006

TABLE 5-5
FORMAL AGENCY MEETINGS DURING THE SCOPING AND CORRIDOR STUDY

Date	Location	Attendees
August 18, 1999	GPA's Offices	TPWD, USACE, TCEQ, GLO, TxDOT, FHWA, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
August 26, 1999	GPA's Offices	TPWD, USFWS, TxDOT, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
February 2, 2000	Tomball College	TPWD, USACE, NRCS, FHWA, TxDOT, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
February 24, 2000	USACE – Galveston District Office	USACE, FHWA, TxDOT, GPA, Michael Baker Jr., and PBS&J
February 24, 2000	USFWS – Clear Lake Office	USFWS, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
March 3, 2000	TPWD – Clear Lake Office	TPWD, FHWA, GPA, Michael Baker Jr., and PBS&J
March 3, 2000	USFWS – Clear Lake Office	USFWS, FHWA, GPA, Michael Baker Jr., and PBS&J
November 6, 2000	EPA – Dallas Office	EPA, FHWA, TxDOT, GPA, H-GAC, and PBS&J
April 10, 2001	GPA – Houston Office	USACE, FHWA, TxDOT, GPA, Michael Baker Jr., and PBS&J
May 23, 2001	USACE- Galveston Office (Joint Evaluation Meeting)	USFWS, USACE, GLO, TCEQ, EPA, NMFS, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
June 14, 2001	Michael Baker Jr., Inc	TPWD, USFWS, USACE, GLO, TCEQ, FHWA, TxDOT, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
July 17, 2001	EPA – Dallas Office	EPA, FHWA, TxDOT, GPA, Michael Baker Jr. and PBS&J
July 31, 2001	Michael Baker Jr., Inc.	TPWD, USFWS, USACE, GPA, Michael Baker Jr., and PBS&J
October 1, 2001	GPA – Houston Office	TPWD, USFWS, TxDOT, GPA, Michael Baker Jr., and PBS&J
February 8, 2002	TxDOT ENV – Austin Office	EPA, FHWA, TxDOT, GPA, Michael Baker Jr.
March 27, 2002	EPA – Dallas Office	EPA, GPA, Michael Baker Jr.

Source: Study Team, 2002

TABLE 5-6
RESOURCES/ISSUES CARRIED FORWARD FOR FURTHER CONSIDERATION IN THE CUMULATIVE EFFECTS ANALYSIS (CEA) FOR SEGMENTS E, F-1, F-2, AND G OF THE GRAND PARKWAY

Resource/Issue		Current Health of Resource/Issue	Direct Impacts[1]	Indirect Impacts	Concerns Raised During Project Development	Pertinent Regulations	Further Study Necessary?[2]
Land Use		Changing – Existing land use continues to change due to increasing development. Changing land use from undeveloped to developed could contribute to the decline in health of natural resources.	Direct conversion of 2,664 acres of existing land use (0.4% of the AOI) (see Table 5-12).	11,373 acres of indirect impacts (2% of AOI) above No-Build Alternative. Indirect development in the AOI would be consistent with all local and state government plans and policies.	Concerns over impacts to this resource were raised during scoping and in comments received on the DEISs.	Local planning and building ordinances and selected zoning regulations where applicable.	Yes. Carried forward for further consideration in the CEA. See Section 5.4.2.2 (Step 2: Define the Study Area for Each Resource).
Geology, Soils, and Farmland		Farmland Resources declining - Land use would continue to be converted within the AOI due to suburban growth.	Completion of the formal CPA-106 NRCS form indicates no substantial direct impacts from any of the alternatives associated with the conversion of farmland soils.	Completion of the formal CPA-106 NRCS form indicates no substantial indirect impacts from any of the alternatives associated with the conversion of farmland soils.	The general public, resource agencies, and the Study Team's technical experts did not identify geology, soils, and farmland soils as a resource concern.	FPPA.	No. However see Section 5.4.2.2 (Step 2: Define the Study Area for Each Resource) for continued discussion of cumulative effects to land use.
Social Characteristics		Changing - Rural lifestyle is being replaced by expanding Houston metropolitan area. Land would continue to be converted to residential and commercial uses as area populations increase.	Direct impacts include residential, commercial, and industrial relocations (242 total displacements); impact to undeveloped school property and access to a church; and improved system linkage and mobility.	In the AOI, rural areas are expected to continue to transition to a suburban setting. New development provides potential for new jobs and increased economic utility.	Individual concerns over loss of rural lifestyle were raised during public meetings and in comments received on the DEISs.	EO 12898, Federal Actions to Address Environmental Justice (EJ) in Minority Populations and Low-Income Populations, 1994.	No. Within the AOI, rural areas would continue to transition to a suburban setting as Houston expands and land is converted to residential and commercial uses. New development provides potential for new jobs and increased economic utility.
Economics		Increasing - The greater Houston metropolitan area represents one of the fastest growing economies in the country.	Direct economic impacts of the project consist of construction-associated expenditures. Total cost is estimated to be $1.80 billion, affecting a total output of $4.04 billion, a total value added of $2.05 billion, business tax impact during construction of $105.8 million, and the temporary employment of approximately 28,540 persons in construction-related jobs.	At the county level, direct and indirect expenditures related to the project are predicted to account for an increase of 300 million dollars into the county economy as compared to the total gross product of 307 billion for Harris County and 9 billion dollars for Montgomery County (U.S. Census Bureau, 2002c).	The general public, resource agencies, and Study Team's technical experts did not identify economic impacts as a major concern associated with the proposed project.	In the context of transportation project related impacts, economy is not a regulated resource.	No. Within the AOI, increased commercial development would provide increased income, employment and earnings opportunities, and additional tax revenues. Residential growth could generate additional tax revenues, which could be used for increasing and improving community services, maintaining and improving local roadways, and improving and providing public recreational opportunities.
Air Quality	CO and Ozone	Air Quality is Improving - The Houston-Galveston-Brazoria (HGB) Area is currently classified as a "moderate" non-attainment area for ozone (EPA, 2006a). The state of Texas has requested a reclassification of the HGB non- attainment area from "moderate" to "severe" with an attainment date of June 15, 2019. Texas has made substantial progress over the past 15 years in addressing ozone in the HGB area. The 1-hour ozone rules, which will not be fully implemented until 2008, have already decreased the ozone design value from around 220 parts per billion (ppb) in 1991 to 169 ppb in 2005. TCEQ analysis predicts the area of exceedance of the 8-hour standard will decrease over 80% from 2000 to 2009. These decreases are expected to continue despite a rapid growth in the area's economy and population. The Houston-Galveston Area is currently in attainment for CO.	According to studies conducted by H-GAC and TCEQ, and based on ambient air monitors managed by TCEQ and approved by EPA, the 1-hour and 8-hour ozone design values for the HGB area from 1991 to 2005 have decreased over the past 15 years. The 2005 1-hour design value was 169 ppb, representing a 23% decrease from the value for 1991 (220 ppb). The 2005 8-hour design value was 103 ppb, a 13% decrease from the 1991 value of 119 ppb. These decreases occurred despite a 36% increase in area population. The Grand Parkway Segments E, F-1, and F-2 were included in the area's financially constrained 2025 RTP. Segments E, F-1, and F-2 were also included in H-GAC's conforming 2006-2008 TIP, while Segment G was included in the 2006-2008 TIP, Appendix D, as a project undergoing environmental review and scheduled for implementation beyond the three-year TIP time frame. The 2025 RTP and FY 2006-2008 TIP were adopted by H-GAC in April 2005 and found to conform to the SIP by the U.S. Department of Transportation (FHWA/FTA) on June 3, 2005 and October 31, 2005, respectively. The Grand Parkway Segments E, F-1, F-2, and G are included in H-GAC's 2035 RTP and FY 2008-2011 TIP, as amended. On August 24, 2007, the H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. The U.S. Department of Transportation (FHWA/FTA) found the 2035 RTP and 2008-2011 TIP to conform to the SIP on November 9, 2007.	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.	Concerns over air quality were raised during public meetings and in comments received on the DEISs.	The CAA and amendments regulate emissions and air quality.	No. Analysis of CO indicated that concentrations are not expected to exceed the national standard. In addition, the Grand Parkway has been included in the area's financially constrained 2035 RTP and FY 2008-2011 TIP adopted on August 24, 2007 by H-GAC.

TABLE 5-6 (CONT.)
RESOURCES/ISSUES CARRIED FORWARD FOR FURTHER CONSIDERATION IN THE CUMULATIVE EFFECTS ANALYSIS (CEA) FOR SEGMENTS E, F-1, F-2, AND G OF THE GRAND PARKWAY

Resource/Issue		Current Health of Resource/Issue	Direct Impacts[1]	Indirect Impacts	Concerns Raised During Project Development	Pertinent Regulations	Further Study Necessary?[2]
Air Quality (Cont.)	CO and Ozone (Cont.)	(Cont.)	(Cont.) Changes in modeled parameters between the 2025 RTP and the updated 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional analysis is warranted before FHWA takes final environmental action. This evaluation determined that changes in the modeled parameters were minor, and therefore no additional analysis is warranted. The analysis of 2025-2035 RTP modeled parameters can be found in the Administrative Record.	(Cont.)	(Cont.)	(Cont.)	(Cont.)
	Mobile Source Air Toxics	MSAT are Decreasing through 2025 – Results of MSAT modeling were found to be substantially lower in the future (years 2015 and 2025) compared to the year 2000. MSAT will continue to improve over time due to dramatic improvements in vehicle technology and fuels and traffic flow improvements realized over time.	The proposed project potentially could contribute 10.2 tons/year of MSAT in 2025.	The proposed project potentially could contribute an additional 6.7 tons/year of MSAT indirectly related to the proposed project by 2025.	Concerns related to air quality, specifically MSAT, were raised by the general public, resource agencies, and/or the Study Team's technical experts.	Clean Air Act, Section 202(1) requires the EPA to set standards to control hazardous air pollutants ("air toxics") from motor vehicles. Currently no NAAQS have been established for any of the priority MSAT.	Yes. Carried forward for further consideration in the CEA. See Section 5.4.2.2 (Step 2: Define the Study Area for Each Resource).
Noise		Changing – Existing land use and traffic conditions continue to change due to increasing development. These changes could contribute to the rise in ambient noise levels.	Direct project impacts to 752 sensitive receivers.	Future increases in ambient noise levels associated with projected development are anticipated, especially in proximity to the proposed Grand Parkway. The network of future roadways and subdivision streets, in conjunction with this project, would be expected to contribute to increased ambient noise levels.	Concerns over noise impacts were raised during public meetings and the scoping process and in comments received on the DEISs.	FHWA NAC (23 CFR 772).	No. The AOI would continue to change from a rural to suburban setting thereby altering ambient noise levels of the area. The H-GAC traffic demand model used as inputs to the traffic noise model already assumes reasonable and foreseeable development in the AOI; therefore the cumulative impacts of noise associated with the proposed project is accounted for in the existing noise analysis.
Water Quality		Improving – Overall water quality has been improving nationwide since the CWA was implemented in 1972. However, watersheds within the AOI contain streams listed on the 2006 Texas 303(d) List of Impaired Waters. Elevated levels of bacteria constitute the primary water quality concern for each listed stream segment.	Direct project impacts to resources that would affect water quality include impacts to wetlands, floodplains, and riparian areas as well as direct crossings of waterbodies (see Table 5-15). Project construction would result in temporary increase in sedimentation and turbidity. Construction impacts would be minimized through the incorporation of appropriate BMPs for erosion control.	10,651 acres of undeveloped land (3% of undeveloped land in the AOI) would be converted to residential and commercial use above the No-Build Alternative. New development indirectly caused by the project would result in an increase in impervious cover and greater volumes of runoff during storm events. Runoff could contain oil and grease constituents, which could be carried to off-site waterbodies. New residential development would also result in new municipal discharges from sewage treatment facilities and storm water runoff from new off system roadways.	Water Quality was identified by the Study Team's technical experts as a major environmental concern associated with the proposed project.	CWA and Amendments.	Yes. Carried forward for further consideration in the CEA. See Section 5.4.2.2 (Step 2: Define the Study Area for Each Resource).
Wetland and Vegetative Communities		Declining - Changes in land use due to suburban growth are expected to convert more of the Katy Prairie.	Based on USGS/NOAA Draft 2001 NLCD data, there would be 298 acres of direct project impacts -- < 1% of the 66,098 acres of wetlands within the AOI. Direct impacts because of the project include 1,133 acres of Katy Prairie impacts -- < 1% of the 148,198 acres of Katy Prairie within the AOI.	Based on USGS/NOAA Draft 2001 NLCD data, the Build Alternative could indirectly impact 823 acres of wetland (approximately 1% of the 66,098 acres of total wetlands within the AOI) above that expected for the No-Build Alternative. In addition, the Build Alternative could indirectly impact 2,829 acres of the Katy Prairie (approximately 2% of the 148,198 acres of Katy Prairie within the AOI) above that expected for the No-Build Alternative.	Concerns over impacts to wetland and unique habitat, including the Katy Prairie, were raised by the general public, resource agencies, and Study Team's technical experts.	Section 404 of the CWA regulates the discharge of dredge and fill materials into wetlands. However, Katy Prairie is not a regulated resource.	Yes. Wetlands and Katy Prairie are carried forward for further consideration in the CEA. See Section 5.4.2.2 (Step 2: Define the Study Area for Each Resource).

TABLE 5-6 (CONT.)
RESOURCES/ISSUES CARRIED FORWARD FOR FURTHER CONSIDERATION IN THE CUMULATIVE EFFECTS ANALYSIS (CEA) FOR SEGMENTS E, F-1, F-2, AND G OF THE GRAND PARKWAY

Resource/Issue	Current Health of Resource/Issue	Direct Impacts[1]	Indirect Impacts	Concerns Raised During Project Development	Pertinent Regulations	Further Study Necessary?[2]
Wildlife	Declining - Most wildlife species in the AOI are broadly distributed across southeastern Texas. While impacts to individuals may occur, population impacts are not anticipated. Changes in land use due to suburban growth are expected to convert more of the available wildlife habitat to other uses.	Direct impacts associated with the project could include an increase in wildlife mortality associated with vehicle collisions, which does not include threatened and endangered species and EFH.	Indirect impacts to wildlife include loss of habitat and/or habitat fragmentation– the land use analysis determined that the Build Alternative would indirectly impact 10,651 acres of undeveloped land or potential wildlife habitat (3% of the 371,219 acres of undeveloped land in the AOI) above that expected for the No-Build Alternative.	Concerns related directly to specific vegetative communities and unique habitats like wetlands, Katy Prairie, and Big Thicket, were raised during scoping and public meetings, and in comments on the DEISs.	MBTA requires that impacts to migratory birds, their nests, and their young be avoided.	No. However, see Section 5.4.2.2 (Step 2: Define the Study Area for Each Resource) for continued discussion of cumulative effects to land use, which would affect available wildlife habitat. Most wildlife species in the AOI are broadly distributed across southeastern Texas. While impacts to individuals may occur, population impacts are not anticipated.
Floodplains	Stable - Flooding in the Houston area continues to be an issue. Changes in land use due to suburban growth are expected to result in encroachment of the 100-year floodplain.	Direct impacts, because of the project, include 603 acres of impacts to floodplains - <1% of the 146,054 acres of floodplains within the AOI.	Based on the Expert Panel indirect development would not occur in the floodplains. Access points to the Grand Parkway have also been located outside of the floodplains to the greatest extent practicable to minimize any potential for future floodplain development. New development indirectly caused by the project would result in an increase in impervious cover and greater volumes of runoff during storm events.	Individual concerns over floodplains and drainage were raised during scoping and public meetings, and in comments on the DEISs.	EO 11988 requires federal agencies to evaluate and minimize impacts to floodplains. Additionally, county and local ordinances also regulate development in floodplains.	No. Cumulative effects to floodplains are expected to be minimal. Based on the Expert Panel indirect development would not occur in the floodplains. In addition, county and local ordinances regulate development in floodplains.
Wild and Scenic Rivers	None present in the AOI.	The proposed action is not situated in the vicinity of any river segment on the National Inventory of River Segments included in the National Wild and Scenic River System (NPS, 2007) or on the Nationwide Rivers Inventory list (NPS, 2004); no impacts to wild and scenic rivers would occur.	The AOI is outside any wild and scenic rivers; the proposed project would not have any indirect impacts to wild and scenic rivers resources.	The general public, resource agencies, and Study Team's technical experts did not identify wild and scenic rivers as an issue of concern.	The Wild and Scenic Rivers Act, (PL 90-542 as amended; 16 USC 1271-1287).	No. This resource is not present in the AOI.
Coastal Barriers	None present in the AOI.	The proposed Grand Parkway project area is wholly outside any coastal barrier systems; the proposed project would not have any impacts to coastal barrier resources.	The AOI is outside any coastal barrier systems; the proposed project would not have any indirect impacts to coastal barrier resources.	The general public, resource agencies, and Study Team's technical experts did not identify coastal barrier systems as an issue of concern.	Coastal Barrier Resources Act (PL 97–348, Approved Oct. 18, 1982, 96 Stat 1653 [As Amended Pub. L. 107–136, Jan. 24, 2002]).	No. This resource is not present in the AOI.
Coastal Zone Management	None present in the AOI.	The proposed project is not within the CMP boundary and therefore, complies with the CZMA. Coordination with the CZMA is not required.	The AOI is outside any coastal zone management; the proposed project would not have any indirect impacts to coastal zone management resources.	The general public, resource agencies, and Study Team's technical experts did not identify coastal zone management as an issue of concern.	CZMA of 1972, federal program development and approval regulations, and the Texas Coastal Coordination Act.	No. This resource is not present in the AOI.
Essential Fish Habitat (EFH)	None present in the AOI.	The proposed project does not intersect tidally influenced coastal waters and would have no impact on EFH. Coordination with NMFS is not required.	The AOI is outside any tidally influenced coastal waters; the proposed project would not have any indirect impacts to EFH.	The general public, resource agencies, and Study Team's technical experts did not identify EFH as an issue of concern.	Magnuson-Stevens Fishery Conservation and Management Act (67 FR 2343, January 17, 2002).	No. This resource is not present in the AOI.
Threatened and Endangered Species	Declining - Changes in land use due to suburban growth are expected to convert more of the available wildlife habitat to other uses that potentially encroach and disturb known and unknown species of concern.	No direct impacts to federally protected species are anticipated to occur with the proposed project. Coordination with USFWS and TPWD would continue in order to determine whether additional protected species investigations or consultation are required.	No indirect impacts to federally protected species are anticipated to occur in the AOI.	USFWS expressed concern for Texas prairie dawn.	Endangered Species Act (ESA)(16 USC 1531-1543).	No. No direct or indirect impacts; and therefore, no cumulative effects are anticipated to threatened and endangered species due to this project.
Non-Archeological Historic Resources	Declining - A continuing change in land use from rural to suburban setting is expected to encroach and disturb known and unknown cultural resource sites.	No known NRHP-listed or eligible non-archeological historic properties would be impacted by the alternative alignments.	There is a possibility for indirect impacts to non-archeological historic properties 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 project would.	The general public, resource agencies, and Study Team's technical experts did not identify issues of concern for non-archeological historic resources.	Texas Antiquities Code, National Historic Preservation Act, Section 4(f) of the Department of Transportation Act of 1966.	No. No substantial direct or indirect impacts to non-archeological historic resources are anticipated from this project; therefore cumulative effects to this resource, while possible, are expected to be minimal.

TABLE 5-6 (CONT.)
RESOURCES/ISSUES CARRIED FORWARD FOR FURTHER CONSIDERATION IN THE CUMULATIVE EFFECTS ANALYSIS (CEA) FOR SEGMENTS E, F-1, F-2, AND G OF THE GRAND PARKWAY

Resource/Issue	Current Health of Resource/Issue	Direct Impacts[1]	Indirect Impacts	Concerns Raised During Project Development	Pertinent Regulations	Further Study Necessary?[2]
Archeological Resources	Declining - A continuing change in land use from rural to suburban setting is expected to encroach and disturb known and unknown cultural resource sites.	Two previously recorded archeological sites are located within the ROW of the proposed project. Further study and coordination with the agencies will minimize impacts to these resources.	There is a possibility for indirect impacts to historic 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.	The general public, resource agencies, and Study Team's technical experts did not identify issues of concern for archeological resources.	Texas Antiquities Code, National Historic Preservation Act, Section 4(f) of the Department of Transportation Act of 1966.	No. No substantial direct or indirect impacts to archeological resources are anticipated from this project; therefore cumulative effects to this resource, while possible, are expected to be minimal.
Visual and Aesthetic Qualities	Changing - Transition from a rural to suburban/developed landscape.	The proposed project would be predominately at grade with vegetated shoulders, right-of-way, and medians.	Increases in nighttime ambient light levels would not result in appreciable increases beyond that anticipated under the No-Build Alternative.	The general public, resource agencies, and Study Team's technical experts did not identify impacts to visual or aesthetic quality as a major environmental concern associated with the proposed project.	The visual environment is not a regulated resource.	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.

Note: [1] Direct impacts were calculated from USGS/NOAA Draft 2001 NLCD data using the ROW of the Preferred Alternative Alignments for each of Segments E, F-1, F-2, and G of the proposed Grand Parkway at the time of this document production. Although other alignments could ultimately be selected as the Preferred Alternative Alignment within each segment, results of the indirect and cumulative impacts assessment (the purpose of this section of the EIS) would not be substantially affected.

[2] See Section 5.4.2.1 for a description of Step 1 of the CEA (Identify Resources to Consider).

Source: Study Team, 2006

The results of the Step 1 evaluation identified four major resources/issues that warrant more detailed discussion. These include:

1. Land Use – including farmland from a land use classification;
2. Air Quality;
    a. Mobile Source Air Toxics (MSAT)
3. Water Quality; and
4. Wetlands and Vegetative Communities, including:
    a. Wetlands, and
    b. Katy Prairie.

5.4.2.2 Step 2: Define the Study Area for Each Resource/Issue

Land Use

The cumulative effects resource study area for land use is described in Section 5.1 and is the AOI (Exhibit G–30). The AOI is over 600,000 acres (approximately 945 square miles) in the northwest Houston metropolitan area and includes the communities of Katy, Copperfield, Tomball, The Woodlands, Spring, and Kingwood. As defined, the area outside of the AOI would not experience direct, indirect, or cumulative effects to any resource because of the Grand Parkway project.

Mobile Source Air Toxics

The roads used for the MSAT traffic analysis includes all major roadways potentially affected by the proposed new transportation facility, in this case, the proposed Grand Parkway (Exhibit G–26). This analysis considers the on-road sources for the six priority MSAT (i.e., acetaldehyde, acrolein, benzene, 1,3 butadiene, diesel particulate matter [DPM], and formaldehyde) and is based on future volumes of traffic that have been projected using a travel model that includes all the roadway links within the total traffic study area.

Water Quality

The cumulative effects resource study area for water quality was developed by the Study Team by identifying the watersheds that intersect the AOI. The resource study area for water quality is over 1,646,000 acres (approximately 2,572 square miles) in the northwest Houston metropolitan area. Since the late 1980s, watershed organizations, tribes, and federal and state agencies have moved toward managing water quality by using a watershed approach (EPA, 2005d). In Texas, TCEQ manages the Water Pollution Control Program, the primary regulatory program to maintain, restore, and enhance water quality, by watershed (TCEQ, 2007). The cumulative effects resource study area boundary for water quality was formed by connecting the outermost limits of each of the watersheds that intersected in the AOI (Exhibit G–31) and included the watersheds of Lake Creek, Spring Creek, Cypress Creek, Buffalo Bayou Above Tidal, White Oak Bayou Above Tidal, Greens Bayou, Lake Houston, Peach Creek, West Fork San Jacinto River, and Caney Creek.

Wetland and Vegetative Communities

Wetlands

The cumulative effects resource study area for wetlands was developed by the Study Team using the watershed approach. Watersheds were used to establish the wetlands study area boundary because impacts to wetlands can affect the overall health of a watershed. Since the late 1980s, watershed organizations, tribes, and federal and state agencies have moved toward managing water quality by using a watershed approach (EPA, 2005d). Wetlands are important elements of a watershed because they serve as the link between land and water resources. This link has been demonstrated in practice by resource agency requirements for compensatory mitigation for wetland impacts within the same watershed whenever possible. Impacts to wetlands can greatly affect watershed health because wetlands are directly connected to watershed hydrology through sheet flow or direct hydrologic connections. Collectively, wetlands provide many watershed benefits, including pollutant removal, flood storage, wildlife habitat, groundwater recharge, and erosion control (Mitsch and Gosselink, 1986). The cumulative effects study area boundary for wetlands is identical to the watershed boundary developed for water quality and is shown on Exhibit G–31.

Katy Prairie

The Study Team conducted a literature review to determine the cumulative effects resource study area for the Katy Prairie. Previous studies have identified differing geographic boundaries for this resource based primarily on whether these investigations emphasized the prairie's relationship to historical tall-grass prairie habitats or rice fields/waterfowl habitats. Work conducted for the city of Houston's proposed Westside Airport depicted the study area for the Katy Prairie to be generally contained within Harris, Fort Bend and Waller Counties and bordered by Barker Cypress Road to the east, US 290 to the north, FM 359 as its western boundary to just north of Fulshear, with the southern border just south of the Barker Reservoir paralleling FM 1093 (Turner, Collie, and Braden, Inc., 1998). Hobaugh et al. (1989) and Robertson (1991) depict the Katy Prairie as centrally located between Harris, Waller, and Fort Bend Counties with the geographical center being located within the Katy city limits. These geographical boundaries are directly related to the primary rice prairies along the upper Texas coast.

Lobpries (1994) depicts the boundaries of the Katy Prairie as the Katy-Hockley Prairie and incorporates an area that is described as crops, other native and/or introduced grasses, and pecan-elm forest and pine hardwood forest based on the *Vegetation Types of Texas (*McMahan et al., 1984). This boundary is generally bordered by the Brazos River floodplain to the west and the southwest, the floodplain of Spring Creek to the north between Harris and Montgomery counties, the urban edge of the city of Houston and the pine hardwood forest to the northeast, the edge of Beltway 8 and the urban area of Harris County to the east, and the boundary of US 90 to the Brazos River to the south.

The similarity of the reviewed geographic boundary descriptions is that the Katy Prairie is located within Harris, Waller, and Fort Bend Counties, extends west and south to the Brazos River, and is generally bounded by Spring Creek to the north and urban Houston to the east. The Study Team identified the Katy Prairie cumulative effects resource study area (Exhibit G–32) as the area common to the selected *Vegetation Types of Texas* (McMahan et al., 1984), the rice prairie boundaries as identified by Hobaugh (1989) and Lobpries (1994), and the Grand Parkway AOI. The Brazos River serves as the western boundary of the cumulative effects resource study area as it represents a distinct and unique vegetative break from a grassland prairie to a forested system (riparian corridor). The northern boundary primarily follows Spring Creek and the edge of the native grasses vegetation type (McMahan et al., 1984) within Harris and Waller Counties. The eastern boundary follows SH 6, which generally parallels the boundary of the crops and urban vegetation types (McMahan et al., 1984). Development of the eastern boundary took into consideration the changes in land uses between 1984 and 2005 and incorporates a majority of the Addicks and Barker Reservoirs, which were historically part of the Katy Prairie. US 90 serves as the southernmost boundary of this study area because it generally coincides with Lobpries' (1994) boundaries and provides a logical split between the Katy Prairie and the Danbury Prairie historically located south of US 59.

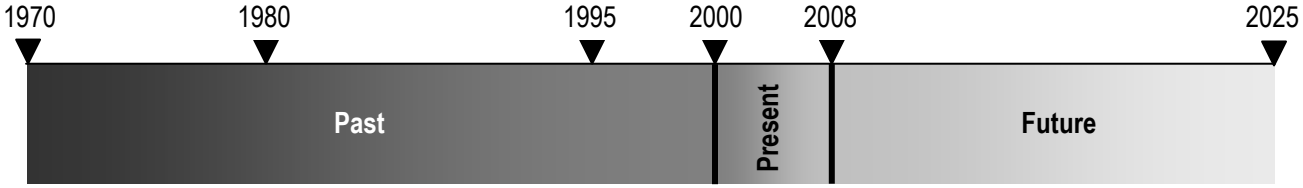
5.4.2.3 Step 3: Describe the Current Health and Historic Context for Each Resource/Issue

Land Use

The CEA integrated information from field reconnaissance; federal, state, regional, and local agencies coordination; public workshops and meetings; analysis of 2001 land-remote sensing satellite (Landsat) data; and 2005 aerial photography to update land use development in the AOI.

The overall time frame spans from 1970 to 2025. The past time frame is from 1970 to 2000, present time is considered 2000 to 2008, and the future time frame is from 2008 to 2025 (Figure 5-2). The Study Team examined aerial photos from 1970, 1980, and 1995 supplied by NRCS to understand land use changes that occurred in the past. Along with the historic aerial photos, a 1999-2000 base map was developed for the Expert Panel (see Section 5.2). The 2000 base map was then updated to 2007 (Exhibit G–33) using aerial photography from H-GAC for comparison with the prior years' photos.

FIGURE 5-2
TIME SCALE



Source: Study Team, 2008

Three basic land use categories were mapped to produce Exhibit G–24a-d and were used in this analysis:

- Residential Development (single and multi-family dwellings);
- Other Development (e.g., commercial, industrial, or other non-residential development); and
- Undeveloped (no visible buildings or infrastructure).

Table 5-7 presents a summary of land use within the AOI. The table shows, for example, that in 1970 12,318 acres of the 604,141-acre AOI was composed of Residential Development (2 percent).

TABLE 5-7
COMPOSITION OF LAND USE IN THE AOI BY YEAR

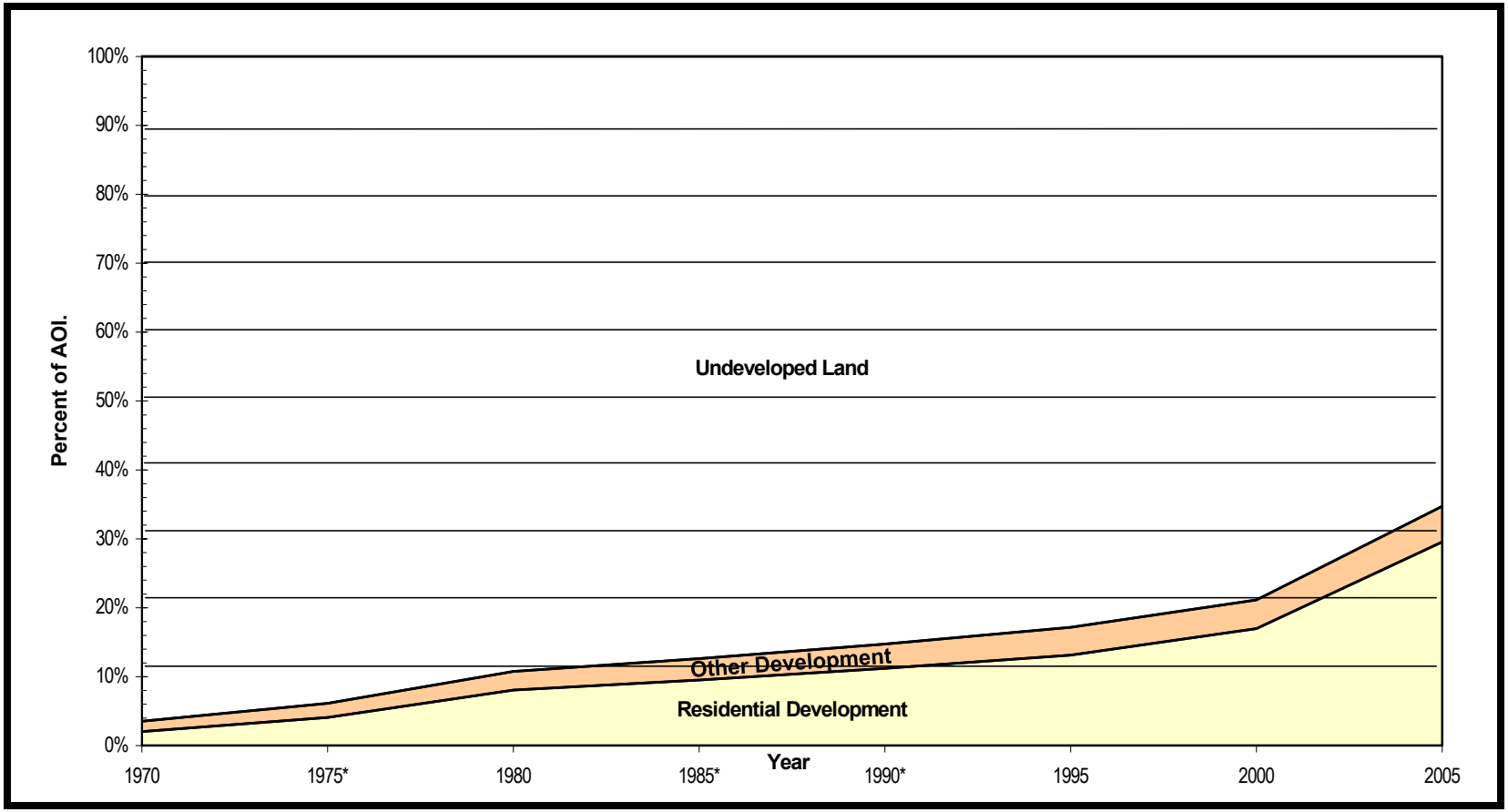
Time Frame	Year	Residential Development		Other Development		Undeveloped	
		Acres	% of AOI*	Acres	% of AOI *	Acres	% of AOI *
Past	1970	12,318	2.0%	9,060	1.5%	582,763	96.5%
	1980	48,671	8.1%	16,373	2.7%	539,097	89.2%
	1995	79,326	13.1%	24,378	4.0%	500,437	82.8%
Present	2000	102,599	17.0%	25,093	4.2%	476,449	78.9%
	2005	201,110	33.3%	31,812	5.3%	371,219	61.4%

Note: * Rounded percent of total acreage in the AOI (604,141 acres).
Source: Study Team, 2000; 2005 and NRCS, 2000b

In the period 1970 to 2000, 90,281 acres of new Residential Development occurred, which translates to a 7.3 percent compound annual growth rate. These data show an approximate 3.5 percent growth in Other Development from 1970 to 2000. As shown in Figure 5-3, Residential and Other Development properties experienced a development boom from 1970 to 1980. In 1980 to 1995, both Residential and Other Development slowed due to an economic downturn. Between 1995 and 2000, the residential market started to rebound, but Other Development remained stagnant, possibly due to utilization of existing structures that had been vacated during the 1980 to 1995 period. From 2000 to 2005, Residential Development has grown approximately 14.4 percent and Other Development has grown 4.9 percent. As development areas increased, undeveloped areas decreased proportionally. Undeveloped properties experienced a decline of 0.7 percent from 1970 to 2000 and 4.9 percent from 2000 to 2005.

The NLCD 2001 data classification provides an overview of the major land use features of the AOI (Exhibit G–34). Tabulations and area calculations provide a comprehensive dataset in terms of the overall landscape and the types and amount of land use categories present in the AOI (Table 5-8). The 21 possible land use categories (Table 5-3) were summarized into eight broader classes for this analysis.

