#### **List of Figures**

1.1	Gulf coast study design	1F-1
1.2	Lexicon of terms used to describe the likelihood of climate outcomes	1F-2
2.1	Map of study area. Study area extends from Mobile, Alabama to Houston/Galveston, Texas. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-1
2.2	Study area counties and Federal Information Processing Standard (FIPS) codes. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-2
2.3	Metropolitan planning organizations in the study area. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-3
2.4	Combined truck flows shipped domestically from Louisiana, 1998. (Source: U.S. Department of Transportation Federal Highway Administration, Freight Management and Operations, Office of Operations)	2F-4
2.5	Navigable inland waterways impacting the study area, shown as named waterways. (Source: U.S. Department of Transportation)	2F-5
2.6	National network of Class I railroads. (Source: Federal Railroad Administration Office of Policy, U.S. Department of Transportation)	2F-6
2.7	Intermodal facilities in the study area. (Source: Bureau of Transportation Statistics, U.S. Department of Transportation)	2F-7
2.8	Highways in the study area. (Source: Cambridge Systematics analysis of U.S. Department of Transportation data)	2F-8
2.9	Total and truck annual vehicle miles traveled (VMT) on nonlocal roads, 2003. (Source: Cambridge Systematics, from 2004 Highway Performance Monitoring System database for Gulf Coast Study supplied by the Bureau of Transportation Statistics, U.S. Department of Transportation)	2F-9
2.10	Nonlocal bridges in the study area (NBI latitude and longitude location). (Source: Cambridge Systematics analysis of U.S. Department of Transportation data)	2F-10

2.11	Freight railroad traffic density (annual millions of gross ton-miles per mile) in the study area. (Source: Bureau of Transportation Statistics, U.S. Department of Transportation)	2F-11
2.12	Sunset Limited route map, Houston, Texas – Mobile, Alabama segment. (Source: Amtrak)	2F-12
2.13	Freight handling ports and waterways in the study area. (Source: Cambridge Systematics analysis of U.S. Army Corps of Engineers data)	2F-13
2.14	Barge tow on the Mississippi River. (Source: U.S. Army Corps of Engineers)	2F-14
2.15	Study area airports. (Source: Bureau of Transportation Statistics, U.S. Department of Transportation)	2F-15
2.16	Surface geology of the southeastern United States. White line denotes inland extent of the coastal plain and grey area is Holocene alluvium. (Source: USGS, 2000a)	2F-16
2.17	Relative elevation of study area counties (delineated in blue). All areas shown in bright orange are below 30 m elevation. (Source: USGS)	2F-17
2.18	Map of terrestrial ecoregions within and adjacent to the study area. (modified from Bailey, 1975)	2F-18
2.19	U.S. Census Bureau Metropolitan Statistical Areas in study area. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-19
2.20	Population density in study area, 2004. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-20
2.21	Estimated population change in study area, 2000 to 2005. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-21
2.22	Mean travel time to work in study area. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-22
2.23	Manufacturers shipments in thousands of dollars, 1997. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-23
2.24	Social vulnerability index for study area. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-24

