Harris County
Multi-Hazard Mitigation Action Plan
Volume 1—Area-Wide Elements

April 2020

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Coordinating Agencies

- Texas Division of Emergency Management
- Federal Emergency Management Agency Region VI
- Insurance Services Office
- Texas Water Development Board
- Bayou City Waterkeeper
- Coalition for Environment, Equity and Resilience
- Cypress Creek Flood Control Coalition
- Alamo Trust
- American Institute of Architects, Houston Chapter
- Bleyl Engineering
- Houston Hospice
- Inframark Water and Infrastructure Services
- Preservation Houston
- Texas Children's Hospital
- Texas Medical Center
- University of Houston, College of Engineering
- West Houston Association
- Region 4 Education Service Center
- Port of Houston Authority
- Greater Houston Flood Mitigation Consortium
- Rice University, Severe Storm Prediction, Education, & Evacuation from Disasters Center
- Rice University, Kinder Institute
- Texas A&M Galveston, Center for Texas Beaches and Shores
- Texas A&M Extension Service, Texas Community Watershed Partners
- University of Houston, Institute of Climate and Atmospheric Science

- University of Houston, Hurricane Resilience Research Institute
- Association of Water Board Directors—Texas
- Bayou City Initiative
- Bayou Land Conservancy
- Houston Advanced Research Center
- Citizens Environmental Coalition
- Texas Houser
- Preservation Houston
- Greater Houston Partnership
- Local Initiative Support Corporation Greater Houston
- NAACP Houston
- Houston Hispanic Chamber of Commerce
- Buffalo Bayou Partnership
- Armand Bayou Nature Center
- American Society of Adaptation Professionals - Houston
- Sierra Club Houston
- Texas A&M University, Hazard Reduction and Recovery Center
- Center for Houston's Future
- Texas Division of Emergency Management
- Texas General Land Office
- Texas Water Development Board
- Texas Forest Service
- San Jacinto River Authority
- U.S. Army Corps Galveston District
- Houston Galveston Subsidence District
- Brazoria County
- Chamber County
- Fort Bend County
- Galveston County
- Liberty County
- Montgomery County
- Waller County
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EXECUTIVE SUMMARY

Hazard mitigation planning for Harris County identifies ways to reduce risk from foreseeable natural hazards that may impact the county. Harris County prepared an initial hazard mitigation plan in 2015, with cities and special purpose jurisdictions in the county participating as partners in the plan. Since the completion of that plan, the County has continued to experience major growth in residential, commercial and infrastructure development.

Over the last five years, 70,390 development permits were issued in Harris County, and the number of residential properties increased by 13 percent. Over the last decade, population outside the Sam Houston Tollway grew faster than the area inside the tollway, adding to development across the county. Current and future development in hazard prone areas may increase risks, impacts and vulnerabilities of people and property in the county.

To address these changes, and to meet federal requirements for keeping hazard mitigation plans current, Harris County has completed the 2020 *Harris County Multi-Hazard Mitigation Action Plan*—the first update to the initial 2015 plan. In preparing it, Harris County again partnered with local cities and special-purpose jurisdictions—38 planning partners in all. Such multi-jurisdictional planning allows these partners to pool resources and eliminate redundant activities within an area that has uniform risk exposure and vulnerabilities.

This hazard mitigation plan reduces risk for those who live in, work in, and visit Harris County. The resources and background information in the plan are applicable across the county, and the plan's goals and recommendations lay groundwork for local mitigation activities and partnerships.

COMMUNITY INVOLVEMENT IN THE HAZARD MITIGATION PLAN UPDATE

This planning effort was led by a core planning team of staff from the Harris County Office of Homeland Security and Emergency Management (HCOHSEM) and consultant Tetra Tech, Inc. The broader Harris County community participated in the development of the update through the following activities:

- **Defining Stakeholders**—The team identified stakeholders to engage during the update. "Stakeholder" was defined as any person or entity that owns or operates facilities that would benefit from the mitigation actions of this plan or has a capability to support hazard mitigation actions.
- **Establishing the Planning Partnership**—The team identified eligible local governments to engage through this plan update process. Over 50 eligible local governments were identified by this screening process for additional outreach. Ultimately, 38 participated as full planning partners (see Table ES-1).
- **Forming the Steering Committee**—Harris County established a 32-member Steering Committee that represents the entire planning partnership to oversee the planning process.
- **Reviewing Previous Hazard Mitigation Plan and Existing Programs**—The planning team and Steering Committee reviewed the 2015 hazard mitigation plan, as well as all laws, ordinances and programs in effect within the county that can affect hazard mitigation actions.
- **Public Outreach**—The update effort included a website describing update activities, a survey distributed throughout the county to gather public input, the use of social media and informational bulletins to report on update activities, and public meetings to explain the update process and gather feedback. More than 1,600 people completed surveys, and thousands attended the various public outreach events.

Table ES-1. Hazard Mitigation Planning Partners Covered Under This Plan

Harris County	City of Humble	City of Seabrook	Houston Independent School District
City of Baytown	City of Hunters Creek Village	City of Shoreacres	Huffman Independent School District
City of Bellaire	City of Jersey Village	City of Spring Valley Village	Pasadena Independent School District
City of Bunker Hill Village	City of Katy	City of Stafford	Houston Community College
City of Deer Park	City of La Porte	City of Taylor Lake Village	Lone Star College
City of El Lago	City of Missouri City	City of Tomball	University of Houston
City of Friendswood	City of Morgan's Point	City of Webster	Harris County Emergency Services District 12
City of Galena Park	City of Nassau Bay	City of West University Place	Texas Medical Center
City of Hedwig Village	City of Pasadena	Harris County Flood Control District	Harris County Hospital District (dba Harris Health System)
City of Hilshire Village	City of Piney Point Village		

PLANNING AREA, HAZARDS OF CONCERN, AND RISK ASSESSMENT

The planning area for this hazard mitigation plan update was defined to consist of the unincorporated county, incorporated cities, and special-purpose districts within the greater Harris County metropolitan area, as well as portions of neighboring counties where any individual planning partners have jurisdiction. The Steering Committee considered the full range of natural hazards that could affect the planning area and then identified those that present the greatest concern.

Risk assessment is the process of estimating the potential loss of life, personal injury, economic injury, and property damage resulting from identified hazards. The risk assessments in this plan describe the risks associated with each identified hazard of concern. The following steps were used to assess the risk of each hazard:

- **Identify and profile each hazard**
- **Determine "exposure" to each hazard**—Exposure was assessed by overlaying hazard maps with an inventory of structures, facilities, and systems to decide which of them would be exposed to each hazard.
- **Assess the "vulnerability" of exposed facilities**—Vulnerability of exposed structures and infrastructure was evaluated by interpreting the probability of occurrence of each event and assessing potential damage to structures, facilities, and systems that are exposed to each hazard.

Table ES-2 summarizes the findings of the risk assessment.

RISK RANKING

This update includes a risk ranking protocol for each planning partner, in which "risk" was calculated by multiplying probability by impact on people, property and the economy. The risk estimates were generated using methodologies promoted by the Federal Emergency Management Agency. The Steering Committee reviewed, discussed and approved the methodology and results. The countywide ranking results are listed in Table ES-3. All planning partners ranked risk for their own jurisdictions following the same methodology.

MISSION STATEMENT, GOALS AND OBJECTIVES

Table ES-4 lists the mission statement, goals and objectives for this hazard mitigation plan update, as established by the Steering Committee.

Table ES-2. Key Findings from Risk Assessment of Hazard of Concern

Hazard of Concern	Key Risk Assessment Findings	
	Exposure	Vulnerability
Coastal erosion	Risk not assessed because no historical damage values could be identified for losses due to erosion within the planning area.	
Dam or levee failure (failure of the Conroe Dam)	• 0.5% of total planning area population • Structures valued at 0.5% of planning area total • 1.2% of all planning area critical facilities	• Damage equal to 0.07% of total planning area property value
Drought	• Entire planning area exposed	• No quantitative loss estimates
Earthquake (500-year probabilistic event)	• Entire planning area exposed	• 2 households displaced • Damage equal to 0.5% of total planning area property value
Flooding (1% annual chance event)	• 8.9% of total planning area population • Structures valued at 8.9% of planning area total • 23.0% of all planning area critical facilities	• 170,000 persons displaced • Damage equal to 0.8% of total planning area property value • 1.4 million tons of debris to be removed • Critical facilities structure damage equal to 9.9% of total value for exposed facilities • Critical facilities content damage equal to 33.4% of total value for exposed facilities
Hurricane, coastal storm (20-year probabilistic event)	• Entire planning area exposed	• 1,083 households displaced • Damage equal to 0.2% of total planning area property value • 240,000 tons of debris to be removed • Minor damage to 4% of critical facilities • Moderate damage to 5.5% of critical facilities • Severe damage to 0.4% of critical facilities
Mass movements	Exposure and vulnerability are low to none, based on the lack of historical occurrence of these types of hazards and the planning area's proactive approach to mitigating subsidence issues starting in 1999.	
Severe weather	• Entire planning area exposed	• No quantitative loss estimates
Tsunami	Exposure and vulnerability are low to none, based on the lack of historical occurrence of tsunami	
Wildfire (Moderate, high or very high wildfire ignition density zone)	• 0.7% of total planning area population • Structures valued at 1.0% of planning area total • 0.4% of all planning area critical facilities	• No quantitative loss estimates

Table ES-3. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Total Score	Category[a]
1	Hurricane and Coastal Storms	51	High
	Severe Weather	51	High
2	Flood	36	High
3	Wildfire	24	Medium
4	Earthquake	16	Medium
5	Coastal Erosion	6	Low
	Drought	6	Low
	Dam Failure	6	Low
	Mass Movements	6	Low
	Tsunami	6	Low

a. Scores of 30 or greater are rated as "high," scores of 15 to 29 are "medium," and scores of less than 15 are "low"

Table ES-4. Mission Statement, Goals and Objectives

Mission Statement	Goals	Objectives
Develop and maintain a comprehensive pre- and post-disaster hazard mitigation program. The Mission Statement is guided by the effective use of technology and data, improved communications and warning, the purchase of necessary equipment, sound planning, the adoption of codes, enhanced transportation networks, expanded education and outreach efforts, strengthened public facilities and infrastructure, the utilization/enhancement of natural resources, the consideration of future hazard conditions and the implementation of projects designed to reduce the vulnerability of individuals, families, households, businesses, infrastructure and critical facilities to the negative effects of natural and human-caused hazards.	1. Expand warning systems and local warning capabilities among departments and between jurisdictions. 2. Improve and coordinate data collection efforts to fully maximize the intent of the efforts and to improve the mitigation capabilities of the county and all jurisdictions. 3. Enhance education strategies to improve the dissemination of information to the public regarding hazards, including the steps that can be taken to reduce their impact. 4. Improve the capabilities of local government officials to reduce or eliminate hazards that cause loss of life, inflict injuries, cause property damage and to improve the protection of natural resources. 5. Work to improve and coordinate existing local plans, codes and regulations to reduce the impacts of natural hazards. 6. Implement property protection measures to reduce the effects of natural hazards throughout the county, including measures that reduce or eliminate repetitive loss occurrences. 7. Investigate and implement a range of structural projects that will reduce the effects of natural hazards on public and private property throughout the county. 8. Investigate and implement a range of nature-based solutions and utilize and enhance natural resources and their ability to reduce the impacts from natural hazards	1. Improve and expand systems that provide warning and emergency communications to the whole community 2. Implement wildfire mitigation and watershed protection strategies through local, state, tribal, federal and private partnerships. 3. Improve understanding of the locations, potential impacts, and linkages among threats, hazards, vulnerability, and measures needed to protect life safety and health. 4. Reduce the impacts of hazards on individuals with disabilities and others with access and functional needs. 5. Coordinate state and local efforts to reduce greenhouse gas emissions and implement climate adaptation strategies through hazard mitigation plans and actions. 6. Control access and provide buffers to maximize resource protection where possible. 7. Encourage all state, regional and local hazard mitigation projects and planning programs to protect the environment and promote implementation of sustainable mitigation and climate resilience actions. 8. Support hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem. 9. Encourage all cities, counties, special districts, Councils of Governments and tribal organizations to develop, adopt, and implement local hazard mitigation principles that may be integrated with local comprehensive plan safety elements, local coastal plans, facilities master plans, and other local plan initiatives. 10. Advance community resilience through preparation, adoption, and implementation of state, regional and local multi-hazard mitigation plans and projects. 11. Encourage projects that simultaneously reduce risk while increasing resilience and sustainability. 12. Manage new and existing development in high hazard areas, especially those known to be repetitively damaged. 13. Support the protection of vital and essential records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery. 14. Through the enforcement of relevant federal, State and local regulations, sustain life and property protection measures for all communities and structures located in the greater Harris County region. 15. Promote disaster resistant development.

MITIGATION ACTION PLANS

Catalogs of hazard mitigation best practices were developed that present a broad range of action alternatives to be considered for use by the planning partners. One catalog was developed for each hazard of concern. The alternatives include actions that will mitigate current risk from hazards and actions that will help reduce risk from changes in the impacts of these hazards resulting from climate change.

Hazard mitigation actions recommended in this plan were selected from an analysis of the alternatives presented in the catalogs. Each planning partner selected appropriate mitigation actions to establish an individual mitigation

action plan for its jurisdiction. Actions were selected based on an analysis of the planning partner's ability to implement the action and general feasibility.

The combined action plans of the 38 planning partners include a total of 750 actions for mitigating hazard risks in the Harris County planning area. The planning partners have prioritized the actions in their action plans and can begin to implement the highest-priority actions over the next five years.

PLAN IMPLEMENTATION AND MAINTENANCE

The effectiveness of the hazard mitigation plan depends on its effective implementation and incorporation of the outlined action items as needed into each partner's existing plans, policies, and programs. Harris County will have lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the jurisdiction-specific action plans.

A formal implementation and maintenance process will ensure that the hazard mitigation plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. The plan maintenance matrix shown in Table ES-5 provides a synopsis of responsibilities for the overall plan maintenance strategy.

Table ES-5. Plan Maintenance Matrix

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
Monitoring-Progress Reporting	Preparation of status updates and action implementation tracking as part of submission for annual progress report.	January to January of each calendar year or upon full update to comprehensive plan or major disaster	Jurisdictional points of contact	Jurisdictional implementation lead
Evaluation	Annual progress reports will be evaluated by an oversight steering committee annually	Finalized progress report completed by March 1 of each year	HCOHSEM	Jurisdictional points of contacts
Update	Reconvene the planning partners, at a minimum, every 5 years to guide a full review and revision of the plan.	Every 5 years or upon full update to comprehensive plan or major disaster	HCOHSEM and oversight steering committee	Jurisdictional points of contacts
Grant Monitoring and Coordination	Monitor grant funding opportunities via agency notifications, state associations and post-disaster response	Ongoing	HCOHSEM	Jurisdictional points of contacts
Plan Integration	Create a linkage between the hazard mitigation plan and individual jurisdictions' comprehensive plans or similar plans	Ongoing as opportunities for integration become available, or according to timelines identified in individual actions plans	Jurisdictional points of contact	Jurisdictional implementation lead
Continuing Public Involvement	Keep the website maintained and receive comments through it over the course of the plan. Planning partners will maintain links to the website. County-wide progress report will be posted to the website.	Ongoing. Progress reports to be posted annually.	HCOHSEM will maintain the overall website and post the progress report annually. Each planning partner will provide a link to the website and may post individual progress reports.	HCOHSEM and jurisdictional implementation lead

PART 1—PLANNING PROCESS AND COMMUNITY PROFILE

1. INTRODUCTION TO HAZARD MITIGATION PLANNING

1.1 WHY PREPARE THIS PLAN?

1.1.1 The Big Picture

Hazard mitigation is defined as any action taken to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster. It involves long- and short-term actions implemented before, during and after disasters. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects, and other steps to reduce the impacts of hazards.

For many years, federal disaster funding focused on relief and recovery after disasters occurred, with limited funding for hazard mitigation planning in advance. The Disaster Mitigation Act (DMA), passed in 2000, shifted the federal emphasis toward planning for disasters before they occur. The DMA requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. Regulations developed to fulfill the DMA's requirements are included in Title 44 of the Code of Federal Regulations (44 CFR).

The responsibility for hazard mitigation lies with many, including private property owners, commercial interests, and local, state and federal governments. The DMA encourages cooperation among state and local authorities in pre-disaster planning. The enhanced planning network called for by the DMA helps local governments to articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk-reduction projects.

The DMA also promotes sustainability in hazard mitigation. To be sustainable, hazard mitigation needs to incorporate sound management of natural resources and address hazards and mitigation in the largest possible social and economic context.

1.1.2 Purposes for Planning

Hazard mitigation planning for Harris County helps to identify strategies and actions that will reduce risk for those who live in, work in, and visit the county. In addition, hazard mitigation planning provides a viable planning framework for all foreseeable natural hazards that may impact the county. Furthermore, participation in the development of the plan by key stakeholders in the county helps to ensure that outcomes will be mutually beneficial. Benefits of hazard mitigation planning include the following:

- Reduce economic hardship and the loss of life, property, essential services, and critical facilities
- Reduce short-term and long-term recovery and reconstruction costs
- Increase cooperation and communication within the community through the planning process
- Increase potential for state and federal funding for pre- and post-disaster projects.

Harris County prepared a hazard mitigation plan in compliance with the DMA in 2015. Cities and special purpose jurisdictions within the county participated as planning partners in the plan. That initial plan identified resources,

information, and strategies for reducing risk from natural hazards. It called for ongoing updates. This *Harris County Multi-Hazard Mitigation Action Plan* fulfills the ongoing update requirement.

In preparing this update, Harris County has again partnered with local cities and special-purpose jurisdictions. One of the benefits of such multi-jurisdictional planning is the ability to pool resources and eliminate redundant activities within a planning area that has uniform risk exposure and vulnerabilities. The Federal Emergency Management Agency (FEMA) encourages multi-jurisdictional planning under its guidance for the DMA. Elements and strategies in the plan were selected because they meet a program requirement and because they best meet the needs of all the planning partners and their citizens.

The *Harris County Multi-Hazard Mitigation Action Plan* will help guide and coordinate mitigation activities throughout the planning area. It was developed to meet the following objectives:

- Identify measures that can be taken to reduce the harmful impacts of hazards and protect lives and property.
- Reassess risk and local hazards of concern considering recent disasters and identified vulnerabilities.
- Meet or exceed state and federal requirements for mitigation planning.
- Enable all planning partners to qualify for federal grant funding to reduce risk through mitigation.
- Meet the planning requirements of FEMA's Community Rating System (CRS), allowing eligible planning partners to consider participation in the CRS program.
- Coordinate existing plans and programs so that high-priority projects to mitigate possible disaster impacts are funded and implemented.
- Lesson economic impacts from disasters and enhance community resiliency.

1.2 WHO WILL BENEFIT FROM THIS PLAN?

All citizens and businesses of Harris County are the ultimate beneficiaries of this hazard mitigation plan. The plan reduces risk for those who live in, work in, and visit the planning area. It provides a viable planning framework for all foreseeable natural hazards. Participation in development of the plan by key stakeholders helped ensure that outcomes will be mutually beneficial. The resources and background information in the plan are applicable across the planning area, and the plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.3 CONTENTS OF THIS PLAN

This plan has been set up in two volumes so that elements that are jurisdiction-specific can easily be distinguished from those that apply to the whole planning area:

- Volume 1—Volume 1 includes all federally required elements of a disaster mitigation plan that apply to the entire planning area. This includes the description of the planning process, public involvement strategy, goals and objectives, planning area hazard risk assessment, and a plan maintenance strategy.
- Volume 2—Volume 2 includes all federally required jurisdiction-specific elements, in annexes for each participating jurisdiction. It includes a description of the participation requirements established by the Steering Committee, as well as instructions and templates that the partners used to complete their annexes. Volume 2 also includes "linkage" procedures for eligible jurisdictions that did not participate in development of this plan but wish to adopt it in the future.

Both volumes include elements required under federal guidelines. DMA compliance requirements are cited at the beginning of subsections as appropriate to indicate compliance.

The following appendices provided at the end of Volume 1 include information or explanations to support the main content of the plan:

- Appendix A—Public involvement information used in preparation of this update
- Appendix B—A summary of federal and state programs and regulations relevant to hazard mitigation.
- Appendix C—Quantitative results from risk assessment modeling.
- Appendix D—A detailed list of historical flood events in Harris County.
- Appendix E—Plan adoption resolutions from planning partners.

All planning partners will adopt Volume 1 in its entirety and at least the following parts of Volume 2: Part 1; each partner's jurisdiction-specific annex; and the appendices.

2. PLAN UPDATE—WHAT HAS CHANGED

2.1 THE PREVIOUS PLAN

The *2015 Harris County, Texas, Multi-Hazard Mitigation Plan* was prepared for a planning partnership that consisted of Harris County, 28 municipalities, four special-purpose jurisdictions, and four non-profit entities within the county. This multi-jurisdiction approach addressed several meaningful considerations:

- Multi-jurisdictional planning allows participating partners to pool resources and eliminate redundant activities within a planning area.
- The County provides many services on a countywide basis that influence or directly impact all phases of emergency management.
- Due to limited financial resources at the municipal level, the ability of each city and special-purpose jurisdiction to prepare a DMA-compliant plan was uncertain.
- FEMA promotes multi-jurisdictional planning, so a multi-jurisdictional partnership was more likely to receive grant funding for the planning effort.

The 2015 plan recommended 672 hazard mitigation actions. The actions address the following identified hazards of concern:

- Flooding
- Hurricanes and coastal storms
- Severe thunderstorms
- Tornados
- Hail
- Wildfire
- Drought
- Extreme heat
- Winter storms and freezes
- Coastal erosion
- Dam/levee failure
- Earthquakes
- Sinkholes
- Subsidence
- Landslides
- Tsunami
- Toxic release/hazardous materials
- Energy pipeline failures

Participating planning partners completed jurisdiction-specific components to the plan, thereby achieving DMA compliance. FEMA issued approval of the plan on July 27, 2015.

2.2 WHY UPDATE?

2.2.1 Federal Eligibility

Under 44 CFR, hazard mitigation plans must present a schedule for monitoring, evaluating, and updating the plan. This provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. A jurisdiction covered by a plan that has expired is not able to pursue elements of federal funding for which a current hazard mitigation plan is a prerequisite.

2.2.2 Changes in Development

Hazard mitigation plan updates must be revised to reflect changes in development within the planning area during the previous performance period of the plan (44 CFR Section 201.6(d)(3)). The plan must describe changes in development in hazard-prone areas that increased or decreased vulnerability for each jurisdiction since the last plan was approved. If no changes in development impacted the jurisdiction's overall vulnerability, plan updates may validate the information in the previously approved plan. The intent of this requirement is to ensure that the mitigation strategy continues to address the risk and vulnerability of existing and potential development and takes into consideration possible future conditions that could impact vulnerability.

The planning area experienced a 14.8-percent increase in population between 2000 and 2018, an average annual growth rate of 1.8 percent per year. In 2018, there were 1,768,827 housing units (U.S. Census Bureau, 2018). This is a 7 percent increase over the 1,768,827 housing units recorded in 2013. Harris County and its municipalities have comprehensive plans that govern land-use decisions and policy-making, as well as building codes based on state and federal guidance. This plan update assumes that some new development triggered by increased population occurred in hazard areas. Because all such new development would have been regulated pursuant to local programs and codes, it is assumed that vulnerability did not increase even if exposure did. Jurisdiction-specific development trends for each planning partner are summarized in the annexes provided in Volume 2.

Harris County continues to experience major changes in development and growth in residential, commercial and infrastructure developments across the county. Over the last five years, 70,390 development permits were issued in the planning area, of which 37,660 were residential structures, valued at an estimated $48.2 billion in new construction. The total number of residential properties in Harris County, including single family, multifamily, and agricultural property, has increased by 13 percent since 2015. Over the last decade, population outside the Sam Houston Tollway has grown significantly faster than the area inside the Tollway; adding to development within the county. Current and future development located within hazard prone areas may increase risks, impacts and vulnerabilities within the county. The mitigation actions proposed in this plan seek to reduce these adverse effects within the county.

2.2.3 New Analysis Capabilities

The risk assessment for the 2015 plan used both quantitative and qualitative analyses. A multi-jurisdictional planning team chose the following risk factors to use as criteria for a risk analysis:

- Severity of impact
- Frequency of impact
- Warning time
- Cascading potential
- Historical occurrence
- Damage vulnerability
- Affected area potential

- Perceived risk survey of all signatories and emergency managers

The planning team assigned weights to each risk factor of 10 or 15 percent, distributed to total 100 percent. Each participating jurisdiction used the weighted risk factors to assess its own risk for every hazard with the potential to affect the planning area. Risk scores were taken into account and each hazard was evaluated using a weighted average. Hazards with the highest score pose the greatest risk to the planning area.

For this plan update, risk ranking used quantitative data from enhanced risk assessment modeling with the Hazus software. This methodology is built upon a definition of risk as follows:

Risk = Probability x Impact

where impact = the impact on the people, property and economy of the planning area

Thresholds were established for each factor and weighted values were assigned so that each planning partner could individually quantify the impacts of each hazard of concern and rank those impacts as high, medium or low. This enabled each planning partner to identify and prioritize actions for hazards of concern with the highest impacts on their jurisdiction. Local knowledge based on practical experience was utilized by each planning partner to validate the results of the quantitative modeling. This approach is a quantitative assessment using data and science, rather than subjective or qualitative assessments used in the 2015 plan methodology.

2.3 THE UPDATED PLAN—WHAT IS DIFFERENT?

The updated plan differs from the initial plan in a variety of ways. Table 2-1 indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

Table 2-1. Plan Changes Crosswalk

44 CFR Requirement	2015 Plan	Updated Plan
§201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: *(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;* *(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and* *(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.*	The plan update process followed a widely recognized approach that meets the requirements of FEMA and the Texas Department of Public Safety, Division of Emergency Management. This process was deployed over three phases that included the opportunity for public comment, agency coordination and the review and incorporation of plans, programs and studies into the plan update. This was fully documented in Section 3 of the plan.	This plan update process built upon the successes of the 2015 planning effort using an approach tied more closely to maximizing credit potential under FEMA's Community Rating System (CRS) program. The process was enhanced with an emphasis on maximizing CRS credit under Activity 510, for Planning Steps 1, 2, and 3 for multi-jurisdictional planning efforts. This included: • A two-phase public outreach strategy deployed to gauge the public's perception of risk early in the process, and an opportunity to comment on the draft plan late in the process. • A strategy for agency coordination and inclusion in the plan update process • A comprehensive core capability assessment process designed to identify existing core capabilities that can support or enhance the outcomes of this plan. All of this is documented in Volume 1, Chapter 3 of the plan update

44 CFR Requirement	2015 Plan	Updated Plan
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The Plan includes a detailed risk assessment of 19 identified hazards of concern. Each hazard of concern was profiled to provide the following information: • General description of the hazard including type, location, and extent of all hazards that impact each jurisdiction within the planning area. • Discussion of destructive characteristics from a national and local perspective • Information on historical occurrences of hazard events • The probability of future hazard occurrence	Volume 1 Part 2 presents a risk assessment of 11 hazards of concern. These identified hazards were condensed from the 2015 plan to streamline the plan. The hazards are profiled as they impact the Harris County planning area. Hazard profiles are standardized for each hazard of concern, so that there is uniformity in the discussion of each hazard and the information provided can support ranking of risk for each jurisdiction. Other hazards of interest were qualitatively assessed to develop a more complete picture of the hazards facing the planning area. The planning area for this update was expanded from that utilized in the 2015 plan to include areas outside of Harris County to cover all assets at risk for planning partners that have jurisdictional boundaries in multiple counties.
§201.6(c)(2)(i): [The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	Each hazard of concern was profiled to include: • Mapping of the extent and location of the hazard • Overview of historical occurrence • Probabilities for future occurrences • Estimate of vulnerability to both population and general building stock	Volume 1 Part 2 presents a risk assessment of each hazard of concern. Each chapter includes the following components: • Hazard profile, including maps of extent and location, historical occurrences, frequency, severity, and warning time. • Secondary hazards • Exposure of people, property, critical facilities and environment. • Vulnerability of people, property, critical facilities and environment. • Future trends in development • Scenarios • Issues
§201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community	Each profiled hazard of concern includes a qualitative assessment of the vulnerability of the population and general building stock to each hazard of concern within the planning area. These vulnerability assessments were broken down by municipal boundaries.	Vulnerability was assessed for all hazards of concern. The Hazus risk assessment platform was used for the dam failure, earthquake, flood and hurricane hazards. These were Level 2 (user defined) analyses using city and county data. Site-specific data on County-identified critical facilities were entered into the Hazus model. Hazus outputs were generated for other hazards by applying an estimated damage function to an asset inventory extracted from Hazus. The risk assessment methodology for this plan update is described in Part 2, Chapter 6 of this volume
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods	Appendix D of the Plan includes a summary profile of repetitive loss properties by jurisdiction within the Planning area.	Volume 1, Part 2, Chapter 13, Section 13.5.2 of the plan includes a comprehensive analysis of repetitive loss areas that includes an inventory of the number and types of structures in the repetitive loss area. Repetitive loss areas are delineated, causes of repetitive flooding are cited, and these areas are reflected on maps.

44 CFR Requirement	2015 Plan	Updated Plan
§201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.	A vulnerability assessment methodology was applied as part a risk factor ranking protocol identified for each planning partner. A detailed high-level vulnerability assessment was then completed for all hazards with the exception of coastal erosion, earthquakes, sinkholes, subsidence, landslides, and tsunamis. Each of these hazards is considered to pose negligible risk to the planning area; the reasons for which are described.	The current update used Hazus to model impacts from dam failure, earthquake, flood and hurricane hazards. A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. Critical facilities were defined for the planning area, and these facilities were inventoried by exposure. Each hazard chapter provides a discussion on future development trends.
§201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	The loss estimation methodology used was derived from the FEMA Inventory Assets Worksheet and Estimated Losses Worksheet identified in *FEMA 386-2: Understanding Your Risks – Identifying Hazards and Estimating Losses*. This process allowed the planning partnership to examine hazards using a uniform methodology.	Dollar loss estimates were generated for all hazards of concern. These estimates were generated by Hazus for the dam failure, earthquake, flood and hurricane hazards. For the other hazards, loss estimates were generated by applying a regionally relevant damage function to the exposed inventory. In all cases, a damage function was applied to an asset inventory. The asset inventory was the same for all hazards and was generated in Hazus.
§201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	The community profile section of the plan includes a discussion on existing land use in the county, but the discussion is not hazard-specific. There is no discussion on future land uses expected for the planning area.	There is a discussion of the overall land use within the planning area, and a spatial analysis of land use was performed for hazards with a clearly defined extent and location. There is a discussion on future development trends as they pertain to each hazard of concern. This discussion looks predominantly at the existing land use and the current regulatory environment that dictates this land use.
§201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.	The plan includes a robust mitigation strategy section, identifying prioritized actions, those responsible for their implementation, potential funding sources, and an estimated target date for completion. Each action is listed with the accompanying information. This approach provides those in charge of the plan's implementation with a clear roadmap that can serve as an important monitoring tool. The collection of actions serves as a menu of policies and projects for decision makers who want to quickly review the key contents of the plan.	The plan contains a mission statement, goals, objectives and actions. The actions are jurisdiction specific and strive to meet multiple objectives. The objectives of this plan are broad but measurable. All objectives meet multiple goals and stand alone as components of the plan. Each planning partner was asked to complete a capability assessment that looks at its regulatory, technical and financial capabilities.
§201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	Based on the findings of the risk assessment and the capabilities assessment, the 2015 plan identifies a mission statement, goals, policies and actions that were intended to guide both the day-to-day operations and the long-term approach taken by counties and municipalities to reduce the impacts of hazards	A mission statement, eight goals, and 15 objectives are described in Part 3 of this volume. Goals were adapted from those in the 2015 plan. Objectives were identified that meet multiple goals and were used to help establish priorities for the action items identified in the plan. The objectives are measurable components of the plan and are the basis for identifying and prioritizing multi-objective actions.

44 CFR Requirement	2015 Plan	Updated Plan
§201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	Many participants attended one of three workshops to assist jurisdictions in developing action items by providing an information sharing forum to identify actions and strategies that meet the goals of the Plan and FEMA guidelines, and that are in some cases being utilized by others in the region. All results from the workshop were provided to all participants immediately following the meeting. All actions chosen by the participants fell into one of the broad categories of mitigation techniques.	Volume 1, Part 3 includes a catalog of mitigation best management practices that was developed through a facilitated process. This catalog identifies actions that manipulate the hazard, reduce exposure to the hazard, reduce vulnerability, or increase mitigation capability. The catalog segregates actions by scale of implementation. A table in each planning partner's action plan analyzes each action by mitigation type to illustrate the range of actions selected.
§201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	NFIP-related action items were identified using the same methods as all other mitigation action items, as listed at the new mitigation action item development and workshops.	All municipal planning partners that participate in the NFIP identified an action stating their commitment to maintain compliance and good standing under the program. Communities that participate in the Community Rating System identified actions to maintain or enhance their standing under that program.
§201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in Section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	All items were analyzed and prioritized using the STAPLEE (Social, Technological, Administrative, Political, Legal, Economic, and Environmental) criteria, which encompassed the technical, administrative, fiscal, and political capabilities of all jurisdictions into the prioritization process. Participants used this system in several ways. They chose actions that met the capabilities and needs of their jurisdiction, did not adversely affect a particular segment of the population, provided long-term reduction of losses with minimal secondary adverse impacts, and were consistent with the community's environmental goals. Beyond STAPLEE, prioritization of mitigation actions for each jurisdiction was based on the following: • Effect of overall risk to life and property • Ease of implementation • Political and community support • Emphasis on a general economic cost/benefit review • Funding availability	Each recommended action was prioritized using a qualitative methodology that looked at the objectives the project will meet, the timeline for completion, how the project will be funded, the impact of the project, the benefits of the project and the costs of the project. This prioritization scheme is detailed in the introduction to Volume 2 of this plan.
§201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	Section 7 of the plan includes a strategy for monitoring, evaluating, and updating the mitigation plan within a five-year cycle, that includes annual progress reporting.	Volume 1, Part 3 details a plan maintenance strategy for monitoring, evaluating, and updating the mitigation plan within a five-year cycle, that includes annual progress reporting.

44 CFR Requirement	2015 Plan	Updated Plan
§201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	The maintenance strategy for the 2015 plan does not include a specific component for plan integration; however, the plan does include mitigation actions for plan integration.	Volume 1, Part 3 details recommendations for incorporating the plan into other planning mechanisms, such as: • Comprehensive plan • Emergency response plan • Capital improvement programs • Municipal code Specific current and future plan and program integration activities are detailed in each participating jurisdiction's annex in Volume 2.
§201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	The plan maintenance strategy in Section 7 of the plan includes elements for continuing public involvement that include: • Publicizing meetings of the hazard mitigation planning committee in the local paper, public bulletin boards and/or city and county office buildings • Utilizing local media to update the public of any maintenance and/or periodic review • activities taking place • Utilizing city and county websites, or related social media to announce any maintenance and/or periodic review activities taking place • Providing copies of the plan for reference in public libraries.	Volume 1, Part 3 details a comprehensive strategy for continuing public involvement.
§201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commission, Tribal Council).	Appendix E of the plan includes all supporting documentation for adoption of the plan by all planning partners	Volume 1, Appendix E includes all supporting documentation for adoption of the plan by all planning partners

3. PLAN UPDATE APPROACH

The planning process of developing the update to the *Harris County Multi-Hazard Mitigation Action Plan* had the following primary objectives:

- Secure grant funding
- Form a core planning team
- Establish a planning partnership
- Define the planning area
- Establish a steering committee
- Coordinate with other agencies
- Review existing programs
- Engage the public.

3.1 GRANT FUNDING

This planning effort was supplemented by a FEMA Hazard Mitigation Assistance grant (Hazard Mitigation Grant Program for DR 4269) in fiscal year 2017. The Harris County Office of Homeland Security and Emergency Management (HCOHSEM) was the applicant agent for the grant. It covered 75 percent of the cost for development of this plan; the planning partners covered the balance through in-kind contributions.

3.2 FORMATION OF THE CORE PLANNING TEAM

This multi-jurisdictional planning effort was led and coordinated by HCOHSEM, which hired Tetra Tech, Inc. to assist with development and implementation of the plan through a standard Harris County procurement process. The Tetra Tech project manager provided subject matter expertise, direction, and project updates to the HCOHSEM project manager. A core planning team (CPT) was formed to lead the planning effort. The CPT was made up of the following discipline leads from Tetra Tech and key staff from HCOHSEM:

- Brian Murray, HCOHSEM Planning Supervisor
- Ashley Schutt, HCOHSEM GIS Specialist
- Brian Dunaway, HCOHSEM GIS Specialist
- Benzon John, HCOHSEM Mitigation Planner
- Rob Flaner, CFM, Tetra Tech, Inc., Project Manager
- Carol Baumann, GISP, Tetra Tech, Inc., Risk Assessment Lead
- Chrissie Angeletti, JD, Tetra Tech, Inc., Outreach
- Brian Rutherford, Tetra Tech, Inc., Lead Planner

The CPT was primarily responsible for overall project management, facilitating meetings and workshops, and developing the updated multi-jurisdiction hazard mitigation plan. Team coordination was through bi-weekly project coordination calls from project inception through completion.

3.3 DEFINING STAKEHOLDERS

At the beginning of the planning process, the CPT identified a list of stakeholders to engage during the update of the Hazard Mitigation Plan. For this planning process, "stakeholder" was defined as any person or public or private entity that owns or operates facilities that would benefit from the mitigation actions of this plan, and/or has an authority or capability to support mitigation actions identified by this plan. Stakeholders were separated into two categories:

- **Participatory Stakeholders**—Stakeholders that actively participated in the planning process as planning partners or members of the Steering Committee.
- **Coordinating Stakeholders**—Stakeholders that were not able to commit to actively participating in the process as a participatory stakeholder but were kept apprised of plan development milestones or were able to provide data that was used in the plan development.

3.4 ESTABLISHMENT OF THE PLANNING PARTNERSHIP

3.4.1 Initial Outreach

Hazard mitigation planning enhances collaboration among diverse parties who can be affected by hazard losses. Harris County opened this planning effort to all participants in the previous multi-jurisdictional hazard mitigation plan, along with all eligible local governments in the planning area that choose to join the partnership. The CPT identified a roster of eligible local governments within the identified planning area to engage through this plan update process. Over 50 eligible local governments were identified by this screening process for additional outreach by the CPT. This roster is available for review upon request.

3.4.2 Planning Partners Kickoff Meeting

The CPT made a presentation at a kickoff meeting on September 18, 2018 to introduce the mitigation planning process and solicit planning partners. Key meeting objectives were as follows:

- Provide an overview of the Disaster Mitigation Act.
- Describe the reasons for a plan.
- Outline the hazard mitigation plan update.
- Outline planning partner expectations.
- Seek commitment to the planning partnership.
- Seek volunteers for the Steering Committee.

3.4.3 Planning Partner Expectations

Planning partners were provided with a packet explaining the following expectations for all planning partners in the hazard mitigation planning process:

- Complete administrative tasks:
  - Establish a local mitigation planning team
  - Designate points of contact for the organization
  - Approve the Steering Committee
  - Complete a letter of intent designating a point of contact for the jurisdiction and confirming a commitment to the process and understanding of expectations
- Participate, as able in additional opportunities:

  - Attend Steering Committee meetings
  - Attend or host public meetings or open houses
  - Participate in and advertise the public review and comment period prior to adoption

- Support the Steering Committee
- Support the public involvement strategy
- Participate in the critical facility update
- Complete the jurisdictional annex template:

  - Attend the mandatory workshops
  - Perform a capability assessment
  - Review the risk assessment and identify hazards and vulnerabilities specific to their jurisdiction
  - Review county-wide mitigation recommendations
  - Develop a mitigation action plan

- Adopt the plan

3.4.4 Local Mitigation Planning Teams and Jurisdictional Annexes

Each participating jurisdiction established a local mitigation planning team to be responsible for preparing a jurisdictional annex to this plan. Team members represented agencies with authority to regulate development and enforce local ordinances or standards.

The jurisdictional annexes are presented in Volume 2 of this plan. Each represents required hazard mitigation planning information specific to individual planning partners. The content of the annexes is tailored to distinguish between municipalities and special-purpose jurisdictions. The annexes were developed through a three-phase process:

- Phase 1—Jurisdiction profiles and review of actions from previous plan
- Phase 2—Core capability assessment
- Phase 3—Risk ranking and action plan development

3.4.5 Participating Planning Partners

The planning partners covered under this plan are shown in Table 3-1. Linkage procedures have been established (see Volume 2 of this plan) for any jurisdiction wishing to link to the *Harris County Multi-Hazard Mitigation Action Plan* in the future.

3.5 DEFINING THE PLANNING AREA

The planning area was defined to consist of the unincorporated county, incorporated cities, and special-purpose districts within the greater Harris County metropolitan area. The planning area does not include areas outside of the Harris County boundary except where it was expanded into other counties to account for planning partners that have jurisdictional areas outside Harris County. This represents an expansion in scope from the 2015 plan. All partners to this plan have jurisdictional authority within the defined planning area.

Table 3-1. Hazard Mitigation Planning Partners Covered Under This Plan

Jurisdiction	Point of Contact	Title	CRS Community?
Harris County	Jonathan Steiber	Permits Manager	Yes
City of Baytown	Jamie Galloway	EMC	Yes
City of Bellaire	Deacon Tittel	Fire Chief/EMC	Yes
City of Bunker Hill Village	Karen H. Glynn	City Administrator	No
City of Deer Park	Robert Hemminger	Emergency Services Director	Yes
City of El Lago	Thomas Merchant	EMC	No
City of Friendswood	Brian Mansfield	Fire Marshal/EMC	Yes
City of Galena Park	Jorge Flores	EMC	No
City of Hedwig Village	Kelly Johnson	City Administrator	No
City of Hilshire Village	Susan Blevins	City Administrator	No
City of Humble	James Nykaza	EMC	No
City of Hunters Creek Village	Tom Fullen	City Administrator	No
City of Jersey Village	Mark Bitz	Fire Chief/EMC	No
City of Katy	Greg Goedecker	EMC	No
City of La Porte	Dena Mahan	Assistant EMC	Yes
City of Missouri City	Matt Rios	Fire Marshall/Dep. EMC	Yes
City of Morgan's Point	Sherri Ditrich	Chief of Police	No
City of Nassau Bay	Jason E. Reynolds	City Manager	Yes
City of Pasadena	Frank Bengochea	EMC	Yes
City of Piney Point Village	Roger Nelson	City Administrator	No
City of Seabrook	Jeff Galyean	Director OEM	Yes
City of Shoreacres	Troy D. Harrison	Chief of Police	Yes
City of Spring Valley Village	Julie M. Robinson	City Administrator	No
City of Stafford	Peter Alvarado	EMC	No
City of Taylor Lake Village	John Powell	Councilman	Yes
City of Tomball	Randy Parr	Fire Chief/EMC	No
City of Webster	Patrick Shipp	Fire Chief/EMC	No
City of West University Place	Aaron Taylor	Fire Chief/EMC	No
Houston Independent School District	William Earl Finley	Sr. Manager, Risk Management	No
Huffman Independent School District	Tim Brittain	Chief Financial Officer	No
Pasadena Independent School District	Carla Merka	Chief Financial Officer	No
Houston Community College	Robert McCracken	Exec. Dir of EM	No
Lone Star College	Derrick Harris	Business Analyst/Project Manager	No
University of Houston	Kelly Boysen	Director of Emergency Management	No
Harris County Flood Control District	Todd Ward	Risk Mitigation Department Manager	No
Harris County Emergency Services District 12	James Novick	Battalion Chief	No
Harris County Hospital District (dba Harris Health System)	Ray W. Higgins	Director of Emergency Management	No
Texas Medical Center	Warren J. Porter	Safety & Emergency Preparedness Manager	No

3.6 THE STEERING COMMITTEE

A key element of the public engagement strategy for this plan update was the formation of a stakeholder steering committee to oversee all phases of the update. Harris County established a Steering Committee that represents the entire planning partnership to oversee the planning process. The members of this committee included planning partner representatives, citizens, and other stakeholders from within the planning area. The CPT assembled a list of candidates representing interests within the planning area that could have recommendations for the plan or be impacted by its recommendations.

One of the identified objectives for this plan update was to maximize the Community Rating System (CRS) credit potential under CRS Activity 510 for all CRS-participating jurisdictions in the planning area. With this objective in mind, the CPT targeted all planning partner cities that participate in the CRS program for seats on the Steering Committee. The CPT identified guidance that each city seeking CRS credit for this plan update must designate two representatives for the Steering Committee and ensure that at least one attended each Steering Committee meeting. The planning partners confirmed a committee of 32 members at the kickoff meeting. Table 3-2 lists the Steering Committee members and designated alternates.

Leadership roles and ground rules were established during the Steering Committee's first meeting, on October 18, 2018. The Steering Committee met bi-monthly through the course of this update process; a total of six times from October 2018 through October 2019. All meetings were open to the public and were advertised on the hazard mitigation plan website (see section 3.10.1). Residents, neighboring communities, and stakeholders were invited to participate in the plan update by attending Steering Committee meetings. Public comments were invited at all Steering Committee meetings.

The CPT facilitated each Steering Committee meeting, which addressed a set of objectives based on an established work plan. Agendas were posted to the website prior to each scheduled Steering Committee meeting, and meeting summaries were posted to the hazard mitigation plan website following their approval by the Steering Committee. Meeting summaries and attendance logs are provided in Appendix A to this volume.

3.7 COORDINATION WITH STAKEHOLDERS AND AGENCIES

Opportunities for involvement in the planning process must be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, businesses, academia, and other private and nonprofit interests (44 CFR, Section 201.6(b)(2)). Agency coordination for this plan was accomplished as follows:

- **Steering Committee Involvement**—Agency representatives were invited to participate on the Steering Committee.
- **Agency Notification**—The agencies listed in Table 3-3 were invited to participate in the plan development process from the beginning and were kept apprised of plan development milestones. These agencies received meeting announcements, meeting agendas, and meeting minutes by e-mail throughout the plan development process and were provided the option to attend meetings. Some agencies supported the effort by attending meetings or providing feedback on issues.
- **Pre-Adoption Review**—All the agencies listed in Table 3-3 were provided an opportunity to review and comment on this plan, primarily through the hazard mitigation plan website (see Section 3.10). All were sent an e-mail message informing them that draft portions of the plan were available for review. Upon completion of a public comment period, a complete draft plan was sent to the Texas Division of Emergency Management for a pre-adoption review to ensure program compliance.

Table 3-2. Steering Committee Members

Name	Title	Jurisdiction/Agency
Communities/Jurisdictions		
Brian Murray[a]	Public Information Officer	HCOHSEM
Jamie Galloway	Emergency Management Coordinator	City of Baytown
Deacon Tittel	Fire Chief/EMC	City of Bellaire
Steven Simmons	Fire Marshal / EMC	City of Friendswood
Dena Mahan	Emergency Management Coordinator	City of La Porte
Dakota Duncan[b]	Emergency Management Coordinator (former)	City of Missouri City (formerly)
Jason Reynolds	Emergency Management Coordinator	City of Nassau Bay
Frank Bengochea	Deputy Emergency Management Coordinator	City of Pasadena
Jeff Galyean	Building Official / Floodplain Manager	City of Seabrook
Troy Harrison	Mayor	City of Shoreacres
Jon Keeney	Emergency Management Coordinator	City of Taylor Lake Village
James Novak	Fire Chief/ EMC	City of West University Place
Todd Ward	Risk Mitigation Department Manager	Harris County Flood Control District
James Novick	Fire Chief / Business Administrator	Harris County Emergency Services District 12
Ecomet Burley	Emergency Management Coordinator	Harris County Department of Education
Other Stakeholders		
Kelly Snook, PLA, LI	Executive Director	Greens Bayou Coalition
Mary Anne Piacentini	President and CEO	Katy Prairie Conservancy
Mark S. Mitchell	President	Lake Houston Economic Development Partnership
Jenna Armstrong	President and CEO	Lake Houston Area Chamber of Commerce
Lisa Graiff	Houston Parks Board	Houston Parks Board
Steve Pine	President	Texas Collections Emergency Response Alliance
Ponmile Olonilua, PhD, CFM	Associate Professor	Texas Southern University, School of Public Affairs
Kelly Boysen	Director, Emergency Management	University of Houston
Mark Steuer, PhD	Vice President	White Oak Bayou Association
Lori Upton, RN, BSN, MS, CEM	Director, Regional Preparedness	Southeast Texas Regional Advisory Council
Dinah Massie, MPA	Executive Director	Houston TranStar
Joey Kaspar	Senior Planner	Houston Galveston Area Council
Dawn Blackmar, DVM	Director, Emergency Management	Houston SPCA / Harris County Disaster Animal Management Task Force
Rogelio Martinez	Hazard Mitigation Planner	City of Houston, Office of Emergency Management
Jeffry Evans	Meteorologist in Charge	National Weather Service – Houston Galveston
Dan Reilly	Warning Coordination Meteorologist	Greens Bayou Coalition
Andy Meyer	Disaster Program Manager	American Red Cross

a. Chairperson
b. No longer with the City of Missouri City

Table 3-3. Stakeholder Agencies Notified About Plan Update Progress

Agency	Title of Contact Person
Texas Division of Emergency Management	State Hazard mitigation Officer
FEMA Region VI	Lead Community Planner
Insurance Services Office	CRS Specialist
Texas Water Development Board	Chief Communications Officer
Bayou City Waterkeeper	Legal Director
Coalition for Environment, Equity and Resilience	Co-Founder
Cypress Creek Flood Control Coalition	President
Alamo Trust	Conservator
American Institute of Architects, Houston Chapter	Executive Director
Bleyl Engineering	Senior Director
Houston Hospice	Facility Manager
Inframark Water and Infrastructure Services	Vice President
Preservation Houston	Community Outreach Coordinator
Texas Children's Hospital	Manager, Emergency Management
Texas Medical Center	Director of Strategy
University of Houston	College of Engineering
West Houston Association	CEO
Region 4 Education Service Center	Executive Director
Port of Houston Authority	Emergency Management Coordinator
Greater Houston Flood Mitigation Consortium	Director
Rice University Severe Storm Prediction, Education, & Evacuation from Disasters Center	Director
Rice University Kinder Institute	Director
Texas A&M Galveston Center for Texas Beaches and Shores	Director
Texas A&M Extension Service, Texas Community Watershed Partners	Director
University of Houston Institute of Climate and Atmospheric Science	
University of Houston Hurricane Resilience Research Institute	

Special assistance with the planning process was provided by the following federal and state agencies:

- FEMA Region VI provided updated planning guidance, provided summary and detailed data for the planning area from the National Flood Insurance Program (NFIP) (including repetitive loss information), and conducted plan review.
- The Texas Division of Emergency Management facilitated FEMA review, provided updated planning guidance, provided guidance on how to address planning for jurisdictions whose boundaries intersect more than one county, and reviewed the draft and final versions of the plan prior to FEMA review.
- The National Oceanic and Atmospheric Administration provided historical weather data.
- The Texas A&M Forest Service provided wildfire risk data.

3.8 REVIEW OF PREVIOUS HAZARD MITIGATION PLAN

Participants in the planning process reviewed the current plan, provided updates on their populations, development trends, capabilities, flood insurance data, and previous mitigation actions, and identified opportunities for integration of mitigation actions with other planning initiatives. This review reexamined hazards and sought input from the public regarding their perceptions of risk, vulnerability and how hazard mitigation resources should be prioritized. Updates that pertained to the greater Harris County region were shared with the

Steering Committee for inclusion in the plan update. Each section of the plan was reviewed and updated as needed.

Workshops were conducted with participating jurisdictions and special districts to assist them in updating and in identifying new mitigation actions to include in the plan. The workshops also provided guidance in cost benefit analysis of potential projects.

Federal Requirement

44 CFR §201.6(d)(3) states, "A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years in order to continue to be eligible for mitigation project grant funding."

3.9 REVIEW OF EXISTING PROGRAMS

Chapter 5 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation actions. In addition, the following programs can affect mitigation within the planning area:

Federal Requirement

Hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports and technical information (44 CFR, Section 201.6(b)(3)).

- Texas Minimum Construction Standards
- State of Texas Hazard Mitigation Plan
- Local capital improvement programs (see jurisdictional annexes in Volume 2).
- Local emergency management plans (see jurisdictional annexes in Volume 2).
- Local comprehensive plans (see jurisdictional annexes in Volume 2).
- Land use elements of comprehensive plans
- Local zoning ordinances
- Local coastal program policies
- Harris County Basic Plan: Outlines the HCOHSEM approach to emergency operations and is applicable to Harris County, cities within the county and emergency service districts adhering to the plan.

Assessments of all planning partners' regulatory, technical and financial capabilities to implement hazard mitigation actions are presented in the individual jurisdiction-specific annexes in Volume 2. Many of these relevant plans, studies and regulations are cited in the capability assessments.

A key step under this phase of the planning process was a "core capability" exercise facilitated with the Steering Committee by the CPT. During the fifth Steering Committee meeting, on July 16, 2019, posters were presented illustrating 30 statements of core capabilities within the planning area. Steering Committee members were asked to review each statement and place a green dot by statements they considered to be strengths for the planning area, and a red dot by those they considered to be weaknesses. The primary objective for this exercise was to inform the identification and prioritization of actions that could increase the core capabilities of the planning partnership, and to identify limitations in capability to implement mitigation actions. Table 3-4 summarizes the results, which were provided to the Steering Committee and all planning partners via project bulletins and were used at jurisdictional annex workshops (see the introduction to Volume 2 of this plan).

Table 3-4. Core Capability Exercise Results

Core Capability Statement	Green Dots		Red Dots	
	Number	% of Total	Number	% of Total
Emergency management is provided by a unified authority or program.	19	90%	2	10%
Current land uses within identified hazard areas are appropriate for the risk posed by each hazard.	29	100%	0	0%
There Is a good understanding of the risk posed by the hazards Gem County is susceptible to.	21	78%	6	22%
Emergency response functions for the County are clearly defined and are effective.	23	88%	3	12%
Members of the public know where to find information about hazards and risk.	16	55%	13	45%
Areas that provide natural resource protection are identified and protected within the County.	0	0%	24	100%
Existing flood control systems are effective and well maintained.	10	34%	19	66%
Roles and responsibilities for emergency management within Harris County are clearly defined.	14	52%	13	48%
Planning Partnership staff are knowledgeable about hazards and their impacts and are willing to share that knowledge with the public	29	100%	0	0%
The capability to assess and mitigate risk from natural hazards is high.	21	75%	7	25%
Planning Partnership Staff members with emergency management functions are adequately trained.	26	96%	1	4%
Harris County Citizens have a good understanding of natural hazard exposure and risk.	22	76%	7	24%
The funding to support risk reduction within Harris County is adequate.	1	4%	27	96%
Strong collaboration and coordination exist between the City, neighboring jurisdictions, the County and state and federal agency partners.	22	81%	5	19%
Appropriate and timely warning systems are in place.	25	96%	1	4%
The Planning Partnership currently has a variety of regulatory and non-regulatory strategies to reduce risk.	15	56%	12	44%
The Planning Partnership currently has adopted policies that encourage development to be located outside of high risk areas.	2	8%	23	92%
Risk from natural hazards within Harris County is adequately mapped and regulated.	7	26%	20	74%
There is strong public support for risk reduction within Harris County.	21	75%	7	25%
The Planning Partnership is prepared for the probable impacts on natural hazards due to the impacts from a changing climate.	1	4%	27	96%
Coordinated public outreach regarding risk from all hazards convey clear, consistent messaging to the public.	12	24%	39	76%
The Planning Partnership risk management programs are fair and equitable.	6	30%	14	70%
Information on flood insurance is readily available within the County.	13	54%	11	46%
There is political support for risk management within the City/County	16	62%	10	38%
All relevant stakeholders are engaged in the City/County's risk management efforts.	2	8%	23	92%
The Planning Partners development regulations for new development within identified hazards zones are adequate to address that risk.	1	4%	24	96%
There is a coordinated program to maintain drainage systems free of debris.	1	5%	21	95%
The enforcement of Codes and Standards within the planning area is strong.	13	52%	12	48%

3.10 PUBLIC INVOLVEMENT

The following sections describe the efforts to involve the public in development of this updated hazard mitigation plan. For this plan update, "public" was defined as the general public within the Harris County planning area. This includes, but is not limited to:

Federal Requirement

Broad public participation in the planning process helps ensure that diverse points of view about local needs are considered and addressed. The public must have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (44 CFR, Section 201.6(b)(1). FEMA's Community Rating System expands on these requirements by making CRS credits available for optional public involvement activities

- Residents
- Visitors
- Employers within the county
- Employees within the county
- Students (primary and secondary education levels).

3.10.1 Strategy

The strategy for involving the public in this plan emphasized the following elements:

- Include members of the public and non-governmental stakeholders on the Steering Committee.
- Use a survey to determine if the public's perception of risk and support of hazard mitigation has changed since the initial planning process.
- Attempt to reach as many planning area citizens as possible using multiple media.
- Identify and involve planning area stakeholders.

Stakeholders and the Steering Committee

Stakeholders are the individuals, agencies and jurisdictions that have a vested interest in the recommendations of the hazard mitigation plan, including all planning partners. The effort to include stakeholders in this process included stakeholder participation on the Steering Committee. The CPT invited all the following potential stakeholders to actively participate in the plan update process:

- **Federal Agencies**—FEMA Region VI provided updated planning guidance and data from the National Flood Insurance Program (including repetitive loss information) and conducted plan review.
- **State Agencies**— Texas Division of Emergency Management (TDEM) facilitated FEMA review, provided updated planning guidance, and reviewed the draft and final versions of the plan prior to FEMA review.
- **Regional and Local Stakeholders**—The following organizations received information about the planning process and invitations to provide input, and elected to participate in the planning process as members or subject matter advisors to the Steering Committee:

  - Bayou City Waterkeeper
  - Bayou Land Conservancy
  - Buffalo Bayou Partnership
  - Center for Houston's Future
  - Citizens Environmental Coalition
  - Coalition for Environment, Equity and Resilience
  - Cypress Creek Flood Control Coalition
  - Greater Houston Flood Mitigation Consortium

- Greater Houston Partnership
- Houston Hispanic Chamber of Commerce
- Local Initiative Support Corporation Greater Houston
- NAACP Houston
- Preservation Houston
- Rice University Severe Storm Prediction, Education, & Evacuation from Disasters Center
- Sierra Club Houston
- Texas A&M Extension Service, Texas Community Watershed Partners
- Texas A&M University, Hazard Reduction and Recovery Center
- University of Houston, College of Engineering
- University of Houston, Institute of Climate and Atmospheric Science

Internet

At the beginning of the plan development process, a website was created to keep the public posted on plan development milestones and to solicit relevant input (https://www.readyharris.org/mitigation; see Figure 3-1). The site's address was publicized in all press releases, mailings, surveys and public meetings. Each planning partner established a link to this site on its own agency website. Information on the plan development process, the Steering Committee, a plan survey, and drafts of the plan was made available to the public on the site throughout the process. Harris County intends to keep a website active after the plan's completion to keep the public informed about successful mitigation projects and future plan updates. This site as well as the social media Facebook sites will be useful to facilitate community involvement via web-based outreach after the plan update process has completed.

Planning Partner and Stakeholder Bulletin

Planning partners and coordinating stakeholders were kept apprised of plan development milestones via a Planning Partner Bulletin that the CPT deployed as needed throughout the process (see Figure 3-2). This bulletin was forward facing and made available to the general public by posting on the hazard mitigation plan website.

Survey

A hazard mitigation plan survey (see Figure 3-3) was developed by the CPT with guidance from the Steering Committee. The survey was used to gauge household preparedness for natural hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. This survey was designed to help identify areas vulnerable to one or more natural hazards. The answers to its 26 questions helped guide the Steering Committee in selecting goals, objectives and mitigation strategies. The survey was made available on the hazard mitigation plan website and advertised throughout the course of the planning process. During the course of this planning process, 1,627 completed surveys were submitted. The complete survey and a summary of its findings can be found in Appendix A of this volume.

Public Notices

The HCOHSEM Public Information Office was utilized to keep the public and media outlets apprised of plan development milestones via a series of public notices released over the course of the plan update process. Six public notices were released, following a standard public notice protocol, from October 2018 to November 2019. All of these notices can be viewed on the hazard mitigation website.

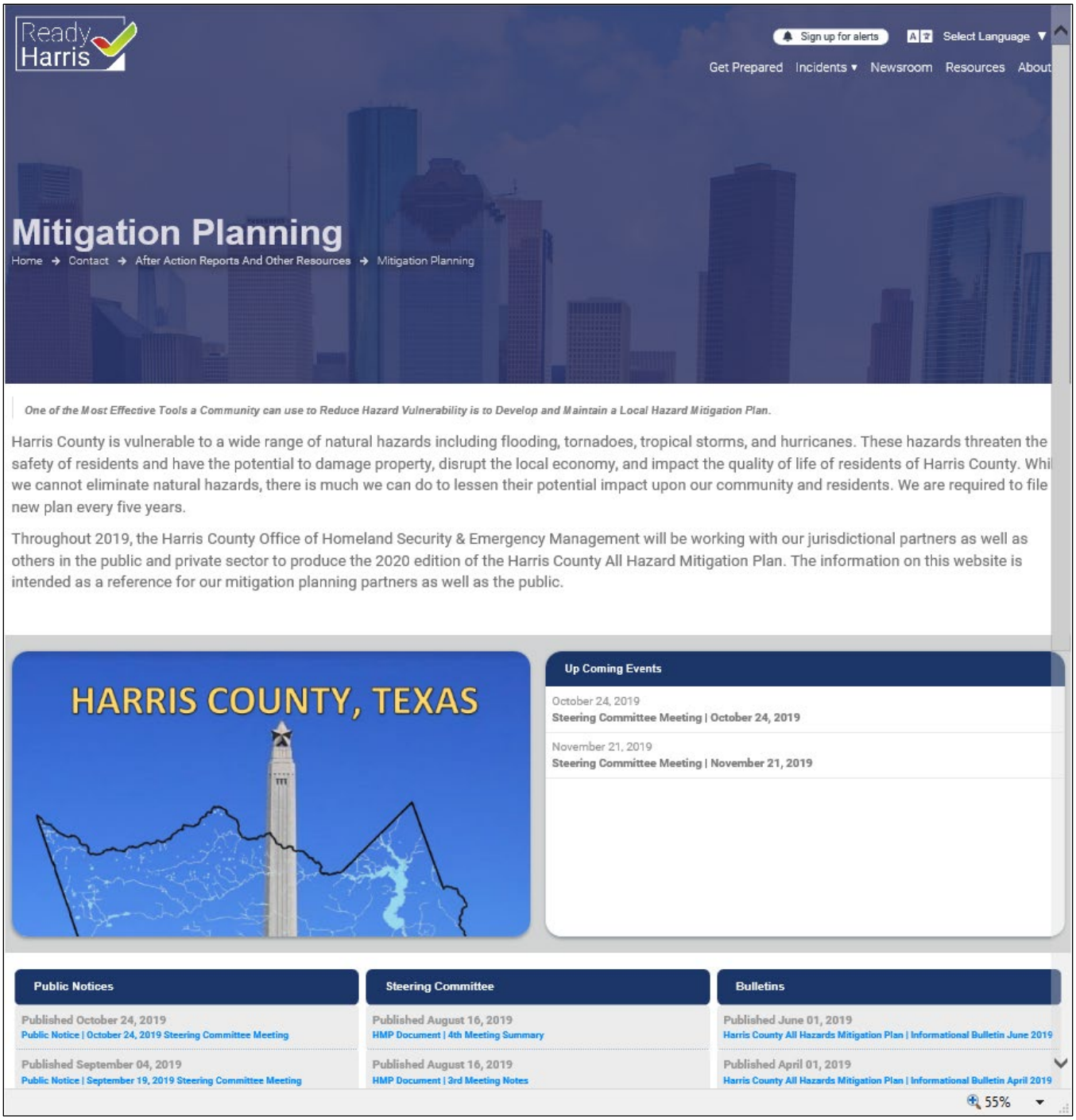


Figure 3-1. Sample Page from Hazard Mitigation Plan Web Site

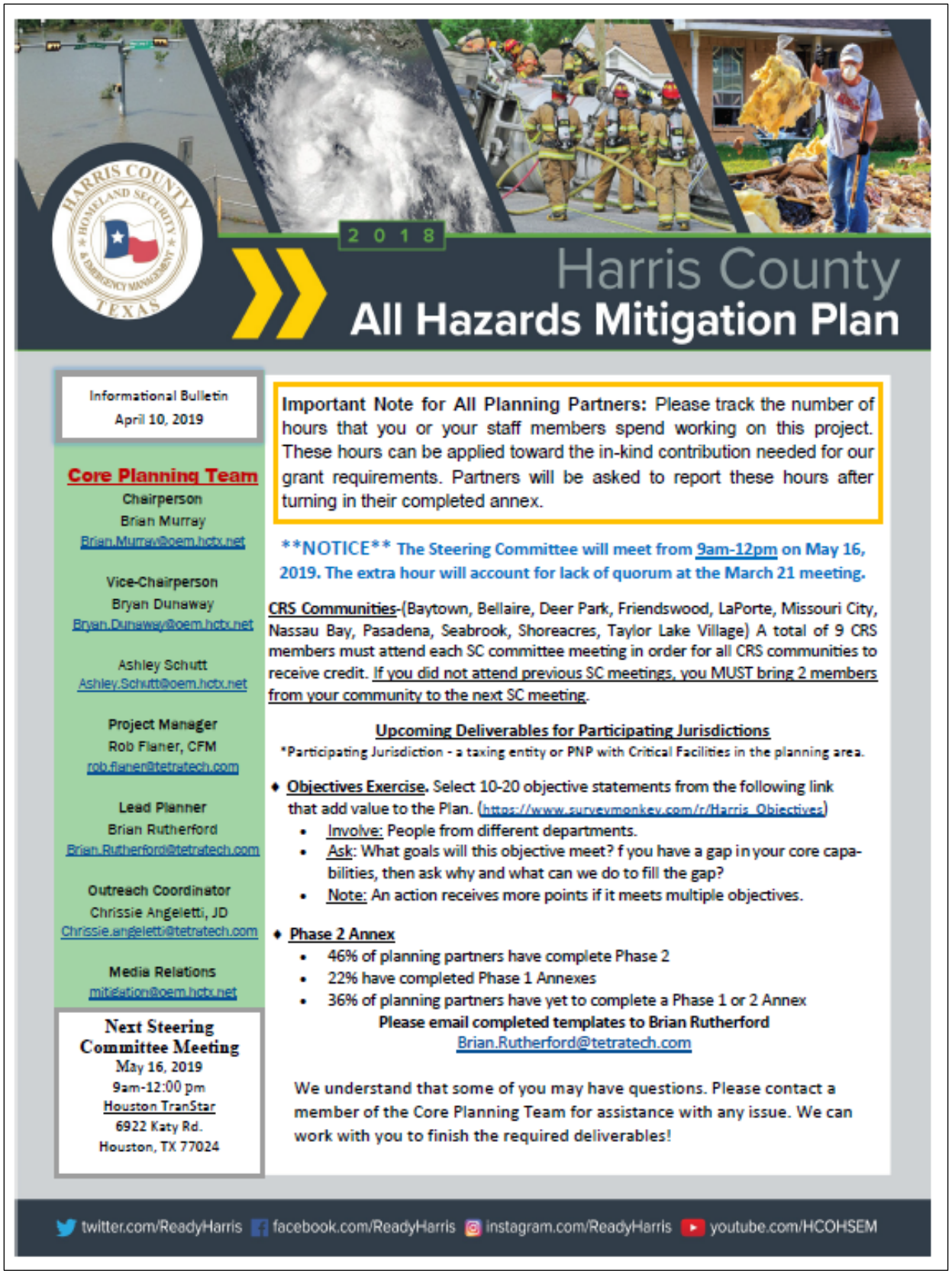
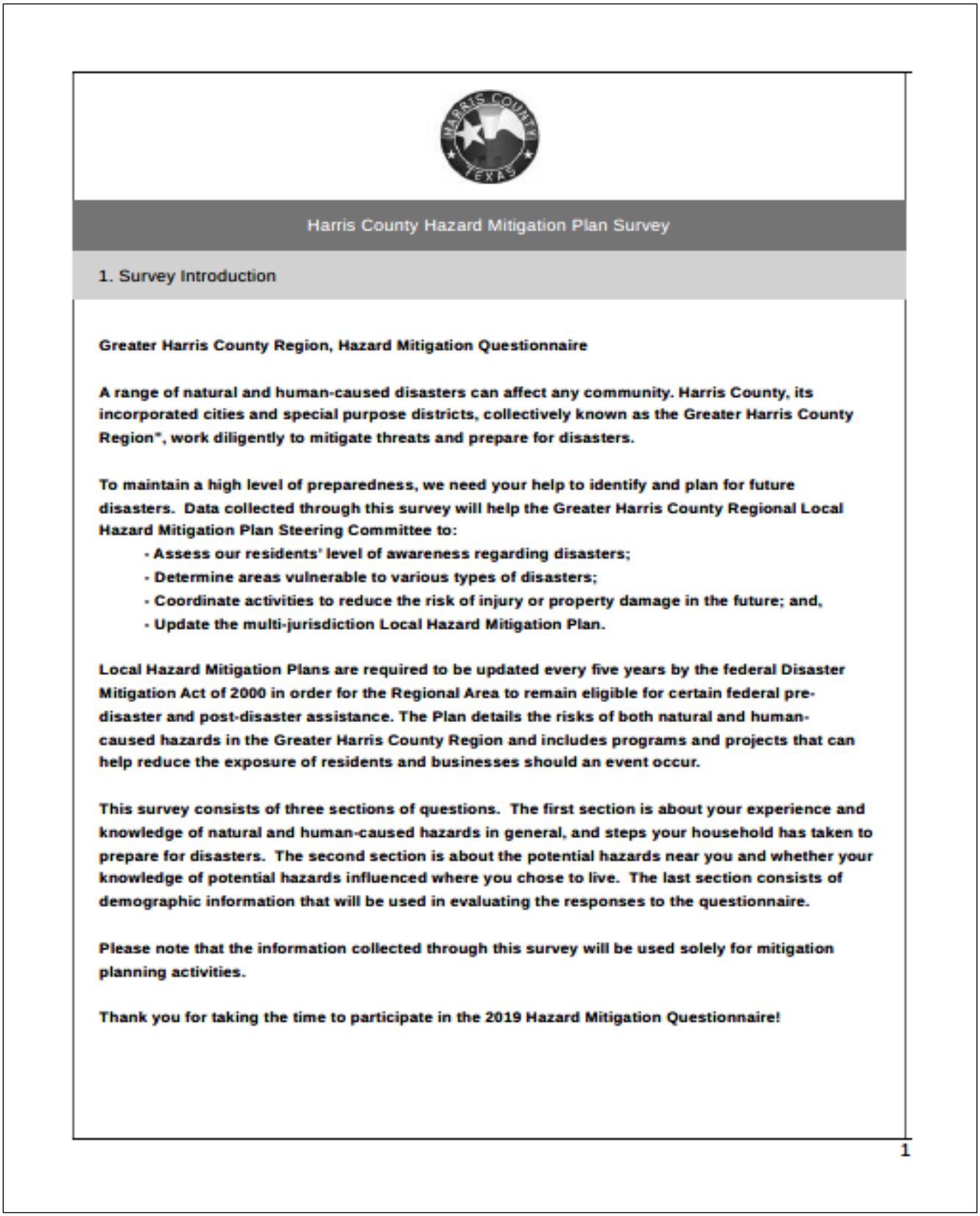


Figure 3-2. Example Planning Process Bulletin



Harris County Hazard Mitigation Plan Survey

1. Survey Introduction

Greater Harris County Region, Hazard Mitigation Questionnaire

A range of natural and human-caused disasters can affect any community. Harris County, its incorporated cities and special purpose districts, collectively known as the Greater Harris County Region", work diligently to mitigate threats and prepare for disasters.

To maintain a high level of preparedness, we need your help to identify and plan for future disasters. Data collected through this survey will help the Greater Harris County Regional Local Hazard Mitigation Plan Steering Committee to:

- **Assess our residents' level of awareness regarding disasters;**
- **Determine areas vulnerable to various types of disasters;**
- **Coordinate activities to reduce the risk of injury or property damage in the future; and,**
- **Update the multi-jurisdiction Local Hazard Mitigation Plan.**

Local Hazard Mitigation Plans are required to be updated every five years by the federal Disaster Mitigation Act of 2000 in order for the Regional Area to remain eligible for certain federal pre-disaster and post-disaster assistance. The Plan details the risks of both natural and human-caused hazards in the Greater Harris County Region and includes programs and projects that can help reduce the exposure of residents and businesses should an event occur.

This survey consists of three sections of questions. The first section is about your experience and knowledge of natural and human-caused hazards in general, and steps your household has taken to prepare for disasters. The second section is about the potential hazards near you and whether your knowledge of potential hazards influenced where you chose to live. The last section consists of demographic information that will be used in evaluating the responses to the questionnaire.

Please note that the information collected through this survey will be used solely for mitigation planning activities.

Thank you for taking the time to participate in the 2019 Hazard Mitigation Questionnaire!

1

Figure 3-3. Sample Page from Survey Distributed to the Public

Public Outreach

The public outreach process for this plan update consisted of two phases. Phase 1 took place early in the process to share information with the public from the risk assessment and gauge perception of risk within the planning area. The second phase was conducted at the end of the process during a formal public comment period to provide the public an opportunity to review and comment on the draft plan.

Phase 1

The Phase 1 public outreach was held during an advertised public meeting on June 20, 2019, at the TranStar facility at 6922 Katy Road in Houston (see Figure 3-4). This was a 3-hour, open house format meeting where members of the public could engage subject matter expertise on risk and risk reduction and learn about individual risks to their property. A short PowerPoint presentation was provided (see Figure 3-5), and hazard extent and location maps were available to review for the entire planning area.

Figure 3-4. Phase 1 Public Meeting

Figure 3-5. Presentation at Phase 1 Public Meeting

The main attraction for this event was the availability of Hazus workstations where property owners could view property-specific information on risk to multiple hazards (see Figure 3-6 and Figure 3-7). Also available at this meeting were hard copies and computer workstations where the attendees could complete the hazard mitigation survey. Nineteen members of the public attended this meeting and the CPT received comments that were incorporated into the planning process and outcomes.

Phase 2

Phase 2 of the public outreach was the two-week final public comment period, November 7 – 22, 2019, following release of the draft hazard mitigation plan. One public meeting at the TranStar facility was held to provide the public an opportunity to comment on the draft plan on Thursday, November 14. This meeting, advertised via a press release, presented a short overview of the draft plan and provided an opportunity for the public to comment. Participants discussed local hazard mitigation planning strategies and the value of coordinating with volunteer agencies in the development and implementation of hazard mitigation actions.

The public comment period gave the public an opportunity to comment on the draft plan update prior to its submittal to TDEM. The principle avenue for public comment on the draft plan was the website established for this plan update. The five comments received through the website were reviewed by the CPT. None resulted in changes to the draft plan; all are available upon request. Three comments also were received from residents who reviewed the draft plan in person at County offices during the public comment period.

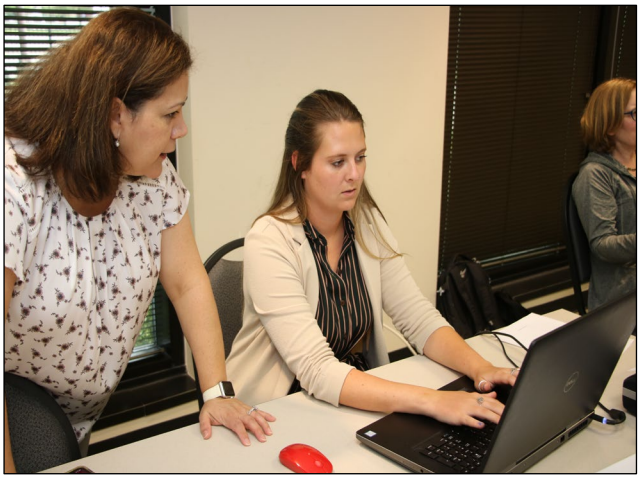


Figure 3-6. Hazus Workstation at Phase 1 Meeting

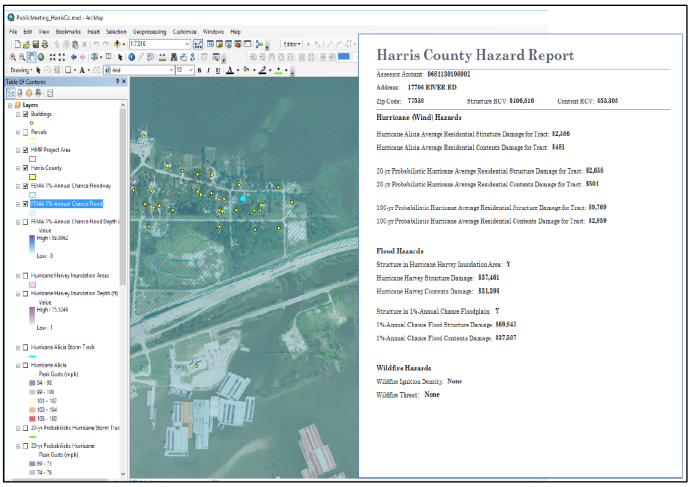


Figure 3-7. Example Workstation Report

Social Media

Another key core capability that was available to support this plan update process was the availability to reach thousands of residents in real time via social media platforms utilized by the HCOHSEM Public Information Office. HCOHSEM has established Facebook, Twitter and Instagram accounts that were utilized during this planning process to provide access to the public on key planning milestones (see Figure 3-8).

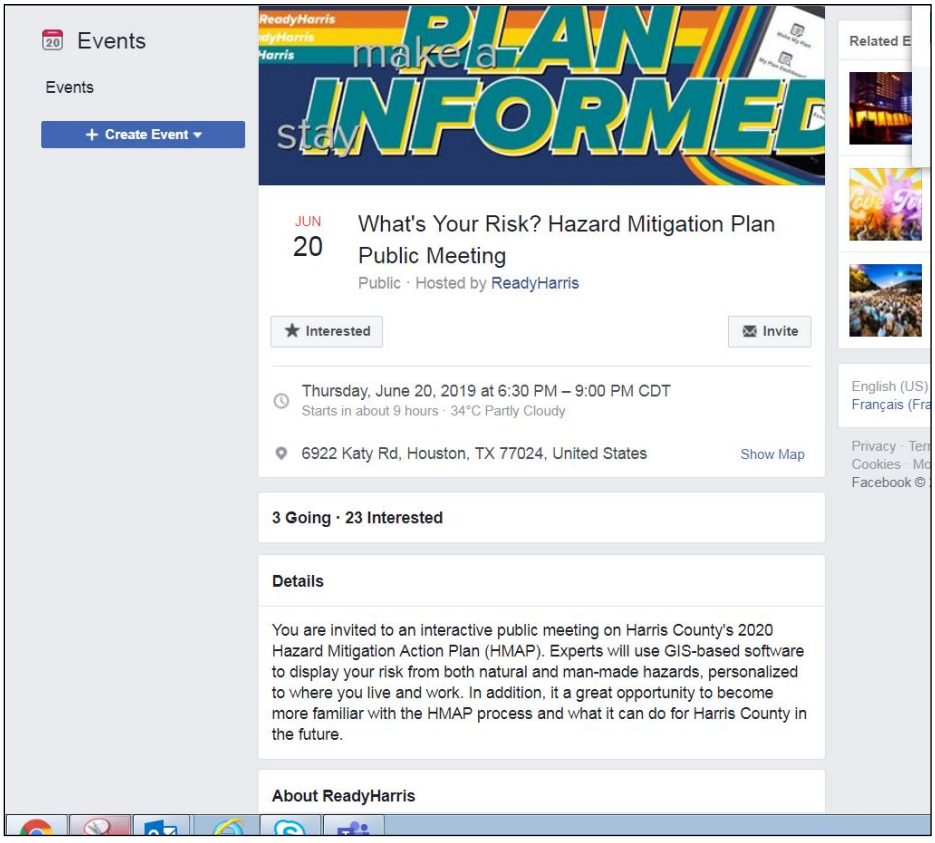


Figure 3-8. Facebook post announcing Hazard Mitigation survey

3.10.2 Public Involvement Results

Survey

Detailed analysis of the survey findings is presented in Appendix A; a summary is as follows:

- Number of hard copy surveys received—None
- Number of surveys completed via the internet—327
- Surveys acquired via social media—1,300
- Total surveys analyzed—1,627
- Surveys were received from each planning partner
- Over 70 percent of respondents have experienced a flood, hurricane or severe weather event in the last 20 years.
- Survey respondents ranked flooding as the hazard of greatest concern, followed by hurricane/coastal storms, severe weather, hazardous materials/toxic release, active shooter, tornado, terrorism, dam failure, drought and wildfire.
- Over 45 percent of respondents feel that they are "somewhat prepared" for a hazard event
- Most respondents (93 percent) expect to receive information on immediate threats caused by hazards from social media, followed by television (84 percent). More than half would expect to be notified by "Ready Harris Alerts."
- 59 percent of respondents indicated that they did consider the impact a disaster could have on their home before purchasing it.
- 76 percent of respondents stated that the presence of a natural hazard risk zone was not disclosed to them before they purchased their home.
- 85 percent of respondents support policies and/or regulations that prohibit or restrict development in identified hazard zones.

Survey results were provided to the Steering Committee for use in confirming the mission statement, goals, and objectives for this plan update. Additionally, the survey results were included in the toolkit provided to each planning partner through the jurisdictional annex process described in Volume 2. Each planning partner was able to use the survey results to help identify actions as follows:

- Gauge the public's perception of risk and identify what citizens are concerned about.
- Identify the best ways to communicate with the public.
- Determine the level of public support for different mitigation strategies.
- Understand the public's willingness to invest in hazard mitigation.

Public Outreach Events

The public involvement strategy used for this plan update introduced the concept of mitigation to the public and provided the Steering Committee with feedback to use in developing the plan. All citizens of the planning area were provided ample opportunities to provide comment during all phases of this plan update process. Details of attendance and comments received from the public outreach events are summarized in Table 3-5.

3.11 PLAN DEVELOPMENT CHRONOLOGY/MILESTONES

Table 3-6 summarizes important milestones in the plan update process.

Table 3-5. Summary of Public Outreach Events

Date	Location	Number of Citizens in Attendance	Number of Comments Received
5/30/2019	East Harris County Manufacturers Assn. Meeting	100	None recorded
6/8/2019	Extreme Weather Expo	2,000	None recorded
6/11/2019	Allen Community Safety Fair, HCOHSEM Booth	800	None Recorded
6/13/2019	Quarterly Homeland Security Briefing – HCOHSEM	50	None recorded
6/13/2019	Smart PAWZ, Pet preparedness event	150	None Recorded
6/18/2019	2019 Boeing Houston Safety Fair	200	None recorded
6/18/2019	Exxon Hurricane and Safety and Preparedness Briefing	85	None Recorded
6/20/2019	TranStar Facility	19	12
6/29/2019	Harris County Public Health, Mobile Health Village	300	None recorded
9/12/2019	Cities of Harris County Meeting, Federal Reserve Bank – Houston	40	None recorded
9/26/2019	Quarterly Homeland Security Briefing – HCOHSEM	50	None recorded
11/14/2019	TranStar Facility	1	None recorded
11/7–22/2019	In-Person Review of Draft Plan at County Offices	2	3
Total		**3,797**	**15**

Table 3-6. Plan Development Chronology/Milestones

Date	Event	Description	Attendance
2018			
5/18	Organize Resources	County released request for proposals for a technical support contractor to facilitate the update to the hazard mitigation plan.	N/A
5/30	Public Outreach	HCOHSEM staff provided a briefing on the hazard mitigation plan update at the East Harris County Manufacturers Association Meeting	100
6/13	Public Outreach	HCOHSEM staff provided a briefing on the hazard mitigation plan update at the quarterly Homeland Security briefing conducted at the HCOHSEM offices.	50
7/20	Organize Resources	County selected Tetra Tech as its technical assistance contractor to facilitate the plan update process.	N/A
8/23	Organize Resources	A Planning Partner kickoff meeting invitation letter was sent to eligible local governments within the planning area by the HCOHSEM Emergency Management Coordinator	N/A
9/12	Public Outreach	HCOHSEM staff provided a briefing on the hazard mitigation plan update at the Cities of Harris County Meeting, Federal Reserve Bank – Houston.	40
9/18	Organize Resources	Planning Process kickoff meeting to organize planning partnership and confirm Steering Committee	105
9/26	Public Outreach	HCOHSEM staff provided a briefing on the hazard mitigation plan update at the quarterly Homeland Security briefing conducted at the HCOHSEM offices.	50
10/1	Public Outreach	Public Notice press release distributed to all media outlets by HCOHSEM Public Information Office staff	N/A
10//18	Steering Committee Meeting #1	• Organized Steering Committee • Defined planning area • Defined critical facilities/infrastructure • Identified hazards of concern • Discussed options for public involvement strategy	50

Date	Event	Description	Attendance
2019			
1/19	Steering Committee Meeting #2	• Provided update on Phase 1 development • Discussed the risk assessment process • Discussed the Texas State Mitigation Plan • Defined mission statement • Discussed current plan goals and objectives • Discussed public survey and outreach	39
3/21	Steering Committee Meeting #3	• Due to a petrochemical explosion that affected many participating jurisdictions, there were not enough planning partner jurisdictions present at the meeting to achieve a quorum. Discussion was limited to project updates and other matters not requiring Steering Committee consensus. • Provided an update on the risk assessment • Discussed jurisdictional annex development • Discussed objective survey participation and bulletin dissemination	31
4/8	Public Outreach	Hazard Mitigation survey deployed	N/A
5/16	Steering Committee Meeting #4	• Update on risk assessment process • Identified objectives for the plan • Discussed the public involvement strategy and survey • Established date for Phase 1 public meeting • Discussed the Phase 3 jurisdiction annex workshop and established dates	39
6/20	Public Outreach	HCOHSEM Facebook post announcing the Hazard Mitigation survey	N/A
6/20	Public Outreach	Phase 1 Public Meeting at TranStar facility at 6922 Katy Road in Houston	19
7/16	Steering Committee Meeting #5	• Presentation of Risk Assessment results • Phase 1, Public Meeting-recap • Hazard Mitigation survey status • Core capability Exercise • Reviewed proposed plan maintenance strategy	52
7/16	Planning Process	1st of 5 Phase-3 Jurisdictional Annex Workshops	22
7/17	Planning Process	2nd of 5 Phase-3 Jurisdictional Annex Workshops, 9:00 AM to Noon	17
7/17	Planning Process	3rd of 5 Phase-3 Jurisdictional Annex Workshops, 1:00 PM to 4:00 PM	6
7/18	Planning Process	4th of 5 Phase-3 Jurisdictional Annex Workshops, 9:00 AM to Noon	13
718	Planning Process	5th of 5 Phase-3 Jurisdictional Annex Workshops, 1:00 PM to 4:00 PM	4
10/24	Steering Committee Meeting #6	• Reviewed Critical Facility/Infrastructure results • Reviewed Core Capability Exercise results • Presented internal review Draft of the plan • Confirmed final Plan Maintenance strategy	48
11/7	Public Outreach	Beginning of the 2-week public comment period on the draft plan	N/A
11/14	Public Outreach	Phase 2 Public Meeting at TranStar facility located at 6922 Katy Road in Houston 6 – 8 p.m.	1
11/22	Public Outreach	End of the 2-week public comment period on the draft plan	N/A
12/4	Plan Submittal	Pre-adoption review draft of the plan submitted to TDEM.	N/A
4/21	APA	Approval Pending Adoption (APA) provided by FEMA Region VI	N/A
4/22	Adoption	Adoption Window opens for planning partnership	N/A
TBD	Approval	Final Plan approval issued by FEMA Region VI	N/A

4. HARRIS COUNTY PROFILE

4.1 PLANNING AREA OVERVIEW

Harris County is located on the upper Gulf Coast in Southeast Texas and is bounded by Waller County on the north and west, Montgomery County on the north, Liberty and Chambers counties on the east, Galveston and Brazoria counties on the south, and Fort Bend County on the west (see Figure 4-1). The county comprises 1,778 square miles (1,729 in land) and is the largest Texas county east of the Nueces River. (Texas State Historical Association, 2019a)

4.1.1 Development and Notable Features

Most of Harris County consists of developed urbanized areas. The county has more than 310 Class A high-rise office properties, hundreds of millions of square feet of warehouse and retail properties, tens of thousands of apartment units and more than 1.2 million homes. There are 23 incorporated cities in the county, including Houston, which is the fourth largest city by population in the United States. (Harris County Appraisal District, 2017)

Industrialized areas of the county include the port facilities of the Houston Ship Channel and Port of Houston, the busiest port in the United States in terms of foreign tonnage and the second busiest in overall tonnage. Harris County is one of the world's major petrochemical centers and includes five refineries, thousands of miles of pipeline and tank storage and dozens of petrochemical processing facilities.

The Texas Medical Center in Houston is the largest medical center complex in the world, containing many world class hospitals and medical research facilities including the world's largest children's hospital and the world's largest cancer hospital. Harris County is also the home to the Lyndon B. Johnson Space Center where NASA's Mission Control is housed as well as the San Jacinto Battleground where the battle for Texas' independence from Mexico was won in 1836.

4.1.2 Transportation

Major highways serving the county include the following:

- Interstate Highways: 69, 35, 45, 10, 110, 610 (Loop)
- U.S. Highways: 59, 75, 80, 90, 281, 290
- State Highways: 6, 225, 249
- Tollways:
    - Maintained by the Harris County Toll Road Authority: Hardy Toll Road, Sam Houston Tollway, Tomball Tollway, Katy Managed Lanes, Ship Channel Bridge
    - Maintained by Texas Department of Transportation: Grand Parkway
    - Maintained by the Fort Bend County Toll Road Authority (partially located within Harris County: Westpark Tollway, Grand Parkway

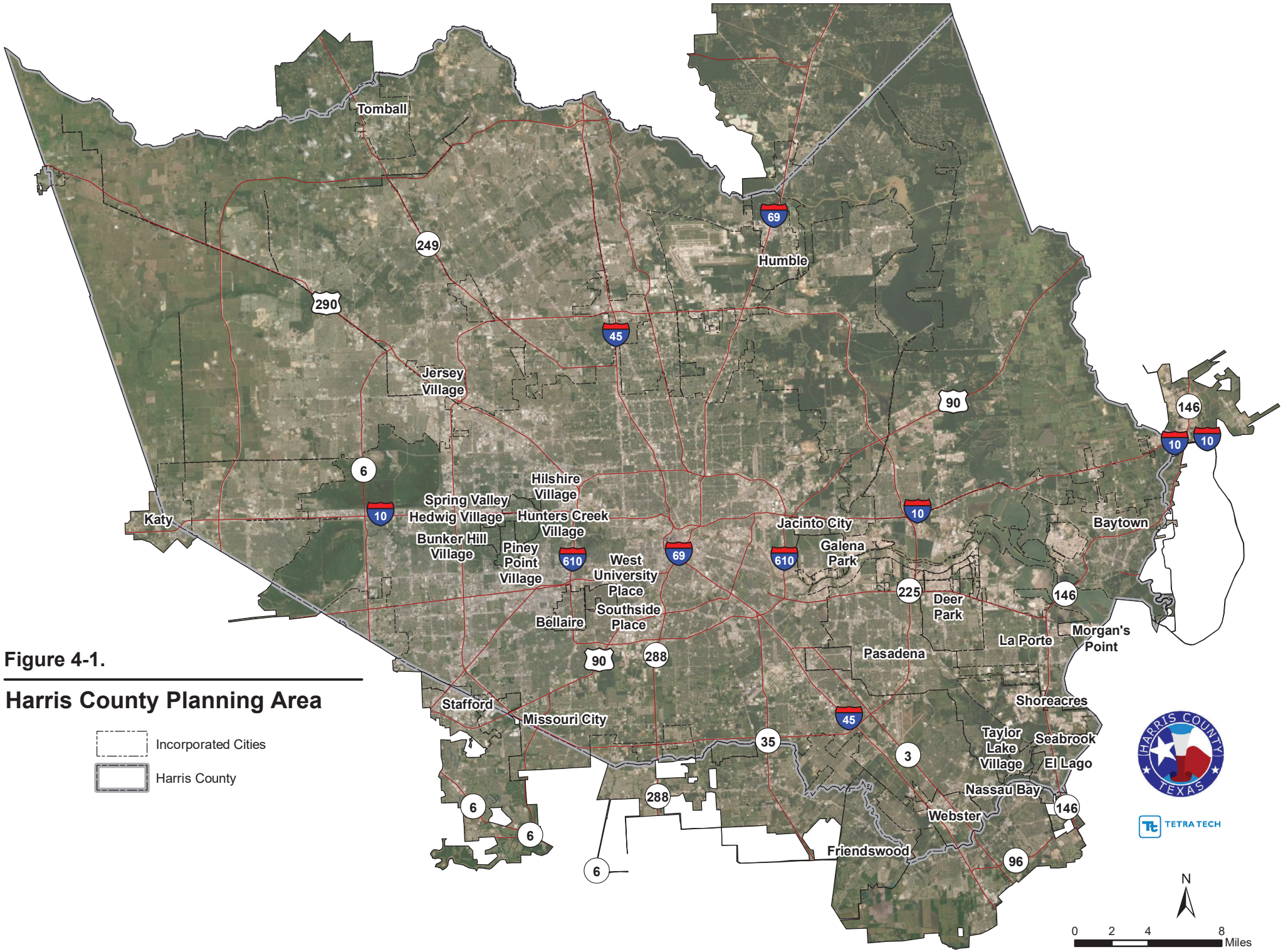


Figure 4-1.

Harris County Planning Area

The county has three major international airports— Dan Jones International Airport, William P. Hobby Airport, and George Bush Intercontinental Airport—and numerous regional airports, including Ellington Field, West Houston Airport, La Porte Municipal Airport, David Wayne Hooks Memorial Airport, Baytown Airport, and Weiser Airpark. Public transportation by bus and light rail across most of the county is provided by the Metro transit authority. Amtrak provides passenger rail service.

4.1.3 Forms of Government

County powers and duties in Texas are specifically granted and limited by the state constitution and state law. Each county has a commissioner's court, which consists of four commissioners, each elected from the Commissioner's precinct, and a county judge elected from the entire county. In smaller counties, the county judge retains judicial responsibilities in probate and insanity cases. Special-purpose jurisdictions are created to perform a specific function.

In Texas, each city follows the local government code, which defines cities' rights and responsibilities regarding properties within their boundaries and surrounding areas (extraterritorial jurisdiction). This code give cities authority to manipulate their boundaries via annexation or dis-annexation (City of Houston, 2019). Texas cities of more than 5,000 citizens adopt home-rule charters and are governed by city councils and either city managers, city administrators, or mayors. Cities with fewer than 5,000 residents, or "general law" cities, have powers and duties specifically granted by the Texas Constitution and state law. A city manager or city administrator plan can be adopted in any general law city. Some home rules cities now have fewer than 5,000 residents because their population has declined since they adopted their home rule charters. Jurisdictional annexes in Volume 2 of this plan describe the government form of each participating planning partner.

4.1.4 Historical Summary

Harris County was founded in 1836, organized in 1837 and named after John Richardson Harris, who also founded the town of Harrisburg. There are records of European settlers in Harris County in the early 1820s, but they did not stay long. Immigrants later settled the areas along the Buffalo Bayou and the City of Morgan's Point. These settlers attempted to utilize the Buffalo Bayou as a trading post for the Brazos River Valley, which now serves as the Houston Ship Channel.

John Richardson Harris arrived in the area in 1824 and settled on land at the junction of Bray's and Buffalo bayous. In 1825, he laid out the city of Harrisburg. Harrisburg Municipal was created by the General Council on December 30, 1835 and designated the town as the seat of its government. On April 21, 1836, the Battle of San Jacinto was fought in the area. This was the deciding battle of the Texas Revolution, which separated the Republic of Texas from Mexico. The name of the area was changed to Harrisburg County in 1836 and to Harris County in December 1839.

4.2 MAJOR PAST HAZARD EVENTS

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government, although no specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses and public entities. Some of the programs are matched by state programs. Review of presidential disaster declarations helps establish the probability of reoccurrence for each hazard and identify targets for risk reduction. Table 4-1 shows the declared disasters that affected Harris County from 1973 through 2018.

Table 4-1. Historical Harris County Natural Hazard Events

Type of Event	Disaster Declaration #	Date
Hurricane Harvey	4332 DR	2017
Severe Storms and Flooding	4269 DR	2016
Severe Storms and Flooding	4272 DR	2016
Severe Storms, Tornados, Straight Line Winds and Flooding	4245 DR	2015
Severe Storms, Tornados, Straight Line Winds and Flooding	4223 DR	2015
Forest Brook Fire	2924 FM	2011
Hurricane Ike	1791 DR	2008
Hurricane Ike	3294 EM	2008
Hurricane Gustav	3290 EM	2008
Hurricane Dean	3277 EM	2007
Tropical Storm Erin	1730 DR	2007
Extreme Wildfire Threat	1624 DR	2006
Hurricane Rita	1606 DR	2005
Hurricane Rita	3261 EM	2005
Hurricane Katrina Evacuation	3216 EM	2005
Severe Storms, Tornados and Flooding	1439 DR	2002
Tropical Storm Allison	1379 DR	2001
Extreme Fire Hazards	3142 EM	1999
Flooding	1257 DR	1998
Tropical Storm Charley	1239 DR	1998
Hurricane Georges	1245 DR	1998
Severe Thunderstorms and Flooding	1041 DR	1994
Severe Thunderstorms and Tornados	970 DR	1992
Severe Storms and Flooding	937 DR	1992
Tropical Storm Allison	836 DR	1989
Severe Storms, Tornados and Flooding	828 DR	1989
Severe Storms and Flooding	727 DR	1984
Hurricane Alicia	689 DR	1983
Severe Storms, Tornados and Flooding	580 DR	1979
Severe Storms and Flooding	603 DR	1979
Severe Storms and Flooding	510 DR	1976
Severe Storms and Flooding	398 DR	1973

Source: FEMA, 2019.

4.3 PHYSICAL SETTING

4.3.1 Watersheds and Drainage Infrastructure

Harris County is drained by 22 watersheds (see Figure 4-2). Buffalo Bayou, the last 16 miles of which make up the Houston Ship Channel, bisects the county from west to east before joining the north-to-south San Jacinto River just above its estuary on upper Galveston Bay. The eastern third of the county is drained by Cedar Bayou. The southern part of the county is drained by Clear Creek and Clear Lake. Spring Creek forms its northern boundary and, joined by parallel Cypress Creek, becomes the West Fork of the San Jacinto River.

Source: Harris County Flood Control District

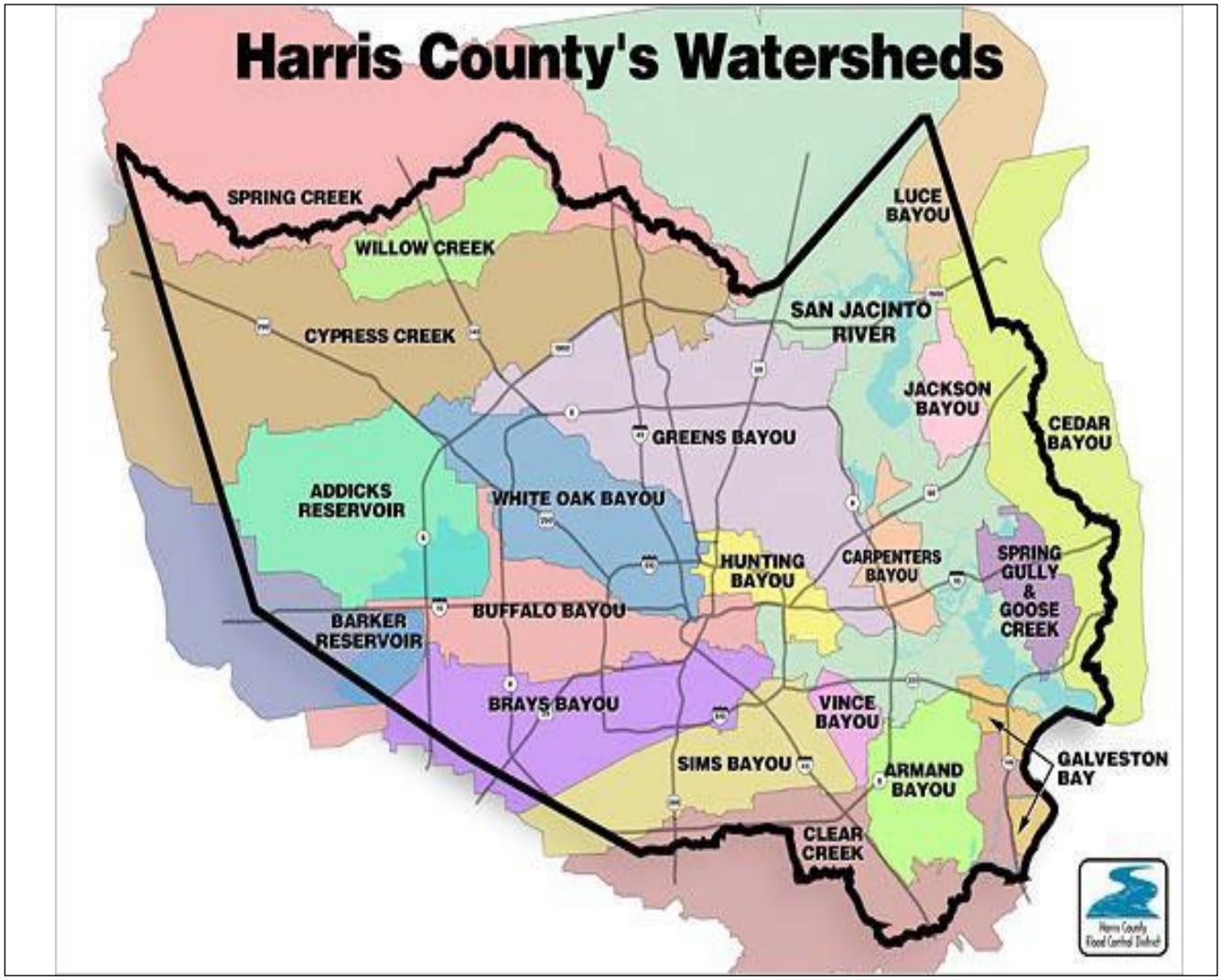


Figure 4-2. Harris County Watersheds

A dam below the East and West Forks of the San Jacinto River created Lake Houston in 1954. The lake is now a popular recreational spot. This reservoir for the City of Houston lessened dependence on subsurface water, the use of which has caused up to 9 feet of subsidence around the confluence of Buffalo Bayou and the San Jacinto River (Texas State Historical Association, 2019a). In western Harris County, Addicks and Barker Dams provide substantial flood control.

4.3.2 Geology

The landscape in Harris County is level to gently undulating with slow surface drainage (Texas State Historical Association, 2019b). The elevation slowly rises from sea level at the county's southeast edge where the land comes in contact with Galveston Bay, to approximately 50 feet above sea level at mid-county, to as high as 300 feet at the far northwest corner of the county. Buffalo Bayou runs through the middle of the county from the City of Katy at the west end of the county to the Houston Ship Channel on the southeast corner of the county. The Houston Ship Channel empties into Galveston Bay and leads to the Gulf of Mexico.

Several fault lines lie within county. The largest of these, the Long Point-Eureka Heights fault system, runs from the center of the Houston metropolitan area out to the west side of the county. While there have been no earthquakes reported in the county, the potential risk cannot be discounted.

4.3.3 Soils and Wetlands

The coast prairie soil of Harris County consists of mostly deep, dark-gray, neutral to slightly acid clay loams and clays. (Texas State Historical Association, 2019b).

Harris County's humid climate supports well-vegetated wetlands. These wetlands are generally flat and consist mostly of grasses and temperate-climate plants. Due to its flat terrain and slow drainage, much of the area is considered wetland with lush marshes throughout most of the year (Texas A&M Agrilife Extension Service, 2019).

4.3.4 Climate

Climate divisions are regions that are climatically homogenous as possible. The National Oceanic and Atmospheric Administration (NOAA) has divided the continental U.S. into 344 climate divisions. The boundaries of these divisions typically coincide with county boundaries. Harris County is located in the Texas Climate Division 8 – Upper Coast (see Figure 4-3**)**.

The average annual rainfall in Harris County is 47 inches, and the mean temperature is 69.1ºF. The average growing season in the Harris County planning area and all participating jurisdictions is 300 days, with the first freeze generally occurring around mid-December (Texas State Historical Association, 2019a).

Source: South Central Climate Science Center, 2015

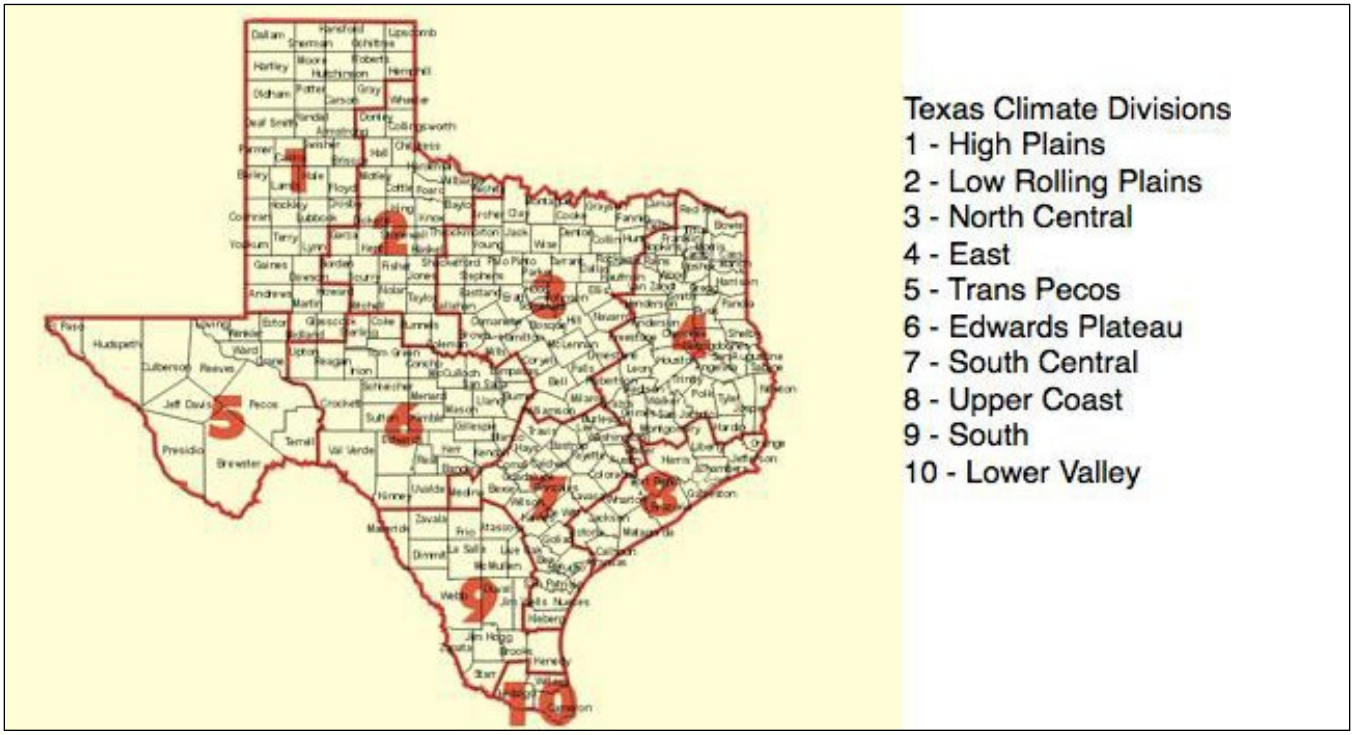


Figure 4-3. Texas Climate Divisions

4.4 DEVELOPMENT PROFILE

Much of the land in the Harris County planning area has been developed, and the primary land use is urban, with highly populated residential areas, along with commercial and industrial areas.

4.4.1 Building Occupancy and Estimated Value

According to Central Appraisal districts for Harris, Fort Bend and Galveston Counties, there are 1,355,132 buildings in the Harris County planning area, with a total appraised value of over $928 billion. The majority of buildings in the planning area are designated for residential use, as indicated in Table 4-2.

4.4.2 Agricultural Uses

Agriculture in the planning area encompasses 50,000 irrigated acres planted with rice, soybeans, grains, hay, corn, and vegetables. Cattle, hogs, horses, and poultry are raised on agricultural lands, as well (Texas State Historical Association, 2019a). Table 4-3 summarizes agricultural land use in the Harris County planning area.

4.4.3 Critical Facilities and Infrastructure

Critical facilities and infrastructure are assets that are essential to the health and welfare of the population. The Steering Committee for this plan reviewed example definitions of critical facilities/infrastructure from other planning efforts and confirmed the following definition for critical facilities and infrastructure:

> Critical facilities and infrastructure are assets that are vital to the Harris County planning area's ability to provide essential services and protect life and property. Major damage to such facilities and infrastructure that causes a long-term loss of their function would likely result in a severe health and welfare, life-sustainment, economic, or other catastrophic impact. For hazard mitigation planning purposes, critical infrastructure and facilities are assets in the following categories:

- **Government Facilities—**Buildings and facilities owned or leased by local governments, political subdivisions, and special purpose districts such as general-use office buildings and other structures that may house critical equipment, networks, or provide essential government services.
- **Education Facilities—**Pre-kindergarten through 12th grade schools, school support facilities, and institutions of higher education.
- **Health and Medical Facilities—**Health and medical services facilities providing direct patient care, public health services, healthcare delivery, and mass fatality services.
- **Transportation Systems—**Transportation modes used to move people and goods through the county, state, country and overseas.
- **Utility Systems**—Lifeline systems that support and sustain all other facilities and infrastructure such as water, wastewater, electrical, and telecommunications.
- **Emergency Services—**Facilities used by first responder and public safety agencies that provide law enforcement, fire response, emergency medical services, incident response, and emergency management.
- **Environmental Areas—**Natural resources, environmentally sensitive areas, wetlands, land preserves, conservation areas, parks and open space, and coastal areas.
- **Historic and Cultural Sites—**Historic properties, art and cultural institutions, cultural resources, and monuments.
- **Hazardous Material Sites—**Tier II chemical facilities, facilities included on the federal Toxics Release Inventory, and federally designated Superfund sites.
- **Water Control Facilities—**Irrigation systems, drainage and pumping systems, levees, dams, and flood control channels.

Table 4-2. Planning Area Building Counts by Occupancy Type

	Number of Buildings			Estimated Total Building Value (structure + contents)
	Residential	Non-Residential	Total	
Baytown[c]	20,309	1,849	**22,158**	$11,458,106,691
Bellaire	6,307	196	**6,503**	$5,726,227,131
Bunker Hill Village	1,302	1	**1,303**	$1,322,346,729
Deer Park	10,575	795	**11,370**	$5,845,168,035
El Lago	1,078	29	**1,107**	$469,295,696
Friendswood[c]	13,072	450	**13,529**	$6,185,226,675
Galena Park	3,032	256	**3,288**	$1,178,706,765
Hedwig Village	818	91	**909**	$1,142,111,969
Hilshire Village	311	10	**321**	$207,926,478
Houston[a, b]	544,150	48,016	**592,166**	$487,379,428,234
Humble	3,979	911	**4,890**	$4,570,456,883
Hunters Creek Village	1,552	20	**1,572**	$1,787,651,957
Jacinto City[a]	2,745	241	**2,986**	$1,261,111,221
Jersey Village	2,348	179	**2,527**	$2,275,428,136
Katy[c]	4,921	631	**5,552**	$3,396,517,744
La Porte	11,467	960	**12,427**	$6,575,613,440
League City[a, b]	386	8	**394**	$280,449,911
Missouri City[c]	23,412	914	**24,326**	$12,398,706,197
Morgan's Point	150	10	**160**	$262,314,866
Nassau Bay	1,504	70	**1,574**	$1,635,924,802
Pasadena	37,128	3,511	**40,639**	$22,505,882,445
Pearland[a]	791	43	**834**	$709,046,327
Piney Point Village	1,188	7	**1,195**	$1,817,131,583
Seabrook	4,105	285	**4,390**	$2,537,671,414
Shoreacres	656	1	**657**	$218,188,519
South Houston[a]	4,050	951	**5,001**	$2,162,541,092
Southside Place[a]	491	17	**508**	$471,918,214
Spring Valley Village	1,466	43	**1,509**	$1,227,871,955
Stafford[c]	3,967	1,038	**5,055**	$6,102,429,982
Taylor Lake Village	1,385	5	**1,390**	$690,404,692
Tomball	2,933	716	**3,649**	$3,569,286,191
Waller[a, b]	197	64	**261**	$221,680,638
Webster	1,774	613	**2,387**	$5,700,342,104
West University Place	5,468	57	**5,525**	$3,722,134,705
Unincorporated	541,942	31,128	**573,070**	$321,033,774,612
Total	**1,260,959**	**94,116**	**1,355,132**	**$928,049,024,033**

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
b. City extends beyond Harris County. Values shown are for Harris County portion only.
c. City extends beyond Harris County. Values shown are for entire city.

Table 4-3. Farms in the Harris County Planning Area 2017

Number of Farms	1,891
Farm Acreage	218,659
Total Land Area (Acres)	1,137,280
Percent of Total Land Area in Farms	19.2%
Market Value of Land and Buildings	$998,851 per farm
Market Value of Agricultural Products	$50.6 million

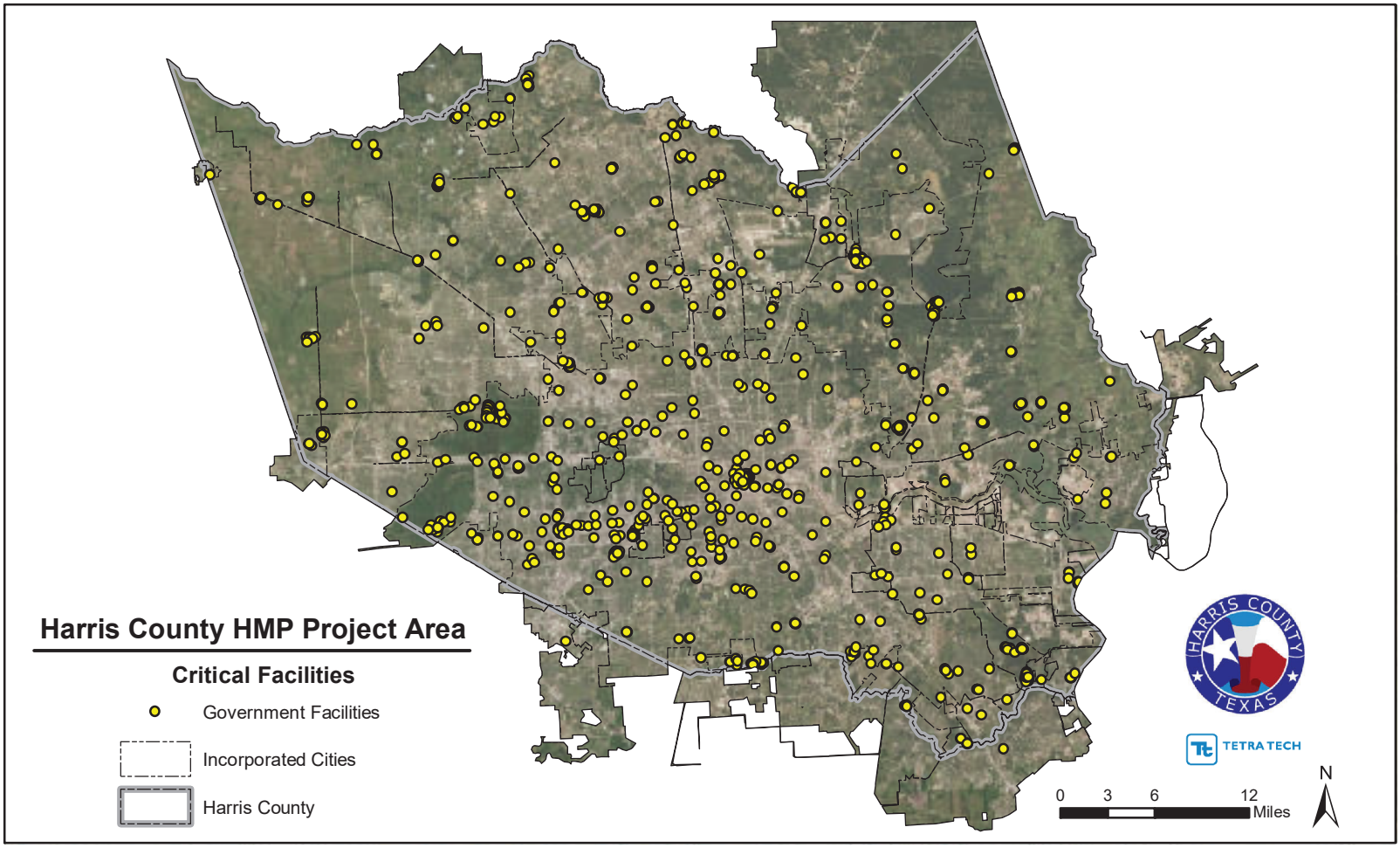
Source: U.S. Department of Agriculture, 2017

Table 4-4 shows examples of facilities under each of the above categories. The CPT created an inventory of assets that meet the definition based on best available data. This inventory was basis for all critical facility analyses completed for this plan. The number and types of facilities within the planning area that meet this definition is considered to be dynamic. It is the intent of the planning partnership to maintain an inventory of these facilities during the performance period of this plan as new information becomes available.

Table 4-4. Typical Facilities in Designated Critical Facilities/Infrastructure Categories

Government Facilities	**Education Facilities**	**Hazardous Material Sites**
Courthouse	Schools (public, private, charter)	Super Fund Sites
Records Storage	Colleges and Universities	Tier II Chemical Facilities
Library	Harris County Department of Education	Toxics Release Inventory Sites
Post Office	Region 4 Education Service Center	**Historic and Cultural Sites**
County Facilities	School Support Facilities	Monuments
City Facilities	**Transportation Systems**	Museums
State Facilities	Airport / Aviation	Religious Organizations
Federal Facilities	Passenger Rail	Auditoriums
Health and Medical Facilities	Maritime Transportation	Community Centers
Hospitals	Roads	Historic Sites
Nursing Homes (8)	Bridges	Art and Cultural Institutions
Senior Homes	Highways	Zoo
Assisted Living	Pipelines	**Water Control Facilities**
Dialysis Centers	Railways	Detention ponds
Hospice	Mass Transit	Dams/levees
Southeast Texas Regional Advisory Council	**Environmental Areas**	Drainage systems
Mass Fatality Management Services	Wetlands	Irrigation systems
Emergency Services	Parks, Recreation, and Open Space	Channels and canals
Law Enforcement	Wildlife Preserve	Pumping facilities
Emergency Operation Center	Land Conservation Area	Flood control channels
Fire Services	Coastal Shorelines and Beaches	**Utility Systems**
Emergency Medical Systems	Natural Resources	Electric
911 Dispatch /Public Safety Answering Point		Telecommunications
		Water
		Wastewater

The designated categories were used to identify critical facilities and infrastructure in the planning area. In order to perform a risk assessment of critical facilities, the identified facilities and infrastructure were reassigned to different categories, as defined in the risk assessment software that was used (FEMA's Hazus software). The Hazus-categorized critical facilities and infrastructure identified for this plan are mapped on Figure 4-4 through Figure 4-7 and listed in Table 4-5.