FIGURE 5-3
PERCENT OF LAND USE OVER TIME



Note: * 1975, 1985, and 1990 were extrapolated using rate of growth for known data points (1970, 1980, and 1995)

Source: Study Team, 2006

TABLE 5-8
USGS/NOAA DRAFT 2001 NLCD – LAND USE/LAND CLASSIFICATION OF THE AOI

Description	Acres	% of Total AOI
Open Water	4,607	<1%
Developed	146,271	24%
Barren	5,740	<1%
Forested Upland	150,025	25%
Scrub/Shrub	33,528	6%
Herbaceous Upland	28,409	5%
Herbaceous Planted/Cultivated	169,463	28%
Wetlands	66,098	11%
Total	**604,141**	**100%**

Source: USGS/NOAA, 2001

Mobile Source Air Toxics

Historic Context

The Air Pollution Control Act of 1955 (APCA) was passed "to provide research and technical assistance relating to air pollution control." This law is the predecessor for all future clean air legislation including the Federal CAA of 1970. The CAA of 1970 was based on the CAA of 1963, which was amended in 1965, 1966, 1967, and 1969. The CAA of 1970 law required the EPA to publish the NAAQS for specific pollutants within 120 days of the signing of the law. The "criteria pollutants" to be regulated included carbon monoxide, nitrogen oxides, sulfur oxides, photochemical oxidants, hydrocarbons, and particulate matter, with standards set for each of the criteria pollutants based upon a collection of the most current research and information with a built-in margin of safety. Currently, 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 ozone depletion.

The EPA is the lead federal agency for administering Section 202 of the CAA and has certain responsibilities regarding the health effects of MSAT (EPA400-F-92-004, August 1994). In 2001, the EPA issued a final rule on controlling emissions of hazardous air pollutants (HAPs) from mobile sources (66 FR 17229, March 29, 2001). This rule was issued under the authority in the CAA, and the rule's preamble provides the following summary information regarding the effects and control of MSAT:

> 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, and DPM and diesel exhaust organic gases (DEOG).

Twenty-one compounds are emitted from motor vehicles that are known or suspected to cause cancer or other serious health effects. The MSAT list includes various VOCs and metals, as well as DPM and DEOG. In its final rule, the EPA also examines the mobile source contribution to national inventories of these emissions and the impacts of existing and newly promulgated mobile source control programs, including the RFG (reformulated gasoline) program, national low emission vehicle (NLEV) standards, Tier 2 motor vehicle emissions standards and gasoline sulfur control requirements, and the EPA's proposed heavy duty engine and vehicle standards and on-highway diesel fuel sulfur control requirements (EPA, 2000b). Between 2000 and 2020, the EPA projects these programs will reduce on-highway emissions of benzene, formaldehyde, 1,3-butadiene, and acetaldehyde by 57 to 65 percent, and reduce on-highway DPM emissions by 87 percent (EPA, 2007a).

In an ongoing review of MSAT, the EPA completed another set of rules under the authority of CAA Section 202(l) to further reduce MSAT emissions. The EPA issued a set of final rules on Control of Hazardous Air Pollutants from Mobile Sources (72 FR 8427, February 26, 2007) under 40 CFR 59, 80, 85, and 86. As a result of this review, EPA adopted the following new requirements to substantially 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 (EPA, 2007a).

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. EPA adopted standards to reduce NMHC 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, 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 grams of hydrocarbons per gallon per day (EPA, 2007a).

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), volatile organic compounds by more than 1,000,000 tons, and $PM_{2.5}$ by more than 19,000 tons.

Current Levels of MSAT in the Greater Houston Area, Available TCEQ Monitor Data

TCEQ and other local entities operate air quality monitors in the Houston area. In the Houston area, there are 57 active monitors. This network of monitors measures the air quality and determines the levels of the various pollutants in the air. With this in mind, the following paragraphs discuss the monitors nearest to the project (Table 3-7), as well as ambient monitors that have detected levels of MSAT.

The closest air quality monitors are between approximately 0.8 miles and 6.1 miles of the Grand Parkway segments (Table 5-9). The closest air quality monitor is about 0.8 miles from Segment F-1. The closest $PM_{2.5}$ monitor used for compliance with the $PM_{2.5}$ NAAQS is about 27.4 miles from Segment G. The official monitor data are found on EPA's national air quality monitor web site (www.epa.gov/air/data). Not all monitors sample for the same pollutants, and not all monitors have one year of complete data to compile an annual average for any given pollutant (Table 5-9).

The Mayor of Houston has recently organized a task force to help reduce air quality health risks in Houston. The main focus of this task force is to "…review and summarize the available evidence on the health risks associated with air pollution in the Houston region, recommend areas of research needed to allow regional leaders to make the best decisions on strategies for reducing pollution, within established legal timetables, and to provide guidance to the City on strategies for reducing health risks."

TABLE 5-9
LOCAL MONITOR DATA

Air Monitor	Activation Date	Average Ozone 2006	Annual Average $PM_{2.5}$ 2006	Average Benzene 2006**	Average 1,3 Butadiene 2006**	Distance from GP/Segment
CAMS 26	April 1997	0.0445 ppm (Standard is a 3 year average which must be 0.080 ppm or below)	N/A	9.48 ug/m^3	0.17 ug/m^3	0.8 miles from F-1
CAMS 555	April 2004	N/A	N/A	N/A	N/A	6.0 miles from G
CAMS 309	February 2001	N/A	11.59 ug/m^3 *	N/A	N/A	5.6 miles from G
CAMS 557	February 2004	N/A	N/A	N/A	N/A	5.7 miles from F-2
CAMS 554	January 2004	N/A	N/A	N/A	N/A	6.1 miles from E
CAMS 148	August 1998	N/A	10.25 ug/m^3 (Standard is a 3 year annual average below 15 ug/m^3)	10.41 ug/m^3	0.69 ug/m^3	Closest $PM_{2.5}$ compliance monitor to any GP segment (27.4 miles from Segment G)

Notes: EPA disclaimer regarding these 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 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."

* Not a regulatory monitor for $PM_{2.5}$ - these monitors do not use the same collection and analysis methods for measuring $PM_{2.5}$ data and are therefore not used for compliance monitoring.

** Currently, no NAAQS have been established for any of the priority MSAT. The EPA is in the process of assessing the risks of exposure to these pollutants. For more information, see the MSAT Technical Report in Appendix F or http://www.epa.gov/iris for potential human health effects that may result from exposure to various MSAT.

Source: EPA, 2007b

Existing MSAT Levels

A basic quantitative analysis for the total mass of six priority MSAT emissions within the traffic study area of Segments E, F-1, F-2, and G was completed. The traffic study area used for this traffic analysis includes all major roadways potentially affected by the proposed new transportation facility, in this case the Grand Parkway. The traffic study area is generally bounded by IH 10 to the south, US 59 to the east, and extends just beyond the proposed Grand Parkway to the north and west. These areas appear graphically in Exhibit G–26.

A discussion of how total MSAT emissions were estimated, and some of the limitations and cautions regarding these estimations is contained in Section 3.6.2 of this volume and Appendix F. A summary of these emissions for the base year is shown in Table 5-10 and Figure 5-4. Total MSAT emissions for just for the proposed Grand Parkway roadway are shown in Table 5-14.

TABLE 5-10
BASE YEAR (2000) TOTAL MSAT EMISSIONS FOR THE ENTIRE TRAFFIC STUDY AREA (SEGMENTS E, F-1, F-2, AND G)

Compound	2000 Base Year (tons/year)
Acetaldehyde	77
Acrolein	10
Benzene	446
Butadiene	66
Formaldehyde	258
Diesel Particulate Matter	659
Total MSAT	**1,516**

Source: Study Team, 2006

Water Quality

Historic Context

Water quality issues in Texas can be historically linked to early 19th century European settlement. The conversion of mature forests and native landscapes contributed to water quality declines through increased sedimentation and erosion. As agricultural practices evolved from small, subsistence family farms to the large-scale mechanized post World War II operations, water quality continued to decline. In addition to agriculture, exploration and development of oil and gas resources in the early 20th century also contributed to water quality concerns. The 20th century also introduced fertilizers, pesticides, concentrated animal wastes, household chemicals, and pollutants from automobiles as potential water contaminants.

Growing public awareness and concern for controlling water pollution led to enactment of the CWA of 1972. The CWA set water quality standards for major rivers and lakes and required discharge permits for both public and private facilities. The act was strengthened in 1977 in an effort to address the most visible causes of water pollution. It explicitly prohibited the discharge into waterways of hazardous substances, including industrial waste, sewage, accidental spills, toxics, and other point sources. Today, TCEQ is the primary agency responsible for water quality management in the state and the EPA is ultimately responsible for insuring that these efforts meet federal water quality standards.

Current Health

Pollution has to some degree affected all of Texas' 15 inland river basins and eight coastal basins, several of its reservoirs, and all of its estuaries, coastal wetlands, and bays. TCEQ regularly monitors the condition of the state's surface waters and assesses the status of water quality every two years. The agency produces an inventory of all state surface waters, and a list of the waters that do not meet one or more of the standards established to ensure the beneficial use of the waterbody, the 303(d) List. In general, the period of record for water quality data and information used in the 2006 Inventory and List is December 1, 1999 to November 30, 2004.

For 2006, the TCEQ surveyed approximately 12 percent of Texas streams (TCEQ, 2007). Many miles of streams and rivers did not have sufficient data to determine if they met state water quality standards, and in fact, TCEQ identified hundreds of miles of streams and rivers with water quality "concerns" but with insufficient data to meet their methodology for calling a stream or river "impaired."

Waterbodies that do not support their water quality standards, and for which existing controls are not adequate, are placed on the 303(d) List of Impaired Waterbodies (as required under Clean Water Act [CWA] Section 303[d]). With an increase in data since the 2004 303(d) List, TCEQ added several segments (e.g., Lake Houston) within the West Fork San Jacinto sub-basin for inclusion on the 2006 303(d) List. Now, with the exception of Lake Creek, all of the stream segments located within the watershed cumulative effects study area appear on TCEQ's 2006 Texas Water Quality Inventory and 303(d) List. Although many segments throughout Texas were removed from the list, none of the segments within the watershed cumulative effects study area were among those delisted.

The primary reason stream segments were listed was for bacteria levels not suitable for the designated use of contact recreation. Reasons found for the elevated bacteria were both non-point and point sources, including urban runoff/storm sewers, on-site treatment systems, sanitary sewer overflows, municipal sources, and unknown sources (TCEQ, 2007). Many of the segments in the watershed cumulative effects study area were listed as Category 5a in the 2006 303(d) List, meaning they require remedial action by the state to restore water quality. The state must develop a TMDL scientific model for the stream segment and a plan to implement it.

Vegetative Communities - Wetlands

Historic Context

Approximately 392 million acres of fresh water and estuarine wetlands existed in 1780 in lands that now form the United States. Of that, 221 million acres were in the conterminous 48 states. As of the 1980s, the lower 48 states support only an estimated 103.3 million acres, a 53 percent loss from the original wetland acreage (TPWD, 1997).

Between the mid-1970s and the mid-1980s, the lower 48 states lost over 2.6 million acres of wetlands, with freshwater systems sustaining 98 percent of that loss. By the mid-1980s, an estimated 97.8 million acres of freshwater wetlands and 5.5 million acres of estuarine (coastal) wetlands remained. Wetlands losses in this period resulted from conversion to agricultural land use (54 percent) and other land uses (41 percent). "Other" uses include land uses that are not classified as agriculture or urban. Urban expansion resulted in 5 percent of the losses (TPWD, 1997). Between 1986 and 1997, an estimated 58,500 acres of wetlands were lost each year in the conterminous United States (EPA, 2006c). Various factors have contributed to the decline in the loss rate including implementation and enforcement of wetland protection measures and elimination of some incentives for wetland drainage. Public education and outreach about the value and functions of wetlands, private land initiatives, coastal monitoring and protection programs, and wetland restoration and creation actions have also helped reduce overall wetland losses (EPA, 2006c).

Statewide

Although wetlands comprise less than 5 percent of its land area, Texas has the fourth greatest wetland acreage in the lower 48 states (following Florida, Louisiana, and Minnesota). An estimated 7,000,000 acres of wetlands were present in Texas in the 1970s. Texas wetlands are particularly important because they provide one of the most important wintering areas for waterfowl (TPWD, 1997).

Prior to the settlement of Texas, an estimated 16 million acres of bottomland hardwood and other forested wetlands existed. These floodplain forests are among the most severely altered ecosystems in the United States. Between 1820 and 1920, most of East Texas' virgin timber, including floodplain forests, were removed for building, commercial logging, grazing, and farming. Bottomland forests have since been impacted by mining and petroleum extraction, urban development, reservoirs, agriculture, lack of forest management, pollution, and minor floodplain modifications. Forested wetlands totaled approximately 6,068,000 acres in 1980, including 5,973,000 acres of bottomland hardwood and other forested riparian vegetation and 95,000 acres of swamps, a 63 percent loss of the original pre-settlement bottomland forests (TPWD, 1997).

The USFWS assessed the status and trends of coastal Texas wetlands to provide detailed information regarding coastal wetland loss rates (Moulton et al., 1997). An estimated 4,105,343 acres of coastal Texas wetlands existed in 1955 and an estimated 3,894,753 acres existed in 1992. Overall, estuarine wetlands decreased by approximately 9.5 percent and

freshwater or non-tidal wetlands decreased by 4.3 percent. Nearly one in three acres of coastal freshwater emergent marshes has been lost, while 11 percent of the coastal freshwater-forested wetlands have disappeared since 1955.

Historically, wetlands in the southeastern portion of the AOI were dominated by coastal prairie wetlands, riparian zones and few forested wetlands. The former tall grass prairies dotted with shallow, ephemeral prairie wetlands and meandering bayous, creeks, and rivers have been replaced by agricultural fields in response to an increased market demand for rice and other crops (Stutzenbaker and Weller, 1989). Wetlands in the central portion of the AOI consisted of forested and non-forested wetlands, which were used for farming and timber production. The majority of wetlands in the northeastern portion of the AOI historically consisted of forested wetlands used for timber production and grazing.

Current Health

Based on the USGS/NOAA Draft 2001 NLCD data for the AOI (Exhibit G–34), 194,687 acres of wetlands are within the wetlands cumulative effects resource study area. Of that total, 66,098 acres (34 percent) are within the AOI (Table 5-11 and Exhibit G–32).

TABLE 5-11
USGS/NOAA DIRECT 2001 NLCD WETLANDS IN CUMULATIVE EFFECTS STUDY AREA

Watershed	Total Wetlands within Watershed (acres)	Wetlands within AOI (acres)	% of Watershed Wetlands within AOI
Buffalo Bayou Above Tidal	18,426	12,867	70%
Caney Creek	18,912	4,282	23%
Cypress Creek	11,887	9,730	82%
Greens Bayou	8,449	70	1%
Lake Creek	31,253	2,987	10%
Lake Houston	37,661	2,100	6%
Peach Creek	12,480	469	4%
Spring Creek	27,135	20,601	76%
West Fork San Jacinto River	28,041	12,974	46%
White Oak Bayou Above Tidal	443	18	4%
Total	**194,687**	**66,098**	**34%**

Source: Study Team, 2006; USGS/NOAA, 2001

The NLCD data identified three major palustrine wetland types within the AOI. Palustrine wetlands include all nontidal or freshwater wetlands dominated by trees, shrubs, and emergent herbaceous vegetation traditionally called freshwater marshes, swamps, bogs, fens, and wet prairies, found throughout the United States. Within the AOI, these wetlands are of greatest concern to the public and to state and federal regulatory agencies.

Non-forested or Palustrine Emergent and Palustrine Scrub-Shrub (Cowardin et al., 1979) wetlands are scattered throughout the AOI. Many of the non-forested wetlands observed are considered early successional communities experiencing secondary succession. Various non-forested wetlands observed within Segment E and portions of Segment F-1 are remnant prairie-pothole wetlands that are known to have occurred historically throughout the Katy Prairie. Many of these wetlands occur within agricultural areas and have been converted for producing crops.

Many of the non-forested wetlands found in the AOI within Segments F-2 and G were most likely forested wetlands prior to conversion 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 observed community represents the new normal circumstance or expected community type. Due to ongoing agricultural practices and increasing urban development within the project area, the probability for these areas to revert to climax forested wetland communities is minimal.

Forested, or Palustrine Forested (Cowardin et al., 1979) wetlands, occur in isolated depressions and bottomland hardwood areas of floodplains throughout the AOI. However, the greatest concentration forested wetlands occurs within Segment G associated with floodplains, oxbows, sloughs, and remnant channels of Spring Creek and the West Fork of the San Jacinto River. The majority of the forested wetlands within Segments F-2 and G are considered mid to late successional forested wetland communities. In addition to the mid to late successional forested wetland communities, several forested wetlands located throughout the project area, especially within Segments E and F-1, appear to be early successional forested wetlands or herbaceous wetlands converting to forested wetlands.

Katy Prairie

The Katy Prairie, sometimes locally referred to as the Katy-Hockley Prairie, originally encompassed approximately 200,000 acres loosely bounded by the Brazos River bottom on the west and southwest, pine-hardwood forest on the north and northeast, and the city of Houston on the east and southeast (Vallette, 1994). Approximately one-quarter of that area has been developed by the westward expansion of the city of Houston (Vallette, 1994). Within the Grand Parkway study area, the Katy Prairie begins at IH 10 and extends northward to approximately Little Cypress Creek, north of US 290 and east to SH 249 (Segments E and F-1).

Historically, the Katy Prairie was part of the tall grass prairie of the North American Great Plains that consisted of a mosaic of tall grass prairie and emergent wetland habitats dissected with riparian corridors and dotted with tree “islands” (Smeins, 1994). In the late 1800s, the first settlers of the Katy Prairie began to raise corn, potatoes, and cattle and started to attract market hunters and sportsmen (Gore, 1994). At the turn of the century, rice farmers appeared creating 30-acre fields (Katy Prairie Conservancy [KPC], 2002). The Katy Prairie has since been converted from its historical tall grass prairie habitat to agriculture (primarily rice), ranching, and commercial/residential development. Agricultural and ranching areas still contain extensive wetland habitats, both natural and human-induced (e.g., rice fields, waterfowl roost

ponds, etc.). The North American Waterfowl Management Plan identifies wetlands within the Katy Prairie as having international significance (Texas Mid-Coast Initiative Team, 1990).

Concurrent with the increase in rice farming during the 1950s and 1960s, expansion of the city of Houston began to encroach on the Katy Prairie. In this post World War II era, new industries began to form along Buffalo Bayou and the Houston Ship Channel and growth expanded to the southwest, west, and northwest to areas outside the influence of the chemical plants (Henry, 1994). Mima mounds were scraped and pushed into lower areas and changed the micro-topographic landscape of the prairies to form areas that retained water for wetland crops (rice, sugarcane). During this period, land ownership shifted from families to investors, rice prices decreased, and as rice farming increased in production costs (BFI Waste Systems, Inc. [BFI], 1998), farmers turned to cattle production. Additionally, the demand for low-cost housing accelerated prairie development and resulted in the loss of approximately 100,000 acres between 1978 and 1983 to urban use (residential development, industrial, retail) (KPC, 2002). The area of rice fields decreased from 66,000 acres from 1977 to less than 17,000 acres in 1993 and soybean fields dropped from 50,000 acres in 1979 to 2,000 acres in 1993 (Woods, 1994). In 1978 alone, 32,000 acres of the Katy Prairie was converted to urban land uses and it was estimated in 1993 that 134,000 acres or nearly 70 percent of the historic prairie had been developed (Henry, 1994). The pre-settlement Katy Prairie no longer exists except for a few remnant pockets and has been replaced by the land uses described previously (Eubanks, 1994).

Health of Resource

The Katy Prairie has been substantially reduced from its historical extent and continues to be reduced by development and growth from the Houston metropolitan area. Henry (1994) reported a nearly 70 percent reduction of the historic Katy Prairie due to changing land uses in the early 1990s and this trend has continued through 2006. The vast majority of the Katy Prairie continues to be affected by encroaching development. The Katy Prairie cumulative effects resource study area totaled 505,905 acres of which 148,198 acres (approximately 30 percent) are within the AOI of the proposed project (Exhibit G–32).

With the advance of urban development, the Katy Prairie landscape currently providing wildlife habitat and outdoor recreation opportunities would be reduced. Many of the functions and values of the Katy Prairie would be lost as a result of the increased development pressures to the area. The Katy Prairie lies within a major migratory bird flyway, with between 350 and 400 species of birds over-wintering in the area, including approximately 18 species of ducks and four species of geese, important game birds within the region (Smeins, 1994). Waterfowl surveys conducted on the Katy Prairie by the USFWS, in 1992 recorded 184,000 snow geese (*Chen caerulescens*), approximately 23 percent of the wintering snow goose population on the Texas coast (Lobpries, 1994). Sport hunting is a sizeable industry in and around the Katy Prairie due to the large numbers of wintering waterfowl and the prairie's convenient location west of metropolitan

Houston (Gore, 1994). Conservation and education efforts are underway by organizations such as the KPC, private landowners, and the Katy-Cypress Wetlands Mitigation Bank (KCWMB). The KCWMB establishes a mitigation bank within the Cypress Creek watershed and provides the ability to enhance and create wetlands within a 579 acres tract near Katy Hockley Cutoff Road and Jack Road (KCWMB, 1996).

There has been a growing trend within the Katy Prairie of exotic and/or nuisance vegetation species invasion. Chinese tallow-tree (*Sapium sebiferum*) is one of these species. Extensive measures are being made by conservation groups, resource agencies, and private/public partners to help eradicate and/or control these species in an effort to restore native plant communities including tall grass prairie on the Katy Prairie.

Due to the developmental pressures on this area, the public and state and federal resource agencies have joined together to slow development and to protect the remaining Katy Prairie habitat. The KPC was formed in 1992 to preserve, protect, and enhance sustainable portions of the Katy Prairie ecosystem. Their goals and missions are to protect areas of the Katy Prairie either in its current state (agricultural) or enhancing and restoring wetlands and prairie habitats (KPC, 2002). The KPC is taking an active role in trying to conserve approximately 30,000 – 60,000 acres of the Prairie, promoting education and ecotourism, and acquiring, managing, conserving, and enhancing existing prairie habitats so that they may be protected in the future (KPC, 2002). The KPC provides opportunities for formal and informal education, and outdoor recreation (including birding, nature walks, hunting, and fishing). Outreach education and ecotourism by the KPC is evident throughout the Prairie with the inclusion of several viewing locations along the Upper Coastal Birding Trail, a part of the Great Texas Coastal Birding Trail.

The BFI Katy Prairie Mitigation Bank was established in western Harris County to provide high quality upland/wetland ecosystems that would offset functions and values lost by proposed dredge/fill activities. This bank serves the Katy Prairie area and associated coastal prairie ecosystems/habitats within the counties surrounding the Houston metropolitan area. The purpose of this mitigation bank is to reestablish historic tall grass prairie environments along with depressional wetlands that, within time, will resemble Katy Prairie habitats. The BFI Katy Prairie Mitigation Bank area will also reestablish historical species usage, eliminating invasive non-native flora and the reintroduction of native plant seed. Microtopography will also be recreated to mimic historic prairie habitats. The BFI Katy Prairie Mitigation Bank is approximately 570 acres in size (BFI, 1998).

5.4.2.4 Step 4: Identify Direct and Indirect Impacts that May Contribute to a Cumulative Effect

For the CEA, the Study Team defined the direct impacts of the project to be those for the ROW of the Preferred Alternative Alignments for each of Segments E, F-1, F-2, and G of the proposed Grand Parkway at the time of this document production. Although other alignments could ultimately be selected as the Preferred Alternative Alignment within each segment, results of the indirect and cumulative impacts assessment (the purpose of this section of the EIS)

would not be substantially affected, which corresponds to the Expert Panel decision that determined that indirect development would be similar for all alignments of the Build Alternative. In addition, for the resources/issues discussed in the subsequent cumulative effects sections, the direct impacts are not appreciably different for the various alignments of the Build Alternative given the area within which this analysis occurs, and results are reported with the AOI comprising 604,141 acres.

Land Use

Potential direct and indirect land use impacts were calculated for the Build Alternative using the USGS/NOAA Draft 2001 NLCD data (Table 5-12 and Table 5-13). The wetland impacts reported in this analysis do not replace the actual direct impacts analysis in Section 4 (Environmental Consequences) of this volume. Direct and indirect impacts in this volume focus specifically on independent segments of the Grand Parkway and on specific alignment alternatives developed in each segment. The Build Alternative would impact or convert 2,664 acres to a roadway use. Based on mapping developed by the Expert Panel (see Section 5.2.1.1), the Build Alternative would indirectly impact 11,373 acres (2 percent of the AOI) above that expected for the No-Build Alternative (Exhibit G–35).

TABLE 5-12
DIRECT USGS/NOAA DRAFT 2001 NLCD LAND USE IMPACTS

Description	Acres	% of AOI
Open Water	4	<0.01%
Developed	204	0.03%
Barren	10	<0.01%
Forested	793	0.13%
Scrub/Shrub	107	0.02%
Grassland/Herbaceous	113	0.02%
Herbaceous Planted/Cultivated	1,135	0.19%
Wetlands	298	0.05%
Total	**2,664**	**0.44%**

Notes: Direct impacts were calculated from USGS/NOAA Draft 2001 NLCD data using the ROW of the Preferred Alternative Alignments for each of Segments E, F-1, F-2, and G of the proposed Grand Parkway at the time of this document production. Although other alignments could ultimately be selected as the Preferred Alternative Alignment within each segment, results of the indirect and cumulative impacts assessment (the purpose of this section of the EIS) would not be substantially affected.

Source: Expert Panel, 2000; Study Team, 2006; USGS/NOAA, 2001

TABLE 5-13
INDIRECT USGS/NOAA DRAFT 2001 NLCD LAND USE IMPACTS IN AOI

Description	Acres	% of AOI
Open Water	27	<0.01%
Developed	722	0.12%
Barren	40	0.01%
Forested	4,360	0.72%
Scrub/Shrub	1,573	0.26%
Grassland/Herbaceous	1,041	0.17%
Herbaceous Planted/Cultivated	2,787	0.46%
Wetlands	823	0.14%
Total	**11,373**	**1.88%**

Source: Expert Panel, 2000; Study Team, 2006; USGS/NOAA, 2001

Mobile Source Air Toxics

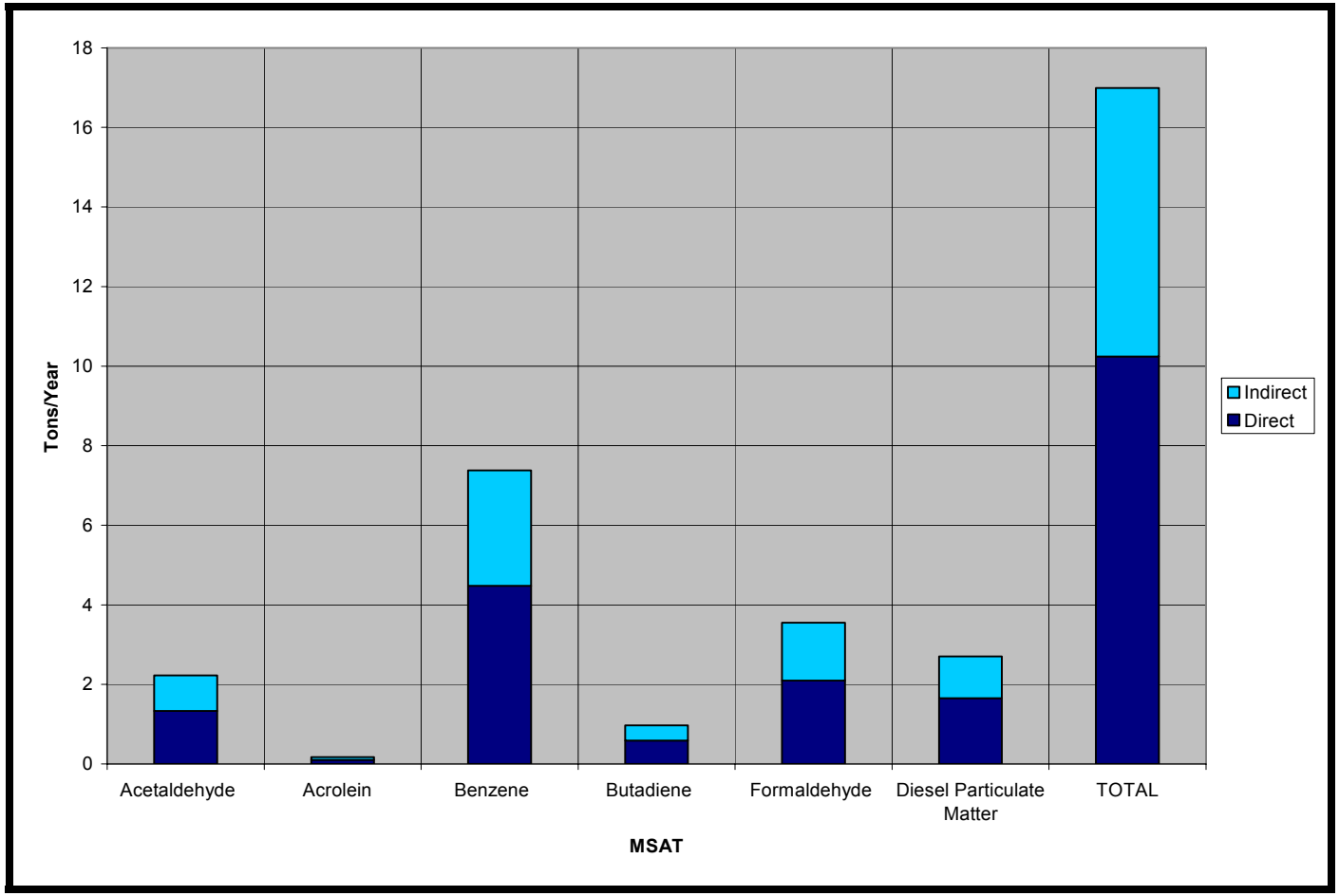
The projected MSAT that would result from the proposed Grand Parkway project are 10.2 tons/year from direct effects and 6.7 tons/year from indirect effects (Table 5-14 and Figure 5-4). Potential indirect development would be similar for all alignments of the Build Alternative and were based on the traffic study area where induced or indirect growth effect of the Build Alternative compared to the No-Build Alternative based on mapping developed by the Expert Panel (see Section 5.2.1.1).

TABLE 5-14
GRAND PARKWAY SEGMENTS E, F-1, F-2, AND G LINKS ONLY - MSAT EMISSIONS (TONS/YEAR)

MSAT	2025	
	Direct	Indirect
Acetaldehyde	2,658 lbs. or 1.3 tons	1,787 lbs. or 0.9 tons
Acrolein	202 lbs. or 0.1 tons	140 lbs. or 0.1 tons
Benzene	8,953 lbs. or 4.5 tons	5,802 lbs. or 2.9 tons
Butadiene	1,173 lbs. or 0.6 tons	762 lbs. or 0.4 tons
Formaldehyde	4,189 lbs. or 2.1 tons	2,910 lbs. or 1.5 tons
Diesel Particulate Matter	3,312 lbs. or 1.7 tons	2,093 lbs. or 1.0 tons
Total	**20,488 lbs. or 10.2 tons**	**13,492 lbs. or 6.7 tons**

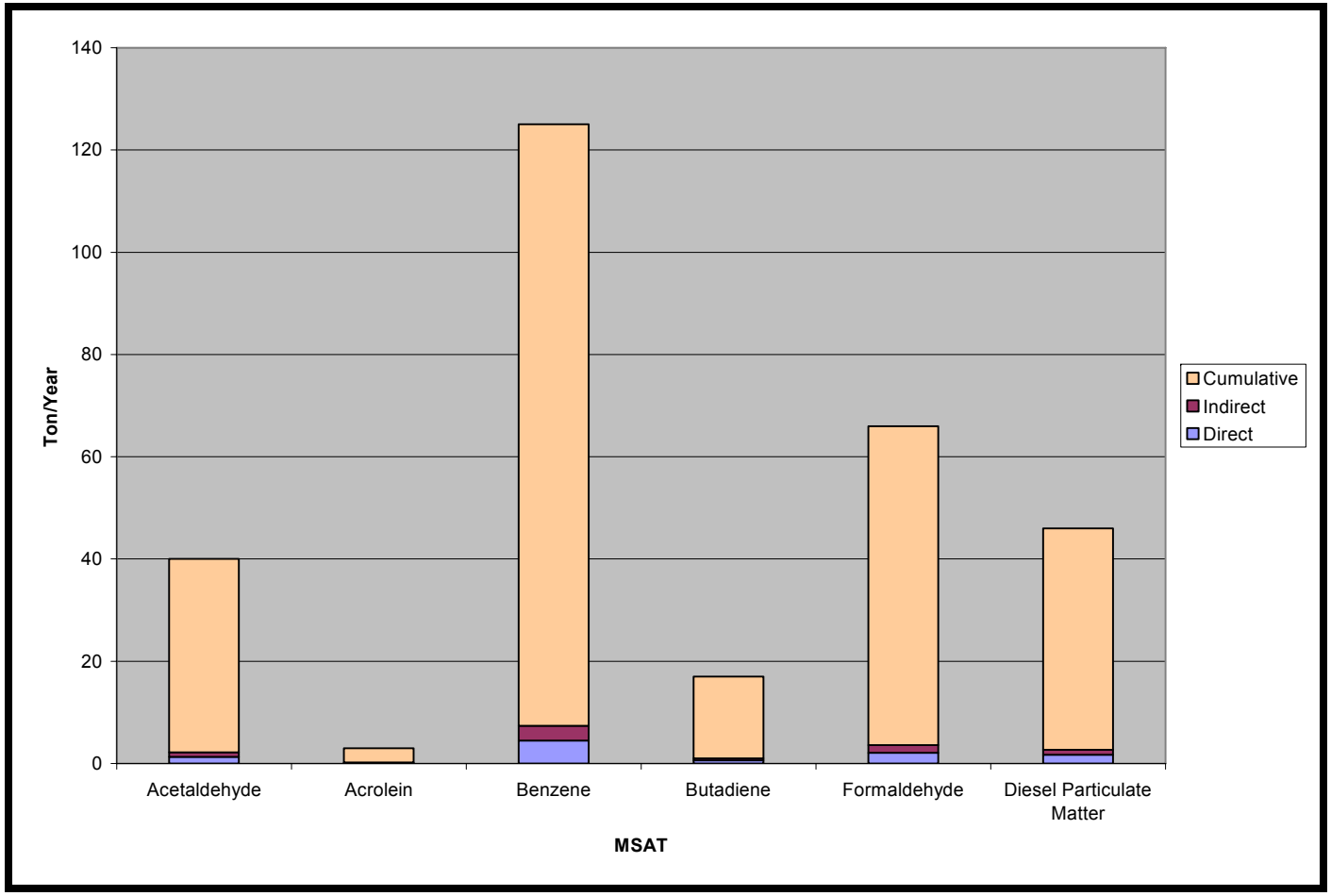
Source: Study Team, 2006

FIGURE 5-4
DIRECT AND INDIRECT MSAT EMISSIONS BY COMPOUND - 2025



Source: Study Team, 2006

FIGURE 5-5
CUMULATIVE EFFECTS OF MSAT BY COMPOUND - 2025



Note: Acrolein direct and indirect impacts are displayed, but minimal.