2.25	Persons in poverty in study area. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-25
2.26	Persons aged 65 and older in study area. (Source: U.S. Census Bureau, ESRI, Inc., National Transportation Safety Bureau)	2F-26
3.1	CO <sub>2</sub> emissions, SO <sub>2</sub> emissions, and atmospheric CO <sub>2</sub> concentration through 2100 for the six "Marker/Illustrative" SRES scenarios and the IS92a scenario (a "business as usual" scenario, IPCC (1992)). (Source: IPCC 2001)	3F-1
3.2	United States Climate Divisions of the central Gulf Coast study area. Empirical trends and variability were analyzed for temperature and precipitation at the Climate Division Dataset (CDD) level for the climate divisions along the Gulf Coast from Galveston to Mobile, including Texas Climate Division 8, Louisiana Divisions 6-9, Mississippi Division 10, and Alabama Division 8. These climatic divisions cover the entire central Gulf Coast study area	3F-1
3.3	Grid area for the GCM temperature and precipitation results presented in Section 3.1.5 of this report, which is a subset of the global grid of a typical GCM output	3F-2
3.4	Scatterplot of seasonal temperature and precipitation predictions by an ensemble of GCMs for the Gulf Coast region in 2050 using the SRES A1B emissions scenario.	3F-3
3.5	Temperature variability from 1905-2003 for the 7 Climate Divisions making up the Gulf Coast study area.	3F-4
3.6	Precipitation variability from 1905 to 2003 for the seven Climate Divisions making up the Gulf Coast study area.	3F-5
3.7	Variability and trends in model-derived surplus (runoff) and deficit from 1919 to 2003 for the Gulf Coast study area	3F-6
3.8	Probability density functions for seasonal temperature change (in °C) in the Gulf Coast study area for 2050 using the A1B emissions scenario.	3F-7
3.9	Probability density functions for seasonal precipitation change (in percent) in the U.S. Gulf Coast study area for 2050 using the A1B emissions scenario	3F-8

3.10	Quantile estimates of monthly precipitation for the 2- to 100-year return period using the 1971 to 2000 baseline period relative to GCM output for the A1B emissions scenario at the 5%, 50%, and 95% quartiles	3F-9
3.11	Quantile estimates of monthly average runoff for the 2- to 100-year return period using the 1971 to 2000 baseline period relative to GCM output for the A1B emissions scenario at the 5%, 50%, and 95% quartiles	3F-10
3.12	Quantile estimates of monthly average deficit for the 2- to 100-year return period using the 1971 to 2000 baseline period relative to GCM output for the A1B emissions scenario at the 5%, 50%, and 95% quartiles	3F-11
3.13	The change in the warmest 10% of July maximum and minimum temperatures at each station across the entire United States, for 1950-2004. Note the number of days above the 90 <sup>th</sup> percentile in minimum temperature is rising faster than maximum temperature.	3F-12
3.14	Historical time series from stations within 500 km of the Dallas, Texas showing anomalies of the number of days above 37.7°C (100°F), for 1950-2004.	3F-13
3.15	The current and future probabilities of having one to twenty days during the summer at or above 37.8°C (100°F) in or near Houston, Texas under the A2 emissions scenario.	3F-14
3.16	Mean model predicted change (Celsius) of the 20-year return value of the annual maximum daily averaged surface air temperature under the A1B emissions scenario in the Gulf States region. This analysis compares the 1990-1999 period to the 2090-2099 period.	3F-15
3.17	Number of times on average over a 20-year period that the 1990-1999 annual maximum daily averaged surface air temperature 20-year return value levels would be reached under the SRES A1B 2090-2099 forcing conditions over 20 years. Under 1990-1999 forcing conditions, this value is defined to be one.	3F-16
3.18	Mean model predicted fractional change of the 20-year return value of the annual maximum daily averaged precipitation under the SRES A1B in the Gulf States region. This analysis compares the 1990-1999 period to the 2090-2099 period.	3F-17