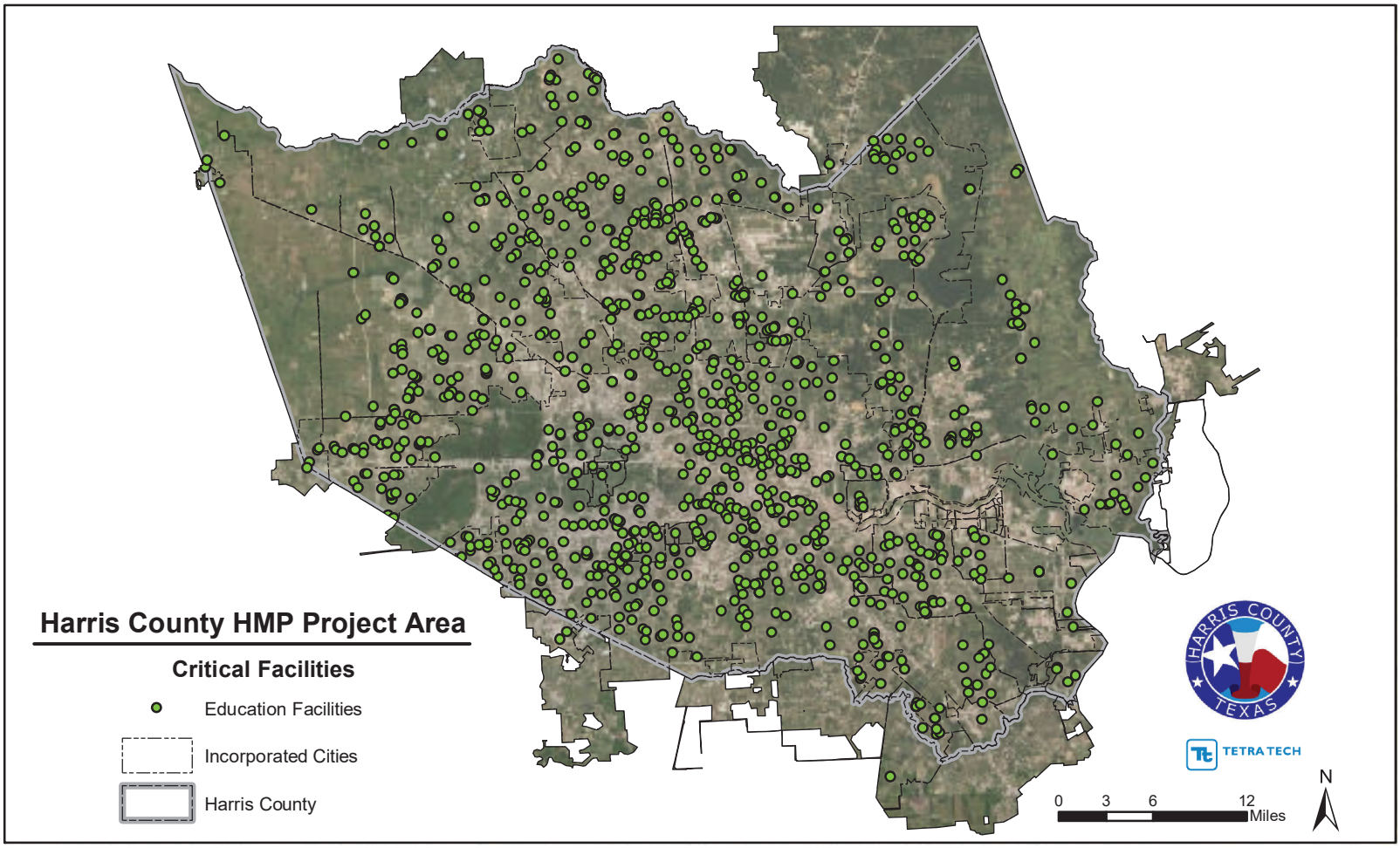
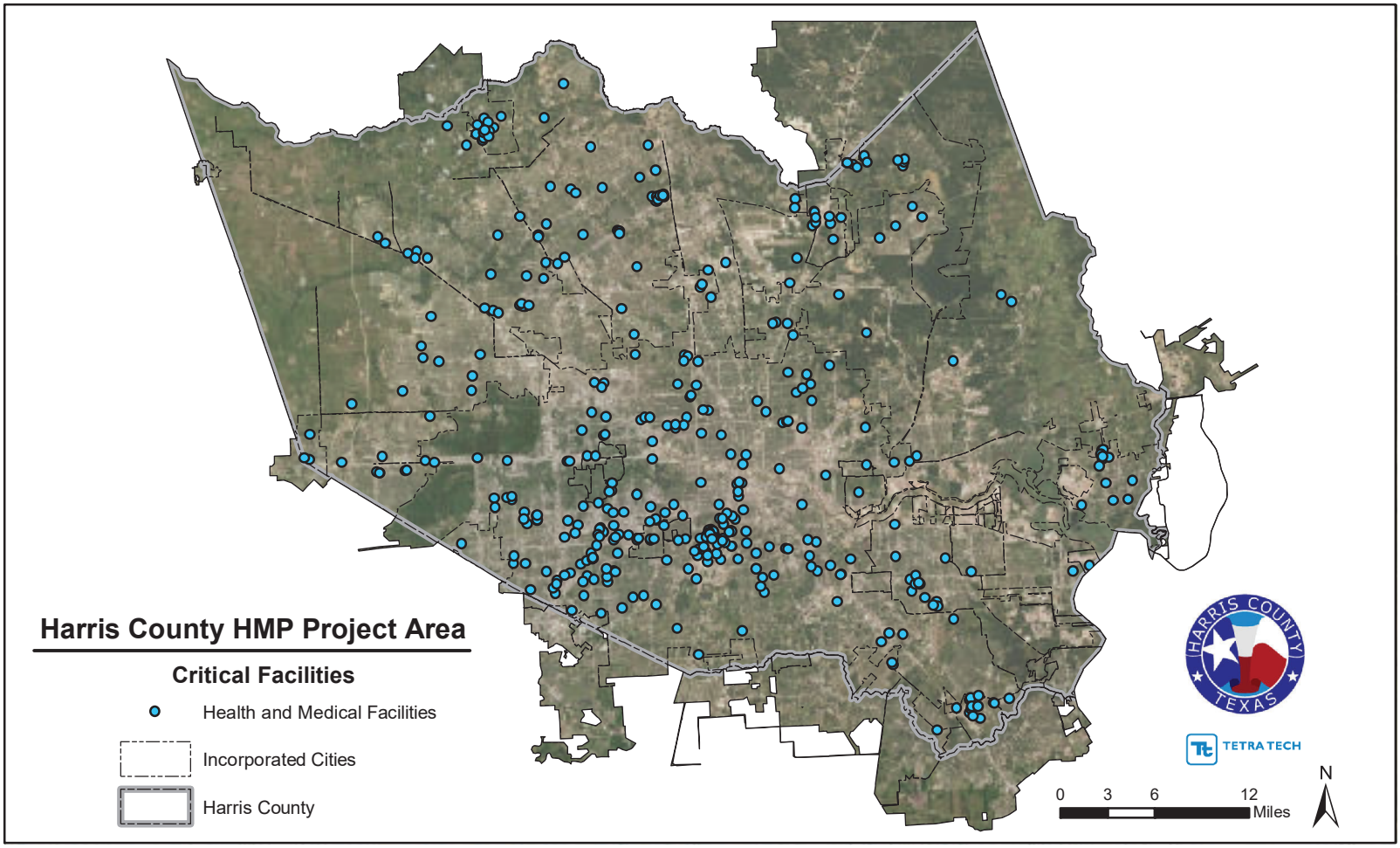


Figure 4-4. Critical Facilities and Infrastructure—Government and Education



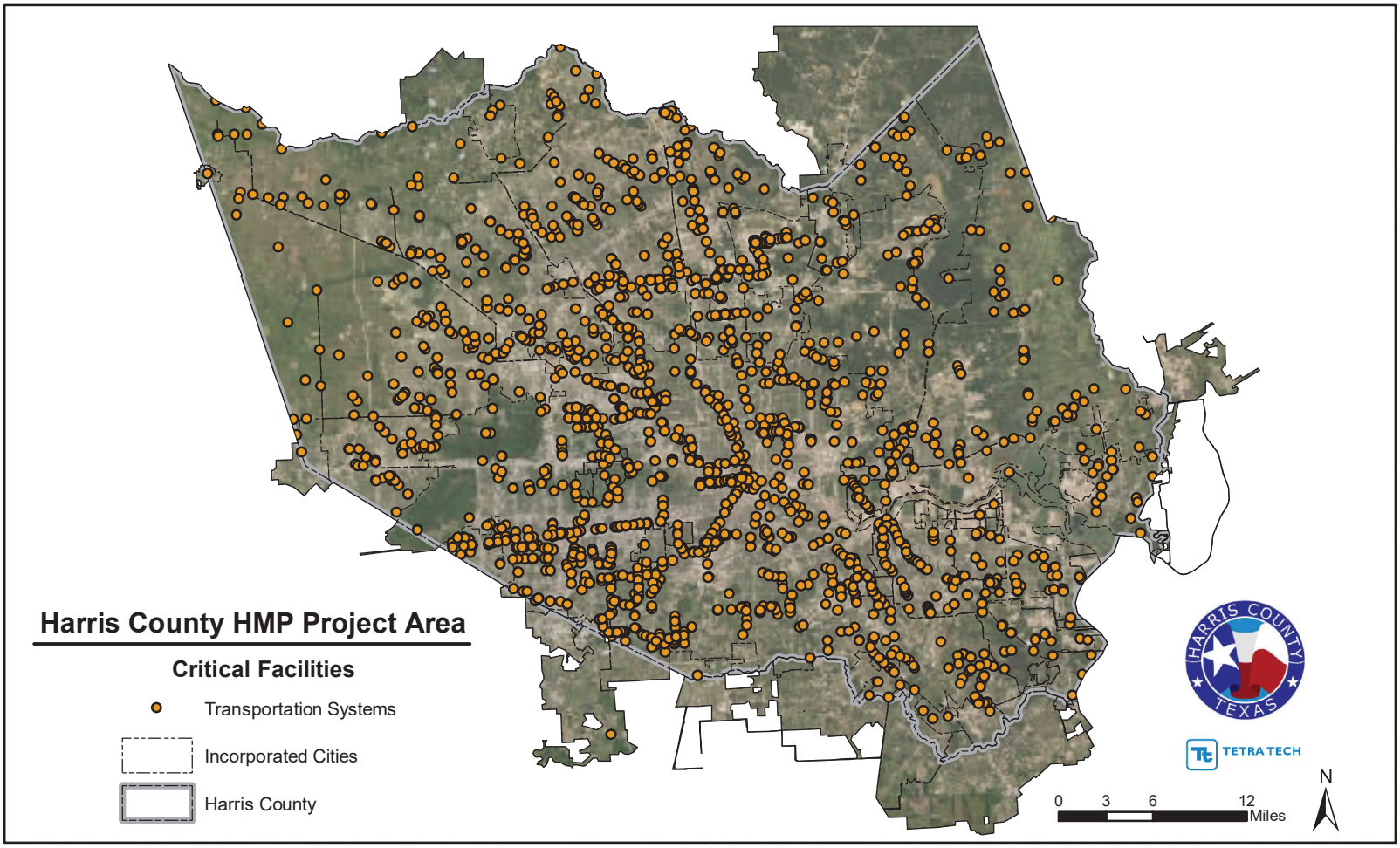
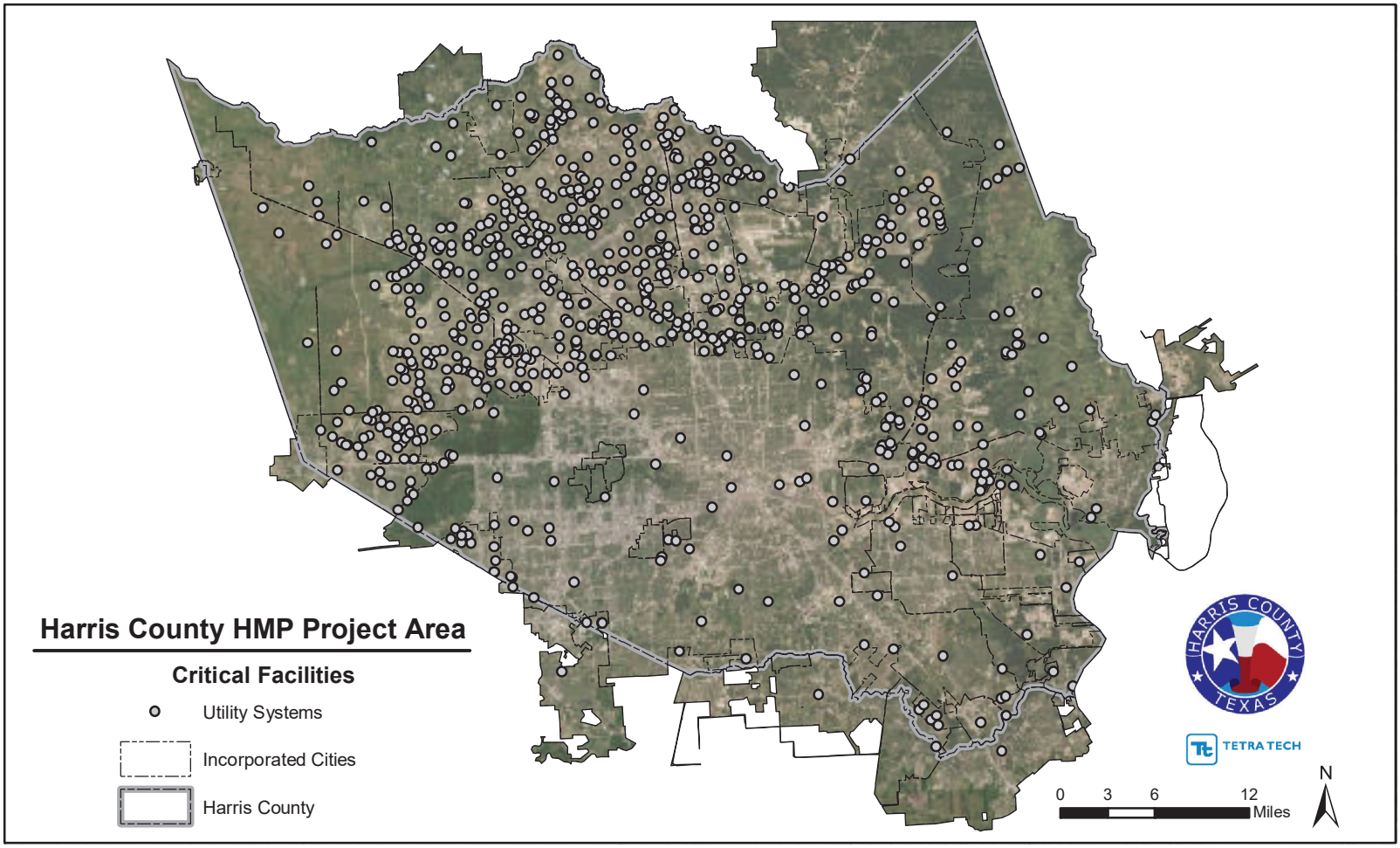


Figure 4-5. Critical Facilities and Infrastructure—Health/Medical and Transportation



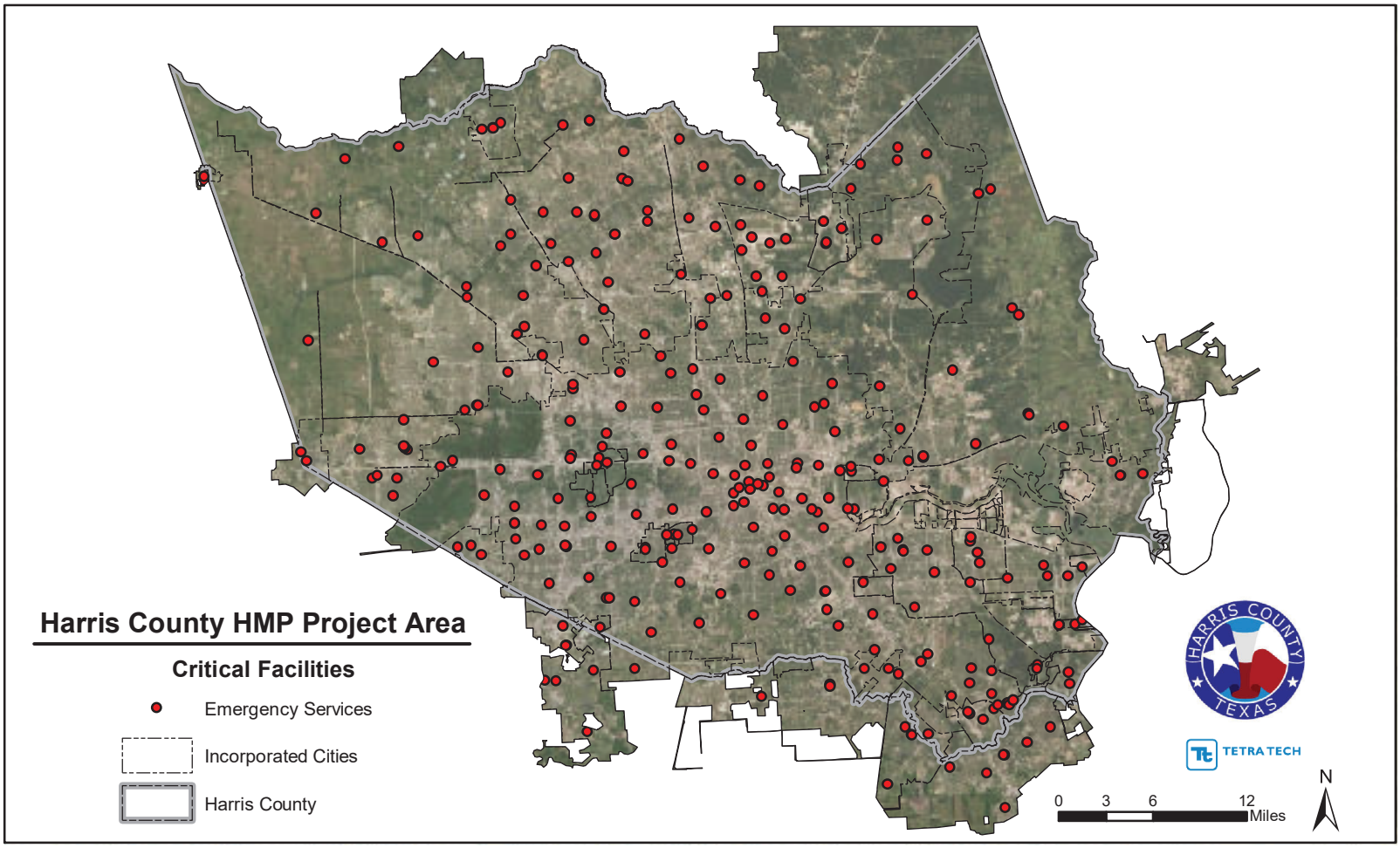
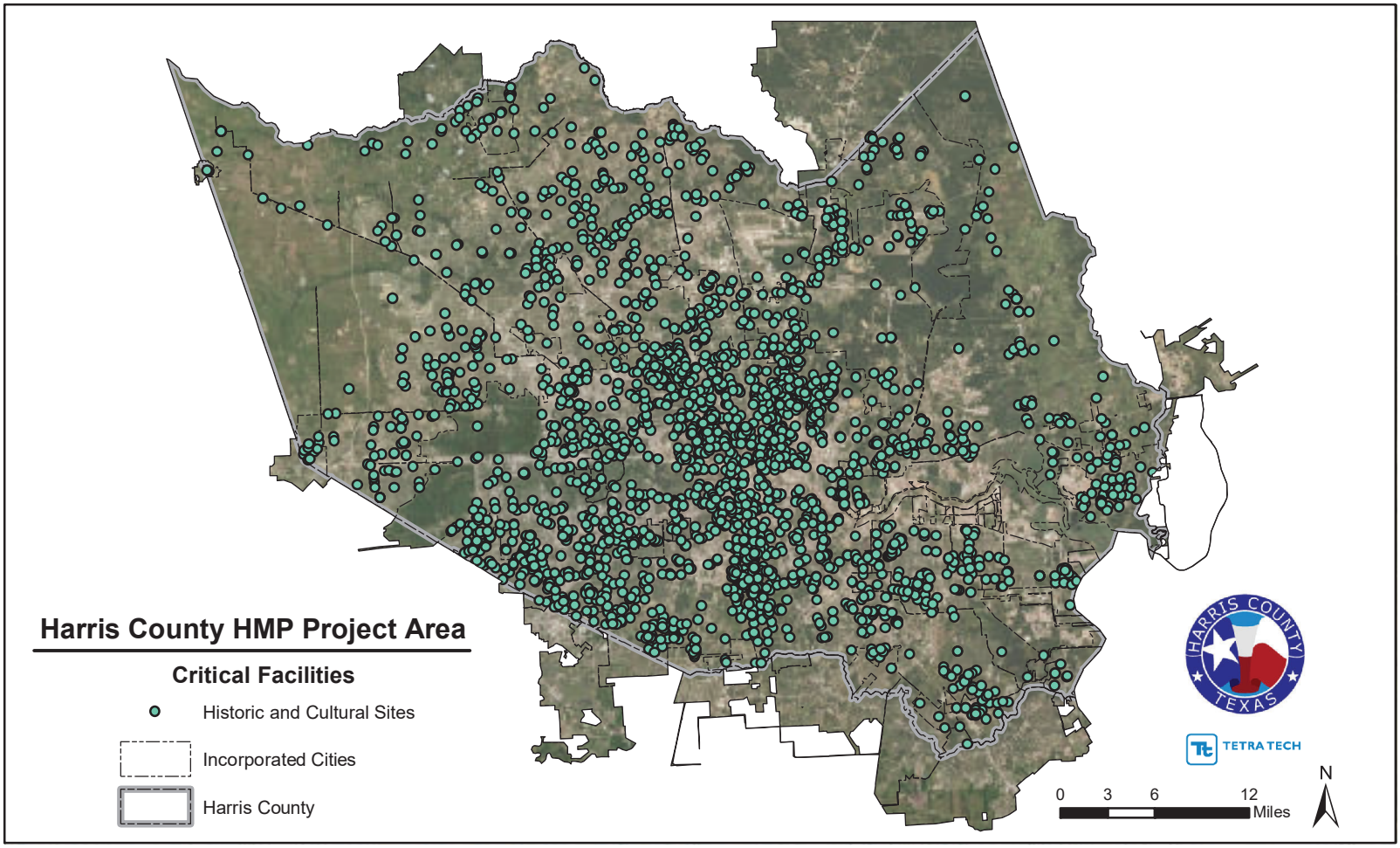


Figure 4-6. Critical Facilities and Infrastructure—Emergency Services and Utilities



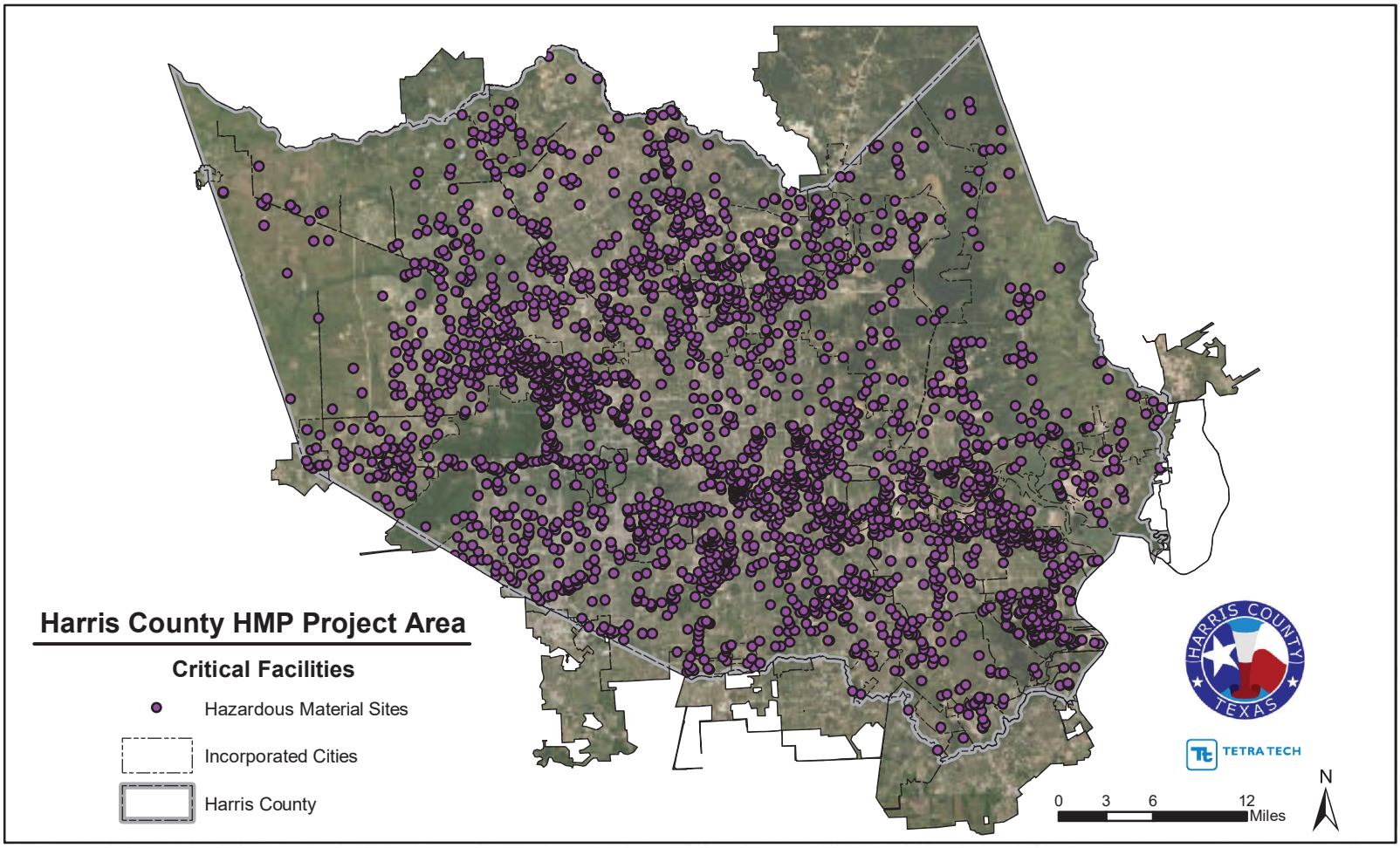


Figure 4-7. Critical Facilities and Infrastructure—Hazardous Materials and Historic/Cultural Sites

Table 4-5. Planning Area Critical Facilities

Planning Unit	Number of Facilities								
	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities	Historic and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown[c]	15	4	7	29	11	72	22	3	**163**
Bellaire	6	2	1	10	6	10	1	1	**37**
Bunker Hill Village	2	0	0	2	0	5	1	0	**10**
Deer Park	10	4	2	34	1	22	10	2	**85**
El Lago	2	0	1	0	0	0	0	1	**4**
Friendswood[c]	3	5	5	2	1	0	2	1	**19**
Galena Park	6	3	2	13	1	9	14	1	**49**
Hedwig Village	1	2	1	2	0	1	2	0	**9**
Hilshire Village	1	0	0	0	0	4	0	0	**5**
Houston[a, b]	492	133	471	1,180	249	1,822	1,083	74	**5,504**
Humble	4	5	9	21	10	40	7	1	**97**
Hunters Creek Village	1	0	0	1	0	1	2	0	**5**
Jacinto City[a]	2	2	1	3	1	7	5	0	**21**
Jersey Village	1	3	1	10	0	2	10	2	**29**
Katy[c]	4	2	3	11	3	11	1	0	**35**
La Porte	8	4	6	29	1	30	32	2	**112**
League City[a, b]	0	7	7	1	0	2	0	1	**18**
Missouri City[c]	0	5	0	2	1	1	6	4	**19**
Morgan's Point	0	1	0	6	1	0	0	1	**9**
Nassau Bay	0	5	1	1	1	3	0	3	**14**
Pasadena	39	11	59	60	13	82	87	5	**356**
Pearland[a]	0	3	2	2	0	2	3	1	**13**
Piney Point Village	2	1	0	2	0	5	3	1	**14**
Seabrook	2	2	6	6	0	6	4	1	**27**
Shoreacres	1	4	0	0	0	0	2	0	**7**
South Houston[a]	6	2	3	16	0	7	11	1	**46**
Southside Place[a]	0	1	1	1	0	0	1	0	**4**
Spring Valley Village	0	2	1	2	1	4	2	0	**12**
Stafford[c]	2	3	1	0	0	0	0	0	**6**
Taylor Lake Village	0	1	0	2	0	1	0	0	**4**
Tomball	6	4	5	13	14	11	2	1	**56**
Waller[a, b]	1	2	1	0	0	2	1	0	**7**
Webster	2	4	2	12	11	19	5	1	**56**
West University Place	1	2	1	1	1	6	2	1	**15**
Unincorporated	561	83	483	1,216	94	717	714	681	**4,549**
Total	**1,181**	**312**	**1,083**	**2,690**	**421**	**2,904**	**2,035**	**790**	**11,416**

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
b. City extends beyond Harris County. Values shown are for Harris County portion only.
c. City extends beyond Harris County. Values shown are for entire city.

4.4.4 Future Trends in Development

Harris County has experienced significant recent growth, increasing in population by 14.5 percent from 2010 to 2018 (Texas Demographic Center, 2019). The Texas A&M University Texas State Data Center population projections indicate that by 2050, with no migration rates, 5,392,104 people will be residing in Harris County and its 34 incorporated communities. This would represent a 14 percent increase from the County's 2018 population.

It is anticipated that future growth in the planning area will push into agricultural areas, converting the land use from agricultural to urban. The planning area experienced a 4.2 percent decrease in agricultural/farmlands during the past performance period. This trend is anticipated to continue through the next performance period of this plan update. It is likely that future growth will extend into hazard areas identified and assessed by this plan.

Harris County and its planning partners are equipped with the core capabilities assed by this plan update to manage growth so that the increased risk can be minimized to the best extent possible. The municipal planning partners have adopted basic or comprehensive plans that govern land use decision- and policy-making in their jurisdictions. Decisions on land use will be governed by these programs. This plan will work together with these programs to support wise land use in the future by providing vital information on the risk associated with natural hazards. All municipal planning partners will incorporate this hazard mitigation plan update in their local plans by reference. This will ensure that future development trends can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan.

4.5 DEMOGRAPHICS

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. Elderly people, for example, may be more likely to require additional assistance. Research has shown that people living near or below the poverty line, the elderly, women, children, ethnic minorities, renters, individuals with disabilities, and others with access and functional needs, all experience more severe effects from disasters than the general population. These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. Detailed spatial analysis to locate areas where there are higher concentrations of vulnerable community members would help to extend focused public outreach and education to these most vulnerable citizens.

4.5.1 Population Characteristics

Knowledge of the composition of the population and how it has changed in the past and how it may change in the future is needed for making informed decisions about the future. Information about population is a critical part of planning because it directly relates to land needs such as housing, industry, stores, public facilities and services, and transportation.

Population Distribution

The total population of Harris County, based on 2018 Census estimates, is 4,698,619. Currently, Harris County is the third most populous county in the United States behind Cook County, Illinois and Los Angeles County, California. The city with the highest population in the county is the City of Houston with a 2010 population of 2,099,451. Houston is the fourth largest city in the nation (U.S. Census Bureau, 2018). Table 4-6 lists the population distribution by city. Figure 4-8 shows the distribution of Harris County's population across the planning area, based on Census 2010 data.

Table 4-6. Population Growth Data

	2012 Estimate (1/1/12)	2017 Estimate (1/1/17)	Change 2012-17	%Change 2012-17
Baytown[a]	73,552	76,205	2,653	3.6
Bellaire	17,134	18,479	1,345	7.8
Bunker Hill Village	3672	3,936	264	7.2
Deer Park	32,849	33,748	899	2.7
El Lago	2709	2,759	50	1.8
Friendswood[a]	36,552	38,811	2,259	6.1
Galena Park	11,804	11,103	-701	-5.9
Hedwig Village	2608	2,662	54	2
Hilshire Village	761	846	103	13.5
Houston[a, b]	2,157,096	2,267,336	110,240	5.1
Humble	15,482	15,736	254	1.6
Hunters Creek Village	4,402	4,749	347	7.9
Jacinto City	10,763	10,748	-15	-0.1
Jersey Village	7,751	7,896	145	1.9
Katya	14,535	17,265	2,730	18.9
La Porte	34,421	35,216	795	2.3
League City[a, b]	86,806	98,215	11,409	13.1
Missouri City[a]	70,016	72,688	2,672	3.8
Morgan's Point[a]	343	333	-10	-2.9
Nassau Bay	4,028	4,092	64	1.6
Pasadena	152,137	153,909	1,772	1.1
Pearland[a, b]	95,359	113,693	18,334	19.2
Piney Point Village	3,128	3,358	230	7.3
Seabrook	12,331	13,325	994	8.0
Shoreacres	1,510	1,796	286	18.9
South Houston[b]	17,367	17,563	196	1.1
Southside Place[b]	1,745	1,704	-41	-2.3
Spring Valley	3,817	4,175	358	9.4
Stafford[a]	18,229	18,092	-137	0.7
Taylor Lake Village	3,545	3,662	117	3.3
Tomball	10,973	11,535	562	5.1
Waller[a, b]	2,342	2,737	395	16.9
Webster	10,622	11,128	506	4.8
West University Place	15,107	15,477	370	2.4
Unincorporated	1,274,273	1,430,542	156,269	12.2
Total	**4,209,769**	**4,525,519**	**315,768**	**7.5**

a. City extends beyond Harris County. Values shown are for entire city.
b. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan

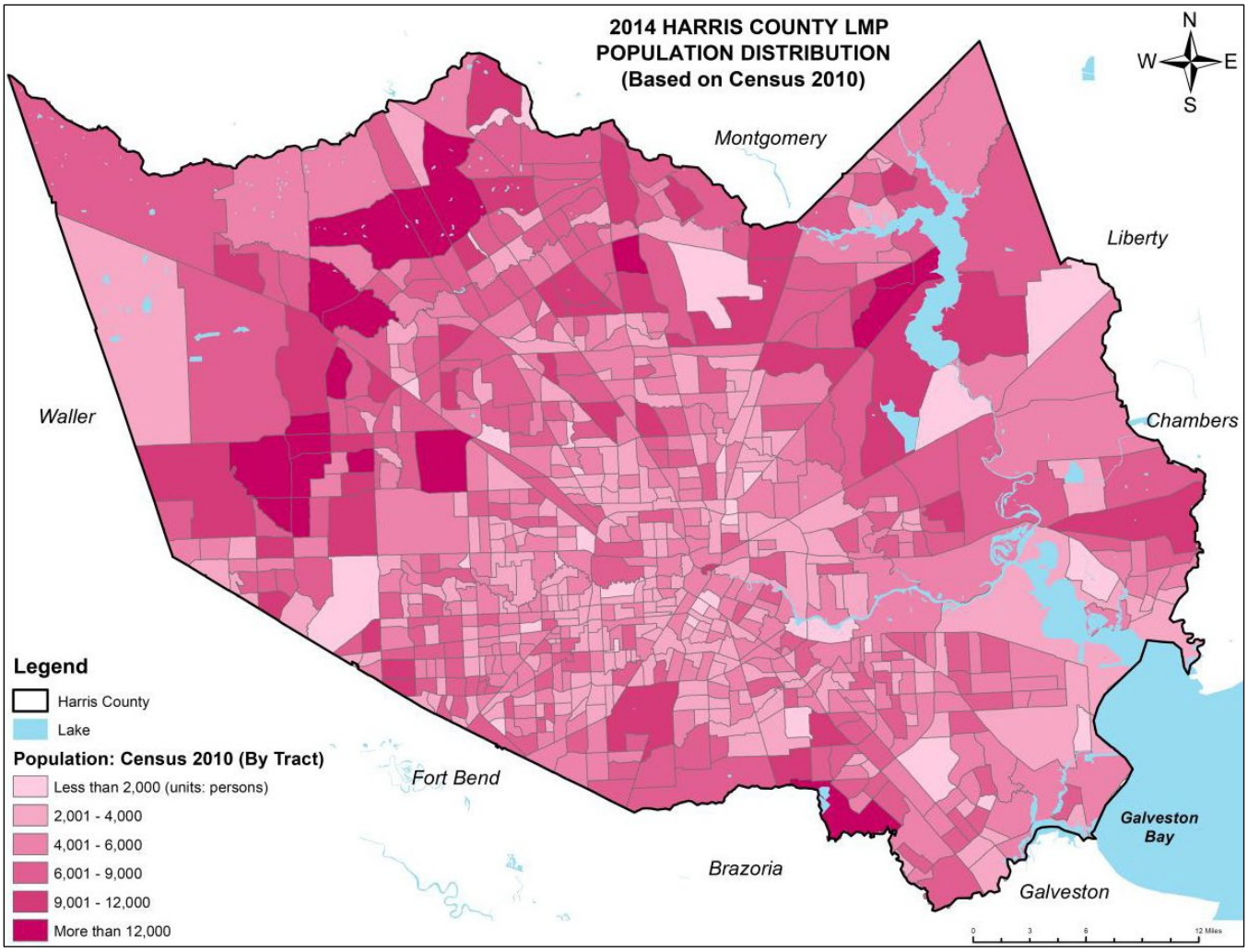


Figure 4-8. Population Distribution in Harris County

Population Trends

Population changes are useful indicators—growing population can indicate a growing economy and decreasing population may signify economic decline. Harris County is growing rapidly due to births and international migration, and, according to the Census Bureau, has been one of the nation's fastest growing counties in terms of numeric change in population for the past 8 years. Between 2010 and 2013, the population of the Houston Consolidated Metropolitan Statistical Area grew 7.5 percent. By comparison, the nation's population increased 3.8 percent over the same period (U.S. Census Bureau, 2019).

Table 4-6 shows the population of incorporated municipalities and unincorporated areas in Harris County from 2012 to 2017. The portion of residents living outside incorporated areas was roughly constant over those years, at about 30 percent. Overall growth during the period was 3.1 percent in unincorporated areas and about 2.8 percent in incorporated areas.

Figure 4-9 shows current and projected Harris County population through 2045. According to Texas A&M University's Texas State Data Center and the Office of the State Demographer, the County population is expected to increase from 4,092,459 in 2010 to 5,288,278 in 2045 (assuming a migration rate of zero). Population projections by Texas State Data Center indicate that by 2050 5,400,000 people will be residing in Harris County.

Source: Texas State Data Center

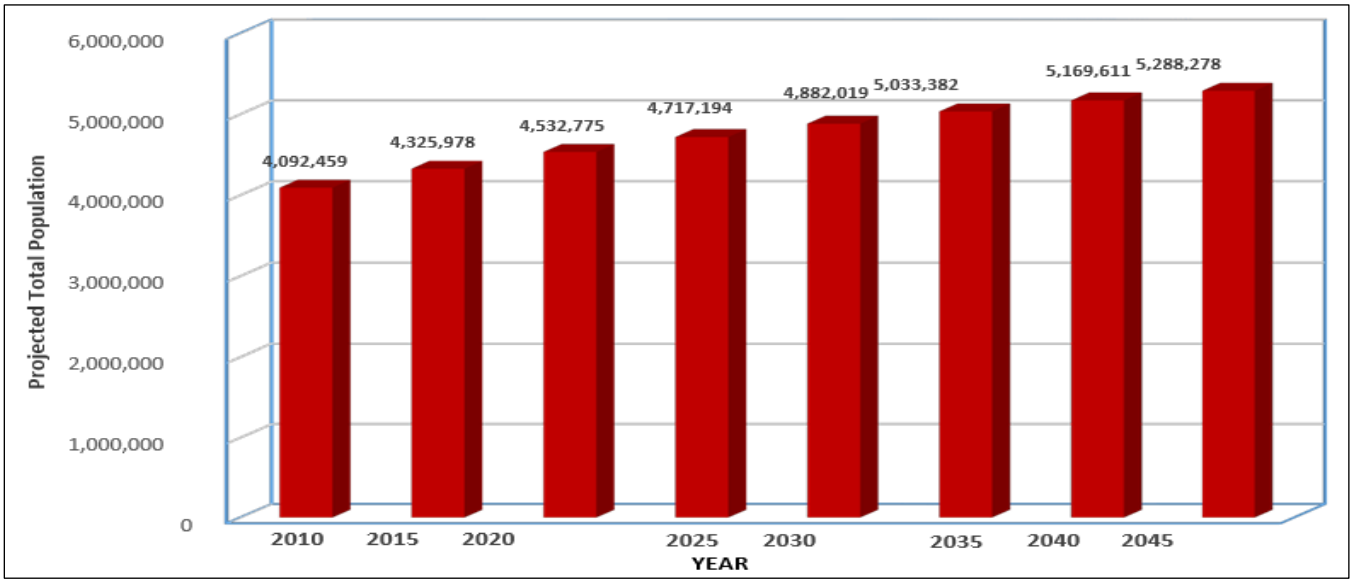


Figure 4-9. Current and Projected Population for Harris County

4.5.2 Households and Homeownership

From 2013 to 2017, the Harris County planning area had an estimated 1,583,000 households. This represents an average of 2.87 people per household. The owner-occupied housing unit rate from 2013 to 2017 was 54.7 percent. Population per square mile in 2010 was 2,404.4 (U.S. Census Bureau, 2019)

4.5.3 Age Distribution

As a group, the elderly are more apt to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences making recovery slower. Additionally, the elderly are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. These facilities are typically identified as "critical facilities" by emergency managers because they require extra notice to implement evacuation. Elderly residents living in their own homes may have more difficulty evacuating their homes and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the American population.

Children under 14 are particularly vulnerable to disaster events because of their young age and dependence on others for basic necessities. Very young children may additionally be vulnerable to injury or sickness; this vulnerability can be worsened during a natural disaster because they may not understand the measures that need to be taken to protect themselves from hazards.

The overall age distribution for the planning area is illustrated in Figure 4-10. Based on U.S. Census data, 10.2 percent of the planning area's population is 65 or older and 26.9 percent of the population is under 18. According to U.S. Census data, 11.3 percent of the over-65 population have incomes below the poverty level. Of children under 18, 25 percent live below the poverty level.

Source: American Fact Finder, 2012-2016 American Community Survey 5-Year Estimates, 2018

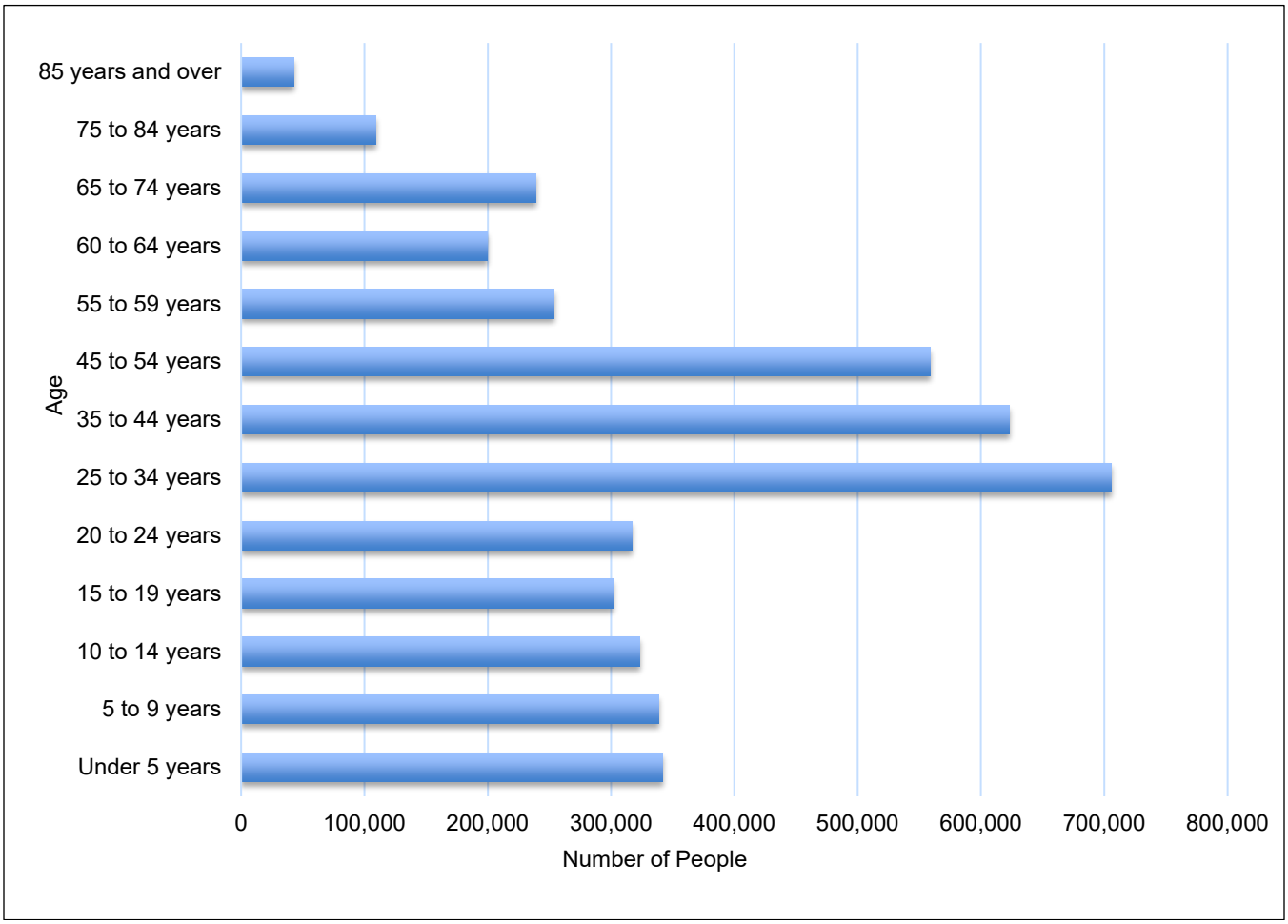


Figure 4-10. Planning Area Age Distribution

4.5.4 Race, Ethnicity and Language

Research shows that minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster. Post-disaster recovery can be ineffective and is often characterized by cultural insensitivity. Since higher proportions of ethnic minorities live below the poverty line than the majority white population, poverty can compound vulnerability. According to the U.S. Census, the racial composition of the planning area is predominantly white, at about 69.8 percent. The largest minority population is black or African American at 19.7 percent. While not considered a separate race, the planning area has a 43 percent Hispanic or Latino population. Figure 4-11 shows the racial distribution in the planning area.

The planning area has a 26-percent foreign-born population. In 2017, only 56.3 percent of the Harris County population spoke only English at home. Other than English, the most commonly spoken language in the planning area is Spanish.

The 2010 census found that no racial or ethnic group constituted a majority of the Houston metro area population; by 2030, under reasonable scenarios, Hispanics could become a majority (see Table 4-7). Asians—over 6 percent of the population in 2010— are projected to increase to 10 percent within the next two decades. (U.S. Census Bureau, 2019)

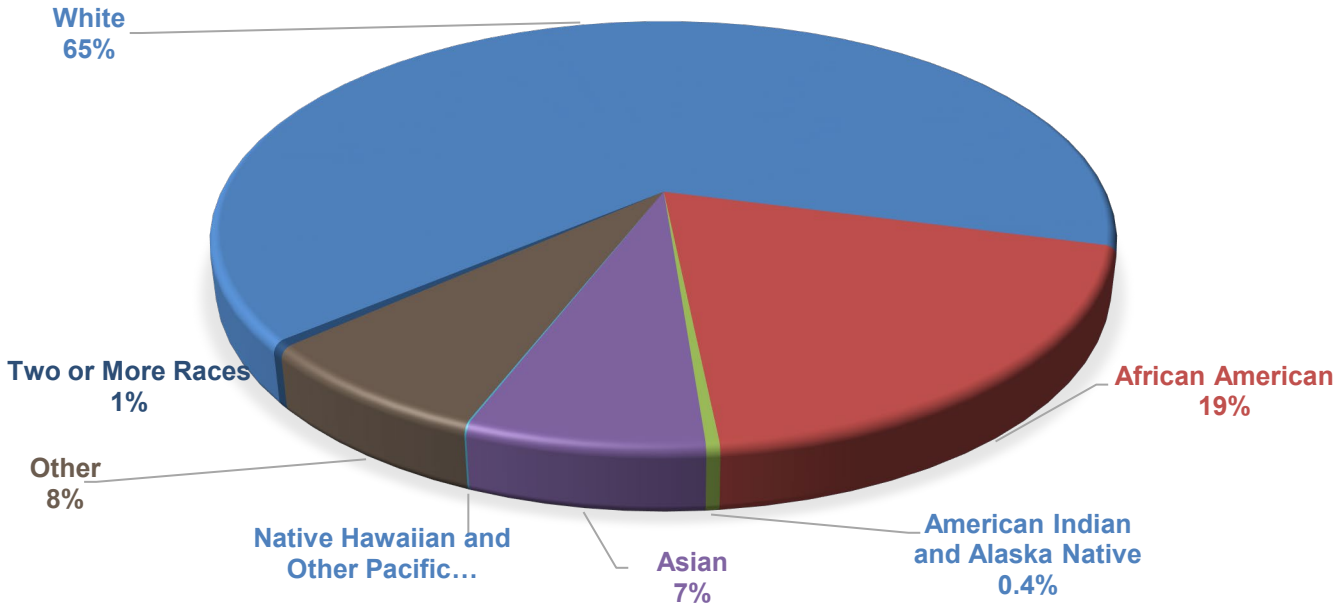


Figure 4-11. Planning Area Race Distribution

Table 4-7. Projected Population 2020—2050 by Race/Ethnicity for Harris County

	Total	Anglo	Black	Hispanic	Other
2020	**4,978,446**	1,448,275	927,092	2,107,349	495,730
2025	**5,446,430**	1,492,051	1,014,616	2,331,411	608,352
2030	**5,922,906**	1,528,178	1,099,527	2,558,266	736,935
2035	**6,403,762**	1,557,438	1,181,044	2,780,373	884,907
2040	**6,892,477**	1,586,178	1,258,987	2,990,485	1,056,827
2045	**7,392,260**	1,617,212	1,332,346	3,185,311	1,257,381
2050	**7,900,994**	1,650,908	1,399,520	3,362,429	1,488,137

Source: Texas State Data Center, Harris County

4.5.5 Individuals with Disabilities or with Access and Functional Needs

The 2010 U.S. Census estimates that 54 million non-institutionalized Americans with disabilities live in the U.S. This equates to about one-in-five persons. Individuals with disabilities are more likely to have difficulty responding to a hazard event than the general population. Local government is the first level of response to assist these individuals, and coordination of efforts to meet their access and functional needs is paramount to life safety efforts. It is important for emergency managers to distinguish between functional and medical needs in order to plan for incidents that require evacuation and sheltering. Knowing the percentage of population with a disability will allow emergency management personnel and first responders to have personnel available who can provide services needed by those with access and functional needs. According to U.S. Census data, 8.7 percent of the of the population reported a disability. Of those with a disability, 0.5 percent were under 5 years old, 9.5 percent were age 5 to 17 years, 55.9 percent were age 18 to 64 years, and 34 percent were 65 and older.

4.5.6 Education

In 2018, 1,264,758 people in the Harris County planning area were enrolled in school (U.S. Census Bureau, 2019). Countywide, 80.5 percent had a high school diploma or higher and 30.5 percent held a bachelor's degree or higher between 2013 and 2017 (U.S. Census Bureau, 2019).

4.6 ECONOMY

Harris County has a diverse economy with 114,218 businesses spanning a wide spectrum of industries. The largest industry sector driving the Harris County economy is health care and social assistance, employing 296,287. The Texas Medical Center, located in Houston, is the largest medical complex in the world, employing 106,000. The energy sector (oil, coal, power) is also a leading driver of the Harris County economy, employing 96,312 (Lone Star College, 2018). Houston has every major energy company represented locally.

4.6.1 Income

In the United States, individual households are expected to use private resources to prepare for, respond to and recover from disasters to some extent. This means that households living in poverty are disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. In urban areas, the poor often live in older houses and apartment complexes, which are more likely to be made of un-reinforced masonry, a building type that is particularly susceptible to damage during earthquakes. Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. This means that residents below the poverty level have a great deal to lose during an event and are the least prepared to deal with potential losses. The events following Hurricane Katrina in 2005 illustrated that personal household economics significantly impact people's decisions on evacuation. Individuals who cannot afford gas for their cars will likely decide not to evacuate.

Based on U.S. Census Bureau estimates, per capita income in the planning area in 2017 was $30,856, and the median household income was $57,791. Table 4-8 shows the distribution of earnings for full time workers in Harris County. Median household income in Harris County was $57,791 which was higher than the median household income for the State of Texas at $57,051, as well as the U.S. median at $57,652. Per capita income in 2017 in Harris County was $30,856 versus $28,985 in the State of Texas and $31,177 for the U.S. (U.S. Census Bureau, 2019).

Table 4-8. Earnings for Full Time Workers in Harris County

Earnings	Percent	Earnings	Percent
$1 to $9,999 or less	1.8	**$50,000 to $64,999**	15.3
$10,000 to $14,999	4.1	**$65,000 to $74,999**	5.9
$15,000 to $24,000	15.0	**$75,000 to $99,999**	9.0
$25,000 to $34,999	15.9	**$100,000 or more**	15.1
$35,000 to $49,999	17.9		

Source: Census Bureau 2017

According to U.S. Census Bureau data, the 5-year poverty status estimate for Harris County from 2013 to 2017 was 16.8 percent or 751,985 people. Statewide, 4,291,394 individuals, or 16.0 percent of the population fell below poverty level. For both Harris County and the State of Texas, the percentage below poverty level exceeded the United States poverty level of 14.6 percent. The Texas Health and Human Services Commission reported for state fiscal year 2018 that Harris County had a Medicaid caseload of 712,504 people, 579,849 of them under the age of 21. 68,228 of the cases were disability related and 51,670 of the cases were age- and Medicare-related.

The State of Texas defines "Small and Impoverished Communities" based on the following criteria:

- Population is less than 3,000
- Community is not located within the boundaries of a larger city
- Average per capita annual income does not exceed 80 percent of the national per capita income
- Local unemployment rate exceeds the national unemployment rate by 1 percentage point or more.

According to the U.S. Census Bureau, the per capita income of the United States was $31,177; 80 percent of which is $24,941. All communities listed in Table 4-6 exceed the maximum per capita income criterion, with the lowest at $27,915 in the City of Waller. Therefore, no communities assessed in this plan meet the state's criteria to be classified as small and impoverished.

4.6.2 Industry, Businesses and Institutions

The planning area's economy is strongly based in education, health and social services (18.8 percent of employed residents), followed by professional and management (13.3 percent); retail trade (10.8 percent); and manufacturing (10 percent). Figure 4-12 shows the breakdown of industry types in the planning area.

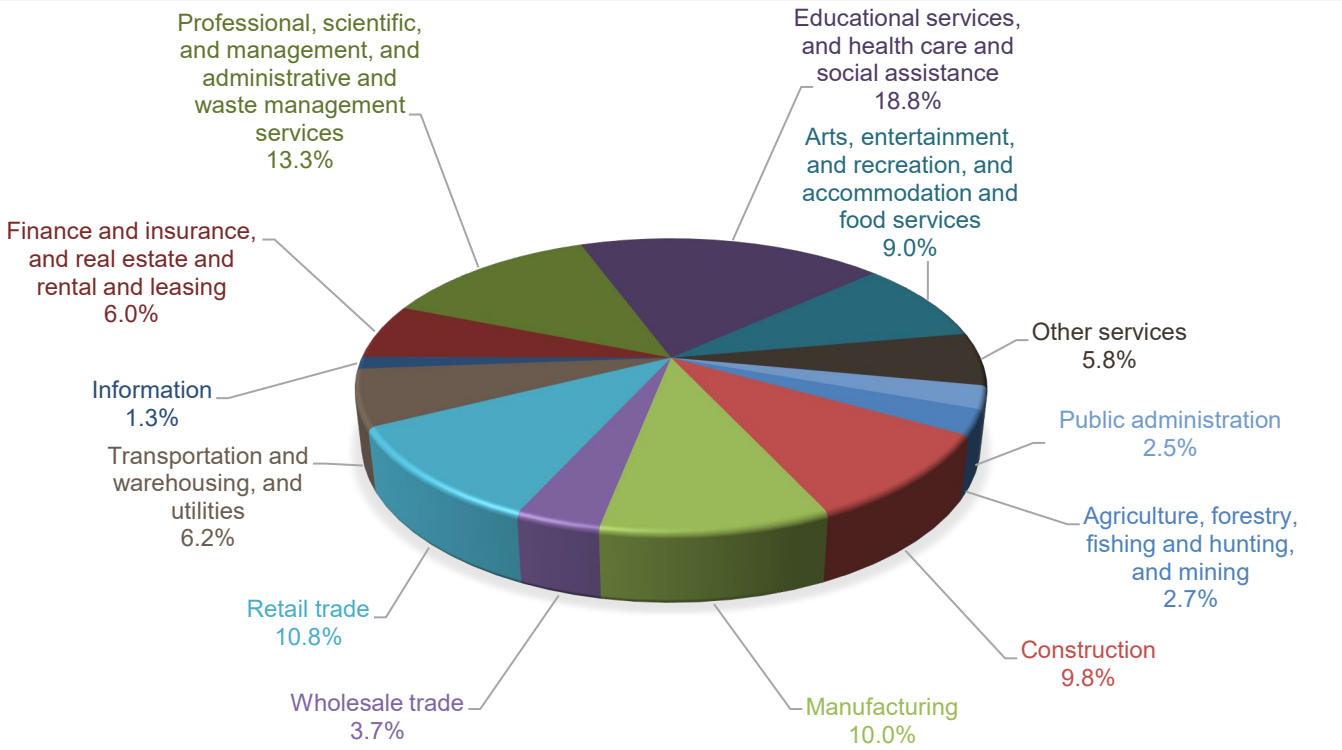


Figure 4-12. Industry in the Planning Area

The local economy has greatly diversified to a variety of industries. Houston ranked fourth among U.S. cities in 2019 with the most Fortune 500 company headquarters—74 (following New York with 217, Chicago with 105, and Los Angeles with 82) (World Atlas, 2019). The top 20 employers in the planning area are as follows (Houston Chronicle, 2019):

1. Walmart
2. Memorial Hermann Healthcare System
3. H-E-B
4. Houston Methodist Hospital System
5. The University of Texas M.D. Anderson Cancer
6. McDonald's Corporation
7. Kroger
8. Exxon Mobil Corp.
9. Texas Children's Hospital
10. United Airlines

11. HCA Gulf Coast Division Family of Hospitals
12. Landry's
13. University of Texas Medical Branch at Galveston Health
14. Schlumberger
15. Shell Oil Co.
16. Whataburger
17. University of Texas Health Science Center at Houston (UT Health)
18. Baylor College of Medicine
19. Harris Health System
20. Goodman Manufacturing

4.6.3 Employment

Employment Rates

The county labor force was 2,215,947 in 2017, a slight increase from the 2012 level of 2,200,985. According to the U.S. Bureau of Labor statistics, the total nonfarm employment in the Houston-The Woodlands-Sugar Land Metropolitan Statistical Area stood at 3,169,300 in July 2019, up 93,600 or 3.0 percent, from one year earlier. During the same period, the national job count increased 1.5 percent. Among the 12 largest metropolitan areas in the country, Houston ranked second in the annual rate of job growth and third in the number of jobs added over the year.

Harris County has a relatively low unemployment rate of 3.8 percent (March 2019), down from 5.1 percent the prior year (Bureau of Labor Statistics). Figure 4-13 compares the U.S., Texas and Harris County unemployment trends from 2010 through 2018. The county's rate tracks consistently with statewide and national averages.

Occupations

Service occupations and management, business, science, and arts occupations make up 35 percent of the jobs in the planning area. Figure 4-14 shows the overall distribution of county employment by occupation class.

Commuting

Between 2013 and 2017, the mean travel time to work in Harris County was 28.9 minutes, compared to the state average of 26.1 minutes. The number of people over age 16 who commuted to work was 2,140,881. The number that worked from home was 79,181. (U.S. Census Bureau, 2019).

Source: Federal Reserve Bank of St. Louis, 2019

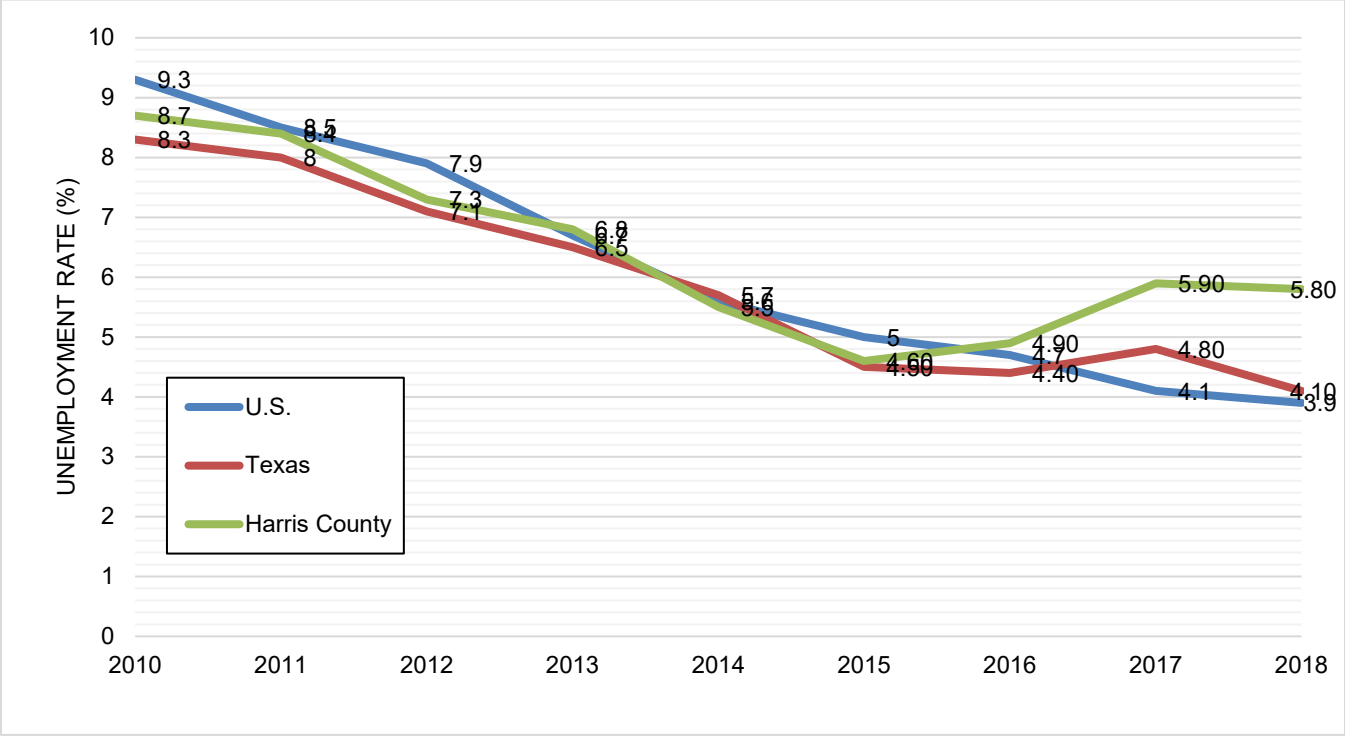


Figure 4-13. Texas and Harris County Unemployment Rate

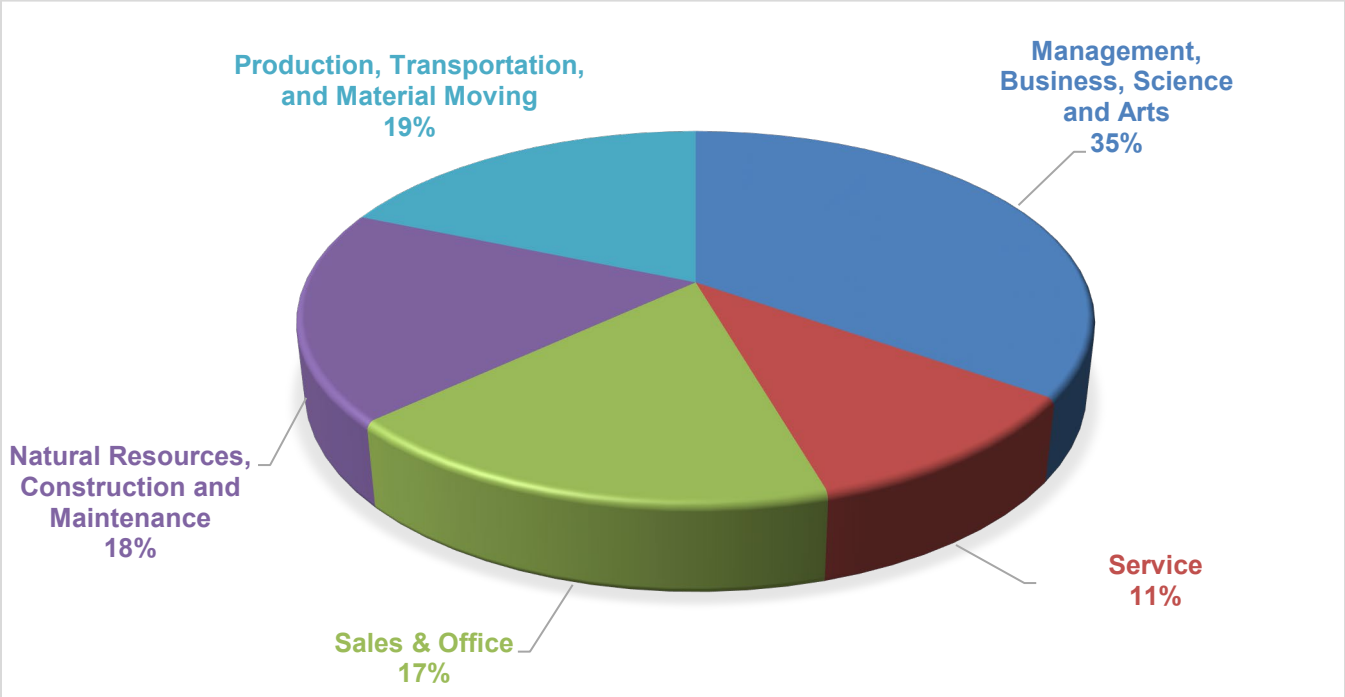


Figure 4-14. Occupations in the Planning Area

5. REGULATIONS AND PROGRAMS

Existing regulations, agencies and programs at the federal, state and local level can support or impact hazard mitigation actions identified in this plan. Hazard mitigation plans are required to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (44 CFR, Section 201.6(b)(3)). Information presented in this section can be used to review local capabilities to implement the action plan this hazard mitigation plan presents. Individual review by each planning partner of existing local plans, studies, reports, and technical information is presented in the annexes in Volume 2.

5.1 FEDERAL AND STATE AGENCIES, PROGRAMS AND REGULATIONS

State and federal regulations and programs that need to be considered in hazard mitigation are constantly evolving. For this plan, a review was performed to determined which regulations and programs are currently most relevant to hazard mitigation planning. The findings are summarized in Table 5-1 and Table 5-2. Short descriptions of each program are provided in Appendix B.

5.2 LOCAL PLANS, REPORTS AND CODES

Plans, reports and other technical information were identified and provided directly by participating jurisdictions and stakeholders or were identified through independent research by the planning consultant. These documents were reviewed to identify the following:

- Existing jurisdictional capabilities.
- Needs and opportunities to develop or enhance capabilities, which may be identified within the local mitigation strategies.
- Mitigation-related goals or objectives, considered during the development of goals and objectives.
- Proposed, in-progress, or potential mitigation projects, actions and initiatives to be incorporated into the updated jurisdictional mitigation strategies.

The following local regulations, codes, ordinances and plans were reviewed in order to develop complementary and mutually supportive goals, objectives, and mitigation strategies that are consistent across local and regional planning and regulatory mechanisms:

- Comprehensive plans (housing elements, safety elements)
- Building codes
- Zoning and subdivision ordinances
- NFIP flood damage prevention ordinances
- Stormwater management plans
- Emergency management and response plans
- Land use and open space plans
- Climate action plans
- Community wildfire protection plans

Table 5-1. Summary of Relevant Federal Agencies, Programs and Regulations

Agency, Program or Regulation	Hazard Mitigation Area Affected	Relevance
A Collaborative Approach for Reducing Wildfire Risks to Communities and the Environment	Wildfire Hazard	This strategy implementation plan prepared by federal and Western state agencies outlines measures to restore fire-adapted ecosystems and reduce hazardous fuels.
Americans with Disabilities Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Bureau of Land Management	Wildfire Hazard	The Bureau funds and coordinates wildfire management programs and structural fire management and prevention on BLM lands.
Civil Rights Act of 1964	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Clean Water Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Community Development Block Grant Disaster Resilience Program	Action Plan Funding	This is a potential alternative source of funding for actions identified in this plan.
Community Rating System	Flood Hazard	This voluntary program encourages floodplain management activities that exceed the minimum National Flood Insurance Program requirements.
Disaster Mitigation Act	Hazard Mitigation Planning	This is the current federal legislation addressing hazard mitigation planning.
Emergency Relief for Federally Owned Roads Program	Action Plan Funding	This is a possible funding source for actions identified in this plan.
Emergency Watershed Program	Action Plan Funding	This is a possible funding source for actions identified in this plan.
Endangered Species Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Federal Energy Regulatory Commission Dam Safety Program	Dam Failure Hazard	This program cooperates with a large number of federal and state agencies to ensure and promote dam safety.
National Environmental Policy Act	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Federal Wildfire Management Policy and Healthy Forests Restoration Act	Wildfire Hazard	These documents mandate community-based collaboration to reduce risks from wildfire.
National Dam Safety Act	Dam Failure Hazard	This act requires a periodic engineering analysis of most dams in the country
National Fire Plan	Wildfire Hazard	This plan calls for joint risk reduction planning and implementation by federal, state and local agencies.
National Flood Insurance Program	Flood Hazard	This program makes federally backed flood insurance available to homeowners, renters, and business owners in exchange for communities enacting floodplain regulations
National Incident Management System	Action Plan Development	Adoption of this system for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards is a prerequisite for federal preparedness grants and awards
Presidential Executive Order 11988 (Floodplain Management)	Flood Hazard	This order requires federal agencies to avoid long and short-term adverse impacts associated with modification of floodplains
Presidential Executive Order 11990 (Protection of Wetlands)	Action Plan Implementation	FEMA hazard mitigation project grant applications require full compliance with applicable presidential executive orders.
U.S. Army Corps of Engineers Dam Safety Program	Dam Failure Hazard	This program is responsible for safety inspections of dams that meet size and storage limitations specified in the National Dam Safety Act.

Agency, Program or Regulation	Hazard Mitigation Area Affected	Relevance
U.S. Army Corps of Engineers Flood Hazard Management	Flood Hazard, Action Plan Implementation, Action Plan Funding	The Corps of Engineers offers multiple funding and technical assistance programs available for flood hazard mitigation actions
U.S. Fire Administration	Wildfire Hazard	This agency provides leadership, advocacy, coordination, and support for fire agencies and organizations.
U.S. Fish and Wildlife Service	Wildfire Hazard	This service's fire management strategy employs prescribed fire throughout the National Wildlife Refuge System to maintain ecological communities.

Table 5-2. Summary of Relevant State Agencies, Programs and Regulations

Agency, Program or Regulation	Hazard Mitigation Area Affected	Relevance
Texas Government Code Chapter 418; Texas Administrative Code Title 37, Part 1, Chapter 7	State and Local Authority; Emergency Management Plans	Establishes roles and responsibilities for emergency management directors. Addresses disaster declarations. Requires emergency operations plans.
Texas Planning Law	Growth Management; Open Space Preservation	Enables local governments to adopt comprehensive plans and authorizes the creation of a conservation easement
Texas Property Code	Hazard Disclosure	Requires flood-related disclosures for property sales.
Texas Stormwater Management Program	Stormwater Management	Establishes water quality requirements that will apply to any proposed hazard mitigation actions
HB 108, Texas Water Code	Floodplain Management	Requires flood damage prevention ordinances and enrollment in the National Flood Insurance Program.
HOME Program	Housing	Includes disaster relief funding.
Texas Water Development Board	Floodplain Management	Manages flood hazard mapping and monitors NFIP program compliance.
Texas Flash Flood Coalition	Flood Safety	Works to decrease the number of deaths caused by flash flooding in Texas.
Texas Silver Jackets	Inter-Agency Coordination	Provides for an interagency approach to planning and implementing measures to reduce flood risks.
Community Hazard Analysis and Mitigation Planning Support	Risk Communication	Provides data, maps and other information to support hazard assessment.
Texas General Land Office	Public Education/ Awareness	Supports mitigation planning along the Texas coast.

5.3 LOCAL CAPABILITY ASSESSMENT

All participating jurisdictions compiled an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of a jurisdiction's mission, programs and policies, and evaluates its capacity to carry them out. This assessment identifies potential gaps in the jurisdiction's capabilities.

The planning partnership views all core jurisdictional capabilities as fully adaptable to meet a jurisdiction's needs. Every code can be amended, and every plan can be updated. Such adaptability is itself considered to be an overarching capability. If the capability assessment identified an opportunity to add a missing core capability or expand an existing one, then doing so has been selected as an action in the jurisdiction's action plan, which is included in the individual annexes presented in Volume 2 of this plan.

Capability assessments for each planning partner are presented in the jurisdictional annexes in Volume 2. The sections below describe the specific capabilities evaluated under the assessment.

5.3.1 Legal and Regulatory Capabilities

Jurisdictions have the ability to develop policies and programs and to implement rules and regulations to protect and serve residents. Local policies are typically identified in a variety of community plans, implemented via a local ordinance, and enforced through a governmental body.

Jurisdictions regulate land use through the adoption and enforcement of zoning, subdivision and land development ordinances, building codes, building permit ordinances, floodplain, and stormwater management ordinances. When effectively prepared and administered, these regulations can lead to hazard mitigation.

5.3.2 Fiscal Capabilities

Assessing a jurisdiction's fiscal capability provides an understanding of the ability to fulfill the financial needs associated with hazard mitigation projects. This assessment identifies both outside resources, such as grant-funding eligibility, and local jurisdictional authority to generate internal financial capability, such as through impact fees.

5.3.3 Administrative and Technical Capabilities

Legal, regulatory, and fiscal capabilities provide the backbone for successfully developing a mitigation strategy; however, without appropriate personnel, the strategy may not be implemented. Administrative and technical capabilities focus on the availability of personnel resources responsible for implementing all the facets of hazard mitigation. These resources include technical experts, such as engineers and scientists, as well as personnel with capabilities that may be found in multiple departments, such as grant writers.

5.3.4 NFIP Compliance

Flooding is the costliest natural hazard in the United States and, with the promulgation of recent federal regulation, homeowners throughout the country are experiencing increasingly high flood insurance premiums. Community participation in the NFIP opens up opportunity for additional grant funding associated specifically with flooding issues. Assessment of the jurisdiction's current NFIP status and compliance provides planners with a greater understanding of the local flood management program, opportunities for improvement, and available grant funding opportunities.

5.3.5 Public Outreach Capability

Regular engagement with the public on issues regarding hazard mitigation provides an opportunity to directly interface with community members. Assessing this outreach and education capability illustrates the connection between the government and community members, which opens a two-way dialogue that can result in a more resilient community based on education and public engagement.

5.3.6 Participation in Other Programs

Other programs, such as the Community Rating System, StormReady, and Firewise USA, enhance a jurisdiction's ability to mitigate, prepare for, and respond to natural hazards. These programs indicate a jurisdiction's desire to go beyond minimum requirements set forth by local, state and federal regulations in order to create a more resilient community. These programs complement each other by focusing on communication, mitigation, and community preparedness to save lives and minimize the impact of natural hazards on a community.

5.3.7 Development and Permitting Capability

Identifying previous and future development trends is achieved through a comprehensive review of permitting since completion of the previous plan and in anticipation of future development. Tracking previous and future growth in potential hazard areas provides an overview of increased exposure to a hazard within a community.

5.3.8 Adaptive Capacity

An adaptive capacity assessment evaluates a jurisdiction's ability to anticipate impacts from future conditions. By looking at public support, technical adaptive capacity, and other factors, jurisdictions identify their core capability for resilience against issues such as sea level rise. The adaptive capacity assessment provides jurisdictions with an opportunity to identify areas for improvement by ranking their capacity high, medium or low.

5.3.9 Integration Opportunity

The assessment looked for opportunities to integrate this mitigation plan with the legal/regulatory capabilities identified. Capabilities were identified as integration opportunities if they can support or enhance the actions identified in this plan or be supported or enhanced by components of this plan. Planning partners considered actions to implement this integration as described in their jurisdictional annexes.

PART 2—RISK ASSESSMENT

6. IDENTIFIED HAZARDS OF CONCERN AND RISK ASSESSMENT METHODOLOGY

Risk assessment is the process of estimating the potential loss of life, personal injury, economic injury, and property damage resulting from identified hazards. The process focuses on the following elements:

- **Hazard identification**—Use all available information to determine what types of hazards may affect a jurisdiction, how often they can occur, and their potential severity.
- **Exposure identification—**Estimate the total number of people and properties in the jurisdiction that are likely to experience a hazard event if it occurs.
- **Vulnerability identification and loss estimation**—Assess the impact of hazard events on the people, property, environment, economy and lands of the region, including estimates of the cost of potential damage or cost that can be avoided by mitigation.

The risk assessment for this hazard mitigation plan evaluates the risk of natural hazards prevalent in the planning area and meets requirements of the Disaster Mitigation Act (44 CFR, Section 201.6(c)(2)). To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual personal or public properties.

6.1 IDENTIFIED HAZARDS OF CONCERN

The Steering Committee considered the full range of natural hazards that could affect the planning area, beginning with those hazards that were profiled in the prior plan, and then listed hazards that present the greatest concern. The process incorporated a review of state and local hazard planning documents as well as information on the frequency of, magnitude of, and costs associated with hazards that have struck the planning area or could do so. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, this plan addresses the following hazards of concern (presented in alphabetical order; the order of listing does not indicate the hazards' relative severity):

- Coastal erosion
- Dam/levee failure
- Drought
- Earthquakes
- Flooding
- Hurricanes and coastal storms
- Mass movement (landslides, sinkholes, and subsidence)
- Severe weather (thunderstorms, hail, extreme heat, tornados and damaging winds, winter storms and freezes)
- Tsunami
- Wildfire

The coastal erosion, mass movement and tsunami hazards are included in this list more for their potential to occur in the future than based on historical occurrence with impacts in the planning area. Given their lack of historical

occurrence in the planning area, these hazards rank as low or negligible risk under the risk ranking protocol utilized in this plan (Chapter 19 of this volume). However, the County and the Steering Committee have determined that they warrant inclusion in this plan, as they did in previous versions. This forward-looking treatment of these hazards positions the planning partnership for benefit eligibility should an event of this type occur during the performance period of this plan.

An additional chapter provides a profile of other hazards of concern, calling attention to hazards that may impact the planning area but whose risk is difficult to quantify due to a lack of data or well-established assessment parameters. This chapter does not assess these hazards to the same level of detail as the primary hazards of concern, and they are not included in the risk ranking for this plan update. These other hazards include:

- Toxic release/hazardous materials
- Energy pipeline failures

6.2 RISK ASSESSMENT TOOLS

6.2.1 Mapping

National, state, and local databases were reviewed to locate available spatially based data relevant to this planning effort. Maps were produced using geographic information system (GIS) software to show the spatial extent of hazards when such datasets were available. These maps are included in the hazard profile chapters of this document and the jurisdiction-specific annexes in Volume 2.

6.2.2 Modeling

Overview

In 1997, FEMA developed the standardized Hazards U.S. (Hazus) computer simulation model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. Hazus was later expanded into a multi-hazard methodology with additional capabilities to estimate potential losses from hurricanes and floods.

Hazus is a GIS-based software program that provides a wide range of inventory data, such as demographics, building stock, critical facilities, transportation elements, and utilities. The program maps and displays hazard data and the results of damage and economic loss estimates for buildings and infrastructure. Its advantages include the following:

- Provides a consistent methodology for assessing risk across geographic and political entities.
- Provides a way to save data so that they can readily be updated as population, inventory, and other factors change and as mitigation planning efforts evolve.
- Facilitates review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.
- Supports grant applications by calculating benefits using FEMA definitions and terminology.
- Produces hazard data and loss estimates that can be used in communication with local stakeholders.
- Is administered by the local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

Levels of Detail for Evaluation

Hazus provides default data for inventory, vulnerability, and hazards; these default data can be supplemented with local data to provide a more refined analysis. The model can carry out three levels of analysis, depending on the level of detail of information about the planning area:

- **Level 1**—All of the information needed to produce an estimate of losses is included in the software's default data. These data are derived from national databases and describe in general terms the characteristic parameters of the planning area.
- **Level 2**—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics, and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
- **Level 3**—This level of analysis generates the most accurate estimate of losses. It requires detailed engineering and geotechnical information to customize it for the planning area.

6.3 RISK ASSESSMENT APPROACH

The risk assessments in this plan describe the risks associated with each identified hazard of concern. The following steps were used to assess the risk of each hazard:

- **Identify and profile each hazard**—The following information is given for each hazard:
  - A summary of past events that have impacted the planning area
  - Geographic areas most affected by the hazard
  - Event frequency estimates
  - Severity estimates
  - Warning time likely to be available for response.
- **Determine exposure to each hazard**—Exposure was assessed by overlaying hazard maps with an inventory of structures, facilities, and systems to decide which of them would be exposed to each hazard.
- **Assess the vulnerability of exposed facilities**—Vulnerability of exposed structures and infrastructure was evaluated by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and Hazus were used for this assessment for the flood, earthquake, and tsunami hazards. Outputs similar to those from Hazus were generated for other hazards, using data generated through GIS.

6.3.1 Earthquake, Flood and Hurricane

The following hazards were evaluated using Hazus:

- **Earthquake**—A Level 2 analysis was performed to assess earthquake vulnerability for the 500-year probabilistic event.
- **Flood**—A Level 2 user-defined analysis was performed for general building stock in flood zones and for critical facilities and infrastructure. Current flood mapping for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance and Hurricane Harvey flood events. To estimate damage that would result from a flood, Hazus uses pre-defined relationships between flood depth at a structure and resulting damage, with damage given as a percent of total replacement value. Curves defining these relationships have been developed for damage to structures and for damage to typical contents within a structure. By inputting flood depth data and known property replacement cost values, dollar-value estimates of damage were generated.

- **Hurricane**—A Level 2 analysis was performed to assess hurricane wind vulnerability for one historical and two probabilistic events:

  - Hurricane Alicia (1983) historical event.
  - The standard Hazus 20- and 100-year probabilistic events.

6.3.2 All Other Assessed Hazards

Historical datasets were not adequate to model future losses for most of the hazards of concern. However, areas and inventory susceptible to some of the hazards of concern were mapped by other means and exposure was evaluated. A qualitative analysis was conducted for other hazards using the best available data and professional judgment. The risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern because drought does not affect structures.

6.4 SOURCES OF DATA USED

6.4.1 Building and Cost Data

Replacement cost values and structure information derived from parcel and tax assessor data provided by Harris County were loaded into Hazus. As several of the planning partner jurisdictions extend into neighboring counties, parcel and tax assessor data for these areas were also acquired. When available, an updated inventory was used in place of the Hazus defaults for critical facilities and infrastructure.

Replacement cost is the cost to replace the entire structure with one of equal quality and utility. Replacement cost is based on industry-standard cost-estimation models published in *RS Means Square Foot Costs* (RS Means, 2018). It is calculated using the RS Means square foot cost for a structure, which is based on the Hazus occupancy class (i.e., multi-family residential or commercial retail trade), multiplied by the square footage of the structure from the tax assessor data. The construction class and number of stories for single-family residential structures also factor into determining the square foot costs.

6.4.2 Hazus Data Inputs

The following hazard datasets were used for the Hazus Level 2 analysis conducted for the risk assessment:

- **Flood:**

  - The effective Digital Flood Insurance Rate Map (DFIRM) for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance flood event. The DFIRM is effective as of May 2, 2019, with the latest incorporated letter of map revision dated May 13, 2019. A 1-percent-annual-chance flood depth grid provided by the Harris County Flood Control District was used as the base and updated to reflect the effective DFIRM and include coastal flood zones and the pending DFIRM (to be effective November 15, 2019). Updates were generated using the floodplain boundaries and the U.S. Geological Survey's (USGS) 2-meter digital elevation model. For areas where planning partner jurisdictions extended into neighboring counties, the flood depth grid was extended using the DFIRM data for those counties.
  - For the Hurricane Harvey flooding analysis, a depth grid of calculated inundation areas generated by FEMA Region VI in November 2017 was integrated into the Hazus model. This depth grid was created using high water mark data from Harris County Flood Control District, USGS, and Individual Assistance data.

- **Hurricane**—Probabilistic and Hurricane Alicia historical event data contained in Hazus were used for the analysis of the hurricane wind hazard.

- **Earthquake**—Hazus probabilistic data were used for the analysis of the earthquake hazard.

6.4.3 Other Local Hazard Data

Locally relevant information on hazards was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, emergency management specialists, and others. Data sources for specific hazards were as follows:

- **Dam Failure**—Lake Conroe Dam breach inundation area data was provided by Harris County.
- **Wildfire**—Wildfire threat and ignition density data was acquired from the Texas Wildfire Risk Assessment Portal.

6.4.4 Data Source Summary

Table 6-1 summarizes the data sources used for the risk assessment for this plan.

6.5 LIMITATIONS

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

- Approximations and simplifications necessary to conduct a study
- Incomplete or outdated inventory, demographic or economic parameter data
- The unique nature, geographic extent, and severity of each hazard
- Mitigation measures already employed
- The amount of advance notice residents have to prepare for a specific hazard event.

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate and should be used only to understand relative risk. Over the long term, Harris County will collect additional data to assist in estimating potential losses associated with other hazards.

Table 6-1. Hazus Model Data Documentation

Data	Source	Date	Format
PROPERTY DATA			
Harris County property parcel data	Harris County Appraisal District	2018	Digital (GIS) format
Harris County building footprints	Harris County Appraisal District	2018	Digital (GIS) format
Harris County surveyed first floor elevations	Harris County Flood Control District	2018	Digital (GIS) format
Harris County real property data	Harris County Appraisal District	2018	Digital (tabular) format
Fort Bend County certified parcel data	Fort Bend Central Appraisal District	2018	Digital (GIS) format
Fort Bend County building footprints	Fort Bend County	2016	Digital (GIS) format
Galveston County parcels	Galveston Central Appraisal District	2018	Digital (GIS) format
Galveston County certified roll	Galveston Central Appraisal District	2018	Digital (tabular) format
Building replacement cost	RS Means	2018	Paper format. Updated RS Means
POPULATION AND GROWTH DATA			
Population data	FEMA Hazus version 4.2 SP03	2010	Digital (GIS and tabular) format
Regional Growth Forecast (land use)	Houston-Galveston Area Council	2017	Digital (GIS) format
HAZARD AND TOPOGRAPHY DATA			
100-yr Flood depth grid (5-ft horizontal resolution)	Harris County Flood Control District	2019	Digital (GIS) format
Harris County Effective DFIRM (May 2, 2019; latest letter of map revision May 13, 2019)	FEMA	2019	Digital (GIS) format
Harris County Pending DFIRM (November 15, 2019)	FEMA	2019	Digital (GIS) format
Brazoria County Preliminary DFIRM (June 29, 2018)	FEMA	2018	Digital (GIS) format
Chambers County Effective DFIRM (January 19, 2018)	FEMA	2018	Digital (GIS) format
Fort Bend County Effective DFIRM (December 21, 2017; latest letter of map revision June 12, 2018)	FEMA	2018	Digital (GIS) format
Galveston County Preliminary DFIRM (February 28, 2018)	FEMA	2018	Digital (GIS) format
Montgomery County Effective DFIRM (December 21, 2017; latest letter of map revision June 12, 2018)	FEMA	2018	Digital (GIS) format
Waller County Effective DFIRM (February 18, 2009; latest letter of map revision September 30, 2016)	FEMA	2016	Digital (GIS) format
Depth Grid of Calculated Inundation Areas for Disaster Declared Counties, Texas, USA, DR-4332 (Hurricane Harvey)	FEMA	2017	Digital (GIS) format
Lake Conroe Dam breach analysis inundation area	Harris County	2018	Digital (GIS) format
Texas Wildfire Risk Assessment Portal Wildfire Threat & Ignition Density	Texas A&M Forest Service	Unknown	Digital (GIS) format
2-meter Digital Elevation Model	U.S. Geological Survey	2008	Digital (GIS) format

Data	Source	Date	Format
CRITICAL FACILITIES DATA			
Harris County facilities	Harris County	Unknown	Digital (GIS) format
Correctional institutions	Harris County	Unknown	Digital (GIS) format
Libraries	Harris County	2015	Digital (GIS) format
Post offices	Harris County	2015	Digital (GIS) format
Educational facilities	Harris County	2017	Digital (GIS) format
Elementary schools	Harris County & Houston Independent School District	2017	Digital (GIS) format
Middle schools	Harris County & Houston Independent School District	2017	Digital (GIS) format
High schools	Harris County & Houston Independent School District	2017	Digital (GIS) format
Universities & colleges	Harris County	2013	Digital (GIS) format
Community colleges	Harris County	2016	Digital (GIS) format
Texas Medical Center facilities	Texas Medical Center	2019	Digital (GIS) format
Medical facilities (Southeast Texas Regional Advisory Council)	Harris County	2018	Digital (GIS) format
County health facilities	Harris County	Unknown	Digital (GIS) format
Medical clinics	Harris County	2015	Digital (GIS) format
Hospices	Harris County	2015	Digital (GIS) format
Nursing/convalescent homes	Harris County	2013	Digital (GIS) format
Residential care homes	Harris County	2015	Digital (GIS) format
Adult care facilities	Harris County	2015	Digital (GIS) format
Airports	Harris County	2004	Digital (GIS) format
METRO transit centers	Houston METRO	2004	Digital (GIS) format
METRO bus park & rides	Houston METRO	2005	Digital (GIS) format
METRO rail stations	Houston METRO	2015	Digital (GIS) format
Highway bridges	TXDOT	2017	Digital (GIS) format
Communications facilities	Harris County	2012	Digital (GIS) format
Water treatment plants	Harris County	2009	Digital (GIS) format
Municipal wastewater treatment plants	Harris County	2017	Digital (GIS) format
Wastewater lift stations	Harris County	2009	Digital (GIS) format
Emergency operations centers	Harris County	Unknown	Digital (GIS) format
Police stations	Harris County, Houston Police Department, Harris County Sheriff's Office	2009-2016	Digital (GIS) format
Fire stations	Greater-Harris County 911	2013	Digital (GIS) format
Community centers	Harris County	2015	Digital (GIS) format
Churches	Harris County	2015	Digital (GIS) format
Synagogues	Harris County	2015	Digital (GIS) format
Mosques	Harris County	Unknown	Digital (GIS) format
Museums	Harris County	2015	Digital (GIS) format
Zoos	Harris County	2015	Digital (GIS) format
Tier II facilities	Harris County	Unknown	Digital (GIS) format

7. COASTAL EROSION

7.1 GENERAL BACKGROUND

Coastal erosion is the gradual breakdown and movement of shoreline due to physical and chemical processes of water, wind, and meteorological conditions. The extent of coastal erosion is measured in terms of loss of shoreline. Natural erosion has occurred since the Earth's formation and continues at a slow and uniform rate.

Note: The risk from this hazard is considered to be low to negligible, mainly because of the lack of historical occurrence in the planning area. However, this hazard profile is provided in order to address the possibility of a future event in the planning area. This positions the planning partnership for benefit eligibility should an event of this type occur during the performance period of this plan.

7.1.1 Causes

Soil erosion consists of two types:

- Wind erosion can cause significant soil loss. Winds blowing across sparsely vegetated or disturbed land can pick up soil particles and carry them through the air, thus displacing them.
- Water erosion can occur over land or in streams and channels. Water erosion that takes place over land may result from raindrops, shallow sheets of water flowing off the land, or surface flow, which is concentrated in areas of lower elevation. Stream channel erosion may occur as the volume and velocity of water flow increases enough to cause movement of the streambed and bank soils.

Major storms such as hurricanes may cause significant erosion by combining high winds with heavy surf and storm surge to significantly impact the rate of shoreline erosion.

An area's potential for erosion is determined by the following factors:

- **Soils—**Soils composed of a large percentage of silt and fine sand are most susceptible to erosion. As the clay and organic material content of soils increases, the potential for erosion decreases. Well-drained and well-graded gravels and gravel-sand mixtures are the least likely to erode. Coarse gravel soils are highly permeable and have a good capacity for absorption, which can prevent or delay the amount of surface runoff.
- **Vegetative Cover**—Vegetative cover can help control erosion by shielding the soil surface from falling rain, absorbing water from the soil, and slowing the velocity of runoff.
- **Topography**—Runoff is affected by the topography of the area, including size, shape and slope. The greater the slope length and gradient, the more potential an area has for erosion.
- **Climate**—Climate can affect the amount of runoff, especially the frequency, intensity and duration of rainfall and storms. When rainstorms are frequent, intense, or of long duration, erosion risks are increased, all other factors held constant. Seasonal changes in temperature and rainfall amounts define the period of highest erosion risk.

7.1.2 Impacts

The primary concerns with regard to coastal erosion relate to the economic impacts that result when property and infrastructure close to the eroding coasts lose their natural protection from the water and waves or are affected by destabilization of the land upon which they were constructed. Environmental impacts from erosion include the loss of animal habitats and esthetic losses. Fishing industries that depend on coastal habitats can suffer losses from changes caused by coastal erosion. A loss of tourism can result in similar economic impacts.

7.1.3 Mitigation

During the past 25 years, the importance of erosion control has gained increasing attention. Erosion control measures consistent with sound agricultural and construction operations are needed to minimize the adverse effects associated with settling out of soil particles due to water or wind. Increased government regulatory programs and public concern in the United States have resulted in a wide range of erosion control products, techniques, and analytical methodologies. The preferred method of erosion control in recent years has been the restoration of vegetation.

7.1.4 Texas Coastline Erosion

According to the Texas General Land Office, Texas once had one of the highest erosion rates in the country. It is estimated that over 27,000 acres of gulf shoreline were lost to coastal erosion from the mid-1800s through 1982. The geomorphic features that span the Texas Gulf coast include deltaic headlands, peninsulas, barrier islands, and spits, and their depositional origins provide clues on sediment erodibility. Variations in the wave climate impacting those features influence the amounts of sediment that are supplied to the littoral drift (the amount of sediment carried along the shoreline) as well as the direction the sediment travels. Elevations of beaches and dunes can control whether episodic high wave and tidal events allow overwash and landward barrier migration or merely erosion of the beach-face that can be repaired by quieter waves.

If left unmitigated or managed, the severity of the coastal erosion hazard in Texas could significantly impact critical assets in identified coastal erosion zones. Along the 367 Gulf miles and more than 3,300 bay miles of Texas shoreline, erosion has resulted in habitat loss, navigational challenges, and structures on the beach or teetering on the line of vegetation threatening public access.

7.2 HAZARD PROFILE

7.2.1 Past Events

No historical damage values could be identified for losses due to erosion within the planning area. In fact, Figure 7-1 shows that shoreline areas closest to the Harris County planning area, at the mouth of Galveston Bay, have been gaining shoreline rather than losing it since the 1930s.

7.2.2 Location

The Harris County planning area has a minimal coastal exposure. Coastal erosion is not likely to occur within any of the planning area.

Source: Texas General Land Office, 2014

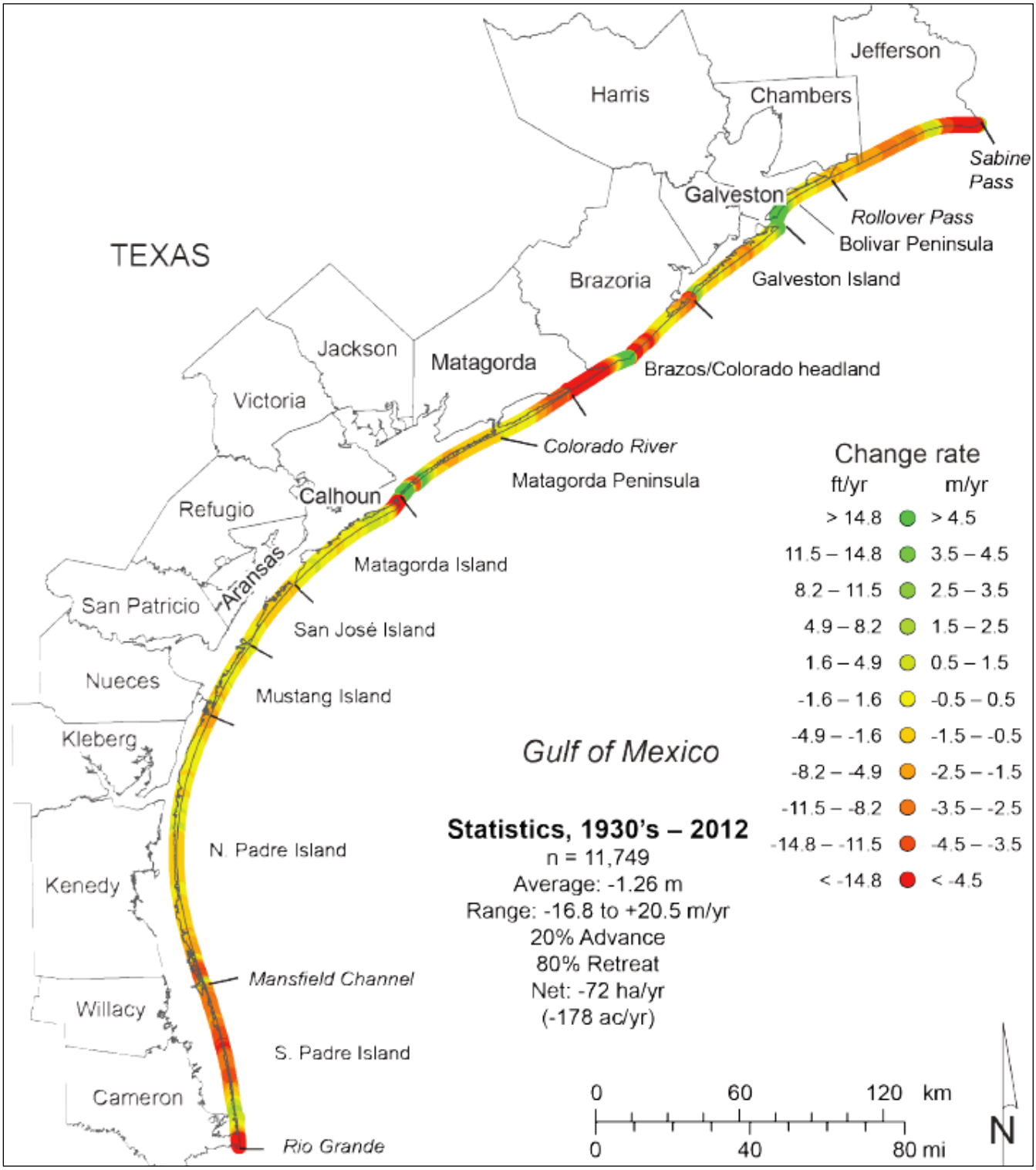


Figure 7-1. Shoreline Changes Between 1930s and 2012

7.2.3 Frequency

The Harris County planning area is not projected to be impacted by the coastal erosion hazard. Based on the recorded erosion rates for the Texas Gulf Coast counties from the 1930s to 2012 (Figure 7-1), the planning area has not experienced significant losses in land or shoreline due to coastal erosion, and none should be expected in the future.

7.2.4 Severity

Once again, the Harris County planning area is not projected to be impacted by the coastal erosion hazard.

7.2.5 Warning Time

The warning time for a coast erosion hazard event is associated with the monitoring of erosion rates in areas susceptible to the costal erosion hazard. The key for warning for this hazard in knowing the linear distance from the shorelines that are experiencing erosion to the assets that are at risk. That distance can be divided by the observed erosion rates, and a lead time can be determined for response or even preparedness options.

7.3 SECONDARY HAZARDS

No secondary hazards have been identified that are likely to result from coastal erosion in the planning area.

7.4 EXPOSURE AND VULNERABILITY

For reasons described above, a detailed hazard exposure and vulnerability assessment was not performed for coastal erosion. It can be assumed that the risk of coastal erosion in the Harris County planning area and all participating jurisdictions, as well as potential losses due to coastal erosion impact, is negligible.

7.5 FUTURE TRENDS IN DEVELOPMENT

Any future development within the Harris County planning area is not anticipated to interface any coastal erosion hazards during the 5-year performance period for this plan. This is due to the fact that there are no clearly identified areas of risk to this hazard as of this plan update.

7.6 SCENARIO

There are currently no identified scenarios for this hazard that could impact the planning area during the 5-year performance period for this plan.

7.7 ISSUES

Harris County and its planning partners will continue to monitor coastal erosion hazard potential within the planning area, especially as coastal hydrologic and hydraulic conditions change due to impacts from sea-level rise in the future.

8. DAM OR LEVEE FAILURE

8.1 GENERAL BACKGROUND

8.1.1 Definition

Dams

A dam is an artificial barrier that has the ability to store water, wastewater, or liquid-borne materials for many reasons—flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control. Many dams fulfill a combination of these functions. They are an important resource in the United States (Association of State Dam Safety Officials, 2013).

Dams can be classified according to their purpose, the construction material or methods used, their slope or cross-section, the way they resist the force of the water pressure, or the means used for controlling seepage. Materials used to construct dams include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, plastic, rubber, and combinations of these.

Levees

A levee is a physical barrier constructed to protect areas from rising floodwaters. Levees are not feasible in most cases in Harris County for a variety of reasons. Levees typically remove valuable floodplain storage and block the ability of the channel to move water. There are also concerns with rainfall that falls on the levee itself. Most important is the possibility for catastrophic and sudden failure under extreme flood events, potentially resulting in loss of life and total destruction of property.

8.1.2 Causes of Failure (Breach)

Dams

Dam failures typically occur when spillway capacity is inadequate and excess flow overtops the dam, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-filled water that rushes downstream, damaging anything in its path. Dam failures in the United States typically occur in one of four ways:

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining 6 percent of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States are secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage (Association of State Dam Safety Officials, 2016).

Levees

A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. Earthen levees can be damaged in several ways. Strong river currents and waves can erode the surface. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

8.1.3 Impacts of Failure

Dams

More than a third of the country's dams are 50 or more years old. Approximately 14,000 of those dams pose a significant hazard to life and property if failure occurs. There are about 2,000 unsafe dams in the United States, located in almost every state. Dam hazard definitions, as accepted by the National Interagency Committee on Dam Safety, are as follows:

- **Low Hazard Potential—**Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/ or environmental losses. Losses are principally limited to the dam owner's property.
- **Significant Hazard Potential—**Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or other concerns. Significant hazard potential classification dams are often located in rural or agricultural areas but could be located in areas that contain large populations and significant infrastructure.
- **High Hazard Potential—**Dams assigned the high hazard potential classification are those where failure or mis-operation will likely cause the loss of human life.

Levees

The resulting torrent from a levee breach can quickly swamp a large area behind the failed levee with little or no warning. When a levee system fails or is overtopped, severe flood damage can occur due to increased water surface elevation associated with levees and the resulting increase in water velocity.

8.1.4 Regulatory Oversight

Dams

National Dam Safety Act

Potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of the majority of dams in the country; exceptions include the following:

- Dams under jurisdiction of the Bureau of Reclamation, Tennessee Valley Authority, or International Boundary and Water Commission
- Dams constructed pursuant to licenses issued under the Federal Power Act
- Dams that the Secretary of the Army determines do not pose any threat to human life or property.

The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect lives and property. The National Dam Safety Program is a partnership among states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most of the dams in the United States.

Texas State Dam Safety Program

The Texas Commission on Environmental Quality Dam Safety Program monitors and regulates private and public dams in Texas. The program periodically inspects dams that pose a high or significant hazard and makes recommendations and reports to dam owners to help them maintain safe facilities. This program is governed by Texas Administrative Code Title 30, Part 1, Chapter 299: Dams and Reservoirs.

Effective September 1, 2013, dams are exempt from safety requirements if they meet all of the following criteria:

- Are located on private property
- Have a maximum impoundment capacity of less than 500 acre-feet
- Are classified as low or significant hazard
- Are located in a county with a population of less than 350,000 (per the 2010 census)
- Are not located within the corporate limits of a municipality.

Owners of exempt dams still have to comply with maintenance and operation requirements. There is no exemption expiration date. Figure 8-1 shows the counties covered by the population exemption. Harris County is not an exempt county.

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers operates and maintains approximately 700 dams nationwide. It is also responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety. The Corps maintains the National Inventory of Dams, which contains information about a dam's location, size, purpose, type, last inspection and regulatory status (U.S. Army Corps of Engineers, 2019).

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) cooperates with a large number of federal and state agencies to ensure and promote dam safety. More than 3,000 dams are part of regulated hydroelectric projects in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important.

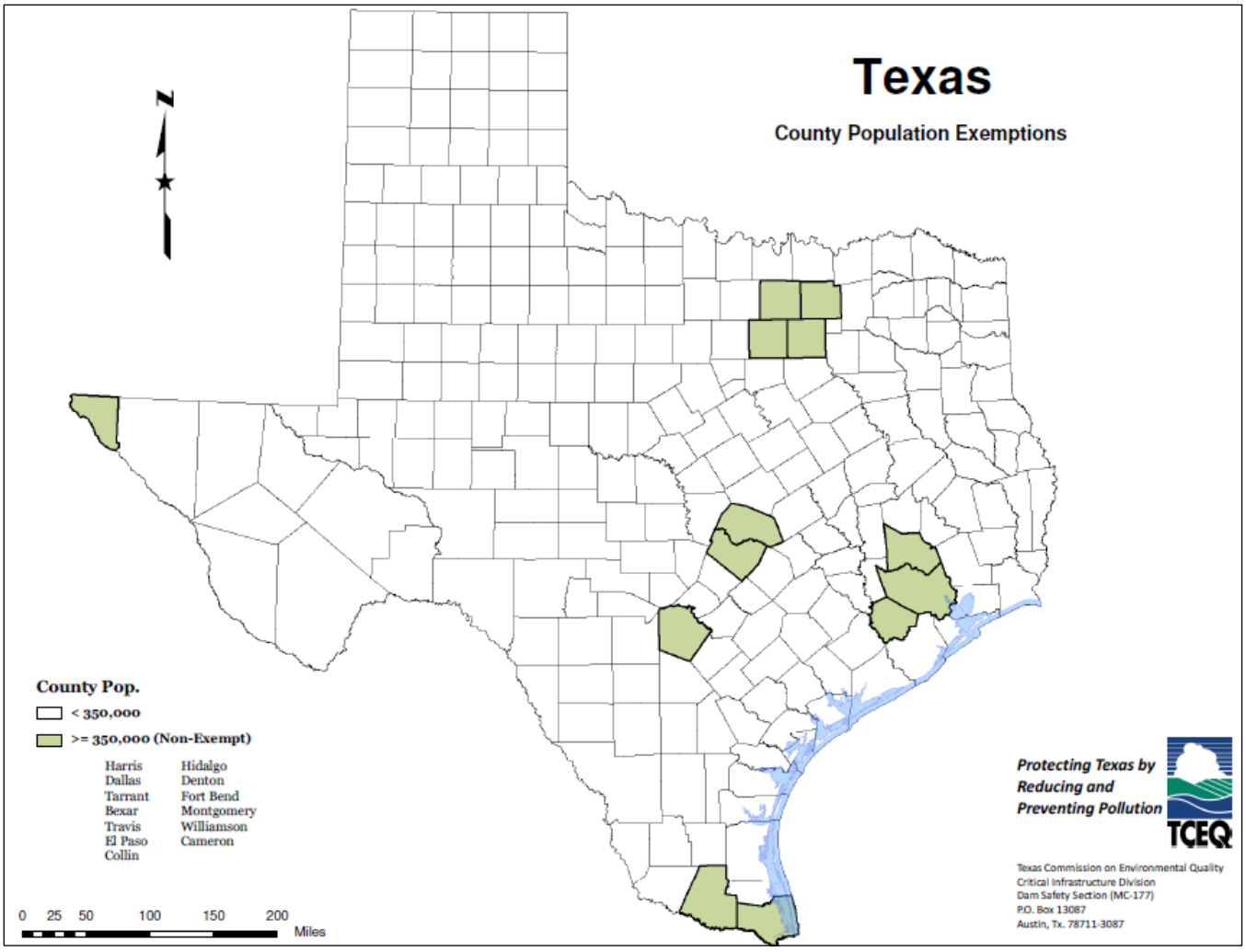


Figure 8-1. Counties Exempt from the Texas Dam Safety Program

FERC inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters), or with a total storage capacity of more than 2,000 acre-feet.

FERC monitors seismic research and applies it in performing structural analyses of hydroelectric projects. FERC also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

Levees

Corps of Engineers and FEMA Levee Oversight

The Corps and FEMA have differing roles and responsibilities related to levees. The Corps addresses operation and maintenance, risk communication, risk management, and risk reduction issues as part of its responsibilities under the Levee Safety Program. FEMA addresses mapping and floodplain management issues related to levees, and it accredits levees as meeting requirements set forth by the National Flood Insurance Program.

Depending on the levee system, the Corps and FEMA may be involved with a levee sponsor and community independently or jointly. The two agencies' long-term goals are similar: to reduce risk and lessen the devastating consequences of flooding. Corps and FEMA partnering activities related to levees include the following:

- Joint meetings with levee sponsors and other stakeholders
- Integration of levee information into the National Levee Database
- State Silver Jackets teams
- Sharing of levee information
- Targeted task forces to improve program alignment.

Coordination between the Corps and FEMA on levees is now standard within many of each agency's policies and practices. Over the past several years, both agencies coordinated policies where appropriate; jointly participated in meetings with stakeholders; and participated in many multiagency efforts, such as the National Committee on Levee Safety, the Federal Interagency Floodplain Management Task Force, and the Silver Jackets Program, which brings together state, federal, tribal, and local agencies to learn from each other and apply their knowledge to reduce risk from hazards.

National Committee on Levee Safety

Congress created the National Committee on Levee Safety—made up of representatives from state, regional, and local agencies; the private sector; the Corps; and FEMA—to develop a national levee safety program. The Committee has been working toward this goal since October 2008.

Maintenance Requirements

No levee provides protection from events for which it was not designed, and levees require maintenance to continue to provide the level of protection they were designed and built to offer. Maintenance responsibility belongs to a variety of entities including local, state, and federal government and private landowners. Well-maintained levees may obtain certification through independent inspections.

Levees may not be certified for maintaining flood protection when the levee owner does not maintain the levee or pay for an independent inspection. The impacts of an un-certified levee include higher risk of levee failure. In addition, insurance rates may increase because FEMA identifies on Flood Insurance Rate Maps that the structures are not certified to protect from a 1-percent annual chance flood event.

8.2 HAZARD PROFILE

8.2.1 Past Events

There is no record of significant dam failure in the Harris County planning area. While technically not considered "dam failures," dam operation by design can cause significant impacts during flood events. This was evidenced during Hurricane Harvey, most notably at the Lake Houston Dam. During Hurricane Harvey, water entered the lake at a rate of 430,000 cubic feet per second, causing the lake to reach an elevation of 53.01 feet. The lake was not able to release water fast enough, which caused water to back up and contributed to the flooding of thousands of homes and businesses in the Lake Houston area.

8.2.2 Location

Dams

The National Inventory of Dams lists 30 dams in Harris County (see Table 8-1). Figure 8-2 shows the locations of these dams within the planning area. Table 8-2 provides the most recent inspection dates for these dams. Dam failure inundation mapping to the scope and scale needed for risk and vulnerability assessment of the dam failure hazard was not available to support this plan update.

Table 8-1. Harris County Dam Hazard Data

Name	National ID #	Purpose[a]	Water Course	Owner	Year Built	Dam Type[b]	Crest Length (feet)	Height (feet)	Storage Capacity (mi^2)	Spillway Type[c]
Seaberg Reservoir No. 3 Dam	TX03384	I	Off Ch-Tr-Adlong Ditch	Roy Seaberg	1948	RE	6750	8	267	N
Seaberg Reservoir No. 3 Dam	TX03385	I	Off Ch-Cedar Bayou	Roy Seaberg	1953	RE	10,133	8	713	N
Seaberg Levee No. 2	TX03386	I	Off Ch-Cedar Bayou	Ra Seaberg Et Al	1965	RE	6000	10	790	N
Seaberg Levee No. 1	TX03387	I	Off Ch-Cedar Bayou	Ra Seaberg Et Al	1949	RE	2800	10	160	N
Hegar Brothers Lake Dam	TX03389	I	Off Ch-Little Cypress Creek	Hegar Brothers	1962	RE	2640	9	414	N
Dennison Lake Dam	TX03391	I	Off Ch-Mound Creek	As Dennison	1960	RE	7500	8	568	N
Adams Lake Dam	TX03392	S	Tr-Spring Creek	Bud Adams Ranches Inc	1960	RE	1140	19	137	N
Japhet Lake Dam	TX03393	P	Tr-Spring Creek	EC Japhet	1960	RE	1230	18	648	N
Lynch Lake Dam	TX03394	P	Tr-Spring Creek	Bud Adams Ranches Inc	1960	RE	720	14	112	N
Cedar Bayou Lake Dam	TX03397	I	Off Ch-Cedar Bayou	Gene Brown	1969	RE	10750	9	531	N
Warren Lake Dam	TX03398	R	Rock Hollow Creek	Warren Group Inc; Katy Prairie Conservancy	1961	RE	2009	19	2000	U
Chudleigh Farms Dam No. 1	TX03403	IP	Tr-Cypress Creek	Chudleigh Farms Inc	1958	RE	800	8	108	N
Chudleigh Farms Dam No. 2	TX03404	I	Off Ch-Cypress Creek	Chudleigh Farms Inc	1970	RE	2550	10	90	N

Name	National ID #	Purpose[a]	Water Course	Owner	Year Built	Dam Type[b]	Crest Length (feet)	Height (feet)	Storage Capacity (mi^2)	Spillway Type[c]
House Lake Dam	TX03405	I	Off Ch-Cypress Creek	Calvin House	1962	RE	--	10	120	N
Fisher Lake Dam	TX03406	I	Off Ch-Cypress Creek	H Fisher	1962	RE	--	8	144	N
Hegar Lake Dam	TX03408	I	Off Ch-Langham Creek	Lh Hegar	1970	RE	12600	8	960	N
Cypress Farms Lake No. 1 Dam	TX03409	O	Off Ch-Langham Creek	Cypress Farms	1970	RE	2500	9	225	N
Lynchburg Reservoir Dam	TX03413	O	Off Ch-San Jacinto River	Coastal Water Authority	1976	RE	15315	35	5188	N
Highlands Reservoir Dam	TX03414	S	Off Ch-Goose Creek	San Jacinto River Authority	1944	RE	34700	20	5885	U
Sheldon Reservoir Dam	TX03415	R	Carpenters Bayou	Texas Parks And Wildlife Department	1944	RE	36600	12	21138	U
Lake Houston Dam	TX03416	IORS	San Jacinto River	City Of Houston	1954	CBCNRE	12097	65.8	281800	U
Buckhorn Lake Dam	TX04391	P	Granite Creek	George Faulkner	1967	RE	2238	9	256	N
Sludge Fill Pond Levee No. 1	TX04819	O	Off Ch-San Jacinto River	St Regis Paper Company	1976	RE	3000	19	71	N
Sludge Pond Levee No. 1	TX04820	O	Off Ch-San Jacinto River	Champion International Corporation	1966	RE	2450	12	53	N
Ramey Lake Dam	TX05858	I	Off Ch-Cypress Creek		1953	RE	10530	7	650	N
Teal Lake Dam	TX05859	I	Off Ch-Cypress Creek		1953	RE	6560	8	325	N
Cook Levee	TX06277	I	Tr-Buffalo Bayou	Pv Cook	1979	RE	2728	7	70	N
Logenbaugh Estate Dam	TX06278	I	Tr- Buffalo Bayou	Logenbaugh Estate	1981	RE	3728	9	95	U
Lower Greens Bayou Regional Detention Facility	TX06947	C	Greens Bayou	Harris County Flood Control District	1995	CNRE	21400	47	4684	N
Bayport Reservoir Dam	TX07291	S	Off-Channel Near Armand Bayou	Coastal Water Authority	1975	PGRE	3380	16	326	U

Source: Texas Commission on Environmental Quality and National Inventory of Dams

a. I= Irrigation, S= Water Supply, P=Fire Protection, R= Recreation, O= Other, C= Flood Control

b. RE= Earth, ER= Rockfill, PG=Gravity, CB=Buttress, VA=Arch, MV= Multi-Arch, CN= Concrete, MA = Masonry, St=Stone, TC=Timber Crib, OT=Other

c. C=Controlled, U= Uncontrolled, N=None

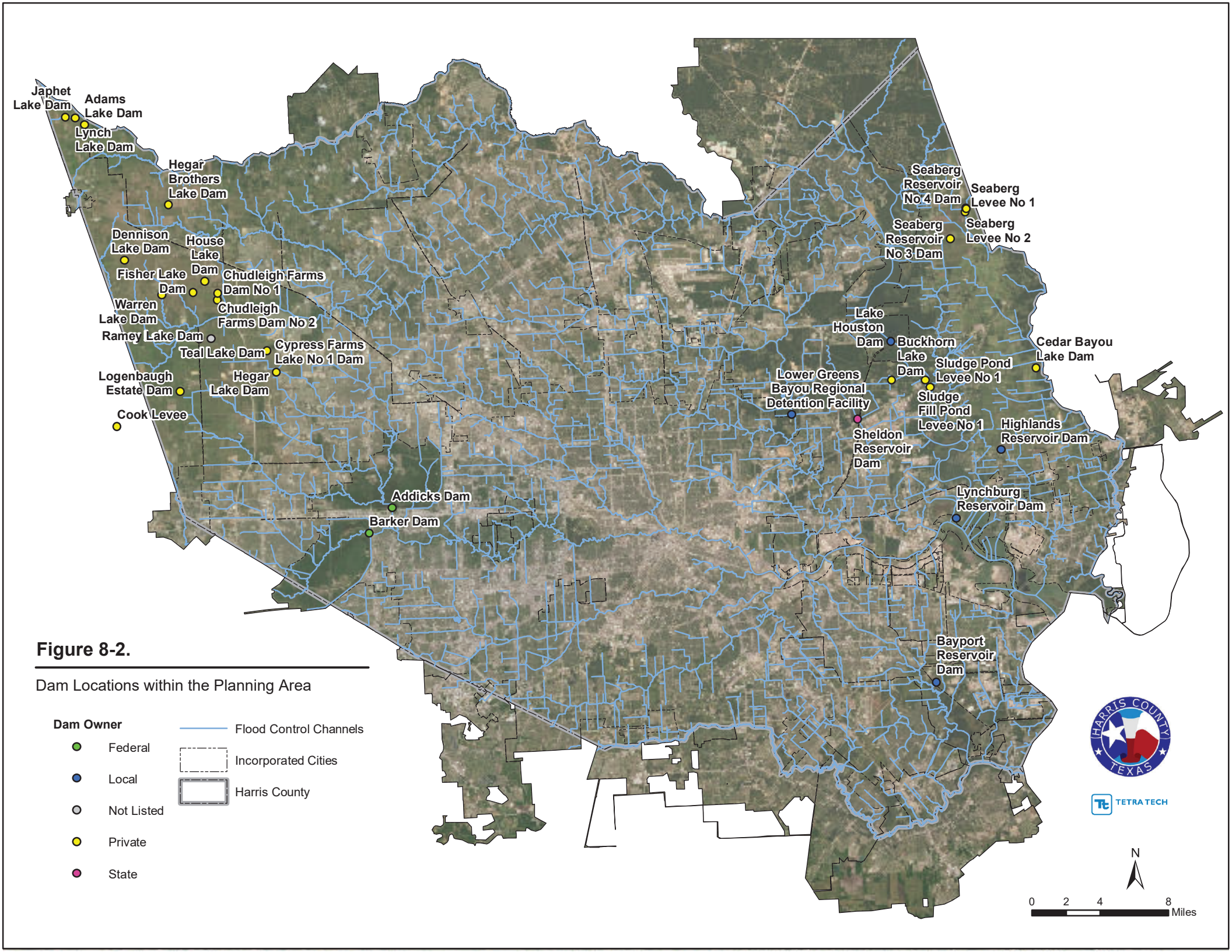


Figure 8-2.

Dam Locations within the Planning Area

Table 8-2. Harris County Dam Inspection Dates

Dam Name	Inspection Date	Dam Name	Inspection Date
Seaberg Reservoir No. 3 Dam	3/8/1971	Hegar Lake Dam	None Reported
Seaberg Reservoir No. 4 Dam	2/10/1982	Cypress Farms Lake No. 1 Dam	None Reported
Seaberg Levee No. 2	3/8/1971	Lynchburg Reservoir Dam	8/11/2011
Seaberg Levee No. 1	3/8/1971	Highlands Reservoir Dam	9/17/2015
Hegar Brothers Lake Dam	None Reported	Sheldon Reservoir Dam	10/25/2016
Dennison Lake Dam	None Reported	Lake Houston Dam	9/10/2012
Adams Lake Dam	None Reported	Buckhorn Lake Dam	1/21/1987
Japhet Lake Dam	None Reported	Sludge Fill Pond Levee No. 1	None Reported
Lynch Lake Dam	None Reported	Sludge Pond Levee No. 1	None Reported
Cedar Bayou Lake Dam	2/12/1982	Ramey Lake Dam	2/3/1983
Warren Lake Dam	2/23/2011	Teal Lake Dam	2/3/1983
Chudleigh Farms Dam No. 1	10/20/1976	Cook Levee	None Reported
Chudleigh Farms Dam No. 2	None Reported	Logenbaugh Estate Dam	None Reported
House Lake Dam	None Reported	Lower Greens Bayou Regional Detention Facility	2/18/2011
Fisher Lake Dam	3/8/1971	Bayport Reservoir Dam	8/10/2011

Source: U.S. Army Corps of Engineers, 2019

HCOHSEM provided digital mapping of inundation areas for the Conroe Dam, which is in Montgomery County but would impact portions of Harris County should it fail. Table 8-3 provides hazard data for Conroe Dam. This was the only available dam failure inundation mapping in digital format suitable for risk analysis for this plan update. This mapping was the sole basis for the exposure and vulnerability analyses for this hazard assessment. The need for further inundation mapping has been identified as an issue by this assessment. The Planning Partnership has identified a county-wide action in this plan to address this need.