Source: Study Team, 2007

Water Quality

Direct impacts to resources, which would affect water quality associated with the proposed project, are listed in Table 5-15. Construction would also result in direct impacts to water quality, albeit temporary in nature. During construction, soils could enter runoff and contribute to turbidity and sediment loading of downstream waterbodies. From an operational perspective, direct effects to surface water quality would include an increase in storm water runoff associated with new impervious cover created by paved surfaces of the facility. Runoff could contain oil and grease constituents, which could be carried to off-site waterbodies.

TABLE 5-15
DIRECT IMPACTS TO WATER-RELATED RESOURCES

Scenario	Wetlands[1]	Waterbodies[2]	Floodplains[3]	Riparian[4]	Wells[5]
Build Alternative	298 acres	34 crossings	603 acres	140 acres	73

Notes: Direct impacts were calculated using the ROW of the Preferred Alternative Alignments for each of Segments E, F-1, F-2, and G of the proposed Grand Parkway at the time of this document production. Although other alignments could ultimately be selected as the Preferred Alternative Alignment within each segment, results of the indirect and cumulative impacts assessment (the purpose of this section of the EIS) would not be substantially affected.

[1] Wetland impacts were calculated from USGS/NOAA Draft 2001 NLCD data.\

[2] Includes stream crossings, lakes, and ponds

[3] Includes floodway and 100-year floodplain impacts

[4] Includes impacts to riparian forest and bottomland hardwood forest

[5] Well impacts include the displacement of private wells and the crossing of public wellhead protection areas

Source: USGS/NOAA, 2001 and Study Team, 2007

Based on the Expert Panel, new development would continue in the AOI and would likely consist of new residential subdivisions and associated infrastructure. Any new development indirectly caused by the project would result in an increase in impervious cover and greater volumes of runoff during storm events. New residential development would also result in new municipal discharges from sewage treatment and storm water runoff from new off system roadways.

In addition to this new development, the project could also change the type of development adjacent to the new facility. Under the No-Build Alternative, the project corridor would likely consist predominantly of residential development. Should the proposed project be constructed, areas adjacent to the new facility and areas at the new interchanges would likely develop commercially. Commercial developments could include gas stations with above or underground storage tanks, restaurants with grease traps and other types of commercial development, which could result in discharges of pollutants into groundwater or local surface waterbodies.

Wetlands and Vegetative Communities

Wetlands

Direct and indirect impacts to USGS/NOAA Draft 2001 NLCD Classified Wetlands in the AOI are shown in Table 5-16. The Build Alternative would directly impact 298 acres of wetlands and could indirectly impact 823 acres of wetlands above that expected for the No-Build Alternative. Wetlands within the cumulative effects resource study area totaled 194,687 acres of which 66,098 acres or 34 percent are in the AOI. The Build Alternative direct and indirect wetland impacts would be 1,121 acres or less than 2 percent of the wetlands within the AOI or less than 1 percent of the wetlands within the cumulative effects resource study area.

Katy Prairie

Direct and indirect impacts to the USGS/NOAA Draft 2001 NLCD Classified Katy Prairie in the AOI are shown in Table 5-16. The Build Alternative would directly impact 1,133 acres of prairie and could indirectly impact 2,829 acres of prairie above that expected for the No-Build Alternative. The Katy Prairie cumulative effects resource study area totaled 505,905 acres of which 148,198 acres or 29 percent are within the AOI. The Build Alternative direct and indirect impacts to the Katy Prairie would be 3,962 acres or approximately 3 percent of the prairie within the AOI or approximately 1 percent of the Katy Prairie within the cumulative effects resource study area.

TABLE 5-16
POTENTIAL DIRECT AND INDIRECT VEGETATIVE COMMUNITIES WETLAND AND KATY PRAIRIE IMPACTS IN AOI

Resource	Direct Impacts		Indirect Impacts		Total Impacts	
	No-Build	Build	No-Build	Build	No-Build	Build
Wetlands	0	298	0	823	0	1,121
Katy Prairie	0	1,133	0	2,829	0	3,962

Notes: Direct impacts were calculated from USGS/NOAA Draft 2001 NLCD data using the ROW of the Preferred Alternative Alignments for each of Segments E, F-1, F-2, and G of the proposed Grand Parkway at the time of this document production. Although other alignments could ultimately be selected as the Preferred Alternative Alignment within each segment, results of the indirect and cumulative impacts assessment (the purpose of this section of the EIS) would not be substantially affected.

Source: USGS/NOAA, 2001 and Study Team, 2007

5.4.2.5 Step 5: Identify Other Reasonably Foreseeable Actions that May Affect Resources

Reasonably foreseeable actions are those that are likely to occur, or are probable, rather than those that are merely possible. Many of these reasonably foreseeable actions in the AOI include moderate to large master planned residential communities and linear transportation projects. The Study Team contacted local officials (Table 5-17), community groups (Table 5-8), and independent school districts (ISDs) (Katy, Cy-Fair, Tomball, Klein, Spring, Conroe, New Caney) to determine the location of existing or proposed reasonably foreseeable projects.

TABLE 5-17
LOCAL OFFICIALS MEETING

Date	Name	Affiliation
August 1999	Peter R. McStravick	Tomball Area Chamber of Commerce - Mobility and Transportation Committee
	Brad Brown	Grand Parkway Subcommittee
	Kent McLemore	Houston Airport System
	Warren Driver	City Manager of Tomball
	Carol Sigler	Representative Paul Hilbert
	Clayne Stouall	City Council of Tomball
	Bruce Hillegeist	Tomball Area Chamber of Commerce
	James Jackson	Port of Houston Authority
	Paul Hawkins	Precinct 3, Harris County
	Mary Schneider	U.S. Senator Kay Bailey Hutchison
	Rose Hernandez	Judge Eckels
	Ed Shackelford	Precinct Engineer, Harris County, Precinct 4
	Senator Jon Lindsay	Senator, NHA
	Catherine Wray	NHA
	John Jackson	City of Houston – Planning and Development
	Anthony Tangwa	City of Houston – Planning and Development
	Joe Crabb	State Representative
	Lisa Gonzales	Engineering Manager – HCTRA
	Kristen Bishop	H-GAC
	Art Salinas	Montgomery County, Precinct 3, Ed Chance
October 2000	Peter R. McStravick	Tomball Area Chamber of Commerce - Mobility and Transportation Committee
	Brad Brown	Grand Parkway Subcommittee
	Kent McLemore	Houston Airport System
	Warren Driver	City Manager of Tomball
	Carol Sigler	Representative Paul Hilbert
	Clayne Stouall	City Council of Tomball
	Bruce Hillegeist	Tomball Area Chamber of Commerce
	James Jackson	Port of Houston Authority
	Paul Hawkins	Precinct 3, Harris County
	Mary Schneider	U.S. Senator Kay Bailey Hutchison
	Rose Hernandez	Judge Eckels
	Ed Shackelford	Precinct Engineer, Harris County, Precinct 4
	Senator Jon Lindsay	Senator, NHA

TABLE 5-17 (CONT.)
LOCAL OFFICIALS MEETING

Date	Name	Affiliation
October 2000 (Continued)	Catherine Wray	NHA
	John Jackson	City of Houston – Planning and Development
	Anthony Tangwa	City of Houston – Planning and Development
	Joe Crabb	State Representative
	Lisa Gonzales	Engineering Manager – HCTRA
	Kristen Bishop	H-GAC
	Art Salinas	Montgomery County, Precinct 3, Ed Chance

Source: Sign-In Sheets from August 1999 and October 2000

TABLE 5-18
COMMUNITY GROUPS

Home Owner Associations (HOAs)/ Residential Subdivisions	Presentation Date
Bridgestone HOA or MUD	3/15/2001*, 6/12/2001, 7/9/2001, 5/25/2005**
Candle Light	3/15/2001*
Dove Meadows	3/15/2001*, 6/25/2001
Fairfield Village	11/4/2002, 5/28/2003
Five Oaks	3/15/2001*
Forest North	6/5/2000, 3/15/2001*, 5/25/2005**
Fox Hollow West	5/25/2005**
Fox Run	3/15/2001*, 4/2/2001, 4/19/2001
Gleannloch Farms	12/6/2000, 11/4/2002, 5/13/2004, 5/24/2004, 6/16/2004
Grayson	1/17/2003
Greengate Acres	3/15/2001*
Hampton Oaks	3/15/2001*
Hannover Forest	3/15/2001*
Londonderry	3/15/2001*
Mossy Oaks	3/15/2001*, 5/25/2005**
Normandy Forest	3/15/2001*
Northampton HOA or MUD	3/15/2001*, 5/24/2001, 6/5/2001, 6/14/2001, 1/21/2003, 5/13/2004
Northgate Crossing	12/6/1999, 3/15/2001*, 9/13/2001, 6/25/2002
Northwood Park	3/15/2001*
Spring Creek Oaks	3/15/2001*, 6/11/2001, 9/1/2004
Spring Stuebner Estates	3/15/2001*, 5/25/2005**

TABLE 5-18 (CONT.)
COMMUNITY GROUPS

Home Owner Associations (HOAs)/ Residential Subdivisions	Presentation Date
Willow Glen	10/25/2000, 11/9/2000, 5/25/2005**
Windrose (wrote article for HOA)	10/17/2001
Amegy Bank Advisory Board	5/25/2005
American Metro Study Corporation	10/21/1999, 1/18/2000, 3/1/2000, 8/5/2004
Century 21 Executive Northwest	4/10/2001
City of Houston, Airport System	1/12/2000
Conroe Noon Lion's Club	9/6/2000
Continental Airlines	1/6/2000
CREN – Commercial Real Estate Network	6/3/2005
Cy-Fair Area Chamber of Commerce	4/1/1999, 6/1/2000, 11/7/2002
Cy-Fair Area Chamber of Commerce, Transportation Committee	11/7/2002, 11/3/2003
Excalibur Construction	3/29/2000
FM 1960 Forum Transportation Symposium	9/22/1999
Greater Houston Builders Association	3/6/2002, 9/22/2004
Hooks Airport	5/25/2001, 1/31/2002, 3/13/2002, 7/29/2002, 8/5/2002, 1/6/2003, 1/15/2004, 2/18/2004, 7/20/2004
Houston Association of Realtors Northwest	4/10/2002, 6/20/2002
Humble Area of Chamber of Commerce	3/11/2003, 5/20/2003, 2/14/2006
Katy Chamber of Commerce	11/18/2004
Katy Area Economic Development Corporation	4/19/2001, 5/5/2004, 11/9/2004
Katy Prairie Conservancy (KPC)	10/29/1993, 3/20/2000
Klein Bank Advisory Board, Transportation Forum	9/20/2000
Klein Methodist Church, Building Committee	11/30/2000, 5/12/2001
Klein Methodist Church, Men's Club	5/12/2001
Legacy Land Trust	7/22/2004, 9/1/2004
Lion's Club, Old Town Spring	7/20/2000
Midway Companies	2/16/2000
New Light Church	8/29/2002, 11/7/2002, 3/4/2004
North Houston Association (NHA)	8/18/1999, 12/20/1999, 7/16/2001, 2/22/2002, 10/30/2002, 1/22/2003, 2/26/2003, 1/4/2006
North Houston Chamber of Commerce	9/5/2000
Northwest Houston Chamber of Commerce	5/19/2004
Porter First Baptist Church, Senior Citizens Group	4/20/2005
River of Praise Church	11/6/2002, 2/5/2003, 3/2/2004, 8/26/2004, 9/9/2004

TABLE 5-18 (CONT.)
COMMUNITY GROUPS

Home Owner Associations (HOAs)/ Residential Subdivisions	Presentation Date
Sierra Club, Lone Star Chapter	7/24/2001
Society of American Mechanical Engineers	4/17/2002
Society of American Military Engineers	7/19/2000, 2/26/2002
South Montgomery County Woodlands Chamber of Commerce	10/28/1998, 7/12/2002, 7/15/2003, 6/15/2004, 2/21/2006
Spring Tabernacle Church	2/5/2001, 3/15/2001
Spring Volunteer Fire Department	5/3/2001
Tomball Area Chamber of Commerce and Transportation Committee	9/15/1998, 10/26/1998, 8/18/1999, 6/13/2000, 3/13/2001, 7/9/2002, 3/13/2001, 7/9/2002, 2/26/2003, 11/11/2003, 11/22/2003
United to Save Our Spring	7/26/2001, 8/23/2001, 10/25/2001
West Houston Association (WHA)/Transportation Committee	4/12/2000, 10/10/2001, 3/20/2003, 11/30/2005
Women's Council of Realtors	6/12/2002
Woodlands Operation Company, Mobility Team	2/17/1998, 10/19/1999, 1/18/2000, 3/1/2000, 11/1/2001
Woodlands Rotary Club	11/1/2001
Media	
1) 8/11/1999—Telephone interview with Graham Harvey of the *Conroe Courier*	
2) 3/9/2001—Interviewed by Kevin Green, Channel 13	
3) 3/12/2001—Telephone interview by Deborah Wrigley, Channel 13 News	
4) 3/16/2001—Radio talk show call-in	
5) 7/26/2001—Telephone interview with Doug Miller, Channel 11 News	
6) 7/30/2001—Interview with Kim Canon, *Houston Chronicle*, This Week reporter	
7) 8/10/2001—Interviewed by Eric Aikin of the *1960 Sun*	
8) 3/7/2002—Media interview with Dave Fehling, Channel 11 news reporter	
9) 3/4/2003—Telephone interview with David Schafer, *Houston Chronicle*, re: Segment E DEIS	
10) 3/17/2003—Telephone interview with Matthew Trana of the *Kingwood Observer*	
11) 11/6/2003—Met with Kim Canon of the *Houston Chronicle*	
12) 12/10/2003—Telephone media interview with Beth Kuhles of the *Houston Chronicle*	
13) 1/8/2004—Met with Brandon Moeller of the *Tomball Tribune News*	
14) 3/10/2004—Telephone interview with Kim Canon of the *Houston Chronicle*	
15) 3/11/2004—Telephone interview with Kim Canon of the *Houston Chronicle*	
16) 3/23/2004—In-house media interview with KHOU Channel 11 reporter Mike Zientek	
17) 6/7/2004—Attended North Houston Association Press Conference	
18) 6/10/2004—On-site media interview with Channel 2 news reporter Mary Benton	
19) 6/15/2004—Telephone media interview with Lauren Hutton of the *Conroe Courier*	

TABLE 5-18 (CONT.)
COMMUNITY GROUPS

Media
20) 7/1/2004—Telephone media interview with Kim Canon of the *Houston Chronicle*
21) 8/10/2004—Telephone interview with Beth Kuhles of the *Houston Chronicle*
22) 10/4/2004—Media telephone interview with Kathy Parks of the *Observer* newspaper
23) 11/19/2004—Media telephone interview with Kathy Parks of the *Observer* newspaper, re: public relations with State Representative Debbie Riddle
24) 11/22/2004—Media telephone interview with Kathy Parks of the *Observer* newspaper, re: public relations with State Representative Debbie Riddle
25) 1/26/2005—Media telephone interview with Kim Jackson of the *Houston Chronicle*
26) 4/11/2005—In-house KHOU Channel 11 media interview with Carolyn Campbell

Notes: * 3-15-2001—Presentation was made at the Spring Tabernacle Church. This meeting was arranged by the "Citizens for Construction of the Grand Parkway along the Historical Alignment," Segment F-2, Reach 7" led by Mr. David Eastwood. Estimated attendance was 750-1,000 citizens from the neighborhoods indicated.

** 5/25/2005—Presentation was made at the Klein Collins High School. This meeting was arranged by local homeowners associations.

Source: Study Team, 2005

In addition, developers were contacted to determine location, percent build-out (as of September 2006), proposed build-out date, and approximate total number of structures proposed in each subdivision currently under construction or proposed within the study area for Grand Parkway Segments E, F-1, F-2, and G (Table 5-19). Subdivisions not under construction, but that have approved plats were considered reasonably foreseeable projects.

TABLE 5-19
STATUS OF DEVELOPMENTS IN THE STUDY AREA

Contact[1]	Subdivision[2]	% Build-Out	Year Build-Out	Lots
Segment E				
KB Homes	Enclave at Bridgewater	100%	2005	168
First General Realty	Morton Creek Ranch	0%	2020	~2,500
Beazer Homes	Waterstone	0%	N/A	2,000
Rouse	Bridgelands	8%	2024	19,000
Segment F-1				
Mustang Development	Lakes of Fairhaven (formerly Stable Creek) Section 1	100%	2007	320
Friendswood Development	Fairfield	55%	2011	7,000
Land Tejas Development	Canyon Gate at Northpointe	100%	2005	1,091
Kerry R. Gilbert	Cypress Lake Crossing	0%	N/A	N/A
--	Stone Lake	35%	N/A	67

TABLE 5-19 (CONT.)
STATUS OF DEVELOPMENTS IN THE STUDY AREA

Contact[1]	Subdivision[2]	% Build-Out	Year Build-Out	Lots
Segment F-2				
Meridian Homes	Three Lakes	100%	2004	N/A
Meridian Homes	Three Lakes East	100%	2004	249
D.R. Horton	Stonepine	55%	~2008	235
Willow Falls Development Ltd/Gehan Homes	Willow Falls	98%	~2008	421
KB Homes	Springbrook	100%	2007	561
KB Homes	Northern Point	5%	2008	527
Great America Company	Inverness Estates	5%	2014	710
Meritage	Miramar Lakes	80%	2008	267
Elan Development, L.P.	Willow Trace	50%	2008	560
Elan Development/Centex Homes	Willow Dell	100%	2004	241
Elan Development, L.P/ ObrA Homes	Fox Hollow South	100%	2005	110
Beazer Homes	Northcrest Village	15%	2009	690
D.R. Horton	Bella Sera	95%	~2008	180
--	Bridgestone Lakes	100%	2007	318
Centex Homes	Spring Terrace	98%	2008	600
Brighton Homes	Gosling Pines Section 1	95%	2008	216
Glenn Champions	Gleannloch Farms	100%	2007	3,200
DR Horton	Rhodes Landing	100%	2005-2006	192
Sowell Property	Meadow Hill Run	60%	2008	226
Royce Builders	Hannover Springs	75%	2009	174
Lennar Homes	Hannover Village	100%	2006/2007	396
Steve Costello	Hannover Estates	100%	2005	139
Steve Costello	Hannover Forest	100%	2005	189
Alexander Engineering, Inc.	Lakes of Avalon	5%	2009	800
Segment G				
Charter Development	Northgate Crossing	100%	2007	534
Land Tejas Development	Legends Ranch	80%	2008	1,626
KB Homes	Legends Run	70%	2007/2008	1,240
Elan Development	Estates of Legends Ranch	100%	2007	195
Midway Spring Trails Partner	Spring Trails	15%	2015	4,000
Lipar Group	Benders Landing	50%	2010	747
Lipar Group	Creekside Village	30%	2010	637
Lipar Group	Benders Landing Estates	0%	2018	1,394

TABLE 5-19 (CONT.)
STATUS OF DEVELOPMENTS IN THE STUDY AREA

Contact[1]	Subdivision[2]	% Build-Out	Year Build-Out	Lots
Segment G (Cont.)				
Vogt Engineering, LP	Riverwalk (Northern Section)	5%	2011	~1,000
Mark Martin	Cumberland Crossing	30%	2013/2014	1,200
Mark Martin	Timberland Estates	100%	2000	200
Mark Martin	Timberland Ranchettes	100%	2003	15
Mark Martin	Timberland Grove	100%	2003	65
Mark Martin	Timberland North	40%	2011	300
Signorelli Holdings, Ltd	Valley Ranch	10%	2011/2012	3,500
The Signorelli Company	Forest Colony	85%	2008	354
Elan Development	Legends Trace	0%	2015	1,300
Clint Pendleton	Spring Bridge Trails	0%	N/A	66

Notes: [1] With the permission of the developer or builder, detailed contact information can be provided if requested.
[2] May not represent a complete list due to the continuing growth in the study area.
Source: Study Team, 2008

Other reasonably foreseeable actions include approximately 425 ($6.96 billion) transportation improvement projects that H-GAC has developed in the 2025 RTP (Appendix C). Major reasonably foreseeable transportation-related actions within the AOI include:

- IH 10 (Katy Freeway Improvements):
  - FHWA signed a ROD in January of 2002 to improve IH 10 (Katy Freeway) from Loop 610 to the Fort Bend County line (Brazos River). The project is currently under construction and completion is anticipated by spring 2009;
- US 290:
  - The TxDOT-Houston District is considering improvements in the US 290 corridor from IH 610 to FM 2920, a distance of approximately 38 miles (including the Hempstead Highway corridor and the connections to the IH 610 West Loop). The MIS has been completed and the project is moving forward with an EIS study and Schematic Design. In a separate study on US 290, HCTRA is in the process of evaluating toll lanes from IH 610 to SH 99 (Grand Parkway);
- SH 249 (Bypass):
  - TxDOT will construct a bypass from Willow Creek to Brown Road in two phases. Phase I will build two three-lane frontage roads and an overpass at FM 2920. Frontage road construction began in summer 2005 and completion is anticipated within three years. The second phase will build the six main lanes and could begin construction as early as fall 2006, and

- For the rest of SH 249 from Westlock to Willow Creek, the project has been divided into two phases. Plans call for constructing the road to six lanes, building two three-lane frontage roads, and relocating the Boudreaux Road intersection;

- SH 249 Extension:
  - The SH 249 MIS was completed in the winter of 2002/2003. The study was initiated in June 2000 and was conducted by TxDOT Houston District. The purpose of this study was to identify transportation needs and potential solutions for the corridor, as well as recommend the "most feasible" alignment for the extension of SH 249 between FM 149 in Pinehurst and FM 1774 in Todd Mission. The project corridor is an approximate 14-mile segment extending through Montgomery, Waller, and Grimes Counties. The MIS selected Alternative E3 as the recommended most feasible alternative and recommended widening FM 1774 to a four-lane facility between Pinehurst and FM 1486 to relieve the projected congestion along this section;
- IH 45/North-Hardy Corridor:
  - METRO, TxDOT, and H-GAC, along with the FTA and FHWA, are conducting a planning study to develop future transportation options. The study is currently in the phase of preparing a DEIS, sponsored by the FTA, to evaluate transit improvements in the North-Hardy Corridor of the Houston metropolitan area;
- Grand Parkway, Segments H and I-1:
  - On April 28, 2005, the Texas Transportation Commission authorized the GPA to perform the route and environmental studies on Segments H and I-1. A request for proposal (RFP) was issued in July 2005 for the project with all proposals to be submitted by August 19, 2005. The project is a tiered NEPA corridor study for the development of SH 99 from US 59 (North) to IH 10 (East) in Montgomery, Harris, Liberty, and Chambers Counties, a distance of approximately 36 miles. Tier One studies will examine a broad study area to determine a corridor for ROW preservation only. A future second tier NEPA document, not included as a part of this project, will examine the best location within the identified corridor to build a final route alignment for Segments H and I and will include a detailed evaluation of potential effects to the natural and human environment. Tier Two studies will be initiated when construction of the facility, or segments thereof, is imminent and will include the preparation of schematic plans and all required permitting and mitigation; and

Reasonably foreseeable actions would involve:

- The conversion of rangeland/forest land to residential/commercial uses;
- Potential temporary and permanent degradation or loss of water resources from surface runoff;
- A change in the economic and social environment due to the increased employment and housing opportunities;
- An increase in usage and acreage of park and recreational activities related to development; and
- Potential degradation of habitats and wildlife populations from construction and ongoing operation.

Other future actions not included in an approved Regional Transportation Plan are therefore not reasonably foreseeable but currently under study:

- IH 69/Trans-Texas Corridor (TTC-69) Study (Houston Area):
  - TxDOT is conducting an environmental study for the TTC-69 project. This study is being conducted in two phases (known as tiers). Tier One studies have examined a broad area that is approximately 20 to 50 miles wide, extending from northeast Texas to the Texas/Mexico border. This study has determined that the Grand Parkway Segments E, F-1, F-2, and G are not within the IH 69/TTC Recommended Reasonable Corridors (see I-69/TTC Recommended Reasonable Corridors map in Appendix G). The Grand Parkway falls within an area identified as a Modal Transition Zone within which TTC and locally developed facilities will be incorporated to best serve the various transportation modes (auto, truck, freight rail, etc.) and their respective destinations. Details of the connections will be studied during the Tier Two environmental and planning process.

5.4.2.6 Step 6 and 7: Assess Potential Cumulative Effects to Each Resource and the Results

Step 6 analyzes the magnitude and significance of potential cumulative effects for the specific resource categories of interest. For the purpose of this analysis, magnitude relates to quantity, and significance is discussed in terms of its geographic extent (i.e., how widespread the effect might be), as well as in terms of duration and/or frequency (i.e., temporary, short-term, or long-term).

Land Use

No-Build Alternative

The Expert Panel devoted substantial time to a discussion of the No-Build Alternative. The general consensus of the Expert Panel was that while the cumulative effects under the No-Build Alternative would be relatively consistent with the Build Alternative, the pattern and density would differ. Without the improved access provided by the proposed Grand Parkway, land between existing arterials would be designated low-density single family (R2) (Table 5-20). The Expert Panel concluded that high-density single family (R1) residential development would be concentrated along major arterials in the No-Build condition. Historic growth patterns would cause R1 and R2 to maintain their designations even in the No-Build Alternative. Some tracts on the outer reaches of the AOI could remain undeveloped. Exhibit G–36 presents the No-Build Alternative Land Use Map with the 2005 Study Team updates.

Build Alternative

The Expert Panel concluded that the Build Alternative could change the development pattern by causing the higher density development to occur both inside and along the proposed Grand Parkway. Higher density residential development could be concentrated along major radial facilities such as US 290, SH 249, and IH 45, although development would not extend as far north and west as in the No-Build Alternative. Higher density residential development could occur at intersections with the Grand Parkway and in areas where dense residential development would occur otherwise. The Expert Panel located two master planned communities on large tracts of land under single ownership. Since the Expert Panel's predictions in 2000, residential development has increased over 50 percent and four

large master planned communities have now been established (Valley Ranch, Bridgelands, Spring Trails, and Legends Ranch).

The Expert Panel concluded that land in the northern and western portions of the AOI (extending beyond the Grand Parkway) would be developed as R2, or less dense. Areas with limited access, or where development has historically been slow, would also experience less dense development. As in the No-Build Alternative, some tracts on the outer reaches of the AOI would remain undeveloped. Exhibit G–37 presents the Build Alternative Land Use Map. Table 5-20 presents the land use for the 2025 No-Build and Build Alternatives.

TABLE 5-20
COMPARISON OF PREDICTED CUMULATIVE AND INDIRECT EFFECTS TO 2025 LAND USE FOR THE NO-BUILD AND BUILD ALTERNATIVES

Land Use	2025 No-Build Alternative Predicted from 2005 Data (acres)	2025 Build Alternative Predicted from 2005 Data (acres)	Difference/Change Between 2025 No-Build and Build	
			Acres	Percent
Residential Development *	165,960	176,228	10,268	6.2%
Other Development	8,349	9,369	1,020	12.2%
Undeveloped	196,910	185,622	-11,288	-5.7%
Existing Development	232,922	232,922	0	0.0%
Total	**604,141**	**604,141**	**N/A**	**N/A**

Note: * Residential Development contains R1 (high density single family), R2 (low density single family), R3 (multi-family), and master planned community. (The Residential and Other Development figures are for the area the Expert Panel "developed.")
Source: Study Team (2000, 2005) and Expert Panel (2000)

Population and Employment Forecasts

The land use maps were a critical step toward the generation of 2025 household and employment projections. Exhibits G–20 through G–23 present the population and employment statistics for present and past years used for predictions of 2025 development (Exhibits G–36 and G–37).

Households

The land use described in Table 5-2 was used to provide a forecast of households. Four residential land use categories were developed as follows:

- R1: 63 percent of the total acreage as R1 would be allocated at a higher density of two houses per acre (master planned communities were included in the R1 category);
- R2: 77 percent of the total acreage designated as R2 was allocated to residences at a lower density of one house per 3.5 acres;
- R3: 3 percent of the total R1 and R2 acreage were allocated as multi-family housing (R3) at a density of 15 units per acre; and
- Remaining acreage was allocated to ancillary urban development that included commercial and institutional uses, parks, ROW, and undeveloped lands.

Employment

The Expert Panel agreed that four categories would characterize future employment: commercial-retail, commercial-office, commercial-industrial, and institutional. Employment projections within the commercial-retail and institutional categories were correlated with population and were derived from standard formulas utilized by the Urban Land Institute (ULI, 1988). Projections within the commercial-office and commercial-industrial categories were based on national data, as verified by local data and experience.

Retail: The calculation for projecting total commercial retail employment incorporated the following information: population, per capita income, dollar amount of sales per square foot, and retail employee per square foot. The population generated from the land use maps was assigned a per capita income reflective of the region ($22,000). ULI data were then applied to this basic retail need to generate the total number of retail employees likely to be present in the AOI.

Institutional: Institutional employment was generated using a combination of national standards assembled by the ULI and local information from Expert Panel members. The ULI's Development Impact Assistance Handbook (1994) has established ratios correlating population to the number of professionals required in the fields of health, public safety, public works, and municipal services. The accuracy of these ratios was enhanced by incorporating local data whenever possible to provide projections that better reflected the region under study. The number of school employees was generated from information obtained from school districts within the AOI. Total institutional employment reflects the sum of these categories.

Office and Industrial: Projections for employment within the commercial-office and commercial-industrial categories were based on three factors: Expert Panel predictions for office and industrial employment, percentage of land allocated to office and industrial uses, and localized data covering employment densities of similar office park/industrial sites.

2025 Households and Employment

The Expert Panel estimate of households and employment growth expected by 2025 under the No-Build Alternative is 402,096 households and 226,970 employees. The Build Alternative estimates 460,729 households and 244,512 for employment growth by 2025. These figures include baseline data generated by H-GAC for the year 2005.

The number of new households is 58,633 greater in the Build than in the No-Build Alternative. This difference is primarily due to the greater amount of R1 (higher density) development, which is expected to occur along the proposed Grand Parkway. Without the Grand Parkway, it is expected that the area in between arterials would develop, but at a lower density (R2). In addition, there is a greater amount of multi-family housing anticipated under the Build Alternative.

The number of new employees is 17,542 greater in the Build Alternative than in the No-Build Alternative. The greater number of households in the Build Alternative commands a higher amount of commercial-retail and institutional employment. In addition, the improved access provided by the proposed Grand Parkway is likely to encourage the location of office complexes along or near its route, further increasing the amount of employment within the AOI.

The annual average growth rates for each scenario are presented in Table 5-21. For context, the table also provides projected annual average growth rates for surrounding counties, the city of Houston, and the state of Texas.

TABLE 5-21
COMPOUND ANNUAL HOUSEHOLD GROWTH RATE COMPARISON (2025)

Scenario	Household Growth Rate
No-Build Alternative (AOI) [1]	3.02%
Build Alternative (AOI) [1]	3.73%
H-GAC Projection (AOI)	3.35%
Harris County [2]	1.31%
Fort Bend County [2]	2.72%
Montgomery County [2]	2.87%
Houston Metro [2]	1.18%
Texas [2]	1.54%

Sources: [1] Study Team and Expert Panel, 2000, 2005
[2] TWDB, 2000a and 2000b

The projected growth rates for the No-Build and Build Alternatives are comparable to growth rates for selected other counties within the Houston metropolitan area. While the AOI growth rates are higher than those of the city of Houston, Harris County, and the state of Texas, the Expert Panel anticipates intense growth within the AOI both with and without construction of the Grand Parkway. The household and employment projections for the AOI are a reflection of this consensus opinion.

Projections to 2025

The household and employment figures are derived from the Expert Panel's land use maps. Although it was necessary for the Study Team to project household and employment growth likely to occur by 2025, the Expert Panel agreed that rate and timing at which the growth in each category would occur was difficult to predict. The Expert Panel agreed that complete build-out was unlikely by 2025 based on a comparison of average high growth rates for different portions of the Houston metropolitan area.

In an effort to define the development most likely to occur by 2025, the Study Team evaluated the time frames for development of projects similar to those expected to occur. Residential development is usually first to be constructed in a suburban setting such as Segments E, F-1, F-2, and G.

Retail and institutional construction, directly linked to area population, follows close behind residential development in time. There is typically a substantial time lag between residential development and office/industrial growth.

The Study Team combined these trends with actual household and employment growth rates of zones throughout the Houston metropolitan area, as supplied by H-GAC, to arrive at a most reasonable development schedule. The Expert Panel estimated that the percentage of households would increase to 90 percent based on the growth history of the region. A similar concept was applied to employment data. When area-reflective growth patterns were applied to commercial-office and commercial-industrial employment, the Expert Panel projected that this type of development would have reached 40 percent of its build-out capacity by 2025.

This employment adjustment was applied only to the commercial-office and commercial industrial employment. As a result, commercial-retail and institutional employment figures remained correlated with the 90 percent population build-out anticipated by 2025.

Potential 2001 NLCD Land Use Cumulative Effects

The Study Team overlaid the 2025 No-Build and Build Alternatives developed by the Expert Panel and the Study Team onto the USGS/NOAA Draft 2001 NLCD to determine the extent of potential cumulative effects (see Table 5-22, Figure 5-6, and Exhibits G–38 and G–39). Forested land use has the greatest decline from 150,025 acres in 2001 to 45,339 acres under the No-Build Alternative and 40,979 acres under the Build Alternative for 2025, while development land use increases from 146,271 acres in 2000 to 429,752 acres in the No-Build Alternative and 440,403 acres in the Build Alternative for 2025 (see Table 5-22).