3.19	Geographic distribution of hurricane landfalls along the Atlantic and Gulf Coast region of the U.S., from 1950 to 2006. (Source: NOAA, National Climate Data Center, Asheville, N.C.)	3F-18
3.20	Frequency histogram of landfalling storms of tropical storm strength or greater in Grand Isle, Louisiana summarized on a 5 year basis, for the period 1851- 2005. (Source: NOAA National Hurricane Research Division)	3F-19
3.21	Hemispherical and global mean sea-surface temperatures for the period of record 1855 to 2000. (Source: NOAA, National Climate Data Center, Asheville, N.C.).	3F-20
3.22	Sea surface temperature trend in the main hurricane development region of the North Atlantic during the past century. Red line shows the corresponding 5-yr running mean. Anomalies are departures from the 1971–2000 period monthly means. (Source: Bell <i>et al.</i> 2007)	3F-21
3.23	Sea surface temperature trend in the Gulf of Mexico region produced using the ERSST v.2 database. The plot includes the SST anomalies averaged annually, as well as the anomalies determined from the averages for August only and the July-September peak of the hurricane season. (Source: Smith and Reynolds, 2004)	3F-22
3.24	Satellite imagery of the Gulf of Mexico and warmer waters of the Loop Current that interacted with the track and storm strength of Hurricane Rita (2005). (Source: NASA/JPL/University of Colorado)	3F-23
3.25	Frequency histogram of tropical storm events for coastal cities across the Gulf of Mexico region of the United States over the period of record from 1851 to 2006.	3F-24
3.26	Frequency analysis of storm events exhibiting Category 1, 2, and 3 winds or higher across the Gulf Coast study area.	3F-27
3.27	Latitudinal gradient of declining storm frequency of Category 1 hurricanes or greater from Grand Isle, LA inland illustrating the reduction of storm strength overland away from the coast, for the period 1951-2000	3F-26
3.28	15-, 30-, and 50-year hurricane recurrence potential. Storm frequency variation for 15, 30, and 50 year intervals for Category 1 storms or greater for the most active grid location across the Gulf Coast study region	3F-27

3.29	Simulated wind rows and direction of wind force derived from the HURASIM Model for one of the most active grid cell locations in the study area at Grand Isle, LA for tropical storm and hurricane conditions over the 153-year period of record.	3F-28
3.30	Potential increase in the number of hurricanes by the year 2050 and 2100 assuming an increase in hurricane intensity concomitant with warming sea surface temperatures projected at 5%, 10%, 15%, and 20%	3F-29
3.31	Tide gauge records and mean sea level trend line for three northern Gulf Coast tide stations at Pensacola, FL, Grand Isle, LA, and Galveston, TX corresponding with the eastern, central, and western coverage of the study area (1900-2000).	3F-30
3.32	Sea level change curves from the CoastClim Model illustrating the projected sea-level rise including both land subsidence and future rates of eustatic rise for Low, Mid, and High Projections for all seven GCMs under the A1F1 scenario.	3F-31
3.33	Merged results of Category 2 through 5 hurricane surge simulations of slow moving storm approaching from the southeast (toward northwest in database), using SLOSH model simulations.	3F-32
3.34	Color schemes illustrate the difference in surge inundation between a Category 3 and Category 5 storm approaching the southeastern Louisiana coast from the southeast.	3F-33
3.35	Comparison of Lidar and National Digital Elevation Data (DEM) for eastern Cameron Parish, Louisiana. The advantages of using a LiDAR-derived topography are many, particularly as the effects of climate change are likely to be subtle in the short-term but significant for this low-lying coast where 1 foot of added flooding will impact a large land area.	3F-34
3.36	Trend in summer wave height (1978-2005) in the mid-Gulf of Mexico. (Figure source: Komar, in press; data source: National Buoy Data Center, NOAA, Stennis, Mississippi)	3F-35
4.1	Highways at risk from a relative sea level rise of 61 cm (two feet). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-1
4.2	Highways at risk from a relative sea level rise of 122 cm (four feet). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-2

4.3	NHS Intermodal Connectors at risk from a relative sea level rise of 122 cm (four feet). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-3
4.4	Hurricane Katrina damage to Highway 90 at Bay St. Louis, MS. (Source: NASA Remote Sensing Tutorial)	4F-4
4.5	Highways at risk from storm surge at elevations currently below 5.5 meters (18 feet). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-5
4.6	Highways currently at risk from storm surge at elevations currently below 7.0 meters (23 feet). (Source: Cambridge Systematics analysis of U.S. DOT data).	4F-6
4.7	NHS Intermodal Connectors at risk from storm surge at elevations currently below 7.0 meters (23 feet). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-7
4.8	Fixed bus routes at risk from a relative sea level rise of 122 cm (four feet), New Orleans. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-8
4.9	Fixed transit guideways at risk from a relative sea level rise of 122 cm (four feet), Houston and Galveston. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-9
4.10	Fixed transit guideways at risk from storm surge at elevations currently below 5.5 meters (18 feet), New Orleans. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-10
4.11	Fixed transit guideways at risk from storm surge at elevations currently below 5.5 meters (18 feet), Houston and Galveston. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-11
4.12	Fixed bus routes at risk from storm surge at elevations currently below 5.5 meters (18 feet), New Orleans. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-12
4.13	Fixed bus routes at risk from storm surge at elevations currently below 5.5 meters (18 feet), Houston and Galveston. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-13