Table 8-3. Conroe Dam Hazard Data

Name	National ID #	Purpose[a]	Water Course	Owner	Year Built	Dam Type[b]	Crest Length (feet)	Height (feet)	Storage Capacity (mi^2)	Spillway Type[c]
Conroe Dam	TX00097	IS	West Fork San Jacinto River	San Jacinto River Authority	1973	RE	11,800	82	444	C

Source: Texas Commission on Environmental Quality and National Inventory of Dams

a. I= Irrigation, S= Water Supply, P=Fire Protection, R= Recreation, O= Other, C= Flood Control

b. RE= Earth, ER= Rockfill, PG=Gravity, CB=Buttress, VA=Arch, MV= Multi-Arch, CN= Concrete, MA = Masonry, St=Stone, TC=Timber Crib, OT=Other

c. C=Controlled, U= Uncontrolled, N=None

Levees

The Corps of Engineers National Levee Database identifies three levee systems in the Harris County planning areas, with a total length of 3 miles and an average age of 15 years. These systems are described below.

Cypress Creek System

This system is located along Cypress Creek in the community of Spring, north of Houston. The length of embankment for this system is 0.92 miles. The system protects a population of 384 and 125 structures with an estimated value of $46.1 million. This system is accredited by FEMA and is mapped as such on the Flood Insurance Rate Map (FIRM) for its area.

Lynchburg Pump Station

The Lynchburg Pump Station system was federally constructed in 2002. The system is 4,012 feet long, consisting of 2,851 feet of earthen levee, and 1,161 feet of floodwalls. Both ends of the system tie into the existing reservoir levee on the north side of the project. A southern portion of the levee system was integrated into the Independence Parkway roadway. To facilitate crossing for the system, there is a single swing gate closure structure. A gravity drainage structure allows passage of rainwater from within the system.

The Lynchburg Pump Station system reduces damage associated with hurricane storm surge to the pump station that provides drinking water for the City of Houston. No permanent residents are located inside the levee area. Total protected property value is estimated to be $1 million. The consequences associated with inundation to the protected area also include potentially leaving Houston without enough drinking water. The system is currently operated and maintained by Coastal Water Authority.

Spring Creek System

This system is located along Spring Creek in unincorporated Harris County. The length of embankment for this system is 0.98 miles. The system protects a population of 1,271 and 446 structures with an estimated value of $218 million. This system is accredited by FEMA and is mapped as such on the FIRM for its area.

8.2.3 Frequency

All dams face a “residual risk” of failure, which represents the risk that conditions may exceed those for which the dam was designed. For example, dams may be designed to withstand a probable maximum precipitation, defined as “theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year” (American Meteorological Society, 1959). The chance of occurrence of a precipitation event of a greater magnitude than that represents residual risk for such dams. This in turn represents a theoretical probability of future occurrence for a dam failure event, though the probability of an event exceeding the assumed maximum is not generally calculated as part of dam design.

Levee failure probabilities are considered to be higher than dam failure probabilities because levees are often exposed to more adverse conditions associated with high velocity flood flows, such as erosion and scour. Many levees are designed to overtop in high flow conditions; such overtopping is referred to as design failure.

Since there are no historical occurrences of dam or levee failure within the Harris County planning area and participating jurisdictions, no probability of occurrence can be calculated for the planning area. For the risk assessment for this plan update, the probability of occurrence for both dam and levee failure is considered “low”,.

8.2.4 Severity

Dam failure can be catastrophic to all life and property downstream. The U.S. Army Corps of Engineers developed the classification system shown in Table 8-4 for the hazard potential of dam failures. The severity of a dam failure is affected by the depth and velocity of flows resulting from a breach. That is why digital inundation mapping that can be used to create flood depth grids and thus support depth/damage correlations is critical to risk analysis for dam failure. For example, the flood depth grids for the Conroe Dam inundation mapping utilized in this assessment range from 0 to 32 feet. This type of data allows analysts to estimate damage (as presented in Section 8.5) using models like FEMA’s Hazus risk assessment platform. Table 8-5 provides some severity statistics for the Conroe Dam inundation area based from geospatial analysis.

Table 8-4. Corps of Engineers Hazard Potential Classification

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers, 2011

Table 8-5. Conroe Dam Severity Statistics

Statistic	Structure Count
Structures are in the inundation area	6,642
Number of structures with flood depths of zero feet	758
Number of structures with depths greater than zero and less than or equal to 1 foot of flooding	642
Number of structures with flood depths greater than 1 foot and less than or equal to 5 feet of flooding	1,775
Number of structures with flood depths greater than 5 feet and less than or equal to 10 foot of flooding	2,337
Number of structures with flood depths greater than 10 feet and less than or equal to 15 foot of flooding	642
Number of structures with flood depths greater than 15 feet and less than or equal to 20 foot of flooding	257
Number of structures with flood depths greater than 20 feet and less than or equal to 25 foot of flooding	132
Number of structures with flood depths greater than 25 feet	19

According to the Texas Commission on Environmental Quality (TCEQ) there are seven dams in the planning area classified as High Hazard Potential. Three of these serve only as flood control structures on retention basins and suspend water only when the retention areas become saturated, not on a continuous basis. Therefore, these dams do not pose a substantial threat to the surrounding area most of the time. Information as to which of the dams listed in Table 8-1 are categorized as High Hazard Potential is not readily available via state or national sources (TCEQ or the National Inventory of Dams). This has been identified as a significant data gap for assessing the risk for dam failure hazards.

In the event of a levee failure, floodwaters may ultimately inundate the protected area landward of the levee. The extent of inundation is dependent on the flooding intensity. Failure of a levee during a 1-percent annual chance flood will inundate the floodplain previously protected by the levee. Residential and commercial buildings nearest the levee overtopping or breach location will suffer the most damage from the initial embankment failure flood wave. Landward buildings will be damaged by inundation.

8.2.5 Warning Time

Advance Warning of Failure

Warning time for dam failure varies depending on the cause of the failure. Events of extreme precipitation or massive snowmelt can be predicted in advance, so evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake or human caused activities, there may be no or limited warning time.

Time for Failure to Occur

The process of the dam failure affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted, or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours.

8.3 SECONDARY HAZARDS

Dam and levee failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards are landslides and bank erosion. Levee failures can also cause environmental incidents due to hazardous materials releases when floodwaters infiltrate facilities that store these types of materials.

8.4 EXPOSURE

The Texas Commission on Environmental Quality and the U.S. Army Corps of Engineers do not currently have inundation studies or data to estimate potential losses and vulnerability due to dam/levee failures within the Harris County planning area. Exposure to dam failure hazard was assessed by use of spatial analysis. The inundation area for the Conroe Dam, for which inundation mapping was available, was the sole basis for this analysis. Using qualitative approaches, the following communities within the planning area are estimated to have some degree of dam failure exposure, due to their location downstream of one of the dams listed in Table 8-1:

- Baytown
- Bunker Hill Village
- Deer Park
- Houston
- Humble
- La Porte
- Pasadena
- Unincorporated Harris County

The degree of this exposure is not known, due to the lack of digital inundation mapping for the listed dams.

8.4.1 Population

All residents in a dam failure inundation zone would be exposed to the risk of a dam failure. Table 8-6 summarizes the at-risk population in the planning area. Planning partners with no exposure to this risk are omitted from the table.

Table 8-6. Population Living in the Conroe Dam Failure Inundation Area

Jurisdiction	Affected Population	% of Total Population in the Jurisdiction
Baytown	172	0.22%
Houston	14,544	0.64%
Humble	1,794	11.18%
Unincorporated County	7,616	0.40%
Total	**24,126**	**0.5%**

8.4.2 Property

Based on assessor parcel data, the Hazus model estimated that there are 6,642 planning area structures within the Lake Conroe dam failure inundation area. The value of these exposed buildings was generated using Hazus, as summarized in Table 8-7. This methodology estimated $5 billion worth of building-and-contents exposure to dam failure inundation, representing 0.54 percent of the total replacement value of the planning area. Planning partners with no exposure to this risk are omitted from the table.

Table 8-7. Exposure and Value of Structures in Lake Conroe Dam Failure Inundation Areas

Jurisdiction	Number of Buildings Exposed	Value Exposed			Exposed Value as % of Total Replacement Value
		Structure	Contents	Total	
Baytown	45	9,471,687	4,735,844	14,207,531	0.12%
Houston	3,635	1,816,286,365	1,059,629,339	2,875,915,704	0.59%
Humble	572	515,847,360	476,530,660	992,378,020	21.71%
Unincorporated County	2,390	729,489,007	438,488,556	1,167,977,563	0.36%
Total	**6,642**	**$3,071,094,419**	**$1,979,384,399**	**$5,050,478,818**	**0.54%**

GIS analysis was used to determine the occupancy types of parcels within the mapped inundation areas. Over 90 percent of the 6,642 exposed parcels are residential occupancy. Figure 8-3 shows the distribution of general planning area land use types in the dam inundation areas.

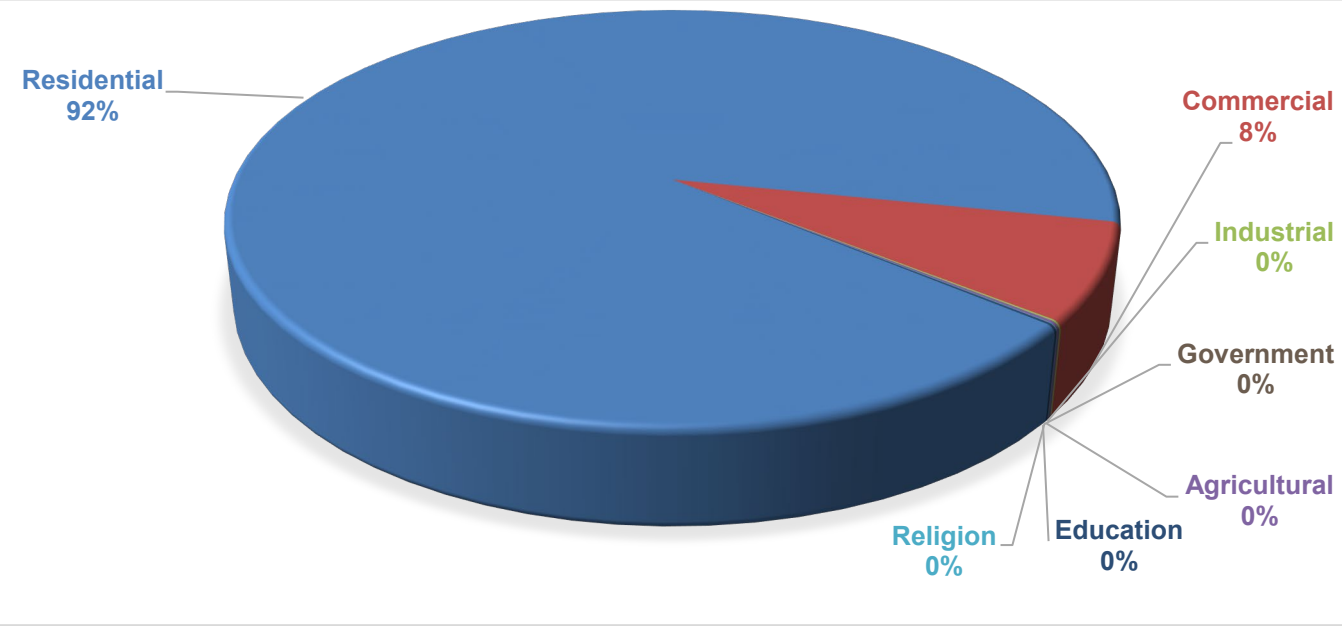


Figure 8-3. Occupancy Types in Lake Conroe Dam Inundation Areas

8.4.3 Critical Facilities

Figure 8-4 shows critical facilities in the Lake Conroe Dam inundation area by facility type. The total count of critical facilities and infrastructure in the dam failure inundation zone (106) represents 1.8 percent of the planning area total of 5,849.

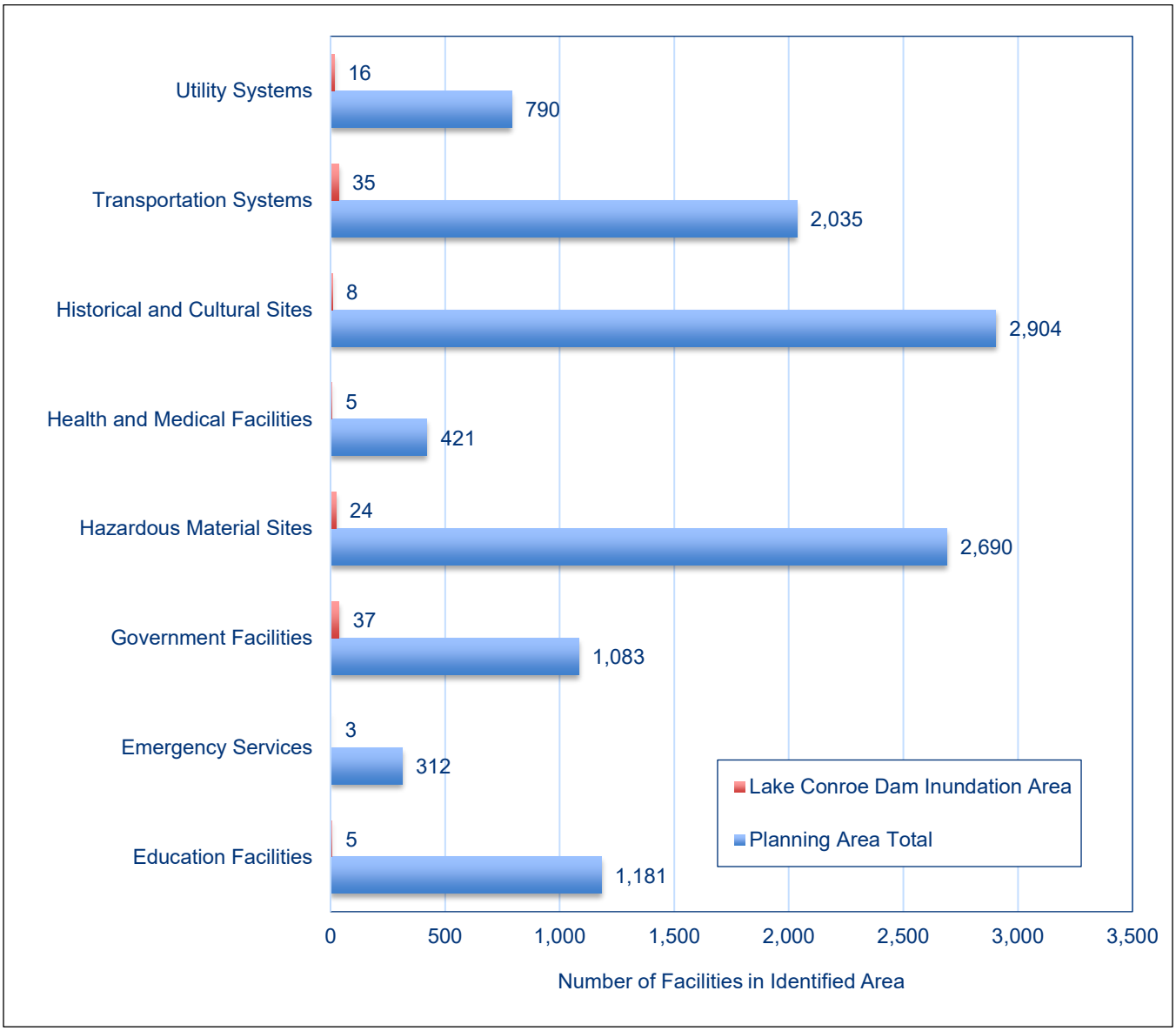


Figure 8-4. Critical Facilities and Infrastructure in Conroe Dam Failure Inundation Zones Countywide

8.4.4 Environment

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways. This could result in destruction of downstream habitat and could have detrimental effects on many species of animals, especially endangered aquatic species such as: the Southern Flounder, Silverband Shiner, Sabine Shiner, Western Creek Chubsucker, saltmarsh topminnow, and the alligator gar.

8.5 VULNERABILITY

8.5.1 Population

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area before floodwaters arrive. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television, radio emergency warning system, siren, or cell phone alert. The potential for loss of life is affected by the capacity and number of evacuation routes available to those living in potential inundation areas.

8.5.2 Property

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

The estimated total loss due to property damage in the combined dam failure inundation area is $669.5 million. This represents 13 percent of the total structure exposure in the inundation area and 0.07 percent of planning-area-wide structure replacement value. Table 8-8 summarizes the loss estimates.

Table 8-8. Loss Estimates for Lake Conroe Dam Failure

Jurisdiction	Estimated Loss Associated with Dam Failure			Estimated Loss as % of Total Replacement Value
	Structure	Contents	Total	
Baytown	$1,515,470	$426,226	$1,941,696	0.02%
Houston	$290,605,818	$95,366,640	$385,972,459	0.08%
Humble	$82,535,578	$42,887,759	$125,423,337	2.74%
Unincorporated County	$116,718,241	$39,463,970	$156,182,211	0.05%
Total	**$**491,375,107	**$**178,144,595	**$**669,519,703	**0.07%**

The vulnerability of communities identified as having exposure due to their location downstream of dams (the cities of Baytown, Bunker Hill Village, Deer Park, Houston, Humble, La Porte, Pasadena and the unincorporated County) is not known due to the lack of digital inundation mapping. However, each of these jurisdictions has a mapped floodplain. Water released by a dam failure would flow toward a water course, so it is logical to assume that the extent and location of the floodplain would approximate to some degree the dam failure inundation. Appendix C to this volume provides a detailed breakdown of flood exposure and vulnerability for these jurisdictions, which is assumed to approximate the dam failure risk.

8.5.3 Critical Facilities

Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues and significant disruption to travel, including all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines in the inundation zone could also be vulnerable. If phone lines were lost, significant communication issues may occur in the planning area due to limited cell phone reception in many areas. In addition, emergency response would be hindered due to

the loss of transportation routes as well as some protective-function facilities located in the inundation zone. Recovery time to restore many critical functions after an event may be lengthy, as wastewater, potable water, and other community facilities are located in the dam inundation zone.

8.5.4 Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals as identified under Section 8.4.4.

8.6 FUTURE TRENDS IN DEVELOPMENT

The municipal planning partners have adopted basic and or comprehensive plans that govern land use decision-making and policy-making in their jurisdictions. This plan will work together with these programs to support wise land use in the future by providing vital information on the risk associated with natural hazards. Most of the areas vulnerable to the more severe impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the comprehensive plans will help to reduce the risk associated with the dam failure hazard for all future development in the planning area.

8.7 SCENARIO

A worst-case dam failure scenario for the planning area would be an accentuation of what occurred during Hurricane Harvey. A hurricane or tropical storm would stall over the planning area and fill reservoirs to capacity, with their ability to release water downstream hindered by high tides and storm surge. The storm then would move inland and dump large amounts of rainfall in the watershed upstream of the dams, further stressing the downstream dams that lack the capacity to absorb these inflows. This could stress the dams to overtopping or even failure.

8.8 ISSUES

The most significant issue associated with dam failure involves the properties and populations in the inundation zone. Flooding as a result of a dam failure would significantly impact these areas. There is often limited warning time for dam failures, which are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather. Important issues associated with the dam failure hazard include the following:

- Digital dam failure inundation mapping suitable for risk analysis is needed for all 30 dams within the planning area to better understand the risk from this hazard.
- There may be dams located in the planning area that do not meet regulatory thresholds for jurisdiction under State of Texas or federal programs.
- Dam infrastructure may require repair and improvement to withstand climate change impacts, such as changing in the timing and intensity of rain events.
- A significant number of the structures located in the dam inundation zone are located outside of special flood hazard areas, meaning that they are not constructed to withstand floodwaters and are less likely to be covered by flood insurance. Even structures that have been designed with flood hazards in mind may not be able to withstand the height and velocity of flow from a dam failure event.
- In the event of a dam failure that interrupted land line phone service, significant issues with communication could occur.
- Most dam failure mapping required at federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. For non-federal-regulated dams, mapping of dam failure scenarios

that are less extreme than the probable maximum flood but have a higher probability of occurrence can be valuable to emergency managers and community officials downstream of these facilities. This type of mapping can illustrate areas potentially impacted by more frequent events to support emergency response and preparedness.

- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.
- Federally regulated dams have adequate oversight and sophistication in the development of emergency action plans for public notification in the unlikely event of failure. The protocol for notification of downstream citizens of imminent failure needs to be tied to local emergency response planning.

9. DROUGHT

9.1 GENERAL BACKGROUND

Drought is a significant decrease in water supply relative to what is typical in a given location. It is a normal phase in the climate cycle of most regions, originating from a deficiency of precipitation over an extended period of time, usually a season or more. This leads to a water shortage for some activity, group or environmental sector.

Droughts are climatic patterns that occur over long periods of time as the result of many causes. Anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of global weather systems.

9.1.1 Monitoring and Categorizing Drought

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity and to map their extent and locations:

- The ***Palmer Z Index*** measures short-term drought on a monthly scale.
- The ***Palmer Drought Severity Index*** measures the duration and intensity of long-term weather patterns. The intensity of drought in a given month is dependent on current weather plus the cumulative patterns of previous months. Weather patterns can change quickly, and the Palmer Drought Severity Index can respond fairly rapidly.
- The ***Palmer Hydrological Drought Index***, quantifies hydrological effects (reservoir levels, groundwater levels, etc.), which take longer to develop and last longer. This index responds more slowly to changing conditions than the Palmer Drought Index.
- The ***Standardized Precipitation Index*** considers only precipitation. In the Standardized Precipitation Index, an index of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The Standardized Precipitation Index is computed for time scales ranging from one month to 24 months.
- The ***Palmer Crop Moisture Index*** measures short-term drought on a weekly scale to quantify impacts on agriculture.

Maps of these indices show drought conditions nationwide at a given point in time. They are not necessarily indicators of any given area's long-term susceptibility to drought. The most current versions of the maps at the time of this plan's preparation are shown on Figure 9-1 through Figure 9-5.

The U.S. Drought Monitor categorizes droughts by impact type and intensity. Impact type indicates whether a drought in a given area is short-term or long-term. Short-term is generally less than six months and impacts are expected on agriculture and grasslands. Long-term drought is typically longer than 6 months and impacts are seen on hydrology and ecology in the area impacted. The intensity of a drought is categorized on a scale of 0 to 4, where 0 is abnormally dry and 4 is exceptional drought.

Source: NOAANational Center for Environmental Information, 2019

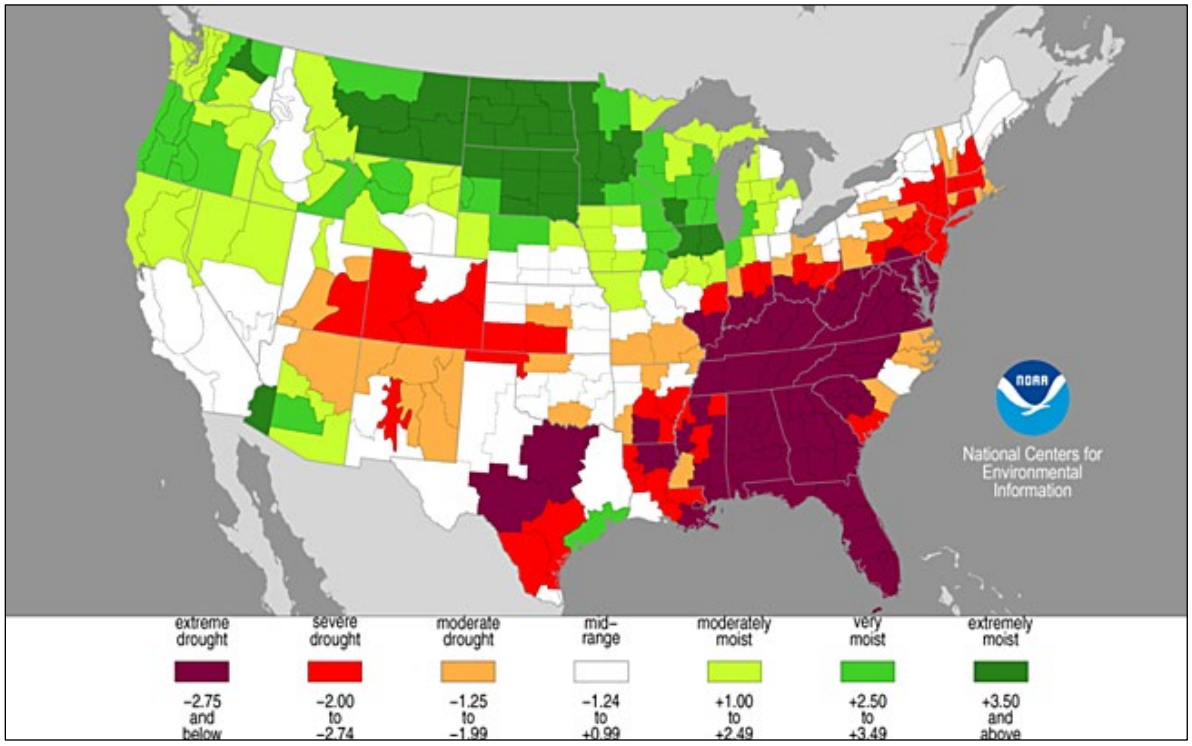


Figure 9-1. Palmer Z Index Short-Term Drought Conditions (September 2019)

Source: NOAA, NWS. 2019

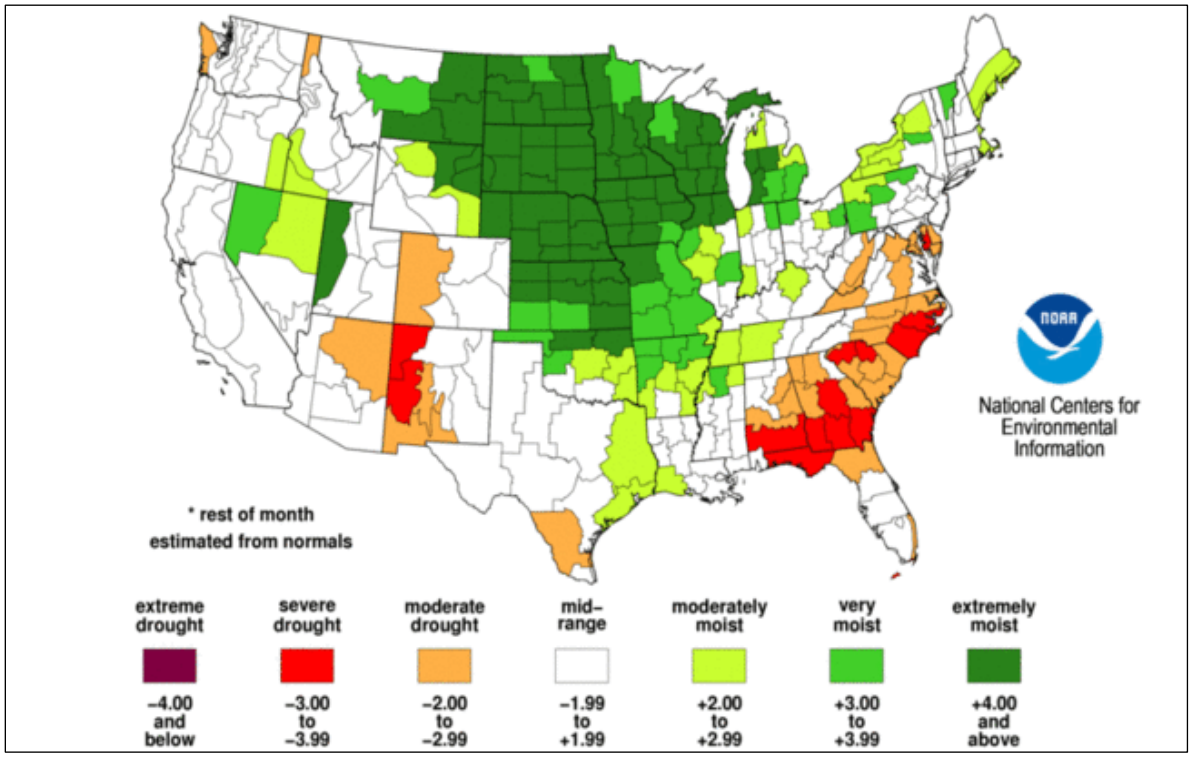


Figure 9-2. Palmer Drought Severity Index (October 2019)

Source: NOAA, NWS. 2019

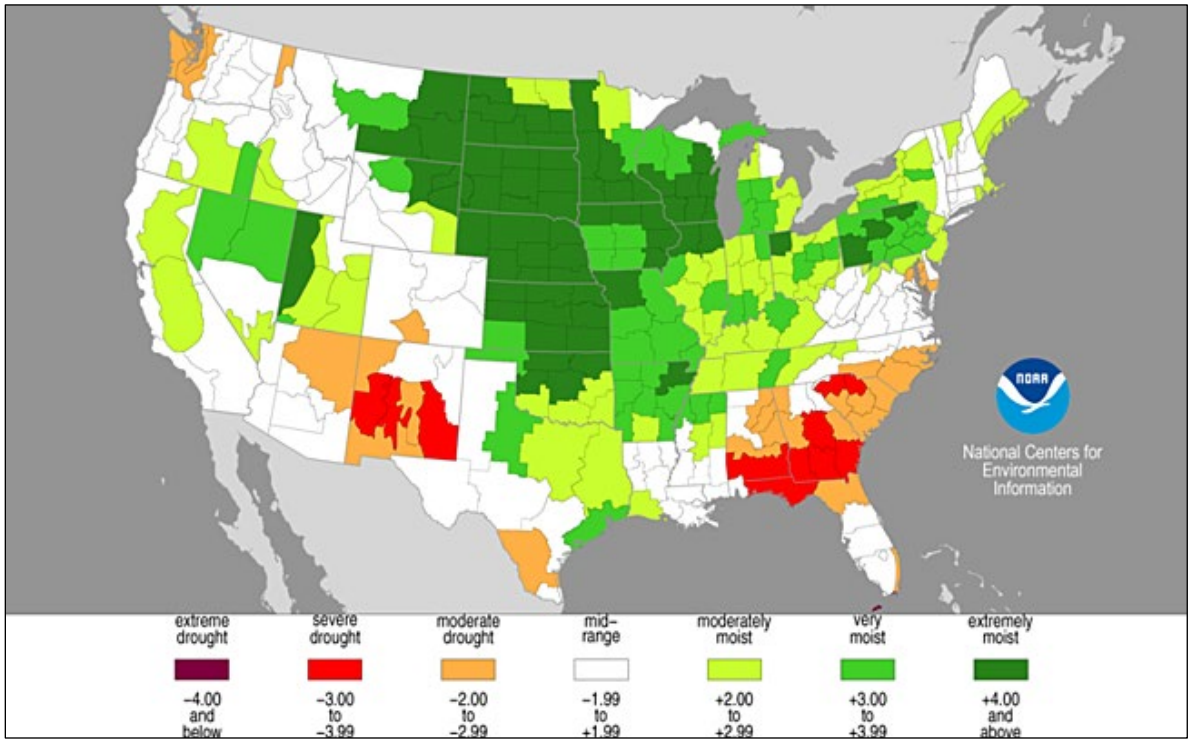


Figure 9-3. Palmer Hydrological Drought Index (September 2019)

Source: National Center for Environmental Information, 2019a

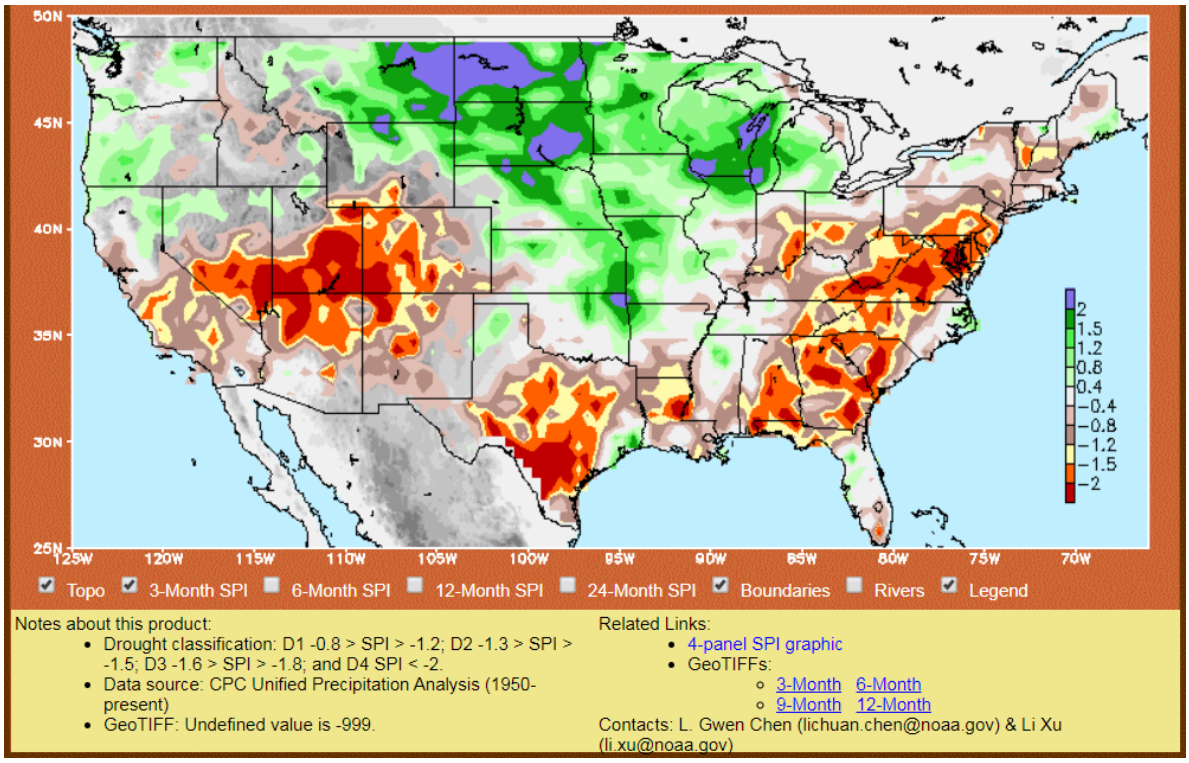


Figure 9-4. 24-Month Standardized Precipitation Index Ending October 14, 2019

Source: U.S. Drought Portal, 2018

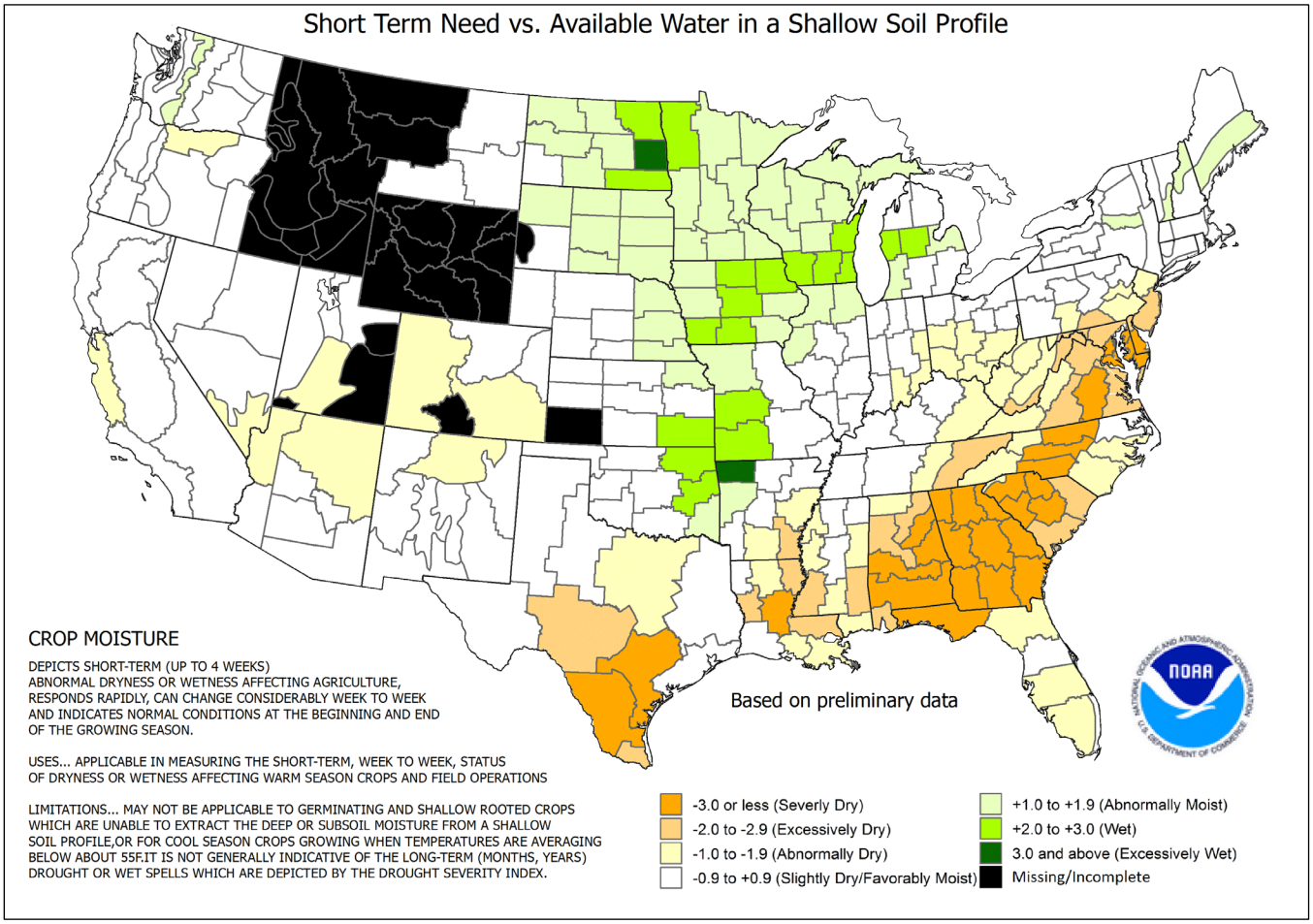


Figure 9-5. Palmer Crop Moisture Index for Week Ending October 12, 2019

9.1.2 Local Water Supply

In Harris County there are approximately 1,200 public drinking water systems, ranging from the City of Houston's, which is the largest in Texas, to many that are among the state's smallest. A public water system is defined as one that serves at least 25 people per day at least 60 days of the year, or has 15 connections. Water supply sources for the planning area are a combination of deep wells drilled into area aquifers and surface water reservoirs fed by local rivers and their tributaries.

9.2 HAZARD PROFILE

The Harris County planning area is susceptible to all ranges of drought as defined by the indices described above; therefore, the entire planning area is at risk for drought. However, since the Harris County planning area is not primarily an agricultural region, its vulnerability to drought is relatively low.

9.2.1 Past Events

The historical information on drought for the planning area utilizes multiple sources to develop a comprehensive record of historical occurrences across the planning area; i.e. the National Climatic Data Center (NCDC) and the U.S. Drought Monitor. The compilation of these sources was necessary because the NCDC information only

include the years between 1996 to 2000. Established in 1999, the U.S. Drought Monitor has maintained a weekly record of drought conditions across the United States; which was also utilized to develop a comprehensive record of past drought conditions within the planning area.

National Climatic Data Center Drought Records

According to the NCDC the following three drought events affected the Harris County planning area between 1996 and 2000:

- **Summer 1996**—Austin, Brazoria, Brazos, Burleson, Chambers, Colorado, Fort Bend, Galveston, Grimes, Harris, Houston, Jackson, Liberty, Madison, Matagorda, Montgomery, Polk, San Jacinto, Trinity, Walker, Waller, Washington and Wharton counties: From April through June 1996, rainfall totals in the Houston area ran more than 10 inches below normal. Other areas to the west and north reported rainfall totals 75 percent below the normal for the first six (6) months of the year. Damage from the extended drought began to reach record proportions as many crops were lost and livestock were sold due to the lack of available fodder. Property damages and agricultural losses reached $10 million and $100 million, respectively, in southeast Texas.
- **May – August 1998**—Austin, Brazoria, Brazos, Burleson, Chambers, Colorado, Fort Bend, Galveston, Grimes, Harris, Houston, Jackson, Liberty, Madison, Matagorda, Montgomery, Polk, San Jacinto, Trinity, Walker, Waller, Washington and Wharton counties: Over 20 people across the region lost their lives due to the extreme heat, and property and crop damage averaged $8.3 million per county.
- **Summer 2000**—Austin, Brazoria, Brazos, Burleson, Chambers, Colorado, Fort Bend, Galveston, Grimes, Harris, Houston, Jackson, Liberty, Madison, Matagorda, Montgomery, Polk, San Jacinto, Trinity, Walker, Waller, Washington and Wharton counties: The combination of excessive heat and dryness resulted in several wildfires during the first week of the month, including a 4,500 acre fire in neighboring Liberty County. By the end of September, damage estimates to cotton, wheat, and forage crops reached $102.3 million in southeast Texas.

Figure 9-6 shows historical drought affecting the Texas Gulf Basin.

Source: National Drought Mitigation Center

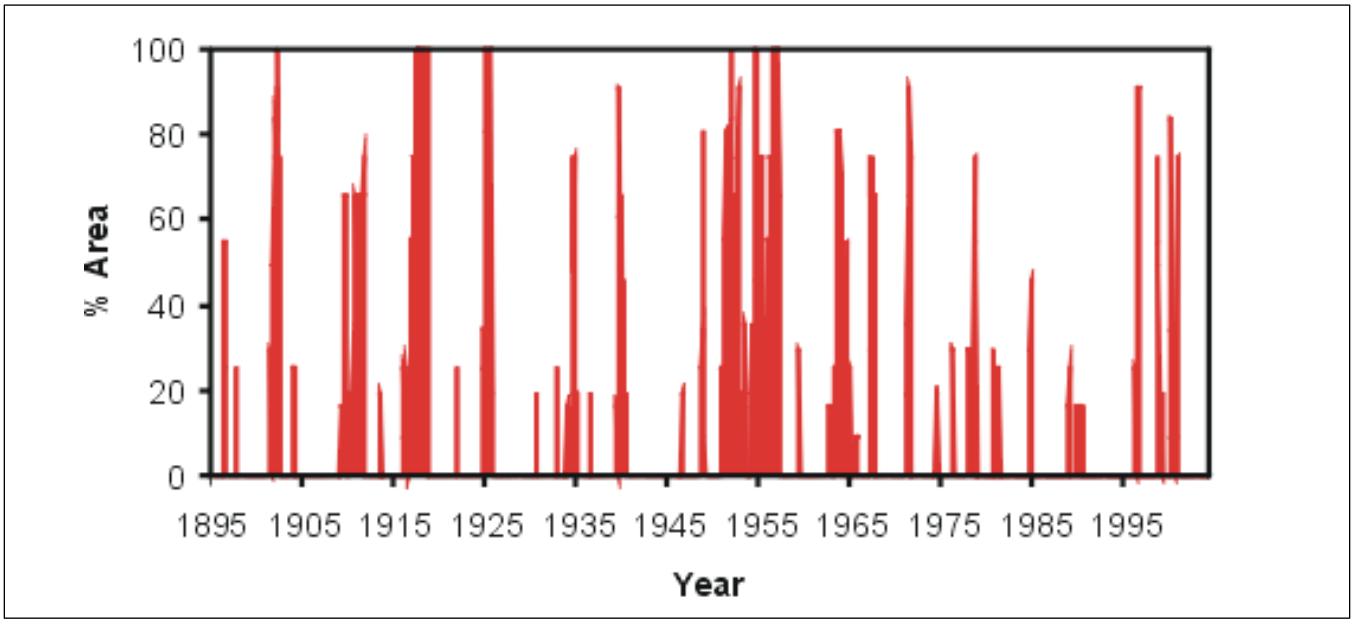


Figure 9-6. Percent Area of the Texas Gulf Basin Experiencing Severe to Extreme Drought

U.S. Drought Monitor Records

Table 9-1 lists severe drought (D2) events in Harris County lasting two or more consecutive week since 2000 as reported by the U.S. Drought Monitor.

Table 9-1. Harris County U.S. Drought Monitor Data 2000-2016

Year	Start Date	End Date	# of Consecutive Weeks
2000	January 4	April 11	15
2000	July 25	October 3	11
2003	June 3	June 24	4
2005	November 15	December 13	5
2006	March 14	March 28	3
2006	April 18	June 13	9
2008	June 3	August 19	12
2009	February 10	April 7	9
2009	June 30	August 29	14
2010-2012	November 30, 2010	March 13, 2012	68
2012-2013	November 27, 2012	January 8, 2013	7
2013	February 5	May 7	14
2013	May 21	June 4	3
2013	June 18	September 24	15
2016	November 11	November 29	3

Source: U.S. Drought Monitor. (https://droughtmonitor.unl.edu/Data/DataDownload/WeeksInDrought.aspx)

USDA Drought Records

The U.S. Department of Agriculture (USDA) Farm Service Agency provides assistance for agriculture-related losses resulting from drought, flood, fire, freeze, tornados, pest infestation, and other natural disasters. The U.S. Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to them.

The USDA designated the Harris County planning area 11 times as either a primary or contiguous county for a drought disaster, as illustrated in Table 9-2. All of the USDA drought disaster designations listed indicates at least a 30% loss in major crops in the county due to drought, which resulted in emergency loans being made available for the county's farmers and ranchers. According to the USDA, the drought in 2011 was the worst on record. In addition, the USDA was authorized to administer livestock programs from 2008 to 2011 because the Harris County planning area was listed as D2 (severe drought) on the Drought Monitor for at least 8 consecutive weeks during the drought period.

Texas Division of Emergency Management Drought Records

According to the Texas Division of Emergency Management (TDEM), the State of Texas issued and renewed 23 state drought disaster proclamations between 2006 – 2018; which included the Harris County planning area as illustrated in Table 9-3.

Table 9-2. USDA Farm Service Agency Drought Disaster Designations for Harris County

Disaster Designation Name/Number	Disaster Description	Incidence period
S3288	Drought	1/1/2012 - continuing
S3122	Drought	1/1/2011-continuing
S2863	Drought	1/1/2009-continuing
S2772[a]	Drought	1/1/2008-continuing
S2845[a]	Drought	1/1/2008-continuing
S2500	Drought	1/1/2006-continuing
S2281	Severe drought, above normal temperatures, & extremely high number of wildfires	4/1/2005-continuing
S2191	Drought	4/1/2005-continuing
S1501	Drought & Excessive Heat	1/1/2000-continuing
EM3142	Excessive fire hazards	8/1/1999-continuing
S1225	Drought	6/1/1997-7/8/1998

a. Contiguous designation – designated due to being located adjacent to a primary designation county. "S" in front of disaster designation number indicates a Secretarial Designation by the U.S. Secretary of Agriculture.

Source: U.S. Department of Agriculture, Farm Service Agency – Harris, Montgomery, and Waller County.

Table 9-3. State Drought Disaster Proclamations for Harris County (2006 – 2018)

Year	Declarations
2006	1
2009	1
2011	10
2012	1
2013	10
TOTAL	**23**

Source: Texas Division of Emergency Management, 2019

9.2.2 Location

Drought is a regional phenomenon. A drought affects all aspects of the environment and the community simultaneously and has the potential to directly or indirectly impact every person in the county as well as adversely affect the local economy.

The 2013 *State of Texas Hazard Mitigation Plan* identifies all of Texas as vulnerable to droughts. However, the areas most vulnerable to drought are west Texas areas around the cities of Amarillo, Lubbock, Midland, Odessa, Fort Stockton, San Angelo, Laredo, and El Paso to be the most at risk in the state to drought. The Harris County planning area is not located within that region and is not identified as a high risk area.

The Harris County planning area is located in the Texas Climate Division 8 – Upper Coast. According to the South Central Climate Science Center, this is an area with recurring drought conditions.

9.2.3 Frequency

The historical information obtained from the NCDC and the U.S. Drought Monitor shows there have been only 25 occurrences of drought since 1996 to 2018. Based on this data, the probability of occurrence for drought

conditions in the Harris County planning area and all participating jurisdictions is once every 0.88 years or every 321 days. This ranks as a high probability of occurrence as defined for risk ranking for this plan.

9.2.4 Severity

Drought can have a widespread impact on the environment and the economy, although it typically does not result in loss of life or damage to structures, as do other natural disasters. The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Vulnerability of an activity to drought depends on its water demand and the water supplies available to meet the demand. Impacts on the planning area due to drought include but are not limited to the following:

- Reduced soil moisture and water supplies
- Damaged and broken pipe systems
- Tree/vegetation stress and die-off
- Temporary restrictions on water consumption
- Water shortages for agricultural purposes
- Depleted recreational water resources
- Low water levels for water transportation
- Low moisture and precipitation creating conditions for wildfire.

Drought can also create stress on water systems and piping, causing damage and breaks. Prolonged drought seasons can have serious health, social, economic and political impacts with far-reaching consequences within the planning area. According to the Association of Electric Companies of Texas, drought can also impact electric generation capacity due to water shortages for cooling reservoirs and cause outages due to high levels of air-borne contaminants such as coastal sea salt deposits and dust, resulting in faulty electrical equipment. According to the U.S. Centers for Disease Prevention and Control, severe drought conditions can negatively impact air quality due to wildfire and dust storms, which suspend particulate matter in the air from these events.

National Drought Mitigation Center Impact Categories

The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- **Economic Impacts**—These impacts of drought cost people (or businesses) money. Farmers' crops are destroyed; low water supply necessitates spending on irrigation or drilling of new wells; water-related businesses (such as sales of boats and fishing equipment) may experienced reduced revenue.
- **Environmental Impacts**—Plants and animals depend on water. When a drought occurs, their food supply can shrink and their habitat can be damaged.
- **Social Impacts**—Social impacts include public safety, health, conflicts between people when there is not enough water to go around, and changes in lifestyle.

Drought Impact Reporter

The National Drought Mitigation Center developed the Drought Impact Reporter in response to the need for a national drought impact database for the United States. Information comes from a variety of sources: on-line, drought-related news stories and scientific publications, members of the public who visit the website and submit a drought-related impact for their region, members of the media, and staff of government agencies. The database is being populated beginning with the most recent impacts and working backward in time.

The Drought Impact Reporter indicates 73 impacts from drought that specifically affected Harris County from 2009 through September 2019 (Drought Impact Reporter, 2019). Most (89 percent) are based on media reports.

The following are the reported numbers of impacts by category (some incidents are assigned to more than one impact category):

- 36 in Agriculture
- 6 in Business & Industry
- 1 in Energy
- 14 in Fire
- 32 in Plants & Wildlife
- 19 in Relief, Response & Restrictions
- 6 in Society & Public Health
- 3 in Tourism & Recreation
- 13 in Water Supply & Quality

9.2.5 Warning Time

Predicting drought depends on the ability to forecast precipitation and temperature. Scientists at this time do not know how to predict drought more than a month in advance for most locations. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

Determination of when drought begins is based on impacts on water users and assessments of available water supply, including water stored in reservoirs or groundwater basins. Different water agencies have different criteria for defining drought. Some issue drought watch or drought warning announcements.

9.3 SECONDARY HAZARDS

The secondary hazard most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. In addition, lack of sufficient water resources can stress trees and other vegetation, making them more vulnerable to infestation from pests, which in turn, can make them more vulnerable to ignition. Millions of board feet of timber have been lost, and in many cases erosion occurred, which caused serious damage to aquatic life, irrigation, and power production by heavy silting of streams, reservoirs, and rivers.

9.4 EXPOSURE

All people, property and environments in the planning area would be exposed to some degree to the impacts of moderate to extreme drought conditions.

9.5 VULNERABILITY

The historical data available for drought only identifies events down to the county level. Localized event data on a more focused level is not currently available. This limits our availability to perform a detailed vulnerability assessment for this hazard within the Harris County planning area. In addition, although the area is vulnerable to drought, estimated losses are difficult to calculate because drought causes little damage to the built environment, and as previously stated, much of the asset information used in this risk assessment is based on building information derived from the Harris County Appraisal District. The entire planning area's vulnerability to drought is equal and relatively low. However, the NCDC narrative information provided in the previous occurrence section above does provide some limited information on property damages and agricultural losses, which demonstrates the adverse impact and vulnerability from drought for the entire planning area and all participating jurisdictions. Vulnerable assets may include residential properties, commercial properties, critical facilities, crops,

farms, boating and fishing industries, marine transportation systems. Throughout the entire planning area, common assets that are vulnerable to drought may include, but are not limited to, recreational resources, such as lakes, rivers and natural resources; drinking water, infrastructure and residential foundations due to dry soil conditions, and electrical transmission and distribution lines.

9.5.1 Population

The entire population of Harris County is vulnerable to drought events. Drought can affect people's health and safety, including health problems related to low water flows, poor water quality, or dust. Droughts can also lead to loss of human life (National Drought Mitigation Center, 2017). Other possible impacts include recreational risks; effects on air quality; diminished living conditions related to energy, air quality, and hygiene; compromised food and nutrition; and increased incidence of illness and disease (Centers for Disease Control and Prevention, 2012).

9.5.2 Property

No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can have significant impacts on other types of property such as landscaped areas and economically important natural resources. Drought causes the most significant economic impacts on industries that use water or depend on water for their business, most notably agriculture and related sectors, power plants, and oil refineries. In addition to losses in yields in crop and livestock production, drought is associated with increased insect infestations, plant diseases, and wind erosion. Drought can lead to other losses because so many sectors are affected—losses that include reduced income for farmers and reduced business for retailers and others who provide goods and services to farmers. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and loss of tax revenue. Prices for food, energy, and other products may also increase as supplies decrease.

9.5.3 Critical Facilities

Critical facilities as defined for this plan will continue to be operational during a drought. Critical facility features such as landscaping may not be maintained due to limited water resources, but the risk to critical facility core functions is low.

9.5.4 Environment

Groundwater and Streams

Drought generally does not affect groundwater sources as quickly as surface water supplies, but groundwater supplies generally take longer to recover. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when stream flows are lowest.

Other Potential Losses

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; wildfires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects. The following are potential impacts of drought:

- Wildlife habitat may be degraded through the loss of wetlands, lakes and vegetation. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity.
- Drought conditions greatly increase the likelihood of wildfires, the major threat to timber resources.
- Water shortages and severe drought conditions would have a significant impact on Native American tribes' way of life in fishing and farming subsistence.
- Any shortage of water supply can have significant economic impacts.

9.6 FUTURE TRENDS IN DEVELOPMENT

Each municipal planning partner in this effort has an established comprehensive plan that includes policies directing land use and dealing with issues of water supply and the protection of water resources. These plans provide the capability at the local municipal level to protect future development from the impacts of drought. All planning partners reviewed their comprehensive plans under the capability assessments performed for this effort. Deficiencies identified by these reviews can be identified as mitigation actions to increase the capability to deal with future trends in development. In addition, water providers in the planning area have plans and programs in place to balance competing needs for water resources within the planning area.

9.7 SCENARIO

A multi-year drought that impacts the southeastern portion of Texas, like the 2008 to 2011 drought, is the worst-case scenario for the planning area. The 2008 drought caused damage to natural systems. If another severe drought occurs before these systems have a chance to recover, it could exacerbate the stress already placed on existing planning area water resources.

9.8 ISSUES

The CPT has identified the following drought-related issues:

- The probability of drought frequencies and durations may increase due to climate change.
- The promotion of active water conservation even during non-drought periods should be encouraged.
- The planning area should plan for frequent droughts or multi-year droughts that can limit the ability to successfully recover from one drought and prepare for the next.
- Drought in the county could increase and expand fire-prone areas and adversely affect the timber economy.
- Planning must address the degree of future development in drought-prone areas.
- More studies need to be done regarding overall county water usage and how it relates to the economy to prepare for a worst-case scenario drought.
- With the possibility of climate change, drought may become a larger issue due to warming trends and wider fluctuations in rainfall patterns.
- Alternative water supplies should be identified and developed.
- Groundwater recharge techniques can be used to stabilize the groundwater supply

10. EARTHQUAKE

10.1 GENERAL BACKGROUND

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Geologists have found that earthquakes tend to reoccur along faults, which are zones of weakness in the earth's crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. In fact, relieving stress along one part of a fault may increase it in another part.

Faults are more likely to have future earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve the accumulating tectonic stresses. Geologists classify faults by their relative hazards. "Active" faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). "Potentially active" faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years).

Determining if a fault is "active" or "potentially active" depends on geologic evidence, which may not be available for every fault. Nearly all the movement between the two plates, and therefore the majority of the seismic hazards, are on the well-known active faults. However, inactive faults, where no displacements have been recorded, also have the potential to reactivate or experience displacement along a branch sometime in the future.

10.1.1 Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as magnitude; or by the impact on people and structures, measured as intensity.

Magnitude

An earthquake's magnitude is a measure of the energy released at the source of the earthquake. Magnitude is commonly expressed by ratings on the moment magnitude scale (M_w), the most common scale used today (USGS, 2017a). This scale is based on the total moment release of the earthquake (the product of the distance a fault moved and the force required to move it). The scale is as follows:

- Great—Mw > 8
- Major—Mw = 7.0 – 7.9
- Strong—Mw = 6.0 – 6.9
- Moderate—Mw = 5.0 – 5.9

- Light—Mw = 4.0 – 4.9
- Minor—Mw = 3.0 – 3.9
- Micro—Mw < 3

Intensity

The most commonly used intensity scale is the modified Mercalli intensity scale. Ratings of the scale as well as the perceived shaking and damage potential for structures are shown in Table 10-1. The modified Mercalli intensity scale is generally represented visually using shake maps, which show the expected ground shaking at any given location produced by an earthquake with a specified magnitude and epicenter. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A shake map shows the variation of ground shaking in a region immediately following significant earthquakes (for technical information about shake maps see USGS, 2018).

Table 10-1. Mercalli Scale and Peak Ground Acceleration Comparison

Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage		Estimated PGA[a] (%g)
		Resistant Buildings	Vulnerable Buildings	
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17% - 1.4%
IV	Light	None	None	1.4% - 3.9%
V	Moderate	Very Light	Light	3.9% - 9.2%
VI	Strong	Light	Moderate	9.2% - 18%
VII	Very Strong	Moderate	Moderate/Heavy	18% - 34%
VIII	Severe	Moderate/Heavy	Heavy	34% - 65%
IX	Violent	Heavy	Very Heavy	65% - 124%
X – XII	Extreme	Very Heavy	Very Heavy	>124%

a. PGA = peak ground acceleration. Measured in percent of g, where g is the acceleration of gravity

Sources: USGS, 2008; USGS, 2010

10.1.2 Ground Shaking

The ground experiences acceleration as it shakes during an earthquake. The peak ground acceleration (PGA) is the largest acceleration recorded by a monitoring station during an earthquake. PGA is a measure of how hard the earth shakes in a given geographic area. It is expressed as a percentage of the acceleration due to gravity (%g). Horizontal and vertical PGA varies with soil or rock type. Earthquake hazard assessment involves estimating the annual probability that certain ground accelerations will be exceeded, and then summing the annual probabilities over a time period of interest.

National maps of earthquake shaking hazards provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (Brown et al., 2001). The USGS updated the National Seismic Hazard Maps in 2014. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2014 map, shown in Figure 10-1, represents the best available data as determined by the USGS.

Source: USGS, 2014

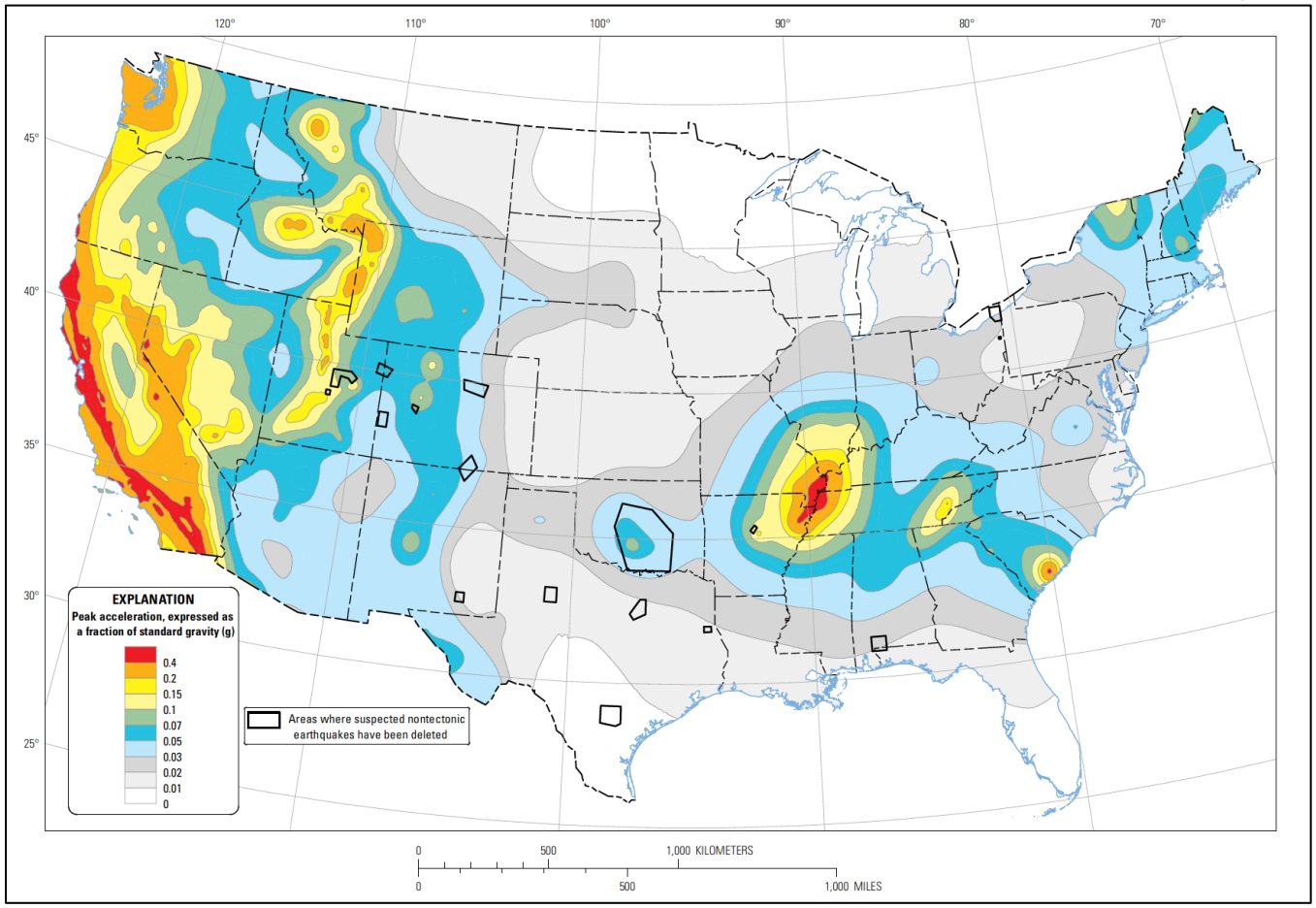


Figure 10-1. Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years

Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. The determination of how great a force a structure should be able to withstand is based on probabilistic seismic mapping of the area. Such mapping identifies the probability of a given magnitude of ground shaking occurring over a specified time period. A common probabilistic rating used for building design is the level of ground shaking that has a 10 percent probability of being equaled or exceeded in a 50-year period.

Buildings, bridges, highways and utilities built to meet modern seismic design requirements are typically able to withstand earthquakes better, with less damage and disruption. PGA values are directly related to these lateral forces that could damage "short period structures" (e.g. single-family dwellings). Longer-period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 10-1 lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

10.1.3 Liquefaction and Soil Types

Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the

environment and people. A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 10-2 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have NEHRP Soils D, E and F (see SCEC, 2018 for general information on NEHRP soils data). In general, these areas are also most susceptible to liquefaction.

Table 10-2. NEHRP Soil Classification System

NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

10.2 HAZARD PROFILE

10.2.1 Past Events

According to the National Geophysical Data Center, there are 585 records of seismic activity in Texas since 1882. However, as shown on Figure 10-2, only 12 seismic events statewide since 1923 have had a magnitude of 4.5 or greater.

At least one notable earthquake has affected the Harris County area. The August 16, 1931 event, with an epicenter 854 miles from Houston, registered as a "III" on the Modified Mercalli Intensity Scale for earthquakes. This would indicate that the event would have registered between 4.2 and 4.8 on the Richter Scale, and that it likely caused little or no damage but would have been felt by people resting similar to if a large truck rumbled by causing minimal to no damage impact (National Geophysical Data Center).

10.2.2 Location

The entire planning area is located in a low risk zone for earthquakes. The Harris County planning area is located in the Gulf Coast Region and is not identified as a hazard area in the *State of Texas Hazard Mitigation Plan*. According to the U.S. Geological Survey, the Harris County planning area is located within the lowest hazard risk area across the nation for earthquakes (see Figure 10-1).

10.2.3 Frequency

Except for the Trans-Pecos, most of Texas has a relatively small probability of experiencing an earthquake (Figure 10-2).

10.2.4 Severity

Figure 10-3 shows the earthquake-induced PGA with a 2-percent chance of being exceeded in 50 years in Texas. The map was compiled by the U.S. Geological Survey (USGS), which conducts global investigations of earthquake, geomagnetic, and landslide hazards. For Harris County, the PGA with that probability is no more than 0.04 g, representing the lowest rating on the Modified Mercalli scale (see Table 10-1).

Source: Texas Almanac

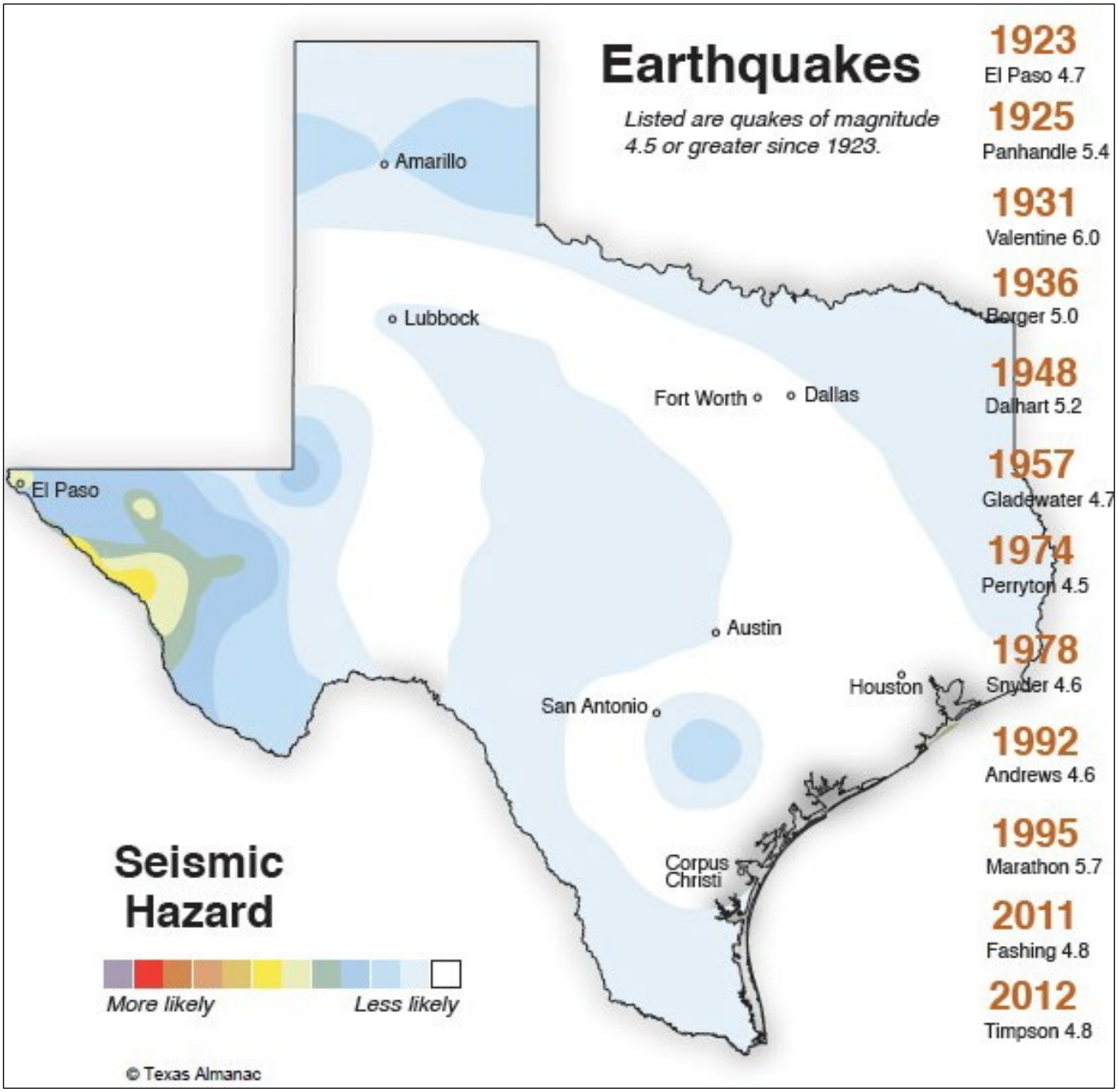


Figure 10-2. Probability of Experiencing an Earthquake in Texas

10.2.5 Warning Time

There is no current reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short, but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

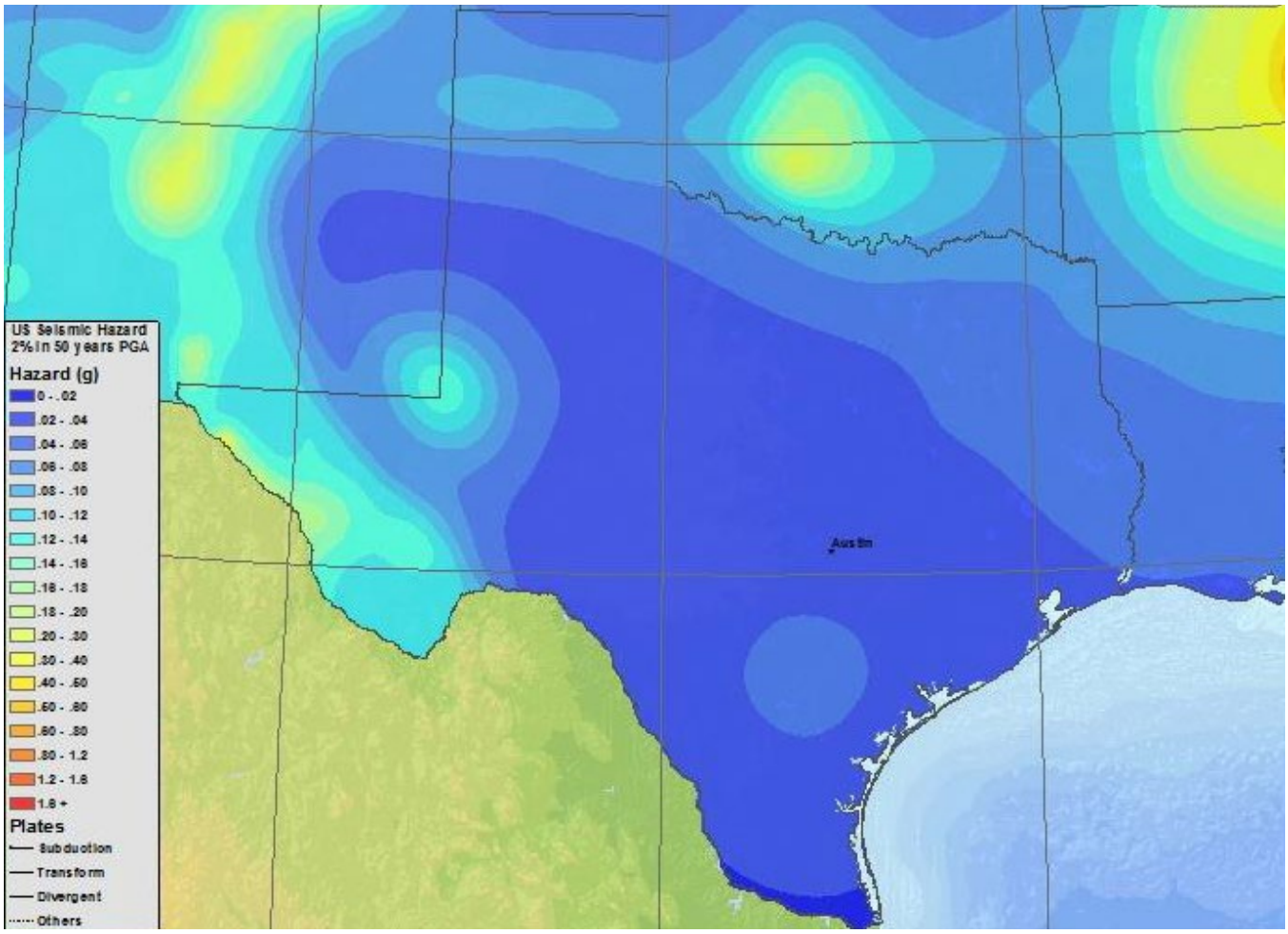


Figure 10-3. Peak Acceleration with 2% Percent Probability of Exceedance in 50 Years

10.3 SECONDARY HAZARDS

Earthquakes can cause disastrous landslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risk exposure to earthquakes. Depending on the location, earthquakes can also trigger tsunamis. Additionally, fires can result from gas lines or power lines that are broken or downed during the earthquake. It may be difficult to control a fire, particularly if the water lines feeding fire hydrants are also broken.

10.4 EXPOSURE

10.4.1 Population

The entire population of the planning area is potentially exposed to direct and indirect impacts from earthquakes. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

10.4.2 Property

According to Central Appraisal districts for Harris, Fort Bend and Galveston Counties, there are 1,355,132 buildings in the planning area, with a total appraised value of over $928 billion. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees, this represents the property exposure to seismic events. Most of the buildings (97 percent) are residential. Table 4-2 shows the exposure value breakdown by municipality.

10.4.3 Critical Facilities and Infrastructure

Since the entire planning area has exposure to the earthquake hazard, all identified 11,416 critical facilities and infrastructure components are considered to be exposed. The breakdown of the numbers and types of facilities is presented in Table 4-5.

10.4.4 Environment

The entire planning area is exposed to the earthquake hazard, including all natural resources, habitat and wildlife.

10.5 VULNERABILITY

Earthquake vulnerability data was generated using a Hazus analysis for the 500-year probabilistic event. Probabilistic maps are not based on a specific earthquake event magnitude or location; instead, they show the ground acceleration at each point that has a given chance of being exceeded in any given year, regardless of the earthquake source. The 500-year probabilistic earthquake map shows the acceleration with a 0.2-percent chance of being exceeded in a given year (see Figure 10-4).

The analysis results are summarized in the sections below, and more detailed information, broken down by municipality, can be found in Appendix C. The results of this analysis are likely to significantly underestimate risk, due to limitations in the modeling parameters:

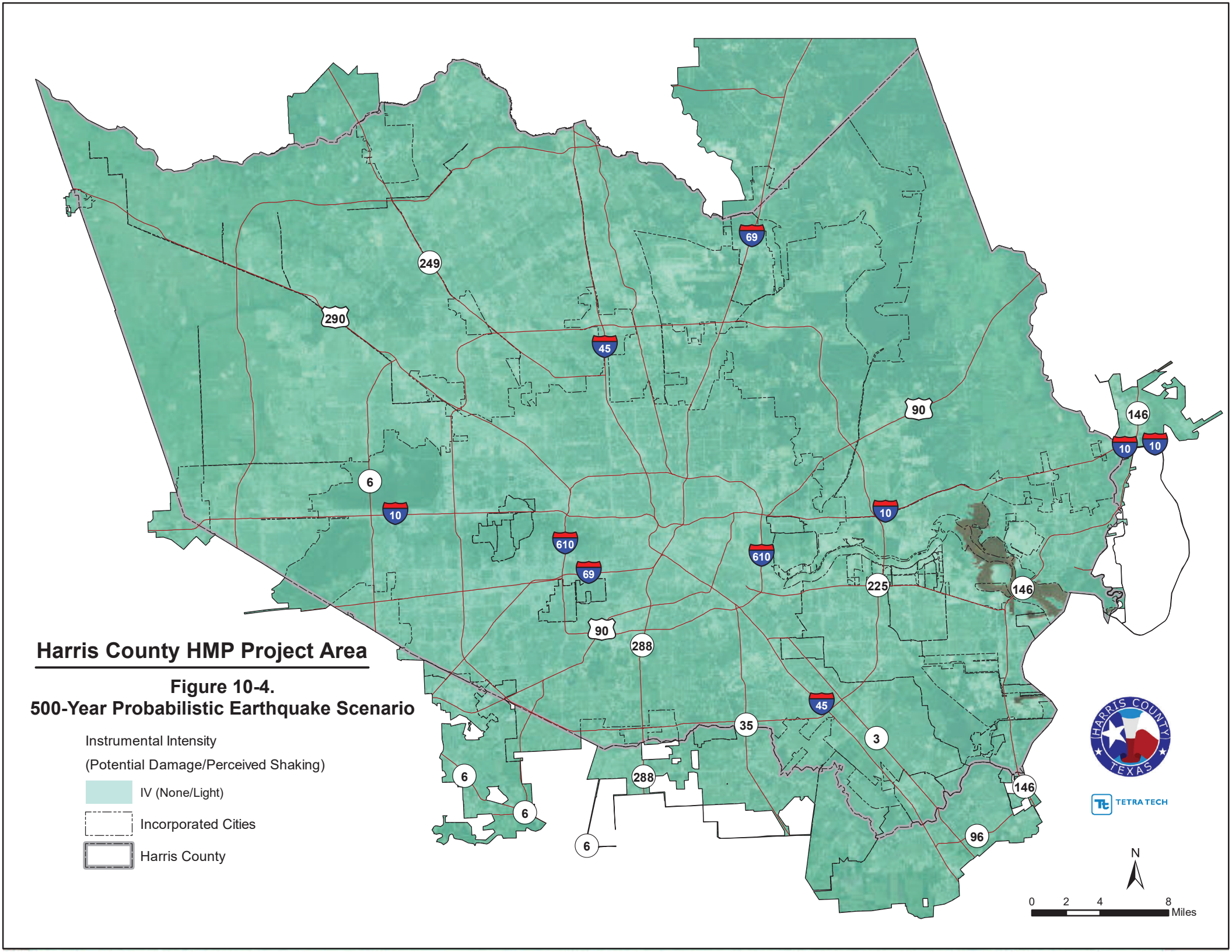
- There is no liquefaction data available for the planning area, so damage estimates do not consider potential structural issues pertaining to liquefiable soils
- All critical facilities are assumed to have been built to high code standards. This may not be the case, especially for older facilities.

10.5.1 Population

Vulnerable Groups

Three population groups are particularly vulnerable to earthquake hazards:

- **Linguistically Isolated Populations**——Problems arise when there is an urgent need to inform non-English speaking residents of an earthquake event. They are vulnerable because of difficulties in understanding hazard-related information from predominantly English-speaking media and government agencies. According to the U.S. Census American Community Survey, the linguistically isolated population represented 11.9 percent of the total population in 2018.
- **Population Below Poverty Level**—These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Poorer residents are also less likely to have insurance to compensate for losses in earthquakes. According to the American Community Survey, the population below poverty represented 16.8 percent of the total population in 2018.


Harris County HMP Project Area
Figure 10-4.
500-Year Probabilistic Earthquake Scenario
Instrumental Intensity
(Potential Damage/Perceived Shaking)
IV (None/Light)
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH

- **Population Over 65 Years Old**—This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations. According to the American Community Survey, the population over 65 years old represented 9.6 percent of the total population in 2018.

Estimated Impact on Households and People

Based on Hazus modeling, the estimated impacts of the 500-year probabilistic earthquake event on persons and households in the planning area are as follows:

- Number of Displaced Households = 2
- Number of Persons Requiring Short-Term Shelter = 1

10.5.2 Property

Building Age

Table 10-3 identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development. Using U.S. Census estimates of housing stock age, estimates were developed of the number of housing units constructed before each of these dates. Approximately 68.9 percent of the planning area's housing units were constructed after the Uniform Building Code was amended in 1994 to include seismic safety provisions. The number of housing units built before 1933 when there were no building permits, inspections, or seismic standards, account for 1.4 percent. Many of the housing units in the planning area are detached, single-family residences of wood construction, which generally perform well during earthquake events.

Table 10-3. Age of Housing Units in Planning Area

Time Period	Number of Current Planning Area Housing Units Built in Period	% of Total Housing Units	Significance of Time Frame
Pre-1933	18,971	1.4	Before 1933, there were no explicit earthquake requirements in building codes. State law did not require local governments to have building officials or issue building permits.
1941-1960	77,243	5.7	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions.
1961-1975	71,822	5.3	In 1975, significant improvements were made to lateral force requirements.
1976-1994	253,410	18.7	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1994 – present	933,686	68.9	Seismic code is currently enforced.
Total	**1,355,132**	**100**	

Note: Number and percent estimates are approximation as housing unit age information does not correspond directly with the time periods indicated. In addition, there are significant margins of error associated with the Census estimates.
Source: 2018 American Community Survey, Harris County, Texas

Unreinforced Masonry Buildings

Unreinforced masonry buildings are constructed from materials such as adobe, brick, hollow clay tiles, or other masonry materials and do not contain an internal reinforcing structure, such as rebar in concrete or steel bracing for brick. Unreinforced masonry poses a significant danger during an earthquake because the mortar holding masonry together is typically not strong enough to withstand significant earthquakes. The brittle composition of

these buildings can break apart and fall away or buckle, potentially causing a complete collapse of the building. The number of unreinforced masonry structure in the planning area is unknown.

Loss Potential

Table 10-4 summarizes Hazus estimates of earthquake damage in the planning area for the 500-year probabilistic earthquake scenario. The debris estimate includes only structural debris; it does not include additional debris that may accumulate, such as from trees. In addition, these estimates do not include losses that would occur from any local tsunamis or fires stemming from an earthquake.

10.5.3 Critical Facilities and Infrastructure

Level of Damage

Hazus classifies the vulnerability of critical facilities to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a probability of each damage state to every critical facility in the planning area. The results found no critical facilities or infrastructure in the planning area likely to be damaged for the 500-year probabilistic scenario.

10.5.4 Environment

Environmental problems as a result of an earthquake can be numerous. Secondary hazards will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly damage surrounding habitat. It is also possible for streams to be rerouted after an earthquake. Rerouting can change the water quality, possibly damaging habitat and feeding areas. Streams fed by groundwater wells can dry up because of changes in underlying geology.

10.6 FUTURE TRENDS IN DEVELOPMENT

With the low degree of risk to the earthquake hazard within the planning area, any future development should be able to adequately manage that risk through the application of codes and standards such as the International Building Code, which have regionally relevant seismic standards contained in its base regulations. The core capability assessments by the municipal planning partners to this effort identified a strong commitment to adoption of uniform codes and standards, which will position the planning partnership well for the mange earthquake risk for future development.

10.7 SCENARIO

There is no feasible scenario to project for an earthquake event for the planning area. At least one notable earthquake has affected the Harris County area. The August 16, 1931 event, which had an epicenter 854 miles from Houston, registered as a “III” on the Modified Mercalli Intensity Scale for earthquakes. This would indicate that the event would have registered between 4.2 and 4.8 on the Richter Scale, and that it likely caused little or no damage but would have been felt by people resting, similar to if a large truck rumbled by causing minimal to no damage impact.

10.8 ISSUES

The CPT identified no significant issues pertaining to the earthquake hazard.

Table 10-4. Estimated Impact of Earthquake Scenario Events in the Planning Area

Jurisdiction	Structure Debris		Damage	
	Tons	Truckloads	Structure + Contents Damage	% of Total Value
Baytown[c]	1,050	42	$1,237,560	0.11
Bellaire	290	12	$490,208	0.009
Bunker Hill Village	100	4	$69,810	0.005
Deer Park	1,012	40	$922,783	0.016
El Lago	0	0	$14,324	0.003
Friendswood[c]	110	4	$227,523	0.004
Galena Park	370	15	$233,460	0.020
Hedwig Village	200	8	$71,354	0.006
Hilshire Village	100	4	$17,984	0.009
Houston[a, b]	80,870	3,235	$72,793,475	0.015
Humble	830	33	$656,093	0.014
Hunters Creek Village	300	12	$113,204	0.006
Jacinto City[a]	360	14	$262,508	0.021
Jersey Village	470	19	$425,276	0.019
Katy[c]	240	10	227,698	0.007
La Porte	2,170	87	$1,541,964	0.023
League City[a, b]	200	8	$22,012	0.008
Missouri City[c]	410	16	$637,129	0.005
Morgan's Point	120	5	$75,174	0.029
Nassau Bay	700	28	$138,554	0.008
Pasadena	3,340	134	$3,162,040	0.014
Pearland[a]	110	4	$93,607	0.013
Piney Point Village	900	36	$150,007	0.008
Seabrook	210	8	$188,214	0.007
Shoreacres	0	0	$8,929	0.004
South Houston[a]	610	24	$456,862	0.021
Southside Place[a]	100	4	$24,238	0.005
Spring Valley Village	600	24	$106,027	0.009
Stafford[c]	340	14	$356,147	0.006
Taylor Lake Village	400	16	$43,328	0.006
Tomball	390	16	$377,658	0.011
Waller[a, b]	400	16	$29,831	0.013
Webster	590	24	$823,692	0.014
West University Place	200	8	$168,442	0.005
Unincorporated	44,060	1,762	$38,758,843	0.012
Total	**142,152**	**5,686**	**$124,925,958.00**	**0.485**

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
b. City extends beyond Harris County. Values shown are for Harris County portion only.
c. City extends beyond Harris County. Values shown are for entire city.

11. FLOODING

11.1 GENERAL BACKGROUND

11.1.1 Types of Flooding

Floods are generally the result of excessive precipitation. In Harris County, flooding generally takes one of the following forms:

- **Riverine Flooding—**Riverine flooding occurs when rivers overflow their banks in response to excessive precipitation levels and water runoff volumes within the watershed. Riverine floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.
- **Coastal Flooding—**Coastal flooding is primarily caused by storm surge, a cascading effect of hurricanes and coastal storms that pushes water toward the shore. The result can be waves that extend further inland, causing damage to development that would not normally be subject to wave action. Storm surge heights, and associated waves, are dependent upon the local width of the continental shelf and the depth of the ocean bottom. A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge but higher and more powerful storm waves. Due to the high risk and vulnerability to this flood specific hazard, it was analyzed independently in this chapter rather than as a cascading effect of hurricanes.
- **Flash Flooding—**Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. However, flash flooding events can also occur from accelerated snow melt due to heavy rains, a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by an ice jam. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces. Flash flood waters move at very high speeds, uprooting trees, destroying buildings, and obliterating bridges and roads.
- **Urban Flooding—**Urban flooding occurs when development has obstructed the natural flow of water and decreased the ability of natural groundcover to absorb and retain surface water runoff.

11.1.2 Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability for river systems and storm surge levels for coastal systems. The discharge probability is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Storm surge levels are determined by modeling water depth, wind speed, vegetative cover and other factors to determine the "wave runup" (how far inland waves will reach) and "wave setup" (the height, speed, and slope of waves relative to the still-water elevation).

Flood studies use historical records to determine the probability of occurrence for different discharge levels and storm surge levels. These measurements reflect statistical averages only; it is possible for multiple floods with a low probability of occurrence (such as a 1-percent-annual-chance flood) to occur in a short time period. For riverine flooding, the same flood event can have flows at different points on a river that correspond to different probabilities of occurrence.

The extent of coastal flooding (storm surge) is determined by a variety of factors such as the range of water depth, the width and slope of the gulf/bay, the path of a hurricane, wind speeds, shape of the coastline, and the forward speed. (NOAA). The forward motion of a storm complements the counterclockwise rotation of the wind field, which usually results in the highest coastal flooding and surges from hurricanes occurring on the right-front (northeast) quadrant of the storm's track. A combination of tools/methods can be used to measure coastal flooding/storm surge, such as tidal stations, high water marks, pressure sensors and the NOAA SLOSH model.

The extent of flooding associated with a 1-percent annual probability of occurrence (also called the base flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water that will result from a given discharge level, which is one of the most important factors used in estimating flood damage.

11.1.3 FEMA Regulatory Flood Zones

FEMA defines flood hazard areas as areas expected to be inundated by a flood of a given magnitude. These areas are determined via statistical analyses of records of river flow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses. Flood hazard areas are delineated on Flood Insurance Rate Maps (FIRMs) or digital Flood Insurance Rate Maps (DFIRMs), which provide the following information:

- Locations of specific properties in relation to the SFHA
- Base flood elevations (1-percent-annual-chance) at specific sites
- Magnitudes of flood in specific areas
- Undeveloped coastal barriers where flood insurance is not available
- Regulatory floodways and floodplain boundaries (1-percent and 0.2-percent-annual-chance floodplain boundaries).

Land area covered by floodwaters of the base flood is the SFHA on a DFIRM—an area where NFIP floodplain management regulations must be enforced, and where mandatory purchase of flood insurance applies. This regulatory boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities, because many communities have maps showing the extent of the base flood and likely depths that will occur.

The base flood elevation (the water elevation of a flood that has a 1-percent chance of occurring in any given year) is one of the most important factors in estimating potential damage from flooding. A structure within a 1-percent-annual-chance floodplain has a 26-percent chance of undergoing flood damage during the term of a 30-year mortgage. The 1-percent-annual-chance flood is used by the NFIP as the basis for insurance requirements nationwide. DFIRMs also depict 0.2-percent-annual-chance flood designations.

FIRMs and DFIRMs are the principle tool used to identify the extent and location of the flood hazard. FEMA and the floodplain management community acknowledge that these maps are not a total depiction of an area's flood risk. They represent the best data source available, but the level of risk they indicate may be understated or overstated compared to current conditions. The following limitations to the accuracy of these maps need to be recognized:

- FIRMs are based on hydrologic conditions at the time they are prepared. FIRMs are not set up to account for changes in hydrology that can occur over time. FIRMs can be up to 25 years old, and therefore fail to reflect the conditions of the watershed as they exist today.
- FIRMs do not account for the flood protection benefits of levees unless the levees are certified as providing 100-year flood protection (according to criteria specified in Section 65.10 of 44 CFR). The

national levee policy is in a state of flux. Some levees are recognized as 100-year levees on FIRMs, others are not. The age of the older maps can draw into question the level of protection provided by levees today. The potential for levees to be certifiable in their current condition requires costly, detailed risk-based analyses.

11.1.4 Floodplain Ecosystems and Beneficial Functions

Connections between a river and its floodplain form a complex physical and biological system that not only supports a variety of natural resources but also provides natural flood and erosion control. When floodwaters recede after a river flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream. Fertile, flat reclaimed floodplain lands are commonly used for agriculture, commerce and residential development. When a river is separated from its floodplain with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive, and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly, but the surge of new growth endures for some time. This makes floodplains valuable for agriculture. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and very quick-growing compared to non-riparian trees.

Floodplains have many natural and beneficial functions, and disruption of natural systems can have long-term consequences for entire regions. Some well-known, water-related functions of floodplains (noted by FEMA) include:

- Natural flood and erosion control
- Provide flood storage and conveyance
- Reduce flood velocities
- Reduce flood peaks
- Reduce sedimentation
- Surface water quality maintenance
- Filter nutrients and impurities from runoff
- Process organic wastes
- Moderate temperatures of water
- Groundwater recharge
- Promote infiltration and aquifer recharge
- Reduce frequency and duration of low surface flows.

Areas in the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species.

11.1.5 Effects of Human Activities

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; riverine floodplain land is fertile and suitable for farming; transportation by water is easily accessible; land is flatter and easier to develop; and there is value placed in ocean views. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage

channels or causing erosion of natural flood protection systems such as dunes. Flood potential can be increased in several ways: reducing a stream's capacity to contain flows; increasing flow rates or velocities downstream; and allowing waves to extend further inland. Human activities can interface effectively with a floodplain as long as steps are taken to mitigate the activities' adverse impacts on floodplain functions.

11.2 HAZARD PROFILE

11.2.1 Flooding Sources

Harris County consists of portions of two primary watershed systems—the San Jacinto River and Buffalo Bayou—along with a number of smaller watershed systems. Each of these ultimately drains into Galveston Bay on the southeast side of the county. Most of the floodwaters in Harris County result from rainfall within the county. With the exception of the San Jacinto River system, minimal flows are conveyed into Harris County from upstream watersheds. These planning area is are drained by 22 major waterways, as described in the following sections.

Waterways in the San Jacinto River System

San Jacinto River

The San Jacinto River drains a 3,600-square-mile watershed (including 487 square miles in Harris County) that originates well outside and upstream of Harris County. It drains all or part of Harris, Montgomery, Waller, Walker, Grimes, Liberty, and San Jacinto Counties. The river is formed by the junction of the West and East Forks, which each enter northern Harris County. Lake Houston is a water supply reservoir in northeast Harris County along the San Jacinto River, which includes the confluence of the East and West Forks. The San Jacinto River extends southward through the eastern portion of Harris County from the Lake Houston Dam to its confluence with the Houston Ship Channel continuing on to its mouth at Galveston Bay. The Port of Houston Authority operates the Houston Ship Channel, which originates at the Turning Basin, follows the original alignment of Buffalo Bayou to the San Jacinto River, and continues through the San Jacinto River and San Jacinto Bay to Galveston Bay. Although it is part of the original alignment of Buffalo Bayou, for organizational purposes the ship channel below the Turning Basin is considered a part of the San Jacinto Watershed. Notable tributaries include the East and West Forks. Spring Creek, Cypress Creek, Little Cypress Creek, Willow Creek, Luce Bayou, Goose Creek, and Jackson Bayou also part of the San Jacinto River system but are described separately. Most of the watershed is rural and undeveloped, although some more moderate levels of development have occurred within Harris County. Communities in the watershed include the Cities of Houston, Baytown, Deer Park, Galena Park, Humble, La Porte, Morgan's Point, Pasadena, and unincorporated Harris County.

Spring Creek

Spring Creek forms the northern boundary of Harris County, bordering Montgomery and Waller Counties. The watershed also includes a portion of Grimes County. The watershed drains 761 square miles in an easterly direction to its confluence with the West Fork of the San Jacinto River upstream of Lake Houston. Notable tributaries and sub-tributaries to Spring Creek from Harris County include Cypress Creek, Little Cypress Creek, and Willow Creek, all of which are described separately in this report. Consequently, this description of the Spring Creek watershed only considers the 59.5 square miles of the watershed that are not in these other watersheds. Notable tributaries from Montgomery County include Lake Creek and Panther Branch. Spring Creek is 68 miles in length. The watershed is lightly developed, with some residential development. Communities in the watershed include the Cities of Houston, Humble, Tomball, and unincorporated Harris County.

Cypress Creek

Cypress Creek is a tributary of Spring Creek and is a part of the San Jacinto River Watershed system. It drains eastward over a length of 50 miles from its origin at the junction of Mound Creek and Snake Creek in Waller County to its confluence with Spring Creek near the West Fork of the San Jacinto River. The Cypress Creek Watershed is 320 square miles, but excluding the Little Cypress Creek Watershed (which is described separately), the watershed is 268 square miles in size. The middle and lower portions of the watershed have a moderate level of residential development, while the upstream portion of the watershed is predominately rural and agricultural. Notable tributaries include Mound Creek, Snake Creek, Rock Hollow, Dry Creek, Little Cypress Creek, Faulkey Gully, Theiss Gully, Seals Gully, and Turkey Creek. Communities within the watershed include the Cities of Houston and Waller and unincorporated Harris County.

Little Cypress Creek

Little Cypress Creek is a tributary of Cypress Creek. It drains southeastward for a length of 22 miles from its headwaters in far northwest Harris County to its confluence with Cypress Creek. The Little Cypress Creek Watershed consists of 52 square miles and has a light amount of predominately residential development. The remainder of the watershed is either open land or agricultural. Communities within the watershed include unincorporated Harris County.

Willow Creek

Willow Creek is a tributary of Spring Creek. It drains northeastward for a length of 20 miles from its headwaters near Tomball to its confluence with Spring Creek. The watershed drains an area of 56 square miles. The watershed has a light amount of residential development. The remainder of the watershed is either open or agricultural. Communities within the watershed include the City of Tomball and unincorporated Harris County.

Luce Bayou

Luce Bayou is a tributary of the East Fork of the San Jacinto River. It drains southward for 35 miles from its headwaters in the Sam Houston National Forest in San Jacinto County to its confluence with the East Fork of the San Jacinto River in the upper portion of Lake Houston. The watershed covers 227 square miles and includes portions of San Jacinto, Liberty, and Harris Counties. The Harris County portion includes only the lower 17 square miles of the watershed. There is minimal development in the watershed; most of the land is forest. Communities within the watershed include the City of Houston and unincorporated Harris County.

Jackson Bayou

Jackson Bayou is a tributary of the San Jacinto River. It drains southward over a length of 7 miles. from its headwaters in east Harris County to its confluence with the San Jacinto River. The Jackson Bayou watershed is 50 square miles in size. It is lightly developed, with some rural subdivisions in the lower portion of the watershed. Notable tributaries include Gum Gully. Communities within the watershed include the City of Houston and unincorporated Harris County.

Goose Creek

Goose Creek is a tributary of the San Jacinto River. It drains southward over a length of 15 miles from its headwaters in east Harris County to its confluence with the San Jacinto River just downstream of its confluence with the Houston Ship Channel. The Goose Creek Watershed is 33 square miles in size. It is moderately developed, but the lower half of the watershed has mostly dense residential along with some concentrations of commercial and industrial development. For descriptive purposes, the Goose Creek watershed includes Spring Gully, which drains directly into the San Jacinto River and does not have a common confluence with Goose Creek. Communities within the watershed include the City of Baytown and unincorporated Harris County.

Waterways in the Buffalo Bayou System

Buffalo Bayou

The Buffalo Bayou Watershed is described as the area downstream of Addicks and Barker Reservoirs that drains to Buffalo Bayou and is not part of another designated watershed tributary to Buffalo Bayou. This area totals 102 square miles and drains into Buffalo Bayou as it extends eastward for 50 miles from Barker Reservoir to the Houston Ship Channel Turning Basin just east of downtown Houston. The Buffalo Bayou Watershed is highly urbanized, with a mix of residential and commercial land uses. Features within the watershed include Memorial Park and downtown Houston. Communities within the watershed include the Cities of Houston, Bunker Hill Village, Hedwig Village, Hilshire Village, Hunter's Creek Village, Piney Point Village, Spring Valley, and unincorporated Harris County.

Sims Bayou

Sims Bayou is a tributary to Buffalo Bayou. It drains eastward over a length of 25 miles from its headwaters in Fort Bend County to its confluence with the Houston Ship Channel. The Sims Bayou watershed is 93 square miles in size. It is moderately developed, consisting mostly of a relatively high-density (for Harris County) residential, with most of the development concentrated in the downstream and upstream portions of the watershed. The largest tributary to Sims Bayou is Berry Bayou. Communities within the watershed include the Cities of Houston, Missouri City, South Houston, Stafford, and Pasadena, and unincorporated Harris County.

Brays Bayou

Brays Bayou is a tributary of Buffalo Bayou. It drains eastward over a length of 32 miles from its headwaters in Fort Bend County and southwest Harris County to its confluence with the Houston Ship Channel. The Brays Bayou Watershed is 128 square miles in size. It is highly developed, with land use ranging from residential to dense commercial. The watershed includes the Texas Medical Center, Herman Park, and the Reliant Park Complex. Notable tributaries include Keegans Bayou and Willow Waterhole Bayou. Communities include the Cities of Houston, Bellaire, Southside Place, Stafford, and West University Place, and unincorporated Harris County.

White Oak Bayou

White Oak Bayou is a tributary of Buffalo Bayou. It drains southeastward over a length of 30 miles from its headwaters in northwest Harris County to its confluence with Buffalo Bayou near downtown Houston. The White Oak Bayou Watershed is 111 square miles in size. It is highly developed, with primarily residential land use. Notable tributaries include Little White Oak Bayou, Brickhouse Gully, Cole Creek, and Vogel Creek. Communities in the watershed include the Cities of Houston and Jersey Village, along with unincorporated Harris County.

Hunting Bayou

Hunting Bayou is a tributary of Buffalo Bayou. It drains eastward and then southward over a length of 15 miles from its headwaters in northeast Houston to its confluence with the Houston Ship Channel near the Washburn Tunnel. The Hunting Bayou Watershed is 30 square miles in size. It is moderately to highly developed, with mostly dense residential development in the upper portion of the watershed and industrial and commercial development in the middle and lower portions of the watershed. Communities within the Hunting Bayou Watershed include the Cities of Houston, Galena Park, and Jacinto City, along with unincorporated Harris County.

Vince Bayou

Vince Bayou is a tributary of Buffalo Bayou. It drains northward for a length of 6 miles from its headwaters in Pasadena to its confluence with the Houston Ship Channel. The watershed is densely developed, with a mixture of residential, commercial, and industrial uses. Communities within the watershed include the Cities of Houston, South Houston, and Pasadena.

Carpenters Bayou

Carpenters Bayou is a tributary of Buffalo Bayou. It drains southward over a length of 13 miles from its headwaters in northeast Harris County to its confluence with the Houston Ship Channel. The Carpenters Bayou Watershed is 31 square miles in size. It has a low to moderate amount of development, consisting mostly of small lot residential and commercial. Sheldon Reservoir is located in the upper basin. This shallow lake and adjoining lands are owned by the State of Texas and were formally used by the Texas Parks and Wildlife Department for fish research and hatchery. Communities within the watershed include the City of Houston and unincorporated Harris County.

Greens Bayou

Greens Bayou is a tributary of Buffalo Bayou. It drains eastward and then southward for a distance of 42 miles from its headwaters in northwest Harris County to its confluence with the Houston Ship Channel. The Greens Bayou Watershed is 211 square miles in size. It is moderately developed; most of the land use is residential and light commercial. The watershed includes George Bush Intercontinental Airport. Notable tributaries include Halls Bayou and Garners Bayou. Communities within the watershed include the Cities of Houston and Humble and unincorporated Harris County.

Barker Reservoir

Barker Reservoir was constructed with Addicks Reservoir to protect downtown Houston and the Houston Ship Channel by impounding flood flows in the upper portion of Buffalo Bayou. The Barker Reservoir Watershed includes all those areas that contribute drainage into the reservoir. This watershed encompasses 129 square miles much of which is within Fort Bend County. A moderate amount of development has occurred in the watershed, consisting predominately of residential development. The primary streams that feed the reservoir are Upper Buffalo Bayou, Cane Island Branch, and Mason Creek. Communities within the watershed include the Cities of Houston and Katy, and unincorporated Harris County.

Addicks Reservoir

Addicks Reservoir was constructed with Barker Reservoir to protect downtown Houston and the Houston Ship Channel by impounding flood flows in the upper tributaries of Buffalo Bayou. The Addicks Reservoir Watershed includes all those areas that contribute drainage into the reservoir. This watershed encompasses 136 square miles of area, all of which is in northwest Harris County. A moderate amount of predominately residential development has occurred in the watershed. The primary streams that feed the reservoir are Langham Creek, South Mayde Creek, Bear Creek, Horsepen Creek, and Dinner Creek. Communities within the watershed include the Cities of Houston and Katy and unincorporated Harris County.

Waterways Directly Tributary to Galveston Bay

Clear Creek

Clear Creek forms the southern boundary of Harris County, bordering Galveston and Brazoria Counties and then extending upstream to its headwaters in Fort Bend County. The watershed drains 198 square miles in an easterly direction into Clear Lake, a natural estuary lake, and then into Galveston Bay. A light to moderate level of

development has occurred in the watershed, with most of it concentrated in the downstream and middle reaches. Although the development is mostly residential and commercial, National Aeronautics and Space Administration's Johnson Space Center and associated industries make up a considerable portion of the development in the areas near Clear Lake in the downstream portion of the watershed. Significant tributaries to Clear Creek include Mary's Creek, Cowart Creek, and Hickory Slough, all of which drain from adjacent counties to the south; and Armand Bayou, which is described separately. Communities in the watershed include the Cities of Houston, El Lago, Friendswood, La Porte, League City, Missouri City, Nassau Bay, Pasadena, Pearland, Seabrook, Shoreacres, Taylor Lake Village, Webster, and unincorporated Harris County.

Armand Bayou

Armand Bayou is a tributary of Clear Creek but is treated as a separate watershed. It drains an area of 59 square miles southward into Clear Lake near Galveston Bay. The watershed is moderately developed, with a mix of residential and dense industrial. This development is evenly distributed across the watershed. Communities in the watershed include the Cities of Houston, Deer Park, La Porte, Nassau Bay, Pasadena, Taylor Lake Village, Webster, and unincorporated Harris County.

Cedar Bayou

Cedar Bayou forms the eastern boundary of Harris County, bordering Chambers County. It drains southward for a distance of 51 miles from its headwaters in Liberty County to its confluence with Galveston Bay. The Cedar Bayou Watershed is 199 square miles in size and is lightly developed. Notable tributaries include Pine Gully. Communities within the watershed include the City of Baytown and unincorporated Harris County.

Galveston Bay Tributaries

The Galveston Bay Tributaries are small tributaries along Galveston Bay between Clear Lake and the Houston Ship Channel that drain directly into Galveston Bay and are not included in other watersheds. This area is moderately developed and includes both residential areas and dense commercial and industrial. Notable tributaries include Little Cedar Bayou and Pine Gully. Communities included in this watershed include the Cities of La Porte, Morgan's Point, Pasadena, Seabrook, Shoreacres, and unincorporated Harris County.

11.2.2 Principal Flood Problems

Harris County is subject to intense local thunderstorms of short duration, general storms extending over periods of several days, and torrential rainfall associated with tropical events. The area features flat terrain, clay soils that do not absorb water well, and an average annual rainfall of 48 inches. The potential for extreme rainfall events, coupled with the flat topography and poorly draining soils, contribute to frequent flooding. Flooding also results from tidal surge along Galveston Bay caused by hurricanes and tropical storms.

The Harris County planning area also is subject to chronic urban flooding. As land use within Harris County has transitioned from rural/agricultural, to more high density urban, the propensity for urban drainage flooding has increased. The two key factors that contribute to urban flooding are rainfall intensity and duration. Topography, soil conditions, urbanization and groundcover also play an important role. Urban flooding occurs when available conveyance systems lack the capacity to convey rainfall runoff to nearby creeks, streams, rivers and bayous. As drainage facilities are overwhelmed, roads and transportation corridors become conveyance facilities.

Urban floods can be a great disturbance of daily life in urban areas. Roads can be blocked, and people may be unable to go to work or school. Economic damage can be high, but the number of casualties is usually limited, because of the nature of the flood. When the city is on flat terrain, the flow speed is low, and people can still drive through it. The water rises relatively slowly and usually does not reach life endangering depths.

11.2.3 Flood Control in the Planning Area

Following severe floods in 1929 and 1935, the State of Texas created the Harris County Flood Control District in 1937 for the purpose of "the control, storing, preservation, and distribution of the storm and flood waters, and the waters of the rivers and streams in Harris County and their tributaries, for domestic, municipal, flood control, irrigation, and other useful purposes, the reclamation and drainage of the overflow land of Harris County, the conservation of forests, and to aid in the protection of navigation on the navigable waters by regulating the flood and storm waters that flow into said navigable streams." Since that time, there have been many significant projects to reduce flood damage in Harris County. Many were the result of partnerships between the Flood Control District and the U.S. Army Corps of Engineers (USACE), FEMA, and others.

The District's drainage and flood control infrastructure is extensive, including more than 1,500 channels totaling about 2,500 miles in length. The District is responsible for devising and implementing flood damage reduction projects and maintaining the primary drainage infrastructure. Its current annual 5-year plan calls for flood damage reduction projects with a budget of nearly $975 million (Harris County Flood Control District).

11.2.4 Flood Insurance in the Planning Area

National Flood Insurance Program

All communities in the planning area participate in the NFIP, with 318,138 flood insurance policies providing $63.1 billion in insurance coverage. According to FEMA statistics, 161,483 flood insurance claims were paid between January 1, 1978 and July 31, 2019, for a total of $8.5 billion, an average of $52,374 per claim. Table 11-1 lists flood insurance statistics that help identify vulnerability in the planning area.

Properties constructed after a FIRM has been adopted are eligible for reduced flood insurance rates. Such structures are less vulnerable to flooding since they were constructed after regulations and codes were adopted to decrease vulnerability. Properties built before a FIRM is adopted are more vulnerable to flooding because they do not meet code or are located in hazardous areas. The first FIRMs in Harris County were available in 1970.

The Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses.
- Facilitate accurate insurance rating.
- Promote awareness of flood insurance.

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) The discount partially depends on location of the property. Properties outside the SFHA receive smaller discounts: a 10-percent discount if the community is at Class 1 to 6 and a 5-percent discount if the community is at Class 7 to 9. The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness.

Table 11-1. Flood Insurance Statistics

Community	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies as of 06/30/2019	Insurance In Force	Total Annual Premium	Claims, as of 7/31/2019	Value of Claims paid, as of 7/31/2019
Baytown	02/26/1970	3,970	$1,208,945,700	$2,153,223	3,073	$119,662,011
Bellaire	09/30/1981	5,057	$1,567,537,900	$4,535,524	3,200	$254,782,750
Bunker Hill Village	04/17/1979	756	$258,702,600	$321,830	274	$8,105,483
Deer Park	08/15/1980	4,393	$1,366,788,800	$2,245,409	1,814	$44,821,404
El Lago	07/02/1971	875	$243,877,000	$522,254	590	$15,431,307
Friendswood	03/03/1972	1,958	$590,773,700	$846,418	1,113	$123,506,213
Galena Park	11/02/1982	267	$65,512,300	$146,340	201	$5,370,540
Hedwig Village	09/28/1990	387	$132,062,100	$199,697	120	$3,457,558
Hilshire Village	09/30/1992	143	$48,532,200	$59,209	32	$1,205,958
Houston[a]	12/11/1972	146,871	$41,457,850,300	$87,331,237	82,200	$4,603,548,089
Humble	09/16/1982	875	$264,594,300	$590,111	825	$55,352,654
Hunters Creek Village	11/05/1980	788	$272,886,800	$345,798	268	$17,847,239
Jacinto City[a]	09/02/1981	257	$63,582,400	$118,598	193	$7,623,298
Jersey Village	03/15/1982	1,364	$425,774,200	$1,204,426	863	$46,404,149
Katy	03/02/1981	1,337	$405,189,300	$672,915	359	$29,572,897
Laporte	02/17/1971	4,841	$1,355,410,600	$2,963,276	3,034	$94,639,112
League City[a]	06/05/1970	164	$59,258,800	$80,845	88	$4,860,113
Missouri City	01/06/1982	329	$85,043,000	$152,004	89	$412,457
Morgan's Point	12/01/1983	86	$30,206,500	$57,119	28	$576,996
Nassau Bay	11/13/1970	1,358	$401,431,400	$1,081,206	1,531	$57,512,427
Pasadena	12/31/1974	10,129	$2,956,117,200	$4,997,515	6,989	$189,938,148
Pearland[a]	07/05/1984	1,359	$457,792,300	$551,735	333	$15,003,279
Piney Point Village	12/02/1980	611	$207,040,600	$347,337	338	$20,537,774
Seabrook	12/31/1974	3,357	$997,428,900	$3,199,871	2,995	$119,675,138
Shoreacres	11/20/1970	526	$139,390,900	$711,869	1,020	$57,079,468
South Houston[a]	03/18/1987	922	$181,099,200	$763,369	1,197	$38,014,251
Southside Place[a]	04/20/2000	383	$126,185,100	$312,815	35	$887,851
Spring Valley Village	06/04/1980	781	$266,865,000	$314,621	122	$2,056,131
Stafford	03/01/1982	21	$6,020,000	$7,502	23	$635,523
Taylor Lake Village	12/31/1974	1,069	$355,199,400	$628,181	708	$16,944,479
Tomball	12/18/1984	478	$155,481,500	$261,117	126	$16,944,479
Waller[a]	9/14/1979	6	$950,000	$2,421	3	$80,380
Webster	12/31/1974	1,145	$261,600,300	$634,723	537	$12,054,116
West University Place	04/20/2000	3,354	$1,130,891,400	$1,684,691	429	$13,084,872
Unincorporated County	05/26/1970	117,921	5,566,925,600	$54,373,817	46,733	$2,459,891,960
Total		**318,138**	**$**63,112,947,300	**$**174,419,023	**161,483**	**$**8,457,520,504

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
Source: FEMA, 2019

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

Harris County and 15 cities currently participate in the CRS program, representing 96.3 percent of the planning area policy base. Their CRS status is summarized in Table 11-2. The total annual savings on flood insurance premiums within the planning area is $33.65 million. Many of the mitigation actions identified in this plan are creditable activities under the CRS program. Therefore, successful implementation of this plan offers the potential for these communities to enhance their CRS classifications and for currently non-participating communities to join the program. Figure 11-1 shows the nationwide number of CRS communities by class as of October 2016, when there were 1,391 communities receiving flood insurance premium discounts under the CRS program.

Table 11-2. CRS Community Status in the Planning Area

Community	NFIP Community #	CRS Entry Date	Current CRS Classification	% Premium Discount, SFHA/non-SFHA	Total Premium Savings
Baytown	485456	10/1/1991	6	20	$430,645
Bellaire	480289	10/1/1993	7	15	$680,329
Deer Park	480291	10/1/2000	7	15	$336,811
Friendswood	485468	10/1/1991	7	15	$126,963
Harris County	480287	5/1/2004	7	15	$8,156,073
Houston[a]	480296	5/1/2002	5	25	$21,832,809
LaPorte	485487	10/1/1999	7	15	$444,491
League City[a]	485488	10/1/1992	6	20	$16,169
Missouri City	480304	5/1/2010	7	15	$22,800
Nassau Bay	485491	10/1/1992	7	15	$162,181
Pasadena	480307	10/1/1991	8	10	$499,752
Pearland[a]	480077	5/1/2005	6	20	$110,347
Seabrook	485507	10/1/2002	7	15	$479,980
Shoreacres	485510	5/1/2014	9	5	$35,593
Taylor Lake Village	485513	5/1/2014	8	10	$62,818
West University Place	480318	10/1/2019	7	15	$252,704
Total					**$33,650,465.00**

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
Source: FEMA, October 1, 2019

Source: FEMA, 2016

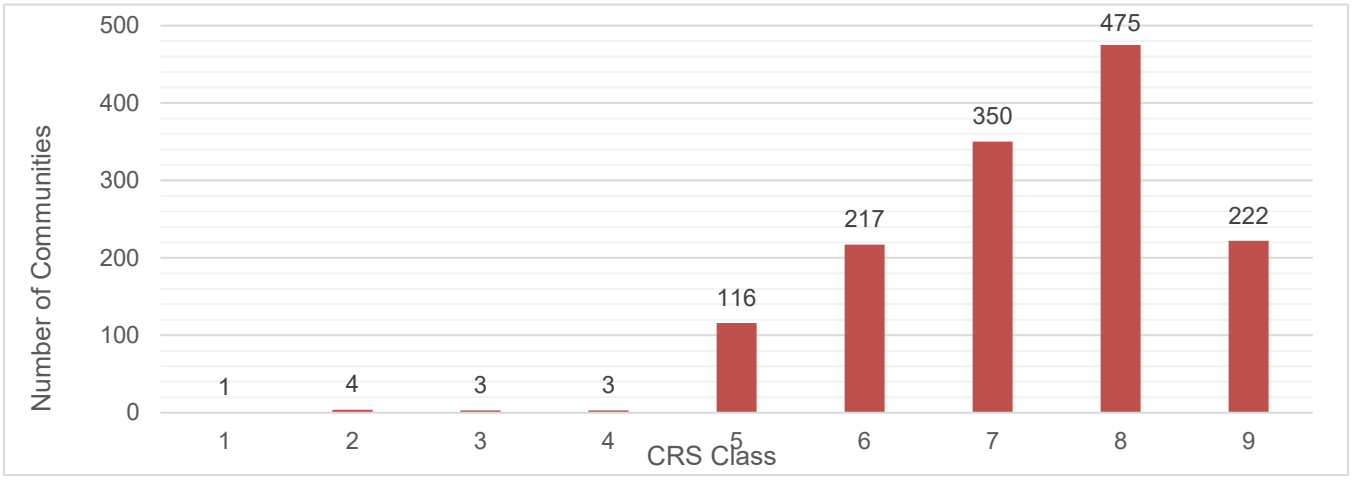


Figure 11-1. CRS Communities by Class Nationwide as of October 2016

11.2.5 Past Events

Following Tropical Storm Allison in 2001, FEMA and the Harris County Flood Control District published a report that included a 103-year flood history for Harris County. This dataset represents the most comprehensive historical occurrence record for the planning area. Table 11-3 summarizes the data, along with information on floods that have occurred since the flood history was published; Appendix D provides additional details on each event, provided by the National Climatic Data Center.