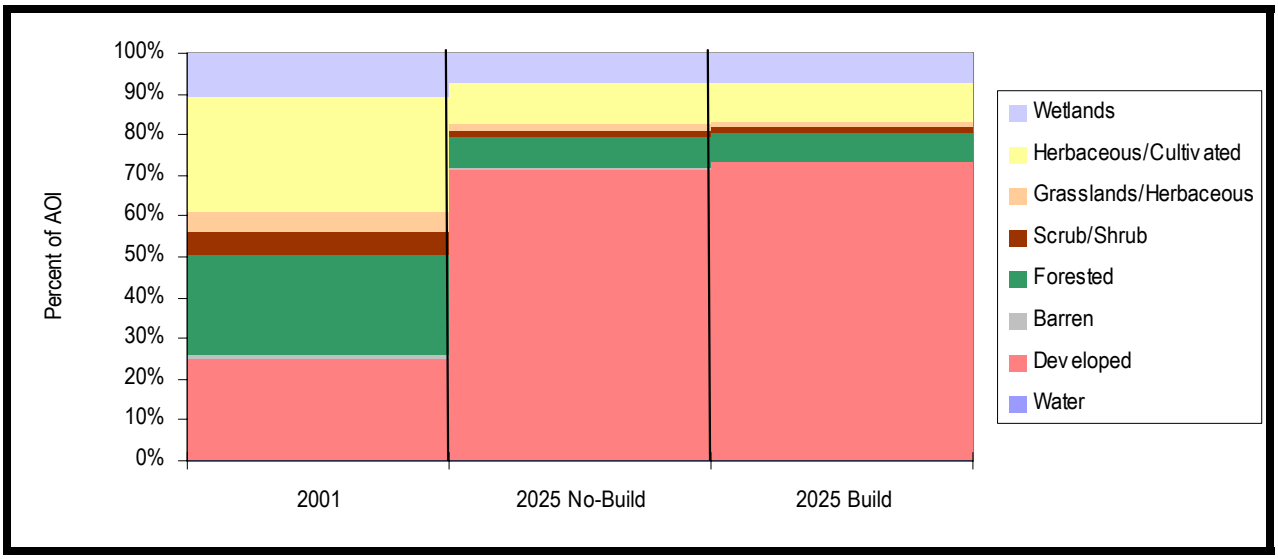
TABLE 5-22
COMPARISON OF 2001 LAND USE AND PREDICTED 2025 LAND USE UNDER THE NO-BUILD AND BUILD ALTERNATIVES

Description	2001 AOI		2025 No-Build AOI		2025 Build AOI		Difference Between Build and No-Build Alternatives
	Acres	% of the AOI	Acres	% of the AOI	Acres	% of the AOI	
Open Water	4,607	0.8%	2,750	0.5%	2,723	0.5%	-27
Developed	146,271	24.2%	429,752	71.1%	440,403	72.9%	10,651
Barren	5,740	1.0%	2,298	0.4%	2,258	0.4%	-40
Forested	150,025	24.8%	45,339	7.5%	40,979	6.8%	-4,360
Scrub/Shrub	33,528	5.5%	10,121	1.7%	8,548	1.4%	-1,573
Grasslands/Herbaceous	28,409	4.7%	9,113	1.5%	8,072	1.3%	-1,041
Herbaceous Planted/Cultivated	169,463	28.1%	61,646	10.2%	58,859	9.7%	-2,787
Wetlands	66,098	10.9%	43,121	7.1%	42,298	7.0%	-823
Total	**604,141**	**100%**	**604,141**	**100%**	**604,141**	**100%**	

Note: Totals may appear not to match sum of parts because of rounding.
Source: Study Team, 2006 and Expert Panel, 2000

The difference between the No-Build and Build Alternative potential cumulative wetland impacts is the indirect impact of 823 acres. This amount was determined by the Study Team and the Expert Panel based on available land and with the assumption that if the Grand Parkway were not built, that the potential direct impact acreage (298 acres) of the Grand Parkway would be developed (e.g., where land has been set aside for ROW, the development would just fill it in with more houses). Therefore, the only difference is the indirect impact of the proposed Grand Parkway.

FIGURE 5-6
COMPARISON OF 2001 LAND USE AND PREDICTED 2025 LAND USE UNDER THE NO-BUILD AND BUILD ALTERNATIVES



Note: The color scheme in this figure corresponds to the color scheme in Exhibits G-38 and G-39.
Source: Study Team, 2006 and Expert Panel, 2000

The difference between the No-Build and Build Alternative potential cumulative Katy Prairie impacts is the indirect impact of 2,829 acres. This amount was determined by the Study Team and the Expert Panel based on available land and with the assumption that if the Grand Parkway were not built, that the potential direct impact acreage (1,133 acres) of the Grand Parkway would be developed (e.g., where land has been set aside for ROW, the development would just fill it in with more houses). Therefore, the only difference is the indirect impact of the proposed Grand Parkway.

Water Quality/Wetlands

TCEQ is the primary agency responsible for water quality management in the state of Texas and the EPA is ultimately responsible for insuring that these efforts meet federal water quality standards. Cumulative effects to water quality and wetlands would include direct and indirect effects to water quality and wetlands discussed in Section 5.4.2.4, as well as the effects caused by the projects listed in Section 5.4.2.5. It should be noted that effects caused by projects listed in Section 5.4.2.5 would be common to the No-Build and Build Alternatives. The most common cause and effect issue is land conversion from undeveloped to developed land, primarily wetlands and other waterbodies, as well as vegetation. Because of such development, stresses on wetlands may include water quality effects, changes in water levels, and

overall effects from urban development and agricultural activities. Effects to water quality and wetlands from the construction of the Grand Parkway, Segments E, F-1, F-2, and G, and associated indirect development would be limited based on the current regulations as presented by TxDOT, FHWA, TCEQ, EPA, and the USACE. Projects require an approved SWPPP to avoid impacts to water quality and a compensatory mitigation plan for any unavoidable impacts to wetlands. Because of the federal mandate with regard to wetlands, "no net loss" of wetlands from future proposed land use would be anticipated. The cumulative effects study area boundary for wetlands is identical to the watershed boundary developed for water quality and is shown on Exhibit G–31. Table 5-23 summarizes the cumulative effects to wetlands in the AOI.

TABLE 5-23
SUMMARY OF POTENTIAL CUMULATIVE WETLAND IMPACTS

Resource	Impact Type						Difference Between No-Build and Build Alternatives*
	Direct		Indirect		Cumulative		
	No-Build	Build	No-Build	Build	No-Build	Build	
Wetlands (acres)	0	298	0	823	22,977	23,800	823

Notes: Direct impacts were calculated from USGS/NOAA Draft 2001 NLCD data.
*Includes direct, indirect, and cumulative effects
Source: Study Team, 2006

Katy Prairie

Cumulative effects to Katy Prairie would include direct and indirect effects to the Katy Prairie as discussed in the previous section (Section 5.4.2.4), as well as the effects caused by the projects listed in Section 5.4.2.5. It should be noted that effects caused by projects listed in Section 5.4.2.5 would be common to the No-Build and Build Alternatives. Conversion of prairie land to developed land primarily results from population and employment growth. Even under the No-Build Alternative, as Texas continues to grow, the conversion of prairie land to accommodate development would likely continue due to the future projected population and employment growth. Transportation projects may influence land conversion by inducing development in some locations. The construction of the proposed facility may accelerate the conversion of rural land in some locations, particularly where interchanges are constructed. Table 5-24 summarizes the cumulative effects to Katy Prairie Land Use in the AOI.

TABLE 5-24
SUMMARY OF POTENTIAL CUMULATIVE KATY PRAIRIE IMPACTS

Resource	Impact Type						Difference Between No-Build and Build Alternatives*
	Direct		Indirect		Cumulative		
	No-Build	Build	No-Build	Build	No-Build	Build	
Katy Prairie (acres)	0	1,133	0	2,829	68,382	71,211	2,829

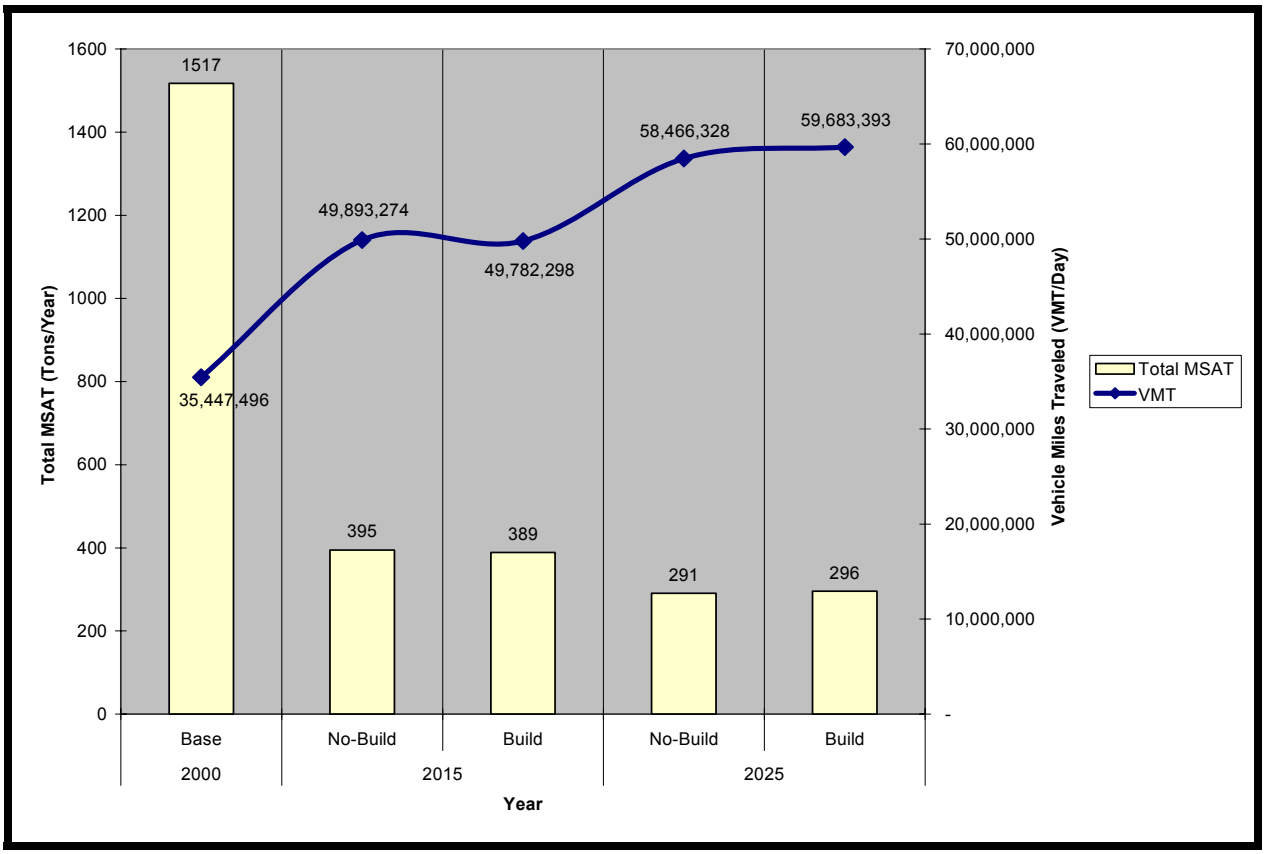
Note: * Includes direct, indirect, and cumulative effects
Source: Study Team, 2006

Mobile Source Air Toxics

The cumulative impacts projected by the MSAT analysis indicates a substantial decrease in MSAT emissions that can be expected for both the No-Build and Build Alternatives (2015 and 2025) versus the base year (2000). The emission trends obtained in this analysis and VMT (Vehicle Miles Traveled) are illustrated in Figure 5-7 for the Grand Parkway, Segments E, F-1, F-2, and G. Emissions of total MSAT are expected to decrease by more than 81 percent in 2025 compared with 2000 levels due to newer technology vehicles, a change in vehicle fuels, both gasoline and diesel fuel, and a change in emission standards that both light-duty and heavy-duty on-highway motor vehicles must meet.

Of the six priority MSAT compounds, the cumulative impact from benzene and DPM contribute the most to the emissions total (see Figure 5-8a-f). The amount of DPM emitted in 2000 is higher than the amount of benzene emitted. In future years a substantial decline in benzene is anticipated (more than a 72 percent reduction in benzene from 2000 to 2025, No-Build), and an even larger reduction in DPM emissions is predicted (about a 93 percent decrease from 2000 to 2025, No-Build).

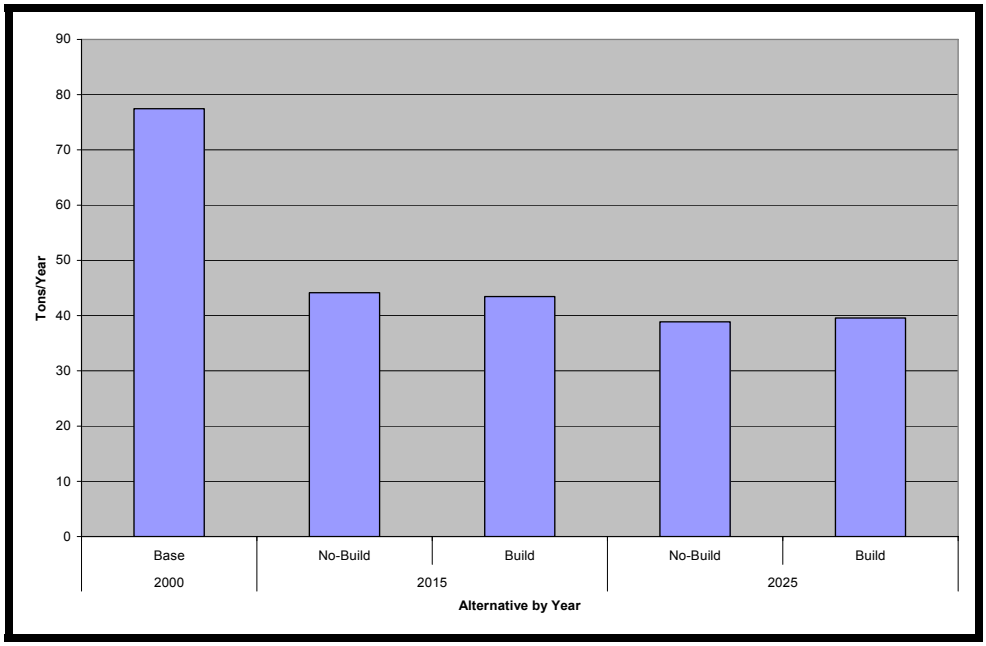
FIGURE 5-7
COMPARISON OF THE GRAND PARKWAY SEGMENTS E, F-1, F-2, AND G
TOTAL MSAT EMISSIONS AND VMT OVER TIME (ENTIRE TRAFFIC STUDY AREA)



Note: Total MSAT results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

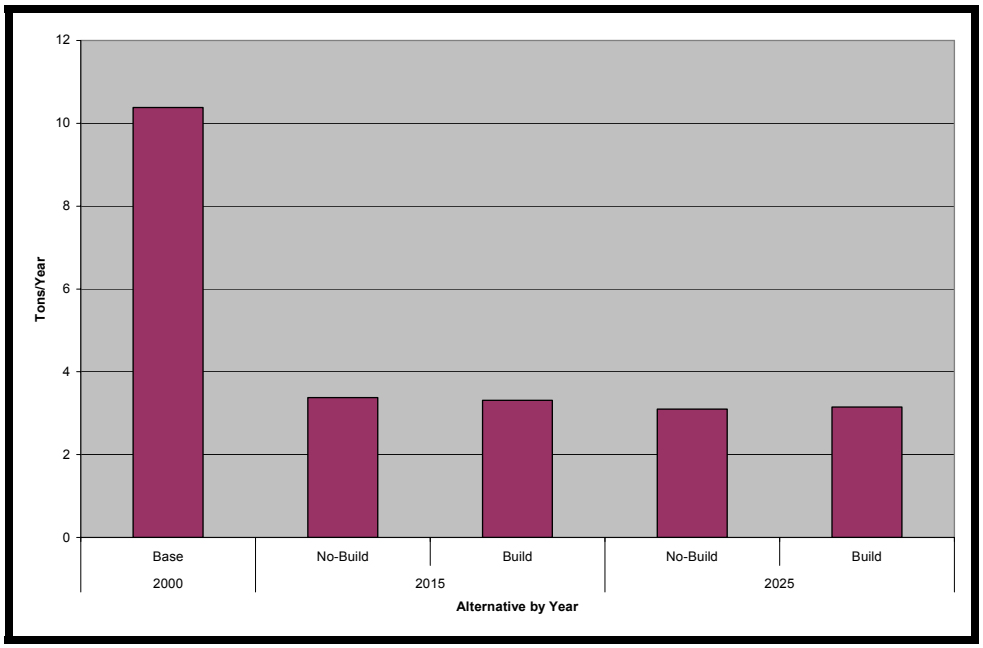
FIGURE 5-8a
COMPARISON OF ACETALDEHYDE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

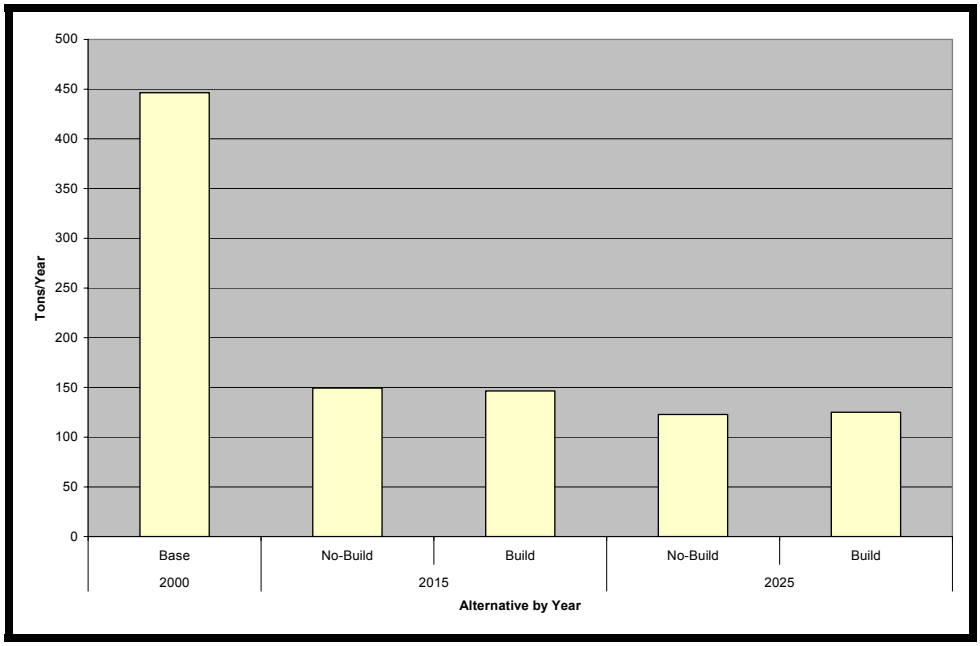
FIGURE 5-8b
COMPARISON OF ACROLEIN BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

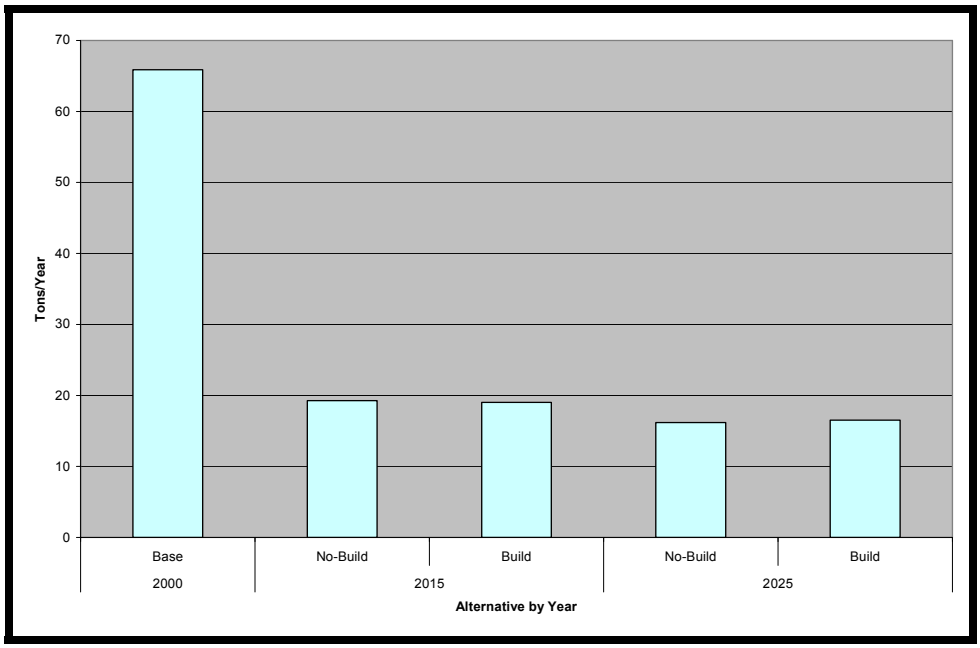
FIGURE 5-8c
COMPARISON OF BENZENE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

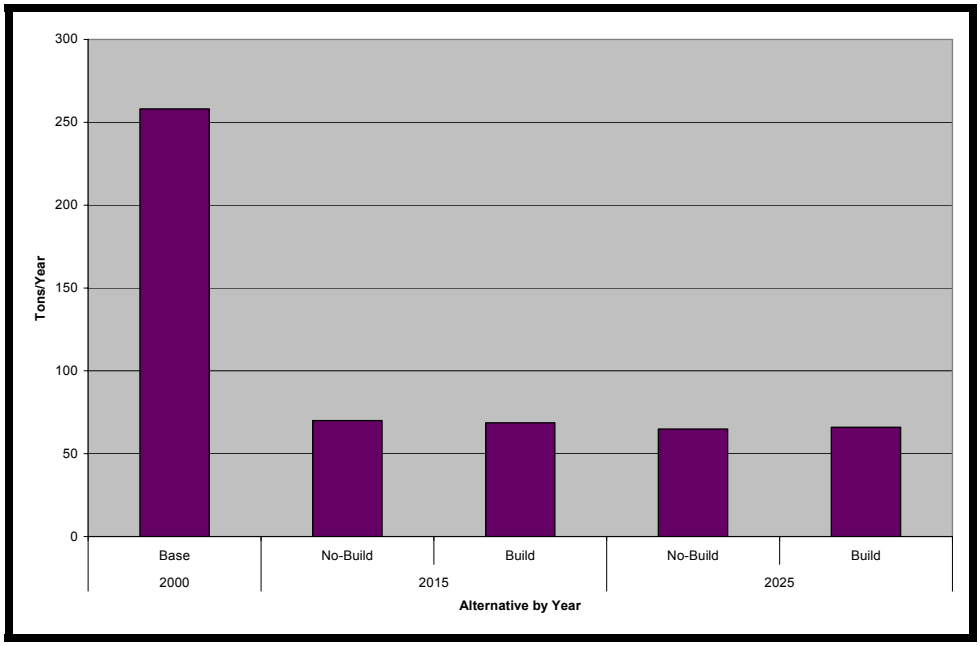
FIGURE 5-8d
COMPARISON OF 1,3 BUTADIENE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

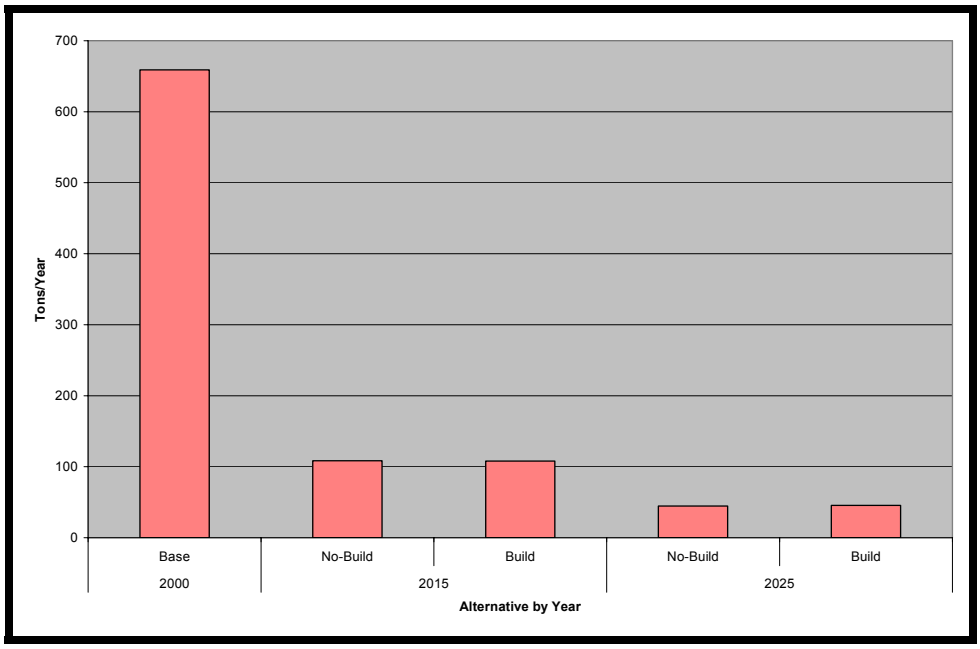
FIGURE 5-8e
COMPARISON OF FORMALDEHYDE BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

FIGURE 5-8f
COMPARISON OF DIESEL PARTICULATE MATTER BY ALTERNATIVE (ENTIRE TRAFFIC STUDY AREA)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

As shown in Figures 5-7 and 5-8a-f, MSAT emission levels are projected to decrease, even if VMT increases and shown in Figure 5-7. These results are consistent with an FHWA analysis which states that even if VMT increases over time, reductions in MSAT can be anticipated from 2000 to 2020 (TxDOT, 2006a). 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 that both light-duty and heavy-duty on-highway motor vehicles must meet. 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 (Tier 2, light-duty vehicle standard, Heavy-Duty Diesel Vehicle and (HDDV) standards and low sulfur diesel fuel, and the EPA's proposed Off-Road Diesel Engine and Fuel Standard). These projected air emission reductions will be realized even with the expected continued growth in VMT (EPA, 2000b; EPA, 1999b; EPA, 1997; TNRCC [currently TCEQ], 1997).

Growth in the Houston area is expected to remain robust through 2025. Population is expected to increase 64.1 percent and employment growth is expected to increase by 56.2 percent from 2000 through 2025 (H-GAC, 2003). The Study Team tracked the growth in the AOI since 1999 and, through coordination and discussions with the Expert Panel, agencies, and private landowners, has attempted to address some of the consequential increase in traffic within the greater Houston area.

Table 5-25 and Figure 5-9 show projected emissions of the six priority MSAT by alternative from base year 2000 to 2025 for the entire Grand Parkway traffic study area, Segments E, F-1, F-2, and G (see also Exhibit G–26). The following table and figure are for all the links of the Grand Parkway AOI. These numbers represent the amount of MSAT being released into the AOI. The fate of MSAT and the concentrations at any specific receptor are unknown due to the current technical shortcomings of emission and dispersion models. In addition, due to the limitations of dispersion modeling and the fact that the EPA has not established health-based standards for air toxics, the potential health impacts of the MSAT emissions from this project on the public cannot be determined.

TABLE 5-25
MSAT EMISSIONS BY ALTERNATIVE (TONS/YEAR)
(ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)

Compound	Year / Alternative				
	2000	2015*		2025	
	Base Year	No-Build	Build	No-Build	Build
Acetaldehyde	77	44	43	39	40
Acrolein	10	3	3	3	3
Benzene	446	149	147	123	125
Butadiene	66	19	19	16	17

TABLE 5-25 (CONT.)
MSAT EMISSIONS BY ALTERNATIVE (TONS/YEAR)
(ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)

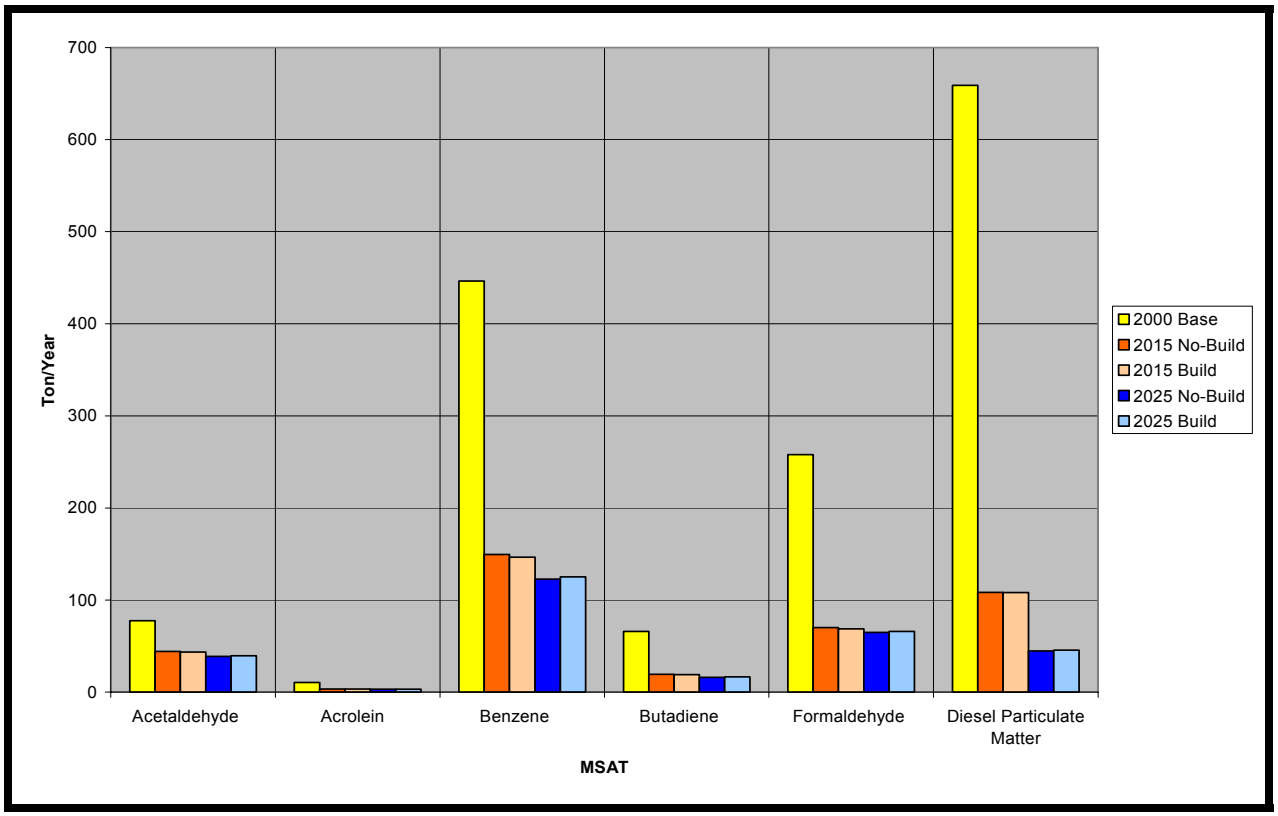
Compound	Year / Alternative				
	2000	2015*		2025	
	Base Year	No-Build	Build	No-Build	Build
Formaldehyde	258	70	69	65	66
Diesel Particulate Matter	659	108	108	45	46
Total MSAT	**1,516**	**393**	**389**	**291**	**297**

Note: * 2015 No-Build Alternative is higher due to more traffic congestion on local roadway links without the proposed Grand Parkway.

Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

FIGURE 5-9
PROJECTED CHANGES IN MSAT EMISSIONS BY ALTERNATIVE OVER TIME
(ENTIRE TRAFFIC STUDY AREA, SEGMENTS E, F-1, F-2, AND G)



Note: Results were calculated using the EPA MOBILE6.2 model (see Appendix F, Part 4 for detailed methodology), which does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a).

Source: Study Team, 2006

The TxDOT 2006 Air Quality Guidelines state that an MSAT analysis is required for road projects that have, or are expected to have, more than 140,000 ADT. Segments E, F-1, F-2, and G do not reach the 140,000 ADT threshold as can be seen in Table 5-26. However, US 290, SH 249, IH 45, and US 59 are expected to approach 140,000 ADT at the crossing of the Grand Parkway by the year 2025.

TABLE 5-26
SEGMENT ADT ROADWAY BY YEAR

Segment	2000*	2015	2025
E	N/A	33,400	38,400
F-1	N/A	26,400	31,000
F-2	N/A	45,100	59,500
G	N/A	43,400	64,500
Total	**N/A**	**148,300**	**193,400**

Note: * The year 2000 is the base year for air toxics modeling and excludes the Grand Parkway.
Source: Study Team, 2006

5.4.2.7 Step 8: Assess and Discuss Mitigation Issues for All Adverse Impacts

Consideration of potential mitigation measures as specified in 40 CFR 1508.20 for this project included:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action;

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation;

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

(e) Compensating for the impact by replacing or providing substitute resources or environments.

Section 4 (Environmental Consequences) of this volume discusses potential mitigation measures for all project resources. Step 8 of this CEA provides additional mitigation discussions for those resources carried through this process.

The magnitude and significance of negative cumulative effects of the Grand Parkway project on the resources in the AOI are expected to be limited and controllable. Efforts have been made to avoid and minimize project effects to all resources at both the corridor and alignment development phases of the project, and measures would be implemented to mitigate the loss of resources where practicable. When project alternatives were developed, several environmental issues were considered that influenced the location of the Grand Parkway including the potential for involvement with § 4(f)/§ 6(f) resources, avoiding and minimizing the filling of wetlands and floodplains, and sensitive biological communities. Other factors affecting the proposed action were also studied including compatibility with local land use plans/policies, housing and business displacements, socioeconomic issues, and community interests. The alternatives evaluation process was

based on the philosophy of avoidance first, minimization second and mitigation last. All project-specific commitments and conditions of approval, including resource agency permitting, compliance, and monitoring requirements, are stated in this volume of the FEISs and in the RODs prepared for the Grand Parkway project, Segments E, F-1, F-2, and G. These project-specific commitments and conditions for approval may vary depending on which alternative is identified as the Preferred Alternative Alignment. Mitigation monitoring would be conducted by the GPA, TxDOT, and other appropriate federal, state, and local agencies to ensure compliance with the agreed upon mitigation measures.

Land Use

All of the alternative alignments developed were consistent with state and local government plans and policies on land use and growth within the project area. Direct land use impacts were mitigated through avoidance and minimization. All of the alternative alignments would result in the reduction of forest and other vegetative communities. Activities to minimize the impacts to vegetative or undeveloped habitats 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. Specific impact minimization to wetland, floodplain, and stream areas may include: the roadway design (use of bridge crossings instead of filled embankment); the use of retention basins and revegetated swales to minimize runoff, sedimentation, turbidity, leaching of soil nutrients, and leaching of chemicals from petroleum products, pavement, and waste material; and maintaining flow patterns to ensure wetland hydrology in spite of roadway design requirements. Indirect impacts to land use would be similar to that of the direct project impacts, but would occur throughout the AOI. 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. These parties all have a stake in the ultimate landscape in which they reside and only proactive, cooperative interactions would provide the optimum blend of natural and developed communities.

Water Quality/Wetlands/Katy Prairie

Proposed construction activities associated with the Grand Parkway would directly impact wetlands and aquatic systems to varying degrees. Land clearing during construction activities would remove vegetative cover. These activities may increase surface runoff during storm events and could lead to erosion. If runoff is allowed to flow into streams without erosion and sediment control measures, increased turbidity and sedimentation may modify water chemistry due to elevated levels of sediments, nutrients and pollutants, which would also diminish suitable habitat for aquatic species, including littoral zone plants. To aid in minimizing such impacts, placement and monitoring of erosion control measures at the start of, during, and after construction will be incorporated into project plans according to TxDOT SWPPP guidelines. Re-vegetation along the ROW will adhere to TxDOT re-vegetation guidelines. Indirect and cumulative effects to wetland resources would be similar.