4.14	Rail lines at risk due to relative sea level rise of 61 and 122 cm (two and four feet). Of the 2,934 miles of rail lines in the region, 146 miles, or five percent, are at risk from a relative sea level rise of two feet or less (yellow lines) and an additional 121 miles for a total of nine percent are at risk from an increase of two to four feet (green lines). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-14
4.15	Freight railroad-owned and served facilities at risk due to relative sea level rise of 61 and 122 cm (two and four feet). Of the 94 facilities in the region, 11 are at risk from two-foot increase in relative sea level (red circles) and an additional eight facilities are at risk from a four-foot increase (purple circles). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-15
4.16	Rail lines at risk due to storm surge of 5.5 and 7.0 meters (18 and 23 feet). Of the 2,934 miles of rail lines in the region, 966 miles are potentially at risk from a storm surge of 18 feet (yellow lines) and an additional 224 miles are potentially at risk from a storm surge of 23 feet (green lines). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-16
4.17	Freight railroad-owned and served facilities at risk due to storm surge of 5.5 and 7.0 meters (18 and 23 feet). Of the 94 facilities in the region, 40 are at risk from a storm surge of 18 feet or less (red circles) and an additional 11 facilities are at risk from storm surge of 18 to 23 feet (purple circles). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-17
4.18	Amtrak facilities at risk due to storm surge of 5.5 and 7.0 meters (18 and 23 feet). Of the 21 Amtrak facilities in the region, 9 are at risk from a storm surge of 18 feet or less (pink circles) and an additional 3 facilities are at risk from storm surge of 18 to 23 feet (blue circles). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-18
4.19	Freight handling ports facilities at risk from relative sea level rise of 61 and 122 cm (two and four feet). (Source: Cambridge Systematics analysis of U.S. Army Corps of Engineers data)	4F-19
4.20	Freight handling ports facilities at risk from storm surge of 5.5 and 7.0 meters (18 and 23 feet). (Source: Cambridge Systematics analysis of U.S. Army Corps of Engineers data)	4F-20
4.21	B757-200 takeoff runway requirements for design purposes. (Source: The Boeing Company, 2002)	4F-21

4.22	Gulf Coast study area airports at risk from storm surge. (Source: Cambridge Systematics analysis of U.S. DOT and USGS data)	4F-22
4.23	Landside pipelines having at least one GIS link located in an area of elevation zero to 91 cm (three feet) above sea level in the study area. (Source: Texas Transportation Institute)	4F-23
4.24	Potential evacuation route highways vulnerable from storm surge of 5.5 meters (18 feet). (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-24
4.25	Risks to Amtrak Facilities due to relative sea level rise and storm surge. (Source: Cambridge Systematics analysis of U.S. DOT data)	4F-25
4.26	Population over age 65 impacted by Hurricane Katrina. (Source: U.S. Census Bureau)	4F-26
4.27	Airports affected by Hurricane Katrina winds. (Source: USGS)	4F-27
5.1	How will climate change affect transportation decisions?	5F-1
5.2	SAFETEA-LU planning factors. Eight planning factors that should guide the development of plans, programs, and projects are identified in SAFETEA-LU. (Source: U.S. Department of Transportation)	5F-2
5.3	Steps in the transportation planning process. (Source: Michael Meyer, Georgia Institute of Technology)	5F-3
5.4	Relationship of transportation planning timeframe and infrastructure service life to increasing climate change impacts	5F-4
5.5	A risk assessment approach to transportation decisions.	5F-4
5.6	Degree of risk and value of performance inform level of adaptation investment.	5F-5