Table 11-3. History of Flood Events

Area Affected	Date	Deaths	Property Damage	Area Affected	Date	Deaths	Property Damage
Widespread	09/1900	6,000 to 8,000	$40,000,000	**Brazoria, Fort Bend, Galveston, Harris**	08/28/2001 - 08/31/2001	0	$1,463,000
Harris County, Houston	1907	0	N/A	**Harris, Houston, Pasadena**	04/08/2002		$70,000
Harris County	12/1913	0	N/A	**Brazoria, Galveston, Harris**	08/15/2002	0	$325,000
Harris County, Houston	08/1915	0	$56,000,000	**Harris, Houston, Bellaire, Jersey Village**	08/22/2002	0	$10,000
Harris County, Houston, Countywide	04/1929	0	N/A	**Harris, Pasadena, Deer Park**	09/08/2002	0	$15,000
Harris County	05/1929	0	N/A	**Harris, Houston**	09/19/2002	0	$55,000
Harris County	05/1930	0	N/A	**Brazoria, Galveston, Harris, Houston**	10/24/2002	0	$250,000
Harris County	08/1932	40	N/A	**Fort Bend, Harris, Liberty, Houston**	10/28/2002	0	$775,000
Harris County, Houston	12/1935	0	N/A	**Harris, Houston**	12/04/2002	0	$10,000
Northeast Harris County	11/1940	0	10,000 head of cattle	**Harris, Pasadena**	08/31/2003	0	$3,000
Harris County	07/1943	0	$16,500,000	**Harris and surrounding area**	11/17/2003	1	$3,000,000
Harris County	10/1943	0	N/A	**Harris, Houston, Memorial Village (The Villages), Pasadena**	05/01/2004	0	$3,000
Harris County	08/1945	0	N/A	**Harris, Houston**	05/13/2004	0	$7,000
Harris County	02/1950	0	N/A	**Harris, Houston**	6/13/2004	0	$50,000
Northern County Harris	05/1955	0	N/A	**Harris, Houston, Westfield**	11/22/2004	0	$15,000
Harris County	06/1957	0	N/A	**Harris, Houston, Aldine**	05/29/2005	0	$10,000
Houston	10/1959	0	N/A	**Harris, Houston**	7/14/2005	0	$115,000
Harris County	06/1960	0	N/A	**Harris, Houston, Clear Lake area**	12/14/2005	0	$40,000
Southern Harris County	09/1961	34 in Texas	$300,000,000	**Harris**	6/19/2006	0	$3,300,000
Harris County	02/1969	0	$3,300,000	**Harris**	6/22/2006	0	$200,000
Northern Harris County	03/1972	0	N/A	**Harris, Houston, Seabrook**	10/16/2006	4	$750,000
Harris County	06/1973	10	$50,000,000	**Harris, Tomball, Baytown**	10/26/2006	0	$150,000
Harris County	07/1979	0	$700,000,000	**Harris, Houston, Cypress, Spring Valley Village, Aldine, Southside Place**	5/10/2007	0	$650,000
Harris County	05/1983	0	$14,000,000	**Harris, Houston, Hedwig Village, Cypress**	05/30/2007	0	$0
Harris County and surrounding area	08/1983	0	$1 billion	**Harris, Houston**	07/06/2007	0	$50,000

Area Affected	Date	Deaths	Property Damage	Area Affected	Date	Deaths	Property Damage
Harris County	09/1983	0	$38,000,000	Harris, Deer Park, Pasadena, La Porte, Clear Lake.	8/16/2007	3	$750,000
Harris County	05/1989	0	N/A	Harris, Houston, Humble	10/15/2007	0	$5,000
Harris County	06/1989	0	N/A	Harris, Houston, Clear Lake, Shoreacres, Taylor Lake Village, Seabrook, County-wide	09/12-14/008	25	$3,000,000,000
Harris County	03/1992	0	N/A	Harris, Houston, Aldine, Humble	10/15/2008	0	$20,000
Austin, Brazoria, Chambers, Colorado, Fort Bend, Galveston, Harris,	10/16/1994 - 10/18/1994	17	$900,000,000	Harris, Houston, Jersey Village, Houston Heights, La Porte, Pasadena, Webster and Hobby	4/18/2009	5	$3,500,000
Liberty, Matagorda, Montgomery, Walker, Waller, Wharton				Harris, Friendswood, Baytown	4/24/2009	0	$1,000,000
Harris, Houston, Pasadena	09/18/1996	0	$1,500,000	Harris, Bellaire, Missouri City,	4/28/2009	1	$15,000,000
Harris, Houston	09/27/1996	0	$0	Harris, Pasadena, Baytown, La Porte, Nassau Bay, Clear Lake, Friendswood	10/22/2009	0	$4,000
Southeast Harris County	01/27/1997	0	$0	Harris, Houston	10/29/2009	0	$16,000
Harris, Houston	03/12/1997	0	$130,000	Harris, Houston	05/14/2010	0	$5,000
Harris, Houston	04/04/1997	0	$0	Harris, Houston	07/02/2010	0	$1,750,000
Harris, Countywide Houston, Jamaica Beach, Nassau Bay, Seabrook, Galveston	04/25/1997	0	$250,000	Harris, Houston	01/09/2012	0	$20,000
Harris, Houston	05/21/1997	1	$50,000	Harris, Houston	01/25/2012	0	$25,000
Harris, Houston	05/24/1997	0	$250,000	Harris, Houston	05/12/2012	0	$40,000
Harris, Houston	05/30/1997	0	$15,000	Harris, Houston	07/12/2012		$512,000
Harris, Webster	11/28/1997	0	$3,000	Harris County, Houston	04/27/2013	0	$3,000,000
Harris, Countywide, Humble, Houston	12/20/1997	0	$20,000	Harris, Houston	05/10/2013	0	$750,000
Harris, Pasadena	01/04/1998	0	$3,000	Harris, Houston, Jersey Village	09/20/2013	0	$75,000
Harris, Bellaire	01/06/1998	0	$5,000	Harris, Houston	10/31/2013	0	$0
Harris, Pasadena	01/21/1998	0	$5,000	Harris, Houston, Tomball	05/26 - 27/2014	0	$0
Harris, County-Wide	09/11/1998	0	$0	Harris, Houston	05/28/2014	0	$0
Harris County	09/1998	0	N/A	Harris County	07/03/2014	0	$5,000
Harris, Baytown	09/14/1998	0	$5,000	Harris, Houston, Pasadena	08/01/2014	0	$100,000
Harris	10/04/1998	0	$5,000	Harris, Houston	09/16/2014	0	$0

Area Affected	Date	Deaths	Property Damage	Area Affected	Date	Deaths	Property Damage
Austin, Brazoria, Brazos, Chambers, Colorado, Fort Bend, Grimes, Harris, Jackson, Liberty, Madison, Matagorda, Montgomery, Waller, Wharton, Humble, County-Wide	10/17/1998 - 10/18/1998	8	$418,000	**Harris, Sugar Land, Houston, Cypress, Hillshire Village, The Village area, Stafford, Hunters Creek Village**	09/18/2014	0	$25,000
Austin, Brazoria, Brazos, Colorado, Fort Bend, Harris, Jackson, Liberty, Madison, Matagorda, Montgomery, Polk, San Jacinto, Walker, Waller, Wharton	11/12/1998 - 11/14/1998	0	$239,000	**Harris, Houston, Katy, Bellaire**	09/19/2014	0	$1,000
Harris, Bellaire	03/19/1999	0	$300,000	**Houston, Bellaire, Pasadena, La Porte**	04/17/2015	0	$300,000
Harris	04/02/2000	0	$50,000	**Webster**	5/12/2015	1	$800,000
Harris, Liberty	05/19/2000	0	$10,400,000	**Houston, Orr**	10/31/2015	2	$1,000,000
Brazoria, Galveston, Harris	09/13/2000	0	$350,000	**Countywide**	04/18/2016	7	$35,000,000
Harris, Houston	03/28/2001	0	$35,000	**Hurricane Harvey**	08/26/2017	36	$10 billion
Harris County, Houston	06/2001	22	$5,000,000	**TOTAL**		**215[a]**	**$16,211,752,000[b]**

a. This figure does not include fatalities from the Galveston Hurricane of 1900; it does include some fatalities that may have occurred in surrounding areas.
b. This figure includes some damage estimates attributable to surrounding areas.
Sources: "Off The Charts: Tropical Storm Allison Public Report" and the National Climatic Data Center, 2019

Hurricane Harvey

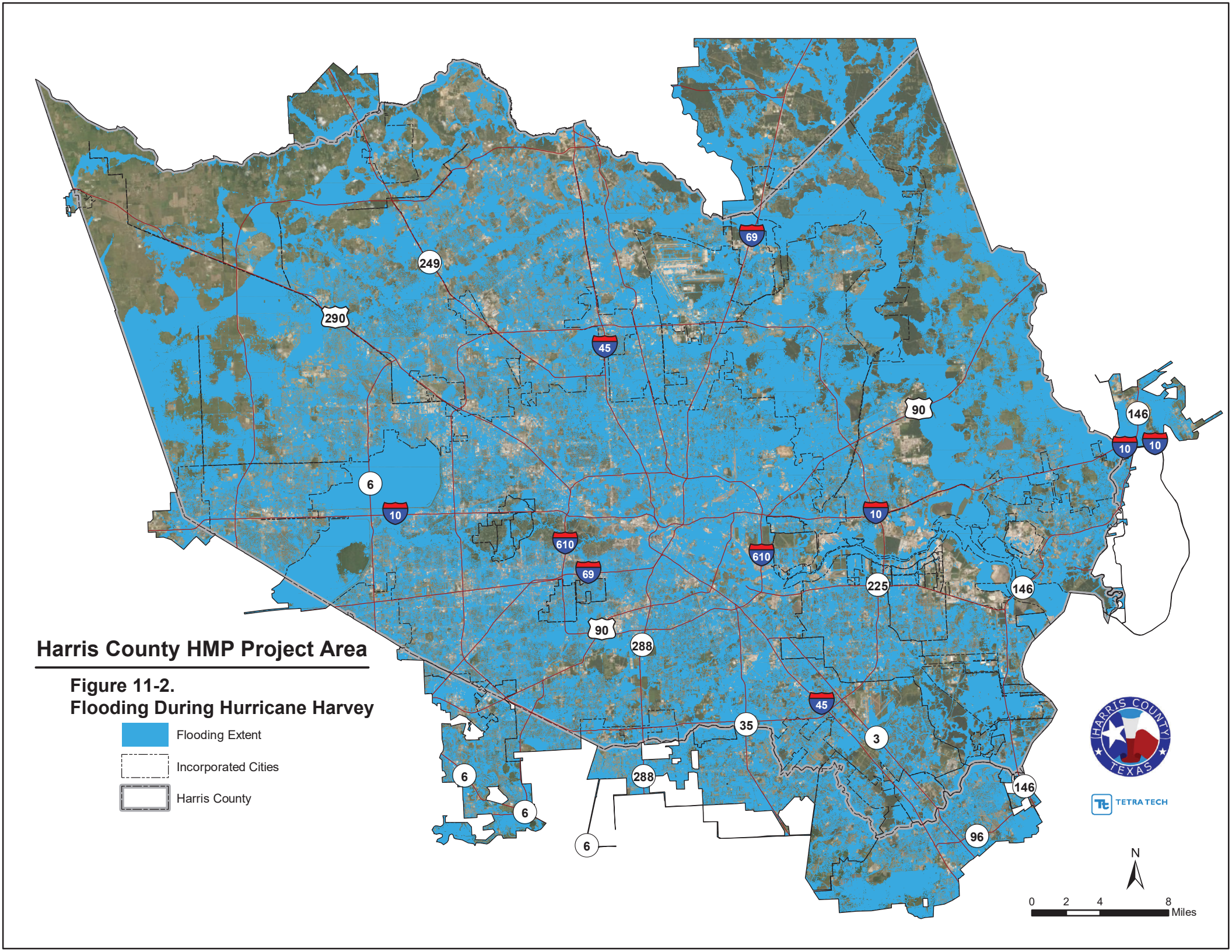
Hurricane Harvey made landfall on August 25, 2017 in Rockport, Texas, as a Category 4 Hurricane. After devastating south central Texas, Harvey returned to the Gulf of Mexico, refueling along its way. Harvey then moved slowly north along the coast, eventually making landfall and centering over the Harris County region for five days, producing unprecedented rainfall amounts. On August 27, all 22 main channels and bayous in the county spilled over their banks,. Never before had every bayou in Harris County flooded at the same time.

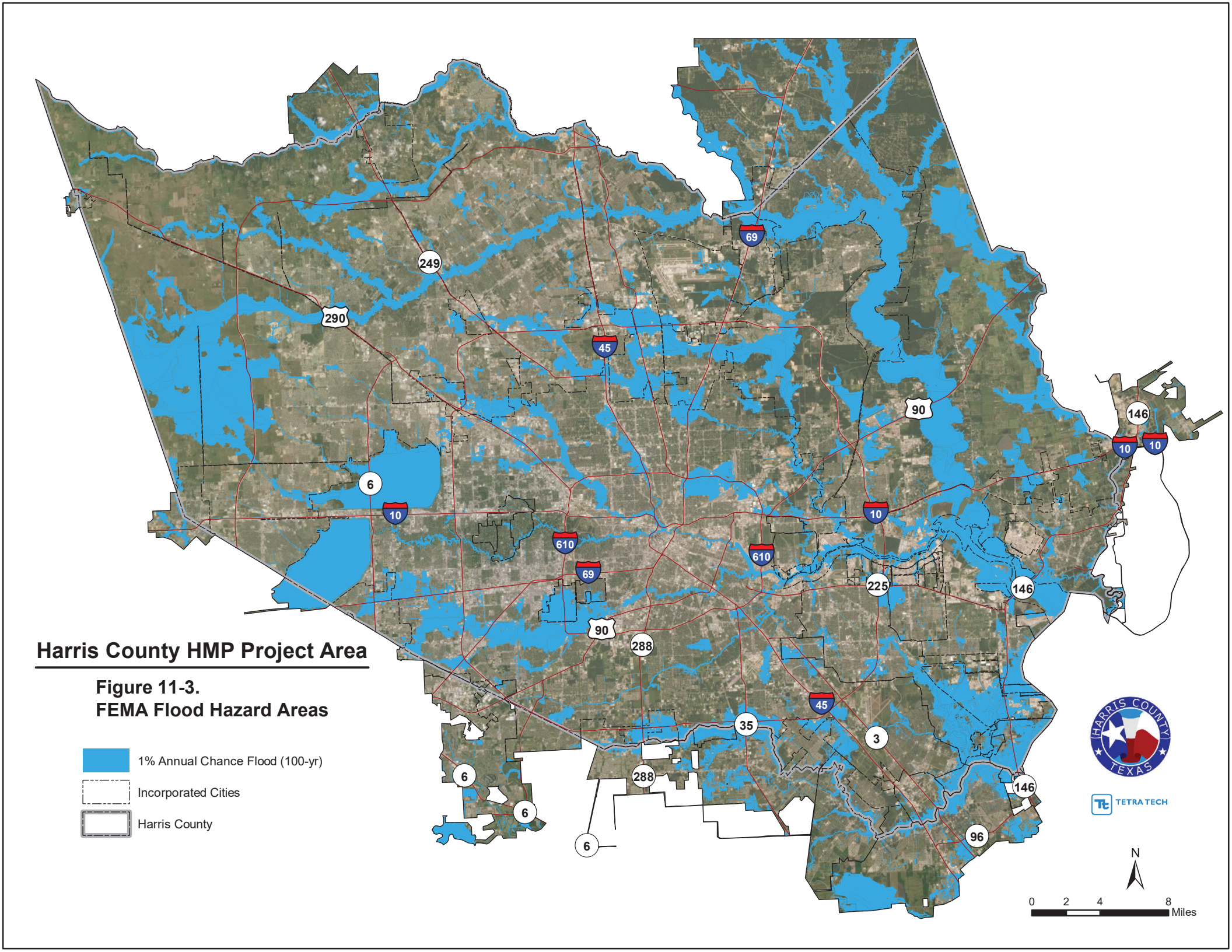
The rain that fell across Harris County over a 4-day period was enough to cover Harris County's 1,800 square miles with an average of 33 inches of water. More than two dozen rainfall gages registered seven-day readings topping 40 inches, with a maximum rainfall of 47.4 inches near Clear Creek at Interstate 45, nearly equal to the county's average rainfall for a year. It is estimated that more than 120,000 structures were flooded in Harris County. Figure 11-2 shows the flood extent and location during Hurricane Harvey.

11.2.6 Location

Riverine

Riverine and coastal floodplains may be broad or narrow, depending on local topography and natural flood defenses such as dune systems or tidal wetlands. There are numerous rivers and streams that wind through Harris County, setting the stage for potential flooding during heavy rain events. Harris County is most susceptible to riverine flooding in the flood zones identified in Figure 11-3.


Harris County HMP Project Area
Figure 11-2.
Flooding During Hurricane Harvey
Flooding Extent
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH


Harris County HMP Project Area
Figure 11-3.
FEMA Flood Hazard Areas
1% Annual Chance Flood (100-yr)
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
HARRIS COUNTY TEXAS
TETRA TECH
N
0 2 4 8
Miles

Coastal

Figure 11-4 shows the location of coastal flood hazard areas within the planning area using 5-foot, 10-foot, 20-foot, and 30-foot surge inundation data. Coastal flooding and storm surge are most likely along Galveston Bay, varying with the depth of coastal flooding. The communities exposed to coastal flooding at the most severe range of a 30-foot depth include Baytown, Deer Park, El Lago, Galena Park, Jacinto City, La Porte, Morgan's Point, Nassau Bay, Pasadena, Seabrook, Taylor Lake Village, Harris County and Webster. Refer to the jurisdictional annexes in Volume 2 for high-resolution maps depicting all participating jurisdictions.

11.2.7 Frequency

Drained by 22 watersheds, Harris County averages a severe flooding event every two years. (Harris County Flood Control District, 2019). Within the County, FEMA has identified numerous repetitive loss properties (NFIP, 2014). Harris County has been the subject of 32 presidential declarations of disaster for flooding since 1975 (FEMA, 2014).

Based on historical data, the probability of the Harris County planning area and all participating jurisdictions being affected by a riverine flood event is once every 0.81 years. The probability of the Harris County planning area and all participating jurisdictions being affected by a coastal flood event is once every 4.21 years. For the risk assessment for this plan update, the probability of occurrence for flooding is considered "high."

11.2.8 Severity

The severity of a flood event is determined by a combination of stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing. The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. Wave action has significant velocity, and waves as small as 1.5 feet can cause substantial damage to structures and other development.

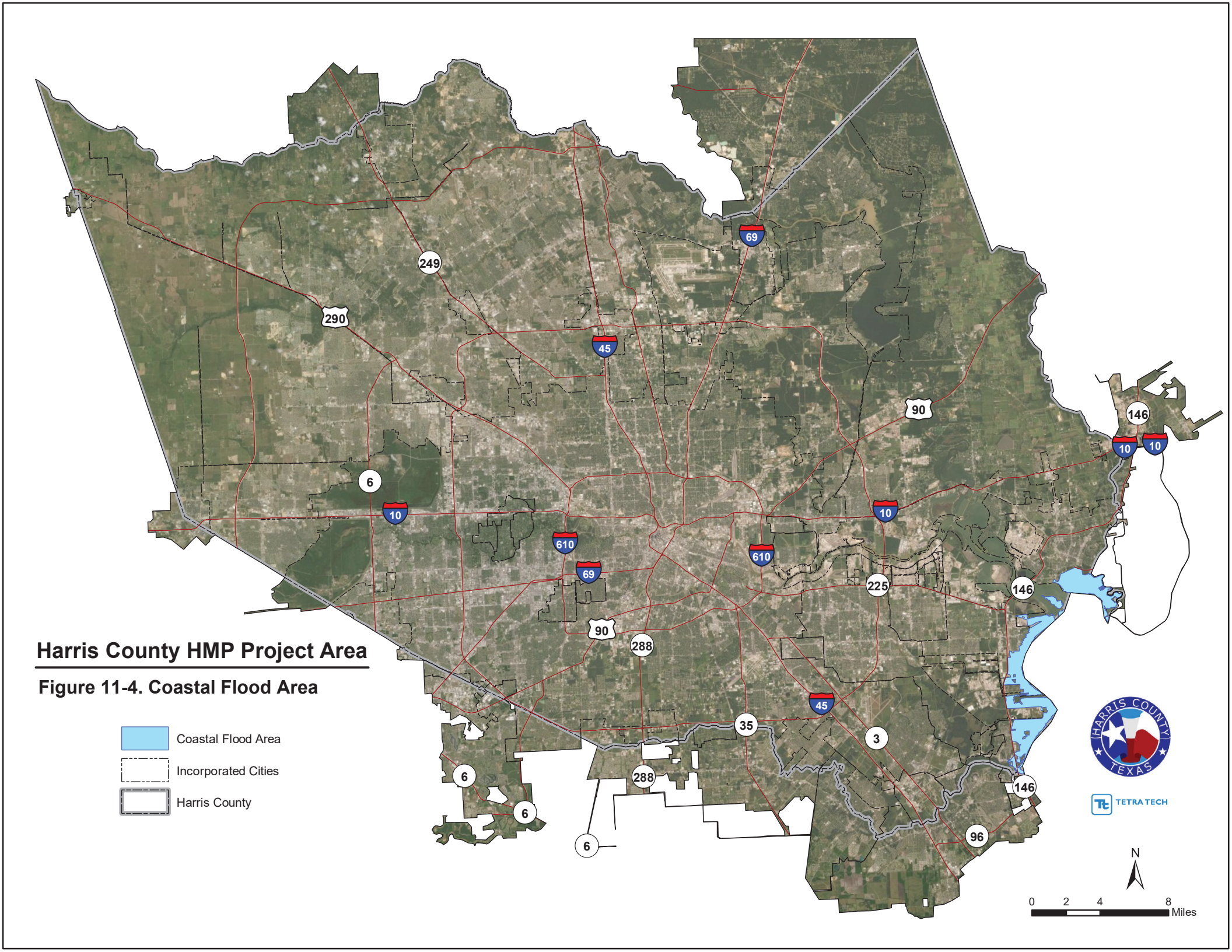
Riverine Flooding

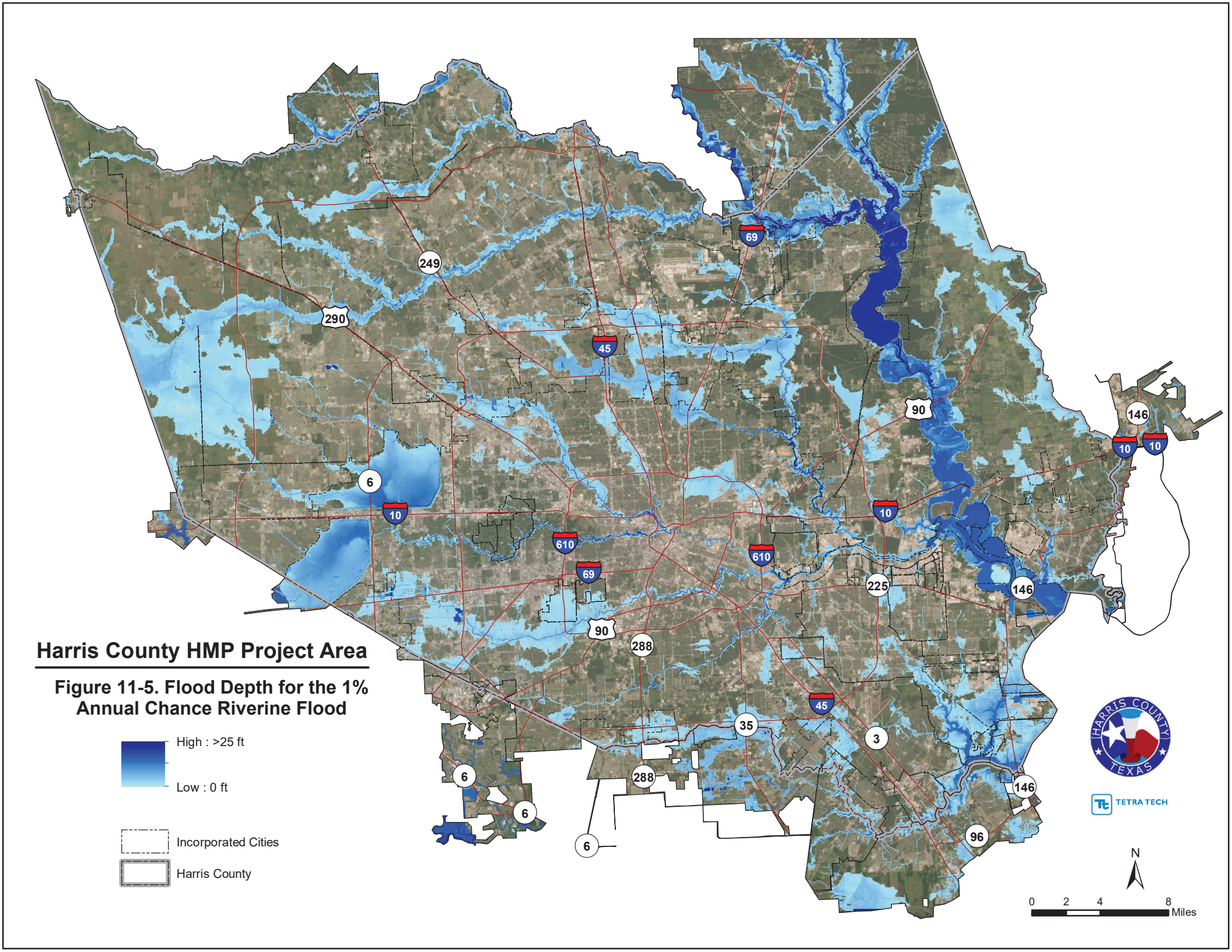
The severity of riverine flooding is defined by the National Weather Service (NWS) as minor, moderate or major:

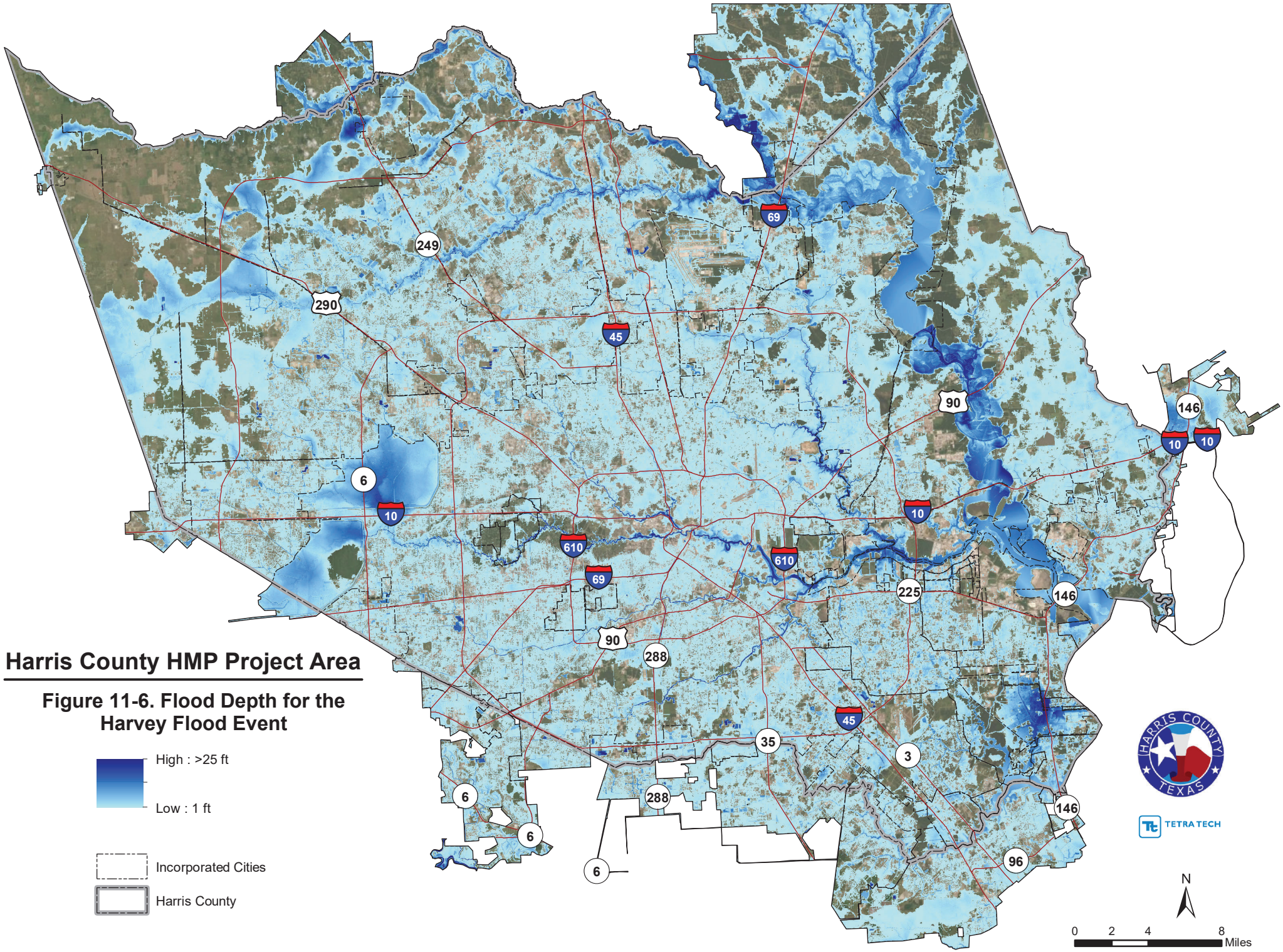
- Minor Flooding—Minimal or no property damage, but possibly some public threat or inconvenience
- Moderate Flooding—Some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding—Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.

Harris County and all participating jurisdictions considers a rainfall of 2 to 3 inches per hour or a creek rise that stays within the creek bank or drainage channel to be a minor flooding severity. In addition, street flooding is considered minor flooding. A major severity to the Harris County planning area is identified as a rainfall of 4 inches per hour and greater, or more than 6 inches in 3 hours on saturated ground, or a creek rise that overflows the banks of the creek or drainage channel. Flash flooding can develop quickly in the region, closing roads/bridges, and endangering life and property. The entire planning area can expect minor, moderate and major flooding in the future.

Figure 11-5 and Figure 11-6 show the estimated depth of flooding across the planning area for the FEMA-mapped 1-percent-annual-chance riverine flood and for the Harvey flood event.


Harris County HMP Project Area
Figure 11-4. Coastal Flood Area
Coastal Flood Area
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH


Harris County HMP Project Area
Figure 11-5. Flood Depth for the 1% Annual Chance Riverine Flood
High : >25 ft
Low : 0 ft
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH


Harris County HMP Project Area
Figure 11-6. Flood Depth for the Harvey Flood Event
High : >25 ft
Low : 1 ft
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
TETRA TECH
N
0 2 4 8
Miles

Water rescues are frequently required during flood events in the County. Impacts on the planning area due to riverine flooding include but are not limited to temporary and permanent displacement of residents and businesses, limited mobility for residents and responders, loss of life, utility and power outages, and temporary closure of critical infrastructure facilities. Impacts may also include soil erosion along rivers and streams due to flooding. Environmental impacts also occur due to chemicals and other hazardous materials contaminating water bodies.

Flood severity for riverine flooding is often evaluated by examining peak discharges; Table 11-4 lists peak flows used by FEMA to map the floodplains of the planning area. Peak discharge is generally described using the measurement cubic feet per second. A discharge rate of 20,000 cubic feet per second would fill an Olympic size swimming pool in about 4 seconds.

Table 11-4. Summary of Peak Discharges in the Planning Area

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Clear Creek Watershed				
At the Mouth	21,618	38,098	46,341	71,847
At confluence of Taylor Bayou	22,481	38,995	47,042	72,745
At confluence of Armand Bayou	20,938	35,377	42,013	64,427
At confluence of Robinson Bayou	14,229	21,633	24,879	33,496
At confluence of Cow Bayou	14,051	21,217	24,557	32,750
At confluence of Landing Ditch	13,563	20,518	23,660	31,516
At confluence of Magnolia Creek	13,407	20,253	23,340	31,269
At confluence of Chigger Creek	13,201	19,868	22,891	30,896
At confluence of Cowart Creek	11,700	17,710	20,329	28,726
At confluence of Mary's Creek	9,343	14,080	16,162	22,566
At confluence of Turkey Creek	6,876	10,632	12,282	17,205
At confluence of Halls Road Ditch	4,361	6,766	7,901	10,572
At confluence of Hickory Slough	2,871	4,553	5,376	7,966
Downstream of SH 288	1,122	1,902	2,342	3,918
At McHard Road (FM 2234)	414	821	1,077	1,925
Armand Bayou Watershed				
At the Mouth	15,433	24,076	29,102	40,693
At confluence of Horsepen Bayou	14,895	23,173	28,030	39,139
At confluence of Big Island Slough	10,116	15,049	17,444	24,139
At confluence of Spring Gully	7,847	11,309	13,278	19,414
At confluence of tributary 9.39 (B111-00-00)	6,360	9,160	10,886	15,687
At confluence of Willow Springs Bayou	5,897	8,643	10,176	14,369
At confluence of tributary 10.46 (B113-00-00)	2,574	4,156	4,770	6,472
At confluence of tributary 12.09 (B114-00-00)	1,138	1,670	1,946	2,759
At Dupont Street	289	431	505	724
Sims Bayou Watershed				
At the Mouth	22,903	38,495	44.553	58,495
Downstream of Plum Creek	22,531	37,816	43,765	57,455
Upstream of Pine Gully	21,760	36,370	42,049	54,410

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Upstream of Berry Bayou	17,568	28,921	33,294	39,974
Upstream of Tributary 10.77 to Sims Bayou	13,785	22,280	26,317	32,542
Upstream of Tributary 13.83 to Sims Bayou	10,712	17,084	20,619	28,736
At Hiram-Clarke Road	5,928	9,366	11,400	16,880
Upstream of Tributary 20.25 to Sims Bayou	2,316	3,712	4,470	6,449
Upstream of Sam Houston Parkway	706	1,090	1,292	1,897
Brays Bayou Watershed				
At the Mouth	37,545	44,124	47,258	55,389
Upstream of Scott Street	32,102	36,320	38,484	44,397
Downstream of Main Street	28,200	30,333	31,831	36,226
Downstream of Chimney Rock Street	25,294	31,219	32,975	37,060
Upstream of Gessner Street	18,869	22,483	23,624	27,142
Downstream of D142-00-00 Confluence	12,970	17,208	18,226	21,615
Upstream of D126-00-00 Confluence	5,293	6,485	7,025	8,095
Upstream of Dairy Ashford Road	4,743	6,098	6,624	8,043
Downstream of SH 6	2,439	3,636	4,250	5,865
White Oak Bayou Watershed				
At the Mouth	29,067	41,250	44,661	56,866
At Heights Blvd	22,617	31,324	34,455	42,293
At Lazybrook Drive	22,833	31,444	34,950	42,584
Downstream of E115-00-00 Confluence	22,105	30,781	34,124	43,028
Downstream of E117-00-00 Confluence	16,431	21,691	24,185	33,857
Downstream of E121-00-00 Confluence	12,447	16,891	19,820	28,253
Downstream of E122-00-00 Confluence	10,836	14,697	16,648	23,368
Downstream of E141-00-00 Confluence, At Beltway 8	9,065	11,769	13,154	17,887
Downstream of E127-00-00 Confluence	7,872	10,214	11,395	15,310
At West Road	5,810	7,500	8,350	10,300
At Jones Road	4,100	5,550	6,250	8,140
Downstream of E133-00-00 Confluence	1,130	1,710	1,990	2,820
Galveston Bay Watershed				
Little Cedar Bayou, at the mouth	1,649	2,440	2,799	3,842
Little Cedar Bayou, at confluence w/tributary F216-01-00	1,609	2,378	2,724	3,744
Pine Gully at the Mouth	1,574	2,333	2,720	3,856
Pine Gully, at confluence w/tributary F220-01-00	1,577	2,335	2,722	3,858
Pine Gully, at confluence w/tributary F220-02-00	1,106	1,630	1,900	2,674
San Jacinto River Watershed				
Buffalo Bayou (Houston Ship Channel) at confluence of San Jacinto River	147,736	209,729	238,342	303,412
San Jacinto River, at Lake Houston Dam	82,400	180,200	246,100	409,900
West Fork of the San Jacinto River, at U.S. Highway 59	62,300	127,200	167,500	306,000

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Ben's Branch, at the Mouth	3,404	4,794	5,454	7,175
Jordan Gully at the mouth	1,782	2,546	2,940	4,118
TXDOT Ditch #4, at the Mouth	1,211	1,756	2,032	2,790
Black's Branch, at the mouth	1,891	2,659	3,061	4,301
East Fort of the San Jacinto River, At north end of Lake Houston	41,400	85,200	109,500	185,000
Caney Creek, at the mouth	22,200	52,000	72,400	133,000
White Oak Creek, at the mouth	1,900	3,480	4,230	6,080
Mill's Branch, at the mouth	421	622	725	1,067
Taylor Gully, at the mouth	1,897	2,739	3,078	4,010
Patrick Bayou, at the mouth	3,985	5,595	6,455	8,669
East 13th St. outfall channel, at the mouth	542	773	894	1,225
Boggy Bayou, upstream of SH 225	1,615	2,121	2,396	3,375
Glenmore Ditch, at the mouth	2,215	3,020	3,408	4,289
Cotton Patch Bayou, at the mouth	893	1,413	1,716	2,565
Panther Creek, at the mouth	1,860	2,575	2,963	4,010
Huntington Bayou Watershed				
At the mouth	6,270	9,002	10,568	15,234
Wallisville Outfall, at the mouth	1,515	2,318	2,735	3,901
Tributary 12.70 to Huntington Bayou, at the mouth	349	535	635	930
Schramm Gully, at the mouth	288	447	534	804
Tributary 12.05 to Huntington Bayou, at the mouth	964	1,493	1,765	2,554
Vince Bayou Watershed				
At the Mouth	8,778	12,199	13,987	18,778
Little Vince Bayou, at the mouth	3,335	4,759	5,505	7,512
Spring Creek Watershed				
Spring Creek, at the mouth	30,772	60,592	76,749	132,093
Bender Lake, at the mouth	1,691	2,536	2,921	4,087
Tributary 21.08 to Spring Creek, at the mouth	1,050	1,613	1,875	2,672
Boggs Gulley, at the mouth	1,860	2,915	3,441	5,024
Tributary 1.25 to Boggs Gully, at the mouth	400	620	790	1,250
Kickapoo Creek, at the mouth	2,565	4,358	5,314	8,132
Cypress Creek Watershed				
At the mouth	15,050	23,186	27,258	38,505
Turkey Creek, at the mouth	4,179	6,749	8,065	11,807
Tributary to Turkey Creek, at the mouth	4,179	6,749	8,065	11,807
Wild Cow Gulch, at the mouth	2,119	3,184	3,676	5,160
Schultz Gulch, at the mouth	1,580	2,319	2,652	3,657
Lemm Gully, at the mouth	1,205	1,895	2,254	3,311
Senger Gully, at the mouth	1,402	2,175	2,567	3,710

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Wunsche Gully, at the mouth	630	1,000	1,250	1,750
Seals Gully, at the mouth	3,450	5,168	6,085	8,723
Kothman Gully, at the mouth	857	1,338	1,577	2,298
Spring Gully, at the mouth	4,525	7,021	8,352	12,183
Theiss Gully, at the mouth	2,297	3,597	4,254	6,195
Dry Gully, at the mouth	1,410	2,222	2,647	3,900
Pilot Gully, at the mouth	1,388	2,247	2,698	4,012
Faulkey Gully, at the mouth	3,916	6,386	7,613	10,986
Dry Creek, at the mouth	1,406	2,281	2,753	4,143
Rock Hollow, at the mouth	401	779	1,012	1,762
Mound Creek, at the mouth	6,932	12,853	16,179	25,158
East Fork Mound Creek, at the mouth	1,657	2,593	3,052	4,438
Little Mound Creek, at the mouth	3,192	4,960	5,839	8,373
Little Cypress Creek Watershed				
Little Cypress Creek, at the mouth	2,676	5,771	7,686	14,060
Willow Creek Watershed				
At the Mouth	4,979	8,769	10,929	17,974
Tributary 0.26 to Willow Creek, at the mouth	608	973	1,155	1,698
Tributary 2.44 to Willow Creek, at the mouth	630	1,045	1,255	1,872
Hughes Gully, at the mouth	597	965	1,147	1,693
Cannon Gully, at the mouth	1,343	2,143	2,524	3,690
Metzler Creek, at the mouth	671	1,058	1,240	1,807
Roan Gully, at the mouth	1,393	2,191	2,608	3,826
Carpenters Bayou Watershed				
At the mouth	6,472	9,815	11,458	16,094
Tributary 3.33 to Carpenters Bayou, at the mouth	1,080	1,629	1,915	2,763
Tributary 11.715 to Carpenters Bayou, at the mouth	551	861	1,025	1,511
Goose Creek Watershed				
Goose Creek, at the mouth	9,597	13,636	15,951	21,578
East Fork Goose Creek, at the mouth	2,125	3,139	3,660	5,169
Spring Cully at the mouth	1,517	2,042	2,324	3,064
Spring Gully Diversion Channel, at the mouth	440	758	951	1,559
Greens Bayou Watershed				
Greens Bayou at the mouth	34,189	43,160	48,545	62,823
Big Gulch, at the mouth	2,012	2,960	3,271	4,142
Sulphur Gulch, at the mouth	744	1,083	1,256	1,743
Spring Gully, at the mouth	1,256	1,811	2,093	2,877
Hall's Bayou, at the mouth	9,944	13,800	15,642	20,346
Garner's Bayou, at the mouth	8,984	12,962	14,877	20,487

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Williams Gully, at the mouth	2,067	3,165	33,727	5,389
Reinhardt Bayou, at the mouth	1,941	2,722	3,163	4,363
North Fork, Green's Bayou, at the mouth	4,810	7,090	8,094	10,554
Cedar Bayou Watershed				
Cedar Bayou, at the mouth	6,286	10,301	12,646	20,442
Pine Gully, at the mouth	933	1,383	1,616	2,297
Cary Bayou, at the mouth	2,397	3,537	4,126	5,886
Horspen bayou, at the mouth	485	915	1,176	2,015
McGee Bayou, at the mouth	1,519	2,236	2,581	3,720
Cedar Bayou Diversion Channel. At the mouth	8,640	11,710	13,302	18,633
Jackson Bayou Watershed				
Jackson Bayou, at the mouth	8,177	12,543	14,755	21,303
Gum Gully, at the mouth	5,833	8,702	10,187	14,770
Luce Bayou Watershed				
Luce Bayou at the mouth	14,650	33,850	45,700	84,540
Shook Gully, at the mouth	1,050	1,588	1,860	2,454
Mexican Gully, at the mouth	362	535	623	872
Baker Reservoir Watershed				
Cane Island Branch, at the mouth	1,230	2,458	3,383	6,420
Mason Creek, at the mouth	4,774	7,666	9,234	13,655
Tributary 2.17 to Tributary 52.9 to Upper Buffalo Bayou/Cane, at the mouth	605	953	1,138	1,682
Addick's Reservoir Watershed				
Langham Creek at Clay Rd	6,973	12,166	15,203	24,506
South Mayde Creek, at the mouth	6,901	11,322	13,294	18,312
Bear Creek, at the mouth	4,548	7,327	8,829	13,106
Horspen Creek, at the mouth	6,244	9,937	11,749	16,989
Dinner Creek, At confluence of Langham Creek	1,207	1,993	2,409	3,642
Addick's Reservoir Diversion Channel, downstream of confluence with Horspen Creek	6,973	12,166	15,203	24,506
Buffalo Bayou Watershed				
At 69th St.	39,606	53,872	61,636	83,981
Spring Branch, at the mouth	3,853	5,996	7,104	10,379
Briar Branch, at the mouth	1,158	1,795	2,142	3,200
Soldiers Creek, at the mouth	496	778	931	1,406
Rummel Creek, at the mouth	2,144	3,392	4,048	5,697
Turkey Creek, at the mouth	1,227	1,915	2,269	3,232
Clodine Ditch, at the mouth	1,215	2,138	2,696	4,419

Source: FEMA Flood Insurance Study Number 48201CV000C, Harris County, Texas and Incorporated Areas, May 2, 2019

Coastal Flooding

A storm surge is a large dome of water, often 50 to 100 miles wide and rising from 4 to 30 feet depending on the magnitude of the storm. The storm surge arrives ahead of the storm's actual landfall and the more intense the hurricane is, the sooner the surge arrives. Water rise can be very rapid, posing a serious threat to those who have not yet evacuated flood- prone areas. A storm surge is a wave that has outrun its power-generating source and becomes a long period swell. The surge is always highest in the right-front quadrant of the hurricane. As the storm approaches shore, the greatest storm surge forms to the north of the hurricane eye. The surge of high water topped by waves driven by hurricane force winds can be devastating to coastal regions, causing severe beach erosion and property damage.

Impacts on the planning area due to coastal flooding include but are not limited to temporary and permanent displacement of residents and businesses, loss of life, widespread power outages, long-term limited mobility for residents and responders, and long-term closure or limited functionality of critical infrastructure facilities including hospitals and industrial facilities.

Table 11-5 summarizes representative still-water elevations along the Galveston Bay coastline, representing the steady state water depth not accounting for breaking waves. These are the projected elevations of floodwaters in the absence of waves resulting from wind or seismic effects. In coastal areas, still-water elevations are determined when modeling coastal storm surge; the results of overland wave modeling are used in conjunction with the still-water elevations to develop the coastal base flood elevations.

Table 11-5. Summary of Stillwater Elevations Along Galveston Bay

Flooding Source/Location	Still-Water Elevation[a] (feet)			
	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Clear Lake and Creek at confluence of Armand Bayou	9.20	12.00	14.80	19.70
Taylor Lake and Taylor Bayou at SR 146	9.16	12.40	15.30	20.20
Cow Bayou at the confluence with Clear Creek	9.10	12.10	14.90	19.80
Armand Bayou at Bay Area Blvd.	9.40	12.40	15.10	20.80
Galveston Bay, at the mouth of Clear Lake	8.90	11.80	14.50	19.80
Little Cedar Bayou, 0.2 miles upstream of Old State Route 146	5.60	10.60	12.50	16.30
San Jacinto River, Houston Ship Channel, at Baytown Nature Center	9.40	12.20	16.00	22.60
Buffalo Bayou (Houston Ship Channel) at, upstream of I10	10.60	14.80	18.70	23.50
San Jacinto River at confluence of Bear Bayou	9.90	13.00	16.40	21.10
Goose Creek at State Highway 16	9.20	11.80	15.00	19.50
Cedar Bayou at State Highway 146	8.80	11.10	14.10	18.60

a. Elevation in 1988 North American Vertical Datum

11.2.9 Warning Time

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

The Harris County Flood Control District's Flood Warning System measures rainfall amounts and monitors water levels in bayous and major streams on a real-time basis to inform of dangerous weather conditions. The system relies on 177 gage stations throughout Harris County with contain sensors that transmit data during times of heavy

rainfall and during tropical storms and hurricanes. Some gages also measure wind speed and direction, barometric pressure, air temperature, road temperature and humidity.

This information is used by the Flood Control District and by Harris County's Office of Homeland Security and Emergency Management to inform residents of imminent and current flooding conditions along bayous. It also is used by the National Weather Service to assist in the issuing of flood watches and warnings. Accurate rainfall and bayou/stream level data help residents and emergency management officials make critical decisions that ultimately can reduce the risk of property damage, injuries and loss of life.

11.3 SECONDARY HAZARDS

The most problematic secondary hazard for flooding is bank erosion. In many cases the threat and effects of bank erosion are worse than actual flooding. This is especially true on the upper courses of the rivers in the county where there are steep gradients, where the floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers or drainage sewers.

11.4 EXPOSURE

A quantitative assessment of exposure to the flood hazard was conducted using the asset inventory developed for this plan and three mapped flood hazard areas:

- The area that was flooded during Hurricane Harvey (see Figure 11-2).
- The 1-percent-annual-chance riverine flood hazard area (see Figure 11-3)
- The 1-percent-annual-chance coastal flood hazard area (see Figure 11-4)

Detailed results are provided in Appendix C and summarized below.

11.4.1 Population

Population was estimated using the residential building count in the flood hazard areas and multiplying by the 2018 estimated average population per household. Using this approach, exposure results are as follows:

- The estimated population residing in the 1-percent-annual-chance riverine flood hazard area is 8.9 percent of the planning area population (429,036 people).
- The estimated population residing in the 1-percent-annual-chance coastal flood hazard area is 0.2 percent of the planning area population (10,479 people)
- The estimated population residing in the Hurricane Harvey inundation area 36.8 percent of the planning area population (1,804,422 people).

11.4.2 Property

Structures in the Floodplain

Table 11-6 summarizes the number of structures in each of the flood hazard areas evaluated. A significant majority of the exposed structures—92 to 97 percent among the three hazard areas—are residential. Table 11-7 summarizes the estimated value of exposed buildings in each of the flood hazard areas evaluated. Appendix C provides breakdowns by jurisdiction.

Table 11-6. Area and Structures in the Flood Hazard Areas of the Planning Area

Flood Hazard Area	Area in Floodplain (acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
1-Percent-Annual-Chance Riverine	284,560	110,590	8,309	516	61	246	14	67	**119,803**
1-Percent-Annual-Chance Coastal	5,720	3,254	84	1	2	3	0	1	**3,345**
Hurricane Harvey	713,352	467,995	35,309	2,009	196	1,031	91	369	**507,000**

Table 11-7. Aggregate Values of Structures Within the Scenario Floodplains

Flood Scenario	Estimated Value within the Floodplain			% of Total Replacement Value
	Structure	Contents	Total	
1-Percent-Annual-Chance Riverine	$49.01 billion	$33.85 billion	**$82.85 billion**	8.9
1-Percent-Annual-Chance Coastal	$823.6 million	$469.3 million	**$1.29 billion**	0.1
Hurricane Harvey	$196.3 billion	$138.7 billion	**$334.9 billion**	35.6

Land Use in the Floodplain

Some land uses are more vulnerable to flooding, such as single-family homes, while others are less vulnerable, such as agricultural land or parks. Table 11-8 shows the existing land use of all parcels in the 1-percent-annual-chance flood hazard areas and the Hurricane Harvey inundation area. Listed land uses that are most suitable for floodplains are parks/open spaces, undevelopable, and vacant developable/farming. In the riverine floodplain, these uses make up 52 percent of the total area. They make up only 26 percent of the coastal floodplain and 36 percent of the Harvey inundation area.

Table 11-8. Existing Land Use Within the Scenario Floodplains

Land Use	1-Percent Annual Chance, Riverine		1-Percent Annual Chance, Coastal		Harvey Inundation Area	
	Area (acres)	% of Total	Area (acres)	% of total	Area (acres)	% of total
Commercial	22,148	9.9%	976	23.3%	63,393	12.6%
Government/Medical/Educational	2,351	1.1%	156	3.7%	10,756	2.1%
Industrial	14,487	6.5%	235	5.6%	35,491	7.0%
Multiple	12,746	5.7%	86	2.1%	38,328	7.6%
Other	874	0.4%	92	2.2%	3,040	0.6%
Parks/Open Spaces	52,961	23.8%	410	9.8%	63,534	12.6%
Residential	48,328	21.7%	1,468	35.1%	161,989	32.1%
Undevelopable	18,619	8.4%	281	6.7%	39,104	7.8%
Unknown	6,278	2.8%	76	1.8%	10,177	2.0%
Vacant Developable (includes Farming)	44,026	19.8%	403	9.6%	78,496	15.6%
Total[a]	**222,816**	**100.0%**	**4,182**	**100.0%**	**504,308**	**100.0%**

a. Totals listed here differ from those in Table 11-6 because they exclude the area of public rights-of-way and open water bodies.

11.4.3 Critical Facilities and Infrastructure

Critical facilities and infrastructure exposed to the flood hazard represent 32 percent (1,880 facilities) of the total critical infrastructure and facilities in the planning area for the 1-percent-annual-chance flood hazard and 56 percent (3,275 facilities) for the Harvey inundation area. The breakdown of exposure by facility type is shown in Figure 11-7.

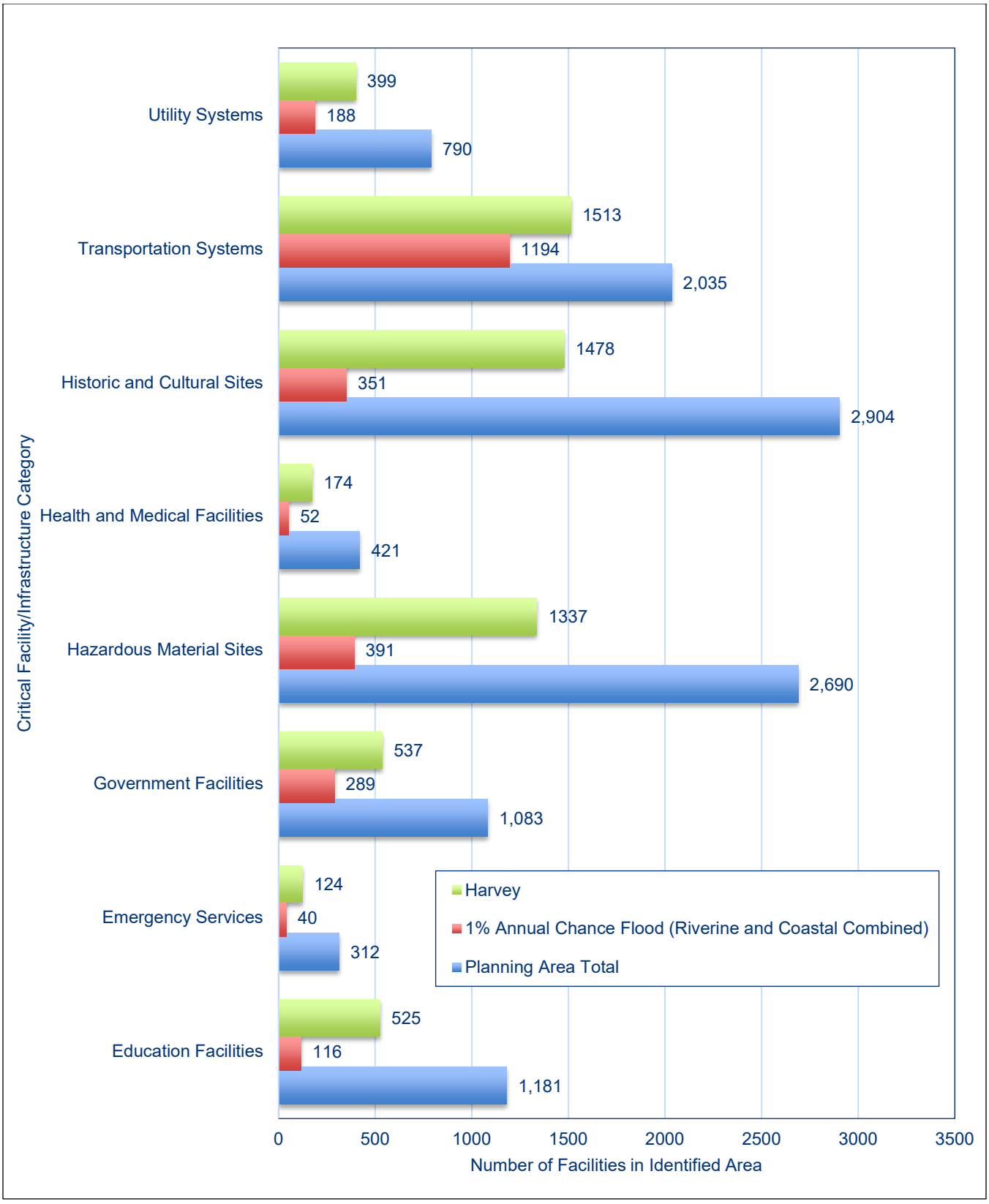


Figure 11-7. Critical Facilities and Infrastructure in Mapped Flood Hazard Areas and Countywide

11.4.4 Environment

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, flooding can impact the environment in negative ways. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees, and logjams from timber harvesting can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

11.5 VULNERABILITY

The results of the vulnerability assessment indicate estimated damage for the 1-percent-annual-chance riverine and coastal flood hazard areas and the Hurricane Harvey inundation area.

11.5.1 Population

Vulnerable Populations

Those who have trouble evacuating, especially if waters rise suddenly without much warning, are most vulnerable. This includes those with access and functional needs, the elderly, and the very young. In addition, economically disadvantaged populations whose houses are impacted by flood events may not have the means to make repairs, especially if they do not have flood insurance. A geographic analysis of demographics using the Hazus model identified populations vulnerable to the flood hazard as follows:

- **Economically Disadvantaged Populations**—The estimated percent of households within the evaluated flood hazard areas that are economically disadvantaged (having household incomes of $20,000 or less) is as follows:
  - 17 percent for the 1-percent-annual-chance riverine flood hazard area and Harvey inundation area
  - 12 percent for the 1-percent-annual-chance coastal flood hazard area
- **Population over 65 Years Old**—The estimated percent of the population within the evaluated flood hazard areas that is over 65 years old is as follows:
  - 8 percent for the 1-percent-annual-chance riverine flood hazard area and Harvey inundation area
  - 14 percent for the 1-percent-annual-chance coastal flood hazard area
- **Population under 16 Years Old**— The estimated percent of the population within the evaluated flood hazard areas that is under 16 years old is as follows:
  - 28 percent for the 1-percent-annual-chance riverine flood hazard area and Harvey inundation area
  - 22 percent for the 1-percent-annual-chance coastal flood hazard area

Estimated Impacts on Persons and Households

Impacts on persons and households in the planning area were estimated for the 1-percent riverine, 1-percent coastal and the Harvey inundation area through the Hazus analysis. Table 11-9 summarizes the results.

Table 11-9. Estimated Flood Impact on Persons and Households

Jurisdiction	Displaced Population			Number of Persons Requiring Short-Term Shelter		
	1% Annual Chance Riverine	1% Annual Chance Coastal	Hurricane Harvey	1% Annual Chance Riverine	1% Annual Chance Coastal	Hurricane Harvey
Baytown[c]	652	31	16,652	36	1	961
Bellaire	12,989	0	6,005	565	0	236
Bunker Hill Village	0	0	2	0	0	0
Deer Park	87	0	6,186	4	0	355
El Lago	1,261	0	698	94	0	44
Friendswood[c]	837	0	7,240	38	0	390
Galena Park	37	0	2,012	1	0	85
Hedwig Village	0	0	35	0	0	2
Hilshire Village	0	0	504	0	0	30
Houston[a, b]	114,281	0	494,973	11,038	0	43,606
Humble	80	0	3,421	3	0	241
Hunters Creek Village	15	0	337	1	0	15
Jacinto City[a]	0	0	2,126	0	0	99
Jersey Village	1,112	0	1,269	60	0	79
Katy[c]	344	0	2,365	18	0	120
La Porte	243	3,370	8,965	6	212	430
League City[a, b]	14	0	175	0	0	13
Missouri City[c]	22	0	8,965	1	0	519
Morgan's Point	0	27	103	0	1	2
Nassau Bay	2,665	0	707	206	0	54
Pasadena	2,357	224	44,617	162	5	3,415
Pearland[a]	61	0	2,658	3	0	170
Piney Point Village	32	0	581	1	0	34
Seabrook	3,680	3,752	3,738	291	214	246
Shoreacres	485	932	639	19	29	20
South Houston[a]	1,906	0	10,260	94	0	631
Southside Place[a]	888	0	331	51	0	15
Spring Valley Village	1	0	662	0	0	33
Stafford[c]	0	0	5,610	0	0	395
Taylor Lake Village	944	0	598	48	0	27
Tomball	2	0	669	0	0	50
Waller[a, b]	13	0	0	0	0	0
Webster	1,358	0	2,028	146	0	248
West University Place	782	0	2,418	20	0	50
Unincorporated	25,330	11	327,218	1,722	0	21,777
Total	**172,478**	**8,379**	**983,003**	**14,627**	**462**	**75,452**

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
b. City extends beyond Harris County. Values shown are for Harris County portion only.
c. City extends beyond Harris County. Values shown are for entire city.

Public Health and Safety

Floods and their aftermath present numerous threats to public health and safety:

- **Unsafe food—**Floodwaters contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat. Refrigerated and frozen foods are affected during power outages caused by flooding. Foods in cardboard, plastic bags, jars, bottles, and paper packaging may be unhygienic with mold contamination.
- **Contaminated drinking and washing water and poor sanitation—**Flooding impairs clean water sources with pollutants. The pollutants also saturate into the groundwater. Flooded wastewater treatment plants can be overloaded, resulting in backflows of raw sewage. Private wells can be contaminated by floodwaters. Private sewage disposal systems can become a cause of infection if they or overflow.
- **Mosquitoes and animals—**Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools. The public should dispose of dead animals that can carry viruses and diseases only in accordance with guidelines issued by local animal control authorities. Leptospirosis—a bacterial disease associated predominantly with rats—often accompanies floods in developing countries, although the risk is low in industrialized regions unless cuts or wounds have direct contact with disease-contaminated floodwaters or animals.
- **Mold and mildew—**Excessive exposure to mold and mildew can cause flood victims—especially those with allergies and asthma—to contract upper respiratory diseases, triggering cold-like symptoms. Molds grow in as short a period as 24 to 48 hours in wet and damp areas of buildings and homes that have not been cleaned after flooding, such as water-infiltrated walls, floors, carpets, toilets and bathrooms. Very small mold spores can be easily inhaled by human bodies and, in large enough quantities, cause allergic reactions, asthma episodes, and other respiratory problems. Infants, children, elderly people and pregnant women are considered most vulnerable to mold-induced health problems.
- **Carbon monoxide poisoning—**In the event of power outages following floods, some people use alternative fuels for heating or cooking in enclosed or partly enclosed spaces, such as small gasoline engines, stoves, generators, lanterns, gas ranges, charcoal or wood. Built-up carbon monoxide from these sources can poison people and animals.
- **Hazards when reentering and cleaning flooded homes and buildings—**Flooded buildings can pose significant health hazards to people entering them. Electrical power systems can become hazardous. Gas leaks can trigger fire and explosion. Flood debris—such as broken bottles, wood, stones and walls—may cause injuries to those cleaning damaged buildings. Containers of hazardous chemicals may be buried under flood debris. Hazardous dust and mold can circulate through a building and be inhaled by those engaged in cleanup and restoration.
- **Mental stress and fatigue—**People who live through a devastating flood can experience long-term psychological impact. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected. Post-flood recovery can cause, anxiety, anger, depression, lethargy, hyperactivity, and sleeplessness. There is also a long-term concern among the affected that their homes can be flooded again in the future.

Current loss estimation models such as Hazus are not equipped to measure public health impacts such as these. The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to flood events.

11.5.2 Property

Structures and Contents

Hazus calculates flood losses to structures based on depth of flooding and type of structure. Impacted structures are those with finished floor elevations below the flood water surface elevation. Using historical flood insurance claim data, Hazus estimates the percentage of damage to structures and their contents by applying established damage functions to an inventory. For this analysis, local data on facilities was used instead of the default inventory data provided with Hazus. The planning-area results by flood scenario are summarized in Table 11-10. Appendix C provides a detailed breakdown by jurisdiction.

Table 11-10. Loss Estimates for Scenario Flood Events

Scenario	Structures Impacted	Estimated Loss Associated with Flood			% of Total Replacement Value
		Structure	Contents	Total	
1-Percent-Annual-Chance Riverine	89,179	$4.05 billion	$3.14 billion	**$7.19 billion**	0.8
1-Percent-Annual-Chance Coastal	2,937	$237.7 million	$135.6 million	**$373.3 million**	0.04
Hurricane Harvey	488,923	$32.2 billion	$32.9 billion	**$65.1 billion**	6.9

Note: Values shown are accurate for comparison of results in this plan.

Flood-Caused Debris

The Hazus analysis estimated the amount of flood-caused debris within the planning area generated by flooding, as summarized in Table 11-11. Appendix C provides a detailed breakdown by jurisdiction.

Table 11-11. Estimated Flood-Caused Debris

Scenario	Debris to Be Removed (tons)[a]	Estimated Number of Truckloads[b]
1-Percent-Annual-Chance Riverine	1,418,026	57,000
1-Percent-Annual-Chance Coastal	59,582	2,400
Hurricane Harvey	5,367,793	215,000

a. Debris generation estimates were based on updated general building stock dataset at a Census Block analysis level.
b. Hazus assumes 25 tons/trucks.
Note: Values shown are accurate for comparison of results in this plan.

Repetitive Loss

A repetitive loss property is defined by FEMA as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property.

A severe repetitive loss property is further defined as follows:

- Four or more paid losses in excess of $5,000 each, with the cumulative amount of such claim payments exceeding $20,000
- At least two separate claim payments made, with the cumulative amount of the building portion of such claims exceeding the market value of the building
- At least two of the above referenced claims occurring within any rolling 10-year period and more than 10 days apart.

Repetitive loss properties make up only 1 to 2 percent of flood insurance policies in force nationally, yet they account for 40 percent of the nation's flood insurance claim payments. The government has instituted programs encouraging communities to identify and mitigate the causes of repetitive losses. A recent report on repetitive losses by the National Wildlife Federation found that 20 percent of these properties are outside any mapped 1-percent-annual-chance floodplain. The key identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by the policies. Flood insurance for severe repetitive loss properties is provided through a special program of the NFIP called the Special Direct Facility.

FEMA-sponsored programs, such as the CRS, require participating communities to identify repetitive loss areas. A repetitive loss area is the portion of a floodplain holding structures that FEMA has identified as meeting the definition of repetitive loss. Identifying such areas helps to identify structures that are at risk but are not on FEMA's list of repetitive loss structures because no flood insurance policy was in force at the time of loss. Under the CRS repetitive loss list correction protocol, losses associated with events considered to be "statistically improbable" (i.e., greater than a 1-percent-annual-chance event) can be removed from the count toward being a repetitive loss property.

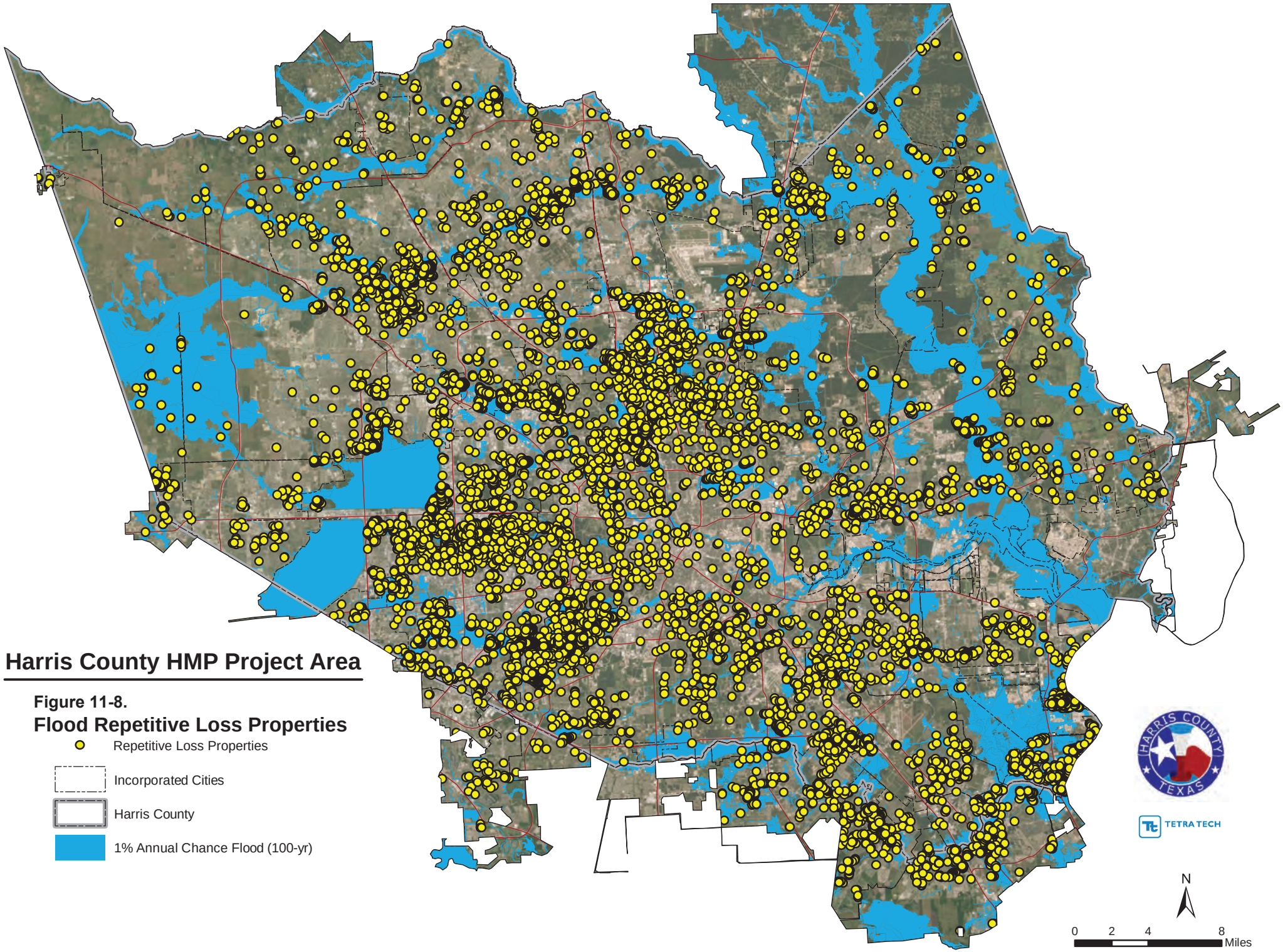
The Harris County Flood Control District identifies 17,945 repetitive-loss properties in the planning area as of February 28, 2018. The location of these properties in the planning area relative to the mapped FEMA floodplain is shown on Figure 11-8. Table 11-12 summarizes characteristics of the identified properties; a breakdown by jurisdiction is provided in Appendix C.

Table 11-12. Repetitive Loss Properties

	Number	% of Total
Total Number of Repetitive Loss Properties	**17,945**	**100%**
Land Use		
Residential	16,996	94.7%
Non-Residential	949	5.3%
Mitigation Status		
Mitigated	2,625	14.6%
Non-Mitigated	15,320	85.4%
Insurance Status		
Insured	9,670	53.9%
Insured as a Severe Repetitive Loss Property	1,152	6.4%
Not Insured	7,123	39.7%
Location Relative to Flood Zone		
In FEMA 100-year Zone	10,236	57.0%
In Hurricane Harvey Flood Zone	12,973	72.3%
Reported Losses		
Number of Losses Filed	57,240	n/a
Total Paid	$3,104,545,841	n/a

Key observations are as follows:

- 95 percent of the properties are residential
- 57 percent of the properties lie within the FEMA-mapped SFHA.
- 72 percent of the properties lie within the Hurricane Harvey inundation area
- 15 percent of the properties have been mitigated
- 60 percent of the properties are currently insured
- The number of properties increased by 39.3 percent since the 2015 planning effort, and the associated loss increased by 62 percent.


Harris County HMP Project Area
Figure 11-8.
Flood Repetitive Loss Properties
Repetitive Loss Properties
Incorporated Cities
Harris County
1% Annual Chance Flood (100-yr)
HARRIS COUNTY TEXAS
TETRA TECH
N
0 2 4 8
Miles

With well over 70 percent of the repetitive-loss properties within the FEMA-mapped flood zone or Hurricane Harvey inundation areas, the apparent cause of repetitive flooding for those areas can be correlated to the risk that is reflected in the mapping. It is reasonable to assume that the 39 percent increase in repetitive-loss properties since the 2015 planning effort is associated with the impacts of Hurricane Harvey. The recurrence interval estimated for Hurricane Harvey in the planning area ranges from 200 to 750 years.

Flooding for repetitive-loss properties outside the SFHA or Harvey inundation area can be attributed to urban drainage flooding, which is a chronic issue in the planning area and is a focus of this hazard mitigation plan.

Flood Insurance Claim History

The following information from flood insurance statistics is relevant to reducing flood risk (see Table 11-1):

- The average cost for a flood insurance policy for the planning area as June 30, 2019 was $548.25, which is 6 percent less than the Texas average and 27.5 percent less than the national average. The policy amounts for the planning area do include credits for communities that participate in the CRS program.
- The average amount of flood insurance coverage in force for the planning area as of June 30, 2019 was $198,382 which represents 30 percent of the average replacement value for the planning are. The average replacement value for the planning area exceeds NFIP coverage limits by 174 percent.
- The average claim paid in the planning area as of July 31, 2019 was $52,374, which is 82.6 percent greater than the national average ($28,683), and 19.9 percent greater that the State of Texas average ($43,673).
- The average claim paid in the planning area represents about 8 percent of the 2018 average replacement value of structures in the floodplain.
- Based on the 2018 U.S. Census American Community Survey median home value of $154,100 and the average claim value of $54,374, the estimated average depth of flooding using the Corps of Engineers' generic flood-depth damage correlations is 4.3 feet above the finished floor.
- The percentage of policies and claims outside a mapped floodplain suggests that not all of the flood risk in the planning area is reflected in current mapping. Based on information from the NFIP, 59.6 percent of policies in the planning area are on structures in an identified SFHA, and 40.4 percent are for structures outside such areas. Of total claims paid, 21.2 percent were for properties outside an identified 1-percent-annual-chance floodplain.

11.5.3 Critical Facilities and Infrastructure

It is important to determine the potential risks if critical facilities and infrastructure are damaged by flooding. Roads or railroads that are blocked or damaged can isolate residents and can prevent access throughout the planning area, including for emergency service providers needing to get to vulnerable populations or to make repairs. Bridges washed out or blocked by floods or debris also can cause isolation. Water and sewer systems can be flooded or backed up, causing health problems. Underground utilities can be damaged. Dikes/levees can fail or be overtopped, inundating the land that they protect.

Table 11-13 and Table 11-14 summarize the Hazus estimates of damage to critical facilities and infrastructure in the planning area.

Table 11-13. Damage Level to Critical Facilities Exposed to the 1-Percent-Annual-Chance Flood

Facility Type	Number of Facilities Exposed	Average % of Total Value Damaged	
		Structure	Contents
Government Facilities	202	10.96	50.57
Education Facilities	94	6.75	37.65
Health and Medical Facilities	14	10.33	49.46
Transportation Systems	4	10.73	14.23
Utility Systems	146	13.53	24.17
Emergency Services	29	9.95	32.74
Historical and Cultural Sites	274	5.56	38.59
Hazardous Material Sites	309	11.71	19.67
Total/Average	**1,072**	**9.94**	**33.39**

Table 11-14. Damage Level to Critical Facilities Exposed to the Harvey Flood Scenario

Facility Type	Number of Facilities Exposed	Average % of Total Value Damaged	
		Structure	Contents
Government Facilities	531	11.14	49.18
Education Facilities	521	7.97	44.52
Health and Medical Facilities	100	7.63	32.74
Transportation Systems	52	14.92	22.48
Utility Systems	399	13.38	22.53
Emergency Services	126	13.03	35.74
Historical and Cultural Sites	1,470	7.96	49.51
Hazardous Material Sites	1,334	13.86	21.81
Total/Average	**4,533**	**11.24**	**34.81**

11.5.4 Environment

The environment vulnerable to flood hazard is the same as the environment exposed to the hazard. Loss estimation platforms such as Hazus are not currently equipped to measure environmental impacts of flood hazards. The best gauge of vulnerability of the environment would be a review of damage from past flood events. Loss data that segregates damage to the environment was not available at the time of this plan. Capturing this data from future events could be beneficial in measuring the vulnerability of the environment for future updates.

11.6 FUTURE TRENDS IN DEVELOPMENT

The County and its planning partners are equipped to handle future growth within flood hazard areas. All partners who are participating in good standing in the NFIP have agreed to regulate new development in the mapped floodplain according to standards that equal or exceed those specified under 44 CFR Section 60.3. In addition, 16 of the municipal planning partners participate in the CRS program and receive credit for the enforcement of higher regulatory standards within the planning area. This will ensure that any development allowed in the floodplain will be constructed such that the flood risk exposure is eliminated or significantly reduced.

11.7 SCENARIO

The Harris County planning area experienced its worst-case flood scenario in 2017 during Hurricane Harvey. The storm dumped more than 27 trillion gallons of rain over Texas, making Harvey the wettest Atlantic hurricane ever measured. Some parts of Houston received about 50 inches of rainfall. All 22 of the County's main surface water channels overtopped, causing severe flooding that had never been seen before within the planning area. The lessons learned from the response and recovery from Hurricane Harvey in the planning area will play a significant role in the preparedness for storms of equal or greater impacts.

11.8 ISSUES

The CPT has identified the following flood-related issues relevant to the planning area:

- The value of property exposed to the flood risk in the planning area is significant, representing 9 to 36 percent of the total replacement value for the planning area.
- There is a significant difference between the extent and location of the 1-percent-annual chance floodplain (regulatory floodplain under the NFIP) and the Hurricane Harvey inundation area. Emergency planners need to determine which area is the true reflection of flood risk for the planning area, and which should be used to inform land uses within the flood hazard area.
- How climate change will affect flood conditions in the planning area is uncertain.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- With the amount of flood insurance in force within the planning area, the rising costs of flood insurance as the NFIP moves to full actuarial rates could have economic impacts on the planning area.
- Over 96 percent of the NFIP policy base within the planning area is within communities that participate in the CRS program. Non-participating communities within the planning area should consider participation in the CRS program.
- As the planning area continues to recover from the impacts of Hurricane Harvey, financial resources to mitigate the impacts of flooding will become available to increase the flood resilience of the planning area.
- Existing floodplain-compatible land uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses within the planning area during times of moderate to high growth.

12. HURRICANE AND COASTAL STORM

12.1 GENERAL BACKGROUND

Hurricanes, tropical storms, nor'easters and typhoons, also classified as cyclones, include any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise in the northern hemisphere (or clockwise in the Southern Hemisphere) and whose diameter averages 10 to 30 miles across. A tropical cyclone refers to any such circulation that develops over tropical waters. Tropical cyclones act as a safety valve, limiting the continued build-up of heat and energy in tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornados. Coastal areas are also vulnerable to the additional forces of storm surge, wind-driven waves, and tidal flooding.

The key energy source for these storms is the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, warm sea surface temperature, rotational force from the spinning of the earth, and the absence of wind shear in the lowest 50,000 feet of the atmosphere. The majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the Atlantic hurricane season, from June through November. The peak of the Atlantic hurricane season is in early to mid-September. On average, six storms reach hurricane intensity per year (Gray, 2009).

As a hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, is given a name, and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour, the storm is deemed a hurricane. Hurricane intensity is classified using the Saffir-Simpson Hurricane Wind Scale, which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense.

12.2 HAZARD PROFILE

12.2.1 Past Events

Southeast Texas and the entire planning area have experienced numerous hurricane and tropical storm landfalls. Figure 12-1 shows the major hurricanes that have affected the region as identified by NOAA. Figure 12-2 shows the tracks of all tropical systems cyclones that have affected the region since 1900. Details of specific storms are provided in the sections below.

Source: National Climatic Data Center

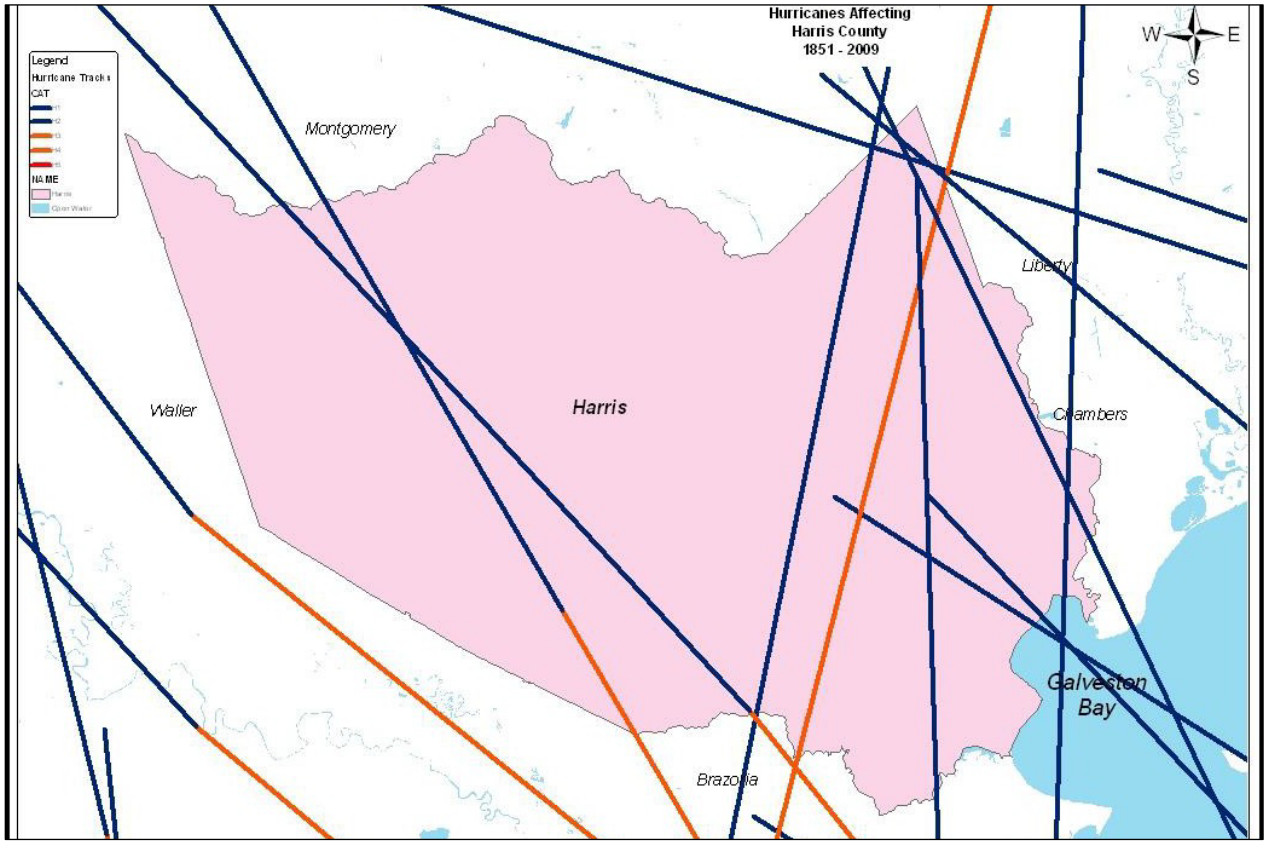


Figure 12-1. Major Hurricanes Since 1851

Source: Hurricane 2000-2009 Edition, Historic with track

Figure 12-2. All Tropical Cyclones Since 1900

Galveston Hurricane 1900

This weather system was first detected over the tropical Atlantic on August 27, 1900. While the history of the track and intensity is not fully known, the system reached Cuba as a tropical storm on September 3 and moved into the southeastern Gulf of Mexico on September 5. A general west-northwestward motion occurred over the Gulf accompanied by rapid intensification. By the time the storm reached the Texas coast south of Galveston late on September 8, it was a Category 4 hurricane. After landfall, the cyclone turned northward through the Great Plains. The system became extra tropical and turned east-northeastward on September 11, passing across the Great Lakes, New England, and southeastern Canada. It was last witnessed over the north Atlantic on September 15.

This hurricane was the deadliest weather disaster in United States history. Storm tides of 8 to 15 feet inundated Galveston Island, as well as other portions of the nearby Texas coast. High tides were largely responsible for the 8,000 deaths (estimates range from 6,000 to 12,000) attributed to the storm. The damage to property was estimated at $30 million (see Figure 12-3).

NOAA Photo Library, NOAA Central Library; National Severe Storms Laboratory

Figure 12-3. Ruined Homes from the Galveston Hurricane

Unnamed Hurricane 1915

Another Galveston-area hurricane caused major damage throughout Harris County in August 1915. Buffalo Bayou and widespread areas of Houston experienced heavy flooding. Damage from this event is estimated at $56 million.

Unnamed Hurricane 1932

A hurricane is reported to have severely impacted Freeport, where 40 Freeport residents were reported to have been killed. Widespread flooding occurred on all bayous throughout Harris County as a result of the storm.

Unnamed Hurricanes 1943

A hurricane near Galveston caused extensive flooding in Harris County in July 1943, resulting in

$16.5 million in damages. Another hurricane in October 1943, this time nearer to Freeport, flooded more than 11,000 residences in Harris County.

Unnamed Hurricane 1945

An August 1945 hurricane affecting the Harris County area produced the heaviest rainfall previously recorded in the county: over 15 inches in 24 hours. Flooding was reported on all bayous and streams.

Hurricane Audrey 1957

Hurricane Audrey crossed the Louisiana/ Texas coast in June 1957, causing flooding in Harris County.

Hurricane Carla 1961

Hurricane Carla made landfall near Port Lavaca on September 14, 1961. Carla was among the largest hurricanes of historical record (number two (2) behind the Great New England Hurricane of 1938). The storm produced numerous tornados, wind gusts reaching 175mph, torrential rains, and a 22-foot storm surge at Port O'Connor. Hurricane force wind gusts were seen along almost the entire Texas Coast. The path of devastation extended from Victoria to Dallas. A death toll of only 34 people in Texas can be attributed in part to what was the largest peacetime evacuation of population in U.S. history. A quarter of a million people fled the middle and upper Texas coasts, moving inland to safety.

Twenty-six tornados were spawned by Hurricane Carla, one of which damaged 120 buildings and killed six (6) people in Galveston. Structures located outside of the protective seawall were severely damaged by the storm surge. Texas City saw 90 percent of its homes flooded. Surfside, near Freeport, received extensive damage. The trail of destruction extended south to Port Isabel, where 4- to 5-foot storm surges were observed. Seventy-five percent of Port O'Connor was destroyed. Heavy flooding was reported in southern Harris County.

Hurricane Beulah 1967

At the time, Hurricane Beulah was the third largest hurricane on record, following Carla in 1961 and the Great New England Hurricane of 1938. Beulah, which struck the coast near Brownsville on September 20, 1967, turned to the southwest, paralleling the coastline.

Hurricane-force winds extended up the coast to Corpus Christi, which had gusts up to 86 mph. Winds gusted to 110 mph at the local Army Corp of Engineers office. The storm surge reached 20 feet along lower sections of Padre Island. Storm surge and wind-driven waves cut 31 new inlets through the island. Citrus fruit and tree damage totaled $15 million in the Lower Rio Grande Valley.

One hundred and fifteen tornados were spawned by the system, the most ever known to be generated by a tropical storm (5 times the previous record set by Isbell in 1964). Most of the tornados were confined to the coast of Texas and were rather weak. One tornado touched down in Palacios on the morning of the September 20, killing four people and injuring six others. Fifteen people died in Texas during Beulah. Five were killed by a tornado and 10 died due to drowning. A total of 110 boats were damaged or destroyed by the storm. Damage was estimated conservatively at $100 million (see Figure 12-4).

NOAA Photo Library, NOAA Central Library; National Severe Storms Laboratory

Figure 12-4. Significant Business District Damage Along the Texas Coast Following Hurricane Beulah

Hurricanes Fern and Edith 1971

Hurricane Fern paralleled the Texas coast and made landfall as a tropical storm. Major flooding occurred along portions of the Frio, Lavaca, Nueces, San Antonio, Guadalupe, Mission, and Aransas Rivers. Wind gusts over 100 mph blew away the anemometer at Port O'Connor. Gusts exceeding 60 mph were seen from Galveston down the coast to south of Corpus Christi. Five tornados were generated by Fern. The highest recorded storm surge reached 6 feet at Freeport. Damage totaled $30 million, $5 million of which occurred in Sinton. Two people died during the storm.

Edith made landfall as a Category 2 hurricane five days later. A 6-foot storm surge overran Highway 87 between Sabine Pass and High Island. Galveston and Port Arthur reported wind gusts of 53 and 47 mph respectively.

Tropical Storm Claudette 1979

Tropical Storm Claudette made landfall near Galveston and made a loop just after landfall, stalling over southeast Texas from July 24 to July 27, 1979. Winds gusted to 60 mph. Tides in Chocolate Bayou reached 5 feet above normal. Rainfall amounts greater than 10 inches fell within 40 miles of the coast from Matagorda Bay to Sabine Pass. Twenty-four hour rainfall totals reached 45 inches in Alvin in Harris County, establishing a new U.S. rainfall record. This caused widespread and unprecedented flooding across the area.

Most streams did not return to their banks until July 30. Fifteen thousand homes and hundreds of businesses were flooded. The rice crop was beaten into the soil by the heavy rain. Six counties in southeast Texas were declared major disaster areas. Claudette produced $700 million in damage, putting it on the National Hurricane Center's list of history's most damaging tropical cyclones in the United States.

Hurricane Alicia 1983

Alicia formed over the north central Gulf of Mexico on August 15, 1983. It drifted slowly westward and northwestward while strengthening on August 16 and 17. Alicia arrived over the west end of Galveston Island as a Category 3 hurricane on August 18. Alicia moved northwestward into Oklahoma as a tropical depression on August 19, and then turned northward before dissipating over Nebraska on August 21 (see Figure 12-5).

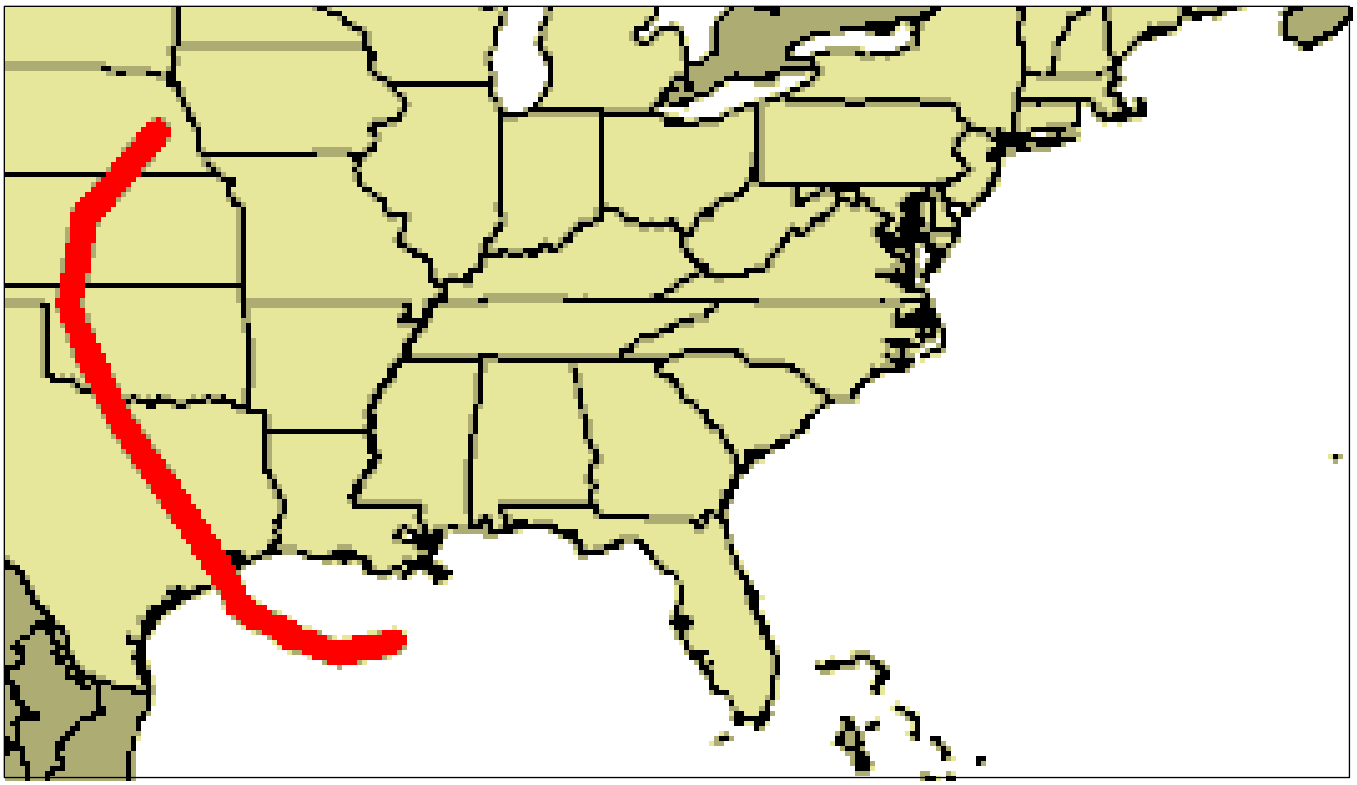


Figure 12-5. Path of Hurricane Alicia, 1983

The U.S. Coast Guard Cutter Buttonwood moored at Galveston due to reported sustained winds of 96 mph with gusts reaching 125 mph. Hobby Airport at Houston, Texas reported 94 mph sustained winds with gusts to 107 mph. Wind gusts of hurricane force in downtown Houston littered the streets with broken glass as windows broke in numerous high-rise buildings. Additionally, 23 tornados were reported from Alicia. Storm surge values of 10 to 12 feet occurred within Galveston Bay and 8 to 10 feet along the Gulf of Mexico beaches. Seabrook recorded a 12.0-foot water level rise and Baytown 10.7 feet. Water levels rose to the tops of roofs in the Brownwood subdivision in Baytown. The Brownwood subdivision was completely bought out after Alicia due to frequent flooding issues. On the west end of Galveston Island, the beach eroded upwards of 150 feet landward. The U.S. Army Corps of Engineers estimated that the Galveston seawall prevented upwards of 100 million dollars in damage. Alicia was responsible for 21 deaths, 3,094 injuries, and $2 billion in damage. A total of 2,297 dwellings were destroyed with another 3,008 suffering major damage.

Hurricane Bonnie 1986

Bonnie became a tropical depression on the June 23 350 miles southeast of New Orleans, and made landfall between High Island and Sabine Pass on June 26 as a Category 1 hurricane. Sustained winds of 97 mph were recorded at Sea Rim State Park along with 75 mph at Jefferson County Airport. Storm surge flooding of 4 to 6 feet was recorded along the eastern Bolivar Peninsula with a maximum tide level of 5.4 feet at Sabine Pass. The majority of the wind damage and flooding rainfall occurred east of Harris County from Sabine Pass to Lake

Livingston. An estimated 1,300 residents were forced from their homes due to rainfall flooding. An estimated 25,000 residents evacuated the upper Texas coast in advance of Bonnie. There were no deaths directly attributed to the hurricane with 4 indirect deaths.

Tropical Storm Allison 1989

Tropical Storm Allison made landfall along the eastern part of Matagorda Bay with sustained winds of 45 mph and minimum central pressure of 1001 mb on June 26, 1989. Excessive rainfall of 10 to 15 inches occurred across the northern and eastern parts of Harris County leading to widespread flooding. Storm surge values of 3 to 5 feet occurred along the upper Texas coast with values upwards of 6 to 7 feet near Baytown and the head of Trinity Bay. Eleven deaths were recorded, all attributed to drowning, and damage totaled around a half-billion dollars, mainly due to flooding.

Hurricane Chantal 1989

Chantal became a tropical storm on July 30 and continued to intensify up until landfall at High Island, TX on August 1, 1989. At the time of landfall maximum sustained winds were 80 mph with storm surge flooding of 5 to 7 feet along portions of the Bolivar Peninsula and areas eastward. Chantal's worst aspect was excessive rainfall. A band of 12 to 18 inches occurred from Rosenberg to Texas City resulting in significant flooding of hundreds of homes across the area. An estimated 3,000 homes in Texas City reported either flood or wind damage. Thirteen deaths occurred from flooding with damage near $100 million.

Hurricane Jerry 1989

Jerry developed into a tropical depression on October 12 in the Bay of Campeche and became a hurricane on October 15 while moving due northward over the western Gulf of Mexico. Jerry made landfall in the early evening of October 15 near Jamaica Beach as a category 1 hurricane. Sustained surface winds of 75 mph with gust to 100 mph were reported on Galveston Island. Jerry was a very small hurricane and weakened rapidly after landfall with neither Hobby nor Intercontinental Airports reporting sustained tropical storm force winds. A storm surge of 5 to 7 feet occurred in the northern and eastern parts of Galveston Bay including 7.0 feet at Baytown and near 8.0 feet near the mouth of the Houston Ship Channel. Rainfall was generally light due to the fast movement and small size with totals averaging less than 3 inches across Harris County. Three deaths occurred in Galveston with damage estimates near 70 million dollars. Jerry is the latest hurricane to ever make landfall on the Texas coast.

Tropical Storm Charley 1998

Charley developed into a tropical depression about 275 off the south Texas coast on August 21 and made landfall on August 22 near Port Aransas, TX with 70 mph sustained winds. Along the upper Texas coast, tides were 2 to 3 feet above normal with rainfall amounts averaging 2 to 4 inches. A report of 9 inches of rainfall occurred at the mouth of the San Bernard River in Brazoria County. Impacts across Harris County were minimal.

Tropical Storm Frances 1998

On September 10, 1998, Tropical Storm Frances formed in the western Gulf of Mexico approximately 250 miles south of Galveston. On September 12, Frances moved inland just southwest of Victoria and remained nearly stationary throughout the day, moving to the north, northeast that evening. At 7 p.m. ET, Frances was downgraded to a Tropical Depression as it moved to the northeast of Victoria.

Most of the damage along the coast was attributed to the high tides that persisted for nearly two days. The high tides in Galveston Bay increased flooding problems experienced further inland by the heavy rains. Over 4 inches of rain fell over the Houston/ Galveston County Warning area. More than 10 inches of rain fell along the coastal counties of Matagorda, Brazoria, Galveston and Chambers. Inland counties, including Harris, Polk, San Jacinto

and Washington received similar rainfall totals. With tides already running 4 to 6 feet above normal, rainfall runoff that normally drained into area bays backed up, resulting in more widespread flooding of inland creeks and bayous. Galveston, Harris, Brazoria, and Matagorda Counties were declared disaster areas. Total damage exceeded $286 million dollars. Most of this damage was along the coast and around Galveston Bay where high tides and winds destroyed dunes and personal property. Nearly 100 single-family homes were destroyed along the upper Texas coast by the high tides and battering waves. Three deaths can be attributed to Tropical Storm Frances.

Tropical Storm Allison 2001

Allison, which began as an area of disturbed weather over the northwestern Gulf of Mexico on June 5, 2001, rapidly developed into a tropical storm. The tropical storm made landfall near Freeport, Texas later that day. Allison hovered over Harris County initially for 4 hours, dumping as much as 12 inches of rain. Allison weakened to a depression on June 6, while drifting northward. The storm then made a slow loop over southeastern Texas from June 7 – 9. The cyclone moved into the Gulf of Mexico on June 10 and acquired subtropical characteristics. It then moved east-northeastward over southeastern Louisiana on June 11, where it re-intensified into a subtropical storm. Allison then weakened to a subtropical depression on June 12 while continuing east-northeastward. This track carried it to southeastern North Carolina by June 14 where it stalled. The cyclone then drifted northeastward on June 15 and 16. This was followed by a faster northeastward motion on June 17 as the center emerged in the Atlantic. Allison regained subtropical storm strength later that day before becoming extra tropical on June 18 southeast of Cape Cod. The system dissipated southeast of Nova Scotia the next day (see Figure 12-6).

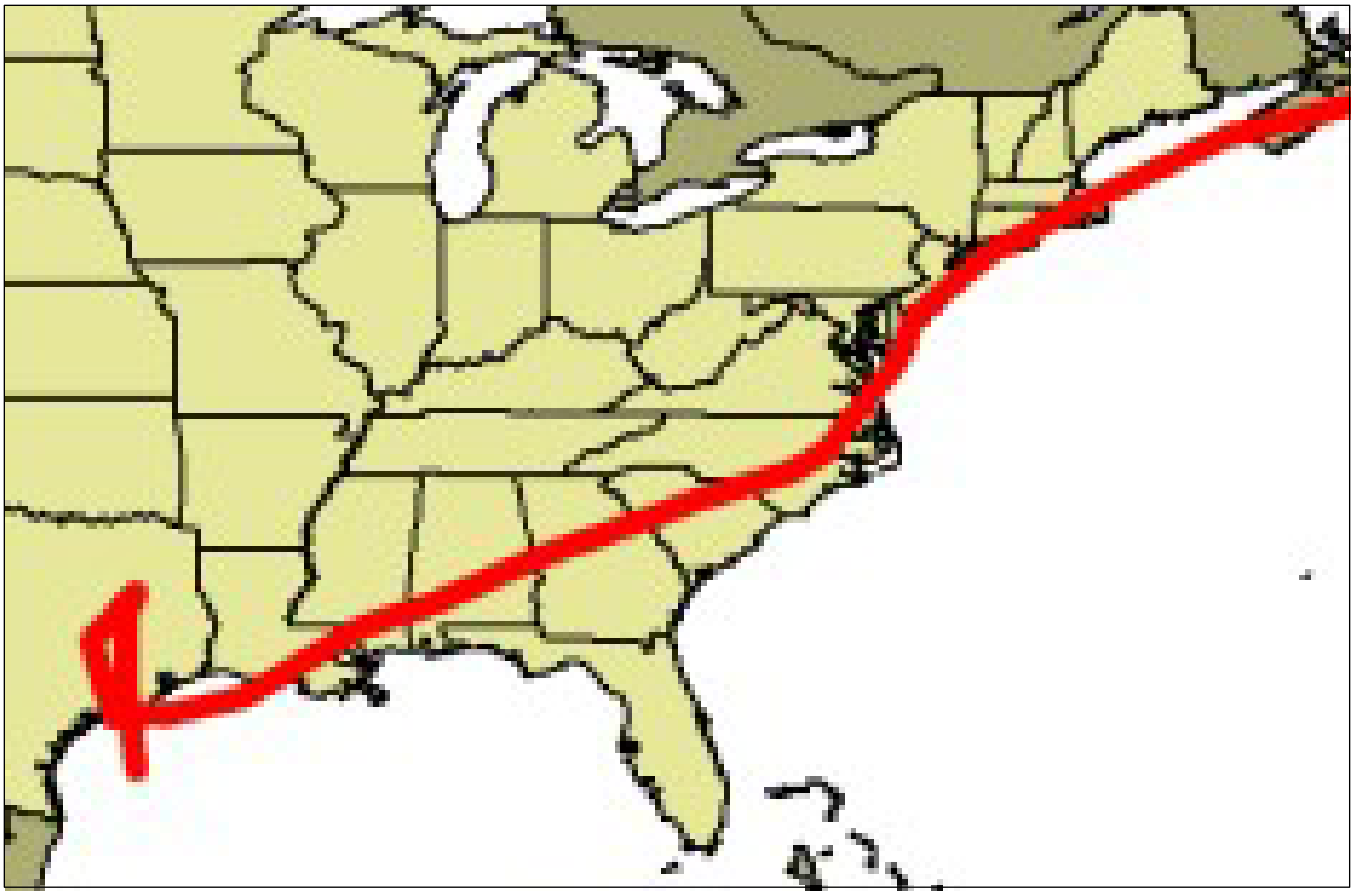


Figure 12-6. Path of Tropical Storm Allison, 2001

By the end of Allison's onslaught, as much as 28 inches of rain had fallen on parts of Harris County. Allison brought tropical-storm-force winds and above normal tides to portions of the Texas and Louisiana coasts. However, the greatest damage sustained was due to the widespread heavy rains and resulting floods along the entire path of the cyclone. Houston, Texas, was the worst affected area, as the Port of Houston reported 37 inches of rain. Several other locations reported more than 30 inches. The storm also spawned 23 tornados. More than 73,000 residences in Harris County were flooded, in addition to hundreds of businesses in the greater Houston area. Allison was responsible for 22 deaths in Harris County and a total of at least $5 billion in damage in the United States, making it the deadliest and costliest U.S. tropical storm on record.

Tropical Storm Fay 2002

Tropical storm Fay formed 125 miles southeast of Galveston on September 5. Fay made landfall near Palacios as a 60 mph tropical storm early on September 7, producing very heavy rainfall and flooding. Rainfall amounts of 10 to 20 inches occurred just southwest of Harris County in Brazoria, Fort Bend, and Wharton counties producing extensive flood damage. Storm surge flooding averaged 3 to 5 feet along the upper Texas coast resulting in beach erosion and an estimated 3.5 million dollars in damage to public roads and beaches in Galveston County alone. There were no deaths related to the storm, however three persons were injured in Fort Bend County when their mobile home was struck by one of the five tornados the storm produced.

Hurricane Claudette 2003

Claudette developed from a tropical wave over the central Caribbean Sea and entered the Gulf of Mexico on July 12. The storm moved steadily across the Gulf and intensified just prior to landfall to a category 1 hurricane with sustained winds of 90 mph. In fact, radar observations and aircraft hurricane hunter missions suggest Claudette continued to intensify while crossing over Matagorda Bay due to very favorable upper air outflow conditions. Extensive storm surge and beach erosion occurred along the upper Texas coast with storm surge levels averaging 5 to 8 feet. Minor flooding occurred on the west side of Galveston bay around Seabrook with more extensive flooding from the west end of the seawall down the coast to Matagorda County where storm surge levels of 8.0 feet were reported at the mouth of the Colorado River. An estimated 10.9 million dollars in damaged occurred in the coastal counties of Galveston, Brazoria, Matagorda, and Jackson with no deaths reported.

Tropical Storm Grace 2003

The ill-defined Grace formed in the Gulf of Mexico about 330 miles southeast of Galveston on August 30. The poorly defined storm crossed the Texas coast near Port O Connor on August 31 with 40 to 50 mph winds. The main impacts were heavy rainfall along and to the east of the track of the center across much of southeast Texas. Rainfall amounts of 6 to 15 inches fell from eastern Galveston County northward into Liberty County. Flooding occurred where these heavy rains fell, although damage was relatively minor.

Hurricane Rita 2005

Hurricane Rita formed east of the Bahamas and moved into the eastern Gulf of Mexico on September 20. Rita rapidly intensified from a category 2 to category 5 hurricane in less than 24 hours with maximum sustained winds reaching 165 mph on the afternoon of September 21. Hurricane Rita made landfall as a 120 mph category 3 hurricane in extreme southwest Louisiana 10 miles east of the Texas state line on September 24. While most of the area fell west and on the weaker side of the hurricane, impacts were still felt along the upper Texas coast. Beach erosion occurred along the entire upper Texas coast along with minor storm surge flooding on the eastern and southern sides of Galveston Bay. Sustained tropical storm force winds occurred mainly along and east of I-45 resulting in power outages. Rita provoked one of the largest evacuations in U.S. history with upwards of 2 million coastal Texans leaving the coast resulting in long traffic delays. Rita caused upwards of 10 billion dollars in damage including 90 million in Harris County alone. Rita also resulted in 7 direct deaths and 149 indirect deaths mainly related to the large evacuation of the elderly and excessive heat prior to landfall.

Tropical Storm Erin 2007

Tropical Storm Erin along the middle Texas coast, just north of Corpus Christi, as a minimal tropical storm early on August 16 with widespread heavy rains developed in strong feeder bands across Harris County. A southeast to northwest feeder band developed around 10:00 a.m. from Katy to the western end of Galveston Island and moved slowly eastward to a line from Clear Lake to Humble by 5:00 p.m. Training of the cells along this southeast to northwest line combined with rainfall rates upwards of 4.0 to 5.0 inches per hour resulted in major street flooding and flooding of several channels.

Overbank conditions occurred along several bayous in the south and southeast part of Harris County resulting in widespread flooding of streets and structures. Widespread major street flooding occurred throughout the afternoon across the eastern half of the county with SH 288 impassable near the 610 south loop, I-10 east closed at Wayside, and numerous secondary roads closed along I-45 S, SH 225, and I-10 E. Additionally, Erin caused eight fatalities across the state of Texas including three in Harris County. Two of the fatalities occurred as a result of a supermarket roof which collapsed under the weight of the heavy rainfall and the third was from a vehicle that drove into a flooded detention pond. Tides were only slightly elevated in Galveston Bay (roughly ½ foot above normal).

Hurricane Humberto 2007

Humberto rapidly developed off the upper Texas coast during the early morning hours of September 12. Humberto deepened from a tropical depression (30 mph) to a category 1 hurricane (90 mph) within 24 hours and is one of the faster rates of intensification ever noted for a developing tropical cyclone. The hurricane crossed the coast near High Island early on September 13 with sustained winds of 90 mph creating wind damage across Chambers, Jefferson, and Orange Counties. Rainfall averaged 10 to 15 inches along and east of a line from Freeport to Winnie cutting off several homes in eastern Chambers County. An estimated 50 million dollars in damage occurred with one death in Bridge City, Texas. A total of 133,000 residents in Texas and Louisiana lost power from Humberto.

Hurricane Ike 2008

Hurricane Ike, which moved into the Gulf of Mexico on September 9, 2008 as a category 1 hurricane. As it crossed the Gulf of Mexico it intensified to a category 2 hurricane, finally making landfall along the north end of Galveston Island, Texas in the early morning hours of September 13, 2008 with maximum winds of 95 kt. Ike weakened to a tropical storm by late September 13 just east of Palestine, Texas, and then became extra tropical when it interacted with a front on September 14 while moving northeastward through northern Arkansas and southern Missouri. The vigorous extra tropical low moved quickly northeastward, producing hurricane force wind gusts across the Ohio Valley on the afternoon of the September 14. Thereafter, the low weakened and moved across southern Ontario and southern Québec and was absorbed by another area of low pressure near the St. Lawrence River September 15.

The storm surge averaged 15 to 18 feet on Bolivar Peninsula and within the eastern portions of Galveston Bay. On the west side of Galveston Bay values averaged 10 to 15 feet including 12.8 feet at Seabrook. Extensive surge and wave related damage occurred along the upper Texas coast from Matagorda County to the Texas/Louisiana state line (see Figure 12-7). The storm surge along the upper Texas coast was one of the highest recorded in recent history surpassing both Hurricane Alicia and Hurricane Carla and had not been experienced since the storm surge of the Great Galveston Hurricane of 1900 and the 1915 Galveston Hurricane.

Source: AP Photo/Frank Franklin II

Figure 12-7. Debris Over Highway 146 in Seabrook, Texas in the aftermath of Hurricane Ike

Excessive rainfall of 8 to 12 inches occurred along the path of the hurricane producing widespread inland flooding across Harris County with upwards of 150 homes flooded from rainfall alone. Wind gusts of hurricane force in downtown Houston littered the streets with broken glass as windows broke in numerous high-rise buildings. Wind damage was mainly limited to roofs, power systems, and vegetation and was well supported within strong tropical storm to minimal category 1 conditions in most areas. Power outages affected more than 2.0 million persons with outages in the hardest hit locations in Harris, Montgomery, Chambers, and Liberty counties lasting upwards of 21 to 25 days. Ike was responsible for 12 deaths and an estimated $19.3 billion in damage. (NOAA National Hurricane Center)

Hurricane Harvey, 2017

While not considered to be a wind impact event, Harvey made landfall as a Category 4 hurricane near Rockport, Texas during the evening of August 25. The storm then weakened to a tropical storm and slowed, looping back and tracking over southeast Texas then back over the Gulf of Mexico, making a second landfall along the Louisiana coast during the morning of August 30. Over that 5-day period over southeast Texas, Harvey produced catastrophic flooding with a large area of 30 to 60 inches of rain, 23 tornados, tropical storm force winds and a moderate storm surge near Matagorda Bay. Communities along the coastline were hit with a range of wind speeds. Port Aransas recorded Category 4 strength maximum wind speeds of 132 mph, while Rockport, 12 miles north and on the inland side of Aransas Bay, saw winds up to 140 mph. Corpus Christi, approximately 30 miles southwest of where Hurricane Harvey made landfall, sustained Category 1 wind speeds between 75 and 95 mph. Houston experienced tropical storm-strength winds between 35 and 75 mph.

12.2.2 Location

Hurricane risk in the United States is located along the entire Gulf of Mexico. Thus the entire Texas coast is located within a hurricane susceptible region; including the Harris County planning area. The Harris County planning area coastline is located on the Galveston Bay and Houston Ship Channel, which is directly exposed to the Gulf of Mexico. Thus, hurricane, high-wind and tropical storms are likely to make landfall located within and affect the entire planning area. Due to Harris County's geographic location, this area of the state, and the entire planning area is vulnerable to damage from hurricane winds and to the inland impacts associated with coastal storms.

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance.

Figure 12-8, Figure 12-9, and Figure 12-10 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 20- and 100-year MRP events as well as a deterministic scenario event looking at observed conditions from Hurricane Alicia. These peak wind speed projections were generated using Hazus. The maximum 3-second hurricane-speed gust wind speeds for Harris County range from 85 mph to 92 mph hurricane speeds for the 20-year MRP event. and 118 mph to 12 mph for the 100-year MRP event. The maximum 3-second gust wind speeds during Hurricane Alicia ranged from 105 mph to 110 mph. The associated impacts and losses from these 20/100-year and Hurricane Alicia model runs are reported in the exposure and vulnerability assessments later in this section.

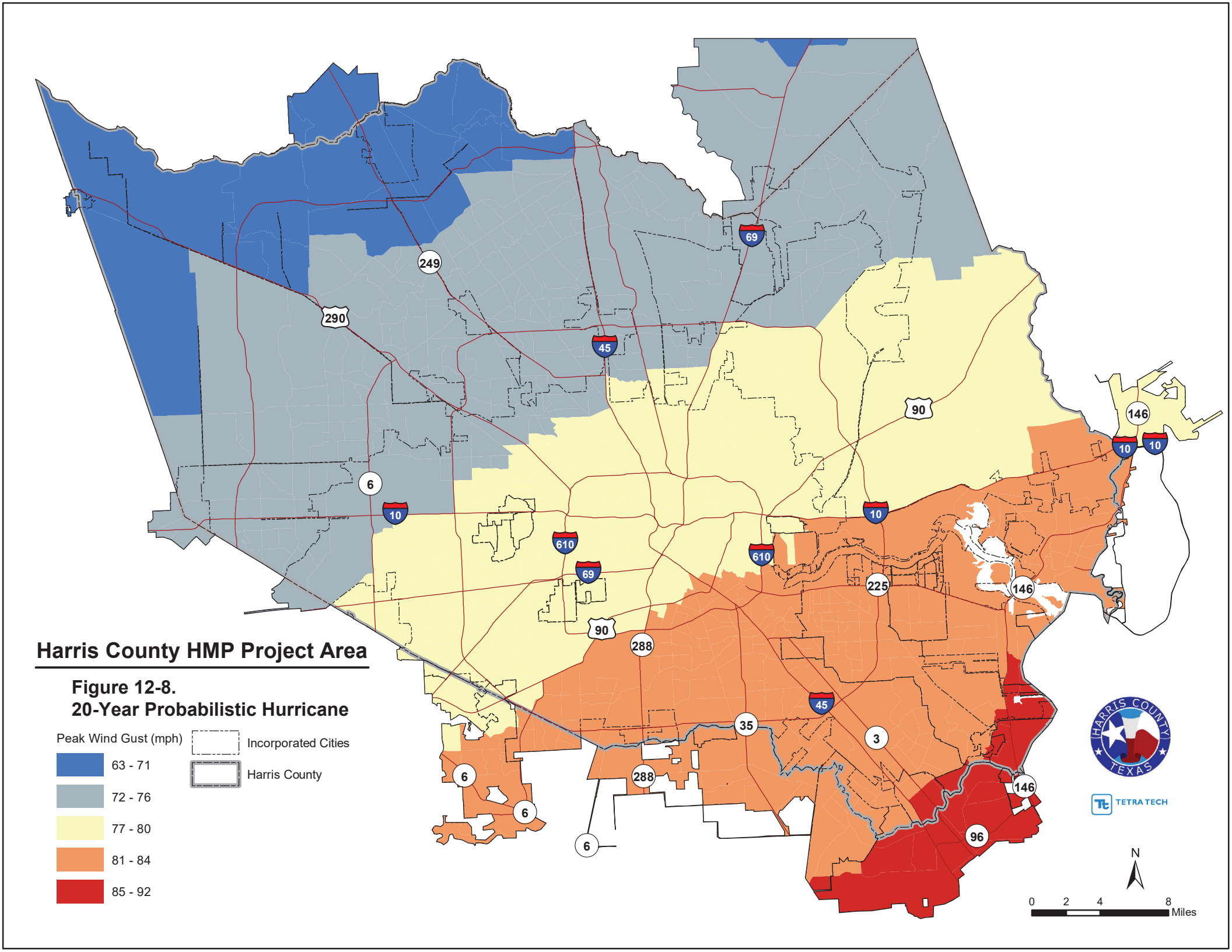
12.2.3 Frequency

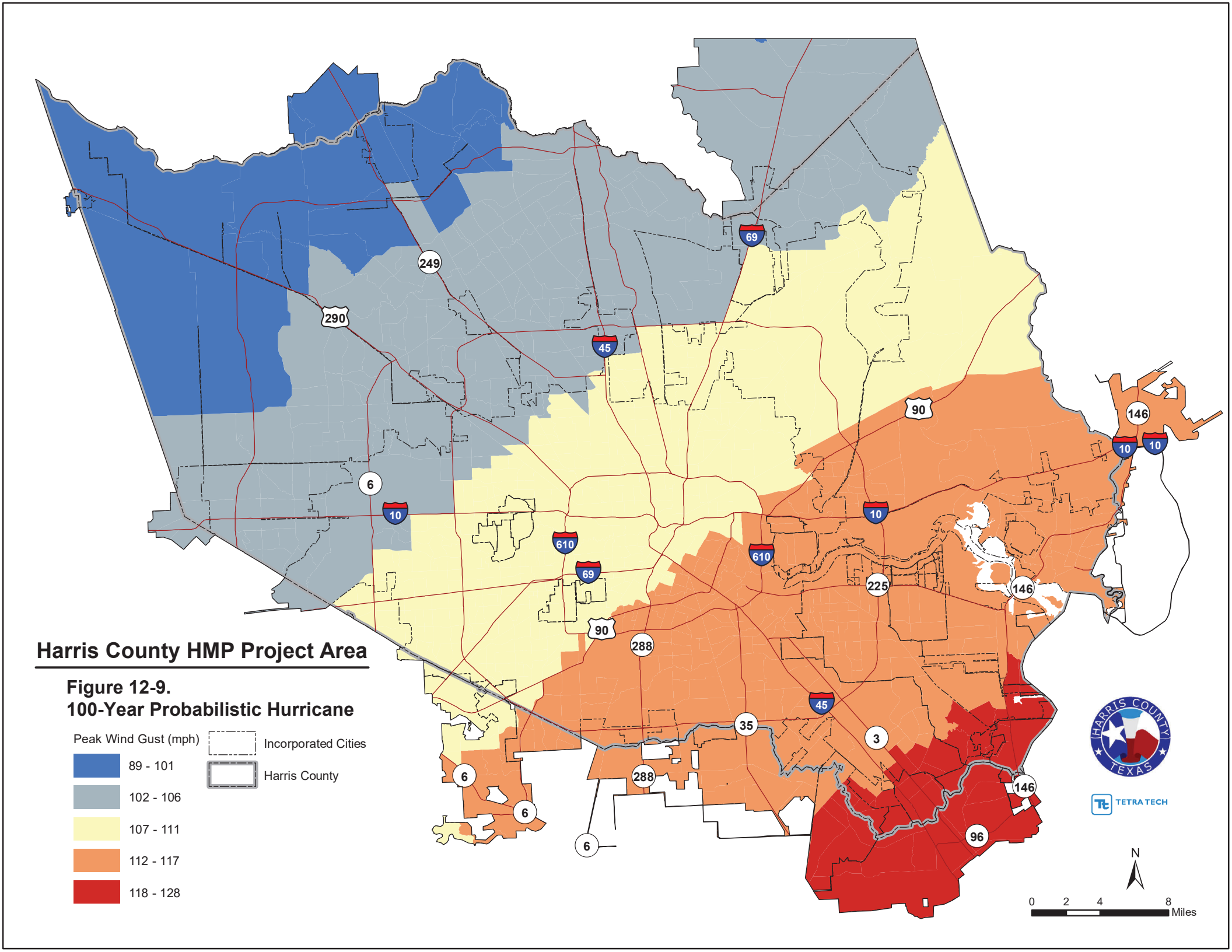
Figure 12-11 shows the likelihood of a tropical storm or hurricane affecting the Atlantic and Gulf of Mexico during the Atlantic hurricane season. The figure was created by the National Oceanic and Atmospheric Administration's Hurricane Research Division using data from 1944 to 1999 and counting hits when a storm or hurricane was within approximately 100 miles (165 km) of each location.

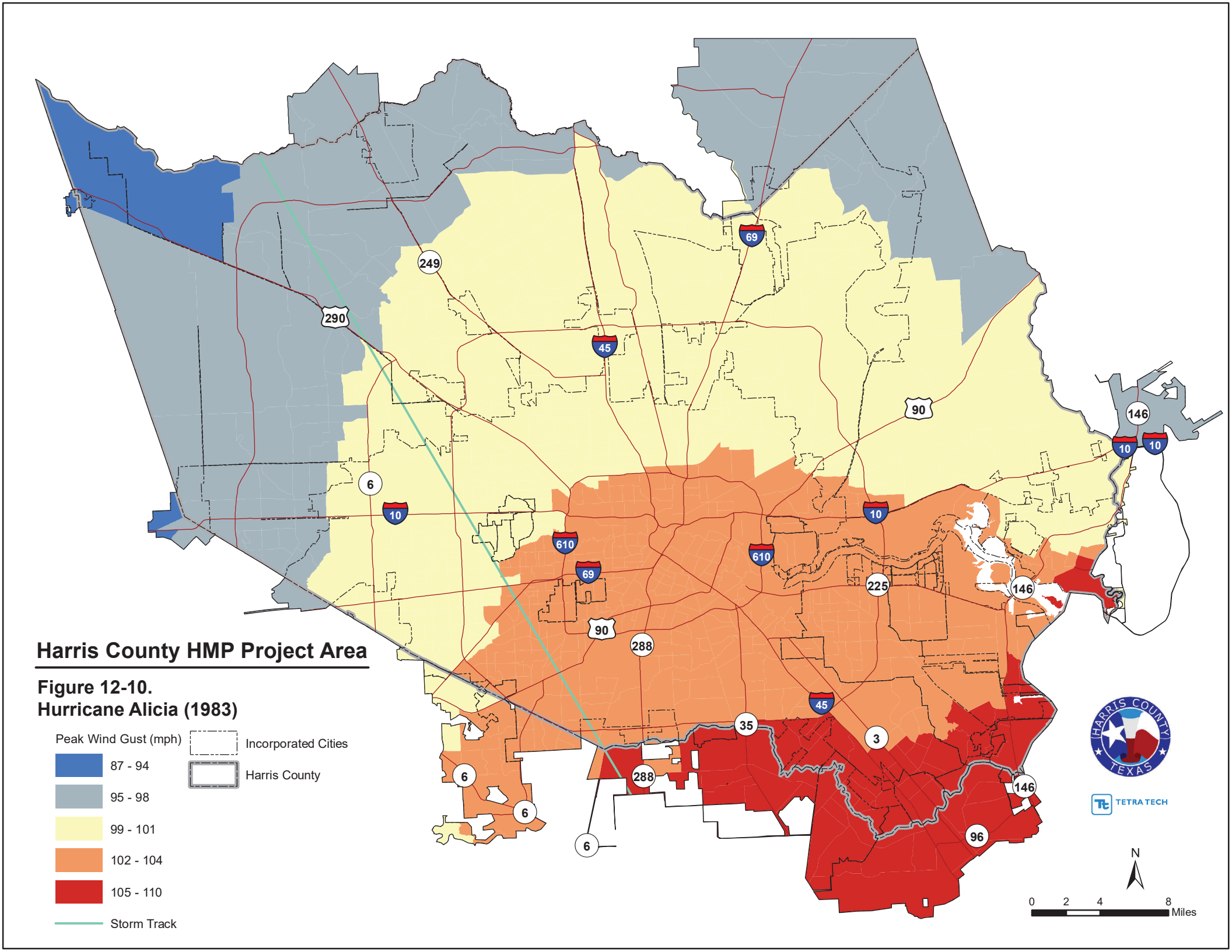
Based on historical data provided by the National Climatic Data Center (NCDC), the average frequency of the Harris County planning area and all participating jurisdictions being affected by a hurricane wind event is once every 4.21 years. For the risk assessment for this plan update, the probability of occurrence for this hazard is considered "high."