Wetland impacts, whether direct, indirect, or cumulative, are regulated through the USACE Section 404 permit process. Natural resource agencies (including TPWD, USFWS, USACE, EPA, and TCEQ) will be involved in decisions regarding appropriate wetland mitigation ratios and the location, size, and character of the mitigation. A compensatory mitigation plan will be submitted to the USACE as part of the Section 404 permit review process.

Non-regulated portions of the Katy Prairie could be mitigated through avoidance and minimizations efforts and through collaboration with local, county, and regional planners, the public, private developers, the KPC, and other conservation groups dedicated to protection and preservation of this natural resource. Future cumulative effects to this resource would continue if land use and conservation plans are not developed to protect and preserve the remaining acreage of this important ecosystem.

Mobile Source Air Toxics

Research has found that the ability to discern differences in MSAT emissions among transportation alternatives is very 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 EPA's new motor vehicle emission control standards. Substantial decreases in MSAT emissions will be realized from the base year (2000) through an estimated time of completion and its design year some 25 years in the future. Even accounting for anticipated increases in VMT and varying degrees of efficiency of vehicle operation, total MSAT emissions were expected to decline approximately 81 percent from 2000 to 2025 (No-Build). While benzene emissions were expected to decline about 72 percent (No-Build), emissions of DPM were expected to decline even more at 93 percent (No-Build).

MSAT are not expected to increase above the base year (2000). The major air toxics from mobile sources especially benzene have dropped dramatically since 1995 and are expected to continue dropping, as demonstrated by the quantitative analysis presented here. 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 MSAT. 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. EPA also has called for dramatic reductions in NOx emissions, and particulate emissions from on-road and off-road diesel engines.

MSAT were modeled and were found to be substantially lower in the future (2015 and 2025) than the existing conditions (2000). MSAT will continue to improve over time because of dramatic improvements in vehicle technology and fuels, and traffic flow improvements realized over time. Other potential air quality impacts could occur with the continued existence of industrial complexes in the area. Generally, industrial facilities that emit air pollutants will be governed and permitted through TCEQ. Because of the proposed Grand Parkway, MSAT are not expected to increase overall air toxics in the Houston area in the future years investigated.

Unavailable Information for Project Specific MSAT Impact Analysis

This document includes a basic analysis of the likely MSAT emission impacts of this project. However, available technical tools do not enable us to predict the project-specific health impacts of the emission changes associated with the alternatives in this document. Because of these limitations, the following discussion is included in accordance with CEQ regulations (40 CFR § 1502.22(b)) regarding incomplete or unavailable information:

Information that is Unavailable or Incomplete: Evaluating the environmental and health impacts from MSAT on a proposed highway project would involve several elements, including emissions modeling, dispersion modeling to estimate ambient concentrations from the estimated emissions, exposure modeling to estimate human exposure to the estimated concentrations, and determination of health impacts based on the estimated exposure. Each of these steps is encumbered by technical shortcomings or uncertain science that prevents a more complete determination of the MSAT health impacts of this project.

- **Emissions:** The EPA tools to estimate MSAT emissions from motor vehicles are not sensitive to key variables of emissions of MSAT in the context of highway projects. While MOBILE6.2 is used to predict emissions at a regional level, it has limited applicability at the project level. MOBILE6.2 is a trip-based model. Emission factors are projected based on a typical trip of 7.5 miles and on average speeds for this typical trip, which means that MOBILE6.2 does not have the ability to predict emission factors for a specific vehicle operating condition at a specific location at a specific time. Because of this limitation, MOBILE6.2 can only approximate the operating speeds and levels of congestion likely to be present on the largest-scale projects, and cannot adequately capture emissions effects of smaller projects. For PM, the model results are not sensitive to average trip speed, although the other MSAT emission rates do change with changes in trip speed. In addition, the emission rates used in MOBILE6.2 for both PM and MSAT are based on a limited number of tests of mostly older technology vehicles, and the model does not include the emission reductions associated with EPA's 2007 final rule, "Control of Hazardous Air Pollutants from Mobile Sources," as published in the Federal Register (EPA, 2007a). Lastly, in its discussions of PM under the conformity rule, EPA has identified problems with MOBILE6.2 as an obstacle to quantitative analysis.

  These deficiencies compromise the capability of MOBILE6.2 to estimate MSAT emissions. MOBILE6.2 is an adequate tool for projecting emissions trends, and performing relative analyses between alternatives for very large projects, but it is not sensitive enough to capture the effects of travel changes tied to smaller projects or to predict emissions near specific roadside locations. However, MOBILE6.2 is currently the only available tool for use by the FHWA and TxDOT and may function adequately for larger-scale projects for comparison of alternatives.

- **Dispersion:** The tools to predict how MSAT disperse are also limited. The EPA's current regulatory models, CALINE 3 and CAL3QHC, were developed and validated more than a decade ago to predict episodic concentrations of carbon monoxide to determine compliance with the NAAQS. Dispersion models are more accurate for predicting maximum concentrations that can occur at some time at some location within a geographic area. This limit makes it difficult to predict accurate exposure patterns at specific times at specific highway project locations across an urban

area to assess potential health risk. The National Cooperative Highway Research Program is conducting research on best practices in applying models and other technical methods in the analysis of MSAT. This work will also focus on identifying appropriate methods of documenting and communicating MSAT impacts in an environmental impact assessment to the public. Along with these general limits of dispersion models, the FHWA is also faced with a lack of monitoring data in most areas for establishing project-specific MSAT background concentrations.

- **Exposure Levels and Health Effects:** Finally, even if emission levels and concentrations of MSAT could be accurately predicted, shortcomings in current techniques for exposure assessment and risk analysis preclude one from reaching meaningful conclusions about project-specific health impacts. Exposure assessments are complicated, which is because it is difficult to accurately calculate annual concentrations of MSAT near roadways and to determine the period of time that people are exposed to those concentrations at a specific location. These difficulties are magnified for 70-year cancer assessments, particularly because unsupportable assumptions would have to be made about changes in travel patterns and vehicle technology (which affect emissions rates) over 70 years. There is also considerable uncertainty with current estimates of toxicity of MSAT, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population. Because of these shortcomings, any calculated difference in health impacts between alternatives is likely to be much smaller than the uncertainty of the calculated impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against other project impacts that are better suited for quantitative analysis.

Summary of Existing Credible Scientific Evidence Relevant to Evaluating the Impacts of MSAT

Research into the health impacts of MSAT is ongoing. For different emission types, many studies show that MSAT are either statistically associated with adverse health outcomes through epidemiological studies (frequently based on emission levels found in occupational settings) or that animals demonstrate adverse health outcomes when exposed to large doses.

Exposure to toxics has been a focus of several EPA efforts. The agency conducted the NATA (National Air Toxics Assessment) in 1996 to evaluate modeled estimates of human exposure at the county level. While not intended for use as a measure or benchmark of local exposure, the modeled estimates in the NATA database best illustrate the levels of various toxics when aggregated to a national or state level. The EPA's current evaluation of the potential hazards and toxicity of the six priority MSAT is listed by chemical in Section 3.6.2, and can be found at http://www.epa.gov/iris. For several of the MSAT, carcinogenicity either cannot be determined or is listed as probable.

There is currently a broad lack of consensus among both the scientific community and the regulatory community on the level at which MSAT may cause a negative health impact. This lack of consensus prevents any meaningful conclusion about the level of MSAT that must be experienced by a population before a health effect is found. Such limits make the study of MSAT concentrations, exposures, and health impacts difficult and uncertain. Thus, accurate and reliable estimates of actual human health or environmental impacts from transportation projects and MSAT are not scientifically

possible at this time. This lack of consensus further prevents decisions from being made about alignments, grade elevations, and even selection of the No-Build Alternative versus the Build Alternative based solely on estimated MSAT levels.

Therefore, the analysis of MSAT presented here is provided as background information on the current levels of MSAT, anticipated future levels of MSAT, and assumptions on what effect the Grand Parkway Segment G project may have on MSAT. The Health Effects Institute, a non-profit organization funded by EPA, FHWA, and industry, has undertaken a major series of studies to research MSAT hot spots near roadways, the health implications of the entire mix of mobile source pollutants, and other topics. The final summary of the series is not expected for several years.

Some recent studies have reported that proximity to roadways is related to adverse health outcomes, particularly respiratory problems.[1] Much of this research is not specific to MSAT, instead surveying the full spectrum of both criteria and other pollutants. The FHWA cannot evaluate the validity of these studies, but more importantly, they do not provide information that would be useful to alleviate the uncertainties listed above and enable the agency to perform a more comprehensive evaluation of the health impacts specific to this project. In addition, as mentioned previously, EPA has not developed health-based standards for MSAT, and instead has focused on regulations to substantially reduce on-road and non-road MSAT emissions.

On February 26, 2007, the EPA issued a final rule on the "Control of Hazardous Air Pollutants from Mobile Sources." In the preamble to this final rule, the EPA summarized recent studies by stating, "Significant scientific uncertainties remain in our understanding of the relationship between adverse health effects and near-road exposure, including the exposures of greatest concern, the importance of chronic versus acute exposures, the role of fuel type (e.g., diesel or gasoline) and composition (e.g., % aromatic), relevant traffic patterns, the role of co-stressors including noise and socioeconomic status, and the role of differential susceptibility within the 'exposed' populations" (EPA, 2007a).

Use of Available Information

Because of the uncertainties outlined above, an assessment of the effects of MSAT emissions impacts on human health cannot be made at the project level. While available tools do allow us to predict relative MSAT emissions changes between alternatives for a proposed project of this magnitude, the amount of MSAT emissions from each of the Segment G project alternatives (Build Alternative and No-Build Alternative) are presented here for consideration of alternatives and for disclosure purposes and are not intended for estimating potential human exposure or health impacts. Therefore, the

[1] *Multiple Air Toxic Exposure Study-II (MATES II)*, South Coast Air Quality Management District (2000); *Highway Health Hazards*, The Sierra Club (2004) summarizing 24 studies on the relationship between health and air quality; *NEPA's Uncertainty in the Federal Legal Scheme Controlling Air Pollution from Motor Vehicles*, Environmental Law Institute (2005), with health studies cited therein; the US 95 Nevada Study and associated case law; and *Recent Research Findings: Health Effects of Particulate Matter and Ozone Air Pollution*, California Environmental Protection Agency - Air Resources Board and American Lung Association of California (2004).

relevance of the unavailable or incomplete information is that it is not possible to make a determination of whether any of the alternatives would have "significant adverse impacts on human health" as related to MSAT emissions.

5.5 CONCLUSION

This analysis follows the requirements and processes outlined in 23 CFR 771, the FHWA Technical Advisory T 6640.8A (1987), CEQ's handbook, *Considering Cumulative Effects Under the National Environmental Policy Act* (CEQ, 1997), *Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process* (FHWA, 2003), CEQ's memorandum *Guidance on the Consideration of Past Actions in Cumulative Effects Analysis* (CEQ, 2005), and TxDOT's *Guidance on Preparing Indirect and Cumulative Impact Analyses* (TxDOT, 2006b).

The objective of this CEA is to evaluate land development and the corresponding environmental effects for two scenarios: the Build Alternative where Segments E, F-1, F-2, and G of the Grand Parkway are fully constructed and the No-Build Alternative where the facility is not constructed. The Study Team defined an AOI within which possible indirect development and potential cumulative effects could occur (Exhibit G–30). In 2000, an Expert Panel was assembled to assist the Study Team in conducting a detailed land use forecasting model for both the No-Build and Build Alternatives within the AOI. In addition to the land use forecasting by the Study Team and the Expert Panel, the Study Team utilized USGS/NOAA Draft NLCD (2001) information to determine the vegetative composition of undeveloped land in the AOI and future effects of the undeveloped land under both of the scenarios of future land use modeling.

The Study Team has continued to solicit input from agency scoping, public meetings, and workshops to determine issues of concern and to evaluate the cumulative effects to all project resources and issues (Table 5-6). Following TxDOT (2006b) guidance (page 7) states that "if a project will not cause direct or indirect impacts on a resource, it will not contribute to a cumulative impact on that resource"; therefore the Study Team identified four major resources/issues that warrant more detailed discussion. These include:

1. Land Use – including farmland from a land use classification;
2. Mobile Source Air Toxics;
3. Water Quality; and
4. Wetlands and Vegetative Communities, including:
    a. Wetlands, and
    b. Katy Prairie.

TABLE 5-27
SUMMARY OF CUMULATIVE EFFECTS

Resource	2001 AOI	Impact Type						Difference Between No-Build and Build Alternatives[1]
		Direct		Indirect 2025		Cumulative 2025		
		No-Build	Build	No-Build	Build	No-Build[1]	Build[2]	
Open Water (acres)	4,607	0	4	0	27	1,857	1,884	27
Developed (acres)	146,271	0	204	0	722	283,481	294,132	722
Barren (acres)	5,740	0	10	0	40	3,442	3,482	40
Forested (acres)	150,025	0	793	0	4,360	104,686	109,046	4,360
Scrub/Shrub (acres)	33,528	0	107	0	1,573	23,407	24,980	1,573
Grassland/Herbaceous (acres)	28,409	0	113	0	1,041	19,296	20,337	1,041
Herbaceous Planted/ Cultivated (acres)	169,463	0	1,135	0	2,787	107,817	110,604	2,787
Wetlands (acres)	66,098	0	298	0	823	22,977	23,800	823
Katy Prairie (acres)	148,198	0	1,133	0	2,829	68,382	71,211	2,829
MSAT (tons/year)	1,516	0	10.2	0	6.7	291	297	6

Notes: [1] The Cumulative No-Build Alternative would include the Direct Build Alternative's acreage due to development even without the proposed project.

[2] The 2025 Build Alternative's cumulative impacts include direct and indirect effects.

Source: Study Team, 2006

The Grand Parkway AOI is undergoing rapid population and employment growth. The 2 percent (11,373 acres) difference between the No-Build and Build Alternatives indirect land use impacts indicates that this growth is anticipated to continue through the year 2025 and beyond under the No-Build Alternative regardless of when or if the Grand Parkway is constructed. However, the Build Alternative will compliment and reinforce the development pattern and effects. The subdivisions discussed (Table 5-19) are already planned and/or under construction. The Grand Parkway may affect the dispersion pattern of growth. Local and regional government agencies continue to plan for this growth and have adopted various land use and transportation plans for the area such as the 2035 RTP. The Grand Parkway Segments E, F-1, F-2, and G, combined with other local/regional development efforts, would serve to accommodate growth and development, either present or planned. In addition, a number of regulatory mechanisms are in place to offset or minimize the adverse effects of social and economic growth (e.g., the ESA [Endangered Species Act], Section 404 permitting processes, and Clean Air Act requirements).

The objective of this CEA was to evaluate land use and corresponding environmental effects against the No-Build and Build Alternatives by using field reconnaissance, agency and public interaction, past and present aerial photography, Draft NLCD 2001 land use, and an Expert Panel to allocate future land use. From these allocations, the expected annual growth rate of the No-Build (3.02 percent) and the Build (3.73 percent) imply that the Grand Parkway, Segments E, F-1, F-2, and G, would have a minor cumulative effect to the rapidly growing AOI.

SECTION 6: AGENCY AND PUBLIC COORDINATION

FHWA, TxDOT, and the GPA have engaged governmental agencies and the public in an extensive coordination effort to both inform others of progress in the planning process and solicit input from them. The Grand Parkway project has been open to comments by any person, and all views on the scope of the proposed project, alternative actions, environmental impacts, and any other matter concerning the proposed Grand Parkway. FHWA, TxDOT, and the GPA have considered all comments to date and will continue to consider all comments in its planning process into the future.

The Study Team documented the public and agency coordination process. The following items are included at the end of Volume I, Section 5 (Agency and Public Coordination):

- Notices of Intent;
- Response to Segment E Scoping, 1993;
- Resource Agency Coordination – meeting agendas, sign-in sheets, and minutes, presented in chronological order;
- Preliminary Public Workshops, August 1999 – materials, comment form, and summaries of comments received;
- Public Scoping Meetings, February 2000 – materials, comment form, and summaries of comments received; and
- Public Workshops, October 2000 – materials, comment form, and summaries of comments received.

Note: The materials included in Volume I, Section 5 span all agency and public coordination conducted for Segments E, F-1, F-2, and G. All public and agency meetings were open to comments on all segments, regardless of location or venue. Comments regarding one study area could have been submitted during the meetings held in other study areas.

In addition, Volume IV of the FEIS includes materials specifically related to the Segment G DEIS Public Hearing and comment period, which was open from February 2, 2007 to April 27, 2007:

- Section 1: Notices of Availability and Public Hearing materials;
- Section 2: Public comment index and responses to those Segment G comments from the GPA in coordination with TxDOT and FHWA; and
- Section 3: Public comments on the Segment G DEIS.

6.1 NOTICE OF INTENT (NOI)

TxDOT and FHWA filed an NOI to prepare and consider an EIS for Segment G of the Grand Parkway on December 23, 1999. The NOI was published in the *Federal Register* on January 5, 2000 and in the *Texas Register* on January 21, 2000. The NOI was mailed to agencies, government organizations, landowners, and other individuals. Notification to the public

was published in the *Houston Chronicle* on December 29, 1999. A copy of the NOI is included at the end of Volume I, Section 5.

6.2 SCOPING AND CORRIDOR STUDY

Scoping involved the early and open process for determining the scope of issues to be addressed and for identifying the issues related to the Grand Parkway. A Preferred Alternative Corridor was identified through an interdisciplinary approach involving active agency participation and an outreach program. The scoping and outreach process included the involvement and participation of the public, local officials, resource agencies, and other interested parties. The following summarizes efforts for scoping and the corridor study phase of Segment G of the Grand Parkway.

6.2.1 Public Involvement

The public was directly involved in the development of a Preferred Alternative Corridor for the Grand Parkway. Comments provided and questionnaires completed at the August 1999 and February 2000 meetings were used in combination with comments from local officials and resource agencies to develop a Preferred Alternative Corridor for Segment G.

6.2.1.1 August 1999

Three preliminary Public Workshops were held in August 1999. One of these workshops was conducted adjacent to the Segment G study area on August 26, 2000, at Kingwood College in Houston. Discussion related to any of the four segments (E, F-1, F-2, and G) could occur at any of the three meetings regardless of their location. Summaries of these meetings can be found at the end of Volume I, Section 5.

Over the course of all three meetings, 70 citizens attended the August 1999 Workshops, where a video presented an explanation of the study approach and project schedule. Aerial photomaps of the study area were available for review, and Study Team members were available to answer questions and take comments. Citizens were asked to complete a questionnaire regarding their viewpoints on existing traffic congestion and expected usage of the Grand Parkway, if constructed. The questionnaire and results for the Segment G study area meeting can be found at the end of Volume I, Section 5. During the meeting, six principal concerns were identified for Segment G:

- Loss of wetlands and wildlife habitat;
- More development;
- Increase in traffic, pollution, and loss of federal highway funds;
- Need for new roadways to keep up with population growth;
- Effects to Spring Creek and San Jacinto River Watersheds and Floodplains; and
- Whether a toll facility will be developed.

6.2.1.2 February 2000

Three formal Public Scoping Meetings took place in February 2000. One of these workshops was conducted adjacent to the Segment G study area on February 3, 2000 at Kingwood College in Houston. Discussion related to any of the four segments (E, F-1, F-2, and G) could occur at any of the three meetings regardless of their location. Summaries of these meetings can be found at the end of Volume I, Section 5.

The Public Scoping Meetings were held to inform the public about the proposed project, discuss alternatives, and receive public input on any issues or concerns associated with the location of the project. The meetings consisted of an initial public workshop and a formal question-and-answer period. A video summarized the history of the project and explained the information being presented at the workshop. The presentation also reviewed the project schedule, environmental issues, and the public involvement process. Preliminary corridor alternatives were shown on detailed aerial photomaps of the study area. Study Team members were available to answer questions and take comments.

One hundred thirty-four citizens attended the meetings over the course of the three-day period. Citizens were asked to complete a questionnaire regarding their viewpoints on existing traffic congestion, expected need for and purpose of the Grand Parkway, and which corridor, if any, they preferred in each reach of the project.

At the Segment G scoping meeting on February 3, 2000, 16 attendees completed the questionnaire, and 69 percent of these respondents (11 people) lived in the Segment G study area. All 16 respondents said they would use Segment G of the Grand Parkway and that the Grand Parkway was “needed” or “greatly needed” to relieve existing or future congestion.

Many respondents indicated preference for certain alternative corridors within each of the corridor reaches. Corridor reaches are defined in Section 2.1 (Corridor Study) of both Volume I and II and are shown on Exhibit G–13. Corridor Reach 5 is partially within the Segment G study area and Corridor Reaches 6 and 7 are entirely within the G study area. The respondents preferred Corridor B in Reach 5 (62 percent), Corridor B in Reach 6 (57 percent), and Corridor A in Reach 7 (42 percent). The number of entrance and exit ramps, increased development, and the effect on truck traffic were identified as concerns during the meeting for Segment G. Substantial issues regarding environmental consequences of Grand Parkway construction were identified during the meeting to be effects to wetlands, increased flooding, and pollution from vehicles.

6.2.2 Local Official Involvement

6.2.2.1 August 1999

On August 18, 1999, a meeting was conducted to initiate coordination with local officials and provide an overview of the study process being implemented for Segment G. Table 6-1 provides a list of attendees and their affiliation. At the meeting, a public education video summarizing the project for the upcoming public workshops was screened. Discussion focused primarily on socioeconomic issues and issues of procedure for the environmental documentation. Comments

from this meeting were used in combination with public and resource agency comments to determine a Preferred Alternative Corridor for Segment G of the Grand Parkway.

TABLE 6-1
LOCAL OFFICIALS/ORGANIZATIONS MEETING, AUGUST 1999 AND OCTOBER 2000 FOR SEGMENT G

Name	Affiliation
Peter R. McStravick	Tomball Area Chamber of Commerce - Mobility and Transportation Committee
Brad Brown	Grand Parkway Subcommittee
Kent McLemore	Houston Airport System
Warren Driver	City Manager of Tomball
Carol Sigler	Representative Paul Hilbert
Clayne Stouall	City Council of Tomball
Bruce Hillegeist	Tomball Area Chamber of Commerce
James Jackson	Port of Houston Authority
Paul Hawkins	Precinct 3, Harris County
Mary Schneider	U.S. Senator Kay Bailey Hutchison
Rose Hernandez	Judge Eckels
Ed Shackelford	Precinct Engineer, Harris County, Precinct 4
Senator Jon Lindsay	Senator, North Houston Association (NHA)
Catherine Wray	NHA
John Jackson	City of Houston – Planning and Development
Anthony Tangwa	City of Houston – Planning and Development
Joe Crabb	State Representative
Lisa Gonzales	Engineering Manager – Harris County Toll Road Authority (HCTRA)
Kristen Bishop	H-GAC
Art Salinas	Montgomery County, Precinct 3, Ed Chance

Source: Sign-In Sheet from August 1999 and October 2000

6.2.3 Resource Agency Involvement

Coordination with various agencies indicated that a number of issues needed to be addressed before identification of a Preferred Alternative Corridor. These issues included identification of remnant prairie elements, forested wetlands and forested floodplains, potential wetland mitigation sites, and state plant species of special concern. These issues were addressed through photo-interpretation, coordination with resource agency representatives, and/or meetings with proposed land developers and city and county officials. The corridor resource inventory was revised, recalculated, and reviewed with the TPWD, USACE, and USFWS (see Section 2, Table 2-1 [Corridor Resources Inventory for Segments E, F-1, F-2, and G] of this volume).

In response to comments received during the public outreach program, a partial corridor, Corridor CB, was developed to avoid remnant prairie topography that is potential habitat for the federally protected Texas prairie dawn species, and to avoid areas that were targeted for development in the following three to five years. Corridor D, a new full-length corridor, was also developed. Corridor D consisted of portions of Corridors A, B, and C as well as five areas where shifts were made to avoid or minimize potential impacts. Copies of agendas and minutes from resource agency scoping and corridor study meetings for Segment G are found at the end of Volume I, Section 5.

6.2.3.1 August 1999

On August 18, 1999, a meeting was conducted at the GPA offices with resource agency representatives, listed in Table 6-2. The meeting was conducted to initiate agency coordination, to review the study process for Segments E, F-1, F-2, and G, and to solicit comments and suggestions from agencies on the issues and useful methodologies for addressing the issues. The Study Team requested feedback from the agencies on resources to be studied in the corridor study. Although not all resource categories and specifics of study methods were discussed, the group reached a general consensus on the following topic areas:

- **Wetlands:** NWI wetlands, supplemented with aerial photo interpretation, would be appropriate for the corridor study. Delineations would be conducted, with right-of-entry, for wetlands within the alternative alignments.
- **Non-Regulatory Impacts**: Route studies should not be solely based on regulatory issues and mitigation costs, but should also consider non-regulatory impacts and avoidance and minimization of those impacts. Mitigation of non-regulatory resources, such as upland habitats, should be considered and possibly included in mitigation planning for regulatory resources. In this category of non-regulated resources are large expanses of contiguous habitat, such as prairies, bottomland hardwoods, and forests. It was agreed that the Study Team would prepare a land cover map of these resources for use in the corridor and alignment studies and review it with the agency representatives.
- **Resource Maps**: The Study Team would also distribute current project area mapping for attendees to identify any known areas of importance. It was agreed that these could be turned around within one month of receipt from the Study Team.
- **NEPA/Section 404 Joint Processing**: The Study Team noted that the Study Team may employ an integrated NEPA/404 process for the project and as such, it is important that early studies, like the corridor review, satisfy the Section 404(b)(1) guidelines. A USACE representative noted that the study process presented by the Study Team appeared to satisfy the intent of the guidelines.

On August 26, 1999, a meeting was conducted at the GPA offices with resource agency representatives, listed in Table 6-2. The meeting was conducted to discuss on-going project coordination in general, agency involvement in data collection, and TPWD's role in Section 404 permitting.

Agency involvement in data collection was discussed. All concurred to the importance of agency involvement and cooperation early in the project and prior to the typical regulatory and permitting phase. As part of this early coordination, the TPWD representatives agreed to provide available environmental inventory data 30 days following written request by the GPA. TPWD representatives agreed to assist in identifying agency specific as well as general environmental issues that should be considered in the analysis.

TABLE 6-2
FORMAL AGENCY MEETINGS DURING THE SCOPING AND CORRIDOR STUDY FOR SEGMENT G

Date	Location	Attendees
August 18, 1999	GPA's Offices	TPWD, USACE, TCEQ, General Land Office (GLO), TxDOT, FHWA, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
August 26, 1999	GPA's Offices	TPWD, USFWS, TxDOT, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
February 2, 2000	Tomball College	TPWD, USACE, NRCS, FHWA, TxDOT, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
February 24, 2000	USACE – Galveston District Office	USACE, FHWA, TxDOT, GPA, Michael Baker Jr., and PBS&J
February 24, 2000	USFWS – Clear Lake Office	USFWS, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers

Source: Study Team, 2002

6.2.3.2 February 2000

On February 2, 2000, resource agencies met to conduct project scoping and review the corridor alternatives. Table 6-2 lists the attendees of this meeting. Principal issues addressed included the mapping of prairie and bottomland hardwoods, prior converted croplands, and general coordination procedures. TPWD concerns were addressed at a later meeting.

On February 24, 2000, a USACE Coordination Meeting was conducted at the USACE office. Attendees of this meeting are listed in Table 6-2. It was announced that the FHWA would send a letter requesting that the USACE participate in the DEIS as a "Cooperating Agency." Additionally, principal issues addressed included bottomland hardwoods and preliminary preferences for corridor selection in each reach. USACE presented rationale, shown in Table 6-3, for a Preferred Alternative Corridor in each reach based on the preliminary information at that time.

TABLE 6-3
USACE PREFERRED ALTERNATIVE CORRIDOR AND RATIONALE FOR SEGMENT G

Corridor Reach	Corridor	USACE Comments
5	C	Best for resources; need more detailed alignment studies to further demonstrate avoidance
6	B	Detailed alignment study must further demonstrate avoidance and minimization of wetland impacts
7	A (or C)	Minimizes wetland impacts; closer in; lower floodplain impacts

Source: February 24, 2000 USACE meeting minutes

On February 24, a USFWS Coordination Meeting took place at the Clear Lake USFWS office. Attendees of this meeting are listed in Table 6-2. Principal issues addressed included mitigation sites and conservation of high quality habitat, indirect impacts, riparian corridors, NEPA/404 process, Texas prairie dawn, and preliminary preferences for corridor selection in each reach. A very general discussion took place regarding any preferences for a corridor in some reaches. This information has been revised to address the USFWS' views (Table 6-4) in its March 16, 2000 letter to the GPA (Appendix B).

TABLE 6-4
USFWS PREFERRED ALTERNATIVE CORRIDOR AND RATIONALE FOR SEGMENT G

Corridor Reach	Corridor	USFWS Comments
5	C	To avoid forest stand impacts
6	No-Build	The selection of No-Build by USFWS was a factor in the Development of Corridor D
7	No-Build	The selection of No-Build by USFWS was a factor in the Development of Corridor D

Source: February 24, 2000 USFWS meeting minutes

6.2.3.3 Preferred Alternative Corridor Recommendation

Results of the resource inventory analysis and public and agency coordination led to the development and selection of Corridor D as the Preferred Alternative Corridor (Exhibit G–14). Therefore, Corridor D was carried forward for the alignment study for Segment G. For more discussion of the corridor selection process, refer to Section 2.1 (Corridor Study) of this volume.

6.3 ALIGNMENT STUDY

Alternative alignments were developed within the Segment G selected corridor to fulfill the need for and purpose of the project and minimize potential environmental impacts. The corridor-level data, supplemented with field-collected data, were used as a guide to determine the alignments that provide the best opportunity to avoid and minimize adverse environmental effects. The following section summarizes outreach efforts conducted during the alignment study phase.

6.3.1 Public Involvement

6.3.1.1 October 2000

During the preparation of the DEIS, public workshops were conducted in October 2000. One of these workshops was conducted adjacent to the Segment G study area on October 26, 2000 at Kingwood College in Houston. The workshops were advertised in local newspapers, including the *Houston Chronicle* on September 22 and October 13, 2000.

The objectives of the workshops were to update the public and to obtain citizens' opinions on the overall study, the preliminary alternative alignments, and any additional issues that should be evaluated in the DEIS prepared for each segment. A video presentation summarized the project progress to date and explained information being presented at the workshop. Preliminary alternative alignments were shown on detailed aerial photographs. Study Team members were available throughout the evening to answer questions and take comments.

Two hundred eighty-seven citizens attended the workshops over the three-day period. Citizens were asked to complete a questionnaire regarding their viewpoints on existing traffic congestion, expected need for and usage of the Grand Parkway, and which alternative alignment they preferred in each reach of the project.

From the workshop held adjacent to the Segment G study area, 21 citizens completed questionnaires. Fifty-nine percent of the respondents from the questionnaires (13 of 21) lived in the Segment G corridor. Eighty-six percent of respondents (18 of 21) said they would use Segment G of the Grand Parkway.

Many respondents indicated preference for certain alternative alignments within each of the alignment reaches. Alignment reaches are defined in Section 2.3.1 (Alternatives Development) of this volume and are shown on Exhibit G–40. The Segment G study area includes alignment Reaches 8, 9, 10, 11, and 12. Forty-three percent of respondents indicated they preferred either Alternative Alignments A or B in Reach 8. Forty-three percent of respondents preferred Alternative Alignments B or C in Reaches 9 and 10, and a majority of respondents preferred Alternative Alignment A in Reaches 11 and 12 (55 and 56 percent, respectively) . Environmental issues identified during the meeting were effects to wetlands, increased flooding, and loss of natural areas. Materials related to this and the other October 2000 public workshops, including questionnaire results, are found at the end of Volume I, Section *5*.

6.3.1.2 DEIS Public Hearing

A Public Hearing for the Segment G DEIS released in January of 2007 was held over two nights on March 7, 2007 at Oak Ridge High School (27330 Oak Ridge School Road, Conroe 77385) and on March 8, 2007 at New Caney High School 9th Grade Campus (22784 US Highway 59 South, Porter 77365). The hearing consisted of an open house, a formal presentation, and a public commenting session. On the first night, 98 people attended, including four elected officials; on the second night, 137 people attended including seven elected officials. Aerial photo maps showing the project area and alternative alignments were available to view prior to the hearing presentation. Study Team members from Michael Baker

Jr., Inc., Brown and Gay Engineers, Inc., and PBS&J along with TxDOT and GPA personnel were available to discuss environmental issues, explain exhibits, discuss the state's ROW acquisition program, and answer any questions from the attendees. Comment forms were available to be filled out at the meetings or mailed/e-mailed/faxed at a later date. Materials documenting the Public Hearing are also presented in Volume IV, Section 1.

The Notice of Availability of the DEIS and an announcement for the Public Hearing were published in the *Federal Register*, *Texas Register*, and *Houston Chronicle*. Additional Public Hearing notices were published in *The East Montgomery County Observer*, *Spring Observer West*, *Spring Observer East*, *The Woodlands Villager*, *Conroe Courier*, and *El Dia*. A total of 1,565 individual notices were mailed to elected officials, government agencies, local organizations, civic groups, businesses, landowners, and interested citizens. Copies of notices and the mailing list for distribution of the DEIS are included in Volume IV, Section 1 of the FEIS.

Copies of the DEIS were made available for review at the following seven locations:

1. Texas Department of Transportation, 7721 Washington Avenue, Houston.
2. Grand Parkway Association, 4544 Post Oak Place, Suite 222, Houston.
3. Houston Public Library -Texas Room, 500 McKinney, Houston.
4. Harris County Public Library - Kingwood Branch, 4102 Rustic Woods, Kingwood.
5. Harris County Public Library - Baldwin Boettcher Branch, 22248 Aldine Westfield Road, Humble.
6. Montgomery County Public Library - South Branch, 2101 Lake Robbins Drive, The Woodlands.
7. Montgomery County Library, R.B. Tullis Branch 21130 US Hwy. 59 #K, New Caney.

The public comment period for the Segment G DEIS ran from February 2 to April 27, 2007. Comments were submitted during the Public Hearing and throughout the comment period. In accordance with CEQ regulations (40 CFR 1503.4), responses to substantive comments are presented in Volume IV, Section 2 of the FEIS. Additionally, copies of all the comments in their entirety are included in Volume IV, Section 3.

Response to the Segment G DEIS included multiple comments on each of the following issues: the alternative of shifting the Grand Parkway to the north; the taking of houses, property values, and reimbursement for property acquisition; the use of mass transit; congestion on IH 45 and its feeder roads; ROW landscaping and reducing ROW width; support and critique of specific alternative alignments; school safety, noise impacts, visual impacts, and general impact to quality of life; and impacts from the Grand Parkway's being a toll road. See Volume IV for responses to these and other comments, including detail on how the FEIS incorporated some changes in response to some comments. Many commenters wrote or spoke to show general support for either the No-Build Alternative or the Build Alternative.

6.3.2 Local Official Involvement

6.3.2.1 October 2000

On October 26, 2000, local officials were given a separate opportunity to view the preliminary alternative alignments for Segment G and provide feedback. The meeting was held at Kingwood College, 20000 Kingwood Drive, Houston. The meeting consisted of a video screening and discussion of the alternative alignments. Table 6-1 provides a list of the 20 attendees and their organizational affiliation.

6.3.3 Resource Agency Involvement

During the preparation of the DEIS, numerous meetings were held with resource agencies in order to address specific concerns and to provide updates on the study process. Dates, locations, and attendees of these meetings are listed in Table 6-5, and further detail is provided in the following sections. Copies of the agendas and minutes from resource agency alignment study meetings for Segment G are found at the end of Volume I, Section 5.

TABLE 6-5
FORMAL AGENCY MEETINGS DURING THE ALIGNMENT STUDY FOR SEGMENT G

Date	Location	Attendees
March 3, 2000	TPWD – Clear Lake Office	TPWD, FHWA, GPA, Michael Baker Jr., and PBS&J
March 3, 2000	USFWS – Clear Lake Office	USFWS, FHWA, GPA, Michael Baker Jr., and PBS&J
November 6, 2000	EPA – Dallas Office	EPA, FHWA, TxDOT, GPA, H-GAC, and PBS&J
April 10, 2001	GPA – Houston Office	USACE, FHWA, TxDOT, GPA, Michael Baker Jr., and PBS&J
May 23, 2001	USACE- Galveston Office (Joint Evaluation Meeting)	USFWS, USACE, GLO, TCEQ, EPA, NMFS, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
June 14, 2001	Michael Baker Jr., Inc.	TPWD, USFWS, USACE, GLO, TCEQ, FHWA, TxDOT, GPA, Michael Baker Jr., PBS&J, and Brown and Gay Engineers
July 17, 2001	EPA – Dallas Office	EPA, FHWA, TxDOT, GPA, Michael Baker Jr., and PBS&J
July 31, 2001	Michael Baker Jr., Inc.	TPWD, USFWS, USACE, GPA, Michael Baker Jr., and PBS&J
October 1, 2001	GPA – Houston Office	TPWD, USFWS, TxDOT, GPA, Michael Baker Jr., and PBS&J
February 8, 2002	TxDOT ENV – Austin Office	EPA, FHWA, TxDOT, GPA, and Michael Baker Jr.
March 27, 2002	EPA – Dallas Office	EPA, GPA, and Michael Baker Jr.

Source: Study Team, 2002

6.3.3.1 U.S. Environmental Protection Agency (EPA)

Throughout the alternative alignment study process, meetings have been held specifically with members of the EPA at the EPA Region 6 office in Dallas. On November 6, 2000, the Study Team provided an overview of the project's progress, the status of the EIS, and the mapping of environmental constraints. On July 17, 2001, an overview of the same issues was provided to EPA, and the organization of the EIS documents was explained and discussed (i.e., the multi-volume

approach). Further discussion focused on reviewing methodologies for data collection, indirect and cumulative effects, and mitigation options. On February 8 and March 27, 2002, the Study Team again provided EPA with updates on the project progress, status of the EIS, and document organization. At all meetings, the Study Team fielded any questions or concerns the agency had regarding the process, methodologies, or other issues.

6.3.3.2 U.S. Army Corps of Engineers (USACE)

An additional meeting was held specifically with the USACE to provide an update on the project's progress and to present the status of the EIS, including a review of the multi-volume approach for Segments E, F-1, F-2, and G. The meeting took place on April 10, 2001 and was conducted at the GPA office in Houston. In addition to the issues listed previously, discussion focused on the calculation of wetland impacts and the selection of a Recommended Alternative Alignment.

6.3.3.3 Additional Resource Agency Meetings

On May 23, 2001, members of the Study Team met with several agency representatives (see Table 6-5) for a Joint Evaluation Meeting at the USACE, Galveston District office. Topics discussed included: a review of the project to date and of the EIS status and schedule, explanation of the EIS organization, the traffic study, air quality impacts, and demographics.

On June 14, 2001, a meeting with resource agencies took place at the Michael Baker Jr., Inc. office in Houston. The meeting began with a bus tour of the Segment G project area. A bound workbook entitled, "Summary and Status of the Grand Parkway Segments E, F-1, F-2 and G" was provided to each attendee. In addition to general review of the project, the principal issues discussed for Segment G included: wetlands, the forested bottomland hardwoods, selection of a Recommended Alternative Alignment, and mitigation.

State and federal resource agencies were invited to participate in a field tour and discussion on the preliminary alignments through out the Segment G project area on July 31, 2001. This meeting began with a drive-through of the Segment G project area and concluded at the Michael Baker Jr., Inc. office. In addition to general review of the project, the principal issues discussed for Segment G at this meeting included: methodology in determining bottomland hardwoods and riparian forests; potential impacts to wildlife and wetlands; Lake Houston Park; hydrologic studies; selection of a Recommended Alternative Alignment; and mitigation. The attendees asked the Study Team to adjust alignments to avoid impacts to Waller Ponds, which provide water for wildlife. After the July 31st meeting, the Study Team, in coordination with the resource agencies, identified bottomland hardwoods and riparian forests with in the project area of Segment G. Appendix B contains a letter (August 30, 2001) that discusses TxDOT's commitment to developing Segment G, and the possible future development of Segment H, without disrupting the continuity of Lake Houston Park.

On October 1, 2001, a meeting with resource agencies took place at the GPA office. A map identifying the locations of the bottomland hardwoods and riparian forest within the project area of Segment G was distributed to all the attendees.

After reviewing and approving the map, the other topics discussed included threatened and endangered species and selection of preliminary alignments.

6.4 ADDITIONAL COORDINATION

6.4.1 Expert Panel

Early in the study process, the Study Team recognized the need to involve not only the public and resource agencies as described previously, but also knowledgeable Houston citizens with first hand experience in planning and/or development in the government, education, and private sectors. Consequently, an Expert Panel was assembled, drawing from a large professional base able to assist the Study Team. Names and organizational affiliations of the Expert Panel are provided in Table 6-6. Meetings of the Expert Panel were held on the following dates: January 18, 2000; March 1, 2000; May 3, 2000; and June 14, 2000, at the GPA offices. Participants at one or more of the meetings included H-GAC, Houston Planning Commission, city of Houston, Cy-Fair ISD, Harris County Planning and Development, Harris County Engineering Department/Park Planning, Harris County Public Infrastructure Department, Woodlands Operating Company, American Metro Study, North Harris Montgomery Community College District, Harris County Precinct 3, Harris County Precinct 4, HCFCD, TxDOT, and FHWA.

Although the Expert Panel initially convened in 2000 to address the land use issues, members of the Study Team have continued to coordinate with members of the panel or the organizations they represent to regularly update information.

TABLE 6-6
THE EXPERT PANEL

Expert Panel Member	Position or Affiliation
John Chiang	Member of Houston Planning Commission; Grand Parkway Board member – Involved in apartment development
Alan Clark	Executive Director of the H-GAC – Oversees regional transportation planning for the eight-county metropolitan area, including demographic forecasts and traffic modeling
Kim Coleman	Cy-Fair ISD – Cy-Fair is a suburban school district within the Segment E and F-1 project areas that has devoted considerable effort in acquiring property to meet projected growth
Charles Dean	Harris County Planning and Development
John deBessonet	Harris County Engineering Department, Park Planning – Parks are important to the quality of life for many people; appropriate expertise in this topic was necessary
Richard DeBose	H-GAC – Travel modeling
John Fourqurean	Director of Planning, Research and Evaluation; Cy-Fair ISD
Reeves Gilmore	Harris County Public Infrastructure Department – Oversees all plat applications and planning documents and coordinates with the city of Houston

TABLE 6-6 (CONT.)
THE EXPERT PANEL

Expert Panel Member	Position or Affiliation
Paul Hawkins, P.E.	Asst. Precinct Engineer, Harris County Precinct 3 – The Grand Parkway would intersect or parallel several precinct roads. This precinct is undergoing substantial development pressure
Robert Heineman	Vice President, Woodlands Operating Company – The Woodlands is Houston's largest master planned community, with development activities since the 1970s
Mike Inselmann	President, American Metro Study – Studied Houston's housing and development market and that of many other U.S. cities
John Jackson	City of Houston Planning and Development
Eric Lambe	City of Houston, Long Range Planning Group
Ray Laughter	North Harris Montgomery Community College District, Vice Chancellor, Center for Business and Economic Development
Madan Mangal	City of Houston Planning and Development
Mark Mooney, P.E.	Montgomery County Engineer – Montgomery County makes up nearly 25% of the Segment G project area and is undergoing current development pressures
Pamela Muhammad	H-GAC – Planning
Andy Mullins	Oversees the travel demand modeling effort for H-GAC; understands the relationship between households, income, and employment to traffic demand
Chris Olavson	Former Director of Transportation Planning, Houston District – TxDOT; currently in private consulting; brings years of experience in planning for the Houston area and working closely with H-GAC
Pamela Rocchi	Harris County Precinct 4 Engineering
Max Samfield	GIS Data Services Manager for H-GAC – Coordinated and analyzes geographic data between the demographers and the traffic engineers
David Schuelke	Tomball ISD – Tomball is a suburban school district within the Segment F-1 and F-2 project areas
Ed Shackleford, P.E.	Precinct Engineer, Harris County Precinct 4 – The Grand Parkway would intersect or parallel several precinct roads; this precinct is undergoing substantial development pressure
Barton Smith, Ph.D.	University of Houston, Professor & Director, Center for Public Policy – Brings years of Houston-specific experience in real estate development, growth and the economy
Jeff Taebel	H-GAC – Planning
Anthony Tangwa	City of Houston Planning
Ralph Taylor	HCFCD – Flooding and runoff issues are critical in most of the Segment E project area; specific expertise was needed in this subject
Chris Van Slyke	H-GAC – Travel modeling

Source: Expert Panel Sign-In Sheets, 2000

6.4.2 Community Groups

The GPA has coordinated extensively with community groups with an interest in the Grand Parkway project. The GPA accepted all invitations to speak to any group or organization concerning the Grand Parkway project. Through 2007, over 170 meetings were held with homeowner associations, the media, and other community groups throughout the Segments

E, F-1, F-2, and G study areas. These community groups have been provided a customized presentation that typically includes the history of the Grand Parkway project, the general status of all segments of the Grand Parkway, and specific information about their particular area and interests. The presentations last approximately 10 to 20 minutes and then are followed by a question and answer period. Handouts may be given to the participants, including schedules, maps, and/or contact information. The level of detailed information is dependent on what stage the process is currently undergoing. The presentations are updated at the time of each request to reflect the most current information. The GPA and the Study Team have also been responsive in providing information for other public media and community newsletters. (A list of Homeowner Associations [HOAs] and Residential Subdivisions that participated in GPA coordination for Segments E, F-1, F-2, and G is located in Volume I, Section 5.4.2, Table 5-12.)

6.4.3 Regional Transportation Plan (RTP) and Transportation Improvement Program (TIP)

The 2035 RTP and the FY 2008-2011 TIP identify the addition of toll facilities, including Segment G, as needed to address congestion and growth. The transportation needs identified during the development of the 2035 RTP and 2008-2011 TIP are consistent with those found by the Grand Parkway public outreach process. To define regional transportation needs, H-GAC conducted an extensive public involvement program to gather input from citizens, neighborhood and business groups, governmental bodies, and transportation agencies. Eight public meetings, including five with formal comment periods, were held before the 2008-2011 TIP was adopted. Segments E, F-1, and F-2 were also included in the conforming 2006-2008 TIP. Segment G was included in the 2006-2008 TIP, Appendix D, as a project undergoing environmental review that is scheduled for implementation beyond the three-year TIP time frame.

The Grand Parkway Segment G is included in H-GAC's 2035 RTP and FY 2008-2011 TIP, as amended. On August 24, 2007, the H-GAC adopted the 2035 RTP and FY 2008-2011 TIP. USDOT (FHWA/FTA) found the 2035 RTP and 2008-2011 TIP to conform to the SIP on November 9, 2007.

Changes in modeled parameters between the 2025 RTP and the 2035 RTP (such as traffic volumes, population, employment, number of households, and vehicle miles traveled) have been evaluated to determine if any additional analysis is warranted before 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 modeled parameters can be found in the Administrative Record.

6.4.4 Website

The GPA has a website at www.grandpky.com for the proposed, 170-mile circumferential highway. The website is updated routinely with current news items; segment progress, including Segment G; and project materials. The website also includes a place to register for the project mailing list.

The GPA maintains an open office concept that allows any individual to telephone or drop by the office to request information on Segment G. Faxes and e-mails are used to transmit information. The GPA will also meet with anyone at his or her convenience at locations outside of the GPA office to answer questions, provide maps and detailed information, or to receive information. These contacts could include the general public, small groups or special interest organizations, agencies, or elected officials.

SECTION 7: LIST OF PREPARERS

This document was prepared by FHWA, TxDOT, and GPA, with assistance from Michael Baker Jr., Inc., PBS&J, Brown & Gay Engineers, Inc., and Community Awareness Services.

7.1 FEDERAL HIGHWAY ADMINISTRATION (FHWA)

Mr. Donald Davis	B.S. in Civil Engineering with 18 years experience in transportation.
Mr. Michael Thomas Leary	B.S. in Civil Engineering with 32 years experience in transportation, including 7 years with Texas Highway Department and 26 years with FHWA (in design, construction, research, transportation planning, and environment).
Mr. Jose Campos	B.S. in Civil Engineering with 15 years experience in transportation planning and air quality.
Mr. Clarence Rumancik, P.E.	B.S. in Civil Engineering with 15 years experience in transportation.

7.2 TEXAS DEPARTMENT OF TRANSPORTATION (TXDOT)

Dr. Stanley W. Cooper	PhD. In Zoology with 7 years experience in NEPA studies.
Mr. Lance Olenius	B.S. in Biology, specializing in Environmental Biology and Ecology, with 3 years experience in NEPA studies, wetland delineation, and permitting.

7.3 GRAND PARKWAY ASSOCIATION (GPA)

Mr. David W. Gornet, P.E.	M.E. in Civil Engineering with 18 years experience in route studies, traffic analysis, preliminary engineering, and NEPA coordination, plus 2 years Assistance Executive Director or Executive Director of the Grand Parkway Association.

7.4 MICHAEL BAKER JR., INC.

Mr. Robb H. Fishman, AICP Manager, Environmental Services *Project Manager*	B.A. in Geology and Geography with 20 years experience in NEPA studies.
Ms. Martha DoByns Environmental Specialist *Assistant Project Manager*	M.S. in Marine Science and B.A. in Anthropology with 8 years experience in environmental analysis, protected species surveys, wetland delineation, and NEPA document preparation.
Dr. Willard McCartney Assistant Engineering Manager *Senior QA/QC*	Ph D. in Biology with 30 years experience in ecological analysis and natural wildlife population dynamics.

Mr. William Cody Air Quality Specialist *GIS, Air Toxics*	B.A. in Geography and Anthropology with 4 years GIS experience and 1 year in air toxic studies.
Mr. Paul M. Prideaux, P.E. Engineering Manager *Task Manager, Traffic*	B.S. in Civil Engineering with 12 years experience in traffic engineering and transportation planning.
Mr. Zachary P. Harris Assistant Engineer *Traffic Engineer*	B.S. Civil Engineering with 2 years experience in traffic engineering.
Ms. Lu Ann N. May Senior Systems Analyst *Environmental Impact Analysis*	B.S. in Management Information Systems with 16 years experience in GIS applications, including 7 years performing corridor location studies.
Ms. Kathe J. Sopenski, P.E. Planning Manager *Task Manager, Socioeconomics*	B.S. in Civil Engineering with 29 years experience with Ohio DOT, including 14 years experience in planning and environmental clearances.
Mr. Randy Luketic Drafting Technician IV *GIS, Graphics*	Technical course for GIS and graphics with 13 years experience in plotting for highway, planning and environmental projects.
Mr. Laurence Gale Environmental Manager *Task Manager, Natural Resources*	M.S. in Marine Biology with 12 years experience in wetland and aquatic resources, OSHA hazardous waste site work, supervisor training, NEPA document preparation and permitting.
Mr. Kenneth J. Corti, P.W.S. Senior Environmental Scientist *Water Quality, Mitigation Plan*	M.S. in Geography and B.S. in Natural Resources Conservation with 18 years experience in environmental documentation and planning, wetland studies, and NEPA project management.
Ms. Rachel A. Hostetter Assistant Environmental Scientist *Surface Water Quality*	B.S. in Environmental Resource Management with 2 years experience in NEPA studies.
Ms. Tamara Smith Technical Writer II *Editor/Document Production*	Certified in Written English, Master's Level with 7 years experience in technical writing and 15 years experience in document production.
Ms. Mindi Nielsen Environmental Planner *Environmental Planner*	B.S. in Environmental Studies with 5 years experience in environmental planning and NEPA studies.
Mr. [Sonny] Clarence Kaiser Environmental Planner *Environmental Planner*	B.S. in Wildlife Fisheries Management with 2 years experience in environmental planning and NEPA studies.

7.5 PBS&J

Ms. Kerry Winkler Sr. Transportation Planner II *Environmental Manager*	B.S. in Wildlife and Fisheries, Ecology with 10 years experience in transportation planning and NEPA document preparation, wetland delineation, and biological assessments.
Ms. Heather Niles Project Manager *Task Manager, Natural Resources*	M.S. and B.S. in Environmental Science with 7 years experience in environmental assessments, wetland studies, and NEPA project management.
Ms. Tricia LaRue Environmental Planner II *Economics*	M.S. in Land Design and Management and B.S. in Biology with 3 years experience in NEPA compliance and environmental studies.
Mr. Steven Ray McVey Senior Geologist *Geology, Hazardous Materials*	B.S. in Geology with 12 years experience in environmental studies and NEPA document preparation.
Mr. Eugene R. Foster Jr. Associate, Senior Staff Historian *Architectural Resources*	B.S. in Cultural Resource Management and Historic Preservation with 15 years experience in cultural resource management.
Mr. James F. Gregory Program Manager *Wetlands, Protected Species, and Mitigation*	M.S. in Forest Game Management with 15 years experience in wetland ecology and NEPA studies.
Mr. John Fulmer Archaeologist *Archaeology*	M.A. in Archaeology with 12 years experience in archaeological field studies and NEPA documentation.

7.6 BROWN & GAY ENGINEERS

Mr. Christopher D. Cotter, P.E. Deputy Director of Transportation *Engineering Manager*	B.S. in Civil Engineering with 16 years experience in schematic and final design of highway projects.
Mr. J. Robert Arroyave, P.E. Director of Transportation *Deputy Project Manager*	B.S. in Civil Engineering with 31 years experience in schematic and final design of highway and bridge projects.
Mr. Matthew W. Brannen, P.E. Project Engineer *Schematic Layouts*	B.A. in Civil Engineering with 10 years experience in roadway design.
Mr. Lee C. Leonard, P.E. Project Manager *Hydrology & Hydraulics Manager*	B.S. in Civil Engineering with 14 years experience in hydrology and hydraulics.
Mr. Alan McLain, R.P.L.S. Director of Surveying *Surveying Manager*	B.S. in Geology with 21 years experience in right-of-way and field surveying.

7.7 COMMUNITY AWARENESS SERVICES

Ms. Jerri Anderson *Principal, Community Awareness Services Reviewer*	A.A. in Business with 19 years of experience with NEPA public involvement programs.

SECTION 8: DISTRIBUTION LIST

AGENCY	NUMBER OF COPIES SENT
Department of Housing and Urban Development 801 Cherry Street P.O. Box 2905 Fort Worth, Texas 76113-2905	2 copies
U.S. Army Corps of Engineers P.O. Box 1229 Galveston, Texas 77553-1229	3 copies
U.S. Department of Agriculture Office of the Secretary Washington, D.C. 20250	1 copy
Director, Office of Environmental Policy and Compliance U.S. Department of the Interior Main Interior Bldg, MS 2340 Washington, D.C. 20240	18 copies
Mr. Michael Jansky, P.E. Environmental Protection Agency Region 6 1445 Ross Avenue Dallas, Texas 75202-2733	5 copies
Ms. Denise Francis State Single Point of Contact Governor's Office of Budget & Planning P.O. Box 12428 Austin, Texas 78711	8 copies
Division Administrator Federal Highway Administration Austin, Texas 78701	7 copies
Federal Railroad Administration Office of Economic Analysis (RRP-32) 400 Seventh Street, SW Washington, D.C. 20590	1 copy
Ms. Kathy Boydston Texas Parks and Wildlife Department Resource Protection Division Environmental Assessment Branch 4200 Smith School Road Austin, Texas 78744	1 copy

Ms. Celeste Brancel-Brown 1 copy
Texas Parks and Wildlife Department
Endangered Resources Branch
3000 South IH 35, Suite 100
Austin, Texas 78704

Mr. Dan Burke 2 copies
Texas Commission on Environmental Quality
Policy and Regulations Division, MC 205
P.O. Box 13087
Austin, Texas 78711-3087

Mr. Alan Clark 1 copy
Houston-Galveston Area Council
Transportation Planning
P.O. Box 22777
Houston, Texas 77227-2777

Mr. Mike Talbott 1 copy
Harris County Flood Control District
9900 Northwest Freeway
Houston, Texas 77092

Mr. Mike Stretch, P.E. 1 copy
Harris County Toll Road Authority
330 Meadowfern Drive
Houston, Texas 77067

Mr. Frank J. Wilson 1 copy
Metropolitan Transit Authority of Harris County
P.O. Box 61429
Houston, Texas 77208-1429

Ms. Dianna Noble, 1 copy
Director, Environmental Affairs Division
Texas Department of Transportation
125 E. 11th Street
Austin, Texas 78701

Mr. Gary K. Trietsch, P.E. 1 copy
District Engineer
Texas Department of Transportation
7721 Washington Avenue
P.O. Box 1386
Houston, Texas 77251-1386

Mr. David Gornet 1 copy
Executive Director
Grand Parkway Association
4544 Post Oak Place, Suite 222
Houston, Texas 77027

SECTION 9: REFERENCES CITED

Abbott, J.T.
2001 Houston Area Geoarcheology: A Framework for Archeological Investigation, Interpretation, and Cultural Resource Management in the Houston Highway District. Texas Department of Transportation. Environmental Affairs Division. Archeological Studies Program, Report 27. Morgan Printing. Austin, Texas.

Adams, L.W. and Geis, A.D.
1981 Effects of Highways on Wildlife. Report No. FHWA/RD-81/067, U.S. Department of Transportation Federal Highway Administration, Washington, D.C. pp.142.
1983 Effects of Roads on Small Mammals. Journal of Applied Ecology 20: pp. 403-415.

Agency for Toxic Substances and Disease Registry (ATSDR)
1997 Toxicological Profile for Benzene (Update). Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA

Ajilvsgi, G.
1979 Wildflowers of the Big Thicket, East Texas and Western Louisiana. Texas A&M University Press. College Station, Texas.

Akimov, Y.A., Pashkar, V.V., and Kuznetsov, S.I.
1989 The Content and Comparison of Volatile Terpenoids in Woody Plants under Conditions of Air Pollution. Sbornik Nauchnykh Trudov 109: pp. 70-79.

Altinger, Roland
2007 Personal communication (telephone) with Roland Altinger, Harris County Appraisal District. 2006 net taxable value for Harris County. February 1, 2007.

American Association of University Women
1977 The Heritage of North Harris County, n.p: North Harris County Branch, American Association of University Women.

Anderson, J.R., Hardy, E.E., Roach, J.T., and Witmer, R.E.
1976 A Land Use and Land Cover Classification System for Use with Remote Sensor Data (USGS Professional Paper 964). Washington, D.C.: USDOI.

Ashworth, J.B. and Hopkins, J.
1995 Major and Minor Aquifers of Texas (Texas Water Development Board Report 345). Austin, Texas: TWBD.

Askins, R.A., Lynch, J.F., and Greenberg, R.
1990 Population Declines in Migratory Birds in Eastern North America. Current Ornithology 7: pp. 1-57.

Aten, L.E.
1983 Indians of the Upper Texas Coast. Academic Press, New York.

Aten, L.E., Chandler, C.K., Wesolowsky, A.B., and Malina, R.M.
1976 Excavations at the Harris County Boy's School Cemetery. Analysis of Galveston Bay Area Mortuary Practices. Texas Archaeological Society Special Publication 3.

Baker Engineering *(see Michael Baker Jr., Inc.)*

Baker, E.T., Jr.
1979 Stratigraphic and Hydrogeologic Framework of Part of the Coastal Plain of Texas (Texas Department of Water Resources Report 236). Austin, Texas: TDWR.

Banerjee, A., Sarkar, R.K., and Mukherji, S.
1983 Reduction in Soluble Protein and Chlorophyll Contents in a Few Plants as Indicators of Automobile Exhaust Pollution. International Journal of Environmental Studies 20: pp. 239-243.

Barbour, R.W. and Davis, W.H.
1969 Bats of America. The University Press of Kentucky. Lexington, Kentucky.

BFI Waste Systems of North America Katy Prairie Mitigation Bank (BFI)
1998 Memorandum of Agreement between BFI, U.S. Army Corps of Engineers, and Mitigating Banking Review Team Agencies. pp. 69.

Blair, W.F.
1950 The Biotic Provinces of Texas. Tex. J. Sci. 2: pp. 93-117.

Boarnet, M.G. and Chalermpong, S.
2001 New Highways, House Prices, and Urban Development: A Case Study of Toll Roads in Orange County, CA, Housing Policy Debate, Vol. 12 Issue 3.

Bogemans, J., Nierinck, L., and Stassart, J.M.
1989 Effect of Deicing Chloride Salts on Ion Accumulation in Spruce (Picea abies (L.) sp.). Plant and Soil 113: pp. 3-11.

Brittingham, M.C. and Temple, S.A.
1983 Have Cowbirds Caused Forest Songbirds to Decline? BioScience 33: pp. 31-35.

Buller, R.J.
1964 Central Flyway. Pages 209-232 in J. P. Linduska, ed. Waterfowl tomorrow. U. S. Fish and Wildlife Service. Washington, D. C.

Bureau of Economic Geology (BEG)
1977 Geologic Atlas of Texas. The University of Texas at Austin: Austin, Texas.
1981 Geologic Atlas of Texas. The University of Texas at Austin: Austin, Texas.
1982 Geologic Atlas of Texas. The University of Texas at Austin: Austin, Texas.

Burton, Stephanie
2007 Personal communication (email) with Stephanie Burton, Montgomery County tax assessor-collector's office. 2006 current taxable value for Conroe ISD. February 2, 2007.

Butler, G.
2003 Personal communication (telephone) regarding Klein ISD Property (off FM 2920 between Boudreaux Rd. and Kukendahl. April 15, 2003.

California Department of Transportation (Caltrans)
2003 Level of Service Graphic. Retrieved from www.dot.ca.gov/ser/forms.htm.
2005 Guidance for Preparers of Indirect and Cumulative Impact Assessments.

California Environmental Protection Agency-Air Resources Board and American Lung Association of California
2004 Recent Research Findings: Health Effects of Particulate Matter and Ozone Air Pollution. Retrieved from: http://www.californialung.org/downloads/hn/Research_HealthEffects_ParticulateMatter.pdf.

Campbell, L.
1995 Endangered and Threatened Animals of Texas: Their Life History and Management. Texas Parks and Wildlife Dept. Press: pp. 130.

Campbell, T.N.
1957 Archaeological Investigations at the Caplen Site, Galveston County Texas. In Texas Journal of Science 9: pp. 448-471.

Chesapeake Bay Program
2001 Riparian Forest Buffers. Retrieved from http://www.chesapeakebay.net/info/forestbuff.cfm.

Cirillo, J.A.
1968 Interstate System Accident Research Study II, Interim Report II, Public Roads, Vol. 35, No. 3. August 1968.
1999 Interstate System Accident Research Study – 1, Volume 1 – Comparison of Accident Experience on the Interstate and Non-Interstate Highways. Report of the Bureau of Public Roads, October.

City of Houston
2003 Growth Indicators – Reporting Building Permit Data for November 2003. Planning and Development Department, Volume 11, No. 12. December.

Claggett, M. and Miller, T.L.
2006 A Methodology for Evaluating Mobile Source Air Toxic Emissions Among Transportation Project Alternatives. Retrieved from http://www.fhwa.dot.gov/environment/airtoxic/msatcompare/msatemissions.htm (Table).

Clark, J.R. and Benforado, J., eds.
1981 Wetlands of Bottomland Hardwood Forests. Proceedings of a workshop on bottomland hardwood forest wetlands of the southeastern United States. Elsevier Scientific Publishing Company. New York, NY.

Conant, R. and Collins, J.T.
1991 A Field Guide Reptiles and Amphibians. Houghton Mifflin Co., Boston.

Council on Environmental Quality (CEQ)
1997 Considering Cumulative Effects under NEPA.
2005 Guidance on the Consideration of Past Actions in the Cumulative Effects Analysis. Memorandum.

Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T.
1979 Classification of Wetlands and Deepwater Habitats of the United States. U. S. Department of the Interior. Fish and Wildlife Service. FWS/OBS-79/31. pp. 131.

Craigmiles, J.P.
1975 Advances in Rice – through Research and Application. In Six decades of rice research in Texas. J. E. Miller, ed. Texas Agricultural Experiment Station Resource Monograph 4. College Station, Texas. pp. 1-8.

Darnell, R.M., Pequegnat, W.E., James, B.M., Benson, F.J., and Defenbaugh, R.A.
1976 Impacts of Construction Activities in Wetlands of the United States. Tereco Corporation. pp. 392.

Davis, W.B. and Schmidly, D.J.
1994 The Mammals of Texas. Texas Parks and Wildlife Dept. Distributed by University of Texas Press.

Dempster, J.P.
1975 Animal population ecology. Academic Press, London. pp. 155.

Dennis, M. and Upchurch, L.
1999 Handbook of Texas Online, s.v. "TOMBALL, TX." Retrieved from http://www.tsha.utexas.edu/handbook/online/articles/ TT/hgt6.html.

Dethloff, H.C.
1999 The Handbook of Texas Online, s.v. "RICE CULTURE." Retrieved from http://www.tsha.utexas.edu/handbook/online/articles (last updated February 15, 1999).

Dice, L.R.
1943 The biotic provinces of North America. Univ. of Michigan Press, Ann Arbour. pp. 78.

Dickinson, N.M., Lepp, N.W., and Surtan, G.T.K.
1987 Lead and Potential Health Risks from Subsistence Food Crops in Urban Kenya. Environmental Geochemistry and Health 9: pp. 37-42.

Dixon, J.R.
1987 Amphibians and Reptiles of Texas. Texas A&M University Press. College Station, Texas.
2000 Amphibians and Reptiles of Texas. 2nd ed. Texas A&M University Press. College Station, Texas.

Duke, P.M.
1999 Handbook of Texas Online, s.v. "KLEIN, TEXAS." Retrieved on May 3, 2006 from http://www.tsha.utexas.edu/ handbook/online/articles/KK/hrk19.html.

Ensor, H.B.
1990 Archeological Survey of Cypress Creek from Spring Branch to Kukendahl Road, Harris County, Texas: Texas A&M University, Archeological Surveys No. 8, College Station, Texas.

Ensor, H.B., Dockall, J.E., Winchell, F.
1991 National Register Eligibility Testing and Assessment at the Al Soloman I and Al Soloman II Sites, Cypress Creek, Harris County, Texas. Texas A&M University, Reports of Investigations No. 12, College Station.

Ensor, H.B., Nordt, L.C., and Prior, M.
1996 Historic Properties Survey of Alternatives 6 and 19, Cypress Creek Flood Control Project, Harris County, Texas. Geo-Marine, Inc. Miscellaneous Reports of Investigations No. 133.

Environmental Law Institute
2005 NEPA's Uncertainty in the Federal Legal Scheme Controlling Air Pollution from Motor Vehicles. ELR 35-ELR 10273.

Environmental Protection Agency (EPA) *(see U.S. Environmental Protection Agency)*

Ernst, C.H., Lovich, J.E., and Barbour, R.W.
1994 Turtles of the United States and Canada. Smithsonian Institution Press. Washington and London.

Eubanks, T.L.
1994 A History and Characterization of the Katy Prairie. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Faaborg, J., Brittingham, M., Donovan, T., and Blake, J.
1992 Habitat Fragmentation in the Temperate Zone: a Perspective for Managers. In: D.M. Finch and P.W. Stangel (eds.), Status and Management of Neotropical Migratory Birds. USDA Forest Service General Technical Report RM-229. Fort Collins, CO.

Farmer, A.M.
1993 The Effects of Dust on Vegetation – a Review. Environmental Pollution. 79: pp. 63-75.

Federal Emergency Management Agency (FEMA)
2000 FEMA Q3 Digital Data. Harris County 100-year floodplain.
2004 FEMA Q3 Digital Data. Harris County 100-year floodplain.

Federal Highway Administration (FHWA)
1987 Guidance for Preparing and Processing Environmental and Section 4(f) Documents. FHWA Technical Advisory T 6640.8A. October 30.
1988 Hazardous Waste Sites Affecting Highway Project Development, Interim Guidance. August.
1990a Purpose and Need in Environmental Documents. Memorandum.
1990b Visual Impact Assessment for Highway Projects. FHWA-RE-90-007.
1992 Position Paper: Secondary and Cumulative Impact Assessment in the Highway Development Process, FHWA Project Development Branch, HEP-31, April.
1993 Guidance on the Development of Logical Project Termini. Memorandum.
2001 23 CFR 722, Procedures for Abatement of Highway Traffic Noise and Construction Noise. Retrieved from http://www.fhwa.dot.gov/hep/23cfr772.htm.
2003 Q&A Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process.
2006 Interim Guidance on Air Toxic Analysis in NEPA Documents. February 3.

FHWA and Federal Transit Administration (FTA)
2005 Integration of Planning and NEPA Processes. Memorandum.

Fields, R.C., Freeman, M.D., and Kotter, S.M.
1983 Inventory and Assessment of Cultural Resources at Addicks Reservoir, Harris County, Texas. Prewitt & Associates, Inc. Reports of Investigations 22. Austin.

Findlay, C.S. and Bourdages, J.
2000 Response Time of Wetland Biodiversity to Road Construction on Adjacent Lands. In: Conservation Biology, Volume 14, No. 1, February.

Fisher, W.L., McGowen, J.H., Brown, Jr., L.F., Groat, C.G.
1972 Environmental Geologic Atlas of the Texas Coastal Zone, Galveston-Houston Area: Bureau of Economic Geology. The University of Texas. Austin, Texas.

Fleck, A.M., Lacki, M.J., and Sutherland, J.
1988 Response of White Birch (Betula papyrifera) to Road Salt Applications at Cascade Lakes, New York. Journal of Environmental Management 27: pp. 369-377.

Flueckiger, W., Fluckiger-Keller, H., and Braun, S.
1984 Untersuchungen Ueber Waldschaeden in der Nordwestscweiz. Schweizerische Zeitschrift fuer Forstwesen 135: pp. 389-444.

Forman, R.T. and Deblinger, R.D.
2000 The Ecological Road-Effect Zone of a Massachusetts (U.S.A.) Suburban Highway. In: Conservation Biology, Volume 14, No. 1, February.

Fox, D.
1980 An Archeological Reconnaissance at the City of Conroe. Letter Report C-48-1227-01.Texas Department of Water Resources.