12.2.4 Severity

The severity of a hurricane is commonly categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures (NOAA 2013b). Table 12-1 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.


Harris County HMP Project Area
Figure 12-8.
20-Year Probabilistic Hurricane
Peak Wind Gust (mph)
63 - 71
72 - 76
77 - 80
81 - 84
85 - 92
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH


Harris County HMP Project Area
Figure 12-9.
100-Year Probabilistic Hurricane
Peak Wind Gust (mph)
89 - 101
102 - 106
107 - 111
112 - 117
118 - 128
Incorporated Cities
Harris County
249
290
45
69
6
10
610
90
146
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH


Harris County HMP Project Area
Figure 12-10.
Hurricane Alicia (1983)
Peak Wind Gust (mph)
87 - 94
95 - 98
99 - 101
102 - 104
105 - 110
Storm Track
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH

Source: National Oceanic and Atmospheric Administration, Hurricane Research Division

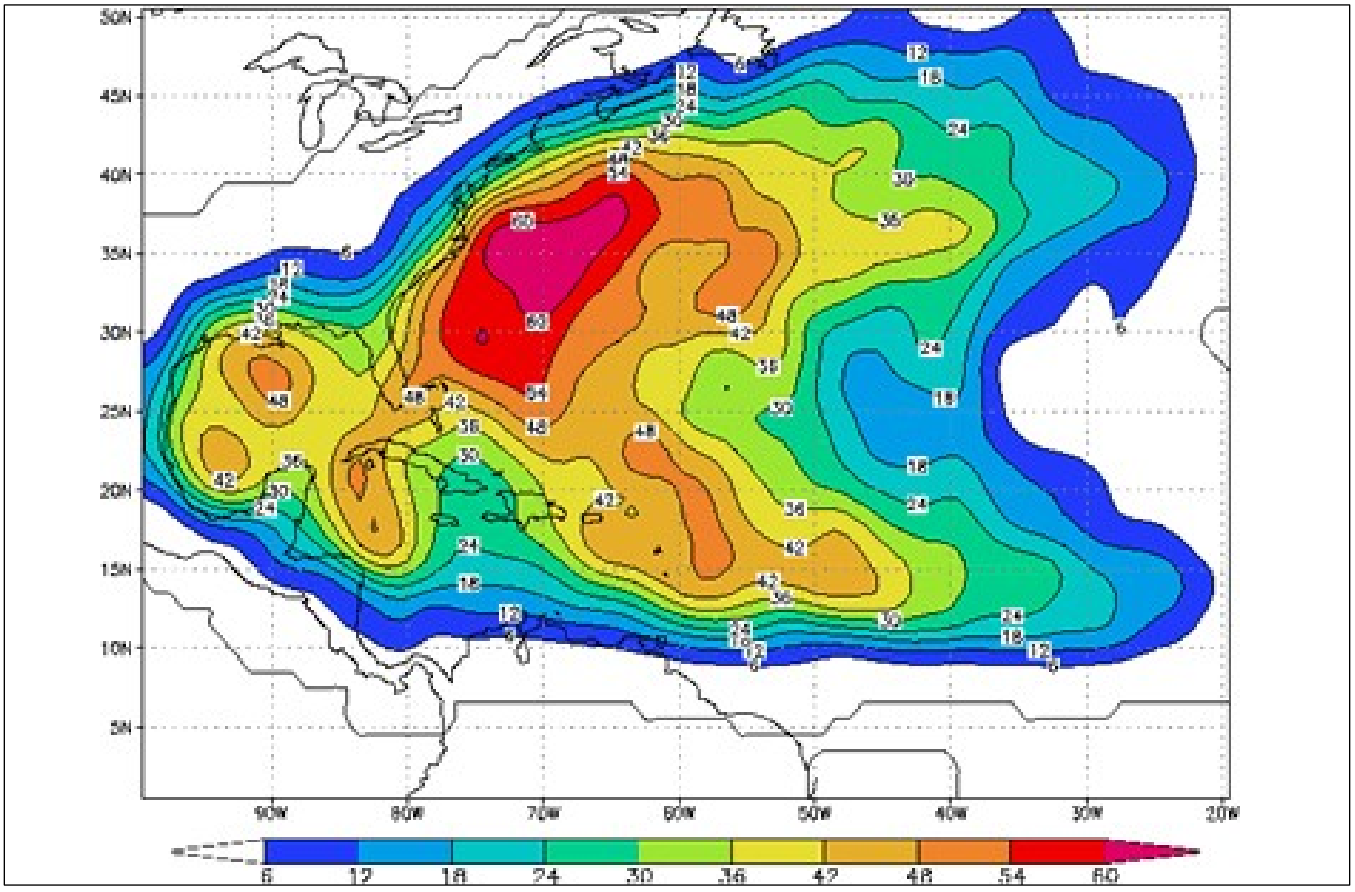


Figure 12-11. Empirical Probability of a Named Storm

Table 12-1. The Saffir-Simpson Scale

Category	Wind Speed	Expected Damage
1	74-95 mph	Very dangerous winds will produce some damage: Homes with well-constructed frames could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	Extremely dangerous winds will cause extensive damage: Homes with well-constructed frames could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph	Devastating damage will occur: Homes with well-built frames could incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph	Catastrophic damage will occur: Homes with well-built frames can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	>157 mph	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NOAA 2013b

Damage during hurricanes may also result from spawned tornados and inland flooding associated with heavy rainfall that usually accompanies these storms. The entire planning area can expect to experience the full range of hurricanes and tropical storms, which may vary in duration, intensity and severity in the future.

Harris County is primarily impacted by coastal storm events with wind speeds in the range of 39 to 73 mph corresponding to tropical storm force events on the Saffir-Simpson Hurricane Wind scale. The National Coastal Services Center shows the average wind speed from coastal storm events that have impacted Harris County at 53.2 mph, with a maximum wind speed of 125 mph (Category 3 Storm on the Saffir-Simpson scale) based on past events.

Impacts on the planning area due to hurricane winds include but are not limited to temporary and permanent displacement of residents and businesses, loss of life, widespread power outages, sewer/sanitation system damage, long-term limited mobility for residents and responders, long-term closure or limited functionality of critical infrastructure facilities including hospitals and industrial facilities, lack of economic and industrial activity due to closures. Major damage to residential property, equipment, and vehicles.

12.2.5 Warning Time

The National Weather Service (NWS) issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The NWS allows the National Hurricane Center to issue advisories during the post-tropical stage. The following are the definitions of the watches and warnings:

- **Hurricane/Typhoon Warning** is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm force winds. The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.
- **Hurricane Watch** is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm force winds.
- **Tropical Storm Warning** is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours in association with a tropical, subtropical, or post-tropical storm.
- **Tropical Storm Watch** is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, sub-tropical, or post-tropical storm (NWS 2013 a).

12.3 SECONDARY HAZARDS

The strong winds of a tropical cyclone can cause dangerous waves that pose a significant hazard to mariners and coastal residents and visitors. The secondary hazards associated with hurricanes are:

- Storm surge and storm tide
- Heavy rainfall and inland flooding
- High winds
- Rip currents
- Tornados.

All these hazards are profiled as primary hazards within this assessment with the exception of rip currents.

Rip currents are channeled currents of water flowing away from shore, usually extending past the line of breaking waves, that can pull even the strongest swimmers away from shore. When waves break along the coast, they can produce rip currents, even at large distances from the storm. As an example, in 2008, despite the fact that Hurricane Bertha was more than 1,000 miles offshore, the storm resulted in rip currents that killed three people along the New Jersey coast and required 1,500 lifeguard rescues in Ocean City, Maryland, over a 1-week period. In 2009, all six deaths in the United States directly attributable to tropical cyclones occurred as the result of drowning from large waves or strong rip current.

12.4 EXPOSURE

A quantitative assessment of exposure to the hurricane hazard was conducted using the mapping shown in Figure 12-8, Figure 12-9, and Figure 12-10 and the asset inventory developed for this plan. Detailed results are provided in Appendix C and summarized below.

12.4.1 Population

The entire population of the planning area is potentially exposed to direct and indirect impacts from hurricanes. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of hurricanes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

12.4.2 Property

According to Central Appraisal districts for Harris, Fort Bend and Galveston Counties, there are 1,355,132 buildings in the planning area, with a total appraised value of over $928 billion. Since all structures in the planning area are susceptible to hurricane impacts to varying degrees, this represents the property exposure to hurricane events. Most of the buildings (97 percent) are residential.

12.4.3 Critical Facilities and Infrastructure

Since the entire planning area has exposure to the hurricane hazard, all identified critical facilities and infrastructure components are considered to be exposed.

12.4.4 Environment

Since the entire planning area has exposure to the hurricane hazard, all environmental assets within the planning area are considered to be exposed to the impacts of the hurricane hazard.

12.5 VULNERABILITY

Hurricane vulnerability data was generated using a Hazus analysis for the 20-year and 100-year probabilistic events as well as a deterministic scenario event for Hurricane Alicia.

12.5.1 Population

Vulnerable Groups

Three population groups are particularly vulnerable to hurricane hazards:

- **Linguistically Isolated Populations**——Problems arise when there is an urgent need to inform non-English speaking residents of an earthquake event. They are vulnerable because of difficulties in

understanding hazard-related information from predominantly English-speaking media and government agencies. According to the U.S. Census, American Community Survey, the linguistically isolated population represented 11.9 percent of the total population in 2018.

- **Population Below Poverty Level**—These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Poorer residents are also less likely to have insurance to compensate for losses in earthquakes. According to the American Community Survey, the population below poverty represented 16.8 percent of the total population in 2018.
- **Population Over 65 Years Old**—This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations. According to the American Community Survey, the population over 65 years old represented 9.6 percent of the total population in 2018.

Estimated Impact on Households and People

Table 12-2 summarizes the estimated impacts of modeled hurricane events on persons and households in the planning area.

Table 12-2. Estimated Hurricane Impact on Persons and Households

	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
20-Year Probabilistic	1,083	767
100-Year Probabilistic	28,793	20,567
Alicia Scenario	9,867	6,925

12.5.2 Property

Structures and Contents

Hazus calculates losses to structures from hurricane by estimating wind induced loads, building response, damage, and then loss. For this analysis, local data on facilities was used instead of the default inventory data provided with Hazus. The results by hurricane scenario (20-year, 100-year and Hurricane Alicia) are summarized in Table 12-3.

Table 12-3. Loss Estimates for Scenario Hurricane Events

	Estimated Loss Associated with Flood			% of Total
Scenario	Structure	Contents	Total	Replacement Value
20-Year Probabilistic	$1,622,489,443	$269,977,524	S1,892,466,967	0.2%
100-Year Probabilistic	$15,279,174,125	$4,287,343,716	$19,566,517,841	2.1%
Hurricane Alicia Scenario	**$7,714,959,513**	**$1,286,695,827**	**$9,001,655,339**	**1.0%**

Note: Values shown are accurate for comparison of results in this plan.

Hurricane-Caused Debris

The Hazus analysis estimated the amount of debris within the planning area generated by the modeled hurricane, as summarized in Table 12-4.

Table 12-4. Estimated Hurricane-Caused Debris

Scenario	Debris to Be Removed (tons)[a]	Estimated Number of Truckloads[b]
20-Yr Probabilistic	243,307	9,732
100-Yr Probabilistic	2,325,648	93,026
Hurricane Alicia Scenario	1,275,875	51,035

a. Debris generation estimates were based on updated general building stock dataset at a Census Block analysis level.
b. Hazus assumes 25 tons/trucks.
Note: Values shown are accurate for comparison of results in this plan.

12.5.3 Critical Facilities and Infrastructure

The Hazus estimates of hurricane damage to critical facilities and infrastructure in the planning area are summarized in Table 12-5, Table 12-6, and Table 12-7.

Table 12-5. Damage Level to Critical Facilities Exposed to the 20-Year Hurricane

	Loss of Use	Predicted Damage Level[a]			
Facility Type	Days	Minor	Moderate	Severe	Complete
Medical & Health	0	2.33%	0.58%	0.02%	0.00%
Education	0.14	2.79%	1.77%	0.04%	0.00%
Emergency Services	0	2.33%	0.52%	0.04%	0.00%
Government	0	4.56%	0.70%	0.07%	0.00%
Transportation	Not reported	1.91%	0.12%	0.01%	0.00%
Utility Systems	Not Reported	4.01%	0.83%	0.08%	0.00%
Historic/Cultural	Not Reported	9.84%	0.98%	0.04%	0.00%
Total/Average	--	**3.97%**	5.50%	**0.43%**	**0.00%**

a. Minor = 0-14% damage to structure; Moderate = 15-29% damage to structure; Severe = 30-50% damage to structure; Complete = 50-100% damage to structure

Table 12-6. Damage Level to Critical Facilities Exposed to the 100-Year Hurricane

	Loss of Use	Predicted Damage Level[a]			
Facility Type	Days	Minor	Moderate	Severe	Complete
Medical & Health	0.31	16.56%	13.43%	1.52%	0.01%
Education	3	10.74%	21.66%	1.69%	0.00%
Emergency Services	0	13.45%	10.12%	2.59%	0.03%
Government	0	23.34%	10.00%	2.11%	0.00%
Transportation	Not reported	34.11%	6.60%	0.31%	0.00%
Utility Systems	Not Reported	16.97%	7.90%	1.71%	0.00%
Historic/Cultural	Not Reported	34.46%	7.29%	0.38%	0.00%
Total/Average	--	**21.38%**	**7%**	**1.47%**	**0.006%**

a. Minor = 0-14% damage to structure; Moderate = 15-29% damage to structure; Severe = 30-50% damage to structure; Complete = 50-100% damage to structure

Table 12-7. Damage Level to Critical Facilities Exposed to the Hurricane Alicia Scenario

Facility Type	Loss of Use	Predicted Damage Level[a]			
	Days	Minor	Moderate	Severe	Complete
Medical & Health	0.0	10.99%	4.00%	0.11%	0.00%
Education	0.4	9.52%	8.20%	0.10%	0.00%
Emergency Services	0	8.46%	2.74%	0.20%	0.00%
Government	0	17.28%	1.32%	0.05%	0.00%
Transportation	Not reported	17.36%	1.45%	0.06%	0.00%
Utility Systems	Not Reported	11.57%	2.78%	0.17%	0.00%
Historic/Cultural	Not Reported	17.28%	1.32%	0.05%	0.00%
Total/Average	--	**13.21%**	**3.12%**	**0.11%**	**0.00%**

a. Minor = 0-14% damage to structure; Moderate = 15-29% damage to structure; Severe = 30-50% damage to structure; Complete = 50-100% damage to structure

12.5.4 Environment

In addition to impacting individuals, homes, and communities, hurricanes have a profound effect on the environment, especially estuarine and coastal habitats. Hurricanes generate strong winds that can completely defoliate forest canopies and cause dramatic structural changes in wooded ecosystems. Animals can be killed by hurricanes or impacted indirectly through changes in habitat and food availability caused by high winds, storm surge, and intense rainfall. Endangered species can be dramatically impacted, such as the Puerto Rican Parrot (*Amazona vittata*), whose population was reduced to half its original size after the passage of Hurricane Hugo in 1989. Hurricane Gilbert pushed the Cozumel Thrasher (*Toxostoma guttatum*), found only on Mexico's Isla Cozumel, to the edge of extinction in 1988. In addition to impacting animals, storm surge and dangerous waves can move large amounts of sand and ultimately reshape the coastal landscape. Hurricanes such as Ivan (2004), Katrina and Rita (2005), and Gustav and Ike (2008) have led to shoreline position changes of about 328 feet in some regions. The loss of land from Hurricanes Katrina and Rita alone was estimated to be about 73 square miles.

By changing environmental conditions in coastal habitats, hurricanes cause a cascade of direct and indirect ecological responses that range from immediate to long-term. In terms of environmental effects, no two hurricanes are alike. Individual characteristics, such as the storm's forward speed, size, intensity, and amount of precipitation, play a large role in the type and temporal extent of a hurricane's impact. Depending on many of these factors, even tropical storms can cause severe damage to property and natural resources.

12.6 FUTURE TRENDS IN DEVELOPMENT

As the Harris County planning continues to grow as projected, the key to mitigating the future impacts from hurricanes will be the continued adoption and enforcement of strong codes and standards within the planning area. The core capability assessments by the municipal planning partners to this effort identified a strong commitment to adoption of uniform codes and standards, which will position the planning partnership well to manage the hurricane risk for future development.

12.7 SCENARIO

The frequency of hurricanes impacting the planning area is well documented, and the scenarios are frequent. While no two storms are exactly alike, lessons learned from storm to storm will enable the planning area to prepare, respond and recover from future storms that are inevitable. This risk assessment has made an attempt to look at a significant past storm event (Hurricane Alicia) and estimate its potential impacts if it were to happen

today. As the climate continues to change, it is likely the frequency and severity of hurricane activity in the Atlantic Ocean and Gulf of Mexico will increase, testing the experience and preparedness of the planning area.

12.8 ISSUES

The CPT has identified the following hurricane-related issues relevant to the planning area:

- The hurricane vulnerability within the planning area is significant, representing 0.2 to 2.1 percent of the total replacement value for the planning area. This does not include the potential flood impacts.
- As the planning area is still recovering from the impacts of past events (Harvey), there is still critical infrastructure that is in need of repair. This creates vulnerability should another storm hit.
- Emergency power sources/supply will always be mission critical to the response and recovery from hurricane events.
- How climate change will affect hurricane conditions in the planning area is uncertain.
- Strong codes and the enforcement of those codes is mission critical to increasing the resilience of the planning area.
- As the Harris County planning area continues to grow, it will be important to inform this new incoming population about hurricane risk.
- The vulnerability of critical facilities and infrastructure varies, but is significant.
- 16.8 percent of the county population is considered to be below the poverty status for the county. This population may lack the core capabilities to withstand impacts from hurricanes.
- Approximate 10 percent of the county population is over 65 years of age, which is considered a vulnerable population to the impacts from hurricanes.
- Detailed spatial analysis is needed to locate the most vulnerable populations, followed by focused public education and outreach mitigation activities for these populations.

13. MASS MOVEMENTS

13.1 GENERAL BACKGROUND

Mass wasting, or mass movement is the transport of large volumes of earth material primarily by gravity. Mass movements can be divided into four main classes**:** falls, slides, creeps and flows. The classes are based on how quickly the rock and sediment moves and how much water there is. Steep and unstable slopes are more likely to have a mass movement than gentle and stable slopes. For this assessment, **three** types of mass movements have been **assessed**:

Note: The risk from this hazard is considered to be low to negligible, mainly because of the lack of historical occurrence in the planning area. However, this hazard profile is provided in order to address the possibility of a future event in the planning area. This positions the planning partnership for benefit eligibility should an event of this type occur during the performance period of this plan.

- Landslides
- Sinkholes
- Subsidence.

13.1.1 Landslide

Landslides are commonly categorized by the type of initial ground failure. Common types of slides are shown on Figure 13-1 through Figure 13-4. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, which are less common than other types.

Other landslide types include the following:

- **Block slides**—Blocks of rock that slide along a slip plane as a unit down a slope.
- **Creep**—A slow-moving landslide often only noticed through crooked trees and disturbed structures.
- **Debris avalanche**—A debris flow that travels faster than about 10 miles per hour (mph). Speeds in excess of 20 mph are not uncommon, and speeds in excess of 100 mph, although rare, can occur. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars, and anything else in its path (Figure 13-5).
- **Earth flows**—Fine-grained sediments that flow downhill and typically form a fan structure.
- **Mudslides or Debris Flows**—Rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt.
- **Rock falls**—Blocks of rock that fall away from a bedrock unit without a rotational component.
- **Rock topples**—Blocks of rock that fall away from a bedrock unit with a rotational component.
- **Rotational slumps**—Blocks of fine-grained sediment that rotate and move down slope.
- **Transitional slides**—Sediments that move along a flat surface without a rotational component.

Source: Washington Department of Ecology, 2014

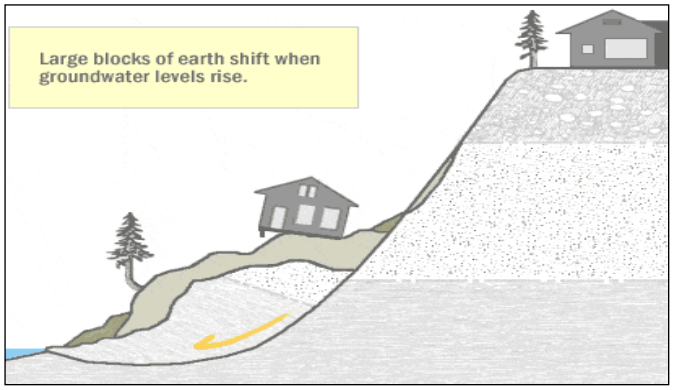


Figure 13-1. Deep Seated Slide

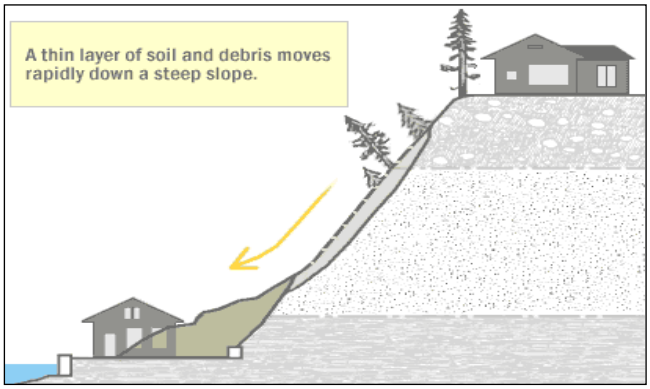


Figure 13-2. Shallow Colluvial Slide

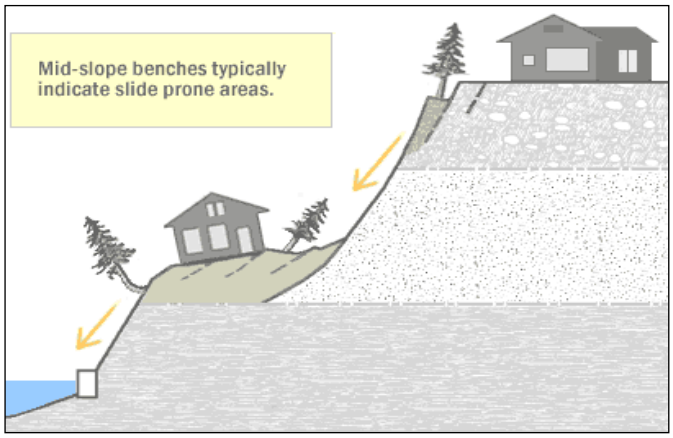


Figure 13-3. Bench Slide

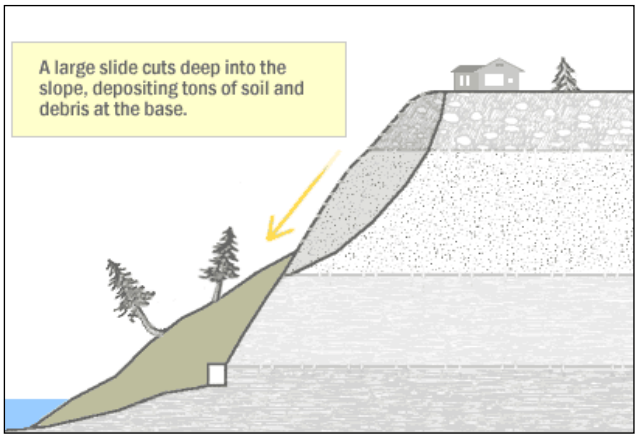


Figure 13-4. Large Slide

Source: California Department of Conservation, 2017c

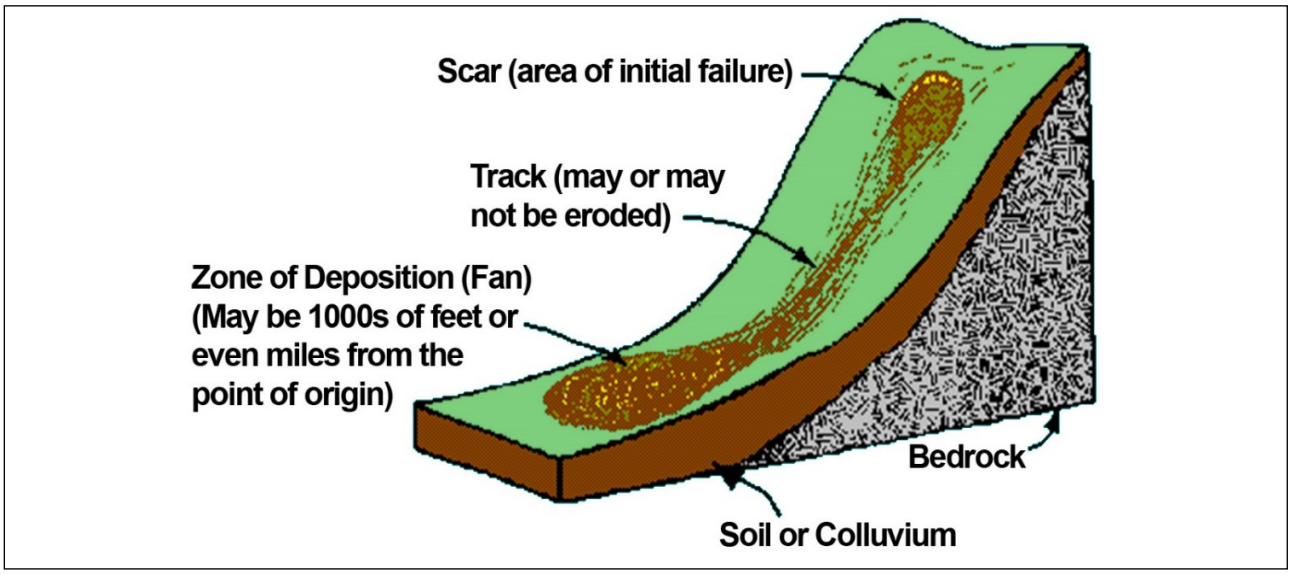


Figure 13-5. Typical Debris Avalanche Scar and Trac

Landslides are caused by a combination of geological and climate conditions, as well as encroaching urbanization. Vulnerable areas are affected by residential, agricultural, commercial, and industrial development and the infrastructure that supports it. The following human activities have particular influence on the landslide hazard:

- **Construction Earthwork—**Excavation, grading and fill during construction of buildings or roads on sloping terrain can steepen the terrain and increase weight loads on slopes, potentially increasing the landslide hazard.
- **Drainage and Groundwater Alterations—**Activities that increase the amount of water flowing into landslide-prone slopes can increase the landslide hazard. This can include broken or leaking water or sewer lines, water retention facilities that direct water onto slopes, lawn irrigation, minor alterations to small streams, and ineffective stormwater management measures. Development that increases impervious surface may redirect surface water to other areas. Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate flow.
- **Changes in Vegetation—**Removal of vegetation from very steep slopes, by wildfire or land clearing, can increase landslide hazards. In addition, woody debris in stream channels (both natural and man-made) may cause the impacts from debris flows to be more severe.

Other factors that can contribute to landslide include the following:

- Change in slope of the terrain
- Increased load on the land, shocks and vibrations
- Change in water content
- Groundwater movement
- Frost action
- Weathering of rocks
- Removing or changing the type of vegetation covering slopes.

13.1.2 Sinkholes

Sinkholes are a natural and common geologic feature in areas with underlying limestone and other rock types that are soluble in water. Most limestone is porous, allowing the acidic water of rain to percolate through their strata, dissolving the limestone and carrying it away in solution. Over time, this persistent erosion process can create extensive underground voids and drainage systems in the carbonate-based rocks. The collapse of overlying sediments into the underground cavities produces sinkholes.

The three general types of sinkholes are subsidence, solution, and collapse. Collapse sinkholes are most common in areas where the overburden (the sediments and water contained in the unsaturated zone above an aquifer) is thick, but the confining layer is breached or absent. Collapse sinkholes can form with little warning and leave behind a deep, steep-sided hole. Subsidence sinkholes form gradually where the overburden is thin and only a veneer of sediments is overlying the limestone. Solution sinkholes form where no overburden is present and the limestone is exposed at the surface.

Sinkholes occur in many shapes, from steep-walled holes to bowl or cone shaped depressions. If there is not enough support for the land above the underground spaces, then a sudden collapse of the land surface can occur. Under natural conditions, sinkholes form slowly and expand gradually. However, human activities such as dredging, constructing reservoirs, diverting surface water, and pumping groundwater can accelerate the rate of sinkhole expansions, resulting in the abrupt formation of collapse sinkholes. Development increases water usage, alters drainage pathways, overloads the ground surface, and redistributes soil. According to FEMA, the number of human-induced sinkholes has doubled since 1930, and insurance claims for sinkhole-related damages increased 1,200 percent between 1987 and 1991.

Although a sinkhole can form without warning, specific signs can signal potential development:

- Slumping or falling fence posts, trees, or foundations
- Sudden formation of small ponds
- Wilting vegetation
- Discolored well water
- Structural cracks in walls and floors.

13.1.3 Subsidence

Subsidence is the sinking of the land surface in an area. The elevation of the land surface is lowered by compressing the many layers of clay below. Some natural land subsidence occurs over long periods of time, due to the natural settling of sediments left over from millions of years ago; however, the main causes of subsidence are human-induced. Mining, removal of groundwater, and organic materials are some of the most common causes of subsidence.

In the Houston-Galveston region, land subsidence is caused by compaction of fine-grained aquifer sediments (silts and clays) below the land surface due to groundwater withdrawals. Removing water from fine-grained aquifer sediments compresses the aquifer, leaving less pore space available to store water resulting in the lowering (sinking or settling) of the land-surface. Most compaction that occurs as a result of groundwater withdrawals is irreversible; even if groundwater levels rise, compacted sediments and the associated land-surface lowering would remain.

13.2 HAZARD PROFILE

13.2.1 Past Events

Landslide

There is no historical evidence of landslide events in the Harris County planning area. The *State of Texas Hazard Mitigation Plan* does not identify landslides as a hazard risk for any location in the State of Texas. During the risk analysis preformed for this plan, landslides were identified as the lowest risk hazard of all profiled. For these reasons, a detailed hazard vulnerability assessment was not performed for this hazard. The risk from landslides is considered negligible and does not require mitigation actions.

Sinkholes

East Texas has few, if any, sinkholes. There has been no recorded property damage or loss of life due to sinkholes in the Harris County planning area. The nearest sinkhole to Harris County was in Daisetta, Texas, 60 miles northeast of Houston, which had a sinkhole measuring 900 feet across and 260 feet deep in May 2008 (U.S. Geological Survey). The *State of Texas Hazard Mitigation Plan* does not identify the Harris County planning area as a high-risk area for sinkholes. For these reasons, a detailed hazard vulnerability assessment was not performed for this hazard. It can be assumed the risk for sinkholes in the Harris County planning area, as well as potential losses due to sinkhole impact are negligible.

Subsidence

Historically, the Harris County planning area was at risk for subsidence due to its dependence on groundwater. Figure 13-6 shows the level of subsidence from 1906 to 2000 in the Harris County and Galveston County areas. The planning area was extremely vulnerable and impacted by the effects of subsidence. Removal of large amounts of groundwater resulted in up to 10 feet in loss of elevation in some part of the county.

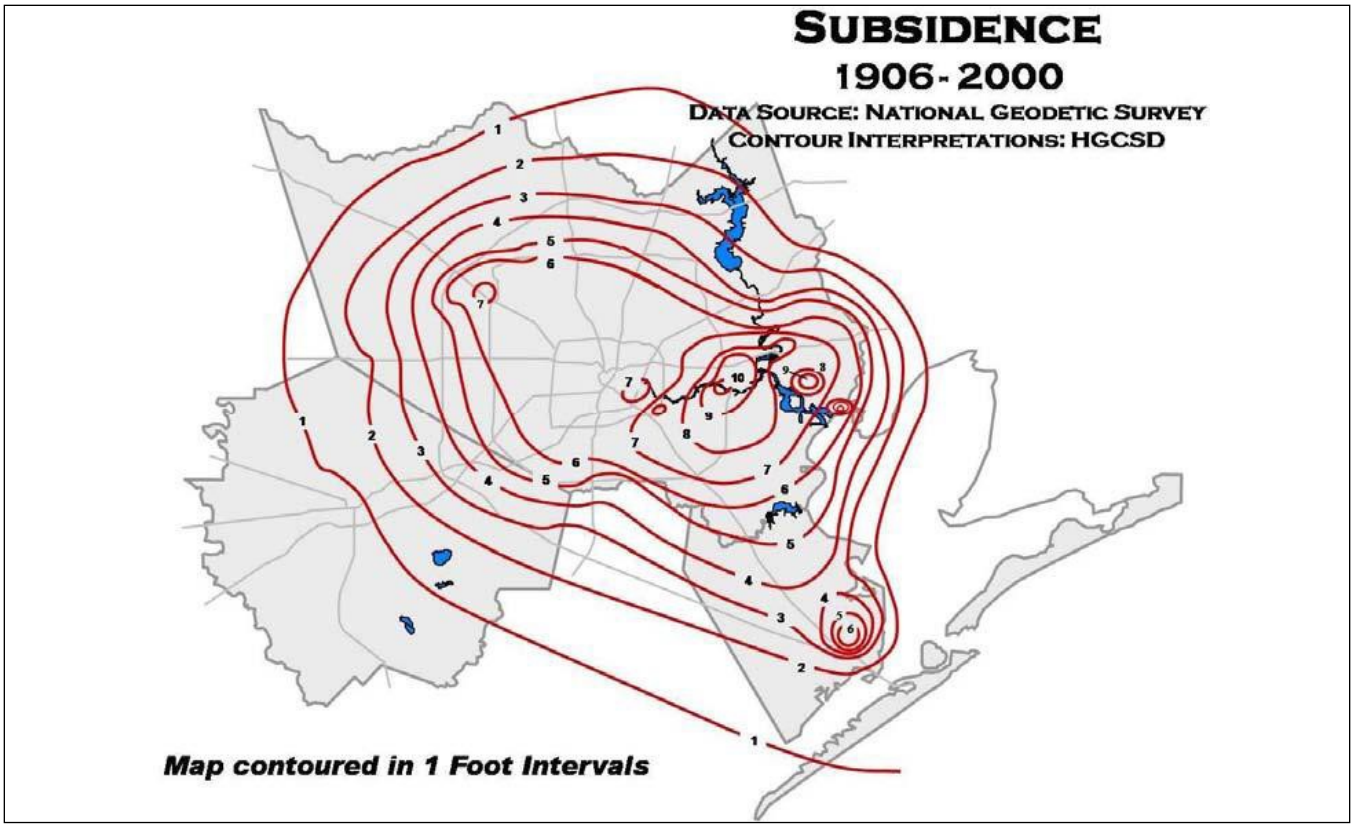


Figure 13-6. Subsidence in Harris County from 1906-2000

The Brownwood Subdivision in Baytown, Texas is an example of the effect of subsidence in Harris County. The loss of elevation in Brownwood resulted in higher-frequency, more-damaging flood events. Brownwood is now mostly underwater. As a result, most of the subdivision was purchased by the government and turned into a nature preserve. Further inland, the impacts of subsidence are not as drastic as they are in coastal areas where the elevation is already close to sea level, but because flooding is a great concern in the County, any loss of elevation, no matter what the initial elevation was, will have an adverse impact on future flooding in the area.

Although Harris County has been vulnerable in the past, research of historical data shows no recorded property damage or loss of life due to subsidence in the Harris County planning area.

13.2.2 Location

No location mapping has been provided for the landslide and sinkhole hazards due to the lack of exposure within the planning area. Future subsidence is not likely to be located in or occur within any of the planning area due to existing groundwater reduction measures. Subsidence is being abated by regional limits on groundwater pumping. Many of the cities in Harris and Galveston counties, industries, and others in the coastal region converted to surface water years ago at a considerable cost.

The Harris-Galveston Coastal Subsidence District's 1999 Regulatory Plan requires Areas 1 and 2 as shown in Figure 13-7 to continue with groundwater reduction requirements (HGCSD, 1999). The 1999 Regulatory Plan focused mostly on the north and west part of Harris County in Area 3. Groundwater reduction plans are required to show how permittees in this area will reduce dependence on groundwater pumping by 30 percent in 2010, 70 percent in 2020 and 80 percent in 2030.

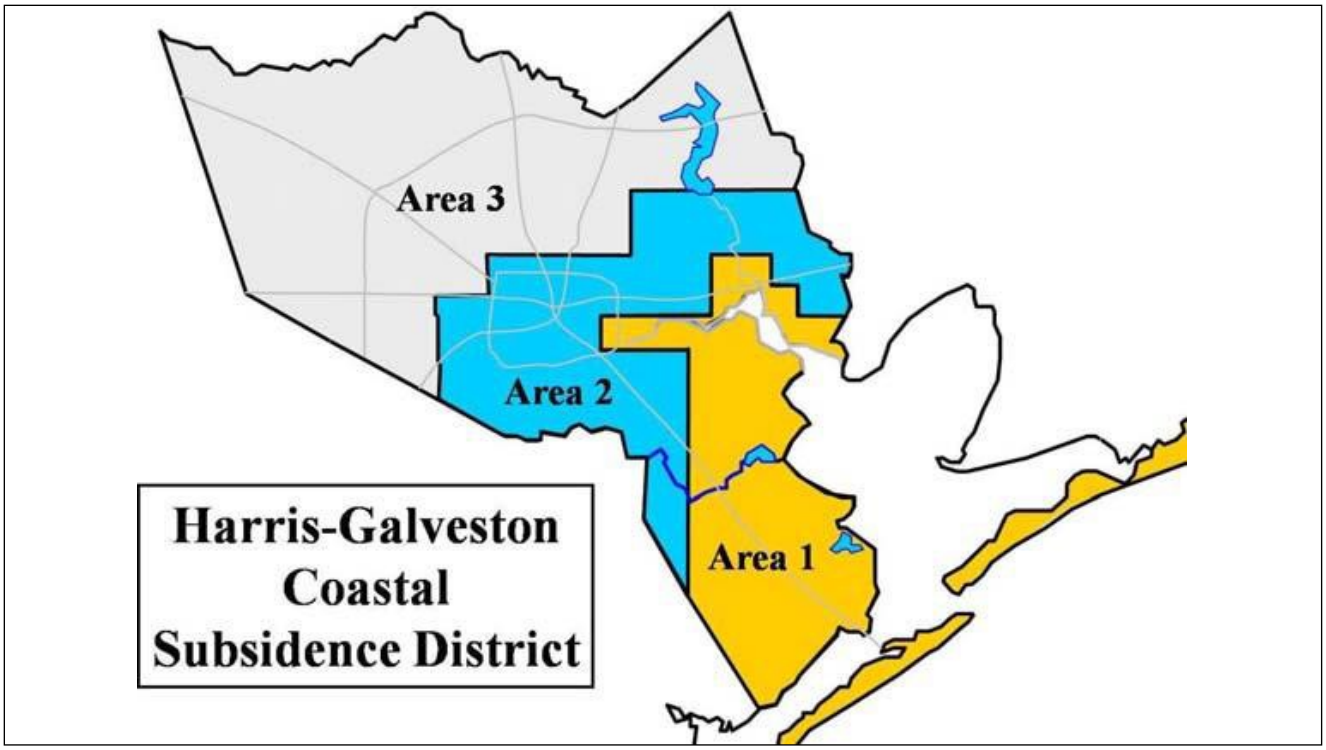


Figure 13-7. Harris-Galveston Coastal Subsidence District Regulatory Area Map

Until the enforcement of regulations in HGCSD Areas 1 and 2 sunsets in 2030, the following communities, which lie within those areas, are considered to have some degree of subsidence risk, though the risk is likely to be low:

- Area 1
  - Baytown
  - Deer Park
  - El Lago
  - Galena Park
  - La Porte
  - League City
  - Morgan's Point
  - Nassau Bay
  - Taylor Lake Village
  - Seabrook
  - Shore Acres
  - Webster
- Area 2
  - Bellaire
  - Hedwig Village
  - Houston
  - Hunters Creek Village
  - Jacinto City
  - Pasadena
  - Piney Point Village
  - Spring Valley Village
  - South Houston
  - West University Place

Current data and regulatory limits indicate the enforcement of the groundwater reduction plans have lowered the past risk of subsidence in Area 3 to a negligible risk.

13.2.3 Frequency

The planning area can expect to experience no significant mass movements due to currently low to negligible risk within the planning area. For the risk assessment for this plan update, the probability of occurrence for mass movement is considered "low."

13.2.4 Severity

Mass movements can destroy property and infrastructure and can take the lives of people. They have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. Slope failures in the United States result in an average of 25 to 50 lives lost per year and an annual cost to society of about $1.5 billion (FEMA, 1997). Landslides can pose a serious hazard to properties on or below hillsides. They can block access to roads, which can isolate residents and businesses and delay commercial, public and private transportation. This can result in economic losses for businesses. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

The severity of the risk for mass movements in the planning area is considered to be low due to the lack of exposure. Unless the frequency of occurrence increases in the future, a worst-case-scenario would be any occurrence of a mass movement, or something comparable the May 2008 Daisetta, Texas, sinkhole event, which measured 900 feet across and 260 feet deep.

13.2.5 Warning Time

The velocity of landslides and other mass movements range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual mass movements. The current standard operating procedure is to monitor situations on a case-by-case basis, and respond after the event has occurred. Generally accepted warning signs for mass movement activity include the following:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

13.3 SECONDARY HAZARDS

Mass movements are not generally known to result in secondary hazards. However, they themselves are often secondary hazards of other event types, such as earthquakes, severe weather or wildfires. Subsidence can have secondary effects by worsening flooding conditions in an area because of the lowering of the local elevation.

13.4 EXPOSURE AND VULNERABILITY

The exposure and vulnerability for the people, property, critical facilities/infrastructure, and environment are low to none for the planning area. This is based on the lack of historical occurrence of the types of hazards and the planning area's proactive approach to mitigating subsidence issues starting in 1999. This does not mean that these types events could not happen in the future, it just means that there is currently no empirical data to assess impacts as of this planning effort.

13.5 FUTURE TRENDS IN DEVELOPMENT

Due the lack of exposure and impacts from these hazards, future development in the planning area is not likely to be impacted by these hazards in the short term. However, as a changing climate continues to influence the frequency, severity and magnitude of hazard events, there could be impacts on future development. Future updates to this plan will have to measure those possibilities as it assesses the mass movement hazards of concern.

13.6 SCENARIO

For the performance period of this plan update (5 years), there is no likely mass movement scenario projected to impact the planning area.

13.7 ISSUES

The CPT has identified no issues pertaining to the mass movement hazard. Harris County and its planning partners will continue to monitor conditions as they pertain to this hazard to inform future updates to this plan.

14. SEVERE WEATHER

14.1 GENERAL BACKGROUND

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. Types of severe weather phenomena vary, depending on the latitude, altitude, topography, and atmospheric conditions. This assessment profiles five types of severe weather events: thunderstorms; hail; extreme heat; tornados and damaging wind; and winter storms and freezes

14.1.1 Thunderstorms

NOAA classifies a thunderstorm as a storm with lightning and thunder produced by cumulonimbus clouds, usually producing gusty winds, heavy rain, and sometimes hail or tornados. Thunderstorms are usually short in duration (seldom more than two hours), but they may deliver enough rainfall to cause urban or flash flooding.

Measuring and Categorizing Thunderstorm Hazards

As shown in Table 14-1, thunderstorm risk categories are based on three-day convective outlooks prepared by NOAA's Storm Prediction Center. These outlooks depict non-severe thunderstorm areas and severe thunderstorm threats across the contiguous United States. The risk categories specify the level of the overall severe weather threat via numbers (1 – 5), descriptive labeling (marginal – high), and colors (green – magenta).

Measuring and Categorizing Lightning

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt." This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near the lightning causes thunder. NOAA's Lightening Activity Level (LAL) scale indicates the amount of lightning associated with thunderstorms, as well as whether or not wetting rains accompany the storms.

- LAL 1—No thunderstorms.
- LAL 2—Isolated thunderstorms. Light rain will occasionally reach the ground. Lightening is very infrequent, 1 to 5 cloud to ground strikes in a 5-minute period.
- LAL 3—Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a 5-minute period.
- LAL 4—Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a 5-minute period.
- LAL 5—Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and
- intense, greater than 15 cloud to ground strikes in a 5-minute period.
- LAL 6—Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag Warning.

Table 14-1. Convective Outlooks – Thunderstorm Risk Categories

Thunderstorm Risk Label	Thunderstorm Risk Category	Thunderstorm Risk Description[a]
TSTM (light green)	General or Non- Severe Thunderstorms	• Delineates, to the right of a line, where a 10% or greater probability of thunderstorms is forecast during the valid period. • No severe thunderstorms expected. Lightning/flooding threats exist with all thunderstorms. Winds to 40 MPH and small hail.
1-MRGL (dark green)	Marginal Risk	• An area of severe storms of either limited organization and longevity, or very low coverage and marginal intensity. • Isolated severe thunderstorms possible. Limited in duration and/or coverage and/or intensity. Winds 40-60 MPH, hail up to 1 inches and low tornado risk.
2-SLGT (yellow)	Slight Risk	• An area of organized severe storms, which is not widespread in coverage with varying levels of intensity. • Scattered severe thunderstorms possible. Short-lived and/or not widespread, isolated intense storms possible. One or two tornados, reports of strong winds/wind damage, and hail approximately 1 inches and isolated 2 inches.
3-ENH (orange)	Enhanced Risk	• An area of greater (relative to Slight risk) severe storm coverage with varying levels of intensity. • Numerous severe storms possible. More persistent and/or widespread, a few intense. A few tornados, several reports of wind damage and damaging hail, 1- 2 inches.
4-MDT (red)	Moderate Risk	• An area where widespread severe weather with several tornados and/or numerous severe thunderstorms is likely, some of which should be intense. This risk is usually reserved for days with several supercells producing intense tornados and/or very large hail, or an intense squall line with widespread damaging winds. • Widespread severe storms likely. Long-lived, widespread and intense. Strong tornados, widespread wind damage and destructive hail 2 inches (+).
5-HIGH (magenta)	High Risk	• An area where a severe weather outbreak is expected from either numerous intense and long-tracked tornados or a long-lived derecho-producing thunderstorm complex that produces hurricane-force wind gusts and widespread damage. This risk is reserved for when high confidence exists in widespread coverage of severe weather with embedded instances of extreme severe (i.e., violent tornados or very damaging convective wind events). • Widespread severe storms expected. Long-lived, very widespread and particularly intense. Tornado outbreak and derecho.

a. All thunderstorm categories imply lightning and the potential for flooding. Categories are also tied to the probability of a severe weather event within 25 miles.

Source: NOAA, NWS, Storm Prediction Center

Nationwide Distribution of Thunderstorms

The National Weather Service collected data for thunder days, the number and duration of thunder events, and lightning strike density for the 30-year period from 1948 to 1977. Figure 14-1 illustrates thunderstorm hazard severity based on the annual average number of thunder events during that period.

14.1.2 Hail

Hailstorms are an outgrowth of severe thunderstorms. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight; they fall as precipitation — as balls or irregularly shaped masses of ice greater than 0.75 inches in diameter (see Figure 14-2). The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size.

Source: National Weather Service

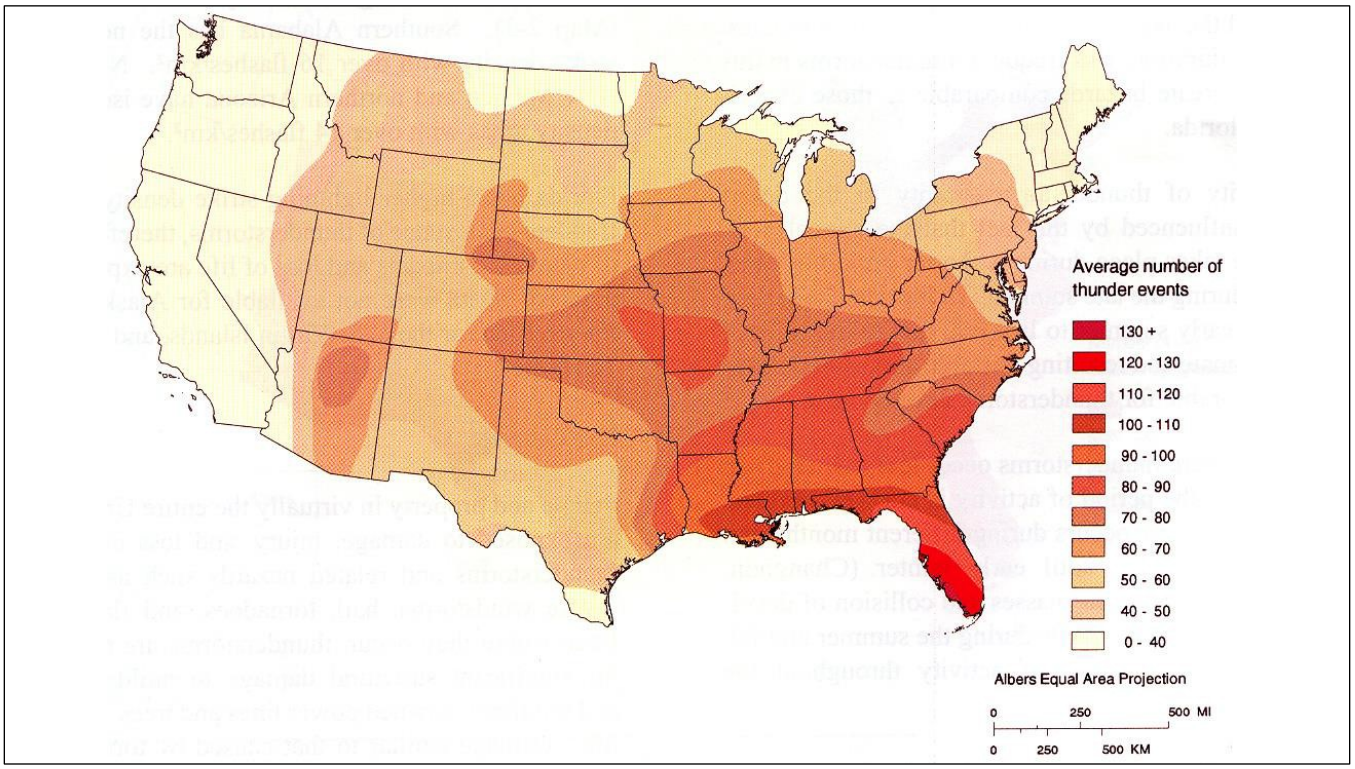


Figure 14-1. Annual Average Number of Thunder Events

NOAA Photo Library, NOAA Central Library; National Severe Storms Laboratory

Figure 14-2. Large Hail on Streets and Grass During a Severe Thunderstorm, with Stones up to 3 Inches

Figure 14-3 shows the annual frequency of hailstorms in the United States as recorded from 2003 to 2012. Hailstorms have been observed in almost every location where thunderstorms occur throughout the United States. They are most frequent in the southern and central plain states, where the climate produces violent thunderstorms.

Source: NOAA Storm Prediction Center

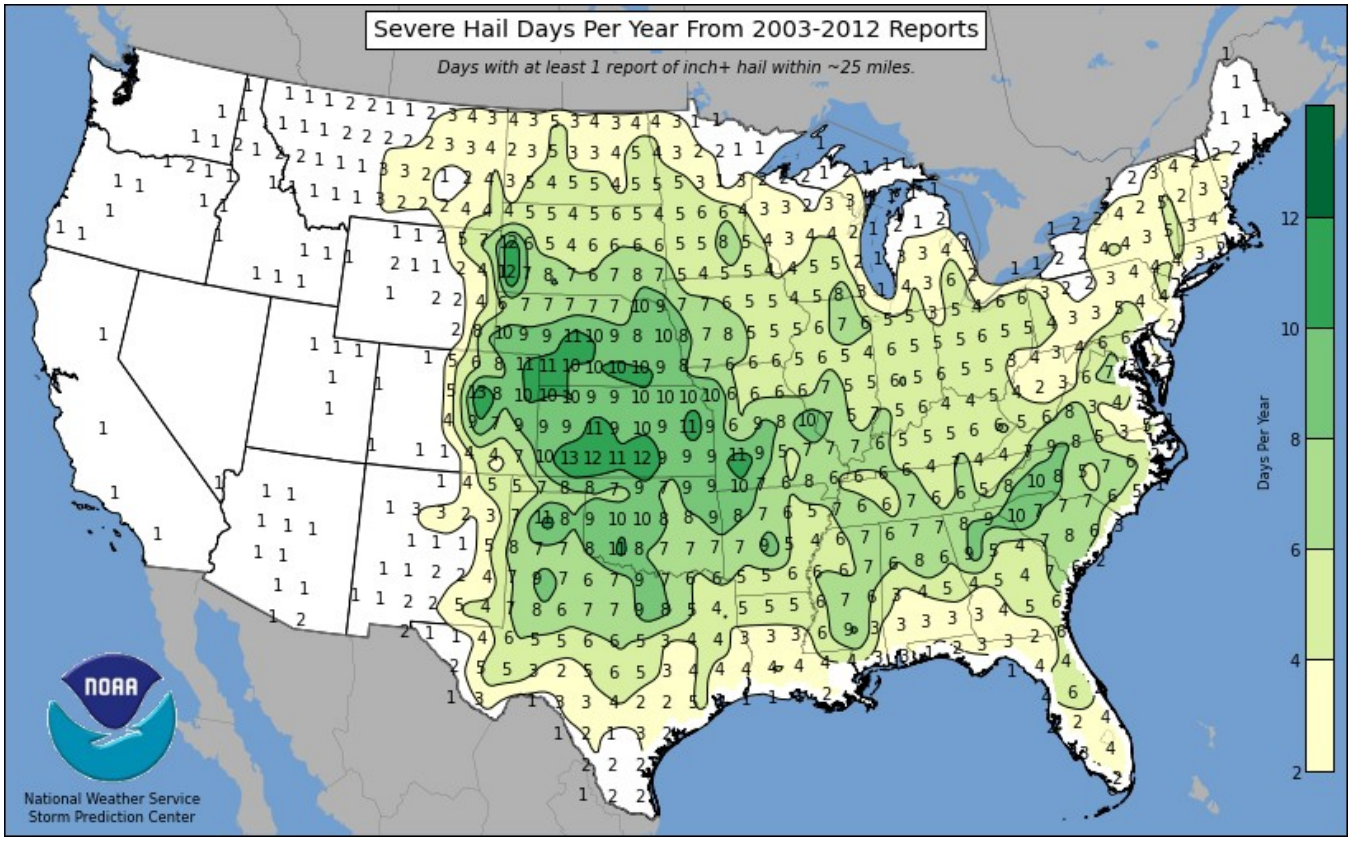


Figure 14-3. Annual Frequency of Hailstorms in the United States

NOAA utilizes the Modified NOAA/TORRO Hailstorm Intensity Scale to assist in measuring hailstorm intensity (see Table 14-2). The scale extends from H0 to H10, with increments of intensity or damage potential related to hail size (distribution and maximum), texture, numbers, fall speed, speed of storm translation, and strength of the accompanying wind.

14.1.3 Extreme Heat

Extreme heat can be defined as temperatures that hover 10 ºF or more above the average high temperature for the region, last for prolonged periods of time, and are often accompanied by high humidity. The "urban heat island effect" can produce significantly higher nighttime temperatures where asphalt and concrete (which store heat longer) gradually release heat at night. The Extreme Heat Index in Figure 14-4 and the criteria for heat advisories measure the severity and intensity of extreme heat.

Extreme heat can pose a significant risk to humans. Under normal conditions, the human body produces perspiration that evaporates and cools the body. However, in extreme heat and high humidity, evaporation is slowed and the body must work much harder to maintain a normal temperature. Studies have shown that a significant rise in heat-related illness occurs when excessive heat persists for more than two days.

Table 14-2. Modified NOAA/TORRO Hailstorm Intensity Scale

Size Code	Intensity Category	Hail Diameter (inches)	Potential Damage
H0	Hard Hail	0.25	No Damage
H1	Potentially Damaging	0.25 - 0.50	Slight general damage to plants, crops
H2	Significant	0.50 - 0.75	Significant damage to fruit, crops, vegetation
H3	Severe	0.75 - 1.25	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
H4	Severe	1.0 - 1.50	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.25 - 1.75	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	1.50 - 2.25	Bodywork of grounded aircraft dented, brick walls pitted
H7	Destructive	2.0 - 3.0	Severe roof damage, risk of serious injuries
H8	Destructive	2.50 - 3.50	Severe damage to aircraft bodywork
H9	Super Hailstorms	3.0 – 4.0	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	4.0 +	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: TORRO, 2019

Source: National Weather Service, 2019

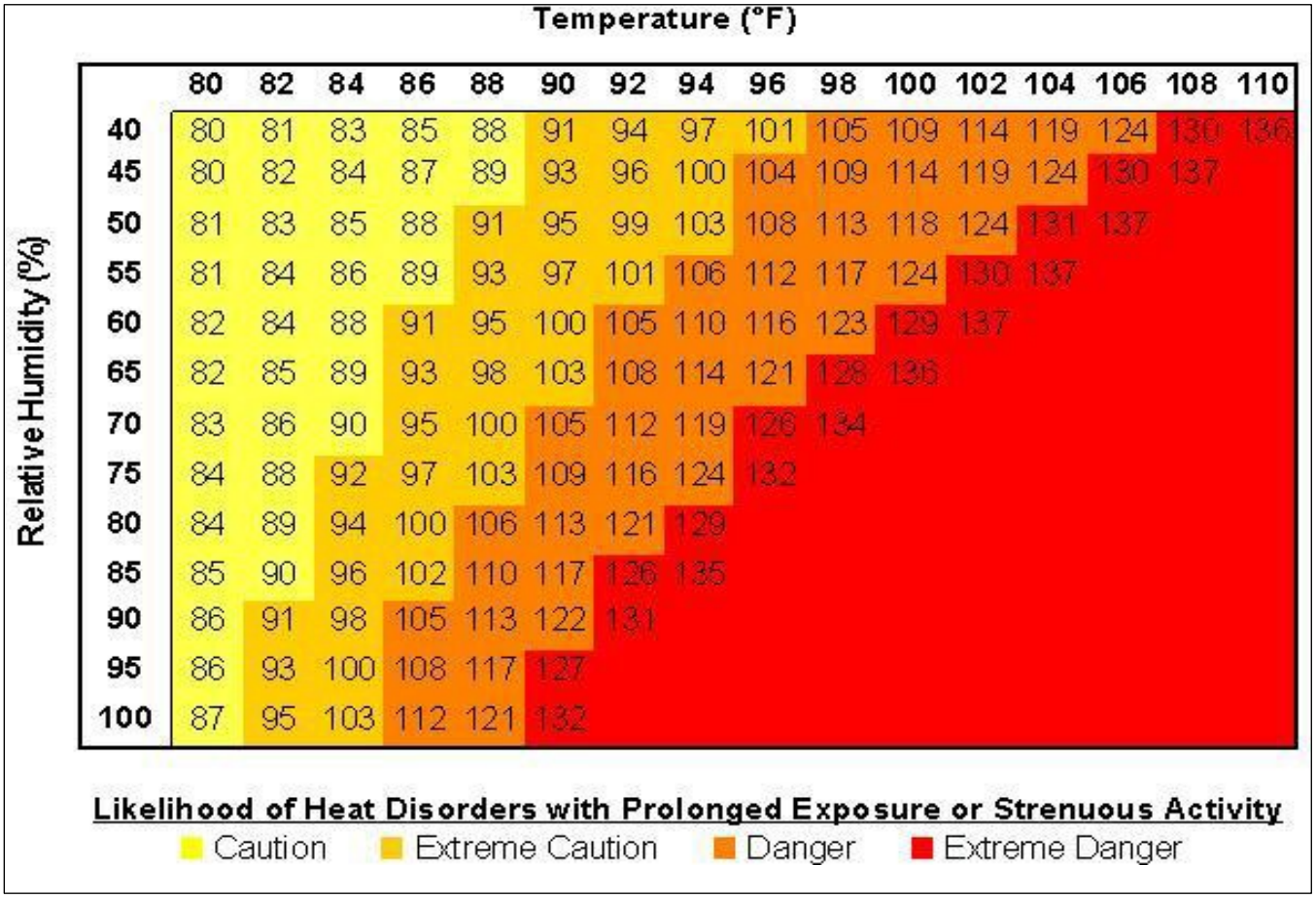


Figure 14-4. Extreme Heat Index

Especially vulnerable populations may include elderly persons, young children, persons with respiratory difficulties, and those who are sick or overweight are more likely to become victims of extreme heat. Because men sweat more than women, they are more susceptible to heat-related illness because they become more quickly dehydrated. Extreme heat in urban areas can create health concerns when stagnant atmospheric conditions trap pollutants, thus adding unhealthy air to excessively hot temperatures. Spending at least 2 hours per day in air conditioning can significantly reduce the number of heat-related illnesses.

14.1.4 Tornados and Damaging Winds

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground (see Figure 14-5. Tornados are most often generated by thunderstorm activity (but sometimes result from hurricanes and other coastal storms) when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. Lightning and large hail frequently accompany these windstorms.

Source: NOAA Photo Library, NOAA Central Library; National Severe Storms Laboratory

Figure 14-5. Tornado South of Dimmitt, Texas, June 2, 1995, Which Reached an F-4 Level of Intensity

According to the National Weather Service, tornado wind speeds range from 40 to more than 300 miles per hour. The most violent tornados have rotating winds of 250 mph or more and are capable of causing extreme destruction. Most tornados are a few dozen yards wide and touch down briefly, but even small short-lived tornados can inflict tremendous damage. Highly destructive tornados may carve out a path over a mile wide and several miles long.

Tornados cause an average of 55 deaths and 1,500 injuries annually (NOAA). The damage caused by a tornado is a result of the high wind velocity and wind-blown debris. Typically, tornados cause the greatest damages to structures of light construction such as residential homes (particularly mobile homes).

Waterspouts are weak tornados that form over warm water and are most common along the Gulf Coast and southeastern states. Waterspouts occasionally move inland, becoming tornados that can cause damage and injury. However, most waterspouts dissipate over the open water, threatening marine and boating interests. Typically, a waterspout is weak and short-lived, and because they are so common, most go unreported unless they cause damage.

Straight-line wind is a general term used to describe damaging winds that are not tornados. They are many different types of straight-line winds. Most damaging straight-line winds are generated by thunderstorm systems, although some result from other types of weather phenomena (National Severe Storms Laboratory, 2018).

Tornado Distribution Nationwide

Each year, an average of over 1,200 tornados are reported nationwide. According to the NOAA Storm Prediction Center, the highest concentration of tornados in the United States has been in Oklahoma, Texas, Kansas and Florida. Although the Great Plains region of the Central United States does favor the development of the largest and most dangerous tornados (earning the designation of "tornado alley"), Florida experiences the greatest number of tornados per square mile of all U.S. states (NOAA, 2018a). Figure 14-6 shows tornado activity in the United States based on the number of recorded tornados per 1,000 square miles (FEMA).

Source: FEMA

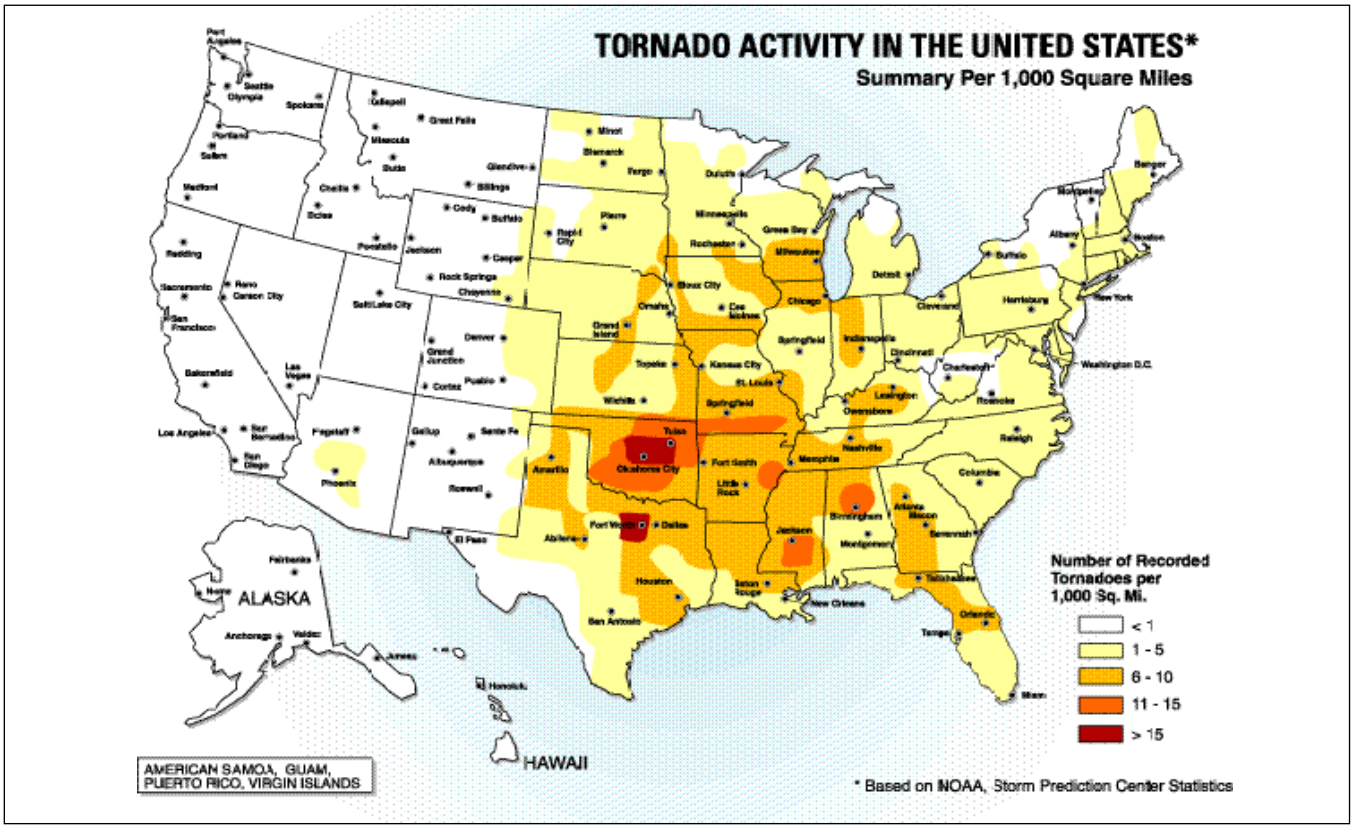


Figure 14-6. Tornado Activity in the United States

Tornado Timing and Location

Tornados are more likely to occur during the spring and early summer months of March through June and can occur at any time of day but are likely to form in the late afternoon and early evening. The tornados associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems

is greatest. This type of tornado usually occurs around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornados commonly occur as part of large outbreaks and generally move in an easterly direction.

Measuring Tornado Magnitude

The Enhanced Fujita-Pearson Scale for Tornados, noted in Table 14-3, was developed to measure tornado strength and associated damages.

Table 14-3. Enhanced-Fujita-Pearson Scale for Tornados

Scale	Wind Speed (mph)	Relative Frequency	Potential Damage
EF0	65–85	53.5%	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornados with no reported damage (i.e. those that remain in open fields) are always rated EF0.
EF1	86–110	31.6%	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111–135	10.7%	Considerable damage. Roofs torn off well- constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136–165	3.4%	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166–200	0.7%	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	<0.1%	Explosive damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (300 ft); steel reinforced concrete structure badly damaged; high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source: NOAA, 2018a

Measuring Damaging Winds

As shown in Table 14-4 the Beaufort Wind Scale is an empirical measure that relates wind speed to observed conditions at sea or on land.

14.1.5 Winter Storms and Freeze

Winter storms may include snow, sleet, freezing rain, or a mix of wintry precipitation. Sleet – raindrops that freeze into ice pellets before reaching the ground – usually bounce when hitting a surface and do not stick to objects. However, sleet can accumulate like snow and cause a hazard to motorists. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice. Even small accumulations of ice can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Figure 14-7 shows the general circumstances that result in different winter precipitation events. The type of precipitation experienced during a winter storm can depend on location. Winter precipitation may fall as snow at higher altitudes but rain at lower elevations, with freezing rain or sleet at elevations in between.

Table 14-4. Beaufort Wind Scale

Force	Wind (knots)	Classification	Appearance of Wind Effects	
			On the Water	On Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted; small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-19 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, “considerable structural damage”
11	56-63	Violent Storm	Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 feet, sea completely white with driving spray, visibility greatly reduced	

Source: NOAA, NWS, Storm Prediction Center

Source: NOAA, NWS, 2018b

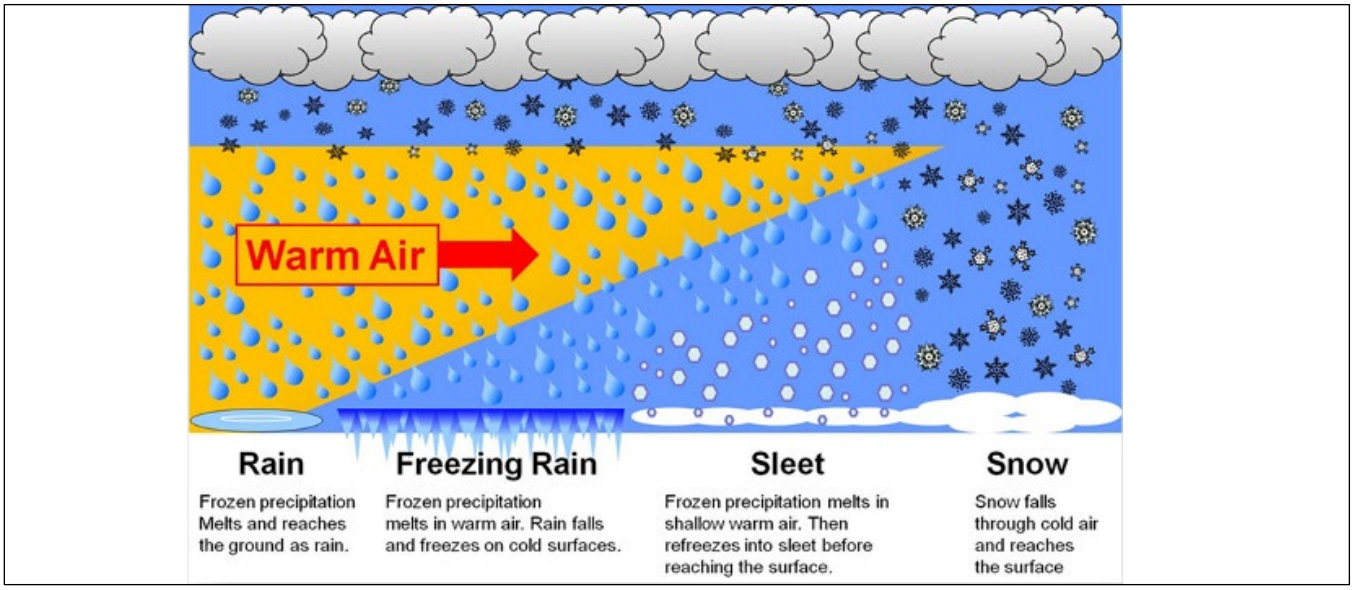


Figure 14-7. Effects of Air Temperature on Winter Precipitation Events

A freeze is weather marked by low temperatures below 32 ºF. Agricultural production is seriously affected when temperatures remain below the freezing point for an extended period of time. Areas unaccustomed to freezing temperatures are more susceptible to associated damages and threats to public health and safety.

Extreme cold can often accompany severe winter storms. Wind can exacerbate the effects of cold temperatures by carrying heat away from the body more quickly, thus making it feel colder than is indicated by the temperature. This phenomenon is known as wind chill. Wind chill is the temperature that your body feels when the air temperature is combined with wind speed. Figure 14-8 shows the value of wind chill based on ambient temperature and wind speed. As the wind increases, the body is cooled at a faster rate, causing the skin temperature to drop. Wind chill does not impact inanimate objects like car radiators and exposed water pipes, because these objects cannot cool below the actual air temperature.

Source: National Weather Service/NOAA

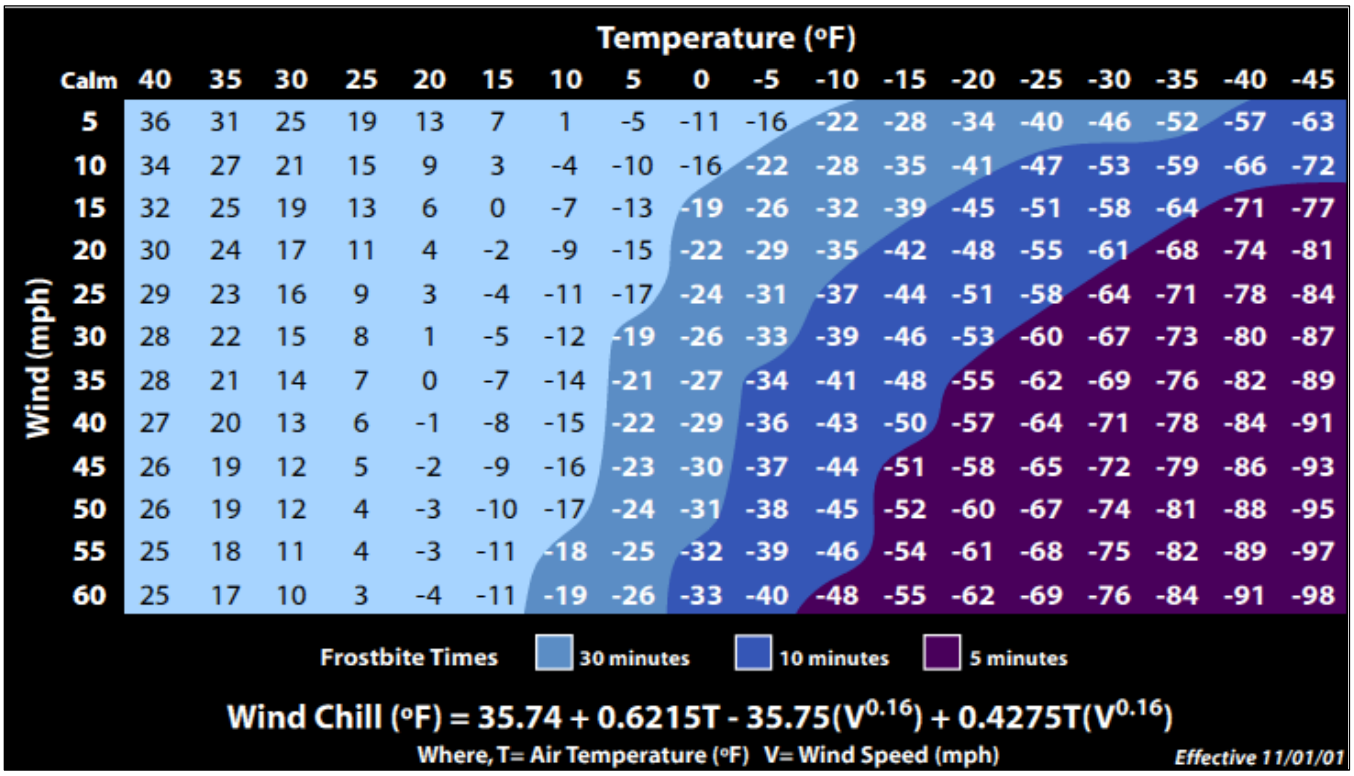


Figure 14-8. Wind Chill Chart

14.2 HAZARD PROFILE

14.2.1 Past Events

According to the National Climatic Data Center (NCDC), the severe weather event history for the planning area is extensive. Since 1999 (the past 20 years), there have been a total of 401 days where severe weather events were significant enough to be recorded by the NCDC. These events were across all five categories of severe weather events profiled for this assessment. Table 14-5 provides the statistical breakdown of these events. Table 14-6 provides a summary of the more significant events by category during this time frame.

Table 14-5. Statistical Breakdown of Severe Weather Events; 1999 to 2019

Category	Days	Casualties	Property Damage
Thunderstorm	195	29	$34.7 million
Hail	118	None reported	$22.4 million
Heat	44	41	None Reported
Tornado	36	7	$22.4 million
Winter Storm/Freeze	8	5	$5,000
Total	**401**	**82**	**$79.5 million**

Source: National Centers for Environmental Information, 2019

Table 14-6. Significant Severe Weather Events by Category; 1999 to 2019

Date	Event Type	Deaths or Injuries	Property Damage
Extreme Heat			
8/1/1999	Heat	6	None Reported
Description: *Excessive heat plagued southeast Texas for the entire month of August. At Houston Intercontinental, high temperatures exceeded 100 degrees on 10 days out of the month, and 95 degrees on 29 out of the 31 days of the month. High temperature records were set on 4 days out of the month, and record high minimum temperatures were set on another 4 days. The temperature of 105 degrees on the 20th was the hottest temperature recorded at Houston Intercontinental Airport since 1980.*			
7/6/200	Heat	17	None Reported
Description: *Excessive heat impacted southeast Texas for much of the month of July. High temperatures ranged from 98 to 105 degrees on a daily basis over all but the immediate coast during a 2-week period. College Station recorded 12 consecutive days with temperatures of 100 degrees or higher. Highest temperatures for the month included 103 degrees at Houston Intercontinental Airport and 105 degrees at College Station. Only traces of rainfall were observed during this period. Of the 19 heat related deaths reported during this period, 17 were in Harris County and 2 were in Galveston County.*			
8/6/2001	Heat	1	None Reported
Description: *Male died of heat exposure while exercising.*			
6/28/2004	Heat	1	None Reported
Description: *Man collapsed and died while mowing lawn.*			
9/21/2005	Heat	34	None reported
Description: *Deaths were all associated with the evacuation for Hurricane Rita, both before and after Rita's arrival. Rita made landfall just east of the Texas/Louisiana border early Saturday morning, September 24th.*			
6/24/2009	Heat	0	None Reported
Description: *An upper level ridge built over the area, corresponding to a period of hot and humid conditions. A number of indirect fatalities were attributed to the heat. Hot, humid conditions led to heat indices above 105 degrees for several days in late June.*			
7/13/2015	Heat	1	None Reported
Description: *A male construction worker died after a full day of outdoor activity during a day with high temperatures in the 90s. A 53-year-old man died from complications from hyperthermia after a full day of outdoor construction work based on coroner's report. Maximum ambient heat index was around 100 F that day.*			
8/21/2017	Heat	1	None Reported
Description: A jogger died of heatstroke while jogging in a Seabrook park.			
6/4/2018	Heat	1	None reported
Description: *A jogger died of heatstroke while jogging in a Seabrook park.*			
7/19/2018	Heat	1	None reported
Description: *A three-year-old boy died after being left unattended for at least four hours in a hot vehicle. Law enforcement said the temperature inside the vehicle was at least 113 degrees.*			

Date	Event Type	Deaths or Injuries	Property Damage
Hail			
9/8/1999	Hail	0	$15K
Description: *Hail storm with hail up to 0.75" in size impacted LaPorte causing property damage.*			
4/2/200	Hail	0	$200K
Description: *Hail shattered windows and damaged cars in the Province Square subdivision along Becker Rd. and Botkins Rd. Hail up to 1.75" observed in many portions of the County.*			
4/16/2001	Hail	0	$20M
Description: *Numerous reports of hail on the west side of Houston. 0.75 inch to 1.5 inch hail along I-10 between Hunters Creek Village and the West Loop. 1 to 1.5 inch hail near South Braeswood and Fondren Road accumulated to several inches deep and was still on the ground 24 hours after the storm. 1.5 inch hail near South Post Oak Road and West Bellfort. 1 inch hail at Westheimer and Hillcroft. 0.8 inch hail near Gessner and Highway 59. Numerous reports of windows broken, and trees and shrubs stripped of their leaves. Hail up to 1.75" observed in many portions of the County.*			
2/21/2002	Hail	0	$15K
Description: *Storm spotter reported 1.00 inch hail at FM 249 and Beltway 8.*			
6/4/2004	Hail	0	$100K
Description: *Hail at Pasadena Blvd and Red Bluff Road. Hail up to 1.75" observed in Pasadena.*			
3/13/2005	Hail	0	$25K
Description: *Reported at the intersection of West 19th and Yale. Hail up to 1.75" observed in many portions of the County.*			
5/4/2006	Hail	0	$100K
Description: *Quarter to tea cup size hail in the Champions Forest Subdivision.*			
5/26/2011	Hail	0	150K
Description: *The trailing cold front from a strong storm system across the north central states triggered evening and overnight severe thunderstorms with very large hail and strong wind gusts across portions of southeast Texas. Ping pong ball size hail occurred in the Pasadena area.*			
8/1/2016	Hail	0	$15K
Description: *A strong upper level storm system moved across the area that aided in the generation of regional thunderstorms. The stronger thunderstorms produced large hail. Tennis ball sized hail occurred in Bellaire.*			
5/9/2019	Hail	0	$0
Description: *Shortwave disturbances traveling across a slow-moving frontal boundary within a moist air mass allowed for the development of high rainfall producing storms. Ping pong ball sized hail was blowing through house windows.*			
Tornado			
11/24/2000	Tornado	0	$350K
Description: *Tornado touched down near intersection of Preston and Crenshaw. Roof blown off of home in Parkgate subdivision. Roof peeled off large storage building. Damage to windows and trailers at First Presbyterian Church. Fences and trees knocked over on western edge of adjoining neighborhood with portion of roof torn off Turner Elementary.*			
10/11/2001	Tornado	0	$3.75 M
Description: *120 homes, 3 apartment complexes, 2 schools, and some businesses damaged by a tornado. The tornado touched down near Fairmont and Shaver, moving northeast to near the intersection of Southmore and Red-Bluff Road.*			
3/30/2002	Tornado	0	$350K
Description: *This Tornado began its path in the Shoreacres subdivision, 3 miles south of La Porte, with a home on Greenleaf Road receiving structural and roof damage (F1), then moved northeast and partially demolished a Super Mart on Broadway (F3), then ripped through an apartment complex across the street causing major roof and window damage and knocking down trees (F2), collapsing a car garage and destroying at least one car. Just northeast of the apartments, a few homes had minor damage with fences and large trees down. On Carlisle Street, in the Bayside Terrace subdivision, a few homes had minor roof damage, yard trees down, and debris from the convenience store, while part of the roof off the Super Mart dropped onto a Truck parked at the north end of Carlisle next to Galveston Bay. No injuries were reported. A survey was conducted.*			

Date	Event Type	Deaths or Injuries	Property Damage
11/17/2003	Tornado	0	$500K
Description: *A total of 24 tornados touched down during this 15 hour period of severe weather in southeastern Texas on November 17, 2003. In addition to these tornados, a major flood developed over Harris and surrounding counties during the middle of this tornadic outbreak. Over 300 homes, along with hundreds of vehicles, were flooded. Tornado touched down in the Meadows subdivision in Fort Bend County and traveled into Harris County. Tornado moved over the intersection of West Bellfort and Kirkwood. Numerous apartments lost roofs in the extensive SW Village Apartment Complex damage.*			
10/31/2015	Tornado	0	$12.00 M
Description: *An EF-2 tornado began near the Genoa Red Bluff and Red Bluff intersection in Pasadena and ended near the Spencer Highway and Myrtle Creek Drive intersection in La Porte. The tornado caused extensive tree, fence and power line damage. Low end EF-2 damage was observed where the tornado demolished an industrial building and caused significant roof loss to several homes in La Porte. One of these homes lost a portion of an exterior brick wall. The estimated peak wind was 125 mph.*			
4/27/2016	Tornado	1	$200K
Description: *NWS surveyed storm damage in the Willow Creek area. A west-northwest to east-southeast damage path was found just less than a half mile long. Numerous large trees were uprooted, several onto homes. An elderly woman died with a large tree crashed into her mobile home. Soils were extremely soft from recent rains and flooding.*			
3/29/2017	*Tornado*	*2 Injuries*	***$300K***
Description: *This EF-1 was the third brief tornado with the larger mesocyclone associated with the HP supercell which moved across La Porte and Morgan's Point. This couplet was well defined on the Houston Hobby terminal doppler radar which spun up quickly along the north side of strong westerly outflow winds from the initial couplet that was responsible for two earlier weak tornados near and in parts of La Porte. This tornado was witnessed to start near the railroad tracks near Highway 146 and it tracked east southeastward across the Barbours Cut Port Facility and parts of Morgan's Point. Much of the more significant damage was to industrial areas around the Port complex. Large steel storage tanks were bent inward from the wind, and many large, metal shipping containers were toppled over. The tornado lifted near the eastern end of Morgan's Point near the Ship Channel. Estimated peak winds were around 105 mph.*			
Thunderstorm			
8/31/1999	Thunderstorm (wind)	1	$990K
Description: *A construction worker was killed when the Hawthorne Suites Motel under construction at intersection of Beltway 8 and Stancliff collapsed. Roof damage reported at Gillman Subaru at Bellaire and U.S. 59, and wall of glass blown down at Red Lion Hotel in Galleria area. Traffic light damaged at intersection of Corporate Dr. and Bellaire, and power lines downed in Westbury area. Numerous reports of trees down across central and southwest Houston including along 5th Street in Alief and in Westbury area. Highest wind gust of 63 MPH at KPRC-TV on U.S. 59.*			
4/2/2000	Thunderstorm (Wind)	0	$800K
Description: *Extensive wind damage over a 3 square mile area along Becker Rd. and Botkins Rd. in the Province Square subdivision. Two homes destroyed and over 20 homes damaged from downburst winds. A barn was also destroyed with several head of livestock injured and trees uprooted.*			
4/16/2001	Thunderstorm (wind)	0	$15M
Description: *Numerous reports of trees down on the west side of Houston. Power lines down near South Post Oak Road and Beltway 8.*			
6/1/2004	Thunderstorm (Lightning)	1	None Reported
Description: *65-year-old woman killed when lightning struck a nearby pine tree while she was walking to catch a bus (Key Map 492S).*			
5/29/2005	Thunderstorm (Lightning)	0	$200K
Description: *Lightning strike sparked a fire that destroyed a church sanctuary.*			
8/19/2015	Thunderstorm (Lightning)	0	$150K
Description: *A lightning strike from an afternoon thunderstorm destroyed a home in Deer Park.*			
4/3/2018	Thunderstorm (Wind)	0	$2.0M
Description: *There was significant damage to a hanger and surrounding aircraft at Houston Hobby Airport due to a microburst. Four aircraft inside the hanger and four aircraft outside of the hanger sustained damage. Hangar destroyed. Debris deposited toward the south and southeast.*			

Date	Event Type	Deaths or Injuries	Property Damage
Winter Storm/Freeze			
1/16/2007	Ice Storm	0	$5K
Description: *A very cold arctic air mass ascending down upon Texas, combined with southwesterly upper level disturbances, produced freezing rain across the northern and central regions of southeast Texas. Widespread ice accumulation on roads, bridges, and the roofing of general structures across the northern and central portions of the county. U.S. 290 to the Harris-Waller county line and the entry ramps on sections of Beltway 8 were iced over.*			
1/23/2014	Winter Storm	0	None Reported
Description: *Snow totals between 1 and 4 inches and some freezing rain was produced by a storm system that moved across the area during the late night and morning hours. Freezing rain produced significant icing on bridges and overpasses with several road closures in and around the Houston area and numerous accidents. Around a tenth of an inch of ice formed on bridges and overpasses from freezing rain and some sleet. The icing caused numerous accidents. Many major routes around Houston were closed due to icy conditions.*			
3/3/2014	Winter Storm	0	None reported
Description: *An upper level disturbance moved across the area and generated light to moderate precipitation within a near freezing air mass. There was an accumulation of ice from freezing rain that formed upon numerous vehicles, trees, power lines, and roadways. As a result, there were downed tree limbs and power lines that caused regional power outages. There was an eighth of an inch of ice accumulation on vehicles and trees at the intersection of Richmond and Beltway 8.*			

Source: National Centers for Environmental Information, 2019

14.2.2 Location

The entire Harris County planning area is at risk for the severe weather events assessed for this plan.

14.2.3 Frequency

Severe weather events can impact the planning area at any time and are frequent based on the review of historical data. Using the data provided in Table 14-5, the probability of the Harris County planning area and all participating jurisdictions being affected by a severe weather event is once every 0.05 years or every 18.2 days. For the risk assessment for this plan update, the probability of occurrence for this hazard is considered "high".

14.2.4 Severity

The severity that severe weather events can bring is evidenced by the fact that severe weather events profiled in this chapter have caused the deaths of 82 people and over $70 million of reported property damage.

Thunderstorms

The National Weather Service classifies a thunderstorm as "severe" if it produces a tornado, has winds of at least 58 mph, or has hail at least 1 inch in diameter (NOAA, NWS, 2018c). The effects on the Harris County planning area of a strong thunderstorm can include fallen trees, downed power lines and interruption of transportation lifelines, damaged homes and public buildings. Fatalities are uncommon, but they can occur. Lightning can cause severe damage and can be deadly.

The entire planning area can expect to experience the full range of thunderstorms in the future, which may vary in duration, intensity and severity. The worst-case scenario event is a storm with a Lightning Activity Level of 6 (see Section 14.1.1) or a Thunderstorm Risk Category of 5-HIGH (see Table 14-1).

Hail

Damage caused by hailstones depends on the hail's size, density, free-fall velocity, shape, directionality, and angle of impact. Pea-sized hail (1/4 of an inch) or marble-sized hail (1/2 inch) might not cause damage. Anything larger, say a dime or a quarter (3/4 to one inch) can cause serious damage. Golf-ball-sized hail is 1-3/4 inches and

softball-sized hail is 4-1/2 inches according to NOAA. The entire planning area can expect to experience the entire range of hail sizes (H-0 to H-10; see Table 14-2) and intensity in the future, from potentially non-damaging to super hailstorms.

Extreme Heat

Impacts on the Harris County planning area due to extreme heat include but are not limited to negative health effects associated with heat due to the increased temperatures, increased risk of heat island effect, crop and vegetation damages, and isolated to widespread power outage. Highways, roads and transportation systems may also be damaged by excessive heat. Electric systems are impacted when power lines sag in high temperatures and the added demand for electricity can create rolling black-outs or power outages. Prolonged excessive heat can also lead to degradation of water quality, stress and breaks of water piping systems and negatively impact wildlife populations and natural resources. This is most dangerous for the small population without air conditioners (Texas Division of Emergency Management, 2013).

A heat advisory is issued by the National Weather Service (NWS) within 12 hours of the heat index reaching one of two criteria levels:

- The NWS Houston Galveston (NWS-HGX) office criteria for a heat advisory is a heat index of 108 ºF or higher for two consecutive days. The NWS-HGX maintains the heat advisory until the max heat index falls below 105 ºF.
- In much of the rest of the county, an advisory is issued if there is a heat index of at least 105°F but less than 115°F for less than 3 hours per day and/or if nighttime low temperatures are above 80°F for two consecutive days.

Tornados and Damaging Winds

The destruction caused by tornados in the planning area can range from light to severe, depending on the intensity, size, and duration of the storm. Impacts include but are not limited to temporary displacement of residents and businesses, limited mobility for residents and responders, loss of life, isolated power outages, and temporary closure or limited access to critical infrastructure facilities.

The planning area and all participating jurisdictions can expect to experience a tornado ranging from EF0 to EF5 on the Enhanced Fujita Scale (Table 14-3). The majority of tornados that occur in Harris County are of the EF0 scale with estimated wind speeds from 65 to 85 mph. The intensity and severity of a tornado event may vary within the planning area due to temperature, high winds, straight-line winds, downbursts and accompanying hazards like thunderstorms, heavy rains and hail.

Damaging winds are those that exceed 50 to 60 mph. The Beaufort Wind Chart (Table 14-4) provides terminology and a description of potential impacts at different levels (National Severe Storms Laboratory, 2018). A worst-case scenario for the planning area would be a Beaufort Force Scale 12 event, which features wind speeds in excess of 64 knots and is classified as a hurricane.

Winter Storms and Freeze

Winter storms are generally categorized by the amount of precipitation, degree of cold or wind chill, and strength of winds. A blizzard occurs when a winter storm has sustained or frequent wind gusts of 30 mph or greater and considerable falling and/or blowing snow that reduces visibility to less than a quarter mile. Generally, blizzards last for a period of three hours or longer (NOAA, NWS, 2009). Snowfall is generally considered heavy when 4 inches or more accumulates in 12 hours or less, or 6 inches or more accumulates in 24 hours or less. In the planning area, severe winter storms generally consist of rain and wind events, rarely snow and ice.

The lowest temperature ever recorded in the planning area was 5 ºF on January 18, 1930 (NWS HGX). The lowest wind chill possible at that temperature is –26 ºF (see Figure 14-8). A worst-case scenario for the planning area would be any event with wind chill lower than –26 ºF.

The effects of an ice storm or snowstorm are downed power lines and trees and a large increase in traffic accidents. These storms can cause death by exposure, heart failure due to strenuous snow removal activity, traffic accidents (over 85 percent of ice storm deaths are caused by traffic accidents), and carbon monoxide poisoning. These storms also have the potential to cause large losses of livestock, primarily due to dehydration. Two major concerns for snowfall are dangerous roadway conditions and collapse of structures due to heavy snow load on roofs. In addition, ice can create dangerous situations on roadways as well as freeze pipes.

14.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe thunderstorms. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of a storm. Some storms may come on quickly, with only a few hours of warning time.

14.3 SECONDARY HAZARDS

Localized flooding can occur when heavy rain overwhelms local drainage systems or pools in low-lying areas. Rain falling on saturated soils on slopes or on areas recently burned by wildfire may lead to landslides. Lightning during thunderstorms presents a risk of starting a wildfire.

14.4 EXPOSURE

All the people, property (including critical facilities and infrastructure), and environment of the planning area are exposed to some degree to the severe weather hazard.

14.5 VULNERABILITY

14.5.1 Population

The most common problems associated with severe weather events are immobility and loss of utilities. Although all populations in the planning area are exposed to severe weather events, some populations are more vulnerable. Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations in low-lying areas are at risk for possible flooding. In general, populations who lack adequate shelter during severe weather events, those who are reliant on sustained sources of power in order to survive, and those who live in isolated areas with limited ingress and egress options are the most vulnerable.

The most common impacts of specific weather event types on people are as follows:

- **Damaging Winds**—Debris carried by extreme winds and trees felled by gusty conditions can contribute directly to loss of life and indirectly to the failure of protective building envelopes. Utility lines brought down by thunderstorms have also been known to cause fires, which start in dry roadside vegetation. Electric power lines falling down to the pavement create the possibility of lethal electric shock.
- **Extreme Temperatures**—Individuals with physical or mobility constraints, cognitive impairments, economic constraints, or social isolation are typically at greater risk to the adverse effects of excessive

heat events. The average summertime mortality for excessive heat events is dependent upon the methodology used to derive such estimates. Certain medical conditions, such as heat stroke, can be directly attributable to excessive heat, while others may be exacerbated by excessive heat, resulting in medical emergencies. Individuals who lack shelter and heating are particularly vulnerable to extreme cold and wind chill

- **Thunderstorms**—Nationally, lighting is one of the leading causes of weather-related fatalities. Lightning strikes are far more common in other areas of the country than they are in the west. The majority of injuries and deaths associated with lighting strikes occur when people are outdoors; however, almost one-third of lightning-related injuries occur indoors. Males are five times more likely than females to be struck by lighting and people between the ages of 15 and 34 account for 41 percent of all lightning strike victims (CDC, 2013).
- **Hail—**It is possible for hailstones of significant size to kill an adult who is unable to find cover during a hailstorm. Massive hailstones are known to cause fatal head trauma or concussions.

14.5.2 Property

All property is vulnerable during the severe weather events profiled in this chapter, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse. Extreme heat events are not known for causing direct damage to buildings, but may damage building systems such as heating, ventilation and cooling systems or infrastructure.

Loss estimations for the severe weather hazards profiled in this assessment are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 14-7 lists the loss estimates.

14.5.3 Critical Facilities

All critical facilities are vulnerable during severe weather events, especially those that lack backup power generation capabilities. If facilities supplying power to planning area land line telephone systems were disrupted, significant issues would arise with communication in the planning area. In addition, some facilities are particularly vulnerable to specific types of severe weather events:

Critical facilities in the direct path of a tornado would be particularly vulnerable. Facilities located near trees or power lines that are likely to fall are also vulnerable. Roads and other transportation infrastructure could be blocked by downed trees or other debris.

Electric power losses due to severe weather can be estimated using standard values for loss of service for utilities published in FEMA's *2009 Benefit Cost Analysis Reference Guide*. The values associated with the loss of power are based on the affected population. Table 14-8 presents estimates for power failure associated with severe weather in the event of 10, 30 or 50 percent of the total planning area population losing power simultaneously. These results do not account for physical damage to utility equipment and infrastructure.

Table 14-7. Loss Potential for Severe Weather

Jurisdiction	Exposed Value	Estimated Loss Potential from Severe Weather		
		10% Damage	30% Damage	50% Damage
Baytown[c]	$11,458,106,691	$1,145,810,669	$3,437,432,007	$5,729,053,346
Bellaire	$5,726,227,131	$572,622,713	$1,717,868,139	$2,863,113,565
Bunker Hill Village	$1,322,346,729	$132,234,673	$396,704,019	$661,173,365
Deer Park	$5,845,168,035	$584,516,804	$1,753,550,411	$2,922,584,018
El Lago	$469,295,696	$46,929,570	$140,788,709	$234,647,848
Friendswood[c]	$6,185,226,675	$618,522,667	$1,855,568,002	$3,092,613,337
Galena Park	$1,178,706,765	$117,870,677	$353,612,030	$589,353,383
Hedwig Village	$1,142,111,969	$114,211,197	$342,633,591	$571,055,984
Hilshire Village	$207,926,478	$20,792,648	$62,377,943	$103,963,239
Houston[a, b]	$487,379,428,234	$48,737,942,823	$146,213,828,470	$243,689,714,117
Humble	$4,570,456,883	$457,045,688	$1,371,137,065	$2,285,228,442
Hunters Creek Village	$1,787,651,957	$178,765,196	$536,295,587	$893,825,979
Jacinto City[a]	$1,261,111,221	$126,111,122	$378,333,366	$630,555,611
Jersey Village	$2,275,428,136	$227,542,814	$682,628,441	$1,137,714,068
Katy[c]	$3,396,517,744	$339,651,774	$1,018,955,323	$1,698,258,872
La Porte	$6,575,613,440	$657,561,344	$1,972,684,032	$3,287,806,720
League City[a, b]	$280,449,911	$28,044,991	$84,134,973	$140,224,956
Missouri City[c]	$12,398,706,197	$1,239,870,620	$3,719,611,859	$6,199,353,098
Morgan's Point	$262,314,866	$26,231,487	$78,694,460	$131,157,433
Nassau Bay	$1,635,924,802	$163,592,480	$490,777,441	$817,962,401
Pasadena	$22,505,882,445	$2,250,588,244	$6,751,764,733	$11,252,941,222
Pearland[a]	$709,046,327	$70,904,633	$212,713,898	$354,523,163
Piney Point Village	$1,817,131,583	$181,713,158	$545,139,475	$908,565,792
Seabrook	$2,537,671,414	$253,767,141	$761,301,424	$1,268,835,707
Shoreacres	$218,188,519	$21,818,852	$65,456,556	$109,094,260
South Houston[a]	$2,162,541,092	$216,254,109	$648,762,328	$1,081,270,546
Southside Place[a]	$471,918,214	$47,191,821	$141,575,464	$235,959,107
Spring Valley Village	$1,227,871,955	$122,787,196	$368,361,587	$613,935,978
Stafford[c]	$6,102,429,982	$610,242,998	$1,830,728,995	$3,051,214,991
Taylor Lake Village	$690,404,692	$69,040,469	$207,121,408	$345,202,346
Tomball	$3,569,286,191	$356,928,619	$1,070,785,857	$1,784,643,096
Waller[a, b]	$221,680,638	$22,168,064	$66,504,191	$110,840,319
Webster	$5,700,342,104	$570,034,210	$1,710,102,631	$2,850,171,052
West University Place	$3,722,134,705	$372,213,470	$1,116,640,411	$1,861,067,352
Unincorporated	$321,033,774,612	$32,103,377,461	$96,310,132,384	$160,516,887,306
Total	**$**928,049,024,033	**$**92,804,902,402	**$**278,414,707,210	**$**464,024,512,019

a. City at least partly in Harris County not participating as planning partner to his hazard mitigation plan
b. City extends beyond Harris County. Values shown are for Harris County portion only.
c. City extends beyond Harris County. Values shown are for entire city.

Table 14-8. Loss of Use Estimates for Power Failure for the Planning Area

Affected Planning Area Population	Number of People Affected	Estimated Electric Loss of Use[a]
10%	482,177	$62.2 million
30%	1,446,531	$186.6 million
50%	2,410,885	$311 million

a. $126 per person per day; assuming 24 hours of functional downtime, based on FEMA's 2009 Benefit Cost Analysis Reference Guide

14.5.4 Environment

The environment is highly vulnerable to severe weather events. Natural habitats such as streams and trees exposed to the elements during a severe storm risk major damage. Prolonged rains can saturate soils and lead to slope failure. Extended periods of extreme heat can impact drops and agriculture. Perhaps one of the most destructive effects of severe weather events can be observed on farms. A hailstorm with powerful winds can physically damage crops across large areas. The falling hailstones and strong winds bend and break plants and strip them of leaves and bark. Thus, farmers suffer heavy losses during such storms. Months of hard work by farmers can be destroyed almost instantly.

14.6 FUTURE TRENDS IN DEVELOPMENT

All future development will be affected by severe weather events. As the Harris County planning continues to grow as projected in Chapter 4, section 4.6.6 of this plan, the key to mitigating the future impacts from severe weather events will be the continued adoption and enforcement strong codes and standards within the planning area. The core capability assessments by the municipal planning partners to this effort identified a strong commitment to adoption of uniform codes and standards, which will position the planning partnership well for the mange hurricane risk for future development.

14.7 SCENARIO

A worst-case severe-weather event would involve prolonged high winds during a tornado or thunderstorm event. Such an event would have both short-term and long-term effects. Initially, schools and roads would be closed due to power outages caused by high winds and downed tree obstructions. Some areas of the county could experience limited ingress and egress. Intense rainfall associated with thunderstorm activity would produce flooding, overtopped culverts with ponded water on roads and mud over roadways. Prolonged power outage would have a significant economic impact on the planning area due to the area's reliance on power.

14.8 ISSUES

Important issues associated with severe weather in the planning area include the following:

- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as damaging winds.
- Mobile homes are vulnerable to damaging winds.
- Redundancy of power supply must be evaluated, especially for critical facilities.
- Dead or dying trees are more susceptible to falling during severe storm events.
- Power outages that disrupt land line service could cause significant communication disruption.
- 16.8 percent of the county population is considered to be below the poverty status for the County. This population may lack the core capabilities to withstand impacts from severe weather events.
- 10.2 percent of the county population is over 65 years of age, which is considered a vulnerable population to the impacts from severe weather.

- Detailed spatial analysis is needed to locate the most vulnerable populations, followed by focused public education and outreach mitigation activities for these populations.
- Climate change may cause more severe weather patterns that could impact vulnerable populations within the planning area. Increased frequency and intensity of storms may result in greater damage.
- The risk associated with the severe weather hazard overlaps the risk associated with other hazards such as earthquake, landslide and flood. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- Isolated population centers are most vulnerable to the severe weather hazard.
- Public education on dealing with the impacts of severe weather needs to continue to be provided so that citizens can be better informed and prepared for severe weather events. In particular, fog should be considered, since fog may be downplayed despite its potential for transportation accidents.
- Debris management (downed trees, etc.) must be addressed, because debris can impact the severity of severe weather events, requires coordination efforts, and may require additional funding.

15. TSUNAMI

15.1 GENERAL BACKGROUND

A tsunami is a series of high-energy waves that radiate outward like pond ripples from an area where a generating event occurs, arriving at shorelines over an extended period. Tsunamis can be induced by earthquakes, landslides and submarine volcanic explosions (see Figure 15-1). Tsunamis are typically classified as local or distant, depending on the location of their source in comparison to where waves occur:

Note: The risk from this hazard is considered to be low to negligible, mainly because of the lack of historical occurrence in the planning area. However, this hazard profile is provided in order to address the possibility of a future event in the planning area. This positions the planning partnership for benefit eligibility should an event of this type occur during the performance period of this plan.

- The waves nearest to the generating source represent a local tsunami. Such events have minimal warning time, leaving few options except to run to high ground. The damage from the tsunami itself may be accompanied by additional damage from the triggering earthquake due to ground shaking, surface faulting, liquefaction or landslides.
- The waves far from the generating source represent a distant tsunami. Distant tsunamis may travel for hours before striking a coastline, giving a community a chance to implement evacuation plans.

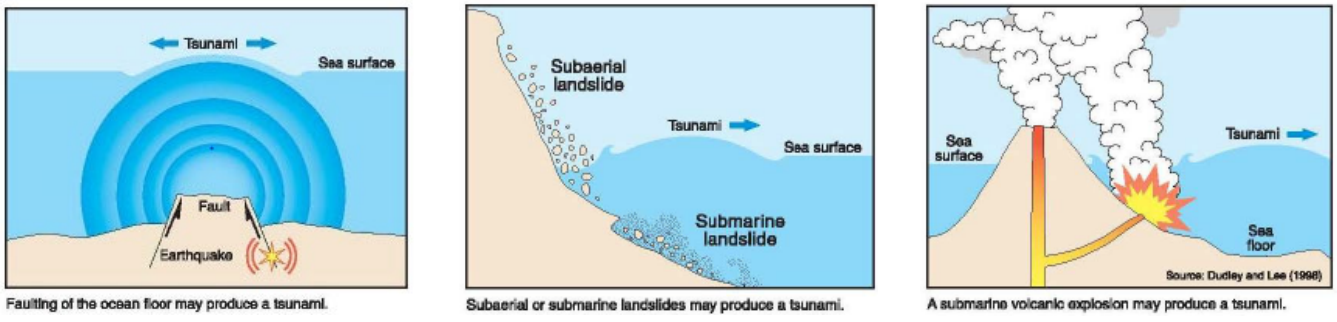


Figure 15-1. Common Sources of Tsunamis

In the open ocean, a tsunami may be only a few inches or feet high, but it can travel with speeds approaching 600 miles per hour. As a tsunami enters the shoaling waters near a coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. At the shoreline, tsunamis may take the form of a fast-rising tide, a cresting wave, or a bore (a large, turbulent wall-like wave). The bore phenomenon resembles a step-like change in the water level that advances rapidly (from 10 to 60 miles per hour). The first wave is usually followed by several larger and more destructive waves.

The configuration of the coastline, the shape of the ocean floor, and the characteristics of advancing waves play important roles in the destructiveness of the waves. Bays, sounds, inlets, rivers, streams, offshore canyons, islands, and flood control channels may cause various effects that alter the level of damage. Offshore canyons can

focus tsunami wave energy, and islands can filter the energy. It has been estimated that a tsunami wave entering a flood control channel could reach a mile or more inland, especially if it enters at high tide. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline. A wave may be small at one point on a coast and much larger at other points. The inundation area for a tsunami event is often described as runup as illustrated in Figure 15-2.

Source: UNESCO, Retrieved from Different Directions: Tsunami, n.d.

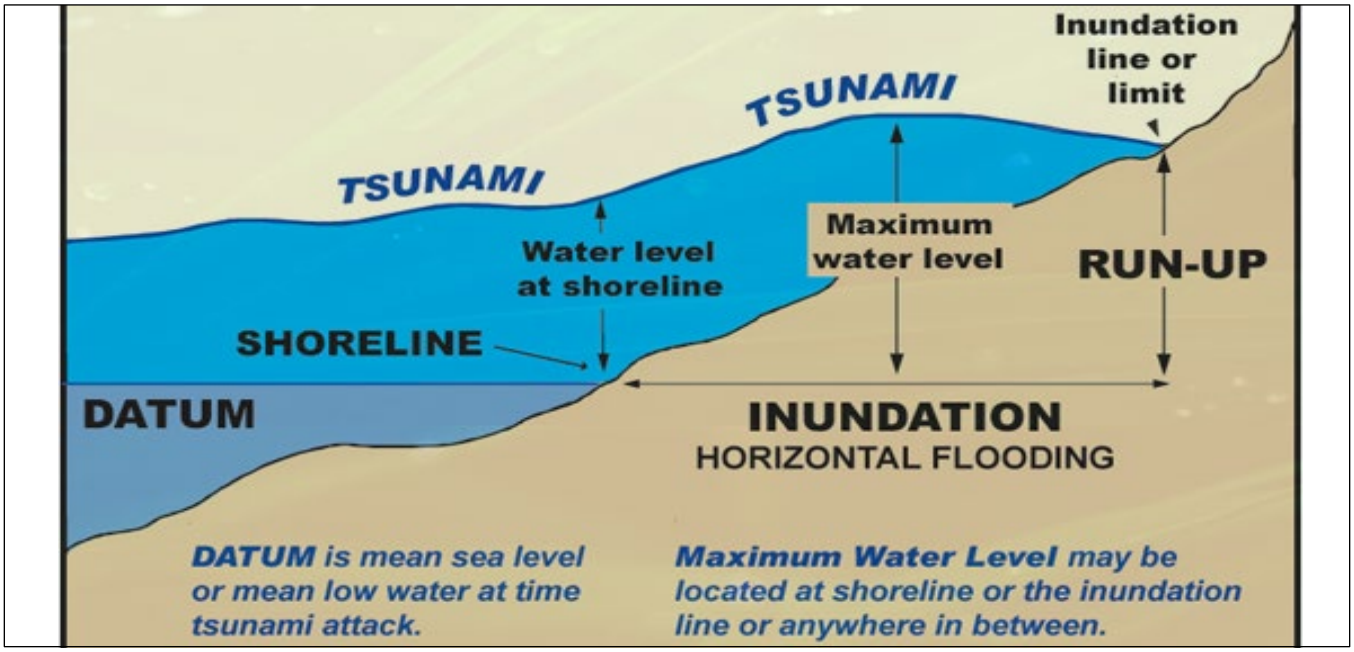


Figure 15-2. Runup Distance and Height in Relation to the Datum and Shoreline

15.2 HAZARD PROFILE

15.2.1 Past Events

Though tsunamis are more likely to affect west coast states, historical evidence does show that tsunamis have affected the eastern United States and Gulf of Mexico, including Texas. The following Texas tsunami evidence was gathered from the National Geophysical Data Center (Tsunami Event Database):

- **October 24, 1918**—A small tsunami, reported to have originated with an earthquake near Puerto Rico, ran ashore in Galveston. Wave height was unknown. No damage, deaths or injuries were recorded.
- **May 2, 1922**—Three tsunami waves ran ashore in Galveston within a 45-minute period, followed 8 hours later by a similar but smaller train of waves. The maximum water height of the highest wave was 0.6 meters above sea level. Researchers maintain that there is some question regarding the origin and nature of these tsunamis, noting that the waves were probably erroneously ascribed to a small earthquake in Puerto Rico (NOAA Center for Tsunami Research).

Research of historical data shows no recorded property damage or loss of life due to tsunami in the Harris County planning area. In addition, the State of Texas Mitigation Plan does not identify tsunamis as a hazard for any location within the State of Texas. According to Figure 15-3, which identifies the tsunami hazard risk areas in the United States based on historical event impacts, the Texas Gulf Coast region (including Harris County) is not identified as a risk area.

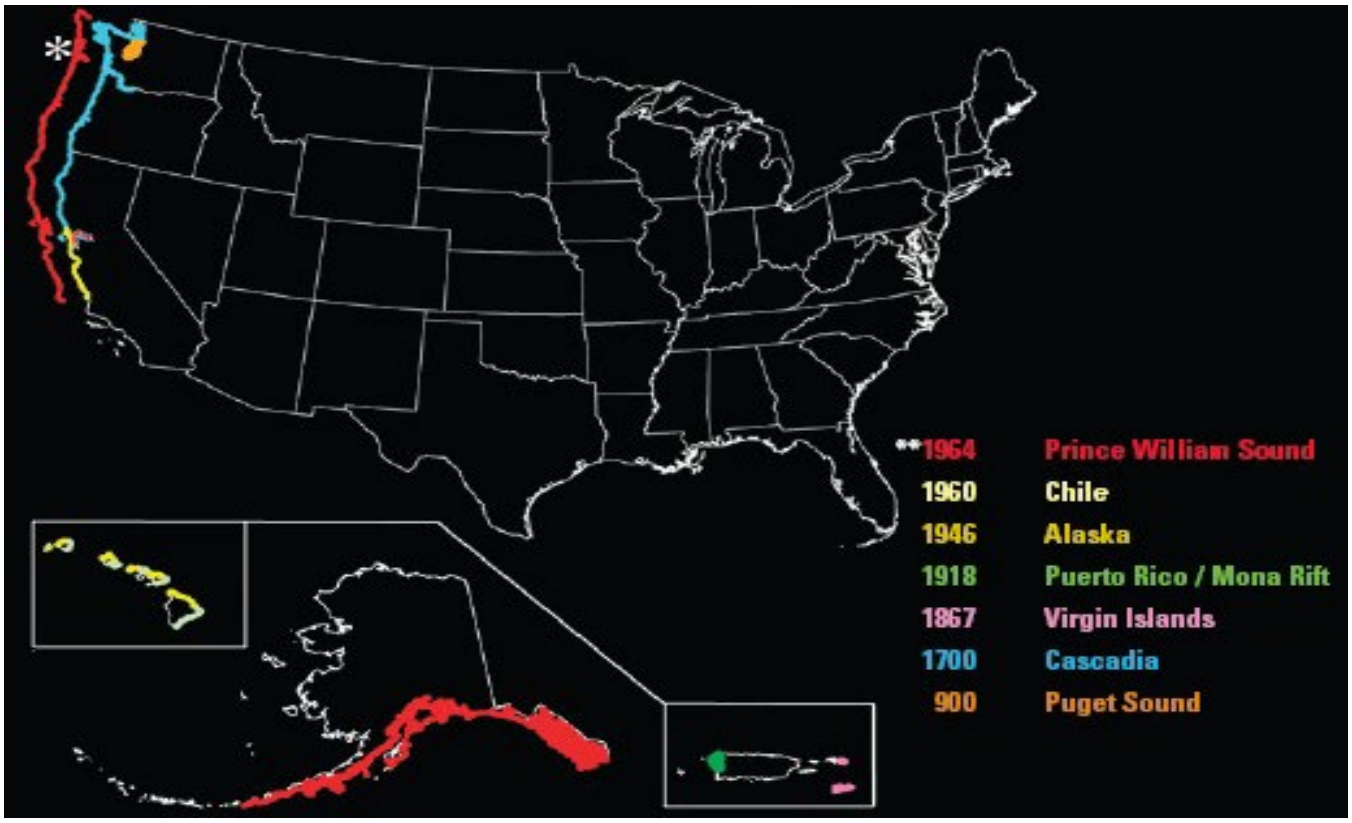


Figure 15-3. Tsunami Risk Based on Historical Impact Events

15.2.2 Location

The Texas A&M University at Galveston Tsunami Research Group has developed a 3D numerical model for what could happen after a submarine landslide. The 3D model is combined with a 2D model to depict how a tsunami could affect coastal areas (see Figure 15-4). There is currently no extent and location mapping of the tsunami hazard available to support tsunami hazard risk assessment for this plan.

Source: AL.com, 2015

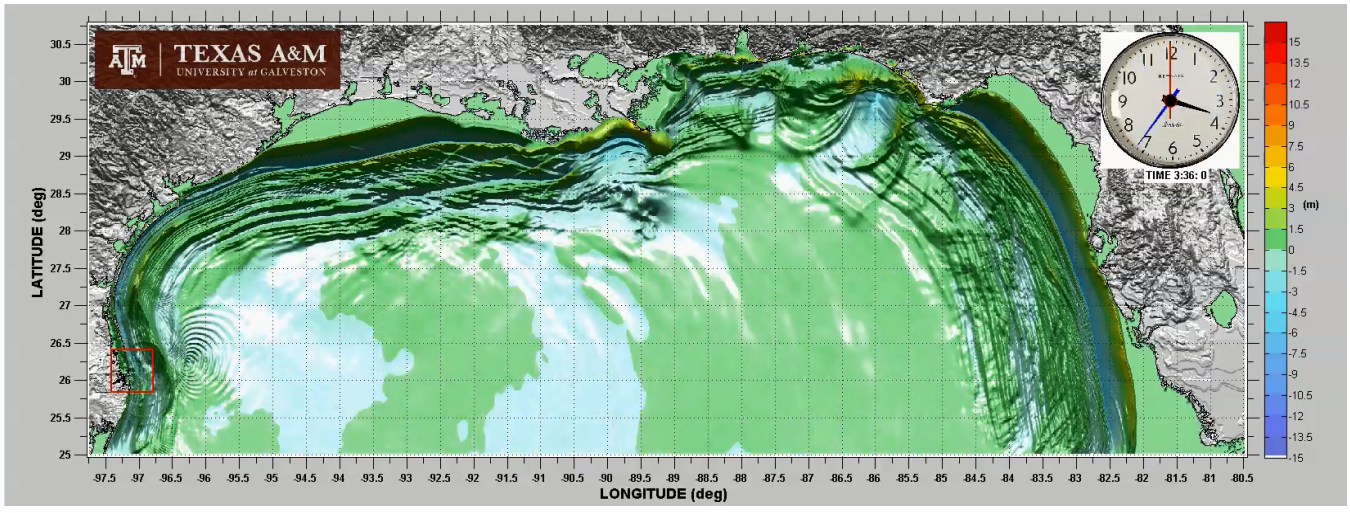


Figure 15-4. Texas A&M Galveston Tsunami Model Simulation

15.2.3 Frequency

Preliminary modeling of potential tsunami sources outside the Gulf of Mexico by USGS has indicated a very low threat and may not pose a tsunami hazard to the Gulf coastal communities or infrastructure. Nevertheless, recent assessments of tsunami hazards along the Gulf of Mexico carried out by the U.S. Geological Survey (USGS) and the National Tsunami Hazard Mitigation Program have identified underwater landslides as the primary potential source of tsunami generation. Although a massive underwater landslide in the Gulf is considered a potential hazard, the probability of such an event is quite low. The probability of occurrence is related to large ancient landslides which were probably active prior to 7,000 years ago when large quantities of sediments were emptied into the Gulf. However, nowadays sediments continue to empty into the Gulf mainly from the Mississippi river. The sediment supply contributes to slope steepening and also to the increasing of the excess pore water pressure in the underlying soils, which may lead to further landslide activities. Recent evidence from seismic records of small-scale energetic seismic-waves in the Gulf have confirmed that there is a probability of recurrence. For the risk assessment for this plan update, the probability of occurrence for this hazard is considered "low."

15.2.4 Severity

According to the National Tsunami Hazard Mitigation Program, tsunami events with runups of more than 1 meter are the most likely to be dangerous to people and property. The tsunami's size and speed, as well as the coastal area's form and depth, affect the impact of a tsunami. At some locations, the advancing turbulent wave front will be the most destructive part of the tsunami wave. In other situations, the greatest damage will be caused by the outflow of water back to the sea between crests, sweeping away items on the surface and undermining roads, buildings, bulkheads, and other structures. This outflow action can carry enormous amounts of highly damaging debris, resulting in further destruction. Ships and boats, unless moved away from shore, may be dashed against breakwaters, wharves, and other craft, or be washed ashore and left grounded after the withdrawal of the seawater (National Tsunami Hazard Mitigation Program, 2001). A local tsunami resulting from an underwater landslide in the Gulf of Mexico presents the most severe risk to the planning area.

15.2.5 Warning Time

While tsunamis in the Gulf of Mexico are rare, the Gulf states were added to the U.S. Tsunami Warning System in 2005. The main purpose of the warning system is to enable local emergency management to act in response to warnings. To plan for the warning response, emergency managers must understand what specific areas within their jurisdictions are threatened by tsunamis. Potential tsunami sources for the Gulf of Mexico are local submarine landslides and earthquakes (induced co-seismic tsunami source) along the Caribbean plate boundary faults. However, preliminary modeling of potential tsunami sources outside the Gulf has indicated a very low threat and may not pose a tsunami hazard to the Gulf coastal communities or infrastructure.

Visible Indications

Tsunamis are difficult to detect in the open ocean; with waves generally less than 3 feet high. The first visible indication of an approaching tsunami may be either a rise or drop in water surface levels (National Tsunami Hazard Mitigation Program, 2001):

- A drop in water level (draw down) can be caused by the trough preceding the advancing, large inbound wave crest. Rapid draw down can create strong currents in harbor inlets and channels that can severely damage coastal structures due to erosive scour around piers and pilings. As the water's surface drops, piers can be damaged by boats or ships straining at or breaking their mooring lines. The vessels can overturn or sink due to strong currents, collisions with other objects, or impact with the harbor bottom.
- The advancing tsunami may initially arrive as a strong surge increasing the sea level. This can be similar to the rising tide, but the tsunami surge rises faster and does not stop at the shoreline. Even if the wave

height appears to be small, 3 to 6 feet for example, the strength of the accompanying surge can be deadly. Waist-high surges can cause strong currents that float cars, small structures, and other debris. Boats and debris are often carried inland by the surge and left stranded when the water recedes.

National Tsunami Warning System

The Tsunami Warning Centers depend on an observation system that includes seismic and water-level networks from around the world to help them determine when and where to issue tsunami messages. These networks are critical to the warning centers' ability to provide timely and accurate messages:

- **Seismic Networks**—When an earthquake occurs, seismic networks provide information about its location, depth, magnitude, and other source characteristics. The warning centers analyze this information to determine if the earthquake could have generated a tsunami and if a tsunami message is necessary.
- **Water-Level Networks**—If an earthquake meets certain criteria, the warning centers turn to water-level information, looking for changes in water-level height that could indicate the existence and size of a tsunami. The primary sources of information about water-level change are a network of Deep-ocean Assessment and Reporting of Tsunami systems and an extensive array of coastal water-level stations.

15.3 SECONDARY HAZARDS

Aside from the tremendous hydraulic force of the tsunami waves themselves, floating debris carried by a tsunami can endanger human lives and batter inland structures. Flooding can cause contamination of drinking water and can result in the spread of disease.

15.1 EXPOSURE AND VULNERABILITY

The exposure and vulnerability for the people, property, critical facilities/infrastructure, and environment are low to none for the planning area. This is based on the lack of historical occurrence of the tsunami hazard and/or the lack of extent and location data for the planning area to support risk assessment of the tsunami hazard. This does not mean that these types events could not happen in the future, it just means that there is currently no empirical data to assess impacts as of this planning effort. Therefore, no exposure and vulnerability analysis was performed for this hazard.

15.2 FUTURE TRENDS IN DEVELOPMENT

Due the lack of exposure and impacts from these hazards, future development in the planning area is not likely to be impacted by the tsunami hazard in the short term. However, as a changing climate continues to influence the frequency, severity and magnitude of hazard events, there could be impacts to future development. Future updates to this plan will have to measure those possibilities as it assesses the mass movement hazards of concern.

15.3 SCENARIO

For the performance period of this plan update (5 years), there is no likely tsunami scenario projected to impact the planning area.

15.4 ISSUES

Other than a lack of extent and location data to support risk assessment of the tsunami hazard for the planning area, the CPT has identified no issues related to the tsunami hazard. Harris County and its planning partners will continue to monitor conditions as they pertain to this hazard to inform future updates to this plan.

16. WILDFIRE

16.1 GENERAL BACKGROUND

A wildfire is any uncontrolled fire on undeveloped land that requires fire suppression. Wildfires can occur naturally and are important to many ecosystem processes, but most are started by people. The second most common cause for wildfire is lightning. There are three classes of wildland fires:

- A surface fire is the most common class and burns along the floor of a forest, moving slowly and killing or damaging trees.
- A ground fire (muck fire) is usually started by lightning or human carelessness and burns on or below the forest floor.
- Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees.

Fire probability depends on local weather conditions, outdoor activities such as camping, debris burning, and construction, and the degree of public cooperation regarding the use of fire prevention measures. Drought conditions and other natural disasters (tornadoes, hurricanes, etc.) increase the probability of wildfires by producing fuel in both urban and rural settings. Forest damage from hurricanes and tornadoes may block interior access roads and fire breaks, pull down overhead power lines, or damage pavement and underground utilities.

Many individual homes and cabins, subdivisions, resorts, recreational areas, organizational camps, businesses, and industries are located within high fire hazard areas. Increasing recreational demands place more people in wildlands during holidays, weekends, and vacation periods. Unfortunately, wildland residents and visitors are rarely educated or prepared for the inferno that can sweep through the brush and timber, destroying property in minutes. Approximately 90 percent of all wildfires in Texas are believed to be human-caused, due primarily to the unchecked burning of debris.

State and local governments can impose fire safety regulations on home sites and developments to help curb wildfire. Land treatment measures such as fire access roads, water storage, helipads, safety zones, buffers, firebreaks, and fuel breaks can be designed as part of an overall fire defense system to aid in fire control. Fuel management, prescribed burning, and cooperative land management planning can also be encouraged to reduce fire hazards.

16.1.1 Fire Risk Index Based on Drought

The continuous fire risk index provides a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers directly relating to the flammability of organic material in the ground:

- 0-200—Soil moisture and large class fuel moistures are high and do not contribute much to fire intensity. Typical of spring dormant season following winter precipitation.
- 200-400—Typical of late spring, early growing season. Lower litter and duff layers are drying and beginning to contribute to fire intensity.
- 400-600—Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and will burn actively.

- 600-800—Often associated with more severe drought with increased wildfire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to burn actively at these levels.

16.1.2 Wildfire Classifications

The National Wildfire Coordinating Group provides a standard code and definition for classifying a fire into one of several ranges of fire sizes based on the number of acres within the final fire perimeter:

- Fire Size Class A—0 – 1/4 acre
- Fire Size Class B—1/4 – 10 acres
- Fire Size Class C—10 – 99 acres
- Fire Size Class D—100 – 299 acres
- Fire Size Class E—300 – 999 acres
- Fire Size Class F—1,000 – 4,999 acres
- Fire Size Class G—5,000+

16.2 HAZARD PROFILE

16.2.1 Past Events

Accurate historical occurrence data is difficult to obtain for the wildfire hazard and does not follow a standard criterion. The National Climatic Data Center (NCDC) does not show any history of wildfire within the Harris County planning area since 1950.

In determining the historical occurrences of wildfires in the Harris County planning area, wildfires classified as Fire Size Class A were excluded due to their limited impact and size. According to the U.S. Geological Survey (USGS), the Harris County planning area and all participating jurisdictions experienced 174 wildfires between 2005 and 2016. Table 16-1 outlines the historical occurrences of wildfires in the Harris County planning area for all participating jurisdictions, with the exception of Fire Size Class A.

The USGS Federal Wildland Fire Occurrence Data identifies all reported wildfires in the Harris County planning area using the National Fire Incident Reporting System reporting method. The data, shown on Figure 16-1, was utilized for historical occurrence records, vulnerability assessment and risk analysis.

16.2.2 Location

The wildfire urban interface definition in the Federal Register was developed to identify communities as risk in the vicinity of public lands; the area where houses meet or intermingle with undeveloped vegetation. The entire planning are can expect to experience wildfires in the future; especially jurisdictions within the wildland urban interface area. Figure 16-2 from the Texas Forest Service identifies the wildfire urban interface areas within Harris County. The intensity and severity of the wildfire may vary within the planning area due to variations in wildland vegetation, defensible space, weather conditions and fuel sources. The sections below describe two sources of fire hazard mapping used for this risk assessment.

Table 16-1. Wildfire Historical Occurrences in Harris County (2005 – 2016)

Year	Fire Size Class	Locations	# of Fires
2005	B	Houston, TX 77044	21
2006	B, C, and D	Cypress, TX 77433 Hockley, TX 77447 Crosby, TX 77532 Tomball, TX 77377 Houston, TX 77044	39
2006	None Reported	N/A	0
2007	None Reported	N/A	0
2008	B and C	Katy, TX 77493 Houston, TX 77084 Hockley, TX 77447	16
2009	B and C	Houston, TX 77049 Humble, TX 77396 Huffman, TX 77336 Atascocita, TX 77346 Spring, TX 77373	10
2010	B and C	New Caney, TX 77357 Crosby, TX 77532 Huffman, TX 77336	3
2011	B and C	Atascocita, TX 77346 Crosby, TX 77532 Highlands, TX 77562 Houston, TX 77049 Hockley, TX 77084 Humble, TX 77396 Huffman, TX 77336 Atascocita, TX 77346 Spring, TX 77373 Tomball, TX 77375 Waller, TX 77484 Webster, TX 77598	76
2012	B	Houston, TX 77044	4
2013	B	Houston, TX 77044	5
2014	None reported	N/A	0
2015	None reported	N/A	0
2016	None Reported	N/A	0
Total			174

Source: USGS, 2019

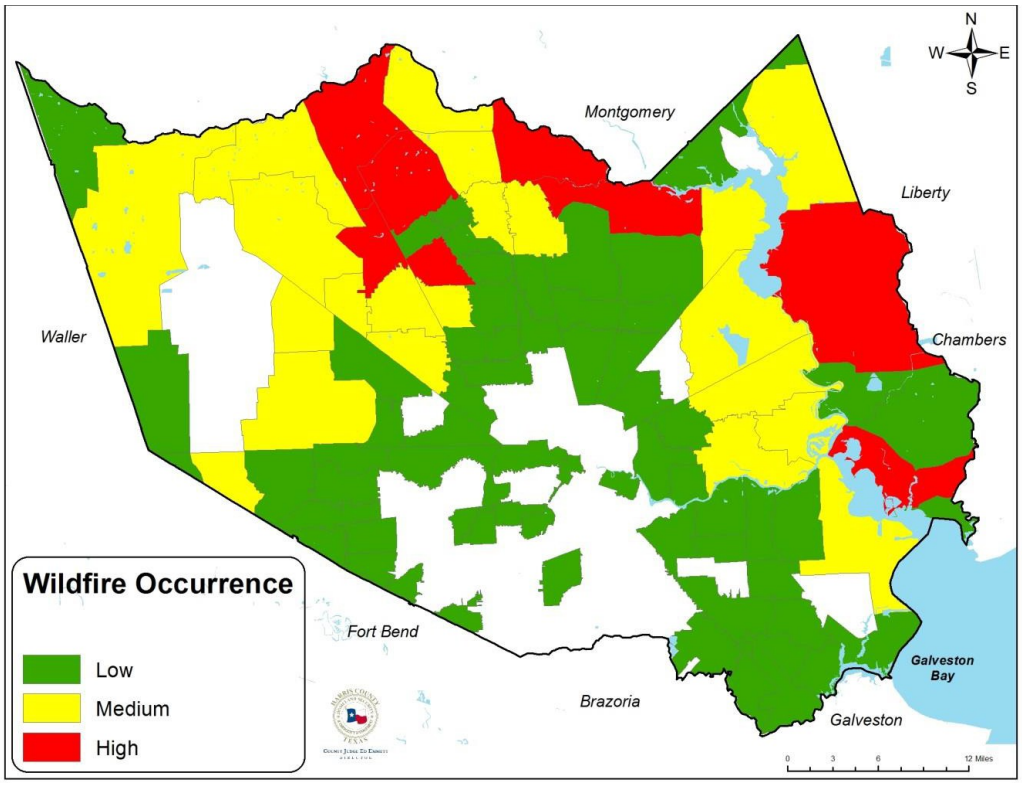


Figure 16-1. Wildfire Historical Occurrence Information for Harris County

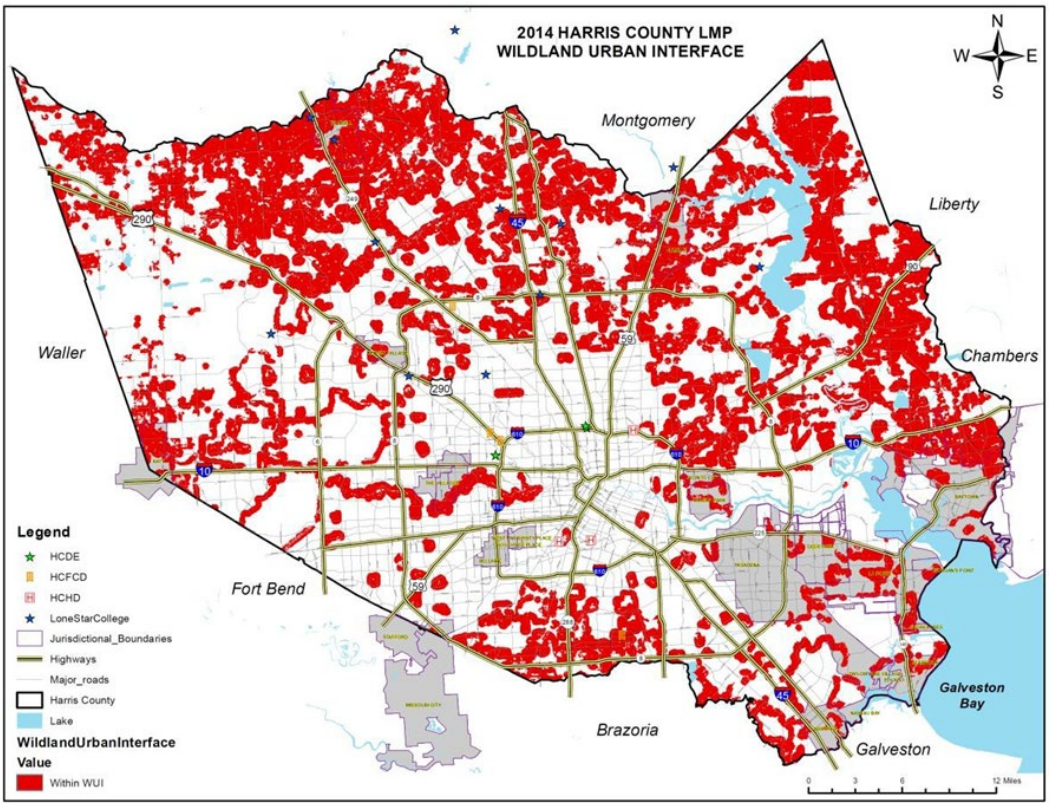


Figure 16-2. Texas Forest Service Wildland Urban Interface In and Around Harris County

Wildfire Threat

Wildfire threat is the likelihood of a wildfire occurring or burning into an area. Threat is derived by combining a number of landscape characteristics including surface and canopy fuels, resultant fire behavior, historical fire occurrence, percentile weather derived from historical weather observations, and terrain conditions. These inputs are combined using analysis techniques based on established fire science.

The measure of wildfire threat used in the Texas Wildfire Risk Assessment is based on the Wildland Fire Susceptibility Index. The index combines the probability of an acre igniting (wildfire ignition density), and the expected final fire size based on rate of spread in four percentile weather categories. The Wildland Fire Susceptibility Index is defined as the likelihood of an acre burning. This index is calculated consistently for all areas in Texas, so it allows for comparison of areas across the entire state. For example, a high threat area in East Texas is equivalent to a high threat area in West Texas.

The threat map is derived at a 30-meter resolution. This scale of data was chosen to be consistent with the accuracy of the primary surface fuels dataset used in the assessment. While not appropriate for site specific analysis, it is ideal for state and regional scale analysis. The wildfire threat mapping for the planning area is shown in Figure 16-3. The only wildfire threat zone within the planning area has been classified as “low” as defined by the wildfire threat parameters defined by the Texas Wildfire Risk Assessment Portal.

Wildfire Ignition Density

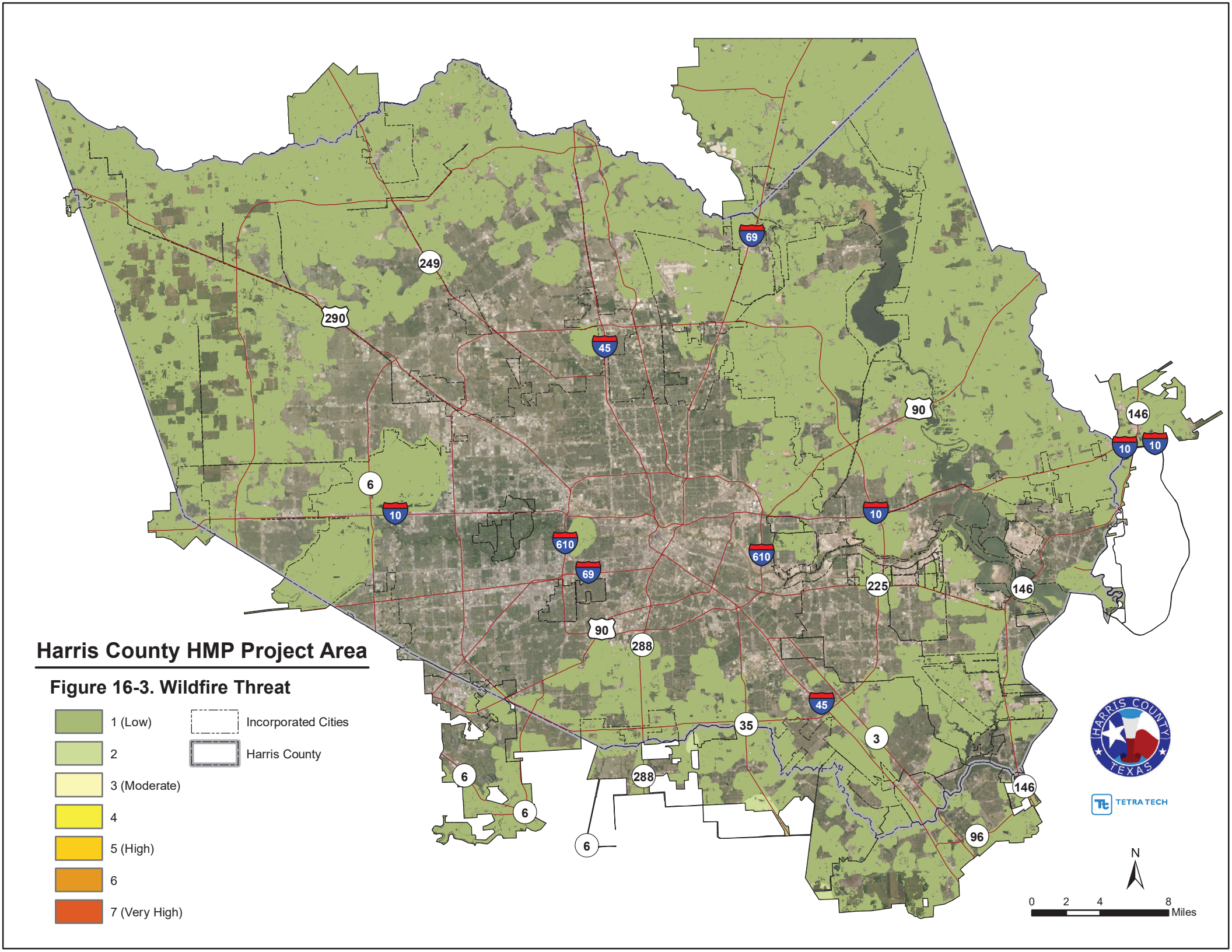
The measure of wildfire occurrence used in the Texas Wildfire Risk Assessment is called the wildfire ignition density. Wildfire ignition density is the likelihood of a wildfire starting based on historical ignition patterns. Occurrence is derived by modeling historical wildfire ignition locations to create an average ignition rate map. The ignition rate is measured in the number of fires per year per 1,000 acres. Since all areas in Texas have ignition density calculated consistently, it allows for comparison and ordination of areas across the entire state. For example, a high occurrence area in East Texas is equivalent to a high occurrence area in West Texas.

Five years of historic fire report data was used to create the ignition points for all Texas fires. Data was obtained from federal, state and local fire department report data sources for the years 2005 to 2009. For East Texas, additional fire data was obtained for state fires for the years 2000 to 2004. The compiled wildfire occurrence database was cleaned to remove duplicate records and to correct inaccurate locations. The database was then modeled to create a density map reflecting historical fire ignition rates.

The Ignition Density map is derived at a 30-meter resolution. This scale of data was chosen to be consistent with the accuracy of the primary surface fuels dataset used in the assessment. While not appropriate for site specific analysis, it is appropriate for regional, county or local planning efforts. The Wildfire Ignition Density mapping for the planning area is shown in Figure 16-4.

16.2.3 Frequency

Based on the historical data provided by the U.S. Geological Survey (USGS), the probability of the Harris County planning area and all participating jurisdictions being affected by a wildfire event is once every 0.04 years or 14.6 days. For the risk assessment for this plan update, the probability of occurrence for this hazard is considered “high.”


Harris County HMP Project Area
Figure 16-3. Wildfire Threat
1 (Low)
2
3 (Moderate)
4
5 (High)
6
7 (Very High)
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
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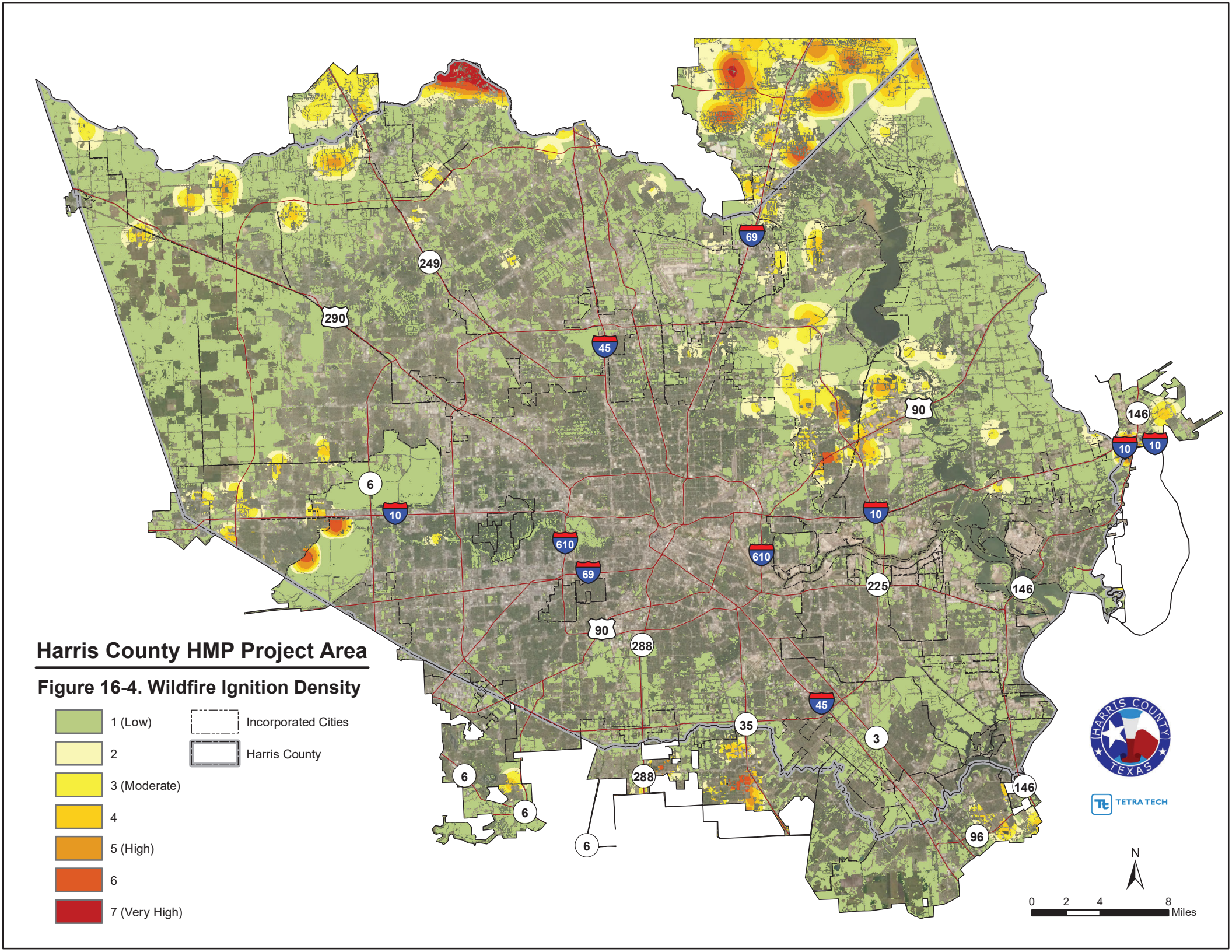
TETRA TECH


Harris County HMP Project Area
Figure 16-4. Wildfire Ignition Density
1 (Low)
2
3 (Moderate)
4
5 (High)
6
7 (Very High)
Incorporated Cities
Harris County
249
290
45
69
90
146
10
6
610
225
288
35
3
96
N
0 2 4 8
Miles
HARRIS COUNTY TEXAS
TETRA TECH

16.2.4 Severity

Potential losses from wildfire include human life, structures and other improvements, and natural resources. Given the immediate response times to reported fires and the proximity to firefighting resources, the likelihood of injuries and casualties is minimal. However, under the right conditions, fire can move quickly and overwhelm an initial response. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides) and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

Air quality for Harris County is monitored by the Pollution Control Services Department (PCS). PCS Outdoor Air Program conducts activities that include complaint response and investigations, monitoring activities, emissions events investigations, programmatic inspections and permit reviews.

16.2.5 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. Since fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest.

Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time; however, the lack of reliable cell service in many parts of the planning area means that providing warning to those in the path of a fire may still be difficult, particularly if individuals are not in areas with land lines.

16.3 SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire. Most wildfires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

16.4 EXPOSURE

A quantitative assessment of exposure to the wildfire hazard was conducted using the wildfire threat and ignition density mapping shown in Figure 16-3 and Figure 16-4 and the asset inventory developed for this plan. Detailed results are provided in Appendix C and summarized below.

16.4.1 Population

Population was estimated using the residential building count in each mapped hazard area and multiplying by the 2018 estimated average population per household. The population exposure estimates by risk area are shown in Table 16-2.

Table 16-2. Harris County Population Exposure to the Wildfire Hazard

Fire Hazard Zone	Population Exposed	% of Total Population
Wildfire Threat Zones		
Low Wildfire Threat	1,153,102	23.91%
Wildfire Ignition Density Zones		
Very High	4,384	0.09%
High	6,995	0.14%
Moderate	25,712	0.53%
Total for ignition Density	**37,091**	**0.76%**

16.4.2 Property

The property exposure estimates by risk area are shown in Table 16-3. Of the structures located in the very high, high and moderate Wildfire Ignition Density zones, over 96% are residential structures.

Table 16-3. Harris County Property Exposure to the Wildfire Hazard

Fire Hazard Zone	Value of Structure/Contents	% of Total Planning Area Value
Wildfire Threat Zones		
Low Wildfire Threat	$198.2 billion	21.4%
Wildfire Ignition Density Zones		
Very High	$824.9 million	0.09%
High	$1.7 billion	0.18%
Moderate	$6.5 billion	0.69%
Total for ignition Density	**$9.02 billion**	**0.96%**

16.4.3 Critical Facilities and Infrastructure

Critical facilities and infrastructure exposed to the wildfire hazard represent less that 1 percent of the total critical infrastructure and facilities in the planning area. The breakdown of exposure by ignition density zone and facility type is shown in Figure 16-5. Most (84%) exposed critical facilities are in the moderate wildfire ignition density zone. Linear, above-ground infrastructure, such as power lines, is also exposed to damage from wildfire.

16.4.4 Environment

All natural resources and habitats in mapped fire hazard severity zones are exposed to the risk of wildfire.

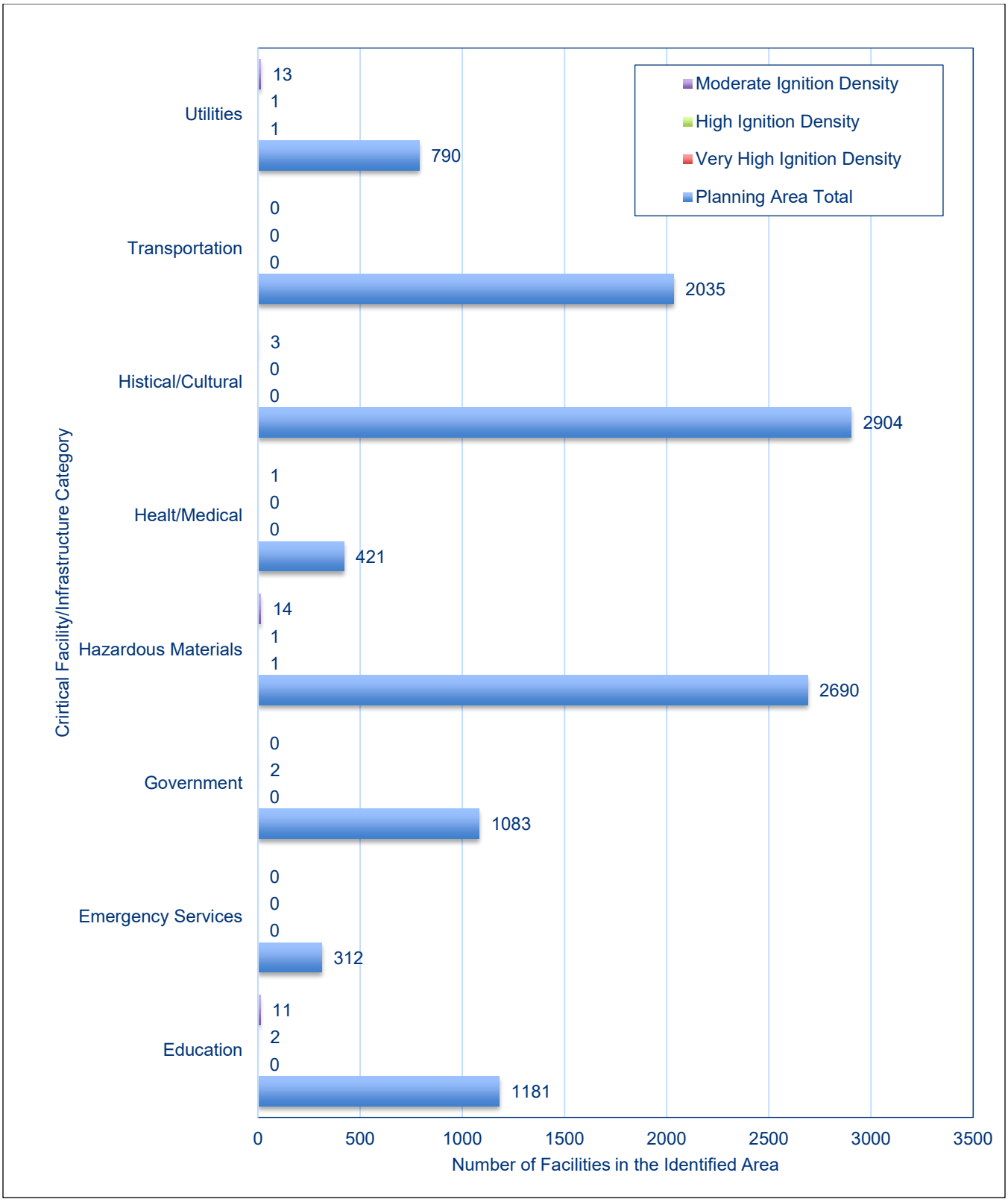


Figure 16-5. Critical Facilities Mapped Wildfire Ignition Density Zones Countywide

16.5 VULNERABILITY

Vulnerability estimates for the wildfire hazard are described qualitatively. No loss estimation of these facilities was performed because damage functions have not been established for the wildfire hazard. Modeling based on identified fire hazard areas would overestimate potential losses because it is unlikely that all areas susceptible to wildfire would experience a fire at the same time.

16.5.1 Population

All people exposed to the wildfire hazard are potentially vulnerable to wildfire impacts. Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly and those with respiratory and cardiovascular diseases. In addition, wildfire may threaten the health and safety of those fighting the fires. First responders are exposed to dangers from the initial incident and after-effects from smoke inhalation and heat stroke. Persons with access and functional needs, the elderly and very young may be especially vulnerable to a wildfire if there is not adequate warning time before evacuation is needed.

16.5.2 Property

All property exposed to the wildfire hazard is vulnerable. Structures that were not constructed to standards designed to protect a building from a wildfire may be especially vulnerable. As of 2008, the International Building code requires minimum standards be met for new buildings in fire hazard severity zones. Most housing in the planning area—84 percent—was built prior to this code requirement (U.S. Census, 2018). It is unknown how many of these structures are in fire hazard zones.

Estimates were developed to indicate the loss that would occur if wildfire damage were equal to 10, 30 or 50 percent of the exposed property value, as summarized in Table 16-4. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure.

Table 16-4. Loss Estimates for Fire Hazard Severity Zones

Wildfire Ignition Density Zone	Exposed Value	Damage = 10% of Exposed Value		Damage = 30% of Exposed Value		Damage = 50% of Exposed Value	
		Loss	% of Total Replacement Value	Loss	% of Total Replacement Value	Loss	% of Total Replacement Value
Very High	$824,988,075	$82,498,808	0.009%	$247,496,423	0.03%	$412,494,037	0.04%
High	$1,677,483,353	$167,748,335	0.02%	$503,245,006	0.05%	$838,741,676	0.09%
Moderate	$6,515,392,102	$651,539,210	0.7%	$1,954,617,631	0.21%	$3,257,696,051	0.35%
Total	**$**9,017,863,530	**$**901,786,353	0.73**%**	**$**2,705,359,060	0.29**%**	**$**4,508,931,764	0.48**%**

16.5.3 Critical Facilities and Infrastructure

Critical facilities not built to fire protection standards, utility poles and lines, and facilities containing hazardous materials are most vulnerable to the wildfire hazard. Most road and railroads would be without damage except in the worst scenarios, although roads and bridges can be blocked by debris or other wildfire-related conditions and become impassable. The following critical facilities are located in very high and high severity zones and their vulnerability could complicate response and recovery efforts during and following an event:

- **Hazardous Materials and Fuel Storage**—During a wildfire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition, they could leak into surrounding areas, saturating soils and seeping into surface waters, and have a disastrous effect on the environment.

- **Communication Facilities**—If these facilities are damaged and become inoperable, it would exacerbate already difficult communication in the planning area.
- **Fire Stations**—There are three fire stations as well as facilities that support firefighting efforts located in these risk areas.

16.5.4 Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, affecting the types, structure, and spatial extent of native vegetation. However, it also can cause severe environmental impacts:

- **Damaged Fisheries**—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- **Soil Erosion**—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- **Spread of Invasive Plant Species**—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- **Disease and Insect Infestations**—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- **Destroyed Endangered Species Habitat**—Fire can have negative consequences for endangered species.
- **Soil Sterilization**—Some fires burn so hot that they can sterilize the soil. Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost.
- **Reduced Timber Harvesting**—Timber can be destroyed and lead to smaller available timber harvests.
- **Reduced Agricultural Resources**—Wildfire can have disastrous consequences on agricultural resources, removing them from production and necessitating lengthy restoration programs.
- **Damaged Cultural Resources**—Scenic vistas can be damaged, access to recreational areas can be reduced and destruction of cultural resources may occur.

16.6 FUTURE TRENDS IN DEVELOPMENT

As a highly urbanized planning area, wildfire risk exposure is low. Urbanization tends to alter the natural fire regime, and can create the potential for the expansion of urbanized areas into wildland areas. The expansion of development toward wildfire hazard areas can be managed with strong land use and building codes. The International Building Code includes minimum standards related to the design and construction of buildings in fire hazard zones. The planning area is well equipped with these tools and this planning process has assessed capabilities with regards to the tools. As the planning area experiences future growth, it is anticipated that the exposure to this hazard will remain as assessed or even decrease over time due to these capabilities.

16.7 SCENARIO

A major wildfire in the planning area might begin with a wet spring, adding to fuels already present on the forest floor. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot winds. Carelessness with combustible materials or a tossed lit cigarette, or a sudden lightning storm could trigger a multitude of small isolated fires.

The embers from these smaller fires could be carried miles by hot, dry winds. The deposition zone for these embers could be deep in forested areas. Fires that start in flat areas move slower, but wind still pushes them. It is not unusual for a wildfire pushed by wind to burn the ground fuel and later climb into the crown and reverse its

track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed. These new small fires would most likely merge. Suppression resources would be redirected from protecting the natural resources to saving more remote subdivisions.

The worst-case scenario would include an active fire season throughout the American west and southwest, spreading resources thin. Firefighting teams would be exhausted or unavailable. Many federal assets would be responding to other fires that started earlier in the season.

To further complicate the problem, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing floodplains and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With the forests removed from the watershed, stream flows could easily double. Floods that could be expected every 50 years may occur every couple of years. With the streambeds unable to carry the increased discharge because of increased sediment, the floodplains and floodplain elevations would increase.

16.8 ISSUES

Issues for wildfire are the following:

- Human activities have been the cause of 63 percent of wildfires nationally.
- Much of the planning area's building stock is of wood-frame construction built before 2008 when International building codes began requiring minimum standards for buildings in fire hazard severity zones.
- Several vulnerable and isolated populations are in areas of high and very high risk for wildfire.
- Public education and outreach to people living in the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- Climate change could affect the wildfire hazard.
- Future housing growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities. This would include enhancement through expansion of the target areas as well as additional resources.
- Fire departments require reliable water supply in high risk wildfire areas.
- Certifications and qualifications should be expanded for fire department personnel. All firefighters should be trained in basic wildfire behavior and basic fire weather, and all company officers and chief level officers should be trained at the wildland command and strike team leader level.

17. OTHER HAZARDS OF INTEREST

The hazards of concern assessed in Chapters 7 through 16 and rated and ranked in Chapter 19 are those that present significant risks in the Harris County planning area. Additional hazards, both natural and human-caused, were identified by the Steering Committee as having some potential to impact the planning area, but at a much lower risk level than the hazards of concern. These other hazards are identified as hazards of interest.

The sections below provide short profiles of each hazard of interest, including qualitative discussion of their potential to impact Harris County. No formal risk assessment of these hazards was performed, and no mitigation initiatives have been developed to address them. However, all planning partners for this plan should be aware of these hazards and should take steps to reduce the risks they present whenever it is practical to do so.

17.1 ENERGY PIPELINE FAILURE

17.1.1 General Background

The energy infrastructure of the United States consists of many components, including the physical network of pipes for oil and natural gas, electricity transmission lines, and other means for transporting energy to the nation's consumers. This infrastructure includes facilities that convert raw natural resources into energy products, as well as rail networks, trucking lines and marine transportation (U.S. Department of Energy, 2009). Much of this infrastructure is aging, and in addition to the challenges of keeping the infrastructure up-to-date with the latest technological advances and consumer needs, the potential for an energy pipeline failure must be considered.

The 1.6 million miles (Bureau of Transportation and Statistics, 2009) of petroleum and gas pipelines in the United States are the principal mode for transporting oil, natural gas, and other petroleum products such as gasoline (Allegro Energy, 2001). Much of the oil pipeline infrastructure is old, requiring regular safety and environmental reviews to ensure its safety and reliability. The potential risk of pipeline accidents is a significant national concern.

The energy infrastructure is vulnerable to physical and cyber disruption, either of which could threaten its integrity and safety (U.S. Department of Energy, 2009). Disruptions could originate with natural events such as geomagnetic storms and earthquakes, or could result from accidents, equipment failures or deliberate interference. In addition, the nation's transportation and power infrastructures have grown increasingly complex and interdependent — consequently, any disruption could have far-reaching consequences.

17.1.2 Past Events

Due to the secured nature of this data, it was difficult to obtain any historical occurrence information for energy pipeline failures. However, the Harris County Fire Marshal's Office reports a total of 55 energy pipeline failures between 2006 and 2013 within the planning area. Harris County will attempt to include additional information in future updates of this plan if new studies or future releases of data become available.

17.1.3 Location

Energy pipelines cross counties throughout southeast Texas. Although the majority of Harris County is at risk, the eastern region of the planning area is likely the most vulnerable due to an increased quantity of pipelines in the area. Figure 17-1 identifies all areas within the Harris County planning area within a quarter-mile of an identified pipeline; this was used as the focal point for the vulnerability and estimated exposure analysis.

Figure 17-1. Pipeline Failure Hazard Areas in Harris County

17.1.4 Frequency

Based on historical data provided by the Harris County Fire Marshal's Office, the probability of the Harris County planning area and all participating jurisdictions being affected by a pipeline failure event is once every 0.13 years or 47.45 days. The majority of pipeline incidents are isolated; although the risk area and estimated exposure appear large, the actual exposure per event, even for large events, is isolated.

17.1.5 Severity

The impacts associated with a pipeline failure are highly dependent upon the product being transported. If any of the energy pipelines in the planning area were to rupture, such an event could endanger lives and cause damage to property in the immediate area (within less than a half-mile radius).

17.1.6 Warning Time

Energy pipeline failures are occasional events, with an event possible in the next five years. Energy pipeline failures are not subject to seasonal patterns; an event can occur at any time of year. Warning time for pipeline accidents is minimal or none. Most pipelines are continuously monitored by their operators. Information about the pipeline's operating equipment and parameters is constantly communicated to the control center where personnel use computers to monitor pipeline pressure, temperature, flow, alarms, and other conditions in the pipeline. While pipeline operators work hard to achieve reliable incident-free operation, accidents do occur. In the event of an emergency, the control center may be able to immediately shutdown the pipeline and begin to isolate the source of the leak. The pipeline operator's control center may also have the capability to remotely open and close valves and transfer products both to and from the main pipeline at marketing and distribution facilities.

17.1.7 Secondary Hazards

Pipeline spills and leaks can pollute waterways exposing fish to toxic chemicals that can kill on impact or cause disease over the long-term. Spills of petrochemicals can also negatively impact the growth of other aquatic life destroying plant habitat and insect food sources. Common secondary hazards associated with pipeline failure include:

- Fire
- Mass movements
- Air Quality
- Public Health

17.2 TOXIC RELEASE/HAZARDOUS MATERIALS

17.2.1 General Background

In a hazardous materials incident, solid, liquid and/or gaseous contaminants may be released from fixed or mobile containers. Nationwide, an average of almost 6,800 hazardous materials events occur each year: 5,500 highway incidents, 1,000 railroad incidents and 270 events from other causes. The duration of a hazardous materials incident can range from hours to days. This profile focuses on releases from fixed sites.

17.2.2 Causes

Hazardous materials incidents can occur as a result of or in tandem with natural hazard events, such as floods, hurricanes, tornadoes and earthquakes, which in addition to causing incidents can also hinder response efforts. In the case of Hurricane Floyd in September 1999, communities along the Eastern United States were faced with flooded junkyards, disturbed cemeteries, deceased livestock, floating propane tanks, uncontrolled fertilizer spills and a variety of other environmental pollutants that caused widespread concern.

Weather conditions will directly affect how the hazard develops. The micro-meteorological effects of buildings and terrain can alter travel and duration of agents. Non-compliance with fire and building codes, as well as failure to maintain existing fire and containment features can substantially increase the damage from a hazardous materials release. In addition to the primary release, explosions and/or fires can result from a release, and

contaminants can be extended beyond the initial area by persons, vehicles, water, wind and wildlife. These factors contribute to the importance of maintaining an effective response team at all times.

17.2.3 Reporting Standards

The Toxics Release Inventory (TRI) is a publicly available database from the federal Environmental Protection Agency (EPA) that contains information on toxic chemical releases and other waste management activities reported annually by certain industry groups and federal facilities (EPA, 2016a). This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 and expanded by the Pollution Prevention Act of 1990. Each year, facilities that meet certain activity thresholds must report their releases and other waste management activities for listed toxic chemicals to EPA and to their state or tribal entity. A facility must report if it meets the following three criteria:

- The facility falls within one of the following industrial categories: manufacturing; metal mining; coal mining; electric generating facilities that combust coal and/or oil; chemical wholesale distributors; petroleum terminals and bulk storage facilities; RCRA Subtitle C treatment, storage, and disposal facilities; and solvent recovery services;
- Has 10 or more full-time employees, and
- Manufactures or processes more than 25,000 pounds or otherwise uses more than 10,000 pounds of any listed chemical during the calendar year. Persistent, bio-accumulative and toxic chemicals are subject to different thresholds of 10 pounds, 100 pounds or 0.1 grams depending on the chemical.

17.2.4 Past Events

Due to methodology of data reporting used for TRI data, we are unable to determine or provide historical occurrence data for events causing off-site impact based on this information. However, we are able to determine that as of 2012, Harris County has 386 TRI facilities within its boundaries.

The Harris County Hazardous Materials Response Team reports 736 toxic / hazardous materials incident responses between the years 2010 through 2013. Table 17-1 shows the team's number of responses for each year within the planning area.

Table 17-1. Toxic / Hazardous Materials Responses in Harris County (2010 - 2013)

Year	Responses
2010	80
2011	227
2012	185
2013	244
Total	736

Source: Harris County Hazardous Materials Response Team Annual Emergency Operations Performance Metrics (2010-2013)

17.2.5 Location

With one of the largest petrochemical complexes in the nation, the Harris County planning area is at risk to the release of hazardous materials. Based on the TRI data and Tobler's law, the areas in proximity to a TRI facility would be at a higher risk of impact that those further away. Due to the large number of chemicals associated with these facilities, it is not feasible to conduct an analysis based on each chemical and its potential effects. However, the chemical involved in a release is a factor in measuring impacts. Figure 17-2 shows the locations of all 386 toxic sites listed on the TRI in the Harris County planning area.

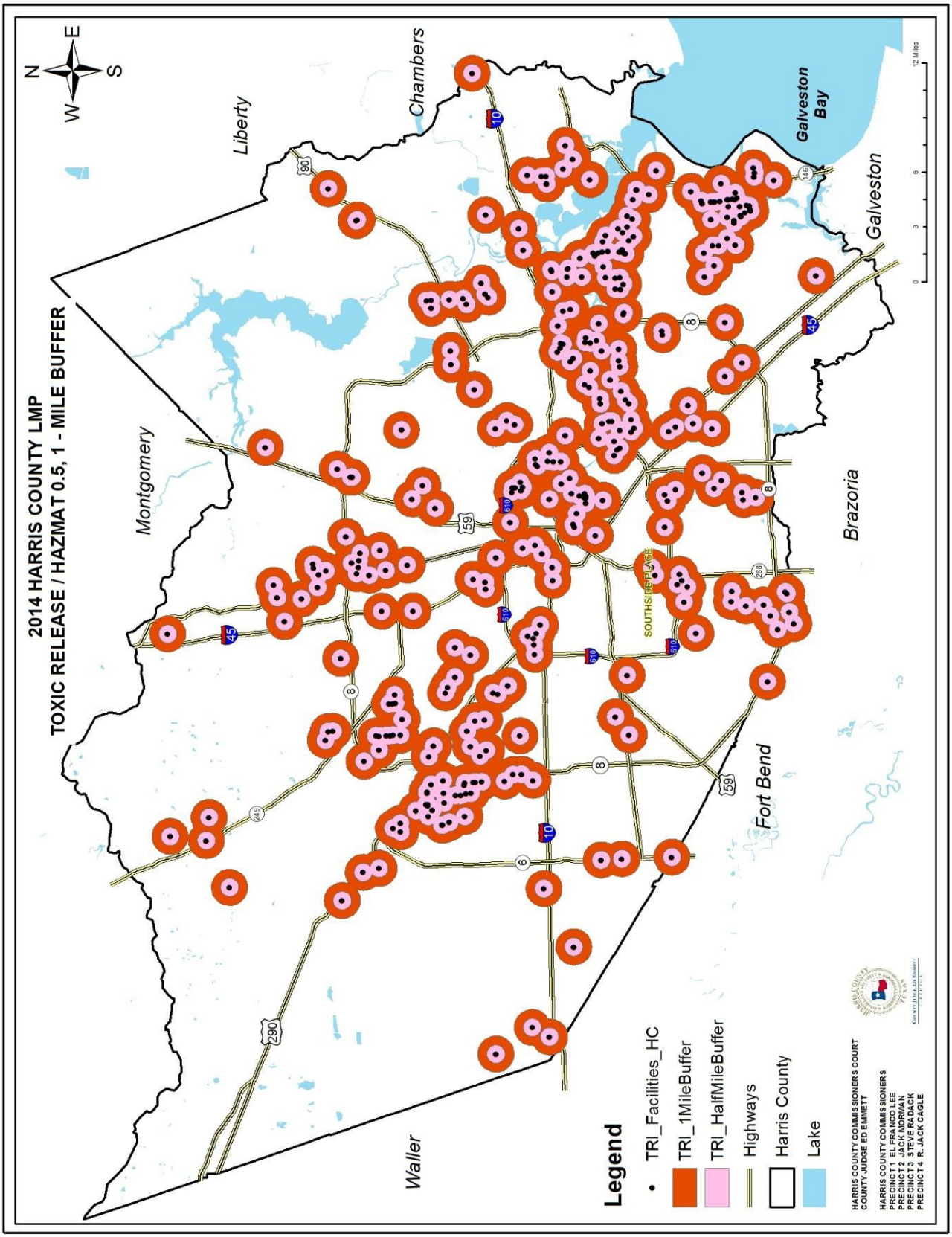


Figure 17-2. Toxic Release / Haz-Mat Hazard Areas in Harris County

17.2.6 Frequency

Based on the historical occurrence data provided by the Harris County Fire Marshal's Office, the probability of the Harris County planning area and all participating jurisdictions being affected by a toxic/hazardous materials event is once every 0.04 years or every 1.46 days.

17.2.7 Severity

Hazardous materials or toxic releases can have a substantial impact. Such events can cause multiple deaths, completely shut down facilities for 30 days or more, and cause more than 50 percent of affected properties to be destroyed or suffer major damage.

Toxic releases can have a substantial impact on the health and safety of the public and first responders. Such events can cause multiple deaths, shut down facilities or operations, and cause major damage to nearby properties. Shielding in the form of sheltering-in-place can protect people and property from harmful effects.

17.2.8 Warning Time

Warning time for hazardous materials incidents is minimal to none.

17.2.9 Secondary Hazards

Common secondary hazards associated with toxic releases and hazardous materials include:

- Fire
- Air quality
- Public health.

18. CLIMATE CHANGE

18.1 GENERAL BACKGROUND

18.1.1 What is Climate Change?

Climate, consisting of patterns of temperature, precipitation, humidity, wind and seasons, plays a fundamental role in shaping natural ecosystems and the human economies and cultures that depend on them. "Climate change" refers to changes over a long period of time. Worldwide, average temperatures have increased 1.8ºF since 1880 (NASA, 2018). Although this change may seem small, it can lead to large changes in climate and weather.

The warming trend and its related impacts are caused by increasing concentrations of carbon dioxide and other greenhouse gases in the earth's atmosphere. Greenhouse gases are gases that trap heat in the atmosphere, resulting in a warming effect. Carbon dioxide is the most commonly known greenhouse gas; however, methane, nitrous oxide and fluorinated gases also contribute to warming. Emissions of these gases come from a variety of sources, such as the combustion of fossil fuels, agricultural production, changes in land use and volcanic eruptions. Carbon dioxide concentrations measured about 280 parts per million before the industrial era began in the late 1700s and are now recorded at more than 407 parts per million (EPA, 2016 and NASA, 2018) (see Figure 18-1).

Source: EPA, 2016

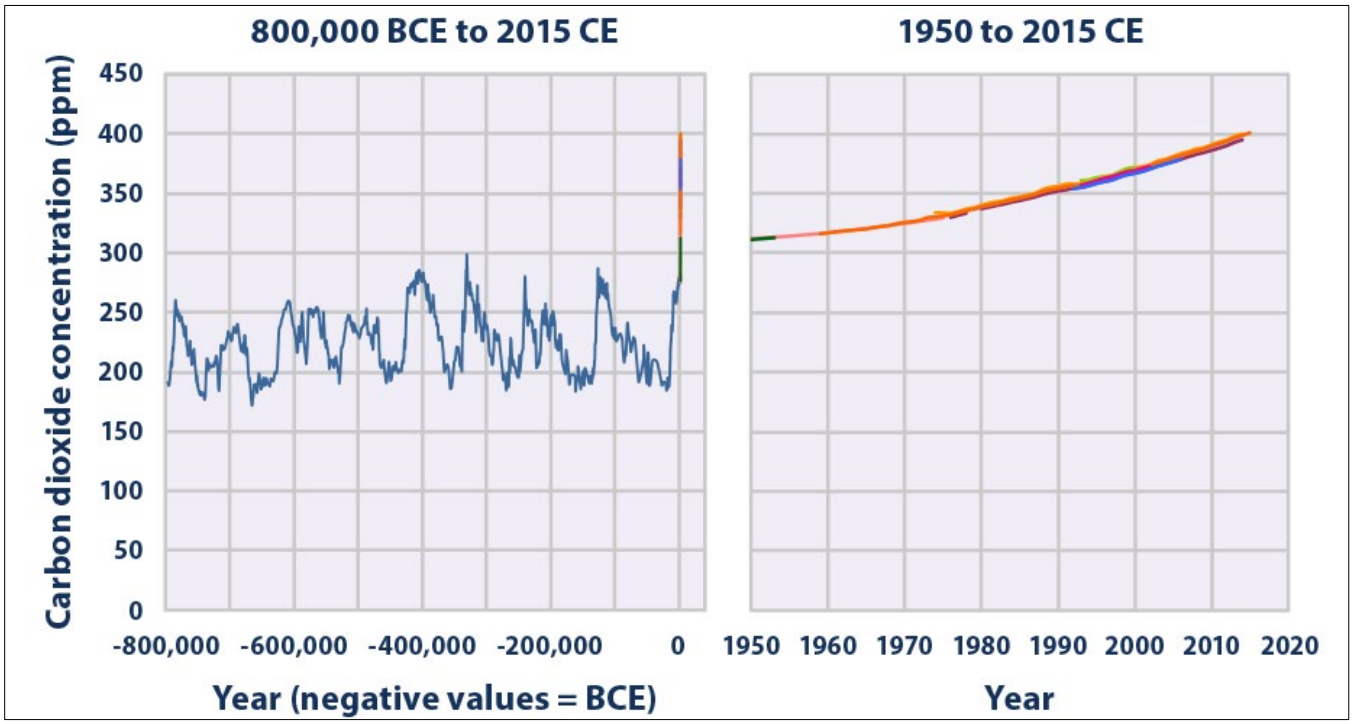


Figure 18-1. Global Carbon Dioxide Concentrations Over Time

In addition, the concentration of methane has almost doubled and nitrous oxide was being measured at a record high of 328 parts per billion as of 2015. In the United States, electricity generation is the largest source of these emissions, followed by transportation (EPA, 2016b).

Scientists are able to place this rise in carbon dioxide in a longer historical context through the measurement of carbon dioxide in ice cores. According to these records, carbon dioxide concentrations in the atmosphere are the highest that they have been in 650,000 years (NASA, 2016). According to NASA, most of this trend is very likely human-induced and it is proceeding at an unprecedented rate (NASA, 2016). There is broad scientific consensus (97 percent of scientists) that climate-warming trends are extremely likely due to human activities (NASA, 2018). Unless emissions of greenhouse gases are substantially reduced, this warming trend is expected to continue.

Climate change will affect the people, property, economy and ecosystems of the planning area in a variety of ways. Climate change impacts are most frequently associated with negative consequences, such as increased flood vulnerability or increased heat-related illnesses/public health concerns; however, other changes may present opportunities. The most important effect for the development of this plan is that climate change will have a measurable impact on the occurrence and severity of natural hazards.

18.1.2 How Climate Change Affects Hazard Mitigation

An essential aspect of hazard mitigation is predicting the likelihood of hazard events. Typically, predictions are based on statistical projections from records of past events. This approach assumes that the likelihood of hazard events remains essentially unchanged over time. Thus, averages based on the past frequencies of, for example, floods are used to estimate future frequencies: if a river has flooded an average of once every 5 years for the past 100 years, then it can be expected to continue to flood an average of once every 5 years.

For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. As flooding is generally associated with precipitation frequency and quantity, for example, the frequency of flooding will not remain constant if broad precipitation patterns change over time. Floods currently considered to be 1-percent-annual-chance events might strike more often, leaving many communities at greater risk. The risks of landslide, severe storms, extreme heat and wildfire are all affected by climate patterns as well. For this reason, an understanding of climate change is pertinent to efforts to mitigate natural hazards. Information about how climate patterns are changing provides insight on the reliability of future hazard projections used in mitigation analysis. This chapter summarizes current understandings about climate change in order to provide a context for the recommendation and implementation of hazard mitigation measures.

18.1.3 Current Indicators of Climate Change

Global Impacts

The major scientific agencies of the United States and the world—including NASA, NOAA and the Intergovernmental Panel on Climate Change (IPCC)—agree that climate change is occurring. Multiple temperature records from all over the world have shown a warming trend. The IPCC has stated that the warming of the climate system is unequivocal (IPCC, 2014). Seventeen of the 18 warmest years on record occurred since 2001, and 2016 was the warmest year on record (NASA, 2017).

Rising global temperatures have been accompanied by other changes in weather and climate. Many places have experienced changes in rainfall resulting in more intense rain, as well as more frequent and severe heat waves (IPCC, 2014a). The planet's oceans and glaciers have also experienced changes: oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. Global sea level has risen approximately 6.7 inches, on average, in the last 100 years (NASA, 2018). This has already put some coastal homes, beaches,

roads, bridges, and wildlife at risk (USGCRP, 2009). At the time of the development of this plan, NASA reports the following trends (NASA, 2017):

- Carbon Dioxide—Increasing trend, currently at 407.61 parts per million
- Global Temperature—Increasing trend, increase of 1.8ºF since 1880
- Arctic Ice Minimum—Decreasing trend, 13.2 percent per decade
- Land Ice—Decreasing trend, 286.0 gigatonnes per year
- Sea Level—Increasing trend, 3.2 millimeters (0.13 inches) per year.

Impacts in Texas

Texas's climate is changing. Most of the state has warmed between one-half and one degree (F) in the past century. In the eastern two-thirds of the state, average annual rainfall is increasing, yet the soil is becoming drier. Rainstorms are becoming more intense, and floods are becoming more severe. Along much of the coast, the sea is rising almost 2 inches per decade (U.S. EPA, 2016c).

18.1.4 Projected Future Impacts

Global Impacts

The *Third National Climate Assessment Report for the United States* indicates that impacts resulting from climate change will continue through the 21st century and beyond. Although not all changes are understood at this time and the impacts of those changes will depend on global emissions of greenhouse gases and sensitivity in human and natural systems, the following impacts are expected in the United States (NASA, 2014):

- Temperatures will continue to rise.
- Growing seasons will lengthen.
- Precipitation patterns will change.
- Droughts and heat waves will increase.
- Hurricanes will become stronger and more intense.
- Sea level will rise 1 to 4 feet by 2100.
- The Arctic may become ice free.

Sea levels have been rising over the past several decades and are expected to continue to rise. Sea level rise is mostly attributed to two factors: the expansion of water as it warms (thermal expansion) and the melting of ice sheets and glaciers. As average ocean temperatures continue to increase, thermal expansion will continue and can be projected with some degree of certainty. Less certain is how quickly ice sheets will melt, accounting for most of the uncertainty in projections. Sea level rise will cause currently dry areas to be permanently or chronically inundated. Temporary inundation from extreme tide events and storm surge also will change.

Impacts in Texas

In the coming decades, storms are likely to become more severe in Texas. Deserts may expand, and summers are likely to become increasingly hot and dry. If the oceans and atmosphere continue to warm, sea level is likely to rise 2 to 5 feet in the next century along much of the Texas coast. Hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm (U.S. EPA, 2016c).

Coastal homes and infrastructure will flood more often as sea level rises, because storm surges will become higher as well. Many cities, roads, railways, ports, airports, and oil and gas facilities along the Gulf Coast are vulnerable to the combined impacts of storms and sea level rise. The amount of rainfall during the wettest days of the year is likely to continue to increase, which would increase flooding (U.S. EPA, 2016c).

Despite the increase in heavy storms, changing climate is likely to make water less available overall. Seventy years from now, Texas is likely to have three or four times as many days per year above 100°F as it has today. As warmer temperatures increase evaporation and water use by plants, soils are likely to continue to become drier. Average rainfall is likely to decrease during winter, spring, and summer. Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires. Warmer air can also increase the formation of ground-level ozone, a key component of smog (U.S. EPA, 2016c).

18.1.5 Responses to Climate Change

Communities and governments worldwide are working to address, evaluate and prepare for climate changes that are likely to impact communities in coming decades. Generally, climate change discussions encompass two separate but inter-related considerations: mitigation and adaptation. The term "mitigation" can be confusing, because its meaning changes across disciplines:

- Mitigation in restoration ecology and related fields generally refers to policies, programs or actions that are intended to reduce or to offset the negative impacts of human activities on natural systems. Generally, mitigation can be understood as avoiding, minimizing, rectifying, reducing or eliminating, or compensating for known impacts.
- Mitigation in climate change discussions is defined as "a human intervention to reduce the impact on the climate system." It includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.
- Mitigation in emergency management is typically defined as the effort to reduce loss of life and property by lessening the impact of disasters.

In this chapter, mitigation is used as defined by the climate change community. In the other chapters of this plan, mitigation is primarily used in an emergency management context.

The IPCC defines adaptation as "the process of adjustment to actual or expected climate and its effects." Mitigation and adaptation are related, as the world's ability to reduce greenhouse gas emissions will affect the degree of adaptation that will be necessary. Some actions can both reduce greenhouse gas emissions and support adaptation to likely future conditions. Some adaptation actions also help communities reach other community goals (often referred to as co-benefits). The ability to adapt to changing conditions is often referred to as adaptive capacity, which is "the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014a).

Societies across the world are facing the need to adapt to changing conditions and to identify ways to increase their adaptive capacity. Some efforts are already underway. Farmers are altering crops and agricultural methods to deal with changing rainfall and rising temperature; architects and engineers are redesigning buildings; planners are looking at managing water supplies to deal with droughts or flooding.

Adaptive capacity goes beyond human systems, as some ecosystems are able to adapt to change and to buffer surrounding areas from the impacts of change. Forests can bind soils and hold large volumes of water during times of plenty, releasing it through the year; floodplains can absorb vast volumes of water during peak flows; coastal ecosystems can hold out against storms, attenuating waves and reducing erosion. Other ecosystem services—such as food provision, timber, materials, medicines and recreation—can provide a buffer to societies in the face of changing conditions. Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change. This includes the sustainable management, conservation and restoration of specific ecosystems that provide key services.

Assessment of the current efforts and adaptive capacity of the planning partners participating in this hazard mitigation plan are included in the jurisdiction-specific annexes in Volume 2.

18.2 CLIMATE CHANGE IMPACTS ON NATURAL HAZARDS

The following sections provide information on how each identified hazard of concern for this planning process may be impacted by climate change and how these impacts may alter current exposure and vulnerability to these hazards for the people, property, critical facilities and the environment in the planning area.

18.2.1 Coastal Erosion

The impacts of climate change—especially sea level rise—are likely to worsen coastal erosion problems. Growing populations and development along the coasts increase the vulnerability of coastal ecosystems to sea level rise. Development can block the inland migration of wetlands in response to sea level rise, change the amount of sediment delivered to coastal areas, and accelerate erosion. As a result of such changes, wetlands may not receive enough sediment to keep up with rising seas, and may no longer function as natural buffers to flooding and erosion (U.S. EPA, 2017).

18.2.2 Dam Failure

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Dams are constructed with safety features known as "spillways." Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as "design failures," result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

18.2.3 Drought

The long-term effects of climate change on regional water resources are unknown, but global water resources are already experiencing the following stresses without climate change:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure.

With a warmer climate, droughts could become more frequent, more severe, and longer-lasting. According to the National Climate Assessment, "higher surface temperatures brought about by global warming increase the potential for drought. Evaporation and the higher rate at which plants lose moisture through their leaves both increase with temperature. Unless higher evapotranspiration rates are matched by increases in precipitation, environments will tend to dry, promoting drought conditions" (U.S. Climate Resilience Toolkit, 2018).

Because changes in precipitation patterns are still uncertain, the potential impacts and likelihood of drought are uncertain.

18.2.4 Earthquake

The impacts of global climate change on earthquake probability are unknown. Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms or heavy precipitation could experience liquefaction or an increased propensity for slides during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events.

18.2.5 Flood

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Scientists project greater storm intensity with climate change, resulting in more direct runoff and flooding. High frequency flood events in particular will likely increase with a changing climate. What is currently considered a 1-percent-annual-chance also may strike more often, leaving many communities at greater risk. Going forward, model calibration must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted.

Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

18.2.6 Mass Movement

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

18.2.7 Severe Weather, Including Hurricanes and Coastal Storms

Climate change presents a challenge for risk management associated with severe weather. The number of weather-related disasters during the 1990s was four times that of the 1950s and led to 14 times as much in economic losses. The science for linking the severity of specific severe weather events to climate change is still evolving; however, a number or trends provide some indication of how climate change may be impacting these events. According to the *U.S. National Climate Change Assessment* (2014), there were more than twice as many high temperature records as low temperature records broken between 2001 and 2012, and heavy rainfall events are becoming more frequent and more severe. The increase in average surface temperatures can also lead to more

intense heat waves. Evidence suggests that heat waves are already increasing, especially in western states. Extreme heat days in the planning area are likely to increase. Climate change impacts on other severe weather events such as thunderstorms and high winds are still not well understood.

18.2.8 Tsunami

The impacts of global climate change on tsunami probability are unknown. Some scientists say that melting glaciers could induce tectonic activity, inducing earthquakes. Other scientists have indicated that underwater avalanches (also caused by melting glaciers), may also result in tsunamis. Even if climate change does not increase the frequency with which tsunamis occur, it may result in more destructive waves. As sea levels continue to rise, tsunami inundation areas would likely reach further into communities than current mapping indicates.

18.2.9 Wildfire

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. Changes in climate patterns may impact the distribution and perseverance of insect outbreaks that create dead trees (increase fuel). When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

18.3 ISSUES

The major issues for climate change are the following:

- Planning for climate change related impacts can be difficult due to inherent uncertainties in projection methodologies.
- Average temperatures are expected to continue to increase in the planning area, which may lead to a host of primary and secondary impacts, such as an increased incidence of heat waves.
- Expected changes in precipitation patterns are still poorly understood and could have significant impacts on the water supply and flooding in the planning area.
- Some impacts of climate change are poorly understood such as potential impacts on the frequency and severity of earthquakes, thunderstorms and tsunamis.
- Heavy rain events may result in inland stormwater flooding after stormwater management systems are overwhelmed.
- Permanent and temporary inundation resulting from sea level rise has the potential to impact portions of the population and assets in the planning area.

19. RISK RANKING

FEMA requires all hazard mitigation planning partners to have jurisdiction-specific mitigation actions based on local risk, vulnerability and community priorities (FEMA, 2011). This plan included a risk ranking protocol for each planning partner, in which "risk" was calculated by multiplying probability by impact on people, property and the economy. The risk estimates were generated using methodologies promoted by FEMA. The Steering Committee reviewed, discussed and approved the methodology and results. All planning partners ranked risk for their own jurisdictions following the same methodology.

Numerical ratings of probability and impact were based on the hazard profiles and exposure and vulnerability evaluations presented in Chapters 7 through 17. Using that data, each planning partner ranked the risk of all the natural hazards of concern described in this plan. When available, estimates of risk were generated with data from Hazus or GIS. For hazards of concern with less specific data available, qualitative assessments were used. As appropriate, results were adjusted based on local knowledge and other information not captured in the quantitative assessments.

Risk ranking results are used to help establish mitigation priorities. Each partner used its risk ranking to inform the development of its action plan. Planning partners were directed to identify mitigation actions, at a minimum, to address each hazard with a "high" or "medium" risk ranking. Actions that address hazards with a low or no hazard ranking are optional.

Volume 2 presents the risk rankings for each planning partner. The following planning-area-wide risk ranking was prepared by the CPT.

19.1 PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)
Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
No exposure—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is based on past hazard events in the area and the potential for changes in the frequency of these events resulting from climate change. Table 19-1 summarizes the probability assessment for each natural hazard of concern for this plan.

Table 19-1. Probability of Hazards

Hazard Event	Probability (high, medium, low)	Probability Factor
Coastal Erosion	Low	1
Dam/Levee Failure	Low	1
Drought	High	3
Earthquake	Low	1
Flood	High	3
Hurricane /Coastal Storms	High	3
Mass Movements	Low	1
Severe Weather	High	3
Tsunami	Low	1
Wildfire	High	3

19.2 IMPACT

Hazard impacts were assessed in three categories: impacts on people, impacts on property and impacts on the local economy. Numerical impact factors were assigned as follows:

- **People**—Values were assigned based on the percentage of the total ***population exposed*** to the hazard event. The degree of impact on individuals will vary and is not measurable, so the calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people. Impact factors were assigned as follows:

  - High—25 percent or more of the population is exposed to a hazard (Impact Factor = 3)
  - Medium—10 percent to 25 percent of the population is exposed to a hazard (Impact Factor = 2)
  - Low—10 percent or less of the population is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the population is exposed to a hazard (Impact Factor = 0)

Property—Values were assigned based on the percentage of the total ***property value exposed*** to the hazard event:

  - High—25 percent or more of the total assessed property value is exposed to a hazard (Impact Factor = 3)
  - Medium—10 percent to 25 percent of the total assessed property value is exposed to a hazard (Impact Factor = 2)
  - Low—10 percent or less of the total assessed property value is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the total assessed property value is exposed to a hazard (Impact Factor = 0)

- **Economy**—Values were assigned based on the percentage of the total ***property value vulnerable*** to the hazard event. Values represent estimates of the loss from a major event of each hazard in comparison to the total replacement value of the property exposed to the hazard. Loss estimates separate from the exposure estimates were generated for the earthquake, flooding, and tsunami hazards using Hazus. For other hazards, such as dam failure, landslide and wildfire, vulnerability was estimated as a percentage of exposure, due to the lack of loss estimation tools specific to those hazards.

  - High—Estimated loss from the hazard is 10 percent or more of the total exposed property value (Impact Factor = 3)

- Medium—Estimated loss from the hazard is 5 percent to 10 percent of the total exposed property value (Impact Factor = 2)
- Low—Estimated loss from the hazard is 5 percent or less of the total exposed property value (Impact Factor = 1)
- No impact—No loss is estimated from the hazard (Impact Factor = 0)

The impacts of each hazard category were assigned a weighting factor to reflect the significance of the impact. These weighting factors are consistent with those typically used for measuring the benefits of hazard mitigation actions: impact on people was given a weighting factor of 3; impact on property was given a weighting factor of 2; and impact on the economy was given a weighting factor of 1. Table 19-2, Table 19-3 and Table 19-4 summarize the impacts for each hazard.

Table 19-2. Impact on People from Hazards

Hazard Event	Impact (high, medium, low, none)	Impact Factor	Multiplied by Weighting Factor (3)
Coastal Erosion	Low	1	1 x3 =3
Dam/Levee Failure	Low	1	1x3=3
Drought	None	0	0x3=0
Earthquake	High	3	3x3=9
Flood	Medium	2	2x3-6
Hurricane /Coastal Storms	High	3	3x3=9
Mass Movements	Low	1	1x3=3
Severe Weather	High	3	3x3=9
Tsunami	Low	1	1x3=3
Wildfire	Low	1	1x3=3

Table 19-3. Impact on Property from Hazards

Hazard Event	Impact (high, medium, low, none)	Impact Factor	Multiplied by Weighting Factor (2)
Coastal Erosion	Low	1	1x2=2
Dam/Levee Failure	Low	1	1x2=2
Drought	None	0	0x2=0
Earthquake	High	3	3x2=6
Flood	Medium	2	2x2=4
Hurricane /Coastal Storms	High	3	3x2=6
Mass Movements	Low	1	1x2=2
Severe Weather	High	3	3x2=6
Tsunami	Low	1	1x2=2
Wildfire	Medium	2	2x2=4

Table 19-4. Impact on Economy from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (1)
Coastal Erosion	Low	1	1x1=1
Dam/Levee Failure	Low	1	1x1=1
Drought	Medium	2	2x1=2
Earthquake	Low	1	1x1=1
Flood	Medium	2	2x1=2
Hurricane /Coastal Storms	Medium	2	2x1=2
Mass Movements	Low	1	1x1=1
Severe Weather	Medium	2	2x1=2
Tsunami	Low	1	1x1=1
Wildfire	Low	1	1x1=1

19.3 RISK RATING AND RANKING

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors, as summarized in Table 19-5. Based on these ratings, a priority of high, medium or low was assigned to each hazard. The hazards of highest concern are Hurricanes/Coastal Storms, severe weather and Flood. Hazards ranked as being of medium concern are wildfire and earthquake. The hazards ranked as being of lowest concern are coastal erosion, drought, dam failure, mass movements and tsunami. Table 19-6 shows the hazard risk ranking for the planning area. Hazard risk ranking and scoring for each participating planning partner can be found in Volume 2 of this plan. Table 19-7 shows risk ranking results for all planning partners.

Table 19-5. Hazard Risk Rating

Hazard Event	Probability Factor	Sum of Weighted Impact Factors	Total (Probability x Impact)
Coastal Erosion	1	3+2+1=6	1x6=6
Dam/Levee Failure	1	3+2+1=6	1x6=6
Drought	3	0+0+2=2	3x2=6
Earthquake	1	9+6+1=16	1x16=16
Flood	3	6+4+2=12	3x12=36
Hurricane /Coastal Storms	3	9+6+2=17	3x17=51
Mass Movements	1	3+2+1=6	1x6=6
Severe Weather	3	9+6+2=17	3x17=51
Tsunami	1	3+2+1=6	1x6=6
Wildfire	3	3+4+1=8	3x8=24

Table 19-6. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category[a]
1	Hurricane and Coastal Storms (51)	High
1	Severe Weather (51)	High
2	Flood (36)	High
3	Wildfire (24)	Medium
4	Earthquake (16)	Medium
5	Coastal Erosion (6)	Low
5	Drought (6)	Low
5	Dam Failure (6)	Low
5	Mass Movements (6)	Low
5	Tsunami (6)	Low

a. Scores of 30 or greater are rated as “high,” scores of 15 to 29 are “medium,” and scores of less than 15 are “low”

Table 19-7. Aggregate Risk Ranking Results for all Planning Partners

Jurisdiction	Coastal Erosion	Dam/Levee Failure	Drought	Earthquake	Flood	Hurricane/ Coastal Storm	Mass Movements	Severe Weather	Tsunami	Wildfire
Harris County	Low	Low	Low	Medium	High	High	Low	High	Low	Medium
City of Baytown	Low	Low	Low	Low	High	High	Low	High	None	Medium
City of Bellaire	None	Low	Low	Low	High	High	Low	High	None	Low
City of Bunker Hill Village	None	None	Low	Low	Low	High	None	High	None	Low
City of Deer Park	None	Low	Low	Low	Medium	High	Low	High	None	High
City of El Lago	None	Low	Low	Low	High	High	Low	High	None	Low
City of Friendswood	None	None	Low	Low	Medium	High	None	High	None	Medium
City of Galena Park	None	Low	Low	Low	Medium	High	Low	High	None	Low
City of Hedwig Village	None	None	Low	Low	None	High	Low	High	None	Low
City of Hilshire Village	None	None	Low	Low	Medium	High	None	High	None	Low
City of Humble	None	Medium	Low	Low	Medium	High	None	High	None	Medium
City of Hunters Creek Village	None	Low	Low	Low	Medium	High	Low	High	None	None
City of Jersey Village	None	None	Low	Low	High	High	None	High	None	Low
City of Katy	None	Low	Low	Low	High	High	Medium	High	None	Medium
City of La Porte	Low	Low	Low	Low	High	High	Low	High	None	Low
City of Missouri City	None	Medium	Medium	Low	High	High	Low	High	Low	Low
City of Morgan's Point	Low	Low	Low	Low	Medium	High	Low	High	None	Low
City of Nassau Bay	Low	None	Low	Low	High	High	Medium	High	None	Low
City of Pasadena	None	Low	Medium	Low	High	High	Low	High	None	Medium
City of Piney Point Village	None	None	Low	Low	Medium	High	Low	High	None	Low
City of Seabrook	None	None	Low	Low	High	High	Low	High	Low	Low
City of Shoreacres	None	None	Low	Low	High	High	Low	High	Low	Medium
City of Spring Valley Village	None	None	Low	Low	Low	High	Low	High	None	Low
City of Stafford	None	None	Low	Low	Low	High	None	High	None	Low
City of Taylor Lake Village	None	None	Low	Low	High	High	Low	High	None	Medium
City of Tomball	None	None	Low	Low	Medium	High	None	High	None	Medium
City of Webster	None	None	Low	Low	High	High	Low	High	None	Low
City of West University Place	None	None	Low	Low	Medium	High	Low	High	None	None
Houston ISD	None	Low	Low	Low	Medium	High	Low	High	Low	Low
Huffman ISD	None	None	Low	Low	High	High	None	Medium	None	Low
Pasadena ISD	None	None	Low	Low	Medium	High	None	High	None	Low
Houston Community College	Low	Medium	Low	Low	High	High	Low	High	Low	Low
Lone Star College	None	Low	Low	Low	Medium	High	None	High	None	Low
University of Houston	None	None	Low	Low	High	High	Low	High	None	Low
Harris County FCD	None	Low	Low	Low	High	High	Low	High	Low	Low
Harris County ESD-12	None	None	Low	Low	Medium	High	None	High	None	Low
Harris County Hospital District (dba Harris Health System)	None	Low	Low	Low	Medium	High	None	High	None	Low
Texas Medical Center	Low	Medium	Low	Low	High	High	Low	High	Medium	Low

PART 3—MITIGATION STRATEGY

20. MISSION STATEMENT, GOALS AND OBJECTIVES

Hazard mitigation plans must identify goals for reducing long-term vulnerabilities to identified hazards (44 CFR Section 201.6(c)(3)(i)). The Steering Committee reviewed the mission statement, goals and objectives from the 2015 Hazard Mitigation Plan. The mission statement, goals, objectives and actions in this plan all support each other. Goals were selected to support the mission statement. Objectives were selected that met multiple goals. Actions (presented in Chapter 19) were prioritized based on their ability to meet multiple objectives.

20.1 MISSION STATEMENT

A mission statement focuses the range of objectives and actions to be considered. This is not a goal because it does not describe a hazard mitigation outcome, and it is broader than a hazard-specific objective. The mission statement for this hazard mitigation plan is as follows:

> *Develop and maintain a comprehensive pre- and post-disaster hazard mitigation program. The Mission Statement is guided by the effective use of technology and data, improved communications and warning, the purchase of necessary equipment, sound planning, the adoption of codes, enhanced transportation networks, expanded education and outreach efforts, strengthened public facilities and infrastructure, the utilization/enhancement of natural resources, the consideration of future hazard conditions and the implementation of projects designed to reduce the vulnerability of individuals, families, households, businesses, infrastructure and critical facilities to the negative effects of natural and human-caused hazards.*

20.2 GOALS

The following are the mitigation goals for this plan:

1. Expand warning systems and local warning capabilities among departments and between jurisdictions.
2. Improve and coordinate data collection efforts to fully maximize the intent of the efforts and to improve the mitigation capabilities of the county and all jurisdictions.
3. Enhance education strategies to improve the dissemination of information to the public regarding hazards, including the steps that can be taken to reduce their impact.
4. Improve the capabilities of local government officials to reduce or eliminate hazards that cause loss of life, inflict injuries, cause property damage and to improve the protection of natural resources.
5. Work to improve and coordinate existing local plans, codes and regulations to reduce the impacts of natural hazards.
6. Implement property protection measures to reduce the effects of natural hazards throughout the county, including measures that reduce or eliminate repetitive loss occurrences.
7. Investigate and implement a range of structural projects that will reduce the effects of natural hazards on public and private property throughout the county.
8. Investigate and implement a range of nature-based solutions and utilize and enhance natural resources and their ability to reduce the impacts from natural hazards

20.3 OBJECTIVES

The selected objectives meet multiple goals. They serve as a stand-alone measurement of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives also are used to help establish priorities. The objectives are as follows:

1. Improve and expand systems that provide warning and emergency communications to the whole community
2. Implement wildfire mitigation and watershed protection strategies through local, state, tribal, federal and private partnerships.
3. Improve understanding of the locations, potential impacts, and linkages among threats, hazards, vulnerability, and measures needed to protect life safety and health.
4. Reduce the impacts of hazards on individuals with disabilities and others with access and functional needs.
5. Coordinate state and local efforts to reduce greenhouse gas emissions and implement climate adaptation strategies through hazard mitigation plans and actions.
6. Control access and provide buffers to maximize resource protection where possible.
7. Encourage all state, regional and local hazard mitigation projects and planning programs to protect the environment and promote implementation of sustainable mitigation and climate resilience actions.
8. Support hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem.
9. Encourage all cities, counties, special districts, Councils of Governments and tribal organizations to develop, adopt, and implement local hazard mitigation principles that may be integrated with local comprehensive plan safety elements, local coastal plans, facilities master plans, and other local plan initiatives.
10. Advance community resilience through preparation, adoption, and implementation of state, regional and local multi-hazard mitigation plans and projects.
11. Encourage projects that simultaneously reduce risk while increasing resilience and sustainability.
12. Manage new and existing development in high hazard areas, especially those known to be repetitively damaged.
13. Support the protection of vital and essential records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery.
14. Through the enforcement of relevant federal, State and local regulations, sustain life and property protection measures for all communities and structures located in the greater Harris County region.
15. Promote disaster resistant development.

21. MITIGATION BEST PRACTICES AND ADAPTIVE CAPACITY

21.1 MITIGATION BEST PRACTICES

Catalogs of hazard mitigation best practices were developed that present a broad range of alternatives to be considered for use in this plan, in compliance with 44 CFR (Section 201.6(c)(3)(ii)). One catalog was developed for each hazard of concern evaluated in this plan. The catalogs present alternatives that are categorized in two ways:

- By who would have responsibility for implementation:
  - Individuals (personal scale)
  - Businesses (corporate scale)
  - Government (government scale).
- By what the alternative would do:
  - Manipulate the hazard
  - Reduce exposure to the hazard
  - Reduce vulnerability to the hazard
  - Build local capacity to respond to or prepare for the hazard.

The alternatives presented include actions that will mitigate current risk from hazards and actions that will help reduce risk from changes in the impacts of these hazards resulting from climate change. Hazard mitigation actions recommended in this plan were selected from an analysis of the alternatives presented in the catalogs. The catalogs provide a baseline of mitigation alternatives that are backed by a planning process, are consistent with the established goals and objectives, and are generally within the capabilities of the planning partners to implement. Some of these actions may not be feasible based on the selection criteria identified for this plan. The purpose of the catalogs was to provide a list of what could be considered to reduce risk from natural hazards within the planning area. Actions selected out of the catalogs were based on an analysis of the planning partner's ability to implement the action and general feasibility. Actions in the catalog that are not included for the partnership's action plan were not selected for one or more of the following reasons:

- The action is not feasible.
- The action is already being implemented.
- The planning partner does not have the capability to implement the action.
- There is an apparently more cost-effective alternative.
- The action does not have public or political support.

The catalogs for each hazard are presented in Table 21-1 through Table-21-9.

Table 21-1. Alternatives to Mitigate the Dam Failure Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Relocate out of dam failure inundation areas • **Reduce vulnerability to the hazard:** ❖ Elevate home to appropriate levels • **Build local capacity to respond to or prepare for the hazard:** ❖ Learn about risk reduction for the dam failure hazard ❖ Learn the evacuation routes for a dam failure event ❖ Educate yourself on early warning systems and the dissemination of warnings	• **Manipulate the hazard:** ❖ Remove dams ❖ Harden dams • **Reduce exposure to the hazard:** ❖ Replace earthen dams with hardened structures • **Reduce vulnerability to the hazard:** ❖ Flood-proof facilities within dam failure inundation areas • **Build local capacity to respond to or prepare for the hazard:** ❖ Educate employees on the probable impacts of a dam failure ❖ Develop a continuity of operations plan	• **Manipulate the hazard:** ❖ Remove dams ❖ Harden dams • **Reduce exposure to the hazard:** ❖ Replace earthen dams with hardened structures ❖ Relocate critical facilities out of dam failure inundation areas ❖ Consider open space land use in designated dam failure inundation areas • **Reduce vulnerability to the hazard:** ❖ Adopt higher floodplain standards in mapped dam failure inundation areas ❖ Retrofit critical facilities within dam failure inundation areas • **Build local capacity to respond to or prepare for the hazard:** ❖ Map dam failure inundation areas ❖ Enhance emergency operations plan to include a dam failure component ❖ Institute monthly communications checks with dam operators ❖ Inform the public on risk reduction techniques ❖ Adopt real-estate disclosure requirements for the re-sale of property located within dam failure inundation areas ❖ Consider the probable impacts of climate change in assessing the risk associated with the dam failure hazard ❖ Establish early warning capability downstream of listed high hazard dams ❖ Consider the residual risk associated with protection provided by dams in future land use decisions

Table-21-2. Alternatives to Mitigate the Drought Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ None • **Reduce vulnerability to the hazard:** ❖ Drought-resistant landscapes ❖ Reduce water system losses ❖ Modify plumbing systems (through water saving kits) • **Build local capacity to respond to or prepare for the hazard:** ❖ Practice active water conservation	• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ None • **Reduce vulnerability to the hazard:** ❖ Drought-resistant landscapes ❖ Reduce private water system losses ❖ Support alternative irrigation techniques to reduce water use and encourage use of climate-sensitive water supplies • **Build local capacity to respond to or prepare for the hazard:** ❖ Practice active water conservation	• **Manipulate the hazard:** ❖ Groundwater recharge through stormwater management ❖ Develop a water recycling program ❖ Increase “above-the-dam” regional natural water storage systems • **Reduce exposure to the hazard:** ❖ Identify and create groundwater backup sources • **Reduce vulnerability to the hazard:** ❖ Water use conflict regulations ❖ Reduce water system losses ❖ Distribute water saving kits • **Build local capacity to respond to or prepare for the hazard:** ❖ Public education on drought resistance ❖ Identify alternative water supplies for times of drought; mutual aid agreements with alternative suppliers ❖ Develop drought contingency plan ❖ Develop criteria “triggers” for drought-related actions ❖ Improve accuracy of water supply forecasts ❖ Modify rate structure to influence active water conservation techniques

Table-21-3. Alternatives to Mitigate the Earthquake Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Locate outside of hazard area (off soft soils) • **Reduce vulnerability to the hazard:** ❖ Retrofit structure (anchor house structure to foundation) ❖ Secure household items that can cause injury or damage (such as water heaters, bookcases, and other appliances) ❖ Build to higher design • **Build local capacity to respond to or prepare for the hazard:** ❖ Practice "drop, cover, and hold" ❖ Develop household mitigation plan, such as creating a retrofit savings account, communication capability with outside, 72-hour self-sufficiency during an event ❖ Keep cash reserves for reconstruction ❖ Become informed on the hazard and risk reduction alternatives available. ❖ Develop a post-disaster action plan for your household	• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Locate or relocate mission-critical functions outside hazard area where possible • **Reduce vulnerability to the hazard:** ❖ Build redundancy for critical functions and facilities ❖ Retrofit critical buildings and areas housing mission-critical functions • **Build local capacity to respond to or prepare for the hazard:** ❖ Adopt higher standard for new construction; consider "performance-based design" when building new structures ❖ Keep cash reserves for reconstruction ❖ Inform your employees on the possible impacts of earthquake and how to deal with them at your work facility. ❖ Develop a continuity of operations plan	• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Locate critical facilities or functions outside hazard area where possible • **Reduce vulnerability to the hazard:** ❖ Harden infrastructure ❖ Provide redundancy for critical functions ❖ Adopt higher regulatory standards • **Build local capacity to respond to or prepare for the hazard:** ❖ Provide better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas (e.g., tax incentives, information) ❖ Include retrofitting and replacement of critical system elements in capital improvement plan ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components such as pipe, power line, and road repair materials ❖ Develop and adopt a continuity of operations plan ❖ Initiate triggers guiding improvements (such as <50% substantial damage or improvements) ❖ Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities. ❖ Develop a post-disaster action plan that includes grant funding and debris removal components. ❖ Consider the probable impacts of climate change on the risk associated with the drought hazard

Table-21-4. Alternatives to Mitigate the Flooding Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ Clear storm drains and culverts • **Reduce exposure to the hazard:** ❖ Locate outside of hazard area ❖ Elevate utilities above base flood elevation • **Reduce vulnerability to the hazard:** ❖ Raise structures above base flood elevation ❖ Elevate items within house above base flood elevation ❖ Build new homes above base flood elevation ❖ Flood-proof structures • **Build local capacity to respond to or prepare for the hazard:** ❖ Buy flood insurance ❖ Develop household plan, such as retrofit savings, communication with outside, 72-hour self-sufficiency during and after an event	• **Manipulate the hazard:** ❖ Clear storm drains and culverts • **Reduce exposure to the hazard:** ❖ Locate critical facilities or functions outside hazard area • **Reduce vulnerability to the hazard:** ❖ Build redundancy for critical functions or retrofit critical buildings ❖ Provide flood-proofing when new critical infrastructure must be located in floodplains • **Build local capacity to respond to or prepare for the hazard:** ❖ Keep cash reserves for reconstruction ❖ Support and implement hazard disclosure for sale of property in risk zones. ❖ Solicit cost-sharing through partnerships with others on projects with multiple benefits.	• **Manipulate the hazard:** ❖ Maintain drainage system ❖ Dredging, levee construction, and providing regional retention areas ❖ Structural flood control, levees, channelization, or revetments. ❖ Stormwater management regulations and master planning ❖ Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff • **Reduce exposure to the hazard:** ❖ Locate or relocate critical facilities outside of hazard area ❖ Acquire or relocate identified repetitive loss properties ❖ Promote open space uses in identified high hazard areas via techniques such as: planned unit developments, easements, setbacks, greenways, sensitive area tracks. ❖ Adopt land development criteria such as planned unit developments, density transfers, clustering ❖ Institute low impact development techniques on property ❖ Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff ❖ Preserve undeveloped and vulnerable shoreline ❖ Restore existing flood control and riparian corridors • **Reduce vulnerability to the hazard:** ❖ Harden infrastructure, bridge replacement program ❖ Provide redundancy for critical functions and infrastructure ❖ Adopt regulatory standards such as freeboard standards, cumulative substantial improvement or damage, lower substantial damage threshold; compensatory storage, non-conversion deed restrictions. ❖ Stormwater management regulations and master planning. ❖ Adopt "no-adverse impact" floodplain management policies that strive to not increase the flood risk on downstream communities ❖ Facilitate managed retreat from, or upgrade of, the most at-risk areas ❖ Require accounting of sea level rise in all applications for new development in shoreline areas • **Build local capacity to respond to or prepare for the hazard:** ❖ Produce better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas (stronger controls, tax incentives, and information) ❖ Incorporate retrofitting or replacement of critical system elements in capital improvement plan ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components ❖ Develop and adopt a continuity of operations plan ❖ Consider participation in the Community Rating System ❖ Maintain and collect data to define risks and vulnerability ❖ Train emergency responders ❖ Create an elevation inventory of structures in the floodplain ❖ Develop and implement a public information strategy ❖ Charge a hazard mitigation fee ❖ Integrate floodplain management policies into other planning mechanisms within the planning area. ❖ Consider the probable impacts of climate change on the risk associated with the flood hazard ❖ Consider the residual risk associated with structural flood control in future land use decisions ❖ Enforce National Flood Insurance Program requirements ❖ Adopt a Stormwater Management Master Plan ❖ Develop an adaptive management plan to address the long-term impacts of sea level rise

Table-21-5. Alternatives to Mitigate the Hurricane Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ Protect, preserve, restore barrier island protection. ❖ Protect, preserve, restore wetland protection. ❖ Protect, preserve and restore beaches and dune protection • **Reduce exposure to the hazard:** ❖ Participate in voluntary property acquisition/relocation programs sponsored by federal, state or local agencies • **Reduce vulnerability to the hazard:** ❖ Elevate your home. ❖ Retrofit your home to meet current building code standards for wind driven forces. • **Build local capacity to respond to or prepare for the hazard:** ❖ Buy flood Insurance ❖ Stockpile property protection measures to be utilized once your receive notice of pending coastal storms.	• **Manipulate the hazard:** ❖ Protect, preserve, restore barrier island protection. ❖ Protect, preserve, restore wetland protection. ❖ Protect, preserve and restore beaches and dune protection • **Reduce exposure to the hazard:** ❖ Participate in voluntary property acquisition/relocation programs sponsored by federal, state or local agencies • **Reduce vulnerability to the hazard:** ❖ Retrofit your facilities to meet current building code standards for wind driven forces. ❖ Maintain drainage facilities that service your property. • **Build local capacity to respond to or prepare for the hazard:** ❖ Develop a continuity of operations plan to address operations before, during and after coastal storm events. ❖ Buy flood Insurance ❖ Partner with personal scale and government scale partners to provide property protection components such as plywood and water resistant barriers in the preparedness phase pending coastal storms.	• **Manipulate the hazard:** ❖ Protect, preserve, restore barrier island protection. ❖ Protect, preserve, restore wetland protection. ❖ Protect, preserve and restore beaches and dune protection ❖ Structural flood control, such as floodwalls, berms and levels • **Reduce exposure to the hazard:** ❖ Preserve, restore, enhance the barrier islands. ❖ Consider open space land uses in areas of high risk exposure to coastal storms. ❖ Acquire or relocate vulnerable properties in high risk areas impacted by coastal storms. ❖ Place utilities underground when and where appropriate. ❖ Consider low-density land use in high risk coastal zones. • **Reduce vulnerability to the hazard:** ❖ Consider appropriate higher regulatory standards to the risk exposure to coastal storms such as: higher freeboard, enclosure prohibitions, coastal zone setbacks, lower substantial damage thresholds, non-conversion deed restrictions ❖ Elevate vulnerable properties in high risk areas impacted by coastal storms. ❖ Adopt/amend building codes such that they will address pre-existing properties. ❖ Implement tree management programs. ❖ Elevate roads that are vital/critical to evacuation and local community operations. ❖ Design or enhance existing drainage systems for higher design storms to provide increased capacity of the drainage system. ❖ Maintain the drainage infrastructure to levels that equal or exceed their design specifications. • **Build local capacity to respond to or prepare for the hazard:** ❖ Develop or enhance existing plans to include comprehensive evaluation of coastal storms and the reduction of their impacts at the local level. Seek to coordinate all levels of planning with this regard. ❖ Support/enhance code enforcement programs at the local level. ❖ Continue to develop, enhance and implement existing emergency response plans to utilize new and developing technology/ information as it become available. ❖ Develop a post-disaster action plan for coastal storm events that will address the local government operations post disaster. ❖ Promote the purchase of Flood Insurance ❖ Adopt regulations that require the disclosure of ocean-related hazards at the time of the purchase or sale of real property. ❖ Implement measures that will provide or help to provide property protection measures to property owners prior to the arrival of coastal storms. ❖ Utilize the best available technology to provide early warning of pending coastal storms to provide ample time to implement property protection measures. ❖ Educate the public on ways to protect their property before and during coastal storms, and where they can acquire the appropriate property protection measures.

Table-21-6. Alternatives to Mitigate the Landslide Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope ❖ Minimize vegetation removal and the addition of impervious surfaces. • **Reduce exposure to the hazard:** ❖ Locate structures outside of hazard area (off unstable land and away from slide-run out area) • **Reduce vulnerability to the hazard:** ❖ Retrofit home • **Build local capacity to respond to or prepare for the hazard:** ❖ Institute warning system, and develop evacuation plan ❖ Keep cash reserves for reconstruction ❖ Educate yourself on risk reduction techniques for landslide hazards	• **Manipulate the hazard:** ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope • **Reduce exposure to the hazard:** ❖ Locate structures outside of hazard area (off unstable land and away from slide-run out area) • **Reduce vulnerability to the hazard:** ❖ Retrofit at-risk facilities • **Build local capacity to respond to or prepare for the hazard:** ❖ Institute warning system, and develop evacuation plan ❖ Keep cash reserves for reconstruction ❖ Develop a continuity of operations plan ❖ Educate employees on the potential exposure to landslide hazards and emergency response protocol.	• **Manipulate the hazard:** ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope • **Reduce exposure to the hazard:** ❖ Acquire properties in high-risk landslide areas. ❖ Adopt land use policies that prohibit the placement of habitable structures in high-risk landslide areas. • **Reduce vulnerability to the hazard:** ❖ Adopt higher regulatory standards for new development within unstable slope areas. ❖ Armor/retrofit critical infrastructure against the impact of landslides. • **Build local capacity to respond to or prepare for the hazard:** ❖ Produce better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas: better land controls, tax incentives, information ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components ❖ Develop and adopt a continuity of operations plan ❖ Educate the public on the landslide hazard and appropriate risk reduction alternatives. ❖ Consider the probable impacts of climate change on the risk associated with the landslide hazard

Table-21-7. Alternatives to Mitigate the Severe Weather Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ None • **Reduce vulnerability to the hazard:** ❖ Insulate house ❖ Provide redundant heat and power ❖ Insulate structure ❖ Plant appropriate trees near home and power lines ("Right tree, right place" National Arbor Day Foundation Program) • **Build local capacity to respond to or prepare for the hazard:** ❖ Trim or remove trees that could affect power lines ❖ Promote 72-hour self-sufficiency ❖ Obtain a NOAA weather radio. ❖ Obtain an emergency generator.	• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ None • **Reduce vulnerability to the hazard:** ❖ Relocate critical infrastructure (such as power lines) underground ❖ Reinforce or relocate critical infrastructure such as power lines to meet performance expectations ❖ Install tree wire • **Build local capacity to respond to or prepare for the hazard:** ❖ Trim or remove trees that could affect power lines ❖ Create redundancy ❖ Equip facilities with a NOAA weather radio ❖ Equip vital facilities with emergency power sources.	• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Develop an urban heat island reduction program that includes an urban forest program or plan • **Reduce vulnerability to the hazard:** ❖ Harden infrastructure such as locating utilities underground ❖ Trim trees back from power lines ❖ Designate snow routes and strengthen critical road sections and bridges • **Build local capacity to respond to or prepare for the hazard:** ❖ Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc. ❖ Establish and enforce building codes that require all roofs to withstand snow loads ❖ Increase communication alternatives ❖ Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors. ❖ Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines ❖ Provide NOAA weather radios to the public ❖ Consider the probable impacts of climate change on the risk associated with the severe weather hazard ❖ Review and update heat response plan in light of climate change (heat events) projections

Table 21-8. Alternatives to Mitigate the Tsunami Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Locate outside of hazard area • **Reduce vulnerability to the hazard:** ❖ Apply personal property mitigation techniques to your home such as anchoring your foundation and foundation openings to allow flow though. • **Build local capacity to respond to or prepare for the hazard:** ❖ Develop and practice a household evacuation plan ❖ Educate yourself on the risk exposure from the tsunami hazard and ways to minimize that risk	• **Manipulate the hazard:** ❖ None • **Reduce exposure to the hazard:** ❖ Locate structure or mission critical functions outside of hazard area whenever possible • **Reduce vulnerability to the hazard:** ❖ Mitigate personal property for the impacts of tsunami • **Build local capacity to respond to or prepare for the hazard:** ❖ Develop and practice a corporate evacuation plan ❖ Educate employees on the risk exposure from the tsunami hazard and ways to minimize that risk	• **Manipulate the hazard:** ❖ Build wave abatement structures (e.g. the "Jacks" looking structure designed by the Japanese) • **Reduce exposure to the hazard:** ❖ Locate structure or functions outside of hazard area whenever possible ❖ Harden infrastructure for tsunami impacts ❖ Relocate identified critical facilities located in tsunami high hazard areas • **Reduce vulnerability to the hazard:** ❖ Adopt higher regulatory standards that will provide higher levels of protection to structures built in a tsunami inundation area ❖ Utilize tsunami mapping to guide development away from high risk areas through land use planning • **Build local capacity to respond to or prepare for the hazard:** ❖ Create a probabilistic tsunami map for the planning area ❖ Provide incentives to guide development away from hazard areas ❖ Develop a tsunami warning and response system ❖ Provide residents with tsunami inundation maps ❖ Join NOAA's Tsunami Ready program ❖ Develop and communicate evacuation routes ❖ Enhance the public information program to include risk reduction options for the tsunami hazard

Table-21-9. Alternatives to Mitigate the Wildfire Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• **Manipulate the hazard:** ❖ Clear potential fuels on property such as dry overgrown underbrush and diseased trees • **Reduce exposure to the hazard:** ❖ Create and maintain defensible space around structures ❖ Locate outside of hazard area ❖ Mow regularly • **Reduce vulnerability to the hazard:** ❖ Create and maintain defensible space around structures and provide water on site ❖ Use fire-retardant building materials ❖ Create defensible spaces around home • **Build local capacity to respond to or prepare for the hazard:** ❖ Employ techniques from the National Fire Protection Association's Firewise USA program to safeguard home ❖ Identify alternative water supplies for fire fighting ❖ Install/replace roofing material with non-combustible roofing materials.	• **Manipulate the hazard:** ❖ Clear potential fuels on property such as dry underbrush and diseased trees • **Reduce exposure to the hazard:** ❖ Create and maintain defensible space around structures and infrastructure ❖ Locate outside of hazard area • **Reduce vulnerability to the hazard:** ❖ Create and maintain defensible space around structures and infrastructure and provide water on site ❖ Use fire-retardant building materials ❖ Use fire-resistant plantings in buffer areas of high wildfire threat. • **Build local capacity to respond to or prepare for the hazard:** ❖ Support Firewise USA community initiatives. ❖ Create /establish stored water supplies to be utilized for fire fighting.	• **Manipulate the hazard:** ❖ Clear potential fuels on property such as dry underbrush and diseased trees ❖ Implement best management practices on public lands • **Reduce exposure to the hazard:** ❖ Create and maintain defensible space around structures and infrastructure ❖ Locate outside of hazard area ❖ Enhance building code to include use of fire resistant materials in high hazard area. • **Reduce vulnerability to the hazard:** ❖ Create and maintain defensible space around structures and infrastructure ❖ Use fire-retardant building materials ❖ Use fire-resistant plantings in buffer areas of high wildfire threat. ❖ Consider higher regulatory standards (such as Class A roofing) ❖ Establish biomass reclamation initiatives ❖ Reintroduce fire (controlled or prescribed burns) to fire-prone ecosystems ❖ Manage fuel load through thinning and brush removal • **Build local capacity to respond to or prepare for the hazard:** ❖ More public outreach and education efforts, including an active Firewise USA program ❖ Possible weapons of mass destruction funds available to enhance fire capability in high-risk areas ❖ Identify fire response and alternative evacuation routes ❖ Seek alternative water supplies ❖ Become a Firewise USA community ❖ Use academia to study impacts/solutions to wildfire risk ❖ Establish/maintain mutual aid agreements between fire service agencies ❖ Develop, adopt, and implement integrated plans for mitigating wildfire impacts in wildland areas bordering on development ❖ Consider the probable impacts of climate change on the risk associated with the wildfire hazard in future land use decisions ❖ Establish a management program to track forest and rangeland health

21.2 ADAPTIVE CAPACITY

Adaptive capacity is defined as "the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014b). This term is typically used while discussing climate change adaptation; however, it is similar to the alternatives presented in the tables for building local capacity. In addition to hazard-specific capacity building, the following list provides general alternatives that planning partners considered to build capacity for adapting to both current and future risks:

- Incorporate climate change adaptation into relevant local and regional plans and projects.
- Establish a climate change adaptation and hazard mitigation public outreach and education program.
- Build collaborative relationships between regional entities and neighboring communities to promote complementary adaptation and mitigation strategy development and regional approaches.
- Establish an ongoing monitoring program to track local and regional climate impacts and adaptation strategy effectiveness.
- Increase participation of low-income, immigrant, non-English-speaking, racially and ethnically diverse, and special-needs residents in planning and implementation.
- Ask local employers and business associations to participate in local efforts to address climate change and natural hazard risk reduction.
- Conduct a communitywide assessment and develop a program to address health, socioeconomic, and equity vulnerabilities.
- Focus planning and intervention programs on neighborhoods that currently experience social or environmental injustice or bear a disproportionate burden of potential public health impacts.
- Use performance metrics and data to evaluate and monitor the impacts of climate change and natural hazard risk reduction strategies on public health and social equity.
- Develop coordinated plans for mitigating future flood, landslide, and related impacts through concurrent adoption of updated comprehensive plan safety elements and local hazard mitigation plans.
- Implement comprehensive plan safety elements through zoning and subdivision practices that restrict development in floodplains, landslide, and other natural hazard areas.
- Identify and protect locations where native species may shift or lose habitat due to climate change impacts (sea level rise, loss of wetlands, warmer temperatures, drought).
- Collaborate with agencies managing public lands to identify, develop, or maintain corridors and linkages between undeveloped areas.
- Promote economic diversity.
- Incorporate consideration of climate change impacts as part of infrastructure planning and operations.
- Conduct a climate impact assessment on community infrastructure.
- Identify gaps in legal and regulatory capabilities and develop ordinances or guidelines to address those gaps.
- Identify and pursue new sources of funding for mitigation and adaptation activities.
- Hire new staff or provide training to current staff to ensure an adequate level of administrative and technical capability to pursue mitigation and adaptation activities.

22. AREA-WIDE ACTION PLAN

22.1 RECOMMENDED MITIGATION ACTIONS

Area-wide actions are actions to be implemented under this plan that will benefit the entire planning partnership. HCOHSEM, with support from the Steering Committee, reviewed the catalogs of hazard mitigation alternatives and selected area-wide actions based on the risk assessment of hazards of concern and the hazard mitigation goals and objectives. These actions are more applicable on a regional scale than on a local scale. All planning partners agree to support the implementation of these area-wide actions by identifying an action in their local action plans provided in Volume 2 of this plan. Table 22-1 lists the recommended area-wide actions. The timeframe in the table is defined as follows:

- Short Term = to be completed in 1 to 5 years
- Long Term = to be completed in greater than 5 years
- Ongoing = currently being funded and implemented under existing programs.

22.2 BENEFIT-COST REVIEW

The action plan must be prioritized according to a benefit/cost analysis of the proposed actions (44 CFR, Section 201.6(c)(3)(iii)). The benefits of proposed actions were weighed against estimated costs as part of the action prioritization process. The benefit/cost analysis was not of the detailed variety required by FEMA for project eligibility under various grant programs. A less formal approach was used because some actions may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time. Therefore, a review of the relative benefit versus relative cost of each action was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to the cost and benefit of these actions.

Cost ratings were defined as follows:

- **High**—Existing funding will not cover the cost of the action; implementation would require new revenue through an alternative source (for example, bonds, grants, and fee increases).
- **Medium**—The action could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the action would have to be spread over multiple years.
- **Low**—The action could be funded under the existing budget. The action is part of or can be part of an ongoing existing program.

Benefit ratings were defined as follows:

- **High—**Action will provide an immediate reduction of risk exposure for life and property.
- **Medium—**Action will have a long-term impact on the reduction of risk exposure for life and property, or action will provide an immediate reduction in the risk exposure for property.
- **Low—**Long-term benefits of the action are difficult to quantify in the short term.

Using this approach, actions with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly.

Table 22-1. Action Plan

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Estimated Cost	Sources of Funding	Timeline
Action AW-1—Utilize best available data and science as it becomes available with relevance to the planning area to map the extent and location of the Coastal Erosion, Dam Failure, Mass Movement and Tsunami hazards. The objective for this hazard mapping would be for the data to be in a geospatial format, suitable to support risk analysis in support of future updates to this plan						
Hazards Mitigated: Coastal Erosion, Dam Failure, Earthquake, Mass-Movements, and Tsunami						
New and Existing	3, 10	HCOHSEM	Local, state and federal agencies that capture and produce data on risk	Medium	Grant Funding, HCOHSEM funds	Long
Action AW-2—Continue to maintain and update the Hazard Mitigation Plan website with relevant information on the plan's implementation such as: annual progress reports, grant funding opportunities, public comment opportunities and plan integration opportunities. . Each planning partner can support this initiative by creating a link to the County hazard mitigation website on their jurisdictional websites .						
Hazards Mitigated: Coastal erosion, Dam/levee failure, Drought, Earthquakes, Flooding, Hurricanes and coastal storms, Mass movement, Severe weather, Tsunami and Wildfire						
New and Existing	1, 3, 5, 9, 10, 15	HCOHSEM	All Planning Partners	Low	HCOHSEM Funds	Ongoing
Action #AW-3—Utilizing the existing public outreach capability of the HCOHSEM Public Information Office; develop, deploy and disseminate targeted outreach projects promoting risk communication, mitigation and resilience to all the hazards of concern addressed by this plan. Note, that projects may include but not be limited to; public meetings/workshops, target mailings, brochures, social media, multi-media releases, web-deployed information, and citizen awareness timeframes.						
Hazards Mitigated: Coastal erosion, Dam/levee failure, Drought, Earthquakes, Flooding, Hurricanes and coastal storms, Mass movement, Severe weather, Tsunami and Wildfire						
New and Existing	1, 3, 5, 9, 10, 15	HCOHSEM	All Planning Partners	Low	HCOHSEM funds	Ongoing
Action #AW-4— Strive to capture time-sensitive, perishable data—such as high-water marks, extent and location of hazard, and loss information—following hazard events to support future updates to the risk assessment as well as other plans and programs that utilize hazard extent and location data						
Hazards Mitigated: Coastal erosion, Dam/levee failure, Drought, Earthquakes, Flooding, Hurricanes and coastal storms, Mass movement, Severe weather, Tsunami and Wildfire						
New and Existing	1, 3, 15	HCOHSEM	All Planning Partners	Medium	Local Funding	Ongoing
Action #AW5— Continue to develop, improve and implement an enhanced mass public warning and alert system (iPAWS) within the Harris County Joint Information Center to provide warning capability throughout Harris County to support the emergency management of all hazards of concern and disasters impacting critical infrastructure and residents.						
Hazards Mitigated: Coastal erosion, Dam/levee failure, Drought, Earthquakes, Flooding, Hurricanes and coastal storms, Mass movement, Severe weather, Tsunami and Wildfire						
New and Existing	1, 4, 10, 11	HCOHSEM	All Planning Partners	Low	HCOHSEM Funds, EMPG, UWASI	Ongoing
Action #AW6— Utilize viable and relevant information, data and tools (Hazus models) developed as part of the update to the risk assessment of this plan update to support training and exercise of the County's preparedness, response and recovery programs						
Hazards Mitigated: Coastal erosion, Dam/levee failure, Drought, Earthquakes, Flooding, Hurricanes and coastal storms, Mass movement, Severe weather, Tsunami and Wildfire						
New and Existing	1, 3, 15	HCOHSEM	All Planning Partners	Low	HCOHSEM Funds, EMPG, UWASI	Short Term

For many of the strategies identified in this action plan, financial assistance may be available through the HMA program, which requires detailed benefit/cost analyses. These analyses will be performed on projects at the time of application using the FEMA benefit-cost model. For actions not seeking financial assistance from grant programs that require detailed analysis, "benefits" can be defined according to parameters that meet the goals and objectives of this plan.

22.3 ACTION PLAN PRIORITIZATION

Table 22-2 lists the priority of each area-wide action. A qualitative benefit-cost review was performed for each of these actions. The priorities are defined as follows:

- Implementation Priority
  - **High Priority**—An action that meets multiple objectives, has benefits that exceed costs, and has a secured source of funding. Action can be completed in the short term (1 to 5 years).
  - **Medium Priority**—An action that meets multiple objectives, has benefits that exceed costs, and is eligible for funding though no funding has yet been secured for it. Action can be completed in the short term (1 to 5 years), once funding is secured. Medium-priority actions become high-priority actions once funding is secured.
  - **Low Priority**—An action that will mitigate the risk of a hazard, has benefits that do not exceed the costs or are difficult to quantify, has no secured source of funding, and is not eligible for any known grant funding. Action can be completed in the long term (1 to 10 years). Low-priority actions are generally "wish-list" actions. They may be eligible for grant funding from programs that have not yet been identified.

- Grant Pursuit Priority
  - **High Priority**—An action that meets identified grant eligibility requirements, has high benefits, and is listed as high or medium implementation priority; local funding options are unavailable or available local funds could be used instead for actions that are not eligible for grant funding.
  - **Medium Priority**—An action that meets identified grant eligibility requirements, has medium or low benefits, and is listed as medium or low implementation priority; local funding options are unavailable.
  - **Low Priority**—An action that has not been identified as meeting any grant eligibility requirements.

Table 22-2. Prioritization of Area-Wide Mitigation Actions

Action #	# of Objectives Met	Benefit	Cost	Do Benefits Equal or Exceed Costs?	Is Action Grant Eligible?	Can Action be Funded Under Existing Programs/ Budgets?	Implementation Priority	Grant Pursuit Priority
AW-1	2	Medium	Low	Yes	Yes	No	Medium	High
AW-2	6	Low	Low	Yes	No	Yes	High	Low
AW-3	6	Low	Low	Yes	No	Yes	High	Low
AW-4	3	Medium	Medium	Yes	Yes	Yes	High	High
AW-5	4	High	Medium	Yes	Yes	Yes	High	High
AW-6	3	High	Low	Yes	Yes	Yes	High	High

22.4 CLASSIFICATION OF MITIGATION ACTIONS

Each recommended action was classified based on the hazard it addresses and the type of mitigation it involves. Please note that this plan is using the 6 mitigation categories defined under activity 510 of the Community Rating System (CRS) program. Please note that the CRS program is considered to be a higher standard than those specified by FEMA for compliance with the provisions of 44CFR, section 201.6. The CRS program criteria was a big driver for this planning effort, as 16 of the municipal planning partners in this effort participate in the CRS program. This classification expands upon the 4 mitigation categories defined by FEMA. Table 22-3 shows these classifications.

Mitigation types used for this categorization are as follows:

- **Prevention**—Government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. Includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
- **Property Protection**—Modification of buildings or structures to protect them from a hazard or removal of structures from a hazard area. Includes acquisition, elevation, relocation, structural retrofit, storm shutters, and shatter-resistant glass.
- **Public Education and Awareness**—Actions to inform residents and elected officials about hazards and ways to mitigate them. Includes outreach projects, real estate disclosure, hazard information centers, and school-age and adult education.
- **Natural Resource Protection**—Actions that minimize hazard loss and preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, wetland restoration and preservation, and green infrastructure.
- **Emergency Services**—Actions that protect people and property during and immediately after a hazard event. Includes warning systems, emergency response services, and the protection of essential facilities.
- **Structural Projects**—Actions that involve the construction of structures to reduce the impact of a hazard. Includes dams, setback levees, floodwalls, retaining walls, and safe rooms.
- **Climate Resiliency**—Actions that incorporate methods to mitigate and/or adapt to the impacts of climate change. Includes aquifer storage and recovery activities, incorporating future conditions projections in project design or planning, or actions that specifically address jurisdiction-specific climate change risks, such as sea level rise or urban heat island effect.
- **Community Capacity Building**—Actions that increase or enhance local capabilities to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Includes staff training, memorandums of understanding, development of plans and studies, and monitoring programs.

Table 22-3. Analysis of Mitigation Actions

Hazard	Actions That Address the Hazard, by Mitigation Type							
	Prevention	Property Protection	Public Education and Awareness	Natural Resource Protection	Emergency Services	Structural Projects	Climate Resilience	Community Capacity Building
Coastal Erosion	AW-1, AW-4		AW-1, AW-2, AW-3		AW-5, AW-6			AW-1, AW-5
Dam/levee Failure	AW-1, AW-4		AW-1, AW-2, AW-3		AW-5, AW-6			AW-1, AW-5
Drought	AW-4		AW-2, AW-3		AW-5, AW-6			AW-5
Earthquakes	AW-1, AW-4		AW-1, AW-2, AW-3		AW-5, AW-6			AW-1, AW-5
Flooding	AW-4		AW-2, AW-3		AW-5, AW-6			AW-5
Hurricanes and Coastal Storms	AW-4		AW-2, AW-3		AW-5, AW-6			Aw-5
Mass Movement	AW-1, AW-4		AW-1, AW-2, AW-3		AW-5, AW-6			AW-1, AW-5
Severe Weather	AW-4		AW-2, AW-3		AW-5, AW-6			AW-5
Tsunami	AW-1, AW-4		AW-1, AW-2, AW-3		AW-5, AW-6			AW-1, AW-5
Wildfire	AW-4		AW-2, AW-3		AW-5, AW-6			AW-5

22.5 AREA-WIDE ACTION PLAN IMPLEMENTATION

The area-wide action plan here and jurisdiction-specific action plans in Volume 2 present a range of action items for reducing loss from hazard events. The planning partners have prioritized actions and can begin to implement the highest-priority actions over the next five years. The effectiveness of the hazard mitigation plan depends on its

effective implementation and incorporation of the outlined action items into all partners' existing plans, policies, and programs. Some action items do not need to be implemented through regulation but can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation.

HCOHSEM will have lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the area-wide and jurisdiction-specific action plans.

23. PLAN ADOPTION, IMPLEMENTATION AND MAINTENANCE

23.1 PLAN ADOPTION

A hazard mitigation plan must document that it has been formally adopted by the governing bodies of the jurisdictions requesting federal approval of the plan (44 CFR Section 201.6(c)(5)). For multi-jurisdictional plans, each jurisdiction requesting approval must document that is has been formally adopted.

This plan update was submitted to the Harris County attorney for review. Once finalized, it was presented to Commissioner's Court for approval to submit to the state. This plan will be submitted for a pre-adoption review to Texas Division of Emergency Management and FEMA Region VI prior to adoption. Once pre-adoption approval has been provided, all planning partners will formally adopt the plan. DMA compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this plan for all planning partners can be found in Appendix E of this volume.

23.2 ACTION PLAN IMPLEMENTATION

The jurisdiction-specific action plans in Volume 2 present a range of action items for reducing loss from hazard events. The planning partners have prioritized actions and can begin to implement the highest-priority actions over the next five years. The effectiveness of the hazard mitigation plan depends on its effective implementation and incorporation of the outlined action items into all partners' existing plans, policies, and programs. Some action items do not need to be implemented through regulation but can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation.

Harris County will have lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the jurisdiction-specific action plans.

23.3 PLAN MAINTENANCE STRATEGY

A hazard mitigation plan must present a plan maintenance process that includes the following (44 CFR Section 201.6(c)(4)):

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan over a 5-year cycle
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate
- A discussion on how the community will continue public participation in the plan maintenance process.

This section details the formal process that will ensure that the hazard mitigation plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years.

This chapter also describes how public participation will be integrated throughout the plan maintenance and implementation process. It also explains how the mitigation strategies outlined in this plan will be incorporated into existing planning mechanisms and programs, such as comprehensive land-use planning processes, capital improvement planning, and building code enforcement and implementation.

The plan's format allows sections to be reviewed and updated when new data become available, resulting in a plan that will remain current and relevant. Pursuant to 44CFR 201.6(c)(4)(i), the plan maintenance matrix shown in Table-23-1 provides a synopsis of responsibilities for the overall plan maintenance strategy, which are discussed in further detail in the sections below.

Table-23-1. Plan Maintenance Matrix

Task	Approach	Timeline	Lead Responsibility	Support Responsibility
Monitoring-Progress Reporting	Preparation of status updates and action implementation tracking as part of submission for annual progress report.	January to January of each calendar year or upon full update to comprehensive plan or major disaster	Jurisdictional points of contact identified in Volume 2 annexes	Jurisdictional implementation lead identified in Volume 2 annexes
Evaluation	Annual progress reports will be evaluated by an oversight steering committee annually.	Finalized progress report completed by March 1 of each year	HCOHSEM	Jurisdictional points of contacts identified in Volume 2 annexes
Update	Reconvene the planning partners, at a minimum, every 5 years to guide a full update to review and revise the plan.	Every 5 years or upon full update to comprehensive plan or major disaster	HCOHSEM and oversight steering committee	Jurisdictional points of contacts identified in Volume 2 annexes
Grant Monitoring and Coordination	Grant funding opportunities will be monitored via agency notifications, state associations and post-disaster response.	Ongoing during the performance period of this plan	HCOHSEM	Jurisdictional points of contacts identified in Volume 2 annexes
Plan Integration	Create a linkage between the hazard mitigation plan and individual jurisdictions' comprehensive plans or similar plans identified in the core capability assessments.	Ongoing during the performance period of this plan as opportunities for integration become available, or according to timelines identified in the actions plans for each planning partner	Jurisdictional points of contact identified in Volume 2 annexes	Jurisdictional implementation lead identified in Volume 2 annexes
Continuing Public Involvement	Keep the website maintained and receive comments through it over the course of the plan. Maintain planning partner links to the website. Post county-wide progress report to the website.	Ongoing during the performance period of the plan. Progress reports to be posted annually. Participating CRS communities are to provide the annual progress report to their governing bodies for their information	HCOHSEM will maintain the overall hazard mitigation plan website and post the Countywide progress report annually. Each planning partner will provide a link to the website and post their individual progress report at their discretion. Participating CRS communities will follow protocol identified under step 10 of the 10-strep CRS planning requirements.	HCOHSEM and Jurisdictional implementation lead identified in Volume 2 annexes

23.3.1 Plan Monitoring-Annual Progress Reporting

The Harris County Office of Homeland Security and Emergency Management (HCOHSEM) will be the lead agency responsible for monitoring the plan, and each partner will have plan implementation by tracking the status of all recommended mitigation actions in its action plan. Staff or departments with primary responsibility are identified in each jurisdictional annex (see Volume 2).

The minimum task of each planning partner will be the monitoring of the progress of its individual action plan during a 12-month performance period. This review will include the following:

- The internal process for monitoring and evaluating the plan's processes will be evaluated as part of the annual progress reporting process.
- Summary of any hazard events that occurred during the performance period and the impact these events had on the planning area
- Review of mitigation success stories
- Review of continuing public involvement
- Brief discussion about why targeted strategies were not completed
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding)
- Recommendations for new projects
- Changes in or potential for new funding options (grant opportunities)
- Impact of any other planning programs or actions that involve hazard mitigation.