Fraser, D. and Thomas, E.R.
1982 Moose-Vehicle Accidents in Ontario: Relation to Highway Salt. Wildlife Society Bulletin, Vol. 10, No. 3, 1982, pp. 261-65.

Frasier, E.
1994 Wetland Habitat Alliance of Texas Coastal Prairie Initiatives. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Gabrysch, R.K.
1977 Approximate Area of Recharge to the Chicot and Evangaline Aquifer Systems in Houston-Galveston Area, Texas (U.S. Geological Survey Report OFR 77-754). Austin, Texas (USGS).

Gaegler, A.M., March, J.W., & Weiner, P.
1979 Dynamic Social and Economic Effects of the Connecticut Turnpike, pp. 28-32.

Garrett, J.M. and Barker, D.G.
1987 A Field Guide to Reptiles and Amphibians of Texas. Texas Monthly Field Guide Series. Texas Monthly Press. Austin, Texas. pp. 225.

Geib, H.V.
1928 Soil Survey of Harris County, Texas. Center for American History

Gore, L.
1994 The Katy Prairie Hunting – Its Historic and Economic Benefits. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Gorney, J.C.
1999 The Community Impact of State Highway 130 in Williamson County, Texas. Fall

Gould, F.W.
1975 The Grasses of Texas. Texas A&M University Press. College Station, Texas.

Graham, D.L. and Kalman, S.M.
1974 Lead in Forage Grass from a Suburban Area in Northern California. Environmental Pollution 7: pp. 209-215.

Guntner, M. and Wilke, B.M.
1983 Effects of De-Icing Salt on Soil Enzyme Activity. Water, Air and Soil Pollution 20: pp. 211-220.

Gunter, P.A.Y.
1993 The Big Thicket: An Ecological Reevaluation. University of North Texas Press. Denton, Texas.

Guttormsen, G.
1993 The Content of Lead, Cadmium and PAH in Vegetables and Strawberries alongside the E18 Motorway. Norsk Landbruksforsking 7: pp. 175-189.

Haig, S.M.
1992 Piping Plover: Charadrius Melodus. In: The Birds of North Amercia, No. 2. American Ornithologists' Union. The Academy of Natural Sciences of Philadelphia. Washington, D.C.

Haig, S.M. and Oring, L.W.
1985 Distribution and Status of the Piping Plover throughout the Annual Cycle. J. Field Ornithol. 56(4): pp. 334-345.

Hamilton, K. and Nelson, P.C.
1984 Habitat Suitability Index Models and Instream Flow Suitability Curves: White Bass. U.S. Fish and Wildlife Serv. Biol Report. 82(10.89). pp. 35.

Harris County Appraisal District
2008 Jurisdiction information: 2007 tax rate. Retrieved from http://www.hcad.org/resources/jurlist.asp. January 14.

Harris County Deed Records
1919 Land Record Research in Houston, Harris County, Texas.

Harris County Flood Control District (HCFCD)
2000 Personal communication to Jim Gregory from Sheblak, Kenneth, P.E. in consultation with Melvin Spinks and Kurt Killian of CivilTech, Inc. regarding Cypress Creek Floodplain Management Plan (pending). October.

Harris-Galveston Subsidence District
2004 HGSDWellInfor.zip (WaterWell_HGSD.shp).

Hatch, S. L., Kancheepuram, N. G., and Brown, L.E.
1990 Checklist of the Vascular Plants of Texas. The Tex. Ag. Exp. Sta. MP 1655. Texas A&M University, College Station, Texas. pp. 158.

Hazlewood, C.
1999 The Handbook of Texas Online, s.v. "KOHRVILLE, TEXAS." Retrieved on May 10, 2006 from http://www.tsha.utexas.edu/handbook/online/articles/KK/hrk18.html.

Henry, M.L.
1994 Growth patterns of Houston and the Katy Prairie. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Hensen, M.S.
1999 The Handbook of Texas Online, s.v. "HARRIS COUNTY." Retrieved from http://www.tsha.utexas.edu (last updated February 15, 1999).

Hobaugh, W.C., Stutzenbacker, C.D., Flickinger, E.L.
1989 The Rice Prairies. Habitat Management for Migrating and Wintering Waterfowl in North America. Texas Tech University Press, Lubbock, Texas.

Hooper, R.G. et al.
1986 Forest stands selected by foraging red-cockaded woodpecker. USDA, Forest Service, Southeastern Forest Experiment Station, Asheville, N.C.

Houston Business Journal
2002 Volume 33, No. 32. December 20-26.

Houston-Galveston Area Council (H-GAC)
1998 Goals For Tomorrow – A Comprehensive Planning Framework for the Houston-Galveston Area Council. Adopted November 1998.
2003 H-GAC Transportation Center, Committee webpage. Retrieved from http://www.hgac.cog.tx.us/transportation/committees.html.
2005a 2025 Regional Transportation Plan (RTP). Houston-Galveston Area. Retrieved on July 20, 2005 from h-gac.com/transportation.
2005b 2006-2008 Transportation Improvement Plan (TIP). Houston-Galveston Area. Retrieved on July 20, 2005 from h-gac.com/HGAC/departments/transportation.
2005c Personal communication with H-GAC regarding crash statistics. July 13, 2005.
2006 The Houston Metropolitan Traffic Safety Planning Program. Ned Levine. Houston, TX: Houston-Galveston Area Council, March 22, 2006.
2007a 2035 Regional Transportation Plan (RTP) and Travel Demand Model. Houston-Galveston Area. Retrieved from http://2035plan.org/documents.htm.
2007b Personal communication regarding the Congestion Management System with Robb Fishman of Michael Baker Jr., Inc. June 11.

Houston Planning Commission
2005 Major Thoroughfare and Freeway Plan. Approved by the Houston Planning Commission on August 4, 2005 and adopted by Houston City Council on October 5, 2005: Council Motion 2005-0972.

Hubbs, C.
1957 Distributional Patterns of Texas Freshwater Fishes. Southwestern Naturalist 2:89-104.
1982 A checklist of Texas freshwater fishes. Tech. Ser. No. 11. Texas Parks and Wildlife Dept., Austin, Texas. pp. 15.

Hubbs, C., Edwards, R.J., and Garrett, G.P.
1991 An Annotated Checklist of the Freshwater Fishes of Texas, with Keys to Identification of Species. Texas Journal of Science 43(4):1-56 (including errata sheet, February 1996).

Hurley, M.
2000 Historic Houston. Retrieved from http://www.houstonhistory.com/decades/history5-5p.htm (last updated August 28, 2000).

James Miertschin & Associates, Inc.
2007 Preliminary Data Review for Lake Houston Watershed Bacteria Impairments. Prepared for the TMDL Program of the TCEQ. August.

Katy-Cypress Wetland Mitigation Bank (KCWMB)
1996 SWC Katy Hockley Cutoff and Jack Road, Harris County, Texas. Final Approval and Signature Documents.

Katy Independent School District (ISD)
2001 Katy ISD Tax Rate Information. Retrieved from http://www.katyisd.org/about_kisd.htm#tax.

Katy Prairie Conservancy (KPC)
2002 The Katy Prairie: History and Importance. Retrieved from http://www.katyprairie.org/prairie.html#topsec1.

Kenmotsu, N.A. and Perttula, T.K.
1993 Archeology in the Eastern Planning Region, Texas: A Planning Document. Department of Antiquities Protection. Cultural Resource Management Report 3. Texas Historical Commission. Austin, Texas.

Kiang, Y.T.
1982 Local Differentiation of Antboxanthum Odoratum L. Populations on Roadsides. American Midland Naturalist 107: pp. 340-350.

Kleiner, D.J.
1999 The Handbook of Texas Online, s.v. "HOCKLEY, TEXAS." Retrieved from http://www.tsha.utexas.edu/handbook/online/ articles (last updated February 15).

Kolbe, C.M.
1994 Water Quality in Cypress Creek: An Effluent Dominated Stream (Segment 1009) (Texas Natural Resource Conservation Commission Report AS-55/SR). Austin, Texas: TCEQ.

Kotter, S.M. and Fields, R.C.
1983 National Register Testing of Site 41HR436, Addicks Reservoir, Harris County, Texas. Prewitt and Associates, Inc. Report of Investigations 23. Austin.

Kreitler, C.W.
1977 Faulting and Land Subsidence from Ground-Water and Hydrocarbon Production, Houston-Galveston, Texas: Bureau of Economic Geology. The University of Texas. Austin, Texas.

Krzusztofiak, L.
1991 The effect of habitat pollution with heavy metals on ant populations and ant-hill soil. Ekologia Polska 39: pp. 181-202.

Lambright, C.
2001 Personal communication (telephone) with Chris Moore (PBS&J) and Christi Lambright (Planner) of Harris County – Community Development Department. September 19.

Langley, C.J.
1976 Adverse Effects of the Washington Beltway on Residential Property Values, Land Economics, pp. 54-65. February.

Lee, D.S., Gilbert, C.R., Hocutt, C.H., Jekins, R.E., McAllister, D.E., and Stauffer, J.R., Jr.
1980 Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History.

Leedy, D.L.
1977 Highways and Wildlife: Implications for Management. In: Classification, inventory, and analysis of fish and wildlife habitat. Proceedings of a National Symposium, Phoenix, Arizona. 24-27 Jan. 1977. U.S. Fish and Wildlife Service, Washington, D.C. pp. 363-383.

Little et al.
2006 Governor's Task Force on Evacuation, Transportation, and Logistics. February 14, 2006.

Lobpries, D.
1994 Waterfowl on the Katy Prairie (Utilization & Trends). Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Mace, R.E., Davidson, S.C., Angle, E.S., Mullican, III, W.F.
2006 Aquifers of the Gulf Coast of Texas, Report 365: Texas Water Development Board. February, 2006.

Malone, J.M., Greer, G., and Simons, H.
1979 Kirbee Kiln: A Mid-19th Century Texas Stoneware Pottery. Office of the State Archeologist Report 31. Texas Historical Commission, Austin, TX.

Maxwell, R.S.
1981 Texas Economic Growth, 1890 to World War II: From Frontier to Industrial Giant.

Maxwell, R.S. and Baker, R.D.
1983 Sawdust Empire: The Texas Lumber Industry, 1980-1940. Texas A&M University Press: College Station, TX.

McGuirk, W.K.
1973 Evaluation of Factors Influencing Driveway Collisions, Report of the Joint Highway Research Project, Purdue University.

McMahan, C.A., Frye, R.G., and Brown, K.L.
1984 The Vegetation Types of Texas including Cropland. An Illustrated Synopsis to Accompany the Map. Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas.

Meyer, W.R. and Carr, J.E.
1979 A Digital Model for Simulation of Ground Water Hydrology in the Houston Area, Texas (Texas Department of Water Resources Report LP-103). Austin, Texas: TDWR.

Michael Baker Jr., Inc.
2000a Working Paper #1: Secondary Development Analysis. April 2000.
2000b Working Paper #2: Socioeconomics and Corridor Study.
2006 Northern Alignment Feasibility Study.

James Miertschin & Associates, Inc.
2007 Preliminary Data Review for Lake Houston Watershed Bacteria Impairments. Prepared for the TMDL Program of the TCEQ. August.

Minnesota Implan Group
2000 Implan Professional – Version 2.0, User's Guide, Analysis Guide, Data Guide, and Input-Output Model for Harris County, Texas. Second Edition. June. Stillwater, Minnesota.

Minoranskii, V.A. and Kuzina, Z.R.
1984 Effect of Environmental Pollution by Motor Transport on the Reproduction and Development of Opatrum Sabulosum. Biologicheskie Nauki (Moscow) 11:43-47.

Mitsch, W.J. and Gosselink, J.G.
1986 Wetlands. Van Nostrand Reinhold. New York, New York, pp. 539.

Montgomery County Tax Office
2008 2007 Entity Tax Rates. Retrieved from http://www.mctx.org/tax/taxrates.html. January 14.

Moore, J.R.
2007 Personal communication (telephone) with J.R. Moore, Montgomery County Tax Assessor-Collector. July 13.

Moore, W.E., Heinrich, P.V., Mallour, L.B., Patterson, L.W., Simons, H., and Sports, L.C.
1989 Archaeological Bibliography for the Southeastern Region of Texas. Office of the State Archeologist Special Report 31. Texas Historical Commission.

Moulton, D.W., Dahl, T.E., and Dall, D.M.
1997 Texas Coast Wetlands Status and Trends, Mid-1950s to Early 1990s, Albequrque, NM.

Moritz, K. and Breitenstein, J.
1985 Damage by Spreading Salt on West German Federal Trunk Roads and Possibilities of Avoiding It. Allgemeine Forstzeitschrift 44: pp. 1192-1193.

Muskett, C.J. and Jones, M.P.
1981 Soil Respiratory Activity in Relation to Motor Vehicle Pollution. Water, Air and Soil Pollution 23: pp. 231-242.

Nasralla, M.M. and Ali, E.A.
1985 Lead Accumulation in Edible Portions of Crops Grown near Egyptian Traffic Roads. Agriculture Ecosystems and Environment 13: pp. 73-82.

National Highway Traffic Safety Administration (NHTSA)
2001 Traffic Safety Occupant Issues. Fatality Analysis Report System. Retrieved from www.nhtsa.dot.gov.
2002 Traffic Safety Occupant Issues. Fatality Analysis Report System. Retrieved from www.nhtsa.dot.gov.

National Oceanic and Atmospheric Administration (NOAA)
1996 Texas Coastal Management Program. State of Texas Coastal Coordination Council; June 1996.

National Parks Service (NPS)
2004 Rivers and Trails, Texas Segments. Retrieved from http://www.nps.gov/ncre/programs/rtca/nri/.
2007 Printable Table of National Wild and Scenic Rivers System. June 2007. Retrieved from http://www.rivers.gov/publications/rivers-table.pdf.

Natural Resources Conservation Service (NRCS)
2000a National Hydric Soils List. Retrieved from ftp://ftp-fc.sc.egov.usda.gov/NSSC/Hydric_Soils/Lists/hydric_soils.xls.
2000b 1970, 1980, 1995, and 2000 Historical Aerial Photography.

Natural Resources Defense Council (NRDC)
2000 End of the Road, the Adverse Ecological Impacts of Roads and Logging: A Compilation of Independently Reviewed Research. Retrieved from http://www.nrdc.org/land/forests/roads/intro.asp.

North Houston Association (NHA)
2004 North Houston Region Demographics. Retrieved on May 2, 2006 from http://www.north-houston.com/developers/demographics.html.

Northover, J.
1987 NaCl Injury to Dormant Roadside Peach Trees and Its Effect on the Incidence of Infections by Leucostoma spp. Phytopathology 77: pp. 835-840.

Oberholser, H.C.
1974 The Bird Life of Texas, Vol. 2. University of Texas Press: Austin, Texas. pp. 1,069.

Parks, H.B., Cory, V.L., et al.
1938 Biological Survey of the East Texas Big Thicket Area. 2nd edition. Sponsored by Texas Academy of Science.

Patterson, L.W.
1972 Letter D.A. Story dated February 2, 1972. Miscellaneous Harris County Files, Texas Archaeological Research Laboratory, Austin, Texas.
1973a Some Texas Blade Technology. Bulletin of the Texas Archaeological Society 44.
1973b A Possible Arrow Point Development Example. Texas Archaeology 17(3):8-9.
1974 Harris County Flint Sources. Houston Archaeological Society Newsletter 48, pp. 13-14.
1975 Evidence of Prismatic Blade Technology in the Texas Archaic. In: The Archaic of Texas. Edited by T. R. Hester. University of Texas at San Antonio Center for Archaeological Research Special Report 2.
1976 An Archaeological Complex in Harris County, Texas. Houston Archaeological Society Newsletter 54.
1977 Archaic-Woodland Site, 41HR223, Harris County, Texas. Houston Archaeological Society Newsletter 56.
1980a 41HR206 A Major Site in Harris County, Texas. In: Papers on the Archaeology of the Texas Coast, edited by L. Highley and T.R. Hester. Center for Archaeological Research Report 11. The University of Texas at San Antonio.
1980b The Owen Site, 41HR315: A Long Occupation Sequence in Harris County, Texas. Houston Archaeological Society Report 3.
1995 Bibliography of the Prehistory of the Upper Texas Coast, No. 9. Houston Archaeological Society, Special Publication.

Payne, R.
2001 Personal communication (telephone) between Chris Moore, PBS&J, and Rick Payne, Asst. Fire Chief of Katy Volunteer Fire Department. April 9, 2001.

PBS&J
2005 TelALL Environmental Data Search for Segment F-2 Update, Harris/Montgomery County, Texas. May 20, 2005.

Pearce, J.E.
1932 The Present Status of Texas Archeology. Bulletin of the Texas Archaeological and Paleontological Society 4: pp. 44-54.

Petersen, A., Eckstein, D., and Liese, W.
1982 Holzbiologische Untersuchengen ueber den Einfluss von Auftausalz auf Hamburger Strassenbaeume. Forstwissenschaftliches Centralblatt 101: pp. 353-364.

Peterson, T.R.
1988 A Field Guide to the Birds of Texas and Adjacent States. Peterson Field Guides. Houghton Mifflin Company. Boston, New York. pp. 304.

Poole, J.M. and Riskind, D.H.
1987 Endangered, Threatened or Protected Native Plants of Texas. Texas Parks and Wildlife Dept. pp. 36.

Popkin, B.P.
1971 Ground-Water Resources of Montgomery County, Texas. Texas Water Development Board Report 136. Austin, Texas.

Porter, N.
2003a A Cultural Resource Survey of a 129-Acre Proposed Floodplain Preservation Area on Cypress Creek, Harris County, TX. Report of Investigation No. 350. Moore Archeology Consulting, Inc.

2003b A Cultural Resource Survey of a Floodplain Preservation Area on Cypress Creek, Harris County, Texas. Report of Investigation No. 344. Moore Archeology Consulting, Inc.

Price, A.H.
1990 (*Phrynosoma cornutum*) (Harlan) Texas Horned Lizard. Catalogue of American amphibians and reptiles. 469: pp. 1-7.

Price, A.H. and Yantis, J.H.
1993 Houston Toad (*Bufo Houstonensis*) Status Survey. Final Report as required by the Endangered Species Act, Section 6, Endangered and Threatened Species Conservation. Texas Project No. E-1-4, Job No. 8. Texas Parks and Wildlife Department, Austin. 13pp and figs.

Railroad Commission of Texas (RRC)
2005 Digital Data of Oil and Gas Wells.

Robbins, C.S., Dawson, D., and Dowell, B.
1989 Habitat Area Requirements of Breeding Forest Birds of the Middle Atlantic States. Wildlife Monographs No. 103. The Wildlife Society, Blacksburg, VA.

Robertson, D.G.
1991 Movements and Habitat Use of Lesser Snow Geese Wintering on the Upper Texas Coast. Master's Thesis. Texas A&M University, Office of Graduate Studies.

Robinson, S.K., Thompson III, F.R., Donovan, T.M., Whitehead, D.R., and Faaborg, J.
1995 Regional Forest Fragmentation and the Nesting Success of Migratory Birds. Science 267: pp. 1987-1990.

Rogers, Greg
2006 Personal communications between Mr. Rogers of the TCEQ Drinking Water Protection Team and Martha DoByns of Michael Baker Jr. September 8th and 13th, 2006.

Rosenberg, K.V. and Raphael, M.G.
1986 Effects of Forest Fragmentation on Vertebrates in Douglas-Fir Forests. In Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates. J. Verner, M. Morrison, C. Ralph, eds. The University of Wisconsin Press. Madison, Wisconsin. pp. 263-272.

Schmidly, J.D.
1991 The Bats of Texas. Texas A&M Univ. Press, College Station, Texas. pp. 188.

Scott, S.L., ed.
1987 Field Guide to the Birds of North America. Second Edition. National Geographic Society, Washington, D.C. pp. 464.

Severence, D.W.
1999 The Handbook of Texas Online, s.v. "SPRING, TEXAS." Retrieved from http://www.tsha.utexas.edu/handbook/online/ articles/SS/hls74.html.

Shafer H. and Baxter, E.
1975 An Archeological Survey of Scotts Ridge and Kaygall Recreation Sites, Sam Houston National Forest. Texas A&M University. College Station, Texas.

Shalkowski, J.S.
2001 A Practical Approach to Addressing Environmental Justice during the NEPA Process: Completing and Documenting the EJ Evaluation. Environmental Analysis in Transportation, Volume XVIII, No. 1.

Sierra Club
2004 Highway Health Hazards. Hulsey, B., Hopkins, E., Olson, E., Burg, E., and Carlson, M., Eds: Washington, D.C. Retrieved from http://www.sierraclub.org/sprawl/report04_highwayhealth/report.pdf.

Smeins, F.E.
1994 Habitat Features of the Katy Prairie. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Smith, Marianne
2007 Personal communication (telephone) with Marianne Smith, Harris County Appraisal District. 2006 net taxable value for Spring ISD. February 1, 2007.

South Coast Air Quality Management District
2000 Multiple Air Toxics Exposure to Study in the South Coast Air Basin (MATES-II). Diamond Bar, CA.

Spring Volunteer Fire Department
2001 Spring Fire Department Online. Retrieved from http://springfd.com/.

Stokes, J.S.
1985 Cultural Resources Management Plan, Wallisville Lake Project, Chamber and Liberty Counties, Texas. Unpublished Masters Thesis, The University of Texas at Austin.

Story, D.A., Guy, J.A., Burnett, B.A., Freeman, M.D., Rose, J.C., and Steele, D.G., et al.
1990 History of the Native Americans. In Archeology and Bioarcheology of the Gulf Coastal Plain, pp.163-366. Research Series No. 38. Arkansas Archeological Survey. Fayetteville, Arkansas.

Stutzenbaker, C.D.
1999 Aquatic and Wetland Plants of the Western Gulf Coast. Texas Parks and Wildlife Press.

Stutzenbaker, C.D. and Weller, M.W.
1989 Habitat Management for Migrating and Wintering Waterfowl in North America. The Texas Coast. pp 385-405 in Smith, L.M., Pederson, R.L., and Kaminski, R.M. (eds.): Texas Tech Press. Lubbock, Texas.

Tacha, T.C.
1994 Wetland Functions and Values in a Prairie Environment. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Tennant, A.
1985 A Field Guide to Texas Snakes. Texas Monthly Press. Austin, Texas. 260 pp.
1998 A Field Guide to Texas Snakes. Texas Monthly Press. Second edition. Austin, Texas. pp. 291.

Terborgh, J.
1989 Where Have All the Birds Gone? Essays in the Biology and Conservation of Birds that Migrate to the American Tropics. Princeton University Press. Princeton, New Jersey. pp. 207.

Texas Commission on Environmental Quality (TCEQ) *(see also TNRCC)*
2006 Water Assessment and Protection Program, TCEQ_Data.zip (GW_Protection_Areas_1.shp, GW_Protection_Areas_2.shp, PWS_Wells.shp, SW_Protection_Areas.shp).
2007 2006 Texas Water Quality Inventory and 303(d) List.

Texas Department of Transportation (TxDOT)
1936 Harris County, Texas, General Highway Map. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1941 Montgomery County, Texas, General Highway Map. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1947 Harris County, Texas, General Highway Map. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1948 Harris County, Texas, General Highway Map, 1941 – partially revised in 1948. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1952 Montgomery County, Texas, General Highway Map. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1953 Harris County, Texas, General Highway Map. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1957 Harris County, Texas, General Highway Map. Texas State Highway Department in cooperation with the U.S. Department of Agriculture Bureau for Public Roads.
1992 Guidelines for Indentifying and Dealing with Hazardous Waste on Highway Projects.
1993 1993 Standard Specifications for Construction of Highways, Streets, and Bridges.
1997 Guildelines for Analysis and Abatement of Highway Traffic Noise. Environmental Affairs Division. July.
1999 Air Quality Guidelines. Environmental Affairs Division.
2000 Storm Water Management Guidelines for Construction Activities. Prepared by Division of Bridges and Structures Hydraulics Section. pp. 83.
2001 Guidance on Purpose and Need. Memorandum.
2004a Seeding for Erosion Control, Item 164. 2004 Standard Specifications Book. Retrieved from http://www.dot.state.tx.us/DES/specs/2004/04rthwk.htm#164.
2004b Project Specific Location (PSL) QuickGuide. Revised April, 2004.
2005 Index of Examples of Recommended Text for Traffic Noise Analysis, Example 2: Common Sound/Noise Levels (Table).
2006a TxDOT Air Quality Guidelines. June, 2006.
2006b Interim Guidance on Preparing Cumulative Impact Analyses.

Texas Historical Commission (THC)
1978 Katy, Texas, Historical Marker files on the Atlas of Texas Online. Retrieved from http://atlas.thc.state.tx.us/Atlas.

Texas Mid-Coast Initiative Team
1990 Texas Mid-Coast Initiative: Gulf Coast Joint Venture, North American Waterfowl Management Plan. U. S. Fish and Wildlife Service, Albuquerque, New Mexico. pp. 27.

Texas Natural Resource Conservation Commission (TNRCC) *(see also TCEQ)*
1997 Revisions to the State Implementation Plan (SIP) for the Control of Ozone Air Pollution: Vehicle Miles Traveled Offset SIP for the Houston/Galveston Nonattainment Area. Rule Log No. 97104-SIP-AI. August 6, 1997.
1998 Receiving Water Assessment of Willow Creek, Harris County, Texas. Houston, Texas.
2000 Draft Texas 2000 Clean Water Act Section 303(d) List. August 31.

2002 Draft 2002 Texas Water Quality Assessment for Individual Water Bodies Inventory. Retrieved from www.tnrcc.state.tx.us/water/quality/02_twqmar/02_305b/.

Texas Ornithological Society (TOS)
1984 Checklist of the birds of Texas, 2nd edition, pp. 147.
1995 Checklist of the birds of Texas, 3rd Edition, pp. 166.

Texas Parks and Wildlife Department (TPWD)
1990 Texas Outdoor Recreation Inventory (TORI) Database. Austin, Texas.
1997 Texas Wetlands Conservation Plan: Austin, TX, pp. 52.
1998 Analysis of Bottomland Hardwood Areas and Assessment of Wildlife Habitat Quality at the Potential Future Waters Bluff Reservoir Site. Final Report to Texas Water Development Board for the fulfillment of interagency. agreement No. 97-483-226. April. Retrieved from www.tpwd.state.tx.us/texaswater/sb1/terrestr/twdb2/h2o_future.html.
1999 Endangered/Threatened Species Data File Review. Austin, Texas. June 21.
2005 East Texas Black Bear Conservation and Management Plan (2005-2015). Retrieved from http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_pl_w7000_1046.
2006 Paddlefish (*Polyodon spathula*). Retrieved from http://www.tpwd.state.tx.us/huntwild/species/pad.
2007a Annotated County Lists of Rare Species, s.v. "Harris." Last updated on August 14, 2007. http://gis2.tpwd.state.tx.us/ReportServer$gis_epasde_sql?%2fReport+Project2%2fReport5&rs:Command=Render&county=Harris (accessed on October 16, 2007).
2007b Annotated County Lists of Rare Species, s.v. "Montgomery." Last updated on August 8, 2007. http://gis2.tpwd.state.tx.us/ReportServer$gis_epasde_sql?%2fReport+Project2%2fReport5&rs:Command=Render&county=Montgomery (accessed on October 16, 2007).
2007c Natural Diversity Database (rare species and natural community data files), s.v. "Grand Parkway Segment G" Agency coordination and data request (July 17, 2007). PBS&J project files.
2007d Personal communication (email) between Chris Gregory (TPWD) to Chad Mitcham (PBS&J) regarding bald eagle nest within the Spring Creek floodplain. July 27.

Texas State Historical Association (TSHA)
1999 Handbook of Texas Online. Retrieved on May 3, 2006 from http://www.tsha.utexas.edu/handbook/online/srticles/WW/rbwas.html.
2001 Handbook of Texas Online, s.v. "BIG THICKET." Retrieved on February 10, 2006 from http://www.tsha.utexas.edu/handbook/online/articles/BB/gkb3.html.

Texas Water Development Board (TWDB)
2000a State Water Plan Population Projections by City 2000-2050 (last updated January 28).
2000b State Water Plan Population Projections by City 2000-2050 (last updated March 24).
2006a 2007 State Water Plan. Adopted November 14, 2006. Retrieved from http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/2007StateWaterPlan.htm.
2006b Aquifers of the Gulf Coast of Texas. TWDB Report 365. Retrieved from http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/R365/AGCindex.htm.
2006c Well Data from TWDB Groundwater Database. Retrieved from http://www.twdb.state.tx.us/mapping/gisdata.asp.

Texas Workforce Commission, Labor Market Information Department.
2007 Civilian Labor Force Estimates, Actual Series, 2000-2006.

Thompson, R.L. and Baker, W.W.
1971 A Survey of Red-Cockaded Woodpecker Nesting Habitat Requirements. pp. 170-186 in the R.L. Thompson's Ecology and Management of the Red-Cockaded Woodpecker. U.S. Bureau Sport Fish and Wildlife and Tall Timbers Research Station, Tallahassee, FL.

Tidwell, S.R. and Davis, J.R.
1989 An Assessment of Six Least Disturbed Unclassified Streams. Texas Water Commission, LP 89-04.

Transportation Research Board (TRB)
2000 Highway Capacity Manual.
2002 NCHRP Report 466: Desk Reference for Estimating the Indirect Effect of Proposed Transportation Project.

Trombulak, S.C. and Frissell, C.A.
2000 Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14:18-30.

Tropical Storm Allison Recovery Project (TSARP)
2006 FEMA Preliminary Flood Insurance Rate Maps Release. Retrieved on October 17, 2006 from http://www.tsarp.org/preliminaryrelease.html.
2007 "TSARP Maps are Effective." Retrieved on June 19, 2007 from http://www.tsarp.org/index.asp.

Turner, Collie, and Braden, Inc.
1998 Reconnaissance Report for Proposed Wetside Airport, Houston, Texas.

Urban Land Institute (ULI)
1988 Business and Industrial Development Handbook. Community Builders Handbook Series.
1994 Development Impact Assessment Handbook. Washington D.C.

U.S. Army Corps of Engineers (USACE)
1987 Corps of Engineers Wetlands Delineation Manual. Environmental Laboratory: Technical Report Y-87-1. USACE Waterways Experiment Station. Vicksburg, Mississippi. 100 pp. and apps (January).
1999 The Highway Methodology Workbook Supplement: Wetland Functions and Values, A Descriptive Approach. U.S. Army Corps of Engineers, New England Division. pp. 32.

U.S. Census Bureau
1980 Census of the Population.
1990 Census of the Population, Population and Housing Characteristics, Summary Files 1 and 3.
1998a County Business Patterns for Harris County, Texas.
1998b County Business Patterns for Montgomery County, Texas.
2000 Census of Population. Population and Housing Characteristics. Summary Files 1 and 3.
2002a County Business Patterns for Harris County, Texas.
2002b County Business Patterns for Montgomery County, Texas.
2002c 2002 Economic Data. Retrieved from http://factfinder.census.gov/servlet/GQRTable?_bm=y&-ds_name=EC0200A1&-geo_id=05000US48201&-_lang=en and http://factfinder.census.gov/ servlet/GQRTable?_bm=y&-ds_name=EC0200A1&-geo_id=05000US48339&-_lang=en.

U.S. Department of Agriculture (USDA)
1972 Natural Resource Conservation Service. Soil Survey of Montgomery County, Texas. In cooperation with Texas Agricultural Experiment Station.
1976 Natural Resource Conservation Service. Soil Survey of Harris County, Texas. In cooperation with Texas Agricultural Experiment Station.

2002 Census of Agriculture.
2004 2002 Census of Agriculture, Texas State and County Data.

U.S. Department of Health and Human Services (HHS)
2008a FAQs Related to the Poverty Guidelines and Poverty. Retrieved on January 29, 2008 from http://aspe.hhs.gov/poverty/faq.shtml#differences.
2008b The 2008 HHS Poverty Guidelines. Retrieved on January 29, 2008 from http://aspe.hhs.gov/poverty/08poverty.shtml.

U.S. Department of Housing and Urban Development
2004 Housing Units Authorized by Building Permits.

U.S. Department of Transportation (USDOT) and Federal Highway Administration (FHWA)
2004 Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended. Retrieved on March 11, 2004 from http://www.fhwa.dot.gov/realestate/act.htm.

U.S. Environmental Protection Agency (EPA)
1979 Final Report on Population Risk to Ambient Benzene Exposures. Prepared by the Carcinogen Assessment Group: Research Triangle Park, NC. EPA/450/5-80-004.
1985 Final Draft for Drinking Water Criteria Document on Benzene. Office of Drinking Water: Washington, DC. PB86-118122.
1990 Clean Air Act. November.
1992 Computer Assisted Environmental Assessment Methodologies, Chapter V, Special Applications, Environmental Equity. Planning and Analysis Section, Management Division, Region 6 EPA. Dallas, Texas.
1994 Computer Assisted Environmental Justice Index Methodology, Office of Planning and Analysis. July.
1996 Proposed Guidelines for Carcinogen Risk Assessment.
1997 National Air Quality and Emissions Trend Report: Research Triangle Park, N.C.
1998 Carcinogenic Effects of Benzene: An Update. EPA/600/P-97/001F. Office of Research and Development. April.
1999a Draft Guidelines for Carcinogen Risk Assessment, Revised.
1999b Regulatory Impact Analysis – Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standard and Gasoline Sulfur Control Requirements, EPA420-R-99-023. December 22, 1999.
2000a Control of Emissions of Hazardous Air Pollutants from Motor Vehicles and Motor Vehicle Fuels. Technical Support Document EPS 420-R-00-023. Office of Transportation and Air Quality. December.
2000b Regulatory Impact Analysis – Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements: Chapter II: Health and Welfare Concerns and Emissions and Benefits from Control of Air Pollution from New Motor Vehicles. EPA420-R-00-026. December 2000.
2000c Draft Regulatory Impact Analysis for the Proposed Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements Rule. Technical Report EPA420-D-00-001. Office of Transportation and Air Quality. May.
2001a Control of Emissions of Hazardous Air Pollutants from Mobile Sources: Final Rule. Federal Register, Vol. 66 No. 61, pp. 17229-17273. March 29.
2001b National Land Cover Database (NLCD) 2001 Land Cover Classification Schemes and Class Definitions. Retrieved from http://epa.gov/mrlc/classification.html and http://www.epa.gov/mrlc/definitions.html.
2003 Potential Environmental Justice (EJ) Index Pilot. EPA Region 6. 11 March.
2005a Title 40 (Protection of Environment) Part 50 (National Primary and Secondary Ambient Air Quality Standards) (40 CFR 50). Retrieved from http://www.access.gpo.gov/nara/cfr/waisidx_05/40cfr50_05.html.
2005b Reference Air Concentration, 40 CFR 266, Appendix IV. Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities. Retrieved from http://www.access.gpo.gov/nara/cfr/waisidx_05/40cfr266_05.html.
2005c AirData: Access to Pollution Data. Retrieved from www.epa.gov/air/data.
2005d Handbook for Developing Watershed Plans to Restore and Protect Our Waters: Washington, DC.