The Core Planning Team has created a template that shows the minimum level of detail that will be sought for preparing a progress report. The Harris County Office of Homeland Security and Emergency Management (HCOHSEM) will oversee progress reporting and will have the discretionary authority on how to capture this information at least annually over the performance period of the plan. This information may be captured by various means available to the planning partnership. This report should be used as follows:

- Posted on the Harris County website page dedicated to the hazard mitigation plan
- Provided to the local media through available media outlets
- Presented to planning partner governing bodies to inform them of the progress of actions implemented during the reporting period
- Provided as part of the CRS annual re-certification package for planning partners that participate in the CRS. The CRS requires an annual recertification to be submitted by October 1 of every calendar year for which the community has not received a formal audit. To meet this recertification timeline, the planning team will strive to complete progress reports between June and September each year.

Uses of the progress report will be at the discretion of each planning partner. Annual progress reporting is not a requirement specified under 44 CFR. However, it may enhance the planning partners' opportunities for funding. While failure to implement this component of the plan maintenance strategy will not jeopardize a planning partner's compliance under the DMA, it may jeopardize its opportunity to partner and leverage funding opportunities with the other partners. Each planning partner was informed of these protocols at the beginning of this planning process (in the "Planning Partner Expectations" package provided at the start of the process), and each partner acknowledged these expectations with submittal of a letter of intent to participate in this process.

23.3.2 Plan Evaluation

The Steering Committee is a total volunteer body that oversaw the development of the Plan and made recommendations on key elements of the plan, including the maintenance strategy. It was the Steering Committee's position that an oversight committee with representation similar to the initial Steering Committee should have an active role in the Plan maintenance strategy. Therefore, it is recommended that a steering committee remain a viable body involved in key elements of the Plan maintenance strategy. The new steering committee should strive to include representation from the planning partners, as well as other stakeholders in the planning area, at the discretion of HCOHSEM.

The principal role of the steering committee in this plan maintenance strategy will be to provide a review forum to be used by Harris County and its Planning Partners to identify enhancements to be considered at the next update. Future plan updates will be overseen by a steering committee similar to the one that participated in this update process, so keeping a steering committee intact will provide a head start on future updates. Completion of the progress report is the responsibility of each planning partner, not the responsibility of the steering committee. It will be the steering committee's role to serve as a resource to the planning partnership as needed to review the progress report in an effort to identify issues needing to be addressed by future plan updates.

23.3.3 Plan Update

Federal regulations require that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits awarded under the Disaster Mitigation Act (44 CFR Section 201.6.d(3) and Section 201.7(d)(3)). This plan's format allows the planning partnership to review and update sections when new data become available. New data can be easily incorporated, resulting in a plan that will remain current and relevant. The planning partnership intends to update the plan on a five-year cycle from the date of plan approval. This cycle may be accelerated to less than 5 years based on the following triggers:

- A presidential disaster declaration that impacts the planning area
- A hazard event that causes loss of life
- An update of a participating jurisdiction's comprehensive plan

It will not be the intent of the update process to develop a completely new hazard mitigation plan. Based on needs identified by the planning team, the update will, at a minimum, include the following elements:

- The update process will be convened through a new steering committee.
- The hazard risk assessment will be reviewed and, if necessary, updated using best available information and technologies.
- Action plans will be reviewed and revised to account for any actions completed, dropped, or changed and to account for changes in the risk assessment or planning partnership policies identified under other planning mechanisms (such as the comprehensive plan).
- The draft update will be sent to appropriate agencies and organizations for comment.
- The public will be given an opportunity to comment on the update prior to adoption.
- Partners' governing bodies will adopt their respective portions of the updated plan.

Because plan updates can require a year or more to complete, HCOHSEM will initiate efforts to update the plan before it expires. HCOHSEM will consider applying for funding to update the plan no later than 2 calendar years before plan expiration.

23.3.4 Grant Monitoring and Coordination

HCOHSEM will identify grant funding opportunities and send notifications to participating partner jurisdictions. Once these opportunities are identified, planning partners interested in pursuing a grant opportunity will convene in a short meeting to review the hazard mitigation plan and pursue a strategy to capture that grant funding. HCOHSEM will assume lead responsibility for planning and facilitating grant opportunity meetings. Review of the hazard mitigation plan at these meetings can include the following:

- Discussion of any hazard events that occurred during the prior year and their impact on the planning area
- Impact of potential grant opportunities on the implementation of mitigation actions
- Re-evaluation of the action plans to determine if the timeline for identified actions need to be amended (such as changing a long-term action to a short-term action because of funding availability)
- Recommendations for new actions

- Impact of any other planning programs or initiatives that involve hazard mitigation.

If multiple planning partners decide to pursue the same grant funding opportunity, partnerships can be formed to utilize the hazard mitigation plan in the grant application.

23.3.5 Incorporation into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan is based on the best science and technology available at the time this plan was prepared. The comprehensive plans of the planning partners are considered to be integral parts of this plan. The planning partners, through adoption of comprehensive plans and zoning ordinances, have planned for the impact of natural hazards. The plan development process provided them with the opportunity to review and expand on policies contained within these planning mechanisms. The planning partners used their comprehensive plans and the hazard mitigation plan as complementary documents that work together to achieve the goal of reducing risk exposure to the citizens of the planning area. An update to a comprehensive plan may trigger an update to the hazard mitigation plan.

All municipal planning partners are committed to creating a linkage between the hazard mitigation plan and their individual comprehensive plans by identifying a mitigation action as such and giving that action a high priority. Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Emergency response plans
- Training and exercise of emergency response plans
- Debris management plans
- Recovery plans
- Capital improvement programs
- Municipal codes
- Community design guidelines
- Water-efficient landscape design guidelines
- Stormwater management programs
- Water system vulnerability assessments
- Community wildfire protection plans
- Comprehensive flood hazard management plans
- Resiliency plans
- Community Development Block Grant-Disaster Recovery action plans
- Public information/education plans.

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

23.3.6 Continuing Public Participation

The public outreach strategy used during development of the current update will provide a framework for public engagement through the plan maintenance process. It can be adapted for ongoing public outreach as determined to be feasible by the planning partnership. A steering committee similar to the one involved in developing this hazard mitigation plan update will be put in place to provide stakeholder input on plan maintenance activities.

The public will continue to be apprised of hazard mitigation activities through the website and reports on successful hazard mitigation actions provided to the media. HCOHSEM will keep the website maintained,

including monitoring the email address where members of the public can submit comments to the steering committee. This site will house the final plan and will be a one-stop shop for information regarding the plan, the partnership and plan implementation. Copies of the plan also will be distributed to the Harris County Library System.

Upon initiation of the next plan update process, a new public involvement strategy will be initiated, with guidance from the new steering committee. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update. At a minimum, it will include the use of local media outlets.

REFERENCES

AL.com. 2015. "Gulf Coast not immune to tsunamis, say researchers." Web site posted March 25, 2015. Accessed at https://www.al.com/news/2015/03/gulf_coast_not_immune_to_tsuna.html

Allegro Energy. 2001. How Pipelines Make the Oil Market Work - Their Networks, Operation and Regulation.

American Meteorological Society, 1959. Glossary of Meteorology. Edited by Ralph E. Huschke. Boston, Mass.

Association of State Dam Safety Officials. 2013. "Introduction to Dams." Dam Safety 101. Accessed 2017. http://www.damsafety.org/news/?p=e4cda171-b510-4a91-aa30-067140346bb2.

Association of State Dam Safety Officials. 2016. Dam Failures and Incidents. The website of the Association of State Dam Safety Officials, accessed January 2016, http://www.damsafety.org/news/?p=412f29c8-3fd8-4529-b5c9-8d47364c1f3e

Brown, W. et al. 2001. U.S. Geological Survey (USGS). "Hazard Maps Help Save Lives and Property." 2001. Accessed 2017. http://pubs.usgs.gov/fs/1996/fs183-96/fs183-96.pdf.

Centers for Disease Control and Prevention (CDC). 2012. "Drought and Health." Accessed February 2017. http://www.cdc.gov/nceh/drought/.

Centers for Disease Control and Prevention (CDC). 2013. Emergency Preparedness and Response: Lightning: Victim Data. The website of the CDC, last reviewed December 23, 2013, http://www.bt.cdc.gov/disasters/lightning/victimdata.asp.

City of Houston. 2019. Annexation web page on the City of Houston web site. Accessed online at http://www.houstontx.gov/planning/Annexation/annexation.html

Drought Impact Reporter. 2019. The website of the National Drought Mitigation Center. Accessed online at http://drought.unl.edu/monitoringtools/droughtimpactreporter.aspx

Federal Emergency Management Agency (FEMA). 1997. FEMA's Multi-Hazard Identification and Risk Assessment; Subpart B, Geological Hazards. January 1, 1997. Accessed 2018. https://www.fema.gov/media-library-data/20130726-1545-20490-9696/mhira_n2.pdf

Federal Emergency Management Agency (FEMA). 2001. Understanding Your Risks; Identifying Hazards and Determining your Risks. FEMA (386-2). August 2001

Federal Emergency Management Agency (FEMA). 2002. Getting Started; Building support for Mitigation Planning; FEMA (386-1). September 2002

Federal Emergency Management Agency (FEMA). 2003. Developing the Mitigation Plan; Identifying Mitigation Actions and Implementing Strategies. FEMA (386-3). April 2003

Federal Emergency Management Agency (FEMA). 2004. Using HAZUS-MH for Risk Assessment, How to Guide, FEMA (433). August 2004

Federal Emergency Management Agency (FEMA). 2007. FEMA, National Flood Insurance Program, Community Rating System; CRS Coordinator's Manual FIA-15/2007 OMB No. 1660-0022

Federal Emergency Management Agency (FEMA). 2014. FEMA Disaster Declaration Summary – Open Government Dataset. Spreadsheet Data Accessed December 10, 2012 from Federal Emergency Management Agency Website: http://www.fema.gov/library/viewRecord.do?id=6292

Federal Emergency Management Agency (FEMA). 2019. Data Visualization: Disaster Declarations for States and Counties, Harris County, Texas. Accessed online at https://www.fema.gov/data-visualization-disaster-declarations-states-and-counties

Federal Reserve Bank of St. Louis. 2019. Unemployment data page of the Economic Research web site of the Federal Reserve Bank of St. Louis. Accessed online at https://fred.stlouisfed.org/series/UNRATE#0v

Harris County Appraisal District. 2017. Harris County Appraisal District 2017 Annual Report. Accessed online at http://hcad.org/assets/uploads/pdf/resources/2019/2017-Annual-Report.pdf

Harris County Flood Control District. 2019. "Harris County's Flooding History." Web paged accessed online at

Harris-Galveston Coastal Subsidence District (HGCSD). 1999. 1999 Regulatory Plan.

Houston Chronicle. 2019. "Greater Houston's top 100 employers." Web paged accessed online at https://www.hcfcd.org/flooding-floodplains/harris-countys-flooding-history/

Intergovernmental Panel on Climate Change (IPCC). 2014. "Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Parts A, B and Annexes." Accessed January 2017. http://www.ipcc.ch/report/ar5/wg2/.

Intergovernmental Panel on Climate Change (IPCC). 2014a. "Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Parts A, B and Annexes." Accessed January 2017. http://www.ipcc.ch/report/ar5/wg2/.

Lone Star College. 2018. Fast Facts Harris County informational flier. Prepared by Lone Star College North Houston Economic Development Center. Accessed online at https://hcoed.harriscountytx.gov/docs/HarrisCountyFastFacts.pdf

National Aeronautics and Space Administration (NASA). 2016. "NASA, NOAA Data Show 2016 Warmest Year on Record Globally." Accessed February 2017. https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally.

National Aeronautics and Space Administration (NASA). 2017. "NASA, NOAA Data Show 2016 Warmest Year on Record Globally" Accessed May 2017. https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally.

National Aeronautics and Space Administration (NASA). 2018. "Global Climate Change: Vital Signs of the Planet." Accessed April 2018. http://climate.nasa.gov/vital-signs

National Centers for Environmental Information. 2018. "Drought – February 2018." The website of NOAA. Accessed 2018. https://www.ncdc.noaa.gov/sotc/drought/201802

National Centers for Environmental Information. 2018a. "Drought Indices and Data." The website of NOAA. Accessed 2018. https://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/indices

National Centers for Environmental Information. 2018b. "NGDC/WDS Global Historical Tsunami Database." Accessed 2018. https://www.ngdc.noaa.gov/hazard/tsu_db.shtml

National Centers for Environmental Information. 2018c. Tsunami Travel Times to Coastal Locations viewer. Accessed 2018. https://maps.ngdc.noaa.gov/viewers/ttt_coastal_locations/

National Centers for Environmental Information. 2019. "Storm Events Database." Web page accessed at https://www.ncdc.noaa.gov/stormevents/

National Drought Mitigation Center. 2017. "Drought Affecting People." Accessed February 2017. http://drought.unl.edu/droughtbasics/ensoandforecasting.aspx.

National Oceanic and Atmospheric Administration (NOAA). 2010. http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms. NOAA, National Climatic Data Center website, accessed 2010

National Oceanic and Atmospheric Administration (NOAA). 2018a. "Enhanced F Scale for Tornado Damage." The website of NOAA. Accessed 2018. http://www.spc.noaa.gov/faq/tornado/ef-scale.html

National Oceanic and Atmospheric Administration and National Weather Service (NOAA and NWS). 2009. "National Weather Service Glossary." Accessed 2018. http://w1.weather.gov/glossary/.

National Oceanic and Atmospheric Administration and National Weather Service (NOAA and NWS). 2018. "Drought Monitoring." The website of NOAA. Last updated 2015. http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml

National Oceanic and Atmospheric Administration and National Weather Service (NOAA and NWS). 2018a. "Introduction to Thunderstorms." The website of the NWS. Accessed 2018. https://www.weather.gov/jetstream/tstorms_intro

National Oceanic and Atmospheric Administration and National Weather Service (NOAA and NWS). 2018b. "Freezing Rain and Sleet." The website of the NWS. Accessed 2018. https://www.weather.gov/rnk/Measure_Icing

National Oceanic and Atmospheric Administration and National Weather Service (NOAA and NWS). 2018c. "Severe Weather Definitions." The website of the NWS. Accessed 2018. https://www.weather.gov/bgm/severedefinitions

National Oceanic and Atmospheric Administration and National Weather Service (NOAA and NWS). 2018d. "Weather Fatalities." The website of NWS. Accessed 2018. http://www.nws.noaa.gov/om/hazstats/resources/weather_fatalities.pdf

National Severe Storms Laboratory. 2018. "Severe Weather 101." The website of the National Severe Storms Laboratory. Accessed 2018. https://www.nssl.noaa.gov/education/svrwx101/wind/types/

National Tsunami Hazard Mitigation Program. 2001. *Designing for Tsunamis: Seven Principles for Planning and Designing for Tsunami Hazards.* Accessed 2018. https://nws.weather.gov/nthmp/documents/designingfortsunamis.pdf

National Weather Service. 2019. "What Is the Heat Index?" Web page accessed online at https://www.weather.gov/ama/heatindex

Texas A&M Agrilife Extension Service. 2019. Texas Coastal Wetlands web page. Accessed online at texaswetlands.org

Texas Demographic Center. 2019. Estimates of the Total Populations of counties and Places in Texas for July 1, 2018 and January 1, 2019. Produced by the Population Estimates and Projections Program at The Texas Demographic Center, University of Texas at San Antonio. October 2019. Accessed online at https://demographics.texas.gov/Resources/TPEPP/Estimates/2018/2018_txpopest_county.pdfv

Texas General Land Office. 2014. Texas Coastwide Erosion Response Plan; 2013 Update. Prepared for the Texas General Land Office by K.K. McKenna, PG. Accessed online at http://www.glo.texas.gov/coast/coastal-management/forms/files/coastwide-erosion-response-plan.pdf

Texas State Historical Association. 2019a. The Handbook of Texas Online. Harris County web page. Accessed online at https://tshaonline.org/handbook/online/articles/hch07

Texas State Historical Association. 2019b. The Texas Almanac web page. Accessed online at https://texasalmanac.com/

Tornado and Storm Research Organisation (TORRO). 2019. Hail Scale web page. Accessed online at http://www.torro.org.uk/site/hscale.php

U.S. Army Corps of Engineers. 2011. Safety of Dams—Policy and Procedures; ER 1110-2-1156. October 28, 2011. Accessed online at https://www.lrh.usace.army.mil/Portals/38/docs/zoar/ER%201110-2-1156%20--%2028%20Oct%2011_2_.pdf

U.S. Army Corps of Engineers. 2019. "National Inventory of Dams." Web page accessed online at https://nid.sec.usace.army.mil/ords/f?p=105:22:13630916806800::NO:::

U.S. Census Bureau. 2018. Quick Facts for Harris County.

U.S. Census Bureau. 2019. American Community Survey. Accessed 2019. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml#

U.S. Climate Resilience Toolkit. 2018. U.S. Climate Resilience Toolkit web page on drought: https://toolkit.climate.gov/topics/water/drought

U.S. Department of Agriculture (USDA), Farm Service Agency, 2018. "Disaster Designation Information. Accessed 2018. https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index

U.S. Department of Agriculture. 2017. National Agricultural Statistics Service, 2017 Census Publications, accessed online at https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/

U.S. Department of Energy. 2009. US Department of Energy. Accessed September 7, 2009, from U.S. Department of Energy at http://www.oe.energy.gov

U.S. Drought Portal. 2018. National Integrated Drought Information System. Accessed 2018. https://www.drought.gov/drought/data-gallery/crop-moisture-index

U.S. Environmental Protection Agency (EPA). 2016. "Climate Change Indicators in the United States." 2016. https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases.

U.S. Environmental Protection Agency (EPA). 2016a. "Toxics Release Inventory (TRI) Program." https://www.epa.gov/toxics-release-inventory-tri-program/learn-about-toxics-release-inventory.

U.S. Environmental Protection Agency (EPA). 2016b. "Climate Change Indicators in the United States." 2016. EPA 430-R-16-004. www.epa.gov/climate-indicators.

U.S. Environmental Protection Agency (U.S. EPA). 2016c. "What Climate Change Means for Texas." Publication EPA 430-F-16-045. August 2016. Accessed online at https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-tx.pdf

U.S. Environmental Protection Agency (U.S. EPA). 2017. "Climate Impacts on Coastal Areas" web page. Accessed online at https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-coastal-areas_.html.

U.S. Geological Survey (USGS). 2008. An Atlas of ShakeMaps for Selected Global Earthquakes. U.S. Geological Survey Open-File Report 2008-1236. Prepared by Allen, T.I., Wald, D.J., Hotovec, A.J., Lin, K., Earle, P.S. and Marano, K.D.

U.S. Geological Survey (USGS). 2010. PAGER—Rapid Assessment of an Earthquake's Impact. U.S. Geological Survey Fact Sheet 2010-3036. September 2010.

U.S. Geological Survey (USGS). 2014. "Global Seismographic Network." Earthquake Hazards Program. Accessed February 2017. http://earthquake.usgs.gov/monitoring/gsn/.

U.S. Geological Survey (USGS). 2017a. "Measuring Earthquakes FAQs." Accessed February 2017. https://www2.usgs.gov/faq/categories/9828/3357.

U.S. Geological Survey (USGS). 2018. "3.3 ShakeMap Archives." The website of USGS. Accessed 2018. http://usgs.github.io/shakemap/manual3_5/shakemap_archives.html#generating-earthquake-scenarios

U.S. Geological Survey (USGS). 2019. "Federal Wildland Fire Occurrence Data" USGS website accessed at: https://wildfire.cr.usgs.gov/firehistory/data.html

U.S. Global Change Research Program (USGCRP). 2009. "Global Climate Change Impacts in the United States." Thomas R. Karl, Jerry M. Melillo and Thomas C. Peterson, (eds.). Cambridge University Press. Accessed 2016. https://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

World Atlas. 2019. "Cities With The Most Fortune 500 Companies." Web page accessed online at https://www.worldatlas.com/articles/cities-with-the-most-company-headquarters.html

LIST OF ACRONYMS

ADA—American with Disabilities Act

BLM—Bureau of Land Management

CDBG-DR—Community Development Block Grant Disaster Recovery

CFM—Certified floodplain manager

CFR—Code of Federal Regulations

CPT—Core Planning Team

CRS—Community Rating System

CWA—Clean Water Act

DFIRM—Digital Flood Insurance Rate Maps

DHS—Department of Homeland Security

DMA —Disaster Mitigation Act

EMC—Emergency management coordinator

EPA—U.S. Environmental Protection Agency

ESA—Endangered Species Act

EWP—Emergency Watershed Protection

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FIRM—Flood Insurance Rate Map

GBS—General Building Stock

GIS—Geographic Information System

GISP—Certified GIS professional

Hazus—Hazards, United States

HCOHSEM—Harris County Office of Homeland Security and Emergency Management

HGCSD— Harris-Galveston Coastal Subsidence District

IBC—International Building Code

IPCC—Intergovernmental Panel on Climate Change

IRC—International Residential Code

MM—Modified Mercalli Scale

mph—Miles per hour

MRP—mean return period

MWh—Megawatt-hour

Mw—Moment Magnitude Scale

NASA—National Aeronautics and Space Administration

NCDC—National Climatic Data Center

NEHRP—National Earthquake Hazards Reduction Program

NFIP—National Flood Insurance Program

NIMS—National Incident Management System

NOAA—National Oceanic and Atmospheric Administration

NPS—National Park Service

NRCS—Natural Resources Conservation Service

NWS—National Weather Service

PGA—Peak Ground Acceleration

SFHA—Special flood hazard area

TDEM—Texas Department of Emergency Management

TORRO—Tornado and Storm Research Organisation

USDA—U.S. Department of Agriculture

USGCRP—U.S. Global Change Research Program

USGS—U.S. Geological Survey

Harris County Multi-Hazard Mitigation Action Plan

Appendix A. Public Involvement Materials

STEERING COMMITTEE MEETING SUMMARIES

Harris County Hazard Mitigation Plan-Update
1st LHMP Steering Committee Meeting
Thursday – October 18, 2018
10:00am – 12:00PM
Houston TranStar | Conference Room 120A
6922 Katy Road, Houston, TX 77024

Welcome and Introductions

- Group Introductions
- Review Agenda

The Steering Committee Role/Ground rules

- SC Purpose
- Schedule
- SC Expectations
- SC Organization
- Reconfirm SC Charter

Defined Planning Area for the update

- TDEM directive
- How this will impact this update
- Cities that are in more than one County
- Data mine

Critical Facilities/Infrastructure Definition

- Review proposed definition
- Proposed changes or enhancements?
- Data sources for CF/CI inventories

Hazards of Concern

- Hazards form the last plan
- Changes, additions or deletion?
- Hazard scenarios to assess

Public Involvement Strategy

- Public Engagement Meetings
- Planning partner coordination (Bulletins)
- Additional Outreach Capabilities (suggestions welcomed)
    - Website
    - Questionnaire
    - Press/media
    - Social Media

Homework (before the next SC meeting)

- Review the TX State Hazard Mitigation Plan (https://www.dps.texas.gov/dem/Mitigation/txHazMitPlan.pdf)
    - Goals, capabilities and actions
- Prior Harris County Plan
    - Changes or enhancements

Action Items and Next Steps

- Phase 1, Jurisdictional Annex process
- Risk Assessment update
- Confirm, Goals and Objectives for the Plan
- Schedule phase 1, Public Outreach
- Next Meeting Location?

Adjourn

MEETING SUMMARY

Date/Time of Meeting:	Thursday – October 18, 2018; 10:00am to Noon
Location:	Houston, TranStar, 6922 Katy Freeway Houston, Texas 77024
Subject:	1st LHMP Steering Committee Meeting
Project Name:	Harris County Hazard Mitigation Plan-Update
In Attendance	***Attendees: 49 persons in attendance, see attached*** **Core Planning Team:** Brian Murray, Brian Dunaway, Ashly Schutt, Rob Flaner, Chrissie Angeletti
Not Present:	N/A
Summary Prepared by:	Courtney Tavares
Quorum – Yes or No	Yes

Item	Action

Welcome and Introductions, Review Agenda

- Rob Flanner opened the meeting and facilitated group introductions.
- Distributed handouts included: Agenda, Steering Committee Charter, Hazards of Concern, Critical Facilities definitions.
- The agenda was reviewed, and no modifications were made.

The Steering Committee Role/Ground Rules

- The purpose of the Steering Committee was discussed.
- The Chairperson and Vice Chairperson were named as well as the roles of these positions.
- Quorum was established as 9 members plus at least 1 of the co-chairs.
- Alternates can be designated in the event a committee member is unable to attend.
- Decision-making – process will seek consensus. If consensus cannot be reached, a decision will be confirmed by a majority vote. A dissenting opinion can be recorded upon request.
- Recommendations from meetings will be recorded in meeting summaries.
- Staffing will be organized by Tetra Tech and Harris County

All committee members must designate the alternate within 2 weeks, by November 1, 2018

Item	Action
• Spokesperson for the committee will be Ms. Rose Tores and Ms. Hallie Frazee – all media request should go through them @ mitigation@oem.hctx.net • Meeting dates – Bi monthly meetings were set for the 3rd Thursday of the month beginning with the January 2019 SC meeting • Attendance – if the committee member is unable to attend, they can send their alternate if one has been designated. Repeated no-shows, member or alternate, will be contacted by the Chair to see if they are still able to support the process • Public Involvement – all meetings are open to the public and will be advertised as such.	Committee members to update contact info within 2 weeks, by November 1, 2018
Defined Planning Area for the Update Direction has been provided by TDEM on how to address the situation where a jurisdiction's boundaries intersect more than 1 county. There are five such cities in the Harris County planning partnership – Friendswood, Waller, Katy, Stafford and Baytown. The direction from TDEM was that in these situations, the risk assessment must extend in to those counties outside of Harris and those cities should identify and prioritize actions for those areas outside of Harris County. This represents a divergence from how this issue has been addressed by7 past planning efforts. Rob explained that each of the 5 cities will need to assist the CPT in mining the necessary data for those areas outside Harris County.	Need to set a point of contact to obtain data info for areas outside of Harris County
Critical Facilities/Infrastructure Definition Under this segment, Rob defined the critical facilities as listed on Section 2.12 – Critical Facilities handout. These facilities include: ○ Government Facilities ○ Education Facilities ○ Health and Medical Facilities ○ Transportation Systems ○ Emergency Services ○ Environmental Areas ○ Historical and Cultural sites ○ Hazardous Material Sites ○ Water Control Facilities It was purposed to add an additional bullet for "Economic Impact".	
Hazards of Concern Under this section, Rob reviewed the hazards profiled under the last plan. It was recommended that all the same hazarded be assessed for this plan	

Item	Action

update, with some being consolidated in to a single hazard profile. It was recommended to consolidate the following:

- Mass Movement
  - Landslides
  - Sink Holes
  - Subsidence
- Severe Weather
  - Extreme Heat
  - Hail
  - Tornadoes
  - Severe Thunderstorms
  - Winter Storms and Freezes
- Non-Natural
  - Toxic release/Hazardous Materials
  - Energy Pipeline Failures

All hazards are still profiled, just grouped under headings. Recommendation to group headings were approved. It was discussed to add a profile for "Active Shooter, terrorist" under non-natural. No formal decision was made on this point at this time.

Public Involvement Strategy

The SC was briefed on the requirement for an open public process for updating hazard mitigation plans. Rob explained that the primary means for keeping the public apprised of plan development milestones will be the HCOHSEM hazard mitigation plan website at: https://www.readyharris.org/mitigation

Rob asked that all planning partners create links to this website on their individual webpages. Rob also explained that with such a large planning partnership, keeping all planning partners apprised of what is going on will be mission critical to the success of this plan update. To accomplish this, the CPT will distribute "bulletins" to all planning partners and coordinating stakeholders at various points during the planning process. At a minimum, bulletins will be distributed following each Steering Committee meeting so that those stakeholders that are not sitting on the SC, will be informed on what is going on. Other methods of outreach to be utilized during this process include:

- Questionnaire
- Public meetings
- Press/media
- Social Media

Committee members and planning partners to add a link on their website to Harris County Mitigation Plan

CPT to distribute Bulletin # 1

Item	Action

Rob explained that the public meeting process will occur in 2 phases. Phase 1 will be early in the plan update process with the principle objective of gauging the public's perception of risk. Phase 2 will be at the end of the process to present the draft plan and to provide the public an opportunity to comment on the draft plan. Rob explained that the outreach strategy will be an agenda item for every SC meeting.

Homework

Before the next steering committee meeting, members are to:

- Review the current state plan and familiarize themselves with current hazards. What are the goals and objectives?
- Review the current Harris County Plan – Volume 1 – everyone and volume 2 – jurisdictional

Links to both plans will be provided via the bulletin.

Meeting was adjourned at 12:00 PM

There will be no meeting in December due to holiday schedules. Next meeting will be January 17, 2019.

SUMMARY MEETING

Attachment: Sign-in Sheet

HC - LMP Steering Committee Meeting

October 18, 2018, 10:00 a.m.

First Name	Last Name	Agency	Email	Phone
Jamie	Galloway	Baytown OEM	jamie.galloway@baytown.org	24/422/1129
Courtney	Tavares	Tetra Tech	courtney.tavares@tetratech.com	832 331 0140
JAMES	NOVICK	HARRIS CO. ESD 12	JNOVICK@CLOVERLEAF-FIRE.ORG	405-488-8466
Joye	Flores	City of Galena Park	Joye.flores@cityofgalenapark.com	713-569-6295
Derek	Mahan	City of La Porte	mahand@laportetx.gov	281-470-5011
Jason	Reynolds	City of Nassau Bay	jason.reynolds@nassaubay.com	281-333-4211
Meredith	Jennings	HGPH	meredith.jennings@phctx.net	501-951-2722
Joshua	Shideler	Houston TranStar	joshua.shideler@houstontranstar.org	281.277.9962
LISA	GRAFF	HOUSTON PARKS BOARD	lisag@houstonparksboard.org	832 335 0078
Deacon	Tittle	City of Bellaire	dtittle@bellairetx.gov	713-662-8001

HC - LMP Steering Committee Meeting

October 18, 2018, 10:00 a.m.

First Name	Last Name	Agency	Email	Phone
Bryan	Dunaway	HCOHSEM	bryan.dunaway@oem.hctx.net	713-881-3100
Dave	Jackson	TDEM Mitigation	david.Jackson@dps.Texas.gov	512-424-7820
Kelly	Brown	TDEM Mitigation	Kelly.Brown@dps.Texas.gov	713-967-7015
Olupomile	Olowiuya	TSU	Olupomile.Olowiuya@tsu.edu	713 313 4820
Anna	Klineberg	HCPH	anna.klineberg@phs.hctx.net	202-577-3444
Ecomet	Burley	Harris County Dept of EoI	cburley@hede-texas.org	915-696-2127
Darrell	Hahn	HCPID - Permits	darrell.hahn@hcpid.org	713-274-3726
Todd	Ward	HCFCD	Todd.Ward@HCFCD.org	713 316 4858
Aaron	Taylor	West University Place	ataylor@westutx.gov	713-662-5836
Jordan	Macha	Bayou City Waterkeeper	jordan@bayoucitywaterkeeper.org	281.501.8493
Mark	Mitchell	CNEDP	mm.tchellalakehouston.org	281-883-7696
Azell	Carter	Pasadena OEM	acarter@ci.pasadena.tx.us	713-478-4477
Gilberto	Octavio	Consulate of Angola	gilbertooctavio17@yahoo.com	8326686154

HC - LMP Steering Committee Meeting

October 18, 2018, 10:00 a.m.

First Name	Last Name	Agency	Email	Phone
Ashley	Schutt	HCOHSEM	ashley.schutt@oem.hctx.net	832-795-7673
Mikal	Orr	TDEM	mikal.orr@dps.texas.gov	
Rob	Flaner	Tetra Tech	Rob.Flaner@TetraTech.com	208-939-4391
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Demetrius	Shepherd	Cypress		281 387-7801
Jennifer	Rupe	Houston	jennifer.jrupe@gmail.com	5082720883

HC - LMP Steering Committee Meeting

October 18, 2018, 10:00 a.m.

First Name	Last Name	Agency	Email	Phone
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RAY	WATSON	SHELDON ISD	watsonr@sheldonisd.com	281-727-2652
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Thomas	Ehlers	Galena Park	tehlers@cityofgalenapark-tx.gov	832 755-0181
Rogelio	Martinez	Houston OEM	rogelio.martinez@houstontx.gov	713-884-4554
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GARCIA	SOARES	CONSULATE OF ANGOLA	garciasoares@yahoo.com.br	

Harris County Hazard Mitigation Plan-Update
2nd LHMP Steering Committee Meeting
Thursday – January 17, 2019
10:00am – 12:00PM
Houston TranStar | Conference Room 120A
6922 Katy Road, Houston, TX 77024

Welcome and Introductions

- Group Introductions
- Review Agenda
- Review/Approve SC Meeting #1 summary
- Planning Partner Status- Final Roster
- Phase 1, Jurisdictional Annex Status

Risk Assessment Update

- Status report
- Flood hazard Scenarios
- Flood extent and location data
- Houston-Galveston Area Council (HGAC) data for growth, employment and land use data. Is this a good data source?

State and Prior Plan review (meeting #1 homework)

- State Plan review
  - Goals- are they consistent with the Current HCHMP goals?
  - Hazards of Concern-What hazards did the State plan say HC was susceptible to
- 2015 HCMHMP review
  - What do you like about it?
  - What do you dislike about it
  - Proposed changes/enhancements
  - Proposed Table of Contents for Volume 1 of 2019 Plan

Mission Statement for the Plan

- Mission statement, what is it?
- Review 2015 HCMHMP Mission Statement
- Changes or enhancements?
- ***Approve the 2019 HCMHMP Mission Statement (If quorum is present)***

Goal Setting

- Review the goals from the 2015 HCMHMP
- Compare HCMHMP goals to state plan goals
- Changes or enhancements?
- ***Approve goals for the 2019 HCMHMP (if quorum is present)***

Introduce Objective's exercise (Homework)

- What is an objective?
- The 2015 HCMHMP did not identify objectives
- The 2019 HCMHMP will identify objectives that will be utilized to support prioritize actions.
- Linear planning components (MS, Goals, Objectives, then actions)
- Homework assignment

Public Involvement Strategy

- Planning Partner Bulletin
  - Did everyone receive Bulleting #1?
  - Suggestions for Content/Presentation changes
  - Timeline for Bulleting #2
- Hazard Mitigation Survey
  - Do we want to do one?

Harris County Hazard Mitigation Plan-Update
2nd LHMP Steering Committee Meeting
Thursday – January 17, 2019
10:00am – 12:00PM
Houston TranStar | Conference Room 120A
6922 Katy Road, Houston, TX 77024

  - Review and example Survey
  - Suggestions for HC specific Content
- Press release status on the planning Process
- Website is up and running. https://www.readyharris.org/mitigation
- Can the website be enhanced?
- Phase 1, Public Meetings:
  - How Many?
  - Format?
  - Where?
  - When?

Action Items and Next Steps

- Confirm Objectives for the Plan
- Phase 2, Jurisdictional Annex process
- Schedule Phase 1 Public Meetings
- Next Meeting Location?

Adjourn

MEETING SUMMARY

Date/Time of Meeting:	Thursday – January 17, 2019; 10:00am to Noon
Location:	Houston, TranStar, 6922 Katy Freeway Houston, Texas 77024
Subject:	2nd LHMP Steering Committee Meeting
Project Name:	Harris County Hazard Mitigation Plan-Update
In Attendance	***Attendees: X persons in attendance, see attached*** **Core Planning Team:** Brian Murray, Brian Dunaway, Ashly Schutt, Rob Flaner, Chrissie Angeletti
Not Present:	N/A
Summary Prepared by:	Chrissie Angeletti
Quorum – Yes or No	Yes

Welcome and Introductions, Review Agenda

- Bill Wheeler and Rob Flanner opened the meeting.
- Distributed handouts included: Agenda, XXXX
- The agenda was reviewed, and no modifications were made.
- CRS Communities - if primary is not in attendance at one meeting that 2 members will need to attend the next meeting.
- Except for a few exceptions Letters of Intent (LOI) and Annexes are for Taxing-entities only. We are seeking input as stakeholder from non-taxing entity.

Phase I Annex Status

- 40% of Phase I Annex, received.
- Phase 1 will be incorporated into Phase 2.
- If there is an issue, it will be highlighted.
- If Phase I has not been submitted, then Phase 2 will be blank.

Discussion of Phase 2 - Risk Assessment Process

- Risk Assessment – to be performed by Carol Bauman. HMEOC coordinating with GIS lead for Risk Assessment.
- 1 - A Base Map is established using LIDAR data - digital elevation modeling.
- General inventory, is input including critical facilities and Infrastructure.
- Data is collected from various sources including assessor records which can provide the size, value, and occupancy for a structure.

- Homeland Security is another source of data for critical facilities.
- Cultural Resources - consider historic buildings, historic district, Indian tribes, environmental resources can also be considered a cultural resource especially wetlands.
- **SC review and complete gaps in data sets.**
- 2 - Next step is to overlay hazards – e.g. flood, earthquake, tsunami, wind (hurricane).
- HAZUS generates a damage assessment and model is created based on severity.
- For example, flood is done by modeling – 5 events (10yr, 50yr, 100yr, 500yr, and Harvey based on high water data). Thus, 5 scenarios to rank for flood including riverine.
- For example, Earthquake – probabilistic model driven by soil type.

***Every profile will be developed using the same methodology.

Review State Plan (Previous Homework)

- Lightening separate hazard of concern
- Dam and Levee failure are under the umbrella of flooding. Recommendation to keep as separate categories for modeling, etc. This way an action can potentially mitigate 2 separate hazards. Additional CRS credits are also provided when they are listed separately.
- Non-natural hazards - States are required to include in the State-wide HMP, due to different requirements (e.g. Threat and Hazard Identification and Risk Assessment "THIRA"). However, jurisdictions do not have to consider non-natural hazards in an HMP.

Discussion of Upcoming Activities

- Phase 3 – Develop the Mitigation Strategy and Actions. Including a discussion of the comprehensive range of alternatives that were considered and why they were/not selected.
- A catalog of best management practices will be provided to assist with the process.
- The SC will also develop a strategy for Plan Maintenance, include roles and responsibilities, action items, and the frequency of updates.
- For this Update, there will be a County-wide section (Volume I) and an additional volume for each separate jurisdiction (Volume II)
- Once FEMA states the Plan is approved-pending adoption, each jurisdiction will adopt volume I and the specific jurisdiction section under volume II.

Development of Executive Summary, Goals and Mission Statement

- Executive Summary will mirror the State's Plan and will summarize risk findings and actions.

Mission Statement

- To include, natural resources and mitigation against future conditions.
- Natural Resources – goal or as a mitigation strategy
- NR Addressed – as non-structural
- Will use core-capabilities as supporting language

Goals

- For Goal 4 – remove emergency management – local government officials. Remove degrade and add "to improve the protection of natural resources."
- 5 – improve and coordinate
- 8 – investigate and implement a range of nature based solutions and utilize and enhance natural resources and their ability to reduce…

Survey Objectives Exercise

- Survey Objectives Exercise – 30min used for public outreach to determine public's perception of risk.
- Review the survey with the intent to reduce the amount of questions and focus on gauging public perception.
- Different Phase II for Districts vs. Municipalities.
- Involve people from different departments e.g. public works, planning, city management, someone familiar with local codes and regulations.
    - Ask - What goals will this objective meet?
    - Select 10-20 objective statements that add value to the Plan.
    - Mitigation actions – how many objectives does it meet? (*More points if an action meets multiple objectives).
    - Note, a viable action is to increase capability through updating codes and regulations.
    - If you say No e.g. if you have a gap in your core capabilities, then why is there a gap? what can we do to fill the gap?

Discussion of Survey

- Issues with questions directed specifically towards Harris County since various jurisdictions are in multiple counties.

Public Outreach

Public Participation in Phase 1 - Principle objective to gauge public's perception of risk. (Utilize Survey Monkey)

Public Participation Phase 2 - will be at the end of the process to present the draft plan and to provide the public an opportunity to comment on the draft plan.

The SC was briefed on the requirement for an open public process for updating hazard mitigation plans.

- **Document Type of public meeting –** Location, outreach efforts, and number of meetings, etc.
    - Is there a fair, or a large event that has a captive audience?
    - planning partners create links on their individual webpages.
    - Link - so that survey can be completed on phone.
    - Recommendation to link other languages back to Harris County.
- Decided that survey will be in the languages that the county is required to do for voting.

Homework

- **Objectives exercise**
- **Phase I Annex if not complete**

- **Phase II Annex**
- **Survey questions**

Meeting was adjourned at 12:00 PM

Next meeting will be March 21, 2019.

Attachment: Sign-in Sheet

Harris County Hazard Mitigation Plan-Update
3rd LHMP Steering Committee Meeting
Thursday – March 21, 2019
10:00am – 12:00PM
Houston Galveston Area Council
3555 Timmons Lane, Suite 120
Houston TX 77027

Welcome and Introductions

- Group Introductions
- Review Agenda
- Review/Approve SC Meeting #2 summary
- Planning Partner Contact Information-Who is not getting Bulletins?

Risk Assessment Update

- Status report

Objective Setting

- Want to identify objectives that meet multiple goals
- Objective Exercise results
- Review the top vote getters
- Refine, define and confirm the objectives for the plan

Phase 2, of the Jurisdictional Annex Process

- What we are seeing so far
- Let's review the phase 2 instructions
- Questions, comments, concerns?

Public Involvement Strategy

- Planning Partner Bulletin
    - Did everyone receive Bulleting #2?
    - Suggestions for Content/Presentation changes
    - Timeline for Bulleting #3
- Hazard Mitigation Survey
    - Confirm Content for Harris County Survey
    - The Goal is to have the survey open before the Phase 1 Public meetings
    - Will need to do a press release to advertise the Survey
    - Will be looking for each planning partner to promote and distribute
- Phase 1, Public Meetings:
    - We are behind schedule due to data availability
    - Target Dates for Phase 1 Outreach
    - Where?
    - How long?
    - Format?

Action Items and Next Steps

- Review Risk Assessment results
- Core Capabilities exercise-SWOO
- Schedule Phase 3, JA Workshops
- Next Meeting Location?

Adjourn

MEETING SUMMARY

Date/Time of Meeting:	Thursday, March 21, 2019; 10:00 a.m. to 10:30 a.m.
Location:	Houston-Galveston Area Council (H-GAC)
	3555 Timmons Lane, Houston, Texas 77027
Subject:	3rd LHMP Steering Committee Meeting
Project Name:	Harris County Hazard Mitigation Plan-Update
In Attendance	***Attendees: 32 persons in attendance, see attached***
	Core Planning Team: Brian Murray and Brian Rutherford
Not Present:	N/A
Summary Prepared by:	Oscar Ortega and Brian Rutherford
Quorum – Yes or No	No

Item	Action

Welcome and Introductions

- Brian Murray opened the meeting and facilitated group introductions.
- Brian Murray announced there were not enough planning partner jurisdictions present at the meeting to achieve a quorum. To achieve a quorum there must be 9 members plus at least one of the co-chairs. However, the group could discuss project updates and other matters not requiring a group consensus.

Risk Assessment Update

Brian Rutherford, with Tetra Tech, provided an update on the risk assessment activities that Tetra Tech is conducting in coordination with Harris County. A copy of the risk assessment report is attached.

Jurisdictional Annex Development

Brian Rutherford reported that Tetra Tech has received 21 completed phase 1 surveys so far. That represents only half of the planning partners involved in the project. Planning partners who have not completed phase 1 templates should complete and send them to Brian Rutherford. Tetra Tech has received 2 completed phase 2 surveys. Phase 2 surveys are due to Brian Rutherford on March 29th.

Planning partners who have not completed phase 1 should work to complete it and email to Brian Rutherford.

Mr. Rutherford encouraged planning partners to refer to the provided instructions in completing both the phase 1 and phase 2 templates. The

Phase 2 templates are due to Brian Rutherford by March 29th.

instructions provide examples to assist planning partners in completion of the templates. In addition, Mr. Rutherford asked planning partners to complete the templates as thoroughly as possible and to contact him with any questions.

Mr. Rutherford invited any questions regarding the templates. Attendees at the Steering Committee had no questions at this time.

Bulletins

Mr. Rutherford polled attendees to see if any attendees did not received the 1st and 2nd bulletins sent out to update members on the status of the project. No attendees indicated that they had not received the bulletins. It was suggested that the objectives survey included in the second bulletin be sent to planning partners by email to increase participation. The purpose of the survey is to select the objectives members would like to see included in the plan.

Tetra Tech will email the link for the objectives survey to planning partners.

Next Steps

Mr. Rutherford discussed the next steps for the project:

- Set up next Steering Committee Meeting.
- Set up dates for public meetings.
- Determine objectives for the plan.
- Determine questions for public survey.

Homework

Before the next steering committee meeting, members are to:

- Complete the survey if they have not already done so.
- Review the example public survey and be ready for the next meeting to provide suggestions for the Harris County Mitigation public survey.

Meeting was adjourned at 10:30 a.m.

The date of the next meeting is May 16th.

Harris County Hazard Mitigation Plan-Update
4th LHMP Steering Committee Meeting
Thursday – May 16, 2019
10:00am – 12:00PM
Houston TranStar | Conference Room 120A
6922 Katy Road, Houston, TX 77024

Welcome and Introductions

- Group Introductions
- Review Agenda
- Review/Approve SC Meeting #3 summary
- Planning Partner Jurisdictional Annex Process-Status Report

Risk Assessment Update

- Status report

Objective Setting

- Want to identify objectives that meet multiple goals
- Objective Exercise results
- Review the top vote getters
- Refine, define and confirm the objectives for the plan

Public Involvement Strategy

- Hazard Mitigation Survey
    1. County has approved a survey for dissemination
    2. Review/Comment on the survey
    3. Need to get the word out!
    4. Every SC member, Planning Partner and Alternate should take the survey
    5. All planning partners should try to distribute to their constituents
    6. Our target is over 2000 surveys!
- Phase 1, Public Meetings:
    1. We are behind schedule due to data availability
    2. Due to recent events, we will down scale phase 1. We will do only 1, reginal event that will be advertised to the entire planning area.
    3. Time frame is mid-June
    4. Open House format
    5. TransStar location

Phase 3, Jurisdictional Annex Workshop

- To be scheduled in concert with the July SC Meeting
- 3-Hour Format
- One for Municipalities
- Once for Districts/Universities/medical centers.
- Will provide multiple options for attendance
- **Attendance to a phase 3 workshop is MANDATORY!**

Action Items and Next Steps

- Review Risk Assessment results
- Core Capabilities exercise-SWOO
- Confirm Plan Maintenance Strategy

Adjourn

MEETING SUMMARY

Date/Time of Meeting:	Thursday – May 16, 2019; 9:00am to Noon
Location:	Houston, TranStar, 6922 Katy Freeway Houston, Texas 77024
Subject:	4th LHMP Steering Committee Meeting
Project Name:	Harris County Hazard Mitigation Plan-Update
In Attendance	***Attendees: 39 persons in attendance, see attached*** **Core Planning Team:** Brian Murray, Bryan Dunaway, Ashley Schutt, Benzon John, Brian Rutherford, Chrissie Angeletti
Not Present:	N/A
Summary Prepared by:	Chrissie Angeletti
Quorum – Yes or No	Yes

Welcome and Introductions, Review Agenda

- Brian Murray opened the meeting.
- The previous meeting notes were reviewed and adopted.
- CRS Communities - If primary is not in attendance at one meeting that 2 members will need to attend the next meeting in order for CRS credit to be received. Additionally, 9 CRS communities must be in attendance for a quorum to be present. CRS communities include: Baytown, Bellaire, Deer Park, Friendswood, LaPorte, Missouri City, Nassau Bay, Pasadena, Seabrook, Shoreacres, Taylor Lake Village.

Phase I and II Annex Status

- 65% of Phase II Annex, received.
- 13% have submitted the Phase I Annex only.
- 22% still need to submit Phase I and Phase II.
- Phase 2 MUST be completed prior to next Steering Committee meeting on July 16, 2019 in order to participate in Phase III.

Plan objectives, discussion and adoption

- Reviewed results of the objectives exercise and selected objective statements that add value to the Plan.
- The objectives were adopted by the steering committee and categorized under the previously adopted goals.
- See Attachment for final goals and corresponding objectives.

Public Survey

- Public Survey was reviewed by steering committee and finalized
- **Goal to collect over 2000 survey results**
- Discussion regarding ways to disseminate including websites, social media (Facebook, Twitter, Instagram, Nextdoor), mail-outs (newsletters and utility bills) and public events (upcoming conferences and fundraisers)

Public Outreach

- Public Participation in Phase 1 - Principle objective to gauge public's perception of risk.
- June 20th Interactive Public Workshop at Houston TranStar 6pm-9pm to present results of Risk Assessment.
    - Due to recent events, we will have ONLY 1 Public Sorkshop for Phase 1.
    - Harris County to create a shareable facebook event.
    - Open-House Format
    - (Note: Public Workshop is for the general public and Steering Committee members are not required to attend).
- Public Survey - All participating jurisdictions and stakeholders to disseminate via website, social media (Facebook, Twitter, Instagram, Nextdoor), Mail-outs (Newsletters and Utility Bills), and public events.

The SC was briefed on the requirement for an open public process for updating hazard mitigation plans.

- **Document Type of public outreach –** Location, outreach efforts, and number of meetings, etc.

Discussion of Upcoming Activities

- Next Steering Committee Meeting is Tuesday, July 16th at Houston Transtar from 10am-12pm. The SC meeting will be held prior to the Phase 3 Jurisdictional Annex workshops.
    - Review Risk Assessment results
    - Core Capabilities exercise-SWOO Strengths, weaknesses, obstacles and opportunities (Mitigation catalog to identify alternatives)
    - Confirm Plan Maintenance Strategy - The SC will also develop a strategy for Plan Maintenance, include roles and responsibilities, action items, and the frequency of updates.

- **Phase 3 Jurisdictional Annex Workshop attendance is MANDATORY for participating jurisdictions!**

- ***Phase 1 and Phase II must be completed prior to attendance!!!!!!!***
- Phase 3 – Develop the Mitigation Strategy and Actions. Including a discussion of the comprehensive range of alternatives that were considered and why they were/not selected.
  - A catalog of best management practices will be provided to assist with the process.
- Different workshop for Municipalities and Special Districts.
- Multiple workshops offered, please sign up for only one (1) workshop.

July 16, 2019 (TUESDAY)

10am-12pm STEERING COMMITTEE MEETING

1pm-4pm – Phase 3 Workshop for Municipalities

July 17th, 2019 (WEDNESDAY)

9am-12pm -Phase 3 Workshop for Municipalities

1pm-4pm – Phase 3 Workshop for Special Districts

July 18th, 2019 (THURSDAY)

9am-12pm – Phase 3 Workshop for Special Districts

1pm-4pm – Phase 3 Workshop for Municipalities

Homework

- ***Complete outstanding Phase 1 and Phase II Annex***
- ***Promote Public Survey through websites, social media (Facebook, Twitter, Instagram, Nextdoor), mail-outs (newsletters and utility bills) and public events (upcoming conferences and fundraisers)***
- ***Promote June 20th Interactive Public Meeting to review Risk Assessment results from 6-9pm at the Houston TranStar facility located at 6922 Katy Freeway, Houston, Texas 77024***

Next meeting will be Tuesday, July 16th at 10am.

Attachment: Sign-in Sheet, Adopted Goals and Objectives

Harris County Hazard Mitigation Plan Goals and Objectives

Goal 1. Expand warning systems and local warning capabilities among departments and between jurisdictions.

Goal 1 Objective:

- Improve and expand systems that provide warning and emergency communications to the whole community

Goal 2. Improve and coordinate data collection efforts to fully maximize the intent of the efforts and to improve the mitigation capabilities of the county and all jurisdictions.

Goal 2 Objectives:

- Implement wildfire mitigation and watershed protection strategies through local, state, tribal, federal and private partnerships.
- Improve understanding of the locations, potential impacts, and linkages among threats, hazards, vulnerability, and measures needed to protect life safety and health.

Goal 3. Enhance education strategies to improve the dissemination of information to the public regarding hazards, including the steps that can be taken to reduce their impact.

Goal 3 Objective:

- Improve and expand systems that provide warning and emergency communications to the whole community.

Goal 4. Improve the capabilities of local government officials to reduce or eliminate hazards that cause loss of life, inflict injuries, cause property damage and to improve the protection of natural resources.

Goal 4 Objectives:

- Reduce the impacts of hazards on individuals with disabilities and others with access and functional needs.
- Coordinate state and local efforts to reduce greenhouse gas emissions and implement climate adaptation strategies through hazard mitigation plans and actions.
- Control access and provide buffers to maximize resource protection where possible.
- Encourage all state, regional and local hazard mitigation projects and planning programs to protect the environment and promote implementation of sustainable mitigation and climate actions.
- Encourage hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem.

Goal 5. Work to improve and coordinate existing local plans, codes and regulations to reduce the impacts of natural hazards.

Goal 5 Objectives:

- Promote enforcement of relevant state regulations and development of local ordinances that significantly reduce life loss and injuries.
- Encourage all cities, counties, special districts, Councils of Governments and tribal organizations to develop, adopt, and implement local hazard mitigation principles to be integrated with local general plan safety elements, local coastal plans, facilities master plans, and other local plan initiatives.
- Implement wildfire mitigation and watershed protection strategies through local, state, tribal, federal and private partnerships.
- Advance community resilience through preparation, adoption, and implementation of state, regional and local multi-hazard mitigation plans and projects.

Goal 6. Implement property protection measures to reduce the effects of natural hazards throughout the county, including measures that reduce or eliminate repetitive loss occurrences.

Goal 6 Objectives:

- Encourage projects that simultaneously reduce risk while increasing resilience and sustainability.
- Retrofit, elevate, purchase, or relocate structures in high hazard areas, especially those known to be repetitively damaged.
- Support the protection of vital and essential records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery.
- Encourage life and property protection measures for all communities and structures located in the greater Harris County region.
- Manage development in geologically hazardous areas and floodplains to protect life and property.

Goal 7. Investigate and implement a range of structural projects that will reduce the effects of natural hazards on public and private property throughout the county.

Goal 7 Objectives:

- Support the protection of vital and essential records, and strengthening or replacement of buildings, infrastructure, and lifelines to minimize post-disaster disruption and facilitate short-term and long-term recovery.
- Encourage life and property protection measures for all communities and structures located in the greater Harris County region.
- Promote disaster resistant development.
- Manage development in geologically hazardous areas and floodplains to protect life and property.

Goal 8. Investigate and implement a range of nature-based solutions and utilize and enhance natural resources and their ability to reduce the impacts from natural hazards.

Goal 8 Objective:

- Encourage all state, regional and local hazard mitigation projects and planning programs to protect the environment and promote implementation of sustainable mitigation and climate actions.

HARRIS COUNTY
OFFICE OF HOMELAND SECURITY & EMERGENCY MANAGEMENT

6922 Katy Road, Houston, Texas 77024
Phone: 713-881-3100 Fax: 713-881-3077
www.hcoem.org

Date: May 16, 2019 **Meeting:** Mitigation Steering Committee Meeting

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* Tom Merchant	El Lago	2816823670	tmerchant@comcast.net
* Katy Atkiss	HILSC	310 422 9226	Katy@houstonimmigration.org

* no name card

HARRIS COUNTY
OFFICE OF HOMELAND SECURITY & EMERGENCY MANAGEMENT

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Phone: 713-881-3100 Fax: 713-881-3077
www.hcoem.org

Date: May 16, 2019 **Meeting:** Mitigation Steering Committee Meeting

	NAME	ORGANIZATION	PHONE	EMAIL
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	JANICE Owolabi	Harris Co. Dept. of Ed	713-696-3142	jowolabi@hcde-texas.org
	Steven Simmons	city of Friendswood	281-996-5336	SSimmons@friendswood.com
	Frank Bangcha	Pasadena	7134715888	fbangcha@ci.Pasadena.TX.us
*	Darrell Hahn	HC Permits	713-274-3776	Darrell.hahn@hcpid.org
*	Howard Miller	Village FD	713-468-7941	miller@villagefire.org
*	Meredith Jennings	Houston Advanced Research Center		mjennings@harcresearch.org
	ChaVonne Sampson	city of Bellaire	713-662-3972	CSampson@bellairetx.gov
	Derrick Harris	Lone Star College	281-290-3667	derrick.d.harris@lonestar.edu
*	Jordan Macha	Bayou city Waterkeeper	713.714.8442	jordan@bayoucitywaterkeeper.org

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6922 Katy Road, Houston, Texas 77024
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www.hcoem.org

Date: May 16, 2019 **Meeting:** Mitigation Steering Committee Meeting

NAME	ORGANIZATION	PHONE	EMAIL
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Charles Galyean	Seabrook	281-291-5700	jgalyean@seabrooktx.gov
NIKI BENDER	FRIENDSWOOD OEM/EMO	281-996-3335	NBENDER@FRIENDSWOOD.COM
Todd Ward	HCFCD	713 316 4858	Todd.Ward@HCFCD.HCTX.NET
Brian Owoseni	HCC	6713-718-2591	oludoyin.owoseni@hccs.edu
ERIK SWEET	PASADENA OEM	713 301 0311	esweet@ci.pasadena.tx.us
Azell Carter	Pasadena OEM	713-475-5588	acarter@ci.pasadena.tx.us
* Ashley Merchant	Stafford OEM	281-261-3993	amerchant@staffordtx.gov
* Carla Mrnka	Pasadena ISD	713-740-0003	Cmrnka@pasadenaisd.org
Aaron Taylor	City of West University	713 662 5836	ataylor@westutx.gov
Dena Mahan	La Porte	281-470-0011	mchand@laportetx.gov

Harris County Hazard Mitigation Plan-Update
5th LHMP Steering Committee Meeting
Tuesday – July 16, 2019
10:00am – 12:00PM
Houston TranStar | Conference Room 120A
6922 Katy Road, Houston, TX 77024

Welcome and Introductions

- Group Introductions
- Review Agenda
- Review/Approve SC Meeting #4 summary
- Phase 1/2 Jurisdictional Annex Status
- Review Final Mission, Goals/Objectives

Risk Assessment Update

- Review R/A results

Phase 1 Public Meeting Recap

- Was held on 6/20/2019
- Attendance
- What we learned?

Public Involvement Strategy

- Hazard Mitigation Survey
    1. Currently over 1350 survey's
    2. We still want to exceed 2000, se please keep promoting
    3. Review preliminary results
- What's next? The Phase 2 process

Capability Exercise

- Why are we doing this?
- Dot exercise on the capability posters
- Green dot = a core capability that is a strength within the Planning Area
- Red dot= a core capability that is a weakness within the planning area

Plan Maintenance Strategy

- What is required, DMA and CRS
- Annual Progress reporting
    - BATool Demonstration
- Review example strategy
- Confirm Plan Maintenance Strategy

Action Items and Next Steps

- Internal review Draft of the plan
- Phase 2 Public Outreach strategy
- Plan submittal protocol
- ***This should be our last meeting for this update process!***

Adjourn

MEETING SUMMARY

Date/Time of Meeting:	Tuesday – July 16, 2019; 10:00am to Noon
Location:	Houston, TranStar, 6922 Katy Freeway Houston, Texas 77024
Subject:	5th LHMP Steering Committee Meeting
Project Name:	Harris County Hazard Mitigation Plan-Update
In Attendance	***Attendees: 52 persons in attendance, see attached*** **Core Planning Team:** Brian Murray, Bryan Dunaway, Ashley Schutt, Benzon John, Rob Flaner, Brian Rutherford, Chrissie Angeletti
Not Present:	N/A
Summary Prepared by:	Chrissie Angeletti
Quorum – Yes or No	Yes

Welcome and Introductions, Review Agenda

- Brian Murray opened the meeting.
- The previous meeting notes were reviewed and adopted.

Phase I and II Annex Status

- 90% of Phase I and II Annex's Completed.
- Participation in Phase III Workshop is mandatory. If a jurisdiction does not attend, they are not able to participate in the Plan.
- If you are not participating in the Plan, you can still participate through the linkage process.
- Phase 2 MUST be completed prior to completing Phase III.

Plan objectives, discussion and adoption

- See Attachment for final goals and corresponding objectives.

- Mission/Goals/Objectives – Objectives to be utilized to prioritize actions (8 Goals/15 objectives). Objectives are referenced in a grant application to support a project's eligibility.

Risk Assessment Results

- Data collected will be available through Harris County.
- Every Participant will receive a Toolkit.
- Tetra Tech ran a Hazus – Level II User-Defined Model. Over 136,000 facilities were modeled with 15 data points, such as occupancy and content value. The model evaluates the value when the structure encounters a hazard to determine loss value.
- Critical facilities – additional value – functional downtime.
- Results by occupancy class.
- Without spatial data, hazards are evaluated on a qualitative/subjective level – e.g. Landslide, Tsunami
- Severe Weather – Discussed in terms of net effect since it cannot be analyzed on a spatial map.
- Benefits of data include:
    a. Assist with determining at what level of event a structure will flood and to what degree.
    b. Grant Applications - Estimating damages/loss - Use the toolkit to determine historic and expected damages.
    c. Table top exercise – utilized data to develop scenarios.
    d. Question regarding Hazardous Materials – Response: Damage functions cannot be adjusted on that level. However, it will tell you that a facility with hazardous materials gets 3ft of flood depth. Can raise a red flag.
    e. Repetitive Loss – Assist with determining how much a structure should be elevated.

Public Survey

- Have received over 1,5000 surveys so far
- **Goal to collect over 2000 survey results. Available through September.**
- Discussion regarding ways to disseminate including websites, social media (Facebook, Twitter, Instagram, Nextdoor), mail-outs (newsletters and utility bills) and public events (upcoming conferences and fundraisers)

Public Outreach

- Public Participation in Phase 1 - Principle objective to gauge public's perception of risk.
- June 20th Interactive Public Workshop at Houston TranStar 6pm-9pm to present results of Risk Assessment.
    - Due to recent events, we will have ONLY 1 Public Sorkshop for Phase 1.
    - Harris County to create a shareable facebook event.
    - Open-House Format
    - (Note: Public Workshop is for the general public and Steering Committee members are not required to attend).
- Public Survey - All participating jurisdictions and stakeholders to disseminate via website, social media (Facebook, Twitter, Instagram, Nextdoor), Mail-outs (Newsletters and Utility Bills), and public events.

The SC was briefed on the requirement for an open public process for updating hazard mitigation plans.

- **Document Type of public outreach –** Location, outreach efforts, and number of meetings, etc.
- Data analytics from the survey on your jurisdiction are available upon request.

Core Capability Exercise

- Dot exercise was performed on capability posters.
- Develop a dot matrix to identify strengths and weaknesses and show FEMA how a comprehensive list of alternatives was developed.

Plan Maintenance Strategy

- DMA requirements:
    a. Must have strategy for continuous public involvement over the next five years.
    b. Description of how Plan will be maintained.
- CRS Requirements:
    a. Public Involvement.
    b. Annual Progress Reporting. Get additional credit if you review twice a year.
- Strategy Must Identify: Reporting format, reporting period, Plan implementation, and what will trigger an update.
    a. E.g. The Report will be web-based and results will be posted to the County's website. Once a year representatives from the SC will meet evaluate and review the report and overarching progress of the Plan. A presidentially declared disaster will trigger an update.
- Reporting makes the Plan dynamic – a jurisdiction may add or remove actions through a progress report, and allows for uncorporation of other Planning Mechanisms and studies.
- BATool Demonstration
- Review/Confirmed Plan Maintenance Strategy

Discussion of Upcoming Activities

- Next Meeting – September 19, 2019 at 10am at Houston TranStar.
- Internal Draft Plan will be presented and reviewed at the next Steering Committee meeting.
- 2-week Public Comment Period and corresponding Public Meeting to be advertised via press-release on websites, social media, public events, etc.
- Finalization of Draft Plan: After public comment period ends and edits have been made, the Draft Plan will go to TDEM for review. After TDEM's comments have been addressed it will go to FEMA for "Approval Pending Adoption." Once APA is received by FEMA, a council briefing packet and power point presentation will go to each participating jurisdiction to present to each jurisdiction's respective City Council for adoption. FEMA will issue final approval on the date FEMA gets the first resolution.

Homework

- ***Complete outstanding Annex's by August 23rd!***
- ***Promote Public Survey through websites, social media (Facebook, Twitter, Instagram, Nextdoor), mail-outs (newsletters and utility bills) and public events (upcoming conferences and fundraisers)***

Attachment: Sign-in Sheet

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting
July 16, 2019 / 1000 - 1200
COMMITTEE MEMBERS SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Cheryl Cepeda	Lone Star College	Lone Star College	281-290-2891	Cheryl.C.Cepeda@lonestar.edu
Buddy Rice	DEER PARK	DEER PARK	281-478-7281	briceedeerparktx.org
Troy D. Harrison	City of Shoreacres		281.471.2244	THarrison@cityofshoreacres.us
Nick Kondejewski	City of Seabrook		281-291-5639	nickk@seabrooktx.gov
Kelly Snook	Greens Bayou Coalition		832 693 6266	ksnook@yahoo.com
Brian Rutherford	TETRA TECH	TETRA TECH	281-414-6741	brian.rutherford@tetratech.com
Ashley Schutte	HC	HCOHSEM	832-795-7673	ashley.schutte@oem.hctx.net
Jamie Galloway	Baytown OEM		281 422 1192	jamiegalloway@baytown.org
Erik Swet	PASADENA OEM	PASADENA	281 484-7758	eswet@pasadenaTx.gov
Frank Banuelos	PASADENA OEM	PASADENA	713 475 5588	fbanuelos@pasadenatx.gov
Chrissie Angeletti	Tetra tech		512.917.7575	Chrissie.Angeletti@tetratech.com
Bryan Dunaway	HCOHSEM		713.881.3100	bryan.dunaway@oem.hctx.net
Angela Smith	Texas Children's C.O.H Hospital	Texas Children's Hospital	832-824-5889	ansmith@texaschildrens.org
Aaron Froedtin	Texas childrens Hospital	Texas childrens Hospital	832-824-1245	afroedtk@texaschildrens.org
Warren Porter	TEXAS MED CTR	TMC	713 791 8843	wporter@tmc.edu
Sherri Ditrich	City of Morgan's Point	EMC/PIO	281-471-2171	sditrich@morganspoint-tx.com
Jason Myers	Webster	Fire	281 316 3751	Jmyers@websterfd.com
Belinda Raindl	San Jacinto River Auth.	River Author	830-822-2576	Braindl@sjra.net
Dawn Blackman	Houston SPCA		281/772-1639	dblackman@houstonspca.org

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting
July 16, 2019 / 1000 - 1200

COMMITTEE MEMBERS SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Charles J. Galyean	Seabrook	OEM	281-291-5700	jgalyean@seabrooktx.gov
James Novick	HC ESD 12		405-488-8468	JNovick@cloverleaf-fire.org
Janice Owolabi	Harris Co.	Harris Co. Dept. of Ed	713-696-3142	jowolabi@hcde-texas.org
DEAN SPENCER	CITY OF WEBSTER	OEM	281-316-3730	dspencer@webstertxfd.com
Jon Powell	City of Taylor Lake Village		713-252-3477	jon@japowell.com
Brian Owoseni	Houston Community College		713-718-2591	oludoyin-owoseni@hccs.edu
Derrick Harris	Lone Star College	Dept. of Emer. Prep.	281-290-3667	derrick.d.harris@lonestar.edu
Steven Simmons	City of Friendswood	EMO/OEM	281-996-3335	ssimmons@friendswood.com
Howard Miller	Village FD		713-468-7941	miller@villagefire.org
Ashley Merchant	City of Stafford	OEM	281-261-3993	amerchant@staffordtx.org
Darrell Hahn	Harris County - HCED	HCED / Permits	713-274-3776	darrell.hahn@hcpid.org
Robert McCracken	Houston Community College	HCC	713 718 7520	ROBERT.MCCRACKEN@hccs.edu
Paige Powell	Air Alliance Houston		713-528-3779	Paige@airalliancehouston.org
Kelly Boysen	University of Houston	OEM	713-743-2841	krboysen@uh.edu
Aaron Taylor	West University Place	OEM	713-662-5836	ataylor@westutx.gov
Benzon K John	Harris County OEM	OEM	832-286-5680	benzon.john@oem.hctx.net
Chavonne Sampson	City of Bellaire		713-662-	CSampson@bellairetx.gov

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting
July 16, 2019 / 1000 - 1200

COMMITTEE MEMBERS SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Dena Mahan	Nassau Bay	OEM	281-333-7373	dena.mahan@nassaubay.com
Jason Reynolds	Nassau Bay	City Manager Deputy EMC	281-333-4211	jason.reynolds@nassaubay.com
DAVID ALAMIA	CoB	EMC	281-422-1168	david.alamia@baytown.org
Natalie Johnson	TDEM / Austin	TDEM	512-377-0005	natalie.johnson@dps.texas.gov
RICK DEEL	HCHSOEM			RICK.DEEL@OEM.HCTX.NET
Lisa Gonzales	HARC / nonprofit	HARC	281-364-6044	lgonzalez@harc.edu
Kristin Gauthier	City of La Porte	OEM	281-470-0009	gauthierk@laportetx.gov
Wm Earl Finley	Houston ISD	HISD Risk Mgt	713 556 9229	wfinley@houstonisd.org
Todd Ward	HCFCD		713 316 4858	Todd.Ward@HCFCD.HCTX.NET
Katy Atkiss	~~HHLSC~~ Houston	HILSC	310-422-9226	Katy@houstonimmigration.org
Deacon Tuttle	Bellaire	CO Bellaire	713-662-8201	dtittle@bellairetx.gov
JAMILA JOHNSON	~~CO~~HOUSTON	COH	832 394 9380	jamila.johnson@houstontx.gov
LISA GRAFF	HOUSTON PARKS BOARD	"	832 335 0078	lisag@houstonparksboard.org
MARK STEUER	WHITE OAK BAYOU ASSOCIATION		713 702 8411	steuers@flash.net

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting
July 16, 2019 / 1000 - 1200

PUBLIC SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Matthew Ford		TFS	281-706-7105	mford@tfs.tamu.edu
Belinda Randle	SJRA	SJRA	830-822-257	brandle@sjra.net

Harris County Hazard Mitigation Plan-Update
6th LHMP Steering Committee Meeting
Thursday – October 24, 2019
10:00am – 12:00PM
Houston TranStar | Conference Room 120A
6922 Katy Road, Houston, TX 77024

Welcome and Introductions

- Group Introductions
- Review Agenda
- Review/Approve SC Meeting #5 summary
- Phase 3 Jurisdictional Annex Status
- CDBG-MIT nexus
- Hazard mitigation Survey Status-1, 624 and counting!

Capability Exercise results

- The results were presented in the Bulletin
- What did we learn?
- How can we address gaps?

Plan Maintenance Strategy

- Review proposed Draft Strategy
- Annual Progress reporting
    - BATool Demonstration
- Confirm Plan Maintenance Strategy

Internal review Draft of the Plan

- The complete draft of the plan is not quite ready
- Both Volumes are at approximately 90% complete
- Planning team will distribute internal review drafts to all SC members by 10/25/2019
- Phase 2 Public meeting will be 11/7/2019 at Transtar.
- We are still targeting a 2-week public comment period, beginning on 11/7
- SC members and stakeholders can still provide comment during public comment period

Action Items and Next Steps

- Internal review Draft of the plan
- Phase 2 Public Outreach strategy during Public Comment period
- Target date for plan submittal to TDEM is 11/29/2019

Adjourn

MEETING SUMMARY

Date/Time of Meeting:	Thursday – October 24, 2019; 10:00am to Noon
Location:	Houston, TranStar, 6922 Katy Freeway Houston, Texas 77024
Subject:	6th LHMP Steering Committee Meeting
Project Name:	Harris County Hazard Mitigation Plan-Update
In Attendance	***Attendees: 42 persons in attendance, see attached*** **Core Planning Team:** Brian Murray, Bryan Dunaway, Ashley Schutt, Benzon John, Rob Flaner, Brian Rutherford, Chrissie Angeletti
Not Present:	N/A
Summary Prepared by:	Chrissie Angeletti
Quorum – Yes or No	Yes

Welcome and Introductions, Review Agenda

- Brian Murray opened the meeting.
- The previous meeting notes were reviewed and adopted.

Phase III Annex Update

- Brian Rutherford provided update on Phase III Annex Completion.
- A corrected form was sent out, however some still used older form. Tetra Tech is working with individual jurisdictions to update any carry over items.
- Jurisdictions to review their Annex in the Internal Draft of the HMP for edits and feedback.

Public Survey

- Have received over 1,627 surveys total. Public Survey period is closed.

CDBG-MIT

- State is currently working on Action Plan, currently due in February.
- Harris County All Hazards Mitigation Plan Update to continue per the original scope. Any additional requirements to be accounted for in an amendment to the Plan.

Capabilities Exercise Results

- Discussion regarding highest and lowest ranked selections.
- Comments included:
    - Results potentially skewed due to participants positions and job functions.
    - Fostering partnerships especially with Non-profits. Benefits of partnerships include additional funding sources and increased public outreach opportunities and resources.
    - Increase support to smaller jurisdictions that are lacking in resources.
    - Increase public outreach:
        - Utilize professional marketing companies.
        - Utilize additional media outlets including news stations, radio, home owners associations, and educational institutions.
        - Increase frequency of communication – bring the message into the common conversation.
        - Share lessons learned and success stories.
    - Utilize data to show the damages prevented after mitigation. E.g. Damages prior and post mitigation action.
    - Real Estate Purchases – Unsure if flood risk and affordable flood insurance is being communicated especially for those with lower economic status. Discussed how flood risk is a reflected in development, especially for City's with Master Plans vs. those homes that are not in an area with planned development or zoning restrictions. Discussed the presence/removal of flood gauges.
- Maapnext.org – Online tool developed to map flood risk.

Plan Maintenance Strategy

- DMA requirements:
    - Must have strategy for continuous public involvement over the next five years.
    - Description of how Plan will be maintained.
- CRS Requirements for Re-Certification:
    - Public Involvement.
    - Annual Progress Reporting. Get additional credit if you review twice a year.
    - Each jurisdiction seeking CRS credit is scored separately – each jurisdiction is required to submit a progress report for their own community to maintain certification.
- Strategy Must Identify: Reporting format, reporting period, Plan implementation, and what will trigger an update.

- The Report will be web based and results will be posted to the County's website.
- Representatives from the SC will meet semi-annually to evaluate and review the report and overarching progress of the Plan. A presidentially declared disaster will trigger an update.
- Reporting will take place at least once a year in March. An additional mid-year report is optional for participating jurisdictions.

- Reporting makes the Plan dynamic – a jurisdiction may add or remove actions through a progress report (do not need to re-adopt the Plan) and allows for incorporation of other Planning Mechanisms and studies.
- BATool Demonstration
  - Web-based software program designed to assist with assessing and reporting on the status of mitigation actions. Subscription to the tool is required. Harris County and participating jurisdictions will receive the tool for free for 1 year.
  - BATool effective 1 year from final approval date of the Harris County All Hazards Mitigation Plan.
- Review/Confirmed Plan Maintenance Strategy

Internal Review of Draft Plan

- Volume I is applicable to all jurisdictions.
- Volume II is jurisdiction specific.
- Maps are included as separate pdf (to be formatted into "PUBLIC REVIEW DRAFT").
- All tables are in pdf versions of vol. I and II.

Instructions

- Please make comments and track changes (review tab in Microsoft) in the Microsoft word version ("docx.") and email to Chrissie.Angeletti@tetratech.com at your earliest convenience.
- Once the internal review comments are received, the team will generate a PUBLIC REVIEW DRAFT with corresponding links and press release. Please note, comments can still be received by participating jurisdictions and stakeholders through the end of the public comment period.

Time Line

- Now – November 5th Internal Comment Period: Receive comments from steering committee on INTERNAL DRAFT.
- November 6th – Generate PUBLIC REVIEW DRAFT.
- November 7th-21st Public Comment Period: Issue PUBLIC REVIEW DRAFT and Press Release, receive comments from the general public.
- November 14th – Public Workshop to review PUBLIC REVIEW DRAFT, Invitation to be distributed, Steering Committee to assist with outreach, Steering Committee does not need to attend.
- November 29th – FINAL DRAFT submitted to TDEM for review.
- June 2020 (Estimated) – FEMA Approved Pending Adoption

Next Steps

- Review and send comments on INTERNAL DRAFT.
- Promote PUBLIC REVIEW DRAFT on websites, social media, etc.
    - Link to view AHMP
        - https://bit.ly/2qua6jK
    - Link to provide public comment:
        - https://www.surveymonkey.com/r/HarrisCounty_Public_Comment
- Promote Public Workshop to review PUBLIC REVIEW DRAFT on November 14th from 6pm-9pm in Room 120A at Houston TranStar located at 6922 Katy Rd, Houston, TX 77024.
- Document Type of public outreach – Location, outreach efforts, and number of meetings, etc. and email them to Chrissie.Angeletti@tetratech.com.
- Data analytics from the survey on your jurisdiction are available upon request.

Attachment: Sign-in Sheet

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting

Oct 24, 2019 / 1000 - 1200

COMMITTEE MEMBERS SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Jamie Galloway	City of Baytown	Baytown	281 422 1129	jamie.galloway@baytown.org
Niki Bender	City of Friendswood	Friendswood	281-996-3335	NBENDER@CI.FRIENDSWOOD.TX.US
Erik Sweet	City of Pasadena	Pasadena	713-475-4877	esweet@pasadenatx.gov
Cheryl Cepeda	Lone Star College		281-290-3891	cheryl.c.cepeda@lonestar.edu
Jenchel Matthews	Houston ~~TX~~ TX	Houston LISC	615,400.0274	Smatthews@lisc.org
Warren Porter	TMC	TMC	713 791 8843	wporter@tmc.edu
Derrick Harris	Lone Star College		281-290-3667	derrick.d.harris@lonestar.edu
James Novick	Harris Co ESD 12 - FD		405-488-8468	JNOVICK@CLOVERLEAFFIRE.NET
Dawn Blackmar	Houston	Houston SPCA	281 772-1639	dblackmar@houstonspca.org
Jon Powell	Taylor Lake Village	Taylor Lake City Council	713-252-3477	jpowell@tlv-tx-us
Howard Miller	Village FD/Mem Village		713-468-7941	miller@villagefire.org
Sherri Ditnch	City of Morgan's Point	Morgan's Point	281-471-2171	sditnch@morganspoint-tx.com
Ashley Merchant	City of Stafford	Stafford OEM	281-261-3993	amerchant@staffordtx.gov
Tom Merchant	El Lago	OEM	281 682 3470	tmerchant@elagotx.net
Aaron Taylor	West University Place	OEM	713-662-5836	ataylor@westutx.gov
Kaly Atkiss	Harris County	HLSC	310-422-9226	Katy@houstonimmigration.org
Ronnie Olonilua	Texas Southern	TSU	713-313-4820	OLURONMILE.OLONILUA@tsu.edu

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting

Oct 24, 2019 / 1000 - 1200

COMMITTEE MEMBERS SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Charles J. Galyean	Seabrook	OEM	281-291-5700	jgalyean@seabrooktx.gov
Nick Kondejewski	Seabrook	Building Flood	281-291-5638	Nickk@seabrooktx.gov
Chrissie Angeletti	Tetra Tech Inc.		512.917.7513	Chrissie.Angeletti@Tetratech.com
Franic Bangchon	Pasadena	Com	7134755 88	fbangchon@pasadenatx.gov
WmEarl Finley	Houston	HISD	713 556 9229	wfinley@houstonisd.org
Tom Fullen	Hunters Creek Village		713-465-2150	tfullen@cityofhunterscreek.org
Robert McCracken	Houston Community College	HCC	713-718-7520	Robert.mccracken@hccs.edu
Kristin Gauthier	La Porte	OEM	281-470-0009	gauthierK@laportetx.gov
MARK STEUER	WHITE OAK BAYOU ASSOCIATION	"	713 702 8411	steuers@flash.net
ATAUL HANNAN	HCFCD	HCFCD	713-684-4117	ataul.hannan@hcfcd.org
Darrell Hahn	HCED	HCED	713-274-3776	Darrell.hahn@hcpid.org
Kelly Boysen	University of Houston	OEM	713-743-2841	Krboysen@uh.edu
Pete Côté	Region 4 Educ. Cntr	Region 4	713-744-6565	Pete.Cote@esc4.net
Deacon Tithel	City of Bellaire	FIRE / OEM	713-662-8201	dtithel@bellairetx.gov
Dena Mahan	Nassau Bay	OEM	281-336-6293	dena.mahan@nassaubay.com
RAY W HIGGINS	HARRIS HEALTH SYSTEM		713-634-1470	RAY.HIGGINS@HARRISHEALTH.ORG
Mary Anne Piacentini	Katy Prairie Conservancy →		713 523 6135 x4003	maryanne@katyprairie.org
Troy D. Harrison	Shoreacres	OEM	713 410 5466	TJHarrison@cityofshoreacres.us
Brian Rutherford	TETRA TECH		281-414-6721	brian.rutherford@tetratech.com

Harris County All Hazards Mitigation Plan Update
Steering Committee Meeting
Oct 24, 2019 / 1000 - 1200

PUBLIC SIGN-IN

NAME	CITY/JURISDICTION	ORGANIZATION	PHONE	EMAIL
Alex Johnson	N/A	Bayou City Waterkeeper	562)370-0685	ajohns31@centralstate.edu
Mel Bartis	City of Houston	OEM	832-393-0917	melanie.bartis@houstontx.gov
LISA GRAFF	Houston Parks Board →		713 942 8500	lisag@houstonparksboard.org
Janice Owolabi	Harris Co. Dept. of ED →		713 · 696 · 3142	jowolabi@hcde-texas.org
Jamisha Kasch	Rice Univ Houston	Rice Univ	713 348 6088	jkasch@rice.edu

PUBLIC COMMENT PERIOD MEETING SIGN-IN SHEET

PUBLIC SIGN-IN

Harris County Multi-Hazard Mitigation Plan-Public Workshop

Thursday, November 14, 2019

First Name	Last Name	Phone (optional)	Email (optional)
BRIAN	RUTHERFORD	281-414-6741	brian.rutherford@tetratech.com
Katy	Atkiss	310-422-9226	Katy@houstonimmigration.org
Bryan	Dunaway	713-881-3100	Bryan.Dunaway@oem.hctx.net
Kathy	Martin	713-426-9419	Kathryn.Martin@sheriff.hctx.net
Aaron	Ewing	713-881-3100	aaron.ewing@oem.hctx.net
Benzon	John	713-881-3100	benzon.john@oem.hctx.net
BRIAN	MURRAY	713-881-3100	brian.murray@oem.hctx.net
HALLIE	FRAZEE	713-881-3100	hallie.frazee@oem.hctx.net
Elizabeth	Campbell	713-881-3100	Elizabeth.Campbell@oem.hctx.net

PUBLIC COMMENT PERIOD IN-PERSON REVIEW OF DRAFT HMP

PUBLIC SIGN-IN

IN-PESON REVIEW: Harris County Multi-Hazard Mitigation Plan

Houston TranStar, 6922 Katy Road, Houston, TX 77024

First Name	Last Name	Date	Time-In	Time-Out	Phone (optional)	Email (optional)
Fuerte	Martha	11/8			(8) 878-5652	Marthafuertealonzo@Hotmail.com
Jim	Robertson	11/15/19			281-370-6243	JHRVER@aol.com
~~David C. Fellows~~	~~Not sure sir~~	~~11/19~~				

Harris County Multi-Hazard Mitigation Plan
Public Comment Card

Date: 11/19/19 Name: Jim Robertson

Phone (optional): 281-370-8243 Email (optional): JHRVER@aol.com

How will HCOHSEM communicate with 1) the public & 2) its planning partners in the situation where a major wind event has eliminated electric power & the internet/cell system in the greater Houston/Harris County area?

I would appreciate it if someone could please contact me & let me know how this issue will be addressed. I don't see this issue covered in the Harris County Multi-Hazard Mitigation Plan.

Thank you.

(continue on back if more space is needed)

Harris County Multi-Hazard Mitigation Plan
Public Comment Card

Date: _____ Name: _____

Phone (optional): _____ Email (optional): _____

Flood repetitive loss properties in the Kingwood area. Declare those areas inhabitable

(continue on back if more space is needed)

Harris County Multi-Hazard Mitigation Plan
Public Comment Card

Date: _____ Name: _____

Phone (optional): _____ Email (optional): _____

The areas in Kingwood that keep getting flooded every month. Declare those areas non-habitable.

(continue on back if more space is needed)

PUBLIC INFORMATION BULLETINS

2018

Harris County All Hazards Mitigation Plan

Informational Bulletin
November 2018

Core Planning Team

Chairperson
Brian Murray
Brian.Murray@oem.hctx.net

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Bryan Dunaway

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Chrissie.angeletti@tetratech.com

Media Relations
mitigation@oem.hctx.net

Next Steering Committee Meeting

January, 17 2019
10:00 am to 12:00 pm

Important Note for All Planning Partners: Please track the number of hours that you or your staff members spend working on this project. These hours can be applied toward the in-kind contribution needed for our grant requirements. Partners will be asked to report these hours after turning in their completed annex.

Upcoming Deliverables

- Please submit a "Letter of Intent to Participate" by December 1, 2018 to Brian Murray at Brian.Murray@oem.hctx.net. **You must submit a new LOI even if you were a participant in the 2015 HMP.**
- Designate a Primary and Alternate point of Contact. E-mail you response to Chrissie Angeletti at Chrissie.Angeletti@tetratech.com
- Review the 2013 State of Texas Hazard Mitigation Plan.
  Become familiar with the current hazards, goals and objectives.
- Review the 2015 Harris County Multi-Hazard Mitigation Plan
  Volume 1 – Harris County and Volume 2 – Jurisdiction Specific
- Phase 1 Annex Template to be sent November 26, 2018 via e-mail to the primary and alternate contact. Each jurisdiction will have 30 days to complete. Please note, the format for the HMP is changing, thus the templates will differ from the 2015 Plan. Please email completed templates to Brian Rutherford at Brian.Rutherford@tetratech.com

We understand this is a busy time of year and the first time many of you have been involved in a hazard mitigation planning process. We hope you are making progress on completing these deliverables, and know that some of you may have questions. Please contact a member of the Core Planning Team for assistance with any issue, we can work with you to finished the required deliverables!

October 18, 2018 Steering Committee Meeting Re-cap

On October 18, 2018, the Core Planning Team hosted the 1st Steering Committee Meeting for the Harris County All Hazards Mitigation Plan with forty-nine persons in attendance. The Steering Committee established the following:

- Ground rules for future meetings and overall planning process
- Bi-monthly meetings set for the 3rd Thursday of the month beginning with the January 2019 SC meeting
- Identified hazards of concern
- Definition of Critical Facilities presented and discussed
- Public Involvement Strategy presented and discussed
- Planning area extends to jurisdictional boundaries effecting the cities of Friendswood, Waller, Katy, Stafford and Baytown
- Committee members and planning partners add a link on their website as part of the public out reach strategy for the Harris County Mitigation Planning Process

Committee Spokesperson

Direct All Media Requests to

Rosio Torres and Hallie Frazee

mitigation@oem.hctx.net

WISHING YOU A HAPPY AND SAFE HOLIDAY

Harris County
Office of Homeland Security and Emergency Management

6922 Old Katy Rd.
Houston, TX 77024

Harris County is committed to creating and sustaining communities that are more resilient to disasters. To fulfill this pledge, Harris County Office of Homeland Security and Emergency Management (HCOHSEM) is in the process of updating the All Hazards Mitigation Plan (HMP) in partnership with cities and special purpose districts throughout the County. Federal rules require this plan be updated every five years.

Representatives from different cities, schools, fire districts, hospitals and utility districts are collaborating with HCOEM and Tetra Tech Incorporated - the contractor leading the hazard assessment and plan development. Decisions regarding plan elements, such as specific hazards to include, are made by a steering committee whose members include representatives from government, private business, non-profits, general public, and academia.

https://www.readyharris.org/mitigation

2018

Harris County All Hazards Mitigation Plan

Informational Bulletin
June 5, 2019

Core Planning Team

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mitigation@oem.hctx.net

Next Steering Committee Meeting

July 16, 2019
10am-12:00 pm
Houston TranStar
6922 Katy Rd.
Houston, TX 77024

Important Note for All Planning Partners: Please track the number of hours that you or your staff members spend working on this project. These hours can be applied toward the in-kind contribution needed for our grant requirements. Partners will be asked to report these hours after turning in their completed annex.

Upcoming Deliverables

- Promote **June 20th Interactive Public Workshop** to review results of Risk Assessment
  - 6-9pm at Houston TranStar, 6922 Katy Freeway, Houston, Texas 77024.
- Promote **Public Survey.** Our goal is to receive over 2000 surveys!
  - Websites
  - Social Media: Facebook, Twitter, Instagram, and Nextdoor
  - Mail-outs: Newsletters and utility bills
  - Public Events: Conferences and fundraisers

https://www.surveymonkey.com/r/ReadyHarris

Phase III Jurisdictional Annex Workshop

Attendance is Mandatory. Phase I and II must be completed prior to attendance!
Phase III Annex Workshop—Develop the Mitigation Strategy and Actions. Different workshop for Municipalities and Special Districts. Multiple workshops offered, please sign up for only one (1) workshop. Email RSVP to Chrissie.angeletti@tetratech.com.

July 16, 2019 (TUESDAY)
10am-12pm STEERING COMMITTEE MEETING
1pm-4pm – Phase 3 Workshop for Municipalities

July 17th, 2019 (WEDNESDAY)
9am-12pm -Phase 3 Workshop for Municipalities
1pm-4pm – Phase 3 Workshop for Special Districts

July 18th, 2019 (THURSDAY)
9am-12pm – Phase 3 Workshop for Special Districts
1pm-4pm – Phase 3 Workshop for Municipalities

Please contact a member of the Core Planning Team for assistance with any issue. We can work with you to finish the required deliverables!

May 16, 2019 Steering Committee Meeting Re-cap

On May 16, 2019, the Core Planning Team hosted the 4th Steering Committee Meeting for the Harris County All Hazards Mitigation Plan with 39 persons in attendance. The Steering Committee established the following:

- An update was presented on the status of completed and received Phase I and II Annexes.
- Reviewed results of the objectives exercise and adopted objective statements that add value to the Plan.

Committee Spokesperson

Direct All Media Requests to

Rosio Torres and Hallie Frazee

mitigation@oem.hctx.net

Public Outreach

- June 20th Public Workshop to present results of Risk Assessment, 6pm-9pm at Houston TranStar. Open-House Format (Steering Committee members are not required to attend).
- Public Survey was reviewed by steering committee and finalized. Goal to collect over 2000 survey results. Disseminate including websites, social media (Facebook, Twitter, Instagram, Nextdoor), mail-outs (newsletters and utility bills), and public events (upcoming conferences and fundraisers)
- Document Type of public outreach – Location, outreach efforts, and number of meetings, etc.

Next Steering Committee Meeting is Tuesday, July 16th at Houston Transtar from 10am-12pm.

- The SC meeting will be held prior to the Phase III Jurisdictional Annex workshops. We will review Risk Assessment results, conduct the Core Capabilities exercise, and confirm the Plan Maintenance Strategy.

Phase III Jurisdictional Annex Workshops

- Attendance is MANDATORY. Phase I and II must be complete prior to attendance.
- Different workshop for Municipalities and Special Districts. Multiple workshops offered, please sign up for only one (1) workshop.

Harris County
Office of Homeland Security and Emergency Management

6922 Old Katy Rd.
Houston, TX 77024

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Representatives from different cities, schools, fire districts, hospitals and utility districts are collaborating with HCOHSEM and Tetra Tech Incorporated - the contractor leading the hazard assessment and plan development. Decisions regarding plan elements, such as specific hazards to include, are made by a steering committee whose members include representatives from government, private business, non-profits, general public, and academia.

https://www.readyharris.org/mitigation

2018

Harris County All Hazards Mitigation Plan

Informational Bulletin
August 2, 2019

Core Planning Team

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mitigation@oem.hctx.net

Next Steering Committee Meeting
September 19, 2019
10am-12:00 pm
Houston TranStar
6922 Katy Rd.
Houston, TX 77024

Important Note for All Planning Partners: Please track the number of hours that you or your staff members spend working on this project. These hours can be applied toward the in-kind contribution needed for our grant requirements. Partners will be asked to report these hours after turning in their completed annex.

Upcoming Deliverables

- Promote **Public Survey.** Our goal is to receive over 2000 surveys!
  - Websites
  - Social Media: Facebook, Twitter, Instagram, and Nextdoor
  - Mail-outs: Newsletters and utility bills
  - Public Events: Conferences and fundraisers

https://www.surveymonkey.com/r/ReadyHarris

Phase III Jurisdictional Annex Due August 23rd

- Deadline to complete Phase I-III Annex moved to COB Friday August 23, 2019.
  - Critical Facility information to be emailed on August 9, 2019.
  - Note, Coastal Erosion and Subsidence/Mass Movement are ranked subjectively.
  - Revised risk ranking tables will be distributed Friday, August 2.

- A jurisdiction unable to participate in the current planning process, may join the Harris County All Hazards Mitigation Plan through the Linkage process.

Please contact a member of the Core Planning Team for assistance with any issue. We can work with you to finish the required deliverables!

July16, 2019 Steering Committee Meeting Re-cap

On July 16, 2019, the Core Planning Team hosted the 5th Steering Committee Meeting for the Harris County All Hazards Mitigation Plan with 52 persons in attendance. The Steering Committee established the following:

- Status of completed received Phase I-II Annexes.
- Presented Results of Risk Assessment
- Conducted Core Capability Exercise
- Confirmed Plan Maintenance Strategy

Committee Spokesperson
Direct All Media Requests to
Rosio Torres and Hallie Frazee
mitigation@oem.hctx.net

Results of July 16, 2019 Core Capabilities Exercise

Current land uses within identified hazard areas are appropriate for the risk posed by each hazard?	100%	0%
Planning Partnership staff are knowledgeable about hazards and their impacts and are willing to share that knowledge with the public?	100%	0%
Planning Partnership Staff members with emergency management functions are adequately trained?	96%	4%
Appropriate and timely warning systems are in place?	96%	4%
Emergency management is provided by a unified authority or program?	90%	10%
Emergency response functions for the County are clearly defined and are effective?	88%	12%
Strong collaboration and coordination exists between the City, neighboring jurisdictions, the County and state and federal agency partners?	81%	19%
There Is a good understanding of the risk posed by the hazards Gem County is susceptible to?	78%	22%
Harris County Citizens have a good understanding of natural hazard exposure and risk?	76%	24%
The capability to assess and mitigate risk from natural hazards is high?	75%	25%
There is strong public support for risk reduction within HarrisCounty?	75%	25%
There is political support for risk management within the City/County?	62%	38%
The Planning Partnership currently has a variety of regulatory and non-regulatory strategies to reduce risk?	56%	44%
Members of the public know where to find information about hazards and risk?	55%	45%
Information on flood insurance is readily available within the County?	54%	46%
The enforcement opf Codes and Standards within the planningarea is strong?	52%	48%
Roles and responsibilities for emergency management within Harris County are clearly defined?	52%	48%
Existing flood control systems are effective and well maintained?	34%	66%
The Planning Partnership risk management programs are fair and equitable?	30%	70%
Risk from natural hazards within Harris County is adequately mapped and regulated ?	26%	74%
Coordinated public outreach regarding risk from all hazards convey clear, consistent messaging to the public?	24%	76%
As a citizen of Harris County, I feel confident that I am prepared for the impacts from any natural hazard that my impact my property?	19%	81%
The Planning Partrnership currnntly has adopted policies that encourage development to be located outside of high risk areas?	8%	92%
All relevant stakeholders are engaged in the City/County's risk management efforts?	8%	92%
There is a coordinated program to maintain drainage sytems free of debris?	5%	95%
The Planning Partners development regulations for new development within identified hazards zones are adequate to address that risk?	4%	96%
Real Estate professionals adequately disclose risk exposure from natural hazards at the time of sale of real property?	4%	96%
The funding to support risk reduction within Harris County is adequate?	4%	96%
The Planning Partnership is prepared for the probable impacts on natural hazards due to the impacts from a changing climate?	4%	96%
Areas that provide natural resource protection are identified and protected within the County?	0%	100%

Harris County Office of Homeland Security and Emergency Management
6922 Old Katy Rd.|Houston, TX 77024

https://www.readyharris.org/mitigation

TETRA TECH

2018

Harris County All Hazards Mitigation Plan

Informational Bulletin
November 7, 2019

Core Planning Team

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Project Manager
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Important Note for All Planning Partners: Please track the number of hours that you or your staff members spend working on this project. These hours can be applied toward the in-kind contribution needed for our grant requirements. Partners will be asked to report these hours after turning in their completed annex.

Thank you for your participation updating the 2020 Harris County All Hazards Mitigation Plan

Promote Public Comment Period for the Draft Harris County All Hazards Mitigation Plan Update—Nov. 7-21, 2019

- **Public Workshop to provide public comment on AHMP Draft**
  - Thursday Nov. 14, 6:00pm-9:00pm
    Houston TranStar
    6922 Katy Rd, Houston, TX 77024

- **Online Public View/Comment of AHMP Draft**
  - Link to view AHMP Public Comment Draft:
    https://bit.ly/2qua6jK
  - Link to provide Public Comment:
    https://www.surveymonkey.com/r/HarrisCounty_Public_Comment

Please utilize the following resources to promote public comment:

- Websites
- Social Media: Facebook, Twitter, Instagram, and Nextdoor
- Mail-outs: Newsletters and utility bills
- Public Events: Conferences and fundraisers

October 24, 2019 Steering Committee Meeting Re-cap

On October 24, 2019, the Core Planning Team hosted the 6th Steering Committee Meeting for the Harris County All Hazards Mitigation Plan with 42 persons in attendance. The Steering Committee established the following:

- An update was presented on the status of completed and received Phase III Annexes,
- Have received over 1,627 surveys total. Public Survey period is closed.
- CDBG-MIT—State working on Action Plan. Harris County All Hazards Mitigation Plan Update to continue per the original scope. Additional requirements to be accounted for in an amendment to the Plan.
- Reviewed and discussed results of the Capabilities Exercise.
- Reviewed and confirmed the Plan Maintenance Strategy including a discussion of DMA and CRS requirements.
- BATool Demonstration provided. BATool is a web-based software program designed to assist with assessing and reporting on the status of mitigation actions.
- Discussed layout of the Plan and timeline for internal and public review of the Plan:
  - November 5th Internal Comment Period Ends: Receive comments from steering committee on INTERNAL DRAFT.
  - November 6th – Generate PUBLIC REVIEW DRAFT.
  - November 7th-21st Public Comment Period: Issue PUBLIC REVIEW DRAFT and Press Release, receive comments from the general public.
  - November 14th – Public Workshop to review PUBLIC REVIEW DRAFT, Invitation to be distributed, Steering Committee to assist with outreach, Steering Committee does not need to attend.
  - November 29th – FINAL DRAFT submitted to TDEM for review.
  - June 2020 (Estimated) – FEMA Approved Pending Adoption

Committee Spokesperson

Direct All Media Requests to

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mitigation@oem.hctx.net

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Office of Homeland Security and Emergency Management

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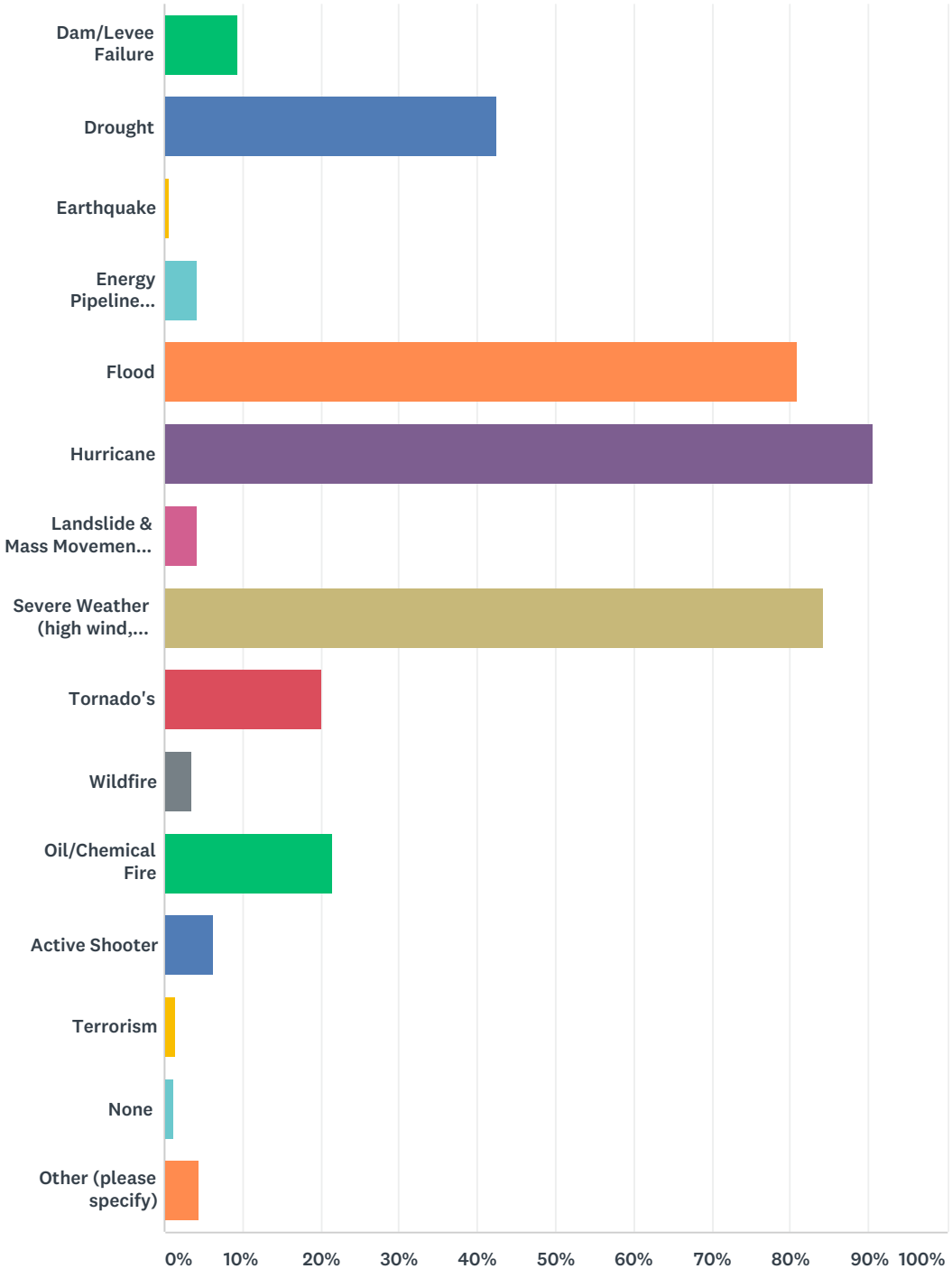
https://www.readyharris.org/mitigation

SURVEY RESULTS

Q1 Which of the following natural hazard events have you, your place of employment, your school, or anyone in your household experienced within the past 20 years in the Greater Harris County Region? (Check all that apply)

Answered: 1,616 Skipped: 11

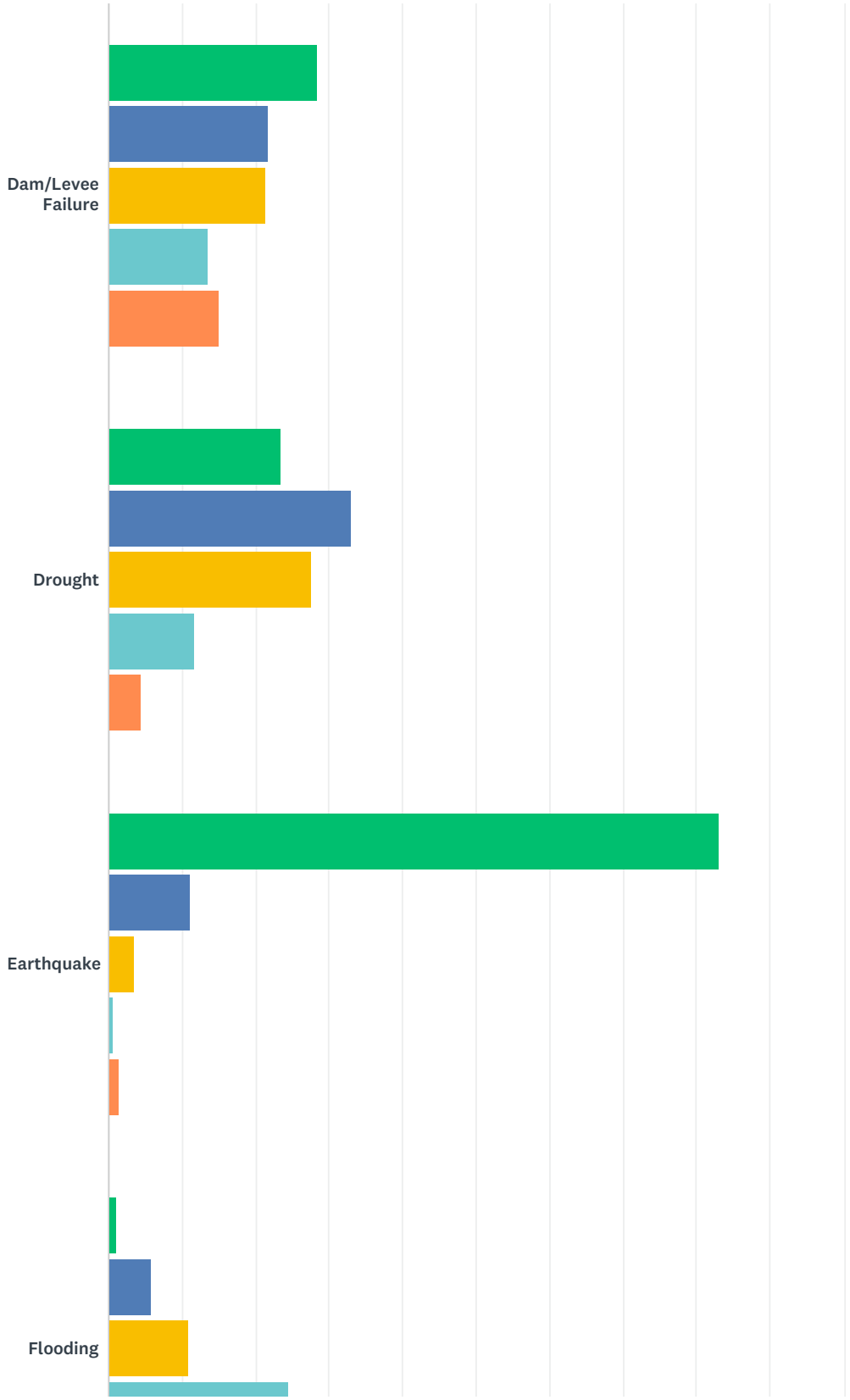


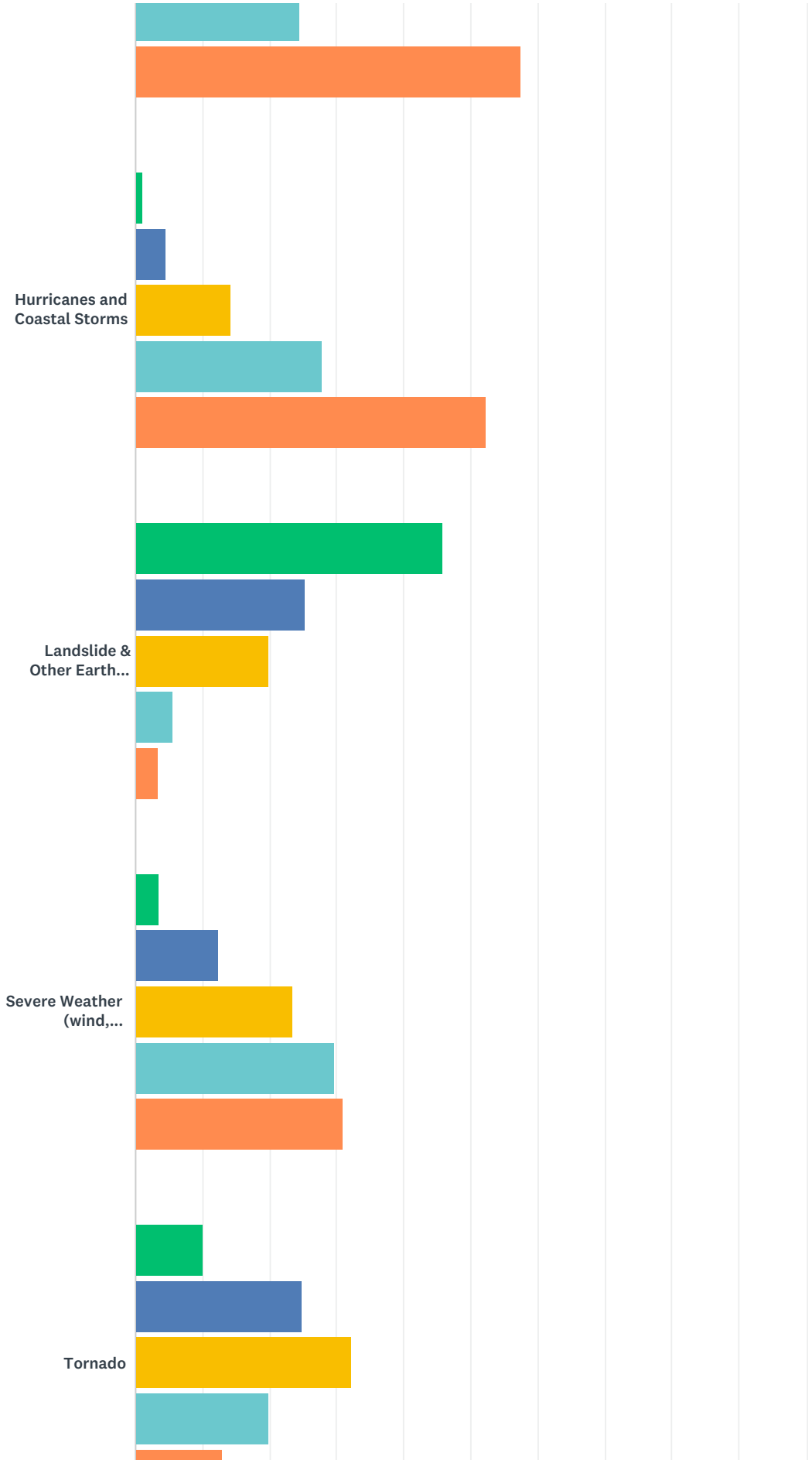
ANSWER CHOICES	RESPONSES

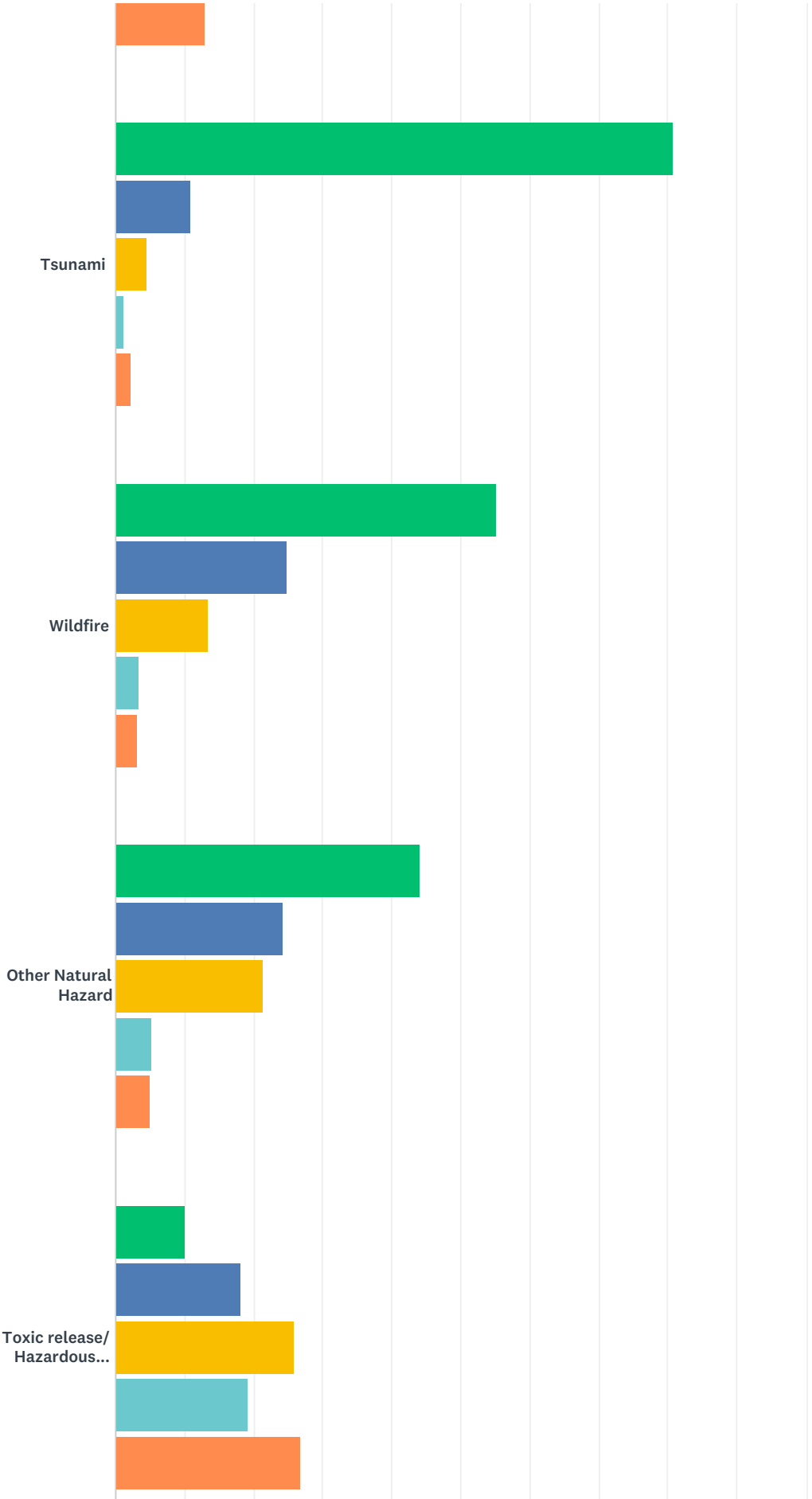
Dam/Levee Failure	9.47%	153
Drought	42.39%	685
Earthquake	0.56%	9
Energy Pipeline Failures	4.21%	68
Flood	81.06%	1,310
Hurricane	90.66%	1,465
Landslide & Mass Movements (sinkholes, subsidence, geologic hazards)	4.21%	68
Severe Weather (high wind, heavy rain, lightning, etc.)	84.34%	1,363
Tornado's	20.11%	325
Wildfire	3.59%	58
Oil/Chemical Fire	21.60%	349
Active Shooter	6.25%	101
Terrorism	1.55%	25
None	1.30%	21
Other (please specify)	4.46%	72
Total Respondents: 1,616		

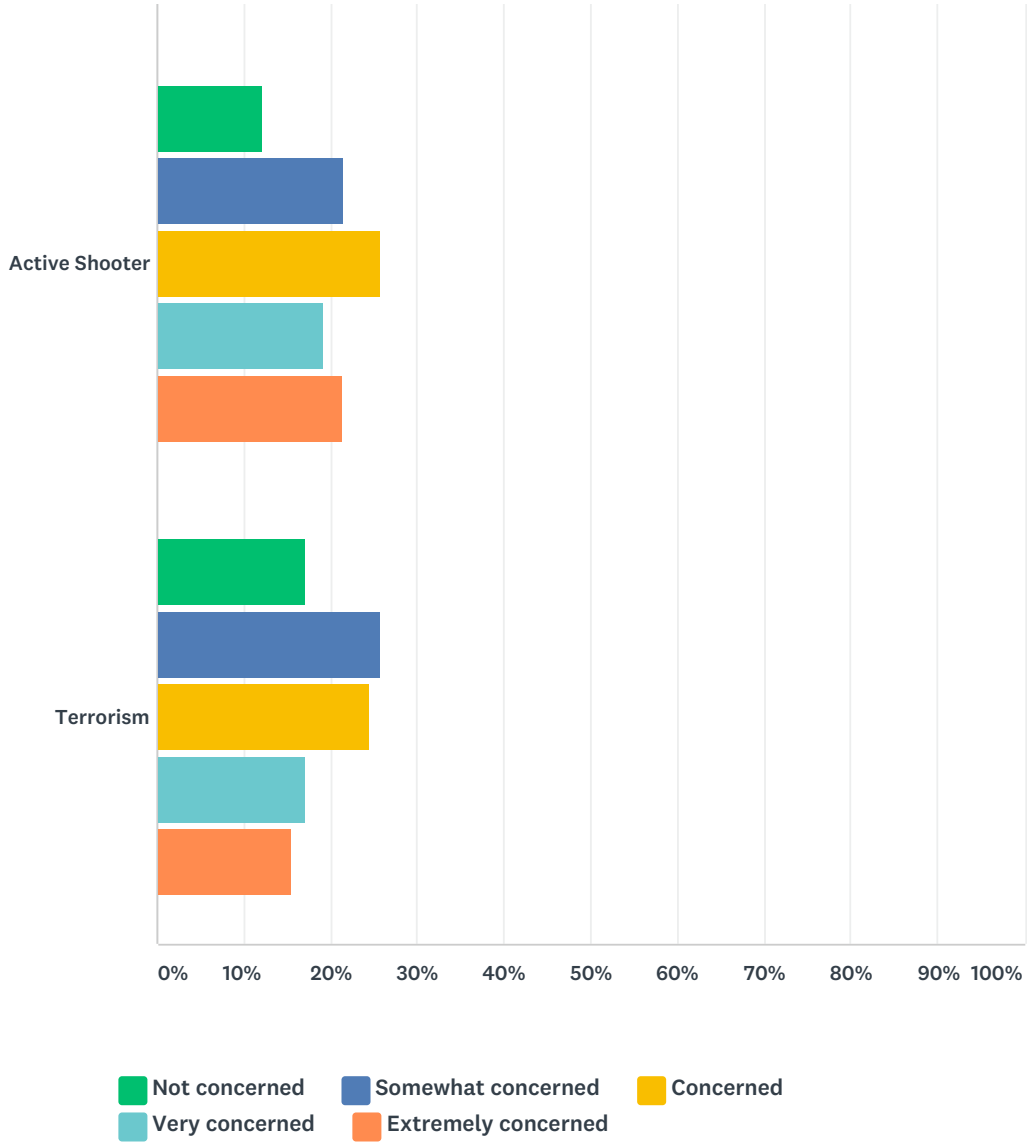
Q2 How concerned are you about the following natural hazards in the Greater Harris County Region? (Please check one for each hazard)

Answered: 1,620 Skipped: 7




Hurricanes and Coastal Storms
Landslide & Other Earth...
Severe Weather (wind,...
Tornado


Tsunami
Wildfire
Other Natural Hazard
Toxic release/ Hazardous...