2006a Houston's Air Quality. Retrieved from http://www.epa.gov/hiri/pilot/houst_airquality.html.
2006b Title 40 (Protection of Environment) Part 50 (National Primary and Secondary Ambient Air Quality Standards) (40 CFR 50).
2006c Wetlands: Status and Trends. Retrieved from http://www.epa.gov/OWOW/wetlands/vital/status.html.
2007a Control of Hazardous Air Pollutants from Mobile Sources: Final Rule to Reduce Mobile Source Air Toxics. EPA Fact Sheet/Regulatory Announcement. EPA-420-07-107. EPA, Office of Transportation and Air Quality: Washington, D.C., Page 4. February.
2007b AirData: Access to Pollution Data. Retrieved from www.epa.gov/air/data.

U.S. Fish and Wildlife Service (USFWS)
1983 Attwater's Prairie Chicken Recovery Plan. U. S. Fish and Wildlife Service, Albuquerque, New Mexico. pp. 48.
1985 Red-Cockaded Woodpecker Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. pp. 88.
1999 Final Rule to Remove the American Peregrine Falcon from the Federal List of Endangered and Threatened Wildlife, U.S. Fish and Wildlife Service, August 25.
2000a Correspondence from Carlos H. Mendoza to Diane Schenke dated January 25.
2000b Correspondence from Carlos H. Mendoza to Diane Schenke dated March 16.
2000c Correspondence from Carlos H. Mendoza to Diane Schenke dated July 11.
2007a U.S. Fish and Wildlife Federally Listed as Threatened and Endangered Species of Texas. Retrieved on August 2 from http://ecos.fws.gov/tess_public/StateListingAndOccurrence.do?state=TX.
2007b Endangered and Threatened Wildlife and Plants; Removing the Bald Eagle in the Lower 48 States From the List of Endangered and Threatened Wildlife. Federal Register: July 9, 2007 (Volume 72, Number 130). Retrieved on August 2 from http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2007_register&docid=fr09jy07-6.
2007c "Authorizations Under the Bald and Golden Eagle Protection Act for Take of Eagles" and "Protection of Eagles; Definition of 'Disturb'." Federal Register: June 5, 2007 (Volume 72, Number 107).
2007d National Bald Eagle Management Guidelines. May.

U.S. Fish and Wildlife Service (USFWS) and IUCN/SSC Captive Breeding Specialist Group
1994 Houston Toad (*Bufo houstonenesis*) Population and Habitat Viability Assessment, Workshop Briefing Book. Austin, Texas. May 1994.

U.S. Geological Survey (USGS)
1918a Addicks, Texas Quadrangle.
1918b Cypress, Texas Quadrangle.
1920 Montgomery and Harris Counties quadrangle maps.

U.S. Geological Survey (USGS)/National Oceanic and Atmospheric Administration (NOAA)
2001 Draft National Land Cover Database (NLCD). Retrieved from ftp://edcftp.cr.usgs.gov/pub/data/disaster/katrina/draft_nlcd_landcover.

Vallette, Y. M.
1994 EPA and the National Environmental Policy Act: Facilitators of Federal Project Planning and Environmental Management. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

Virginia Department of Forestry
2001 Riparian Forest Buffers. Retrieved from http://www.daft.com/~armadilo/vrml/raining/riparian.html.

Wesselman, J.B.
1972 Ground Water Resources of Fort Bend County, Texas (Texas Water Development Board Report 155). Austin, Texas: TWDB.

West Houston Association (WHA)
2003 West Houston Demographic and Development Trends, 2003. Retrieved on May 2, 2006 from http://www.westhouston.org/data.htm.

Wharton, C.R.
1939 Wharton's History of Fort Bend County. The Naylor Company. San Antonio, Texas.

Wheat, J.B.
1953 The Addicks Dam Site: An Archaeological Survey of the Addicks Dam Basin, Southeast Texas. River Basin Surveys Papers 4:1, from Bureau of Ethnology Bulletin 154:143-252. Government Printing Office. Washington D.C.

Wilbur Smith Associates
1999 Fort Bend Parkway Toll Road Traffic and Revenue Study. 1999. Growth evaluation prepared by Dr. Barton Smith. Houston. February.

Wintz, C.D.
2000 Historic Houston: Blacks in Houston Today. Retrieved from http://www.houstonhistory.com/erhnic/history1blacks.htm (last updated August 30, 2000).

Woods, J.D., Jr.
1994 A Farmer's Viewpoint. Presented at the Katy Prairie Conference. Texas Parks and Wildlife, Katy Prairie Land Conservancy, and West Houston Association, Sponsors. April 29 and 30, 1994, Houston, Texas.

SECTION 10: INDEX

Aesthetic(s)..... 3-1, 3-37, 3-38, 3-68, 4-3, 4-12, 4-13, 4-14, 4-21, 4-137, 4-138, 4-139, 4-140, 4-150, 4-156, 4-157, 4-168, 5-13, 5-20

Affected Environment.....2-28, 2-36, 3-1, 4-158, 5-2, 5-63

Agency Coordination.....2-4, 2-9, 2-17, 2-35, 4-91, 4-129, 6-1, 6-5, 6-7

Air Quality.....2-29, 2-30, 3-1, 3-20, 3-21, 3-22, 3-25, 3-26, 4-39, 4-40, 4-41, 4-45, 4-55, 4-56, 4-58, 4-60, 4-61, 4-110, 4-142, 4-143, 4-145, 4-146, 4-151, 4-159, 4-169, 4-171, 4-172, 5-10, 5-17, 5-18, 5-21, 5-26, 5-27, 5-28, 5-63, 5-65, 5-68, 6-11

Air Toxics.....3-20, 3-23, 3-24, 4-42, 4-55, 4-56, 4-58, 5-18, 5-21, 5-26, 5-37, 5-57, 5-61, 5-63, 5-65, 5-67, 5-69

Alternative, Build 2-1, 2-9, 2-10, 2-15, 2-17, 2-18, 2-19, 2-20, 2-25, 2-35, 2-36, 4-27, 4-31, 4-41, 4-42, 4-45, 4-46, 4-47, 4-48, 4-49, 4-50, 4-51, 4-52, 4-53, 4-58, 4-59, 4-61, 4-127, 4-128, 4-141, 4-142, 4-152, 4-159, 5-2, 5-4, 5-5, 5-8, 5-10, 5-11, 5-12, 5-13, 5-18, 5-19, 5-36, 5-37, 5-40, 5-41, 5-50, 5-51, 5-52, 5-53, 5-54, 5-55, 5-56, 5-57, 5-58, 5-59, 5-60, 5-61, 5-62, 5-68, 5-69, 5-70, 6-9

Alternative, No-Build..... 1-4, 1-6, 2-1, 2-9, 2-10, 2-12, 2-13, 2-14, 2-15, 2-16, 2-17, 2-19, 2-20, 2-25, 2-28, 2-36, 2-37, 3-1, 4-1, 4-2, 4-4, 4-19, 4-11, 4-26, 4-27, 4-28, 4-30, 4-37, 4-38, 4-42, 4-45, 4-46, 4-47, 4-48, 4-49, 4-50, 4-51, 4-52, 4-53, 4-58, 4-59, 4-61, 4-81, 4-89, 4-92, 4-106, 4-113, 4-121, 4-126, 4-127, 4-128, 4-130, 4-133, 4-136, 4-139, 4-140, 4-141, 4-142, 4-157, 5-2, 5-4, 5-5, 5-8, 5-10, 5-11, 5-12, 5-13, 5-17, 5-18, 5-19, 5-20, 5-36, 5-37, 5-40, 5-41, 5-50, 5-51, 5-52, 5-53, 5-54, 5-55, 5-56, 5-57, 5-58, 5-59, 5-60, 5-61, 5-62, 5-65, 5-68, 5-69, 5-70, 6-7, 6-9

Alternative, Preferred 2-1, 2-2, 2-10, 2-25, 2-27, 2-28, 2-30, 2-31, 2-33, 2-34, 2-35, 2-36, 2-37, 3-29, 3-53, 3-54, 3-60, 3-61, 3-63, 4-1, 4-2, 4-3, 4-4, 4-5, 4-7, 4-8, 4-9, 4-10, 4-12, 4-13, 4-14, 4-15, 4-19, 4-20, 4-21, 4-22, 4-23, 4-24, 4-26, 4-27, 4-28, 4-29, 4-30, 4-32, 4-33, 4-34, 4-36, 4-37, 4-44, 4-62, 4-70, 4-71, 4-78, 4-81, 4-82, 4-85, 4-88, 4-90, 4-94, 4-96, 4-98, 4-100, 4-101, 4-103, 4-105, 4-106, 4-113, 4-118, 4-121, 4-123, 4-124, 4-125, 4-126, 4-128, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-136, 4-137, 4-138, 4-139, 4-141, 4-147, 4-148, 4-149, 4-150, 4-151, 4-152, 4-153, 4-154, 4-158, 4-159, 4-160, 4-161, 4-163, 4-164, 4-166, 4-167, 4-168, 4-172, 5-20, 5-35, 5-36, 5-40, 5-41, 5-64

Alternative, Recommended 2-9, 2-25, 2-28, 2-29, 2-34, 2-35, 2-37, 3-60, 4-1, 4-5, 4-10, 4-13, 4-14, 4-24, 4-30, 4-32, 4-33, 4-34, 4-36, 4-44, 4-68, 4-69, 4-70, 4-85, 4-96, 4-98, 4-99, 4-101, 4-106, 4-117, 4-122, 4-124, 4-147, 4-171, 4-172, 6-11

Aquatic Habitat.....3-37, 3-44, 3-45, 3-51, 4-111, 4-112, 4-113, 4-154, 5-11

Archeological Resource(s).....3-56, 3-57, 3-59, 3-60, 3-61, 4-131, 4-132, 4-133, 4-155, 5-12, 5-20

Average Daily Traffic (ADT).....1-6, 1-7, 1-8, 2-21, 2-24, 4-55, 4-62, 5-63

Clean Water Act (CWA).....2-2, 3-31, 3-35, 3-64, 4-90, 4-91, 4-92, 4-103, 4-104, 4-164, 5-11, 5-18, 5-30

Coastal Barrier(s).....3-1, 3-49, 4-128, 4-155, 4-167, 5-12, 5-19

Coastal Zone Management.....3-1, 3-50, 4-128, 4-155, 4-167, 5-12, 5-19

Collector Roadways.....1-1, 1-2, 1-5, 1-6, 1-8, 1-11, 1-12, 1-13, 2-14, 2-19, 2-20, 2-21, 2-23, 2-24, 2-25

Construction.....1-4, 1-6, 2-1, 2-4, 2-10, 2-14, 2-15, 2-16, 2-17, 2-18, 2-20, 2-24, 2-25, 2-30, 2-36, 2-37, 3-2, 3-4, 3-18, 3-19, 3-20, 3-22, 3-35, 3-36, 3-38, 3-56, 4-1, 4-2, 4-3, 4-4, 4-7, 4-8, 4-11, 4-12, 4-13, 4-21, 4-24, 4-26, 4-27, 4-28, 4-29, 4-30, 4-31, 4-33, 4-35, 4-36, 4-37, 4-39, 4-59, 4-61, 4-78, 4-80, 4-82, 4-83, 4-84, 4-88, 4-89, 4-90, 4-91, 4-93, 4-92, 4-96, 4-97, 4-101, 4-102, 4-103, 4-104, 4-105, 4-106, 4-107, 4-108, 4-109, 4-110, 4-111, 4-112, 4-113, 4-114, 4-119, 4-124, 4-125, 4-126, 4-127, 4-129, 4-130, 4-131, 4-132, 4-133, 4-134, 4-135, 4-136, 4-137, 4-138, 4-139, 4-140, 4-141, 4-142, 4-143, 4-144, 4-145, 4-146, 4-147, 4-148, 4-149, 4-150, 4-151, 4-152, 4-153, 4-154, 4-156, 4-157, 4-158, 4-159, 4-160, 4-161, 4-162, 4-163, 4-164, 4-165, 4-166, 4-167, 4-168, 4-169, 4-172, 5-8, 5-9, 5-12, 5-13, 5-17, 5-18, 5-40, 5-44, 5-46, 5-48, 5-49, 5-53, 5-56, 5-64, 5-70, 6-3

Corridor A.....2-3, 2-7, 2-8, 6-3, 6-5

Corridor B.....2-3, 2-7, 2-8, 6-3, 6-5

Corridor C.....2-3, 2-7, 2-8, 6-5

Corridor CB.....2-3, 2-8, 6-5

Corridor D.....2-3, 2-8, 2-9, 6-5, 6-7

Corridor Study.....2-2, 2-4, 4-119, 5-16, 5-49, 6-2, 6-3, 6-5, 6-6, 6-7

Corridor, Preferred Alternative.....2-1, 2-2, 2-4, 2-9, 2-25, 3-1, 3-5, 4-7, 4-11, 4-12, 4-158, 6-2, 6-4, 6-6, 6-7

Council on Environmental Quality (CEQ).....2-1, 2-15, 2-17, 2-25, 2-28, 4-15, 4-56, 4-157, 5-1, 5-13, 5-66, 5-69, 6-9

Cultural Resources.....2-5, 2-29, 2-30, 3-1, 3-54, 3-57, 3-59, 4-21, 4-131, 4-133, 4-155, 4-167, 4-171, 4-172, 5-8, 5-12, 5-19, 5-20

Economic Conditions.....3-16, 5-2, 5-13

Employment.....2-10, 2-11, 2-21, 2-13, 2-20, 2-24, 2-25, 3-22, 4-28, 4-29, 4-33, 4-34, 4-35, 4-36, 4-37, 4-40, 4-53, 4-60, 4-61, 4-146, 4-151, 5-3, 5-4, 5-8, 5-10, 5-15, 5-17, 5-18, 5-49, 5-51, 5-52, 5-53, 5-54, 5-56, 5-61, 5-70, 6-13, 6-14

Environmental Consequences.....2-27, 2-36, 4-1, 4-148, 5-7, 5-36, 5-63, 6-3

Environmental Justice (EJ).....2-29, 2-30, 4-12, 4-15, 4-17, 4-18, 4-27, 4-159, 4-171, 4-172, 5-17

Environmental Protection Agency (EPA).....3-20, 3-21, 3-22, 3-23, 3-24, 3-25, 3-26, 3-27, 3-34, 3-35, 3-63, 3-64, 3-65, 4-15, 4-17, 4-26, 4-39, 4-40, 4-45, 4-46, 4-47, 4-48, 4-49, 4-50, 4-51, 4-52, 4-53, 4-54, 4-55, 4-56, 4-57, 4-58, 4-59, 4-91, 4-95, 4-102, 4-107, 4-150, 4-151, 4-162, 4-166, 5-6, 5-16, 5-17, 5-18, 5-21, 5-22, 5-26, 5-27, 5-28, 5-30, 5-31, 5-55, 5-56, 5-57, 5-58, 5-59, 5-60, 5-61, 5-62, 5-65, 5-66, 5-67, 5-68, 6-10, 6-11

Essential Fish Habitat (EFH).....3-1, 3-50, 4-128, 4-155, 4-167, 5-12, 5-19

Farmland(s).....2-5, 2-29, 2-30, 2-34, 3-1, 3-2, 3-5, 3-6, 3-37, 3-39, 3-40, 3-43, 3-44, 3-45, 3-69, 4-5, 4-7, 4-9, 4-10, 4-11, 4-27, 4-83, 4-96, 4-98, 4-99, 4-100, 4-105, 4-106, 4-108, 4-111, 4-113, 4-115, 4-130, 4-146, 4-150, 4-153, 4-158, 5-8, 5-9, 5-11, 5-17, 5-21, 5-69

Federal Emergency Management Agency (FEMA).....3-47, 3-48, 4-119, 4-120, 4-123, 4-124, 4-125

Floodplain(s).....2-2, 2-4, 2-5, 2-7, 2-8, 2-28, 2-29, 2-30, 2-33, 2-34, 2-36, 3-1, 3-10, 3-36, 3-37, 3-39, 3-40, 3-41, 3-42, 3-47, 3-48, 3-49, 3-52, 4-90, 4-103, 4-107, 4-114, 4-119, 4-120, 4-121, 4-122, 4-123, 4-124, 4-125, 4-126, 4-127, 4-128, 4-134, 4-148, 4-153, 4-154, 4-155, 4-163, 4-165, 4-166, 4-167, 4-171, 4-172, 5-4, 5-5, 5-11, 5-12, 5-18, 5-19, 5-20, 5-22, 5-31, 5-33, 5-40, 5-63, 5-64, 6-2, 6-4, 6-7

Floodway(s).....2-29, 2-30, 2-33, 2-34, 3-42, 3-47, 3-48, 3-49, 4-114, 4-119, 4-120, 4-121, 4-122, 4-123, 4-124, 4-125, 4-126, 4-127, 4-128, 4-154, 4-166, 4-167, 4-171, 4-172, 5-40

Geology.....3-1, 3-5, 3-59, 4-11, 4-150, 4-158, 5-8, 5-17

Hazardous Material(s).....2-5, 2-29, 2-30, 3-1, 3-63, 3-65, 4-90, 4-133, 4-134, 4-135, 4-136, 4-156, 4-161, 4-168, 4-171, 4-172, 5-13

Historic and Archeological Resources.....4-129

Houston-Galveston Area Council (H-GAC) 1-2, 1-5, 1-6, 1-8, 1-9, 1-11, 1-12, 1-13, 1-14, 2-1, 2-10, 2-11, 2-12, 2-13, 2-14, 2-15, 2-16, 2-17, 2-18, 2-19, 2-20, 2-21, 2-23, 2-24, 3-3, 3-4, 3-20, 3-22, 4-38, 4-39, 4-40, 4-41, 4-55, 4-59, 4-62, 4-151, 5-1, 5-3, 5-4, 5-16, 5-17, 5-18, 5-23, 5-42, 5-43, 5-48, 5-49, 5-52, 5-53, 5-54, 5-61, 5-69, 6-4, 6-10, 6-12, 6-13, 6-14

Hydrology 3-45, 3-47, 4-83, 4-94, 4-97, 4-102, 4-103, 4-114, 4-126, 4-127, 4-154, 4-162, 4-163, 4-166, 5-15, 5-22, 5-64

Indirect and Cumulative Effects..... 2-36, 4-149, 5-1, 5-2, 5-64, 6-11

Land Use 1-4, 1-6, 2-3, 2-29, 2-30, 2-35, 3-1, 3-2, 3-3, 3-4, 3-28, 3-29, 3-30, 3-31, 3-36, 3-39, 3-42, 3-59, 3-69, 4-1, 4-2, 4-3, 4-4, 4-5, 4-7, 4-9, 4-12, 4-26, 4-27, 4-29, 4-35, 4-71, 4-81, 4-83, 4-95, 4-106, 4-109, 4-113, 4-119, 4-146, 4-149, 4-153, 4-158, 5-1, 5-2, 5-4, 5-5, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 5-13, 5-15, 5-17, 5-18, 5-19, 5-20, 5-21, 5-23, 5-24, 5-25, 5-26, 5-31, 5-34, 5-36, 5-37, 5-50, 5-51, 5-52, 5-53, 5-54, 5-55, 5-56, 5-63, 5-64, 5-65, 5-69, 5-70, 6-12

Level of Mobility (LOM) 1-2, 1-3, 1-6, 1-9, 1-10, 1-11, 1-12, 2-11, 2-12, 2-23, 2-25

Level of Service (LOS).....1-6, 1-9, 1-10, 4-62

Metropolitan Transit Authority (METRO).....1-6, 2-12, 2-13, 2-14, 5-49

Minor Arterial(s).....1-5, 1-7, 1-11, 1-13, 2-19, 2-21, 2-23

Mitigation.....2-4, 2-11, 2-28, 2-36, 4-2, 4-7, 4-11, 4-19, 4-20, 4-27, 4-37, 4-39, 4-61, 4-82, 4-83, 4-89, 4-91, 4-92, 4-93, 4-94, 4-97, 4-101, 4-102, 4-103, 4-104, 4-105, 4-107, 4-118, 4-119, 4-125, 4-127, 4-131, 4-133, 4-134, 4-137, 4-140, 4-142, 4-145, 4-146, 4-149, 4-150, 4-152, 4-154, 4-155, 4-157, 4-158, 4-159, 4-160, 4-161, 4-162, 4-163, 4-164, 4-165, 4-166, 4-167, 4-168, 4-169, 5-4, 5-14, 5-22, 5-35, 5-49, 5-56, 5-63, 5-64, 5-65, 6-4, 6-5, 6-7, 6-11

Mobile Source Air Toxics (MSAT).....3-20, 3-23, 3-24, 3-25, 3-26, 3-27, 4-39, 4-42, 4-45, 4-46, 4-47, 4-48, 4-49, 4-53, 4-54, 4-55, 4-56, 4-57, 4-58, 4-59, 4-60, 4-61, 4-152, 5-10, 5-18, 5-21, 5-26, 5-27, 5-28, 5-29, 5-37, 5-38, 5-39, 5-57, 5-61, 5-62, 5-63, 5-65, 5-66, 5-67, 5-68, 5-69, 5-70

Modal Transportation Improvements.....2-1, 2-10, 2-12, 2-14, 2-15, 2-17, 2-18

National Ambient Air Quality Standards (NAAQS).....3-20, 3-21, 3-22, 3-23, 3-25, 4-39, 4-41, 4-42, 4-54, 4-57, 4-60, 4-61, 4-151, 5-18, 5-26, 5-28, 5-66

National Environmental Policy Act (NEPA).....1-3, 2-1, 3-20, 4-58, 4-101, 4-105, 4-121, 4-157, 4-161, 4-165, 5-1, 5-13, 5-49, 5-68, 5-69, 6-5, 6-7

National Register of Historic Places (NRHP).....3-56, 3-58, 3-59, 3-61, 3-62, 3-63, 4-131, 4-132, 4-133, 4-155, 4-156, 4-167, 5-19

Natural Resources Conservation Service (NRCS).....3-6, 4-7, 4-8, 4-9, 4-11, 4-150, 4-158, 5-9, 5-16, 5-17, 5-23, 5-24, 6-6

Noise Level(s).....3-27, 3-28, 3-29, 3-30, 4-62, 4-77, 4-78, 4-81, 4-82, 4-108, 4-152, 4-160, 5-10, 5-18

Noise Modeling Analysis.....4-63

Ozone (O_3).....3-20, 3-21, 3-22, 3-25, 4-39, 4-53, 4-58, 4-60, 4-109, 4-151, 5-17, 5-18, 5-26, 5-28, 5-68

Permit(s).....2-1, 3-1, 3-35, 3-36, 3-48, 3-65, 3-66, 3-67, 3-68, 4-82, 4-90, 4-91, 4-92, 4-93, 4-102, 4-107, 4-127, 4-131, 4-135, 4-152, 4-153, 4-161, 4-162, 4-166, 4-167, 5-8, 5-9, 5-30, 5-65

Pipeline(s).....3-58, 3-67, 3-68, 4-134, 4-135, 4-136, 4-137, 4-145, 4-156, 4-168

Population.....1-1, 1-2, 1-3, 1-5, 1-6, 1-14, 2-11, 2-12, 2-20, 2-24, 2-25, 3-11, 3-12, 3-13, 3-14, 3-17, 3-18, 3-19, 3-22, 3-26, 3-45, 3-46, 3-56, 4-12, 4-15, 4-16, 4-17, 4-18, 4-19, 4-26, 4-27, 4-35, 4-40, 4-42, 4-53, 4-57, 4-58, 4-59, 4-60, 4-81, 4-97, 4-108, 4-109, 4-110, 4-114, 4-129, 4-130, 4-133, 4-137, 4-150, 4-151, 4-155, 4-159, 4-17, 4-18, 5-4, 5-7, 5-9, 5-17, 5-19, 5-34, 5-49, 5-51, 5-52, 5-53, 5-54, 5-56, 5-61, 5-67, 5-68, 5-70, 6-2, 6-14

Prehistoric.....3-54, 3-57, 3-58, 3-59, 4-132, 4-155

Prime Farmland.....2-5, 2-29, 2-30, 3-6, 4-9, 4-10, 4-11, 4-96, 4-98, 4-158, 4-171, 4-172, 5-9

Principal Arterial(s).....1-5, 1-6, 1-7, 1-11, 1-13, 2-10, 2-19, 2-21, 2-23, 2-35

Public Involvement.....2-4, 4-12, 6-2, 6-3, 6-8, 6-14

Regional Transportation Plan (RTP).....1-4, 1-6, 1-9, 1-11, 1-12, 2-1, 2-10, 2-11, 2-12, 2-13, 2-14, 2-15, 2-16, 2-17, 2-18, 2-20, 2-23, 2-25, 3-4, 3-22, 4-38, 4-39, 4-40, 4-59, 4-60, 4-61, 4-151, 4-152, 5-17, 5-18, 5-48, 5-70, 6-14

Relocation(s).....2-28, 2-33, 2-34, 4-3, 4-4, 4-13, 4-14, 4-15, 4-22, 4-23, 4-24, 4-25, 4-26, 4-35, 4-111, 4-113, 4-115, 4-134, 4-137, 4-144, 4-146, 4-154, 4-156, 4-168, 5-17

Right-of-Way (ROW).....2-4, 2-11, 2-14, 2-16, 2-17, 2-26, 2-27, 2-34, 2-35, 2-36, 2-37, 3-54, 3-62, 3-63, 4-1, 4-2, 4-7, 4-8, 4-10, 4-11, 4-12, 4-19, 4-20, 4-25, 4-27, 4-29, 4-30, 4-35, 4-41, 4-42, 4-43, 4-44, 4-71, 4-78, 4-81, 4-83, 4-84, 4-85, 4-86, 4-87, 4-88, 4-89, 4-93, 4-94, 4-96, 4-97, 4-98, 4-101, 4-102, 4-103, 4-105, 4-107, 4-108, 4-109, 4-110, 4-113, 4-114, 4-120, 4-121, 4-122, 4-123, 4-124, 4-125, 4-129, 4-130, 4-131, 4-133, 4-134, 4-135, 4-136, 4-137, 4-140, 4-145, 4-146, 4-148, 4-149, 4-150, 4-151, 4-153, 4-154, 4-155, 4-156, 4-158, 4-159, 4-160, 4-162, 4-163, 4-165, 4-167, 4-168, 4-169, 5-8, 5-9, 5-20, 5-35, 5-36, 5-40, 5-41, 5-49, 5-51, 5-55, 5-64, 6-9

School(s).....2-2, 2-5, 2-7, 2-29, 2-30, 2-31, 3-14, 3-15, 3-16, 3-26, 3-29, 3-56, 4-14, 4-18, 4-19, 4-20, 4-26, 4-27, 4-42, 4-43, 4-44, 4-71, 4-76, 4-150, 4-151, 4-159, 4-171, 4-172, 5-3, 5-15, 5-17, 5-41, 5-46, 5-52, 6-8, 6-9, 6-12, 6-13

Smart Streets.....1-6, 1-9, 1-11, 1-12, 2-1, 2-10, 2-14, 2-16, 2-18, 2-23, 2-25

Social Characteristics.....3-1, 3-11, 4-150, 5-17

Socioeconomic.....2-1, 2-2, 3-26, 4-59, 5-63, 5-68, 6-3

Soil(s).....2-29, 2-30, 3-1, 3-5, 3-6, 3-7, 3-8, 3-9, 3-10, 3-11, 3-36, 3-40, 3-43, 3-52, 3-53, 3-57, 3-59, 3-67, 4-7, 4-8, 4-9, 4-10, 4-11, 4-83, 4-94, 4-97, 4-98, 4-102, 4-105, 4-107, 4-110, 4-120, 4-135, 4-146, 4-150, 4-158, 4-162, 4-165, 4-169, 5-8, 5-9, 5-17, 5-40, 5-64

State Historic Preservation Officer (SHPO).....3-54, 3-59, 3-61, 3-63, 4-132, 4-155

State Implementation Plan (SIP).....3-22, 4-39, 4-40, 4-60, 4-61, 4-151, 5-17, 6-14

Surface Water.....3-31, 3-34, 3-38, 4-8, 4-82, 4-83, 4-88, 4-89, 4-90, 4-152, 4-160, 5-30, 5-40

Terrestrial Wildlife.....4-98, 4-107, 4-108, 4-110, 4-111, 4-113, 4-153, 5-11

Texas Commission on Environmental Quality (TCEQ).....3-25, 3-31, 3-32, 3-33, 3-34, 3-35, 3-63, 3-64, 3-65, 3-66, 3-67, 4-56, 4-61, 4-82, 4-84, 4-85, 4-88, 4-91, 4-92, 4-102, 4-120, 4-135, 4-162, 5-9, 5-10, 5-16, 5-17, 5-21, 5-27, 5-30, 5-55, 5-56, 5-61, 5-65, 6-6, 6-10

Texas Historical Commission (THC).....3-58, 3-61, 3-63, 4-131, 4-132, 4-133, 4-168

Texas Natural Resource Conservation Commission (TNRCC).....3-31, 4-53

Texas Parks and Wildlife Department (TPWD).....2-4, 2-5, 2-7, 2-8, 3-15, 3-53, 3-54, 4-91, 4-102, 4-103, 4-104, 4-107, 4-129, 4-130, 4-131, 4-155, 4-162, 4-163, 4-164, 4-166, 4-167, 5-16, 5-19, 5-31, 5-65, 6-4, 6-5, 6-6, 6-10

Texas Pollutant Discharge Elimination System (TPDES).....3-35, 4-82, 4-91, 4-92, 4-152, 4-161, 5-9, 5-11

Threatened and Endangered Species.....2-29, 2-30, 3-1, 3-37, 3-50, 5-12, 5-19, 6-12

Topography.....2-5, 2-8, 2-29, 2-30, 3-5, 3-39, 3-47, 3-68, 3-69, 4-7, 4-42, 4-77, 4-78, 4-97, 4-104, 4-118, 4-124, 4-127, 4-164, 4-166, 4-171, 4-172, 6-5

Transportation.....1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-9, 1-10, 1-13, 2-1, 2-7, 2-9, 2-10, 2-11, 2-12, 2-13, 2-14, 2-15, 2-16, 2-17, 2-18, 2-20, 2-24, 2-25, 2-26, 3-1, 3-2, 3-4, 3-6, 3-18, 3-19, 3-22, 3-26, 3-30, 3-54, 3-56, 3-57, 3-62, 3-68, 4-3, 4-9, 4-25, 4-26, 4-36, 4-39, 4-55, 4-58, 4-59, 4-60, 4-100, 4-102, 4-106, 4-113, 4-119, 4-131, 4-132, 4-133, 4-141, 4-142, 4-147, 4-156, 4-157, 4-158, 4-162, 5-2, 5-3, 5-7, 5-10, 5-13, 5-17, 5-19, 5-20, 5-21, 5-29, 5-41, 5-42, 5-44, 5-45, 5-48, 5-49, 5-50, 5-56, 5-65, 5-67, 5-70, 6-4, 6-9, 6-12, 6-13, 6-14

Transportation Improvement Plan (TIP).....2-15, 3-4, 3-22, 4-39, 4-40, 4-59, 4-60, 4-61, 4-151, 5-17, 6-14

Transportation System Management (TSM).....2-1, 2-10, 2-11, 2-12, 2-14, 2-15, 2-16, 2-17, 2-18

Travel Demand Management (TDM).....2-1, 2-10, 2-11, 2-12, 2-14, 2-15, 2-16, 2-17, 2-18

U.S. Army Corps of Engineers (USACE).....2-4, 2-7, 2-8, 3-35, 3-36, 3-37, 3-58, 3-60, 3-61, 4-90, 4-91, 4-92, 4-94, 4-95, 4-97, 4-103, 4-106, 4-107, 4-152, 4-153, 4-162, 4-163, 4-166, 5-11, 5-16, 5-56, 5-65, 6-4, 6-5, 6-6, 6-7, 6-10, 6-11

U.S. Fish and Wildlife Service (USFWS).....2-4, 2-7, 2-8, 3-42, 3-53, 4-91, 4-102, 4-103, 4-104, 4-107, 4-129, 4-130, 4-155, 4-162, 4-163, 4-164, 4-166, 4-167, 5-16, 5-19, 5-31, 5-34, 5-65, 6-4, 6-6, 6-7, 6-10

Vegetation.....3-36, 3-37, 3-39, 3-40, 3-41, 3-43, 3-45, 3-51, 3-52, 3-68, 3-69, 4-2, 4-8, 4-10, 4-11, 4-83, 4-89, 4-93, 4-94, 4-96, 4-97, 4-98, 4-100, 4-101, 4-104, 4-105, 4-106, 4-109, 4-112, 4-114, 4-121, 4-126, 4-138, 4-140, 4-143, 4-150, 4-158, 4-160, 4-162, 4-164, 4-165, 4-166, 5-6, 5-22, 5-23, 5-31, 5-32, 5-35, 5-55

Vehicle Hours Traveled (VHT).....1-2, 2-19

Water Quality.....3-1, 3-31, 3-32, 3-33, 3-35, 3-45, 4-82, 4-83, 4-91, 4-92, 4-93, 4-110, 4-111, 4-112, 4-113, 4-114, 4-120, 4-121, 4-126, 4-130, 4-142, 4-143, 4-145, 4-146, 4-152, 4-157, 4-160, 4-161, 4-166, 4-169, 5-7, 5-10, 5-11, 5-18, 5-21, 5-22, 5-29, 5-30, 5-40, 5-55, 5-56, 5-64, 5-69

Wetlands.....2-1, 2-2, 2-4, 2-5, 2-7, 2-28, 2-29, 2-30, 2-33, 2-34, 3-1, 3-2, 3-35, 3-36, 3-37, 3-38, 3-39, 3-40, 3-41, 3-42, 3-43, 3-44, 3-45, 3-69, 4-2, 4-90, 4-91, 4-92, 4-93, 4-94, 4-95, 4-96, 4-97, 4-98, 4-99, 4-100, 4-101, 4-102, 4-103, 4-104, 4-105, 4-106, 4-107, 4-108, 4-111, 4-113, 4-114, 4-125, 4-128, 4-138, 4-153, 4-161, 4-162, 4-163, 4-164, 4-165, 4-166, 4-171, 4-172, 5-4, 5-5, 5-6, 5-7, 5-11, 5-18, 5-19, 5-21, 5-22, 5-26, 5-30, 5-31, 5-32, 5-33, 5-34, 5-35, 5-36, 5-37, 5-40, 5-41, 5-54, 5-55, 5-56, 5-63, 5-64, 5-65, 5-69, 5-70, 6-2, 6-3, 6-4, 6-5, 6-7, 6-8, 6-11

Wild and Scenic Rivers.....3-1, 3-49, 4-128, 4-155, 4-167, 5-11, 5-19

Wildlife.....3-1, 3-37, 3-38, 3-42, 3-43, 3-44, 3-58, 4-2, 4-93, 4-97, 4-98, 4-105, 4-106, 4-107, 4-108, 4-109, 4-110, 4-111, 4-113, 4-114, 4-153, 4-166, 5-7, 5-11, 5-19, 5-22, 5-34, 5-49, 6-2, 6-11