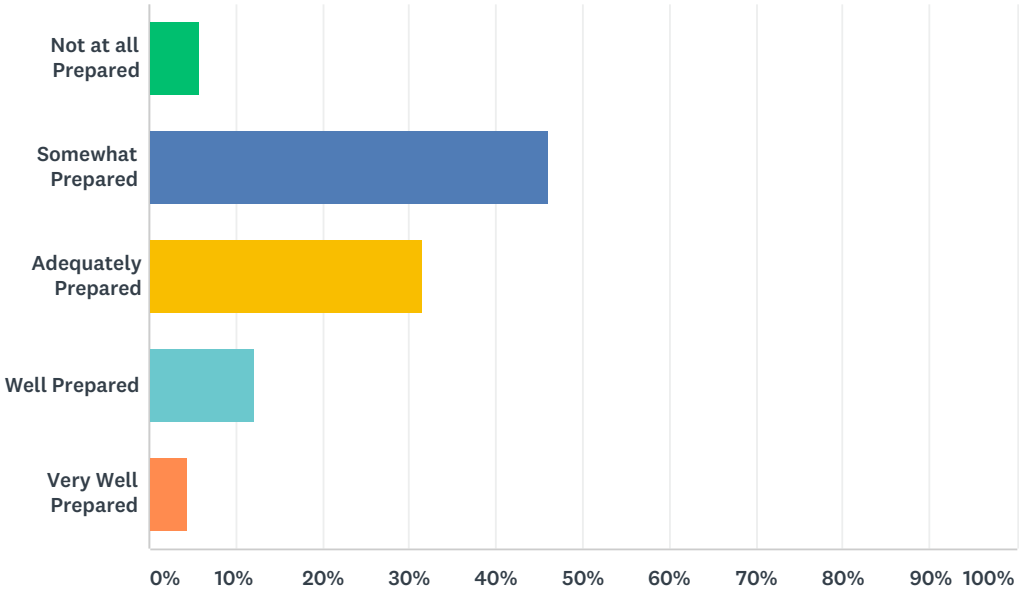


	NOT CONCERNED	SOMEWHAT CONCERNED	CONCERNED	VERY CONCERNED	EXTREMELY CONCERNED	TOTAL	WEIGHTED AVERAGE
Dam/Levee Failure	28.43% 448	21.70% 342	21.26% 335	13.52% 213	15.10% 238	1,576	2.65
Drought	23.44% 369	32.97% 519	27.57% 434	11.69% 184	4.32% 68	1,574	2.40
Earthquake	83.15% 1,278	11.13% 171	3.64% 56	0.72% 11	1.37% 21	1,537	1.26
Flooding	1.12% 18	5.90% 95	10.86% 175	24.58% 396	57.54% 927	1,611	4.32
Hurricanes and Coastal Storms	1.00% 16	4.61% 74	14.20% 228	27.83% 447	52.37% 841	1,606	4.26
Landslide & Other Earth Movements (sinkholes,subsidence and other geologic hazards)	45.89% 715	25.29% 394	19.83% 309	5.71% 89	3.27% 51	1,558	1.95
Severe Weather (wind, lightning, Hail, heavy rains, solar flare, etc.)	3.62% 58	12.29% 197	23.52% 377	29.69% 476	30.88% 495	1,603	3.72

Tornado	10.08% 159	24.79% 391	32.21% 508	19.91% 314	13.00% 205	1,577	3.01
Tsunami	80.86% 1,246	10.97% 169	4.54% 70	1.30% 20	2.34% 36	1,541	1.33
Wildfire	55.21% 858	24.84% 386	13.38% 208	3.41% 53	3.15% 49	1,554	1.74
Other Natural Hazard	44.10% 662	24.32% 365	21.32% 320	5.26% 79	5.00% 75	1,501	2.03
Toxic release/ Hazardous Materials (HAZMAT)	10.01% 158	18.18% 287	25.84% 408	19.25% 304	26.73% 422	1,579	3.35
Active Shooter	12.12% 191	21.64% 341	25.70% 405	19.16% 302	21.38% 337	1,576	3.16
Terrorism	17.20% 269	25.64% 401	24.55% 384	17.20% 269	15.41% 241	1,564	2.88

Q3 The Harris County Office of Homeland Security & Emergency Management website, readyharris.org , provides important information on how to prepare you and your family in the event of a disaster.How prepared is your household for a hazard event? (Check one)

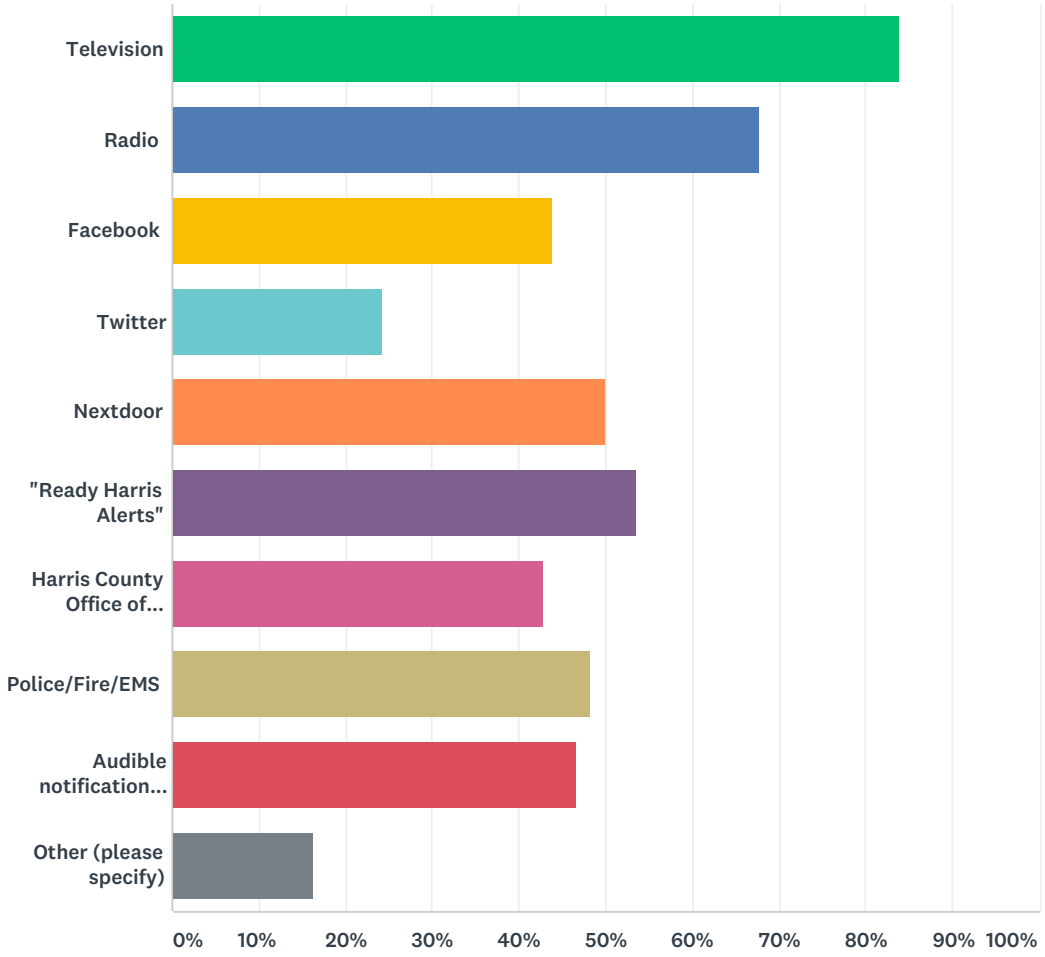
Answered: 1,610 Skipped: 17



ANSWER CHOICES	RESPONSES	
Not at all Prepared	5.90%	95
Somewhat Prepared	45.96%	740
Adequately Prepared	31.49%	507
Well Prepared	12.17%	196
Very Well Prepared	4.47%	72
TOTAL		1,610

Q4 How would you expect to be notified in case of an immediate threat caused by a hazard.Select all that apply.

Answered: 1,616 Skipped: 11

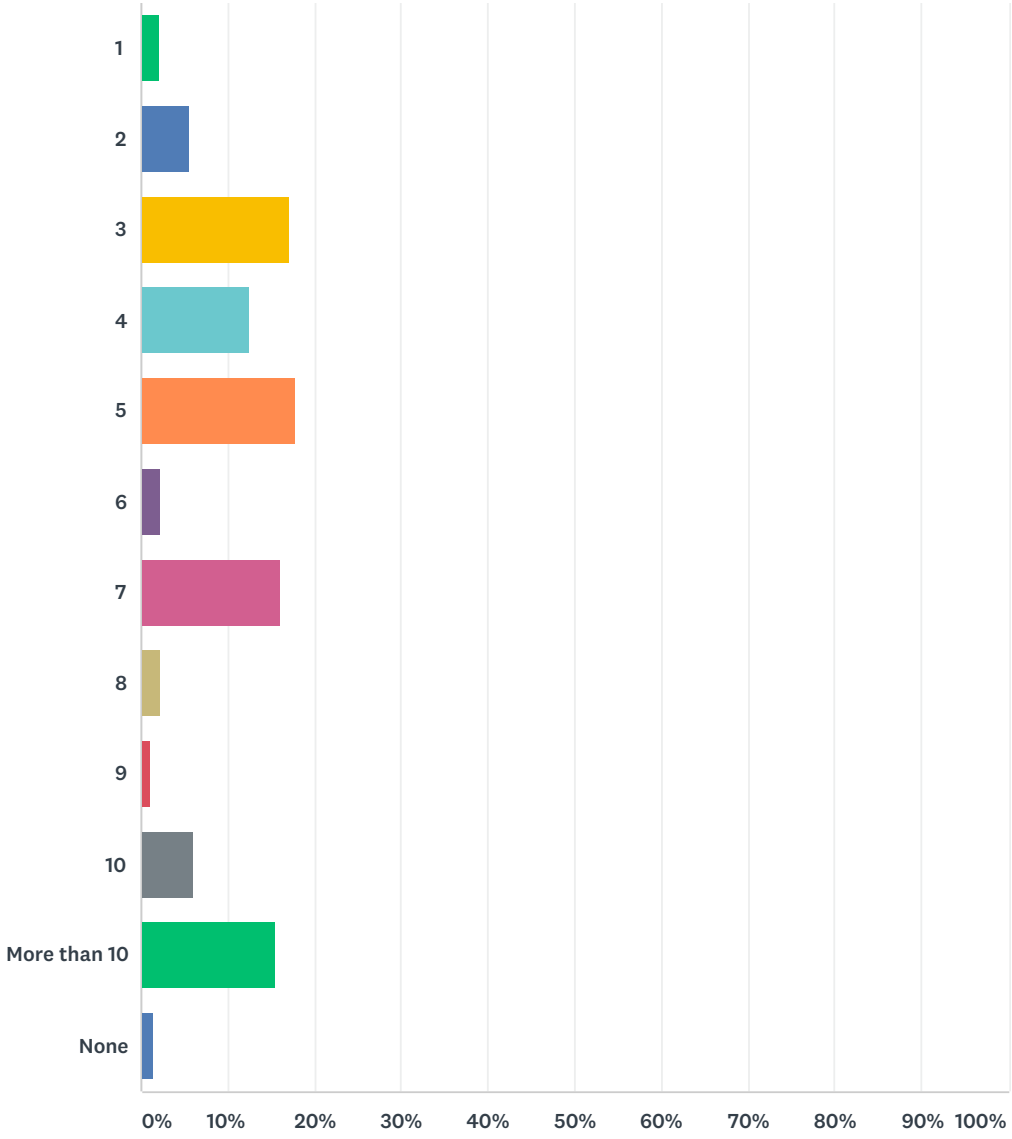


ANSWER CHOICES	RESPONSES	
Television	83.85%	1,355
Radio	67.82%	1,096
Facebook	43.87%	709
Twitter	24.32%	393
Nextdoor	50.06%	809
"Ready Harris Alerts"	53.65%	867
Harris County Office of Homeland Security & Emergency Management website: readyharris.org	42.82%	692
Police/Fire/EMS	48.27%	780
Audible notification system (s)	46.60%	753
Other (please specify)	16.34%	264

Total Respondents: 1,616	

Q5 The Harris County Office of Homeland Security & Emergency Management recommends that households have at least 7 days of food, water, and vital supplies (e.g. medications) in hand in the event of a disaster. How many days of food, water, and vital supplies does your household have on hand in the event of a disaster?

Answered: 1,608 Skipped: 19

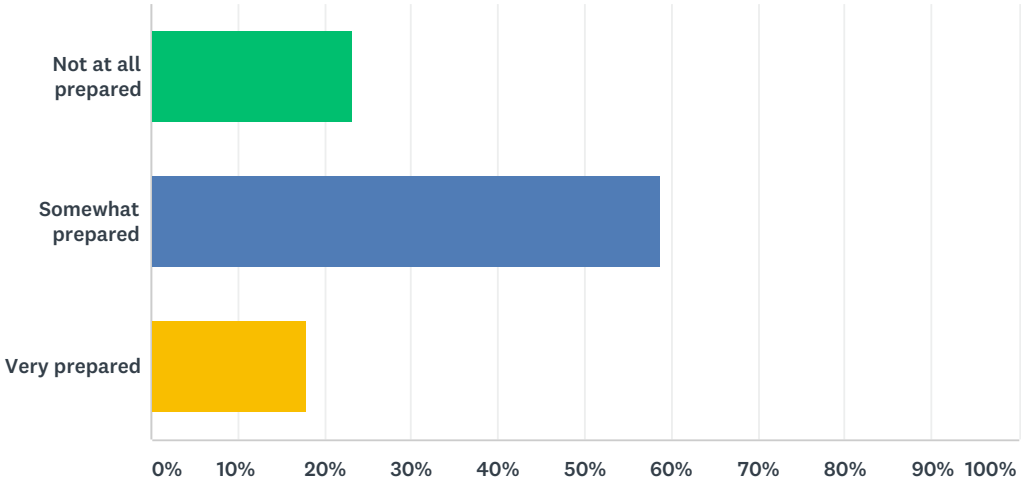


ANSWER CHOICES	RESPONSES	
1	2.05%	33
2	5.60%	90
3	17.16%	276
4	12.50%	201

5	17.79%	286
6	2.30%	37
7	16.17%	260
8	2.36%	38
9	1.00%	16
10	6.09%	98
More than 10	15.55%	250
None	1.43%	23
TOTAL		1,608

Q6 How prepared is your household to get along without electricity or natural gas for one to five days?

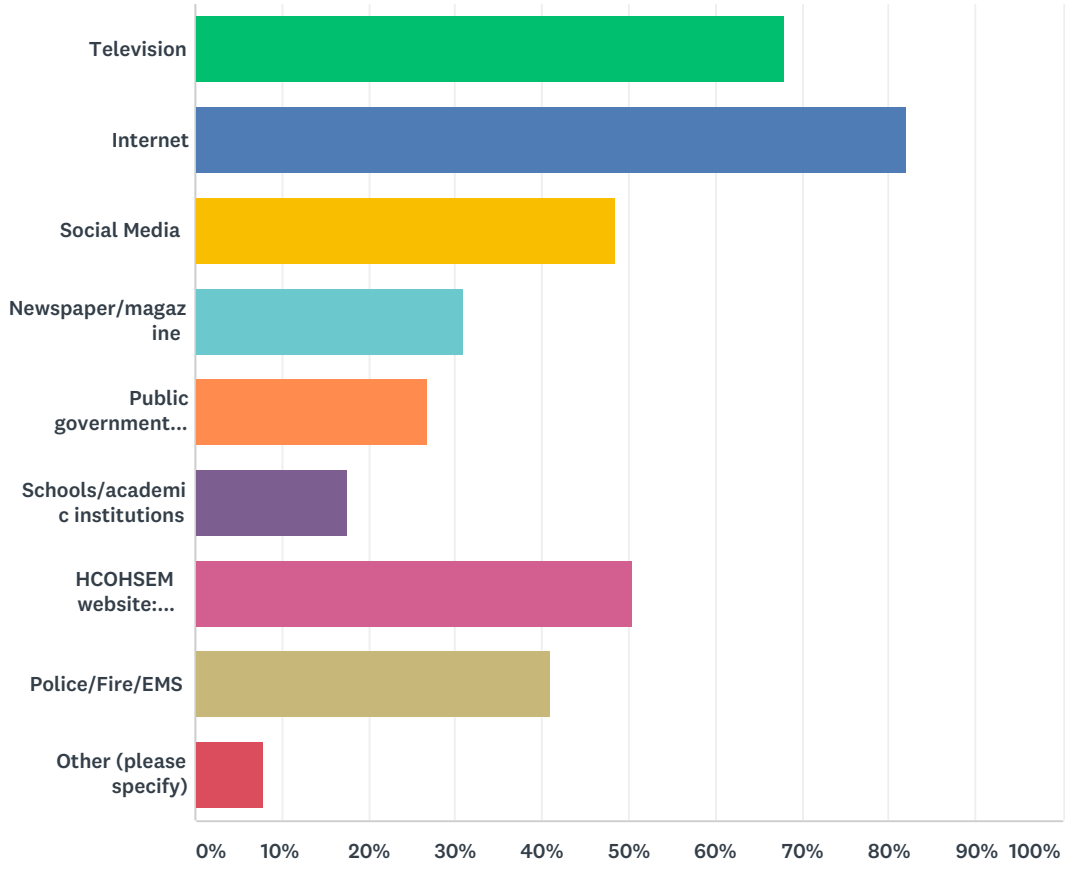
Answered: 1,613 Skipped: 14



ANSWER CHOICES	RESPONSES	
Not at all prepared	23.19%	374
Somewhat prepared	58.77%	948
Very prepared	18.04%	291
TOTAL		1,613

Q7 Where would you expect to find useful information to help you be prepared?Select all that apply.

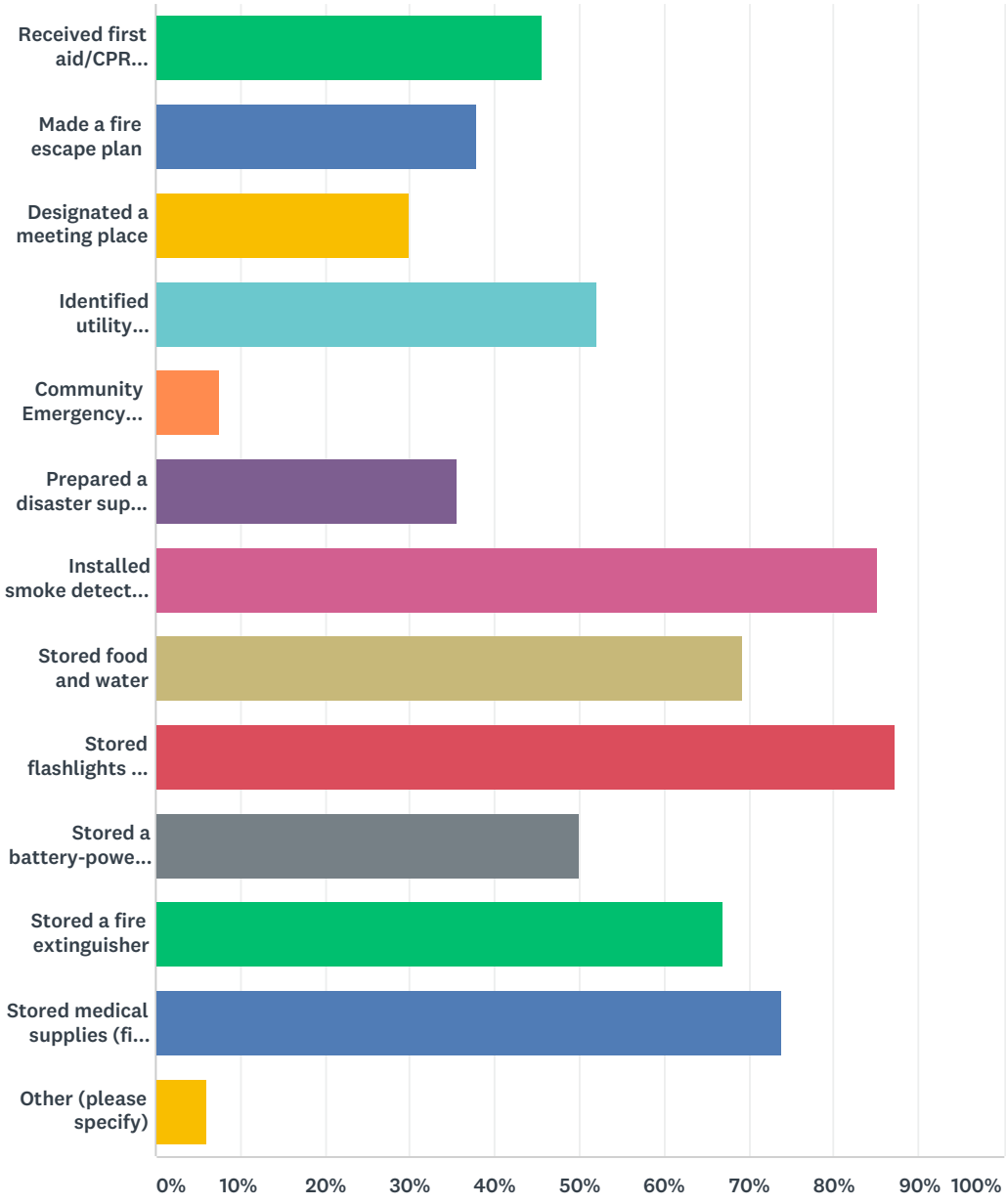
Answered: 1,615 Skipped: 12



ANSWER CHOICES	RESPONSES	
Television	67.99%	1,098
Internet	82.04%	1,325
Social Media	48.61%	785
Newspaper/magazine	30.96%	500
Public government meetings	26.69%	431
Schools/academic institutions	17.52%	283
HCOHSEM website: readyharris.org	50.46%	815
Police/Fire/EMS	40.99%	662
Other (please specify)	7.86%	127
Total Respondents: 1,615		

Q8 Which of the following steps has your household already undertaken to prepare for a disaster?Select all that apply.

Answered: 1,593 Skipped: 34

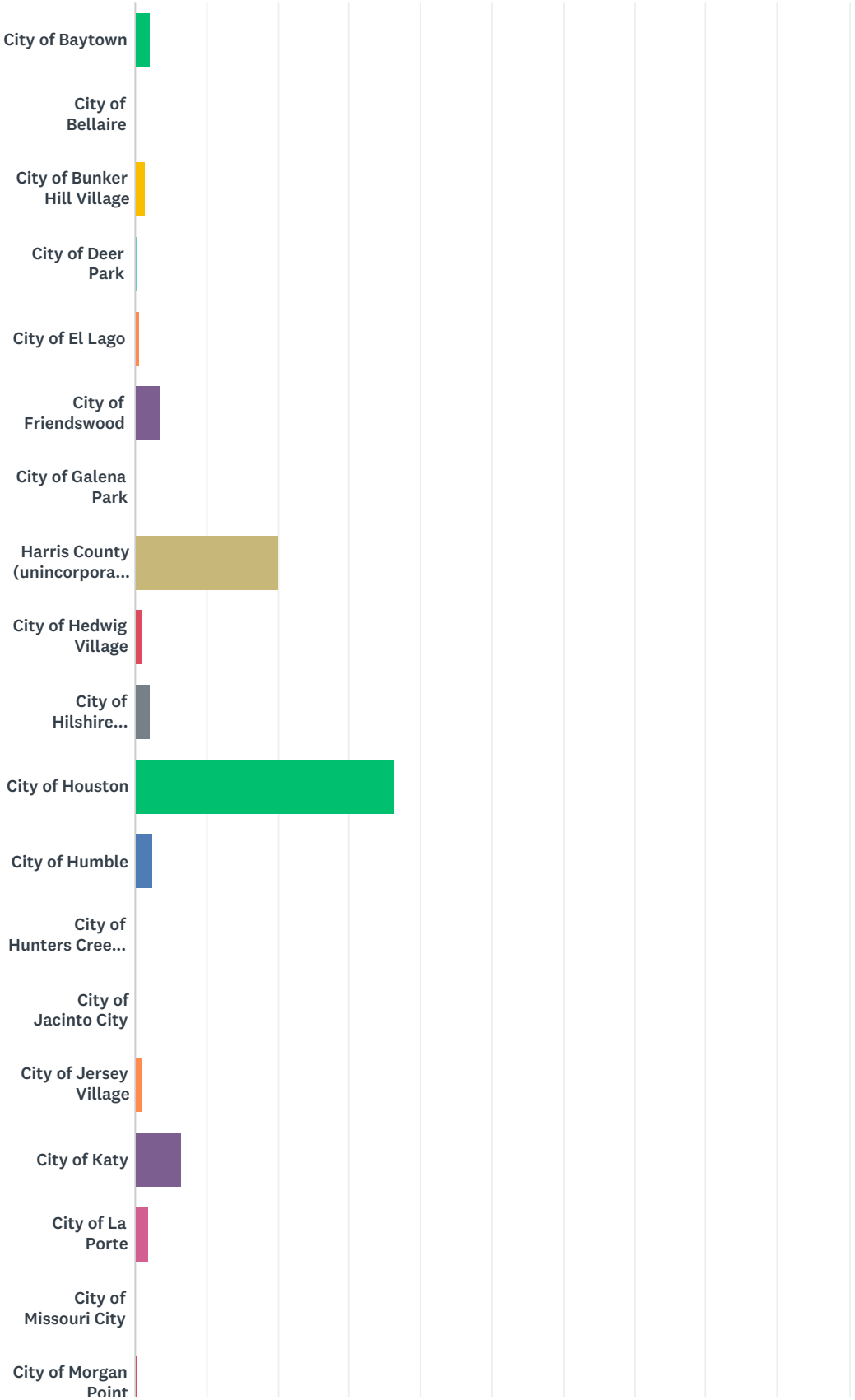


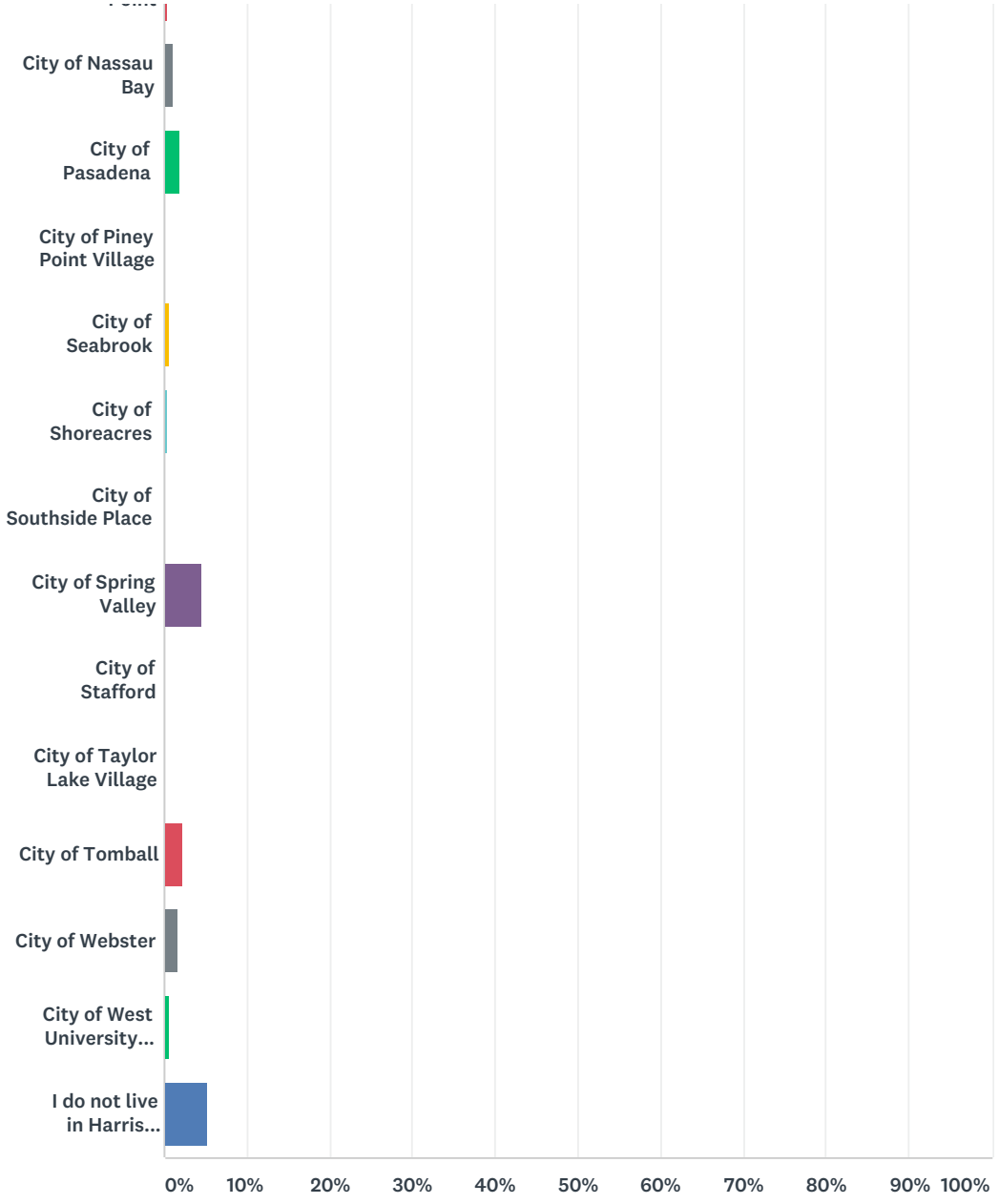
ANSWER CHOICES	RESPONSES	
Received first aid/CPR training	45.51%	725
Made a fire escape plan	37.79%	602
Designated a meeting place	29.94%	477
Identified utility shutoffs	52.17%	831
Community Emergency Response Training (CERT)	7.47%	119

Prepared a disaster supply kit	35.66%	568
Installed smoke detectors on each level of the house	85.19%	1,357
Stored food and water	69.18%	1,102
Stored flashlights and batteries	87.32%	1,391
Stored a battery-powered radio	50.09%	798
Stored a fire extinguisher	67.04%	1,068
Stored medical supplies (first aid kit, medications)	73.82%	1,176
Other (please specify)	6.15%	98
Total Respondents: 1,593		

Q9 Where do you live?

Answered: 1,613 Skipped: 14



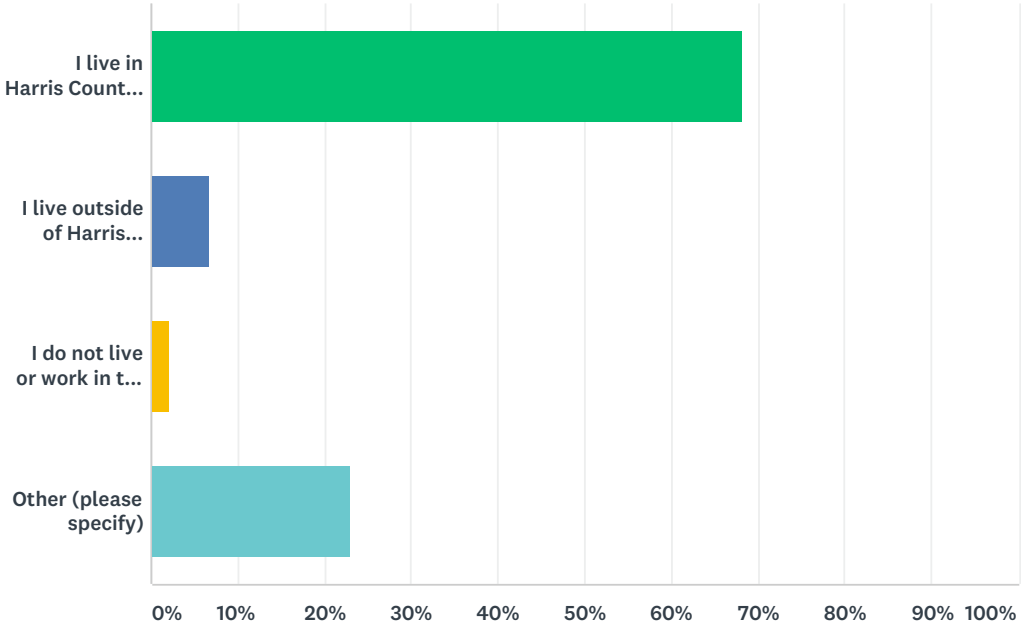


ANSWER CHOICES	RESPONSES	
City of Baytown	2.11%	34
City of Bellaire	0.19%	3
City of Bunker Hill Village	1.55%	25
City of Deer Park	0.43%	7
City of El Lago	0.68%	11
City of Friendswood	3.53%	57
City of Galena Park	0.19%	3
Harris County (unincorporated areas)	20.09%	324
City of Hedwig Village	0.99%	16

City of Hilshire Village	2.17%	35
City of Houston	36.33%	586
City of Humble	2.60%	42
City of Hunters Creek Village	0.25%	4
City of Jacinto City	0.00%	0
City of Jersey Village	1.12%	18
City of Katy	6.57%	106
City of La Porte	1.98%	32
City of Missouri City	0.12%	2
City of Morgan Point	0.50%	8
City of Nassau Bay	1.12%	18
City of Pasadena	1.80%	29
City of Piney Point Village	0.25%	4
City of Seabrook	0.56%	9
City of Shoreacres	0.50%	8
City of Southside Place	0.00%	0
City of Spring Valley	4.59%	74
City of Stafford	0.06%	1
City of Taylor Lake Village	0.06%	1
City of Tomball	2.23%	36
City of Webster	1.67%	27
City of West University Place	0.56%	9
I do not live in Harris County (work only).	5.21%	84
TOTAL		1,613

Q10 Where do you work?

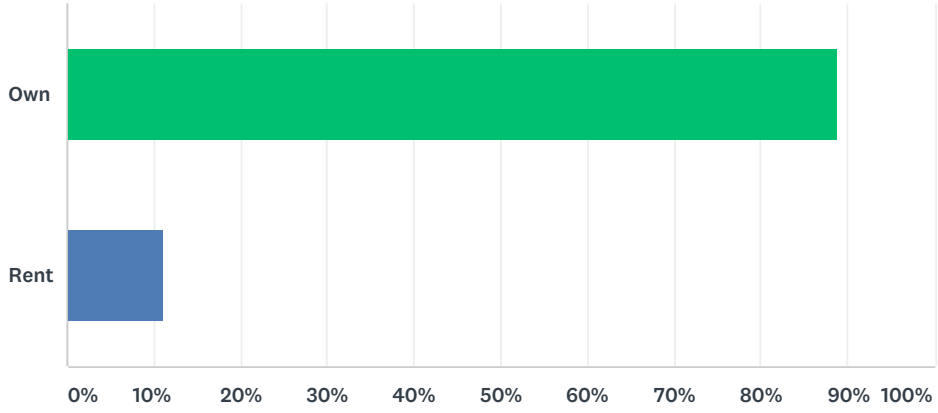
Answered: 1,589 Skipped: 38



ANSWER CHOICES	RESPONSES	
I live in Harris County and Work in Harris County	68.28%	1,085
I live outside of Harris County, but work within the Greater Harris County Region	6.61%	105
I do not live or work in the Greater Harris County Region	2.01%	32
Other (please specify)	23.10%	367
TOTAL		1,589

Q11 Do you own or rent your place of residence?

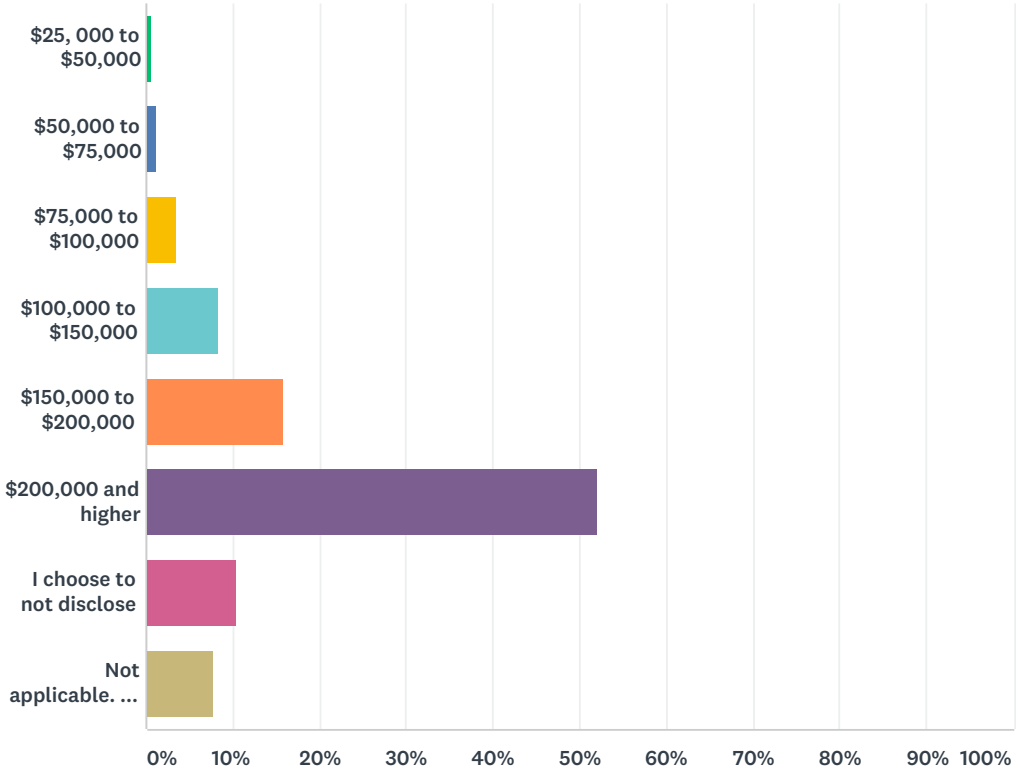
Answered: 1,483 Skipped: 144



ANSWER CHOICES	RESPONSES	
Own	88.94%	1,319
Rent	11.06%	164
TOTAL		1,483

Q12 If you own your home, what is the approximate value of your home?

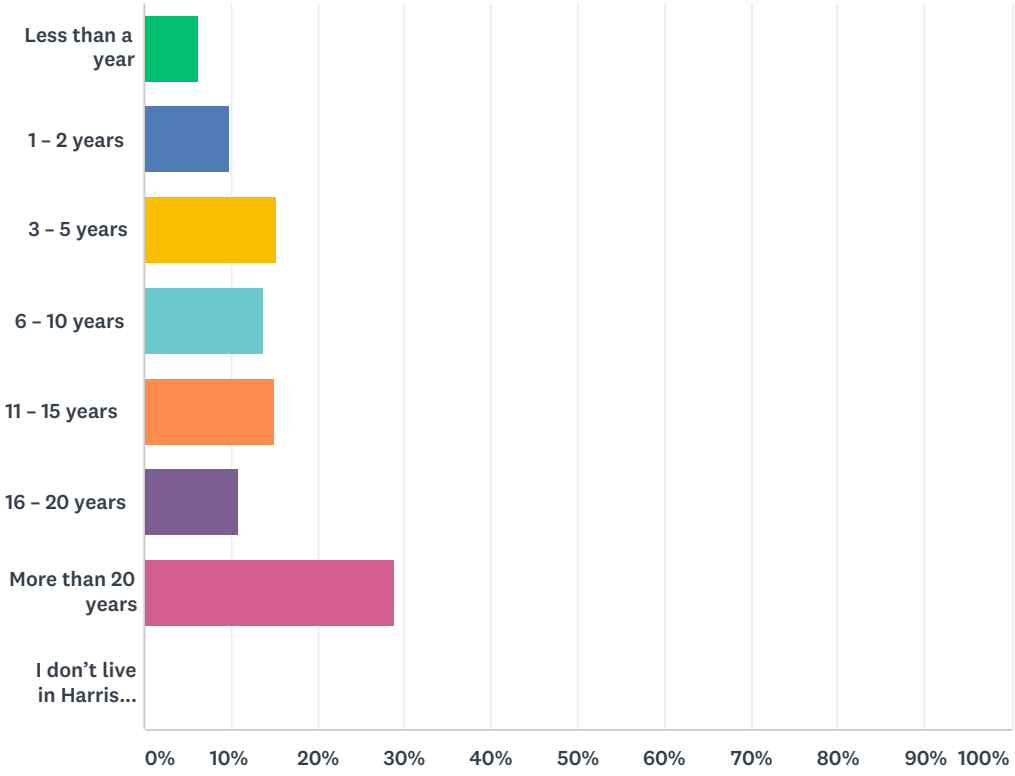
Answered: 1,458 Skipped: 169



ANSWER CHOICES	RESPONSES	
$25, 000 to $50,000	0.55%	8
$50,000 to $75,000	1.30%	19
$75,000 to $100,000	3.50%	51
$100,000 to $150,000	8.30%	121
$150,000 to $200,000	15.91%	232
$200,000 and higher	52.13%	760
I choose to not disclose	10.49%	153
Not applicable. I do not own my home	7.82%	114
TOTAL		1,458

Q13 How long have you lived in at your current residence?

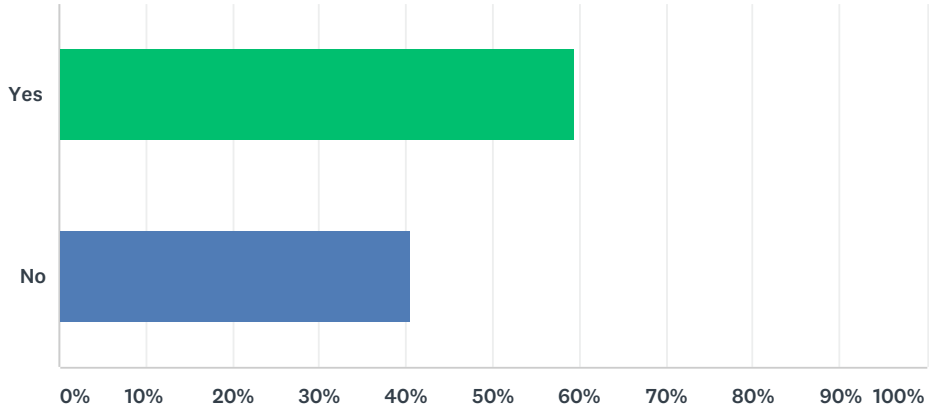
Answered: 1,491 Skipped: 136



ANSWER CHOICES	RESPONSES	
Less than a year	6.24%	93
1 – 2 years	9.86%	147
3 – 5 years	15.29%	228
6 – 10 years	13.82%	206
11 – 15 years	15.09%	225
16 – 20 years	10.87%	162
More than 20 years	28.77%	429
I don't live in Harris County	0.07%	1
TOTAL		1,491

Q14 When you moved into your home, did you consider the impact a disaster could have on your home?

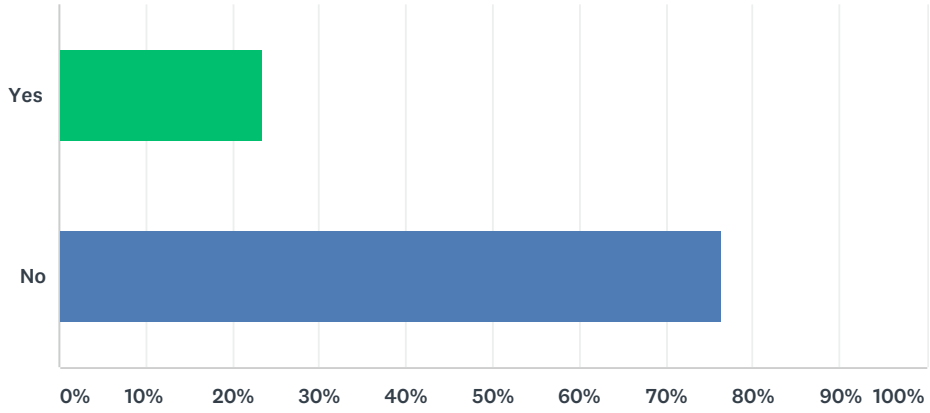
Answered: 1,489 Skipped: 138



ANSWER CHOICES	RESPONSES	
Yes	59.37%	884
No	40.63%	605
TOTAL		1,489

Q15 Was the presence of a natural hazard risk zone (e.g., dam failure zone, flood zone, landslide hazard area, high fire risk area) disclosed to you by a real estate agent, seller, or landlord before you purchased or moved into your home?

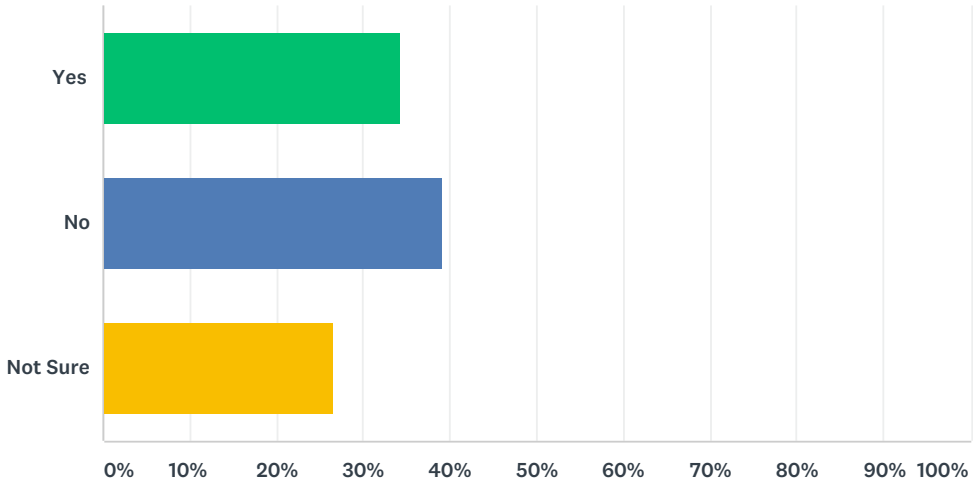
Answered: 1,480 Skipped: 147



ANSWER CHOICES	RESPONSES	
Yes	23.45%	347
No	76.35%	1,130
TOTAL		1,480

Q16 Is your residence located in or near a FEMA designated floodplain?

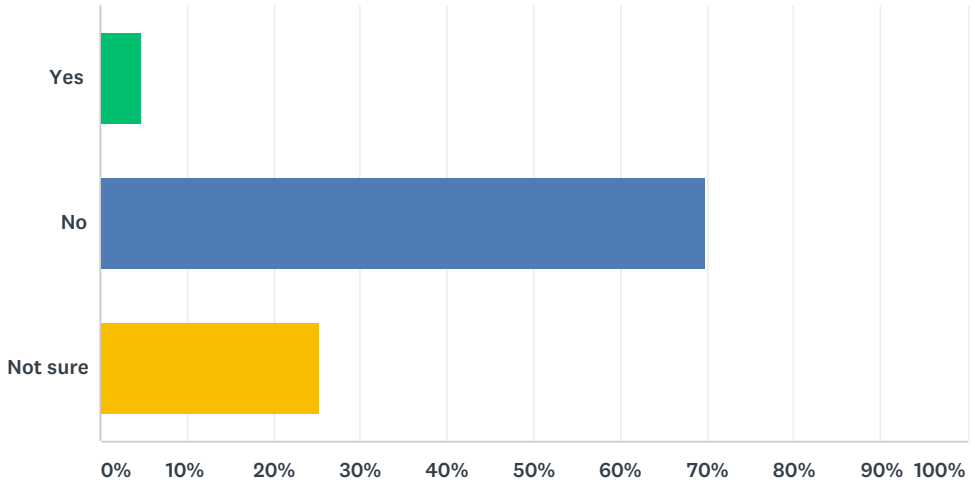
Answered: 1,486 Skipped: 141



ANSWER CHOICES	RESPONSES	
Yes	34.32%	510
No	39.10%	581
Not Sure	26.58%	395
TOTAL		1,486

Q17 Is your residence located in a dam failure zone?

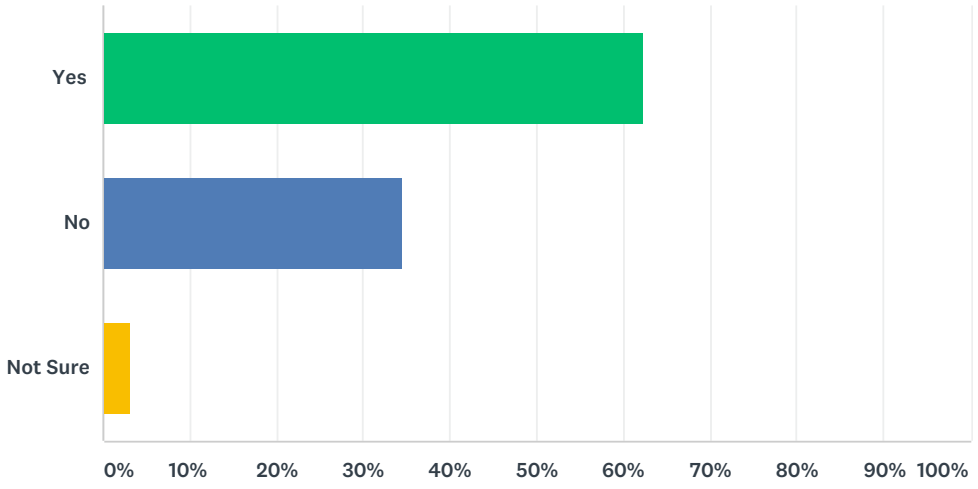
Answered: 1,489 Skipped: 138



ANSWER CHOICES	RESPONSES	
Yes	4.90%	73
No	69.85%	1,040
Not sure	25.25%	376
TOTAL		1,489

Q18 Do you have flood insurance?

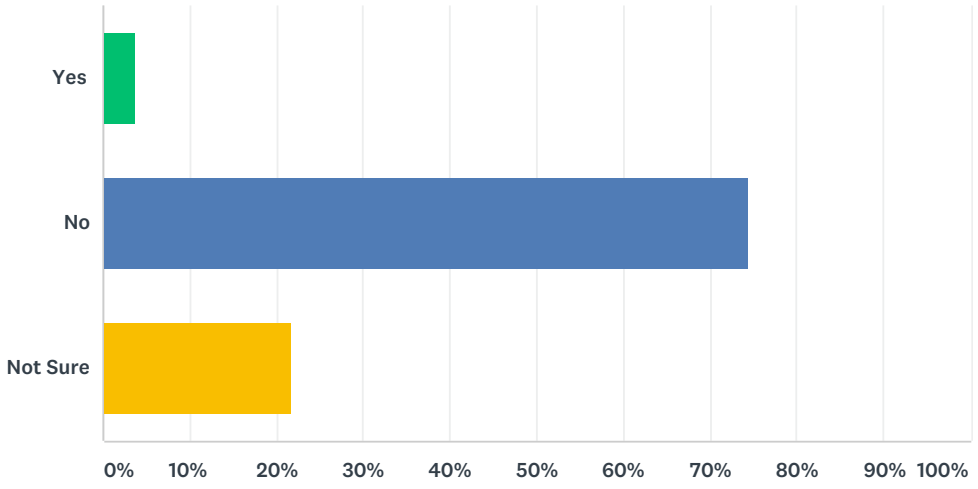
Answered: 1,486 Skipped: 141



ANSWER CHOICES	RESPONSES	
Yes	62.31%	926
No	34.45%	512
Not Sure	3.23%	48
TOTAL		1,486

Q19 Is your property located in an area at risk for wildfires?

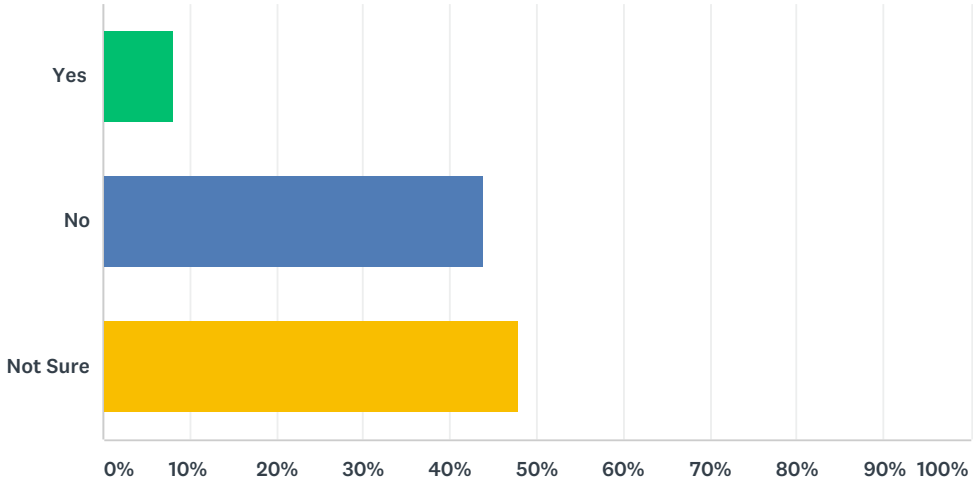
Answered: 1,487 Skipped: 140



ANSWER CHOICES	RESPONSES	
Yes	3.77%	56
No	74.51%	1,108
Not Sure	21.72%	323
TOTAL		1,487

Q20 Is your property located in an area at risk for subsidence, sinkholes, or other geologic hazards?

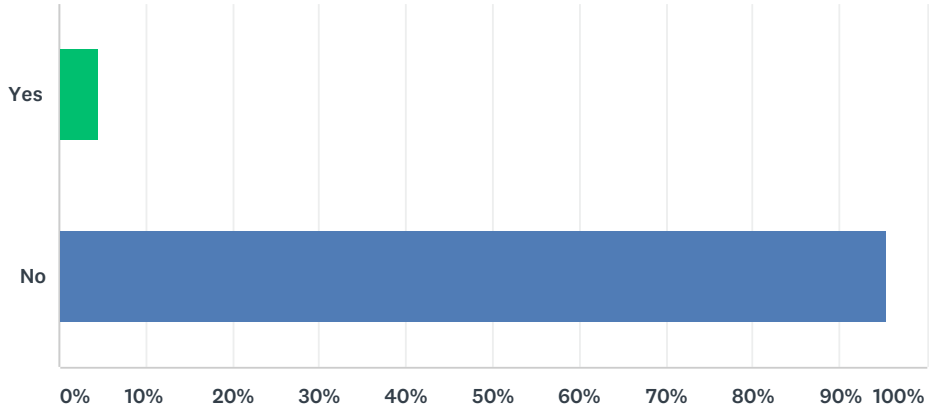
Answered: 1,487 Skipped: 140



ANSWER CHOICES	RESPONSES	
Yes	8.07%	120
No	43.98%	654
Not Sure	47.95%	713
TOTAL		1,487

Q21 Have you ever had problems securing homeowners or renters insurance due to risks from hazards?

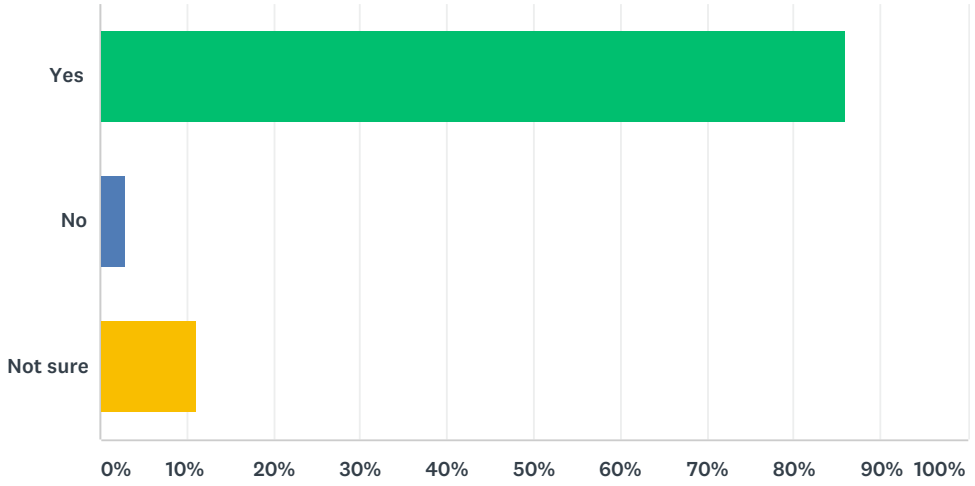
Answered: 1,486 Skipped: 141



ANSWER CHOICES	RESPONSES	
Yes	4.58%	68
No	95.42%	1,418
TOTAL		1,486

Q22 Do you support policies and/or regulations that prohibit or restrict development in identified hazard zones?

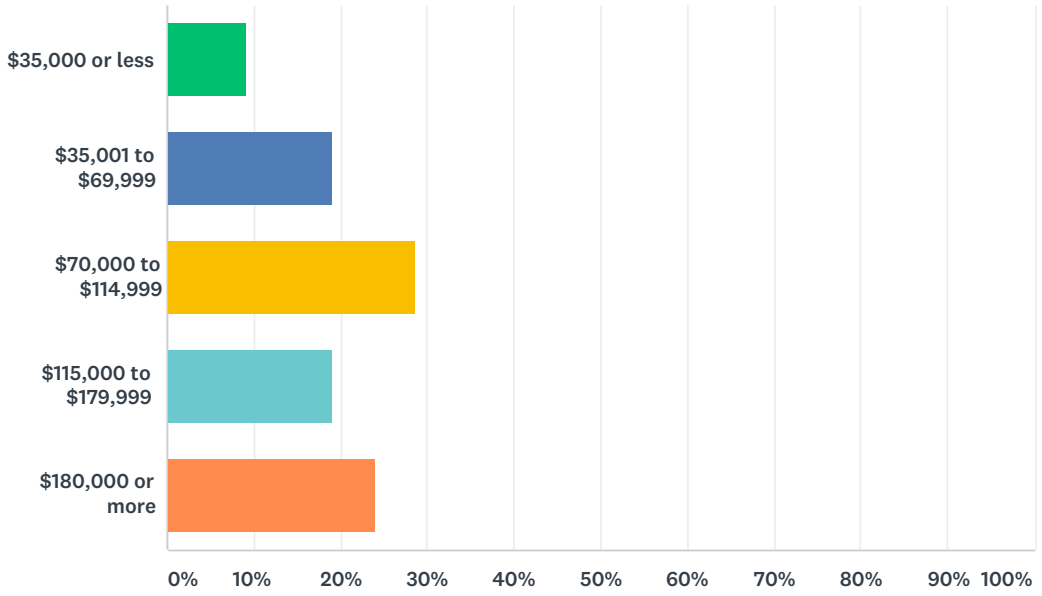
Answered: 1,491 Skipped: 136



ANSWER CHOICES	RESPONSES	
Yes	85.98%	1,282
No	3.02%	45
Not sure	11.00%	164
TOTAL		1,491

Q23 How much is your gross household income?

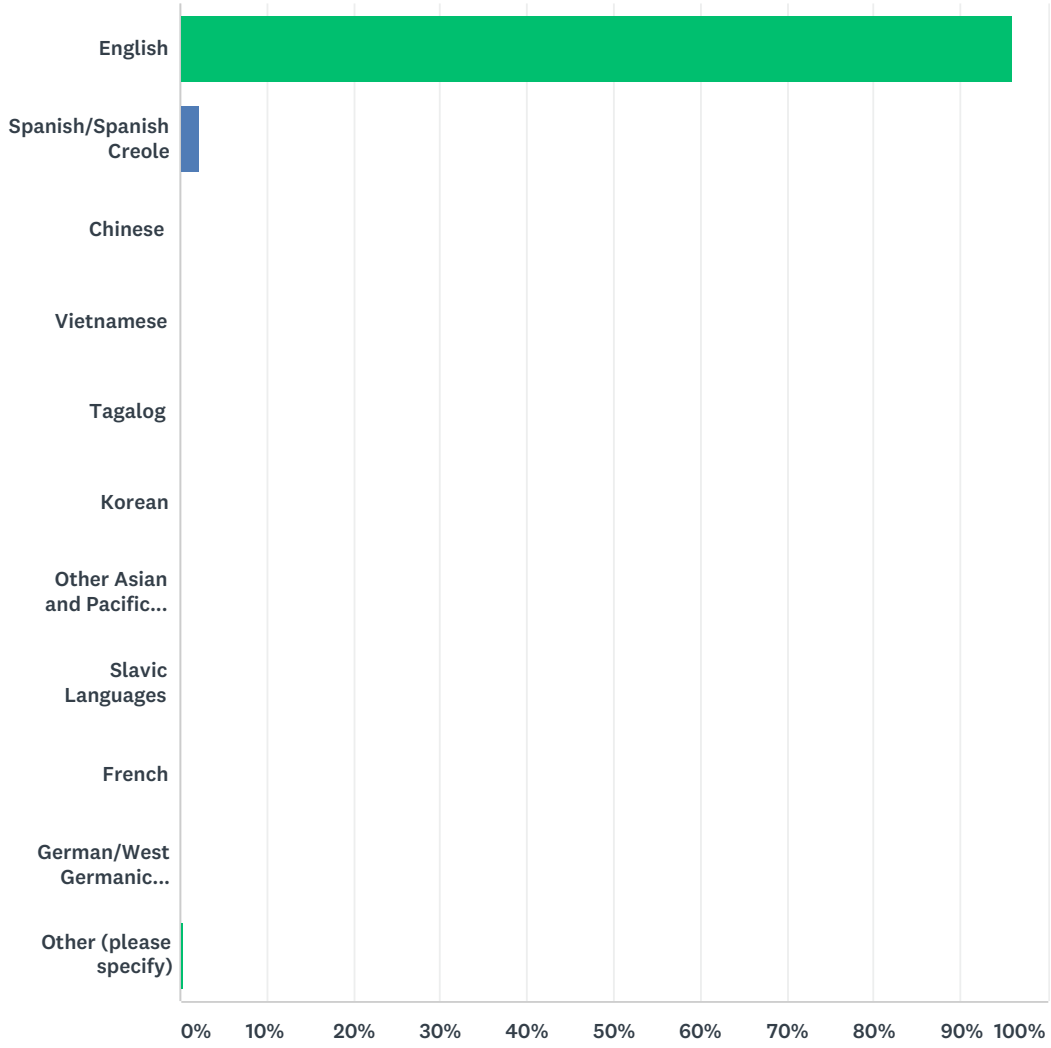
Answered: 1,434 Skipped: 193



ANSWER CHOICES	RESPONSES	
$35,000 or less	9.21%	132
$35,001 to $69,999	19.04%	273
$70,000 to $114,999	28.66%	411
$115,000 to $179,999	19.11%	274
$180,000 or more	23.99%	344
TOTAL		1,434

Q24 Please indicate the primary language spoken in your household.

Answered: 1,540 Skipped: 87



ANSWER CHOICES	RESPONSES	
English	96.10%	1,480
Spanish/Spanish Creole	2.27%	35
Chinese	0.26%	4
Vietnamese	0.13%	2
Tagalog	0.19%	3
Korean	0.06%	1
Other Asian and Pacific Island Languages	0.06%	1
Slavic Languages	0.06%	1
French	0.26%	4
German/West Germanic Languages	0.13%	2

Other (please specify)	0.45%	7
TOTAL		1,540

Q25 Please provide any additional comments you would like to share with the LHMP Steering Committee.

Answered: 315 Skipped: 1,312

Q26 If you would like to receive information regarding upcoming public events, other participatory opportunities regarding hazard mitigation, or general preparedness information, please provide your email address below.

Answered: 505 Skipped: 1,122

Appendix B. Summary of Federal and State Agencies, Programs and Regulations

B. Summary of Federal and State Agencies, Programs and Regulations

Existing laws, ordinances, plans and programs at the federal and state level can support or impact hazard mitigation actions identified in this plan. Hazard mitigation plans are required to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (44 CFR, Section 201.6(b)(3)). The following federal and state programs have been identified as programs that may interface with the actions identified in this plan. Each program enhances capabilities to implement mitigation actions or has a nexus with a mitigation action in this plan. Information presented in this section can be used to review local capabilities to implement the actions found in the jurisdictional annexes of Volume 2. Each planning partner has individually reviewed existing local plans, studies, reports, and technical information in its jurisdictional annex, presented in Volume 2.

FEDERAL

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) seeks to prevent discrimination against people with disabilities in employment, transportation, public accommodation, communications, and government activities. Title II of the ADA deals with compliance with the Act in emergency management and disaster-related programs, services, and activities. It applies to state and local governments as well as third parties, including religious entities and private nonprofit organizations.

The ADA has implications for sheltering requirements and public notifications. During an emergency alert, officials must use a combination of warning methods to ensure that all residents have all necessary information. Those with hearing impairments may not hear radio, television, sirens, or other audible alerts, while those with visual impairments may not see flashing lights or other visual alerts. Two technical documents for shelter operators address physical accessibility needs of people with disabilities, as well as medical needs and service animals.

The ADA intersects with disaster preparedness programs in regards to transportation, social services, temporary housing, and rebuilding. Persons with disabilities may require additional assistance in evacuation and transit (e.g., vehicles with wheelchair lifts or paratransit buses). Evacuation and other response plans should address the unique needs of residents. Local governments may be interested in implementing a special-needs registry to identify the home addresses, contact information, and needs for residents who may require more assistance.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Bureau of Land Management

The U.S. Bureau of Land Management (BLM) funds and coordinates wildfire management programs and structural fire management and prevention on BLM lands. BLM works closely with the Forest Service and state

and local governments to coordinate fire safety activities. The Interagency Fire Coordination Center in Boise, Idaho serves as the center for this effort.

Civil Rights Act of 1964

The Civil Rights Act of 1964 prohibits discrimination based on race, color, religion, sex or nation origin and requires equal access to public places and employment. The Act is relevant to emergency management and hazard mitigation in that it prohibits local governments from favoring the needs of one population group over another. Local government and emergency response must ensure the continued safety and well-being of all residents equally, to the extent possible. FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Clean Water Act

The federal Clean Water Act (CWA) employs regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's surface waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Evolution of CWA programs over the last decade has included a shift from a program-by-program, source-by-source, and pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach, equal emphasis is placed on protecting healthy waters and restoring impaired ones. Numerous issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining water quality and other environmental goals is a hallmark of this approach.

The CWA is important to hazard mitigation in several ways. There are often permitting requirements for any construction within 200 feet of water of the United States, which may have implications for mitigation projects identified by a local jurisdiction. Additionally, CWA requirements apply to wetlands, which serve important functions related to preserving and protecting the natural and beneficial functions of floodplains and are linked with a community's floodplain management program. Finally, the National Pollutant Discharge Elimination System is part of the CWA and addresses local stormwater management programs. Stormwater management plays a critical role in hazard mitigation by addressing urban drainage or localized flooding issues within jurisdictions.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Community Development Block Grant Disaster Resilience Program

In response to disasters, Congress may appropriate additional funding for the U.S. Department of Housing and Urban Development Community Development Block Grant programs to be distributed as Disaster Recovery grants (CDBG-DR). These grants can be used to rebuild affected areas and provide seed money to start the recovery process. CDBG-DR assistance may fund a broad range of recovery activities, helping communities and neighborhoods that otherwise might not recover due to limited resources. CDBG-DR grants often supplement disaster programs of FEMA, the Small Business Administration, and the U.S. Army Corps of Engineers. Housing and Urban Development generally awards noncompetitive, nonrecurring CDBG-DR grants by a formula that considers disaster recovery needs unmet by other federal disaster assistance programs. To be eligible for CDBG-DR funds, projects must meet the following criteria:

- Address a disaster-related impact (direct or indirect) in a presidentially declared county for the covered disaster
- Be a CDBG-eligible activity (according to regulations and waivers)
- Meet a national objective.

Incorporating preparedness and mitigation into these actions is encouraged, as the goal is to rebuild in ways that are safer and stronger. CDBG-DR funding is a potential alternative source of funding for actions identified in this plan.

Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses.
- Facilitate accurate insurance rating.
- Promote awareness of flood insurance.

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) The discount partially depends on location of the property. Properties outside the SFHA receive smaller discounts: a 10-percent discount if the community is at Class 1 to 6 and a 5-percent discount if the community is at Class 7 to 9. The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness.

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

Disaster Mitigation Act

The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Assistance grant funds are available to communities. This plan is designed to meet the requirements of DMA, improving eligibility for future hazard mitigation funds.

Emergency Relief for Federally Owned Roads Program

The U.S. Forest Service's Emergency Relief for Federally Owned Roads Program was established to assist federal agencies with repair or reconstruction of tribal transportation facilities, federal lands transportation facilities, and other federally owned roads that are open to public travel and have suffered serious damage by a natural disaster over a wide area or by a catastrophic failure. The program funds both emergency and permanent repairs (Office of

Federal Lands Highway, 2016). Eligible activities under this program meet some of the goals and objectives for this plan and the program is a possible funding source for actions identified in this plan.

Emergency Watershed Program

The USDA Natural Resources Conservation Service (NRCS) administers the Emergency Watershed Protection (EWP) Program, which responds to emergencies created by natural disasters. Eligibility for assistance is not dependent on a national emergency declaration. The program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, windstorms, and other natural occurrences. EWP is an emergency recovery program. Financial and technical assistance are available for the following activities (Natural Resources Conservation Service, 2016):

- Remove debris from stream channels, road culverts, and bridges
- Reshape and protect eroded banks
- Correct damaged drainage facilities
- Establish cover on critically eroding lands
- Repair levees and structures
- Repair conservation practices.

This federal program could be a possible funding source for actions identified in this plan.

Endangered Species Act

The federal Endangered Species Act (ESA) was enacted in 1973 to conserve species facing depletion or extinction and the ecosystems that support them. The act sets forth a process for determining which species are threatened and endangered and requires the conservation of the critical habitat in which those species live. The ESA provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered. Provisions are made for listing species, as well as for recovery plans and the designation of critical habitat for listed species. The ESA outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species and contains exceptions and exemptions. It is the enabling legislation for the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Criminal and civil penalties are provided for violations of the ESA and the Convention.

Federal agencies must seek to conserve endangered and threatened species and use their authorities in furtherance of the ESA's purposes. The ESA defines three fundamental terms:

- Endangered means that a species of fish, animal or plant is "in danger of extinction throughout all or a significant portion of its range." (For salmon and other vertebrate species, this may include subspecies and distinct population segments.)
- Threatened means that a species "is likely to become endangered within the foreseeable future." Regulations may be less restrictive for threatened species than for endangered species.
- Critical habitat means "specific geographical areas that are…essential for the conservation and management of a listed species, whether occupied by the species or not."

Five sections of the ESA are of critical importance to understanding it:

- Section 4: Listing of a Species—The National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) is responsible for listing marine species; the U.S. Fish and Wildlife Service is responsible for listing terrestrial and freshwater aquatic species. The agencies may initiate reviews for listings, or citizens may petition for them. A listing must be made "solely on the basis of the best scientific and commercial data available." After a listing has been proposed, agencies receive comment

and conduct further scientific reviews for 12 to 18 months, after which they must decide if the listing is warranted. Economic impacts cannot be considered in this decision, but it may include an evaluation of the adequacy of local and state protections. Critical habitat for the species may be designated at the time of listing.

- Section 7: Consultation—Federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed or proposed species or adversely modify its critical habitat. This includes private and public actions that require a federal permit. Once a final listing is made, non-federal actions are subject to the same review, termed a "consultation." If the listing agency finds that an action will "take" a species, it must propose mitigations or "reasonable and prudent" alternatives to the action; if the proponent rejects these, the action cannot proceed.
- Section 9: Prohibition of Take—It is unlawful to "take" an endangered species, including killing or injuring it or modifying its habitat in a way that interferes with essential behavioral patterns, including breeding, feeding or sheltering.
- Section 10: Permitted Take—Through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit a take that would otherwise be prohibited as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). These agreements often take the form of a "Habitat Conservation Plan."
- Section 11: Citizen Lawsuits—Civil actions initiated by any citizen can require the listing agency to enforce the ESA's prohibition of taking or to meet the requirements of the consultation process.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) cooperates with a large number of federal and state agencies to ensure and promote dam safety. More than 3,000 dams are part of regulated hydroelectric projects in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters), or with a total storage capacity of more than 2,000 acre-feet.

FERC monitors seismic research and applies it in performing structural analyses of hydroelectric projects. FERC also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication Engineering Guidelines for the Evaluation of Hydropower Projects guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and

agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

National Environmental Policy Act

The National Environmental Policy Act requires federal agencies to consider the environmental impacts of proposed actions and reasonable alternatives to those actions, alongside technical and economic considerations. The National Environmental Policy Act established the Council on Environmental Quality, whose regulations (40 CFR Parts 1500-1508) set standards for compliance. Consideration and decision-making regarding environmental impacts must be documented in an environmental impact statement or environmental assessment. Environmental impact assessment requires the evaluation of reasonable alternatives to a proposed action, solicitation of input from organizations and individuals that could be affected, and an unbiased presentation of direct, indirect, and cumulative environmental impacts. FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Federal Wildfire Management Policy and Healthy Forests Restoration Act

Federal Wildfire Management Policy and Healthy Forests Restoration Act (2003). These documents call for a single comprehensive federal fire policy for the Interior and Agriculture Departments (the agencies using federal fire management resources). They mandate community-based collaboration to reduce risks from wildfire.

National Dam Safety Act

Potential for catastrophic flooding due to dam failures led to passage of the National Dam Inspection Act in 1972, creation of the National Dam Safety Program in 1996, and reauthorization of the program through the Dam Safety Act in 2006. National Dam Safety Program, administered by FEMA requires a periodic engineering analysis of the majority of dams in the country; exceptions include the following:

- Dams under jurisdiction of the Bureau of Reclamation, Tennessee Valley Authority, or International Boundary and Water Commission
- Dams constructed pursuant to licenses issued under the Federal Power Act
- Dams that the Secretary of the Army determines do not pose any threat to human life or property.

The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect lives and property of the public. The National Dam Safety Program is a partnership among the states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most of the dams in the United States.

National Fire Plan (2001)

The 2001 National Fire Plan was developed based on the National Fire Policy. A major aspect of the National Fire Plan is joint risk reduction planning and implementation carried out by federal, state and local agencies and communities. The National Fire Plan presented a comprehensive strategy in five key initiatives:

- Firefighting—Be adequately prepared to fight fires each fire season.
- Rehabilitation and Restoration—Restore landscapes and rebuild communities damaged by wildfires.
- Hazardous Fuel Reduction—Invest in projects to reduce fire risk.

- Community Assistance—Work directly with communities to ensure adequate protection.
- Accountability—Be accountable and establish adequate oversight, coordination, program development, and monitoring for performance.

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study. The study presents water surface elevations for floods of various magnitudes, including the 1-percent-annual-chance flood and the 0.2-percent-annual-chance flood. Base flood elevations and the boundaries of the flood hazard areas are shown on Flood Insurance Rate Maps, which are the principle tool for identifying the extent and location of the flood hazard. Flood Insurance Rate Maps are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under the local floodplain management program. In recent years, Flood Insurance Rate Maps have been digitized as Digital Flood Insurance Rate Maps, which are more accessible to residents, local governments and stakeholders.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 1-percent-annual-chance flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.
- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) provides federally backed flood insurance in exchange for communities enacting floodplain regulations. Participation and good standing under NFIP are prerequisites to grant funding eligibility under the Robert T. Stafford Act. Full compliance and good standing under the NFIP are application prerequisites for all FEMA grant programs for which participating jurisdictions are eligible under this plan.

National Incident Management System

The National Incident Management System (NIMS) is a systematic approach for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards. The NIMS provides a flexible but standardized set of incident management practices. Incidents typically begin and end locally, and they are managed at the lowest possible geographical, organizational, and jurisdictional level. In some cases, success depends on the involvement of multiple jurisdictions, levels of government, functional agencies, and emergency responder disciplines. These cases necessitate coordination across a spectrum of organizations. Communities using NIMS follow a comprehensive national approach that improves the effectiveness of emergency management and response personnel across the full spectrum of potential hazards (including natural hazards, technological hazards, and human-caused hazards) regardless of size or complexity.

Although participation is voluntary, federal departments and agencies are required to make adoption of NIMS by local and state jurisdictions a condition to receive federal preparedness grants and awards. The content of this plan is considered to be a viable support tool for any phase of emergency management. The NIMS program is

considered as a response function, and information in this hazard mitigation plan can support the implementation and update of all NIMS-compliant plans within the planning area.

Presidential Executive Order 11988, Floodplain Management

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. It requires federal agencies to provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural and beneficial values of floodplains. The requirements apply to the following activities (FEMA, 2015a):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

Presidential Executive Order 11990, Protection of Wetlands

Executive Order 11990 requires federal agencies to provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. The requirements apply to the following activities (National Archives, 2016):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

All actions identified in this plan will seek full compliance with all applicable presidential executive orders.

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers operates and maintains approximately 700 dams nationwide. It is also responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety. The Corps maintains the National Inventory of Dams, which contains information about a dam's location, size, purpose, type, last inspection and regulatory status (U.S. Army Corps of Engineers, 2017).

U.S. Army Corps of Engineers Flood Hazard Management

The U.S. Army Corps of Engineers has several civil works authorities and programs related to flood risk and flood hazard management:

- The Floodplain Management Services program offers 100-percent federally funded technical services such as development and interpretation of site-specific data related to the extent, duration and frequency of flooding. Special studies may be conducted to help a community understand and respond to flood risk. These may include flood hazard evaluation, flood warning and preparedness, or flood modeling.
- For more extensive studies, the Corps of Engineers offers a cost-shared program called Planning Assistance to States and Tribes. Studies under this program generally range from $25,000 to $100,000 with the local jurisdiction providing 50 percent of the cost.

- The Corps of Engineers has several cost-shared programs (typically 65 percent federal and 35 percent non-federal) aimed at developing, evaluating and implementing structural and non-structural capital projects to address flood risks at specific locations or within a specific watershed:

  - The Continuing Authorities Program for smaller-scale projects includes Section 205 for Flood Control, with a $7 million federal limit and Section 14 for Emergency Streambank Protection with a $1.5 million federal limit. These can be implemented without specific authorization from Congress.
  - Larger scale studies, referred to as General Investigations, and projects for flood risk management, for ecosystem restoration or to address other water resource issues, can be pursued through a specific authorization from Congress and are cost-shared, typically at 65 percent federal and 35 percent non-federal.
  - Watershed management planning studies can be specifically authorized and are cost-shared at 50 percent federal and 50 percent non-federal.

- The Corps of Engineers provides emergency response assistance during and following natural disasters. Public Law 84-99 enables the Corps to assist state and local authorities in flood fight activities and cost share in the repair of flood protective structures. Assistance is provided in the flowing categories:

  - Preparedness—The Flood Control and Coastal Emergency Act establishes an emergency fund for preparedness for emergency response to natural disasters; for flood fighting and rescue operations; for rehabilitation of flood control and hurricane protection structures. Funding for Corps of Engineers emergency response under this authority is provided by Congress through the annual Energy and Water Development Appropriation Act. Disaster preparedness activities include coordination, planning, training and conduct of response exercises with local, state and federal agencies.
  - Response Activities—Public Law 84-99 allows the Corps of Engineers to supplement state and local entities in flood fighting urban and other non-agricultural areas under certain conditions (Engineering Regulation 500-1-1 provides specific details). All flood fight efforts require a project cooperation agreement signed by the public sponsor and the sponsor must remove all flood fight material after the flood has receded. Public Law 84-99 also authorizes emergency water support and drought assistance in certain situations and allows for "advance measures" assistance to prevent or reduce flood damage conditions of imminent threat of unusual flooding.
  - Rehabilitation—Under Public Law 84-99, an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the federal system owner, and at 20-percent cost to the eligible non-federal system owner. All systems considered eligible for Public Law 84-99 rehabilitation assistance have to be in the Rehabilitation and Inspection Program prior to the flood event. Acceptable operation and maintenance by the public levee sponsor are verified by levee inspections conducted by the Corps on a regular basis. The Corps has the responsibility to coordinate levee repair issues with interested federal, state, and local agencies following natural disaster events where flood control works are damaged.

All of these authorities and programs are available to the planning partners to support any intersecting mitigation actions.

U.S. Fire Administration

There are federal agencies that provide technical support to fire agencies/organizations. For example, the U.S. Fire Administration, which is a part of FEMA, provides leadership, advocacy, coordination, and support for fire agencies and organizations.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service fire management strategy employs prescribed fire to maintain early successional fire-adapted grasslands and other ecological communities throughout the National Wildlife Refuge System.

STATE

Texas Government Code Chapter 418; Texas Administrative Code Title 37, Part 1, Chapter 7

Under Texas Government Code Chapter 418 (Emergency Management), mayors and county judges serve as emergency management directors. In most jurisdictions, these officials appoint an emergency management coordinator to administer the program. The mayor and county judge are authorized by the Texas Disaster Act to declare a local disaster when conditions exist or when there is an immediate threat.

Texas government Code Chapter 418.014 grants the governor the authority to declare a state-level disaster. At the local level, an emergency management director serves as the governor's designated agent in the administration and supervision of duties under Chapter 418. An emergency management director may exercise the powers granted to the governor under this chapter on an appropriate local scale (Texas Government Code Chapter 418.015) and may declare a local state of disaster (Texas Government Code Chapter 418.108).

Jurisdictions must prepare emergency operations plans that follow TDEM's planning standards (Texas Government Code Chapter 418.102).

Texas Planning Law

The Texas Planning Law enables local governments to adopt comprehensive plans. A municipality may define the content and design of its comprehensive plan, but the state suggests including the following elements:

- Land use
- Transportation
- Public facilities.

The municipality may then, should it choose to do so, enact development regulations that are consistent with the plan. Consistency is defined by the local jurisdiction.

The law also authorizes the creation of a conservation easement that imposes limitations on land use for the purpose of retaining or protecting natural, scenic, agricultural, historical, or open space values of real property. If the conservation easement is not unlimited in duration, as soon as it ends, an additional tax is imposed on the land equal to the tax break received for the five prior years, plus 7 percent annual interest.

Texas Property Code

Section 5.008 of the Texas Property Code establishes requirements for sellers to disclose whether a property is in the floodplain, has suffered flood damage, and has flood insurance coverage.

Texas Stormwater Management Program

The state of Texas and the Texas Commission on Environmental Quality were delegated authority by the U.S. EPA to administer the National Pollutant Discharge Elimination System (NPDES) permitting program for

wastewater and stormwater discharges associated with construction activity and industrial activity, as well as Municipal Separate Storm Sewer System (MS4) activity. Because the EPA and the Clean Water Act require a program for addressing the pollution caused by stormwater discharges, the Texas Commission on Environmental Quality implemented and managed the Texas Pollutant Discharge Elimination System permitting program to fulfill all Clean Water Act and federal mandates. The system provides a process for project owners and operators to attain permit coverage allowing the discharge of stormwater and wastewater into Texas surface waters

HB 108; Texas Water Code

Section 16.3145 of the Texas Water Code requires non-participating flood-prone communities in Texas to adopt a flood damage prevention ordinance and enroll in the National Flood Insurance Program.

HOME Program

The Texas Department of Housing and Community Affairs administers the HOME Program to expand the supply of decent, safe, affordable housing and strengthen public-private housing partnerships between units of local governments, public housing authorities, nonprofits, and for-profit entities. The Department of Housing and Community Affairs has set aside funding for disaster relief and persons with disabilities, among others.

Texas Water Development Board

The Texas Water Development Board manages state programs for flood hazard mapping under FEMA's CTP program. The Board also monitors NFIP program compliance on behalf of the State.

Texas Flash Flood Coalition

The Texas Flash Flood Coalition works to decrease the number of deaths caused by flash flooding in Texas. More than 30 representatives of higher education, media, private industry, local, state and federal governments participate in the coalition.

Texas Silver Jackets

This U.S. Army Corps of Engineers initiative provides a formal and consistent strategy for an interagency approach to planning and implementing measures in order to reduce the risks associated with flooding and other natural hazards.

Community Hazard Analysis and Mitigation Planning Support

Community Hazard Analysis and Mitigation Planning Support (CHAMPS) reports provide summarized descriptions of historical hazard events and future hazard risks for each county in Texas. These have been developed by the Texas Geographic Society in a project funded by FEMA and administered by TDEM. CHAMPS reports have been developed to provide local mitigation planners with data, maps and other information they can use to support the hazard assessment portion of the mitigation planning process.

Texas General Land Office

The General Land Office sponsors education efforts to increase public and private sector awareness and support for mitigation planning along the Texas coast, including the Texas Storm Smart Coasts Network website, Texas Coastal Homeowners Handbook, and the Texas Hazard Mitigation Guidebook.

Harris County Multi-Hazard Mitigation Action Plan

Appendix C. Risk Assessment Results

Dam Failure Risk Assessment

Conroe Dam Inundation Area

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**$11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**$6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Toatal)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Missouri City (Total)	**74,705**	**24,326**	**23,412**	**$12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (Total)	**18,312**	**5,055**	**3,967**	**$6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,821,770**	**1,355,132**	**1,260,959**	**928,049,024,035**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Lake Conroe Dam inundation area data (draft PMF breach) provided by Harris County.
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
(5) Assumed 1foot of flood depth over finished floor and applied aggregate average USACE depth damage curves to estimate loss

Dam Failure Risk Assessment

Conroe Dam Inundation Area

Jurisdiction	Dam Inundation - Lake Conroe Dam (3)						
	Estimated Exposure						
	Estimated Buildings Exposed (2)	Population Exposed (4)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value
Baytown (Harris Co.)	45	172	0.24%	9,471,687	4,735,844	14,207,531	0.14%
Baytown (Chambers Co.)	0	0	0.00%	0	0	0	0.00%
Baytown (Total)	**45**	**172**	**0.22%**	**9,471,687**	**4,735,844**	**14,207,531**	**0.12%**
Bellaire	0	0	0.00%	0	0	0	0.00%
Bunker Hill Village	0	0	0.00%	0	0	0	0.00%
Deer Park	0	0	0.00%	0	0	0	0.00%
El Lago	0	0	0.00%	0	0	0	0.00%
Friendswood (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Friendswood (Galveston Co.)	0	0	0.00%	0	0	0	0.00%
Friendswood (Total)	**0**	**0**	**0.00%**	**0**	**0**	**0**	**0.00%**
Galena Park	0	0	0.00%	0	0	0	0.00%
Hedwig Village	0	0	0.00%	0	0	0	0.00%
Hilshire Village	0	0	0.00%	0	0	0	0.00%
Houston (Harris Co.)	3,635	14,544	0.64%	1,816,286,365	1,059,629,339	2,875,915,704	0.59%
Humble	572	1,794	11.18%	515,847,360	476,530,660	992,378,020	21.71%
Hunters Creek Village	0	0	0.00%	0	0	0	0.00%
Jacinto City	0	0	0.00%	0	0	0	0.00%
Jersey Village	0	0	0.00%	0	0	0	0.00%
Katy (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Katy (Fort Bend Co.)	0	0	0.00%	0	0	0	0.00%
Katy (Waller Co.)	0	0	0.00%	0	0	0	0.00%
Katy (Toatal)	**0**	**0**	**0.00%**	**0**	**0**	**0**	**0.00%**
La Porte	0	0	0.00%	0	0	0	0.00%
League City (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Missouri City (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Missouri City (Fort Bend Co.)	0	0	0.00%	0	0	0	0.00%
Missouri City (Total)	**0**	**0**	**0.00%**	**0**	**0**	**0**	**0.00%**
Morgan's Point (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Nassau Bay	0	0	0.00%	0	0	0	0.00%
Pasadena	0	0	0.00%	0	0	0	0.00%
Pearland (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Piney Point Village	0	0	0.00%	0	0	0	0.00%
Seabrook (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Shoreacres (Harris Co.)	0	0	0.00%	0	0	0	0.00%
South Houston	0	0	0.00%	0	0	0	0.00%
Southside Place	0	0	0.00%	0	0	0	0.00%
Spring Valley Village	0	0	0.00%	0	0	0	0.00%
Stafford (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Stafford (Fort Bend Co.)	0	0	0.00%	0	0	0	0.00%
Stafford (Total)	**0**	**0**	**0.00%**	**0**	**0**	**0**	**0.00%**
Taylor Lake Village	0	0	0.00%	0	0	0	0.00%
Tomball (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Waller (Harris Co.)	0	0	0.00%	0	0	0	0.00%
Webster	0	0	0.00%	0	0	0	0.00%
West University Place	0	0	0.00%	0	0	0	0.00%
Unincorporated County	2,390	7,616	0.40%	729,489,007	438,488,556	1,167,977,563	0.36%
Total	**6,642**	**24,126**	**0.50%**	**3,071,094,420**	**1,979,384,398**	**5,050,478,818**	**0.54%**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Lake Conroe Dam inundation area data (draft PMF breach) provided by Harris County.
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
(5) Assumed 1foot of flood depth over finished floor and applied aggregate average USACE depth damage curves to estimate loss

Dam Failure Risk Assessment

Conroe Dam Inundation Area

Jurisdiction	Estimated Damage to Structure (5)	Estimated Damage to Contents(5)	Total	% of Total
Baytown (Harris Co.)	$1,515,470	$426,226	$1,941,696	0.02%
Baytown (Chambers Co.)	$0	$0	$0	0.00%
Baytown (Total)	**$1,515,470**	**$426,226**	**$1,941,696**	**0.02%**
Bellaire				
Bunker Hill Village				
Deer Park				
El Lago				
Friendswood (Harris Co.)				
Friendswood (Galveston Co.)				
Friendswood (Total)				
Galena Park				
Hedwig Village				
Hilshire Village				
Houston (Harris Co.)	$290,605,818	$95,366,640	$385,972,459	0.08%
Humble	$82,535,578	$42,887,759	$125,423,337	2.74%
Hunters Creek Village				
Jacinto City				
Jersey Village				
Katy (Harris Co.)				
Katy (Fort Bend Co.)				
Katy (Waller Co.)				
Katy (Toatal)				
La Porte				
League City (Harris Co.)				
Missouri City (Harris Co.)				
Missouri City (Fort Bend Co.)				
Missouri City (Total)				
Morgan's Point (Harris Co.)				
Nassau Bay				
Pasadena				
Pearland (Harris Co.)				
Piney Point Village				
Seabrook (Harris Co.)				
Shoreacres (Harris Co.)				
South Houston				
Southside Place				
Spring Valley Village				
Stafford (Harris Co.)				
Stafford (Fort Bend Co.)				
Stafford (Total)				
Taylor Lake Village				
Tomball (Harris Co.)				
Waller (Harris Co.)				
Webster				
West University Place				
Unincorporated County	$116,718,241	$39,463,970	$156,182,211	0.05%
Total	**$491,375,107**	**$178,144,596**	**$669,519,703**	**0.07%**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Lake Conroe Dam inundation area data (draft PMF breach) provided by Harris County.
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
(5) Assumed 1foot of flood depth over finished floor and applied aggregate average USACE depth damage curves to estimate loss

Dam Failure Risk Assessment

Conroe Dam Inundation Area

Jurisdiction	Number of Structures in Dam Inundation Area (2)							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	45	0	0	0	0	0	0	45
Baytown (Chambers Co.)	0	0	0	0	0	0	0	0
Baytown (Total)	**45**	**0**	**0**	**0**	**0**	**0**	**0**	**45**
Bellaire	0	0	0	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0	0	0	0
Deer Park	0	0	0	0	0	0	0	0
El Lago	0	0	0	0	0	0	0	0
Friendswood (Harris Co.)	0	0	0	0	0	0	0	0
Friendswood (Galveston Co.)	0	0	0	0	0	0	0	0
Friendswood (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Galena Park	0	0	0	0	0	0	0	0
Hedwig Village	0	0	0	0	0	0	0	0
Hilshire Village	0	0	0	0	0	0	0	0
Houston (Harris Co.)	3,474	146	0	6	1	1	7	3,635
Humble	445	121	4	2	0	0	0	572
Hunters Creek Village	0	0	0	0	0	0	0	0
Jacinto City	0	0	0	0	0	0	0	0
Jersey Village	0	0	0	0	0	0	0	0
Katy (Harris Co.)	0	0	0	0	0	0	0	0
Katy (Fort Bend Co.)	0	0	0	0	0	0	0	0
Katy (Waller Co.)	0	0	0	0	0	0	0	0
Katy (Toatal)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
La Porte	0	0	0	0	0	0	0	0
League City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Fort Bend Co.)	0	0	0	0	0	0	0	0
Missouri City (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Morgan's Point (Harris Co.)	0	0	0	0	0	0	0	0
Nassau Bay	0	0	0	0	0	0	0	0
Pasadena	0	0	0	0	0	0	0	0
Pearland (Harris Co.)	0	0	0	0	0	0	0	0
Piney Point Village	0	0	0	0	0	0	0	0
Seabrook (Harris Co.)	0	0	0	0	0	0	0	0
Shoreacres (Harris Co.)	0	0	0	0	0	0	0	0
South Houston	0	0	0	0	0	0	0	0
Southside Place	0	0	0	0	0	0	0	0
Spring Valley Village	0	0	0	0	0	0	0	0
Stafford (Harris Co.)	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	0	0	0	0	0	0	0	0
Stafford (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taylor Lake Village	0	0	0	0	0	0	0	0
Tomball (Harris Co.)	0	0	0	0	0	0	0	0
Waller (Harris Co.)	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
West University Place	0	0	0	0	0	0	0	0
Unincorporated County	2,156	230	2	1	1	0	0	2,390
Total	**6,120**	**497**	**6**	**9**	**2**	**1**	**7**	**6,642**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Lake Conroe Dam inundation area data (draft PMF breach) provided by Harris County.
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
(5) Assumed 1foot of flood depth over finished floor and applied aggregate average USACE depth damage curves to estimate loss

Earthquake Risk Assessment

500-Year Probabilistic

Jurisdiction	Estimated Exposure				
	Estimated Population (1)	% Population Exposed	Total Number of Buildings (2)	Total Building Value (Structure and contents in $) (2)	% of Total Value Exposed
Baytown (Harris Co.)	72,879	100%	20,718	$10,081,462,691	100%
Baytown (Chambers Co.)	4,145	100%	1,440	$1,376,644,000	100%
Baytown (Total)	**77,024**	**100%**	**22,158**	**$11,458,106,691**	**100%**
Bellaire	18,966	100%	6,503	$5,726,227,131	100%
Bunker Hill Village	3,982	100%	1,303	$1,322,346,729	100%
Deer Park	33,931	100%	11,370	$5,845,168,035	100%
El Lago	2,727	100%	1,107	$469,295,696	100%
Friendswood (Harris Co.)	11,575	100%	3,570	$1,631,453,165	100%
Friendswood (Galveston Co.)	28,606	100%	9,959	$4,553,773,509	100%
Friendswood (Total)	**40,181**	**100%**	**13,529**	**$6,185,226,675**	**100%**
Galena Park	10,931	100%	3,288	$1,178,706,765	100%
Hedwig Village	2,669	100%	909	$1,142,111,969	100%
Hilshire Village	819	100%	321	$207,926,478	100%
Houston (Harris Co.)	2,278,069	100%	592,166	$487,379,428,234	100%
Humble	16,041	100%	4,890	$4,570,456,883	100%
Hunters Creek Village	4,891	100%	1,572	$1,787,651,957	100%
Jacinto City	10,625	100%	2,986	$1,261,111,221	100%
Jersey Village	7,962	100%	2,527	$2,275,428,136	100%
Katy (Harris Co.)	15,251	100%	4,249	$1,865,017,616	100%
Katy (Fort Bend Co.)	2,159	100%	811	$1,312,561,128	100%
Katy (Waller Co.)	1,806	100%	492	$218,939,000	100%
Katy (Total)	19,216	100%	5,552	$3,396,517,744	100%
La Porte	35,423	100%	12,427	$6,575,613,440	100%
League City (Harris Co.)	1,984	100%	394	$280,449,911	100%
Missouri City (Harris Co.)	6,273	100%	1,876	$770,837,732	100%
Missouri City (Fort Bend Co.)	68,432	100%	22,450	$11,627,868,465	100%
Missouri City (Total)	**74,705**	**100%**	**24,326**	**$12,398,706,197**	**100%**
Morgan's Point (Harris Co.)	345	100%	160	$262,314,866	100%
Nassau Bay	4,037	100%	1,574	$1,635,924,802	100%
Pasadena	153,219	100%	40,639	$22,505,882,445	100%
Pearland (Harris Co.)	5,237	100%	834	$709,046,327	100%
Piney Point Village	3,449	100%	1,195	$1,817,131,583	100%
Seabrook (Harris Co.)	14,291	100%	4,390	$2,537,671,414	100%
Shoreacres (Harris Co.)	1,611	100%	657	$218,188,519	100%
South Houston	17,583	100%	5,001	$2,162,541,092	100%
Southside Place	1,881	100%	508	$471,918,214	100%
Spring Valley Village	4,333	100%	1,509	$1,227,871,955	100%
Stafford (Harris Co.)	309	100%	89	$24,088,003	100%
Stafford (Fort Bend Co.)	18,003	100%	4,966	$6,078,341,979	100%
Stafford (Total)	**18,312**	**100%**	**5,055**	**$6,102,429,982**	**100%**
Taylor Lake Village	3,625	100%	1,390	$690,404,692	100%
Tomball (Harris Co.)	11,761	100%	3,649	$3,569,286,191	100%
Waller (Harris Co.)	600	100%	261	$221,680,638	100%
Webster	11,201	100%	2,387	$5,700,342,104	100%
West University Place	15,676	100%	5,525	$3,722,134,705	100%
Unincorporated County	1,914,463	100%	573,070	$321,033,774,612	100%
TOTAL	**4,821,770**	100%	**1,355,132**	**928,049,024,035**	100%

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Calculated using a Census tract level, general building stock (GBS) analysis in Hazus 4.2 SP03.

Earthquake Risk Assessment

500-Year Probabilistic

Jurisdiction	Economic Impact						
	Structure Debris (x 1,000 Tons) (3)	Number of Displaced Households (3)	People Requiring Short-Term Shelter (3)	Value Structure in $ Damaged (3)	Value Contents in $ Damaged (3)	Total Value (Structure and Contents in $) Damaged (3)	% of Total Value Damaged
Baytown (Harris Co.)	1.04	0	0	$1,117,367	$107,747	$1,225,114	0.012%
Baytown (Chambers Co.)	0.01	0	0	$11,438	$1,009	$12,446	0.001%
Baytown (Total)	**1.05**	**0**	**0**	**$1,128,805**	**$108,755**	**$1,237,560**	**0.011%**
Bellaire	0.29	0	0	$453,452	$36,757	$490,208	0.009%
Bunker Hill Village	0.01	0	0	$63,824	$5,986	$69,810	0.005%
Deer Park	1.12	0	0	$840,885	$81,898	$922,783	0.016%
El Lago	0.00	0	0	$13,073	$1,252	$14,324	0.003%
Friendswood (Harris Co.)	0.07	0	0	$87,499	$8,190	$95,689	0.006%
Friendswood (Galveston Co.)	0.04	0	0	$117,726	$14,108	$131,834	0.003%
Friendswood (Total)	**0.11**	**0**	**0**	**$205,225**	**$22,298**	**$227,523**	**0.004%**
Galena Park	0.37	0	0	$211,773	$21,687	$233,460	0.020%
Hedwig Village	0.02	0	0	$63,341	$8,012	$71,354	0.006%
Hilshire Village	0.01	0	0	$16,068	$1,916	$17,984	0.009%
Houston (Harris Co.)	80.87	2	1	$67,404,367	$5,389,108	$72,793,475	0.015%
Humble	0.83	0	0	$605,387	$50,705	$656,093	0.014%
Hunters Creek Village	0.03	0	0	$103,598	$9,606	$113,204	0.006%
Jacinto City	0.36	0	0	$243,961	$18,546	$262,508	0.021%
Jersey Village	0.47	0	0	$391,560	$33,715	$425,276	0.019%
Katy (Harris Co.)	0.24	0	0	$199,724	$16,565	$216,289	0.012%
Katy (Fort Bend Co.)	0.00	0	0	$5,498	$860	$6,359	0.000%
Katy (Waller Co.)	0.01	0	0	$4,657	$393	$5,050	0.002%
Katy (Total)	0.24	0.00	0.00	209,879.93	17,817.98	227,698	0.007%
La Porte	2.17	0	0	$1,428,585	$113,379	$1,541,964	0.023%
League City (Harris Co.)	0.02	0	0	$20,054	$1,958	$22,012	0.008%
Missouri City (Harris Co.)	0.15	0	0	$116,446	$8,677	$125,123	0.016%
Missouri City (Fort Bend Co.)	0.26	0	0	$449,149	$62,857	$512,006	0.004%
Missouri City (Total)	**0.41**	**0**	**0**	**$565,595**	**$71,534**	**$637,129**	**0.005%**
Morgan's Point (Harris Co.)	0.12	0	0	$69,485	$5,689	$75,174	0.029%
Nassau Bay	0.07	0	0	$126,806	$11,748	$138,554	0.008%
Pasadena	3.34	0	0	$2,903,182	$258,858	$3,162,040	0.014%
Pearland (Harris Co.)	0.11	0	0	$85,290	$8,318	$93,607	0.013%
Piney Point Village	0.09	0	0	$140,040	$9,967	$150,007	0.008%
Seabrook (Harris Co.)	0.21	0	0	$174,109	$14,106	$188,214	0.007%
Shoreacres (Harris Co.)	0.00	0	0	$8,092	$837	$8,929	0.004%
South Houston	0.61	0	0	$425,278	$31,584	$456,862	0.021%
Southside Place	0.01	0	0	$21,527	$2,711	$24,238	0.005%
Spring Valley Village	0.06	0	0	$94,729	$11,298	$106,027	0.009%
Stafford (Harris Co.)	0.01	0	0	$4,936	$351	$5,287	0.022%
Stafford (Fort Bend Co.)	0.33	0	0	$301,742	$49,117	$350,859	0.006%
Stafford (Total)	**0.34**	**0**	**0**	**$306,678**	**$49,469**	**$356,147**	**0.006%**
Taylor Lake Village	0.04	0	0	$39,324	$4,005	$43,328	0.006%
Tomball (Harris Co.)	0.39	0	0	$346,989	$30,669	$377,658	0.011%
Waller (Harris Co.)	0.04	0	0	$27,663	$2,168	$29,831	0.013%
Webster	0.59	0	0	$753,898	$69,795	$823,692	0.014%
West University Place	0.02	0	0	$151,331	$17,112	$168,442	0.005%
Unincorporated County	44.06	0	0	$35,537,925	$3,220,918	$38,758,843	0.012%
TOTAL	**138**	**2**	**1**	**115,181,776**	**9,744,182**	**124,925,958**	0.013%

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.

(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)

(3) Calculated using a Census tract level, general building stock (GBS) analysis in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Riverine

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.)	4,145	1,440	1,280	$1,376,644,000
Baytown (total)	**77,024**	**22,158**	**20,309**	**11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Misouri City (Total)	**74,705**	**24,326**	**23,412**	**12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (total)	**18,312**	**5,055**	**3,967**	**6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated Harris County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,821,770**	**1,355,132**	**1,260,959**	**928,049,024,035**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District

(3) Percent of residential buildings exposed multiplied by the Estimated Population.

(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.

(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.

(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Riverine

Jurisdiction	Estimated Building Exposure						
	Buildings Exposed (2)	Population Exposed (3)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value Exposed
Baytown (Harris Co.)	677	2,409	3.3%	$213,419,969	$140,577,448	$353,997,417	3.5%
Baytown (Chambers Co.)	575	1,736	41.9%	$167,716,000	$108,161,000	$275,877,000	20.0%
Baytown (total)	**1,252**	**4,145**	**5.4%**	**381,135,969**	**248,738,448**	**629,874,417**	**5.5%**
Bellaire	5,359	15,634	82.4%	$2,944,769,141	$1,726,222,179	$4,670,991,320	81.6%
Bunker Hill Village	0	0	0.0%	$0	$0	$0	0.0%
Deer Park	384	687	2.0%	$378,853,512	$419,217,270	$798,070,782	13.7%
El Lago	707	1,720	63.1%	$201,454,689	$107,137,036	$308,591,725	65.8%
Friendswood (Harris Co.)	523	1,717	14.8%	$119,867,843	$61,597,501	$181,465,343	11.1%
Friendswood (Galveston Co.)	656	1,894	6.6%	$197,172,528	$116,972,092	$314,144,620	6.9%
Friendswood (Total)	**1,179**	**3,610**	**9.0%**	**317,040,371**	**178,569,593**	**495,609,963**	**8.0%**
Galena Park	108	382	3.5%	$12,544,057	$6,420,134	$18,964,191	1.6%
Hedwig Village	0	0	0.0%	$0	$0	$0	0.0%
Hilshire Village	0	0	0.0%	$0	$0	$0	0.0%
Houston (Harris Co.)	66,553	259,980	11.4%	$28,661,376,542	$19,272,797,951	$47,934,174,493	9.8%
Humble	207	689	4.3%	$147,328,131	$125,653,165	$272,981,296	6.0%
Hunters Creek Village	45	142	2.9%	$30,666,051	$15,333,025	$45,999,076	2.6%
Jacinto City	1	0	0.0%	$1,557,700	$1,557,700	$3,115,400	0.2%
Jersey Village	675	2,282	28.7%	$223,526,600	$115,736,064	$339,262,665	14.9%
Katy (Harris Co.)	101	392	2.6%	$34,812,480	$17,406,240	$52,218,719	2.8%
Katy (Fort Bend Co.)	89	106	4.9%	$38,262,829	$35,933,271	$74,196,099	5.7%
Katy (Waller Co.)	175	622	34.5%	$52,299,000	$34,307,000	$86,606,000	39.6%
Katy (Total)	**365**	**1,121**	**5.8%**	**125,374,308**	**87,646,510**	**213,020,818**	**6.3%**
La Porte	557	1,498	4.2%	$169,550,275	$129,633,354	$299,183,630	4.5%
League City (Harris Co.)	45	221	11.1%	$17,264,573	$9,974,151	$27,238,725	9.7%
Missouri City (Harris Co.)	88	275	4.4%	$39,478,426	$22,694,827	$62,173,253	8.1%
Missouri City (Fort Bend Co.)	47	67	0.1%	$45,288,292	$42,650,791	$87,939,083	0.8%
Misouri City (Total)	**135**	**342**	**0.5%**	**84,766,718**	**65,345,618**	**150,112,336**	**1.2%**
Morgan's Point (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Nassau Bay	1,217	3,210	79.5%	$583,779,100	$356,806,863	$940,585,962	57.5%
Pasadena	2,699	9,855	6.4%	$1,449,983,675	$1,059,194,630	$2,509,178,305	11.1%
Pearland (Harris Co.)	68	344	6.6%	$79,125,320	$77,265,923	$156,391,243	22.1%
Piney Point Village	65	183	5.3%	$75,922,564	$45,079,635	$121,002,199	6.7%
Seabrook (Harris Co.)	2,028	6,430	45.0%	$805,380,699	$490,042,010	$1,295,422,709	51.0%
Shoreacres (Harris Co.)	274	673	41.8%	$66,046,445	$33,023,222	$99,069,667	45.4%
South Houston	1,245	3,660	20.8%	$407,508,698	$343,861,989	$751,370,687	34.7%
Southside Place	362	1,364	72.5%	$221,612,463	$117,451,501	$339,063,964	71.8%
Spring Valley Village	7	21	0.5%	$2,763,435	$1,381,717	$4,145,152	0.3%
Stafford (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
Taylor Lake Village	634	1,654	45.6%	$231,417,699	$116,457,910	$347,875,609	50.4%
Tomball (Harris Co.)	12	28	0.2%	$41,520,169	$21,620,275	$63,140,444	1.8%
Waller (Harris Co.)	48	125	20.8%	$4,377,310	$3,340,547	$7,717,856	3.5%
Webster	720	4,388	39.2%	$231,985,348	$141,786,974	$373,772,322	6.6%
West University Place	808	2,305	14.7%	$386,080,477	$195,110,666	$581,191,144	15.6%
Unincorporated Harris County	32,044	102,343	5.3%	$10,722,244,302	$8,333,570,785	$19,055,815,087	5.9%
Total	**119,803**	**429,036**	**8.9%**	**49,006,956,341**	**33,845,976,849**	**82,852,933,190**	**8.9%**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District

(3) Percent of residential buildings exposed multiplied by the Estimated Population.

(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.

(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.

(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Riverine

Jurisdiction	Economic Impact							
	Structure Debris (Tons) (4)	Displaced Population (5)	People Requiring Short-Term Shelter (5)	Buildings Impacted (6)	Value Structure in $ Damaged (6)	Value Contents in $ Damaged (6)	Total Value (Structure and Contents in $) Damaged (6)	% of Total Value Damaged
Baytown (Harris Co.)	18,713	490	32	474	$31,378,554	$22,444,865	$53,823,419	0.5%
Baytown (Chambers Co.)	933	162	4	147	$10,367,000	$11,161,000	$21,528,000	1.6%
Baytown (total)	**19,646**	**652**	**36**	**621**	**41,745,554**	**33,605,865**	**75,351,419**	**0.7%**
Bellaire	27,789	12,989	565	4,066	$248,691,296	$158,631,579	$407,322,875	7.1%
Bunker Hill Village	0	0	0	0	$0	$0	$0	0.0%
Deer Park	2,042	87	4	319	$7,368,743	$12,353,532	$19,722,275	0.3%
El Lago	9,004	1,261	94	618	$32,185,495	$19,037,537	$51,223,032	10.9%
Friendswood (Harris Co.)	5,249	457	23	380	$11,327,946	$6,758,841	$18,086,787	1.1%
Friendswood (Galveston Co.)	12,591	380	15	448	$27,594,709	$24,161,616	$51,756,324	1.1%
Friendswood (Total)	**17,840**	**837**	**38**	**828**	**38,922,654**	**30,920,457**	**69,843,111**	**1.1%**
Galena Park	488	37	1	7	$101,936	$59,501	$161,437	0.0%
Hedwig Village	0	0	0	0	$0	$0	$0	0.0%
Hilshire Village	902	0	0	0	$0	$0	$0	0.0%
Houston (Harris Co.)	728,996	114,281	11,038	48,829	$2,388,077,802	$1,876,193,414	$4,264,271,215	0.9%
Humble	4,422	80	3	130	$12,772,817	$27,278,767	$40,051,585	0.9%
Hunters Creek Village	10,310	15	1	10	$1,467,205	$827,378	$2,294,583	0.1%
Jacinto City	212	0	0	1	$0	$55,703	$55,703	0.0%
Jersey Village	10,873	1,112	60	669	$33,027,042	$24,861,390	$57,888,432	2.5%
Katy (Harris Co.)	667	127	8	76	$3,093,857	$1,866,900	$4,960,757	0.3%
Katy (Fort Bend Co.)	319	19	1	71	$1,388,998	$2,875,170	$4,264,168	0.3%
Katy (Waller Co.)	288	198	9	99	$2,621,000	$1,799,000	$4,420,000	2.0%
Katy (Total)	**1,274**	**344**	**18**	**246**	**7,103,855**	**6,541,070**	**13,644,925**	**0.4%**
La Porte	3,876	243	6	348	$8,872,955	$7,394,843	$16,267,798	0.2%
League City (Harris Co.)	584	14	0	25	$1,639,076	$933,354	$2,572,430	0.9%
Missouri City (Harris Co.)	565	15	0	2	$7,154	$56,000	$63,154	0.0%
Missouri City (Fort Bend Co.)	6,458	6	0	9	$592,771	$1,128,864	$1,721,635	0.0%
Misouri City (Total)	**7,023**	**22**	**1**	**11**	**599,925**	**1,184,864**	**1,784,789**	**0.0%**
Morgan's Point (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Nassau Bay	32,168	2,665	206	1,137	$107,919,674	$63,242,293	$171,161,967	10.5%
Pasadena	28,346	2,357	162	1,385	$93,497,484	$61,892,669	$155,390,153	0.7%
Pearland (Harris Co.)	436	61	3	52	$2,781,778	$2,185,948	$4,967,726	0.7%
Piney Point Village	11,892	32	1	14	$9,766,964	$9,558,191	$19,325,155	1.1%
Seabrook (Harris Co.)	22,291	3,680	291	1,865	$109,356,734	$89,659,527	$199,016,261	7.8%
Shoreacres (Harris Co.)	4,682	485	19	274	$13,974,480	$7,904,705	$21,879,185	10.0%
South Houston	4,694	1,906	94	1,085	$21,549,628	$27,580,173	$49,129,802	2.3%
Southside Place	1,573	888	51	219	$10,589,416	$6,544,216	$17,133,632	3.6%
Spring Valley Village	1,202	1	0	5	$255,212	$154,260	$409,471	0.0%
Stafford (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	122	0	0	0	$0	$0	$0	0.0%
Stafford (total)	**122**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0%**
Taylor Lake Village	10,476	944	48	572	$40,656,036	$23,114,793	$63,770,829	9.2%
Tomball (Harris Co.)	962	2	0	9	$195,726	$233,135	$428,862	0.0%
Waller (Harris Co.)	128	13	0	48	$263,026	$223,076	$486,102	0.2%
Webster	8,031	1,358	146	702	$28,721,080	$16,832,161	$45,553,241	0.8%
West University Place	2,759	782	20	427	$11,956,554	$7,467,559	$19,424,113	0.5%
Unincorporated Harris County	442,981	25,330	1,722	24,657	$771,263,688	$620,844,525	$1,392,108,213	0.4%
Total	**1,418,026**	**172,478**	**14,627**	**89,179**	**4,045,323,837**	**3,137,316,486**	**7,182,640,323**	**0.8%**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District

(3) Percent of residential buildings exposed multiplied by the Estimated Population.

(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.

(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.

(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Riverine

Jurisdiction	Acres of Floodplain	Number of Structures in Floodplain (2)							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	3,330	629	44	2	0	1	1	0	677
Baytown (Chambers Co.)	591	536	22	13	0	4	0	0	575
Baytown (total)	**3,921**	**1,165**	**66**	**15**	**0**	**5**	**1**	**0**	**1,252**
Bellaire	1,902	5,199	148	0	4	4	0	4	5359
Bunker Hill Village	0	0	0	0	0	0	0	0	0
Deer Park	886	214	125	44	0	0	0	1	384
El Lago	343	680	22	0	2	2	1	0	707
Friendswood (Harris Co.)	1,437	516	7	0	0	0	0	0	523
Friendswood (Galveston Co.)	1,851	635	20	0	1	0	0	0	656
Friendswood (Total)	**3,288**	**1,151**	**27**	**0**	**1**	**0**	**0**	**0**	**1,179**
Galena Park	384	106	2	0	0	0	0	0	108
Hedwig Village	0	0	0	0	0	0	0	0	0
Hilshire Village	9	0	0	0	0	0	0	0	0
Houston (Harris Co.)	96,995	62,100	4,131	111	17	149	4	41	66553
Humble	1,036	171	32	3	0	1	0	0	207
Hunters Creek Village	174	45	0	0	0	0	0	0	45
Jacinto City	40	0	1	0	0	0	0	0	1
Jersey Village	571	673	1	0	0	1	0	0	675
Katy (Harris Co.)	89	101	0	0	0	0	0	0	101
Katy (Fort Bend Co.)	475	27	61	0	1	0	0	0	89
Katy (Waller Co.)	523	153	15	5	2	0	0	0	175
Katy (Total)	**1,087**	**281**	**76**	**5**	**3**	**0**	**0**	**0**	**365**
La Porte	1,722	485	72	0	0	0	0	0	557
League City (Harris Co.)	458	43	2	0	0	0	0	0	45
Missouri City (Harris Co.)	73	80	8	0	0	0	0	0	88
Missouri City (Fort Bend Co.)	2,765	21	16	0	10	0	0	0	47
Misouri City (Total)	**2,838**	**101**	**24**	**0**	**10**	**0**	**0**	**0**	**135**
Morgan's Point (Harris Co.)	143	0	0	0	0	0	0	0	0
Nassau Bay	905	1,196	21	0	0	0	0	0	1217
Pasadena	7,779	2,388	293	12	1	1	0	4	2699
Pearland (Harris Co.)	824	52	9	7	0	0	0	0	68
Piney Point Village	203	63	2	0	0	0	0	0	65
Seabrook (Harris Co.)	1,606	1,847	177	2	1	0	1	0	2028
Shoreacres (Harris Co.)	348	274	0	0	0	0	0	0	274
South Houston	563	843	388	10	0	4	0	0	1245
Southside Place	117	356	5	0	0	0	1	0	362
Spring Valley Village	29	7	0	0	0	0	0	0	7
Stafford (Harris Co.)	0	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	13	0	0	0	0	0	0	0	0
Stafford (total)	**13**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taylor Lake Village	565	632	2	0	0	0	0	0	634
Tomball (Harris Co.)	467	7	5	0	0	0	0	0	12
Waller (Harris Co.)	40	41	7	0	0	0	0	0	48
Webster	1,017	695	22	2	1	0	0	0	720
West University Place	244	804	4	0	0	0	0	0	808
Unincorporated Harris County	154,043	28,971	2,645	305	21	79	6	17	32044
Total	**284,560**	**110,590**	**8,309**	**516**	**61**	**246**	**14**	**67**	**119,803**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District

(3) Percent of residential buildings exposed multiplied by the Estimated Population.

(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.

(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.

(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Coastal

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Misouri City (Total)	**74,705**	**24,326**	**23,412**	**12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (total)	**18,312**	**5,055**	**3,967**	**6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated Harris County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,906,224**	**1,379,420**	**1,283,467**	**939,761,939,891**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties).
(3) Percent of residential buildings exposed multiplied by the Estimated Population.
(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.
(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.
(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Coastal

Jurisdiction	Estimated Building Exposure						
	Buildings Exposed (2)	Population Exposed (3)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value Exposed
Baytown (Harris Co.)	57	211	0.3%	$6,099,519	$3,439,193	$9,538,712	0.1%
Baytown (Chambers Co.)	1	0	0.0%	$94,000	$94,000	$188,000	0.0%
Baytown (Total)	**58**	**211**	**0.3%**	**6,193,519**	**3,533,193**	**9,726,712**	**0.1%**
Bellaire	0	0	0.0%	$0	$0	$0	0.0%
Bunker Hill Village	0	0	0.0%	$0	$0	$0	0.0%
Deer Park	0	0	0.0%	$0	$0	$0	0.0%
El Lago	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Galveston Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
Galena Park	0	0	0.0%	$0	$0	$0	0.0%
Hedwig Village	0	0	0.0%	$0	$0	$0	0.0%
Hilshire Village	0	0	0.0%	$0	$0	$0	0.0%
Houston (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Humble	0	0	0.0%	$0	$0	$0	0.0%
Hunters Creek Village	0	0	0.0%	$0	$0	$0	0.0%
Jacinto City	0	0	0.0%	$0	$0	$0	0.0%
Jersey Village	0	0	0.0%	$0	$0	$0	0.0%
Katy (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Waller Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
La Porte	1,409	4,226	11.9%	$384,915,453	$233,698,490	$618,613,942	9.4%
League City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Misouri City (Total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
Morgan's Point (Harris Co.)	35	81	23.3%	$15,614,271	$7,807,136	$23,421,407	8.9%
Nassau Bay	0	0	0.0%	$0	$0	$0	0.0%
Pasadena	129	524	0.3%	$22,080,884	$11,376,359	$33,457,243	0.1%
Pearland (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Piney Point Village	0	0	0.0%	$0	$0	$0	0.0%
Seabrook (Harris Co.)	1,264	4,268	29.9%	$305,943,315	$163,697,223	$469,640,539	18.5%
Shoreacres (Harris Co.)	383	938	58.2%	$77,924,992	$41,193,860	$119,118,852	54.6%
South Houston	0	0	0.0%	$0	$0	$0	0.0%
Southside Place	0	0	0.0%	$0	$0	$0	0.0%
Spring Valley Village	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
Taylor Lake Village	0	0	0.0%	$0	$0	$0	0.0%
Tomball (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Waller (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Webster	0	0	0.0%	$0	$0	$0	0.0%
West University Place	0	0	0.0%	$0	$0	$0	0.0%
Unincorporated Harris County	10	21	0.0%	$4,784,385	$4,512,568	$9,296,953	0.0%
Total	**3,345**	**10,479**	**0.2%**	**823,556,337**	**469,258,023**	**1,292,814,360**	**0.1%**

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(3) Percent of residential buildings exposed multiplied by the Estimated Population.
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(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

100-Year Coastal

Jurisdiction	Economic Impact							
	Structure Debris (Tons) (4)	Displaced Population (5)	People Requiring Short-Term Shelter (5)	Buildings Impacted (6)	Value Structure in $ Damaged (6)	Value Contents in $ Damaged (6)	Total Value (Structure and Contents in $) Damaged	% of Total Value Damaged
Baytown (Harris Co.)	551	31	1	52	$2,022,190	$1,109,467	$3,131,657	0.0%
Baytown (Chambers Co.)	0	0	0	1	$1,000	$4,000	$5,000	0.0%
Baytown (Total)	**551**	**31**	**1**	**53**	**2,023,190**	**1,113,467**	**3,136,657**	**0.0%**
Bellaire	0	0	0	0	$0	$0	$0	0.0%
Bunker Hill Village	0	0	0	0	$0	$0	$0	0.0%
Deer Park	0	0	0	0	$0	$0	$0	0.0%
El Lago	0	0	0	0	$0	$0	$0	0.0%
Friendswood (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Friendswood (Galveston Co.)	0	0	0	0	$0	$0	$0	0.0%
Friendswood (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0%**
Galena Park	0	0	0	0	$0	$0	$0	0.0%
Hedwig Village	0	0	0	0	$0	$0	$0	0.0%
Hilshire Village	0	0	0	0	$0	$0	$0	0.0%
Houston (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Humble	0	0	0	0	$0	$0	$0	0.0%
Hunters Creek Village	0	0	0	0	$0	$0	$0	0.0%
Jacinto City	0	0	0	0	$0	$0	$0	0.0%
Jersey Village	0	0	0	0	$0	$0	$0	0.0%
Katy (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Katy (Fort Bend Co.)	0	0	0	0	$0	$0	$0	0.0%
Katy (Waller Co.)	0	0	0	0	$0	$0	$0	0.0%
Katy (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0%**
La Porte	14,811	3,370	212	1,155	$81,416,200	$43,067,216	$124,483,416	1.9%
League City (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Missouri City (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Missouri City (Fort Bend Co.)	0	0	0	0	$0	$0	$0	0.0%
Misouri City (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0%**
Morgan's Point (Harris Co.)	1,869	27	1	27	$5,253,199	$2,461,757	$7,714,956	2.9%
Nassau Bay	0	0	0	0	$0	$0	$0	0.0%
Pasadena	514	224	5	100	$3,506,182	$1,774,621	$5,280,803	0.0%
Pearland (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Piney Point Village	0	0	0	0	$0	$0	$0	0.0%
Seabrook (Harris Co.)	30,805	3,752	214	1,157	$96,015,066	$57,969,127	$153,984,193	6.1%
Shoreacres (Harris Co.)	10,349	932	29	383	$45,735,418	$25,127,098	$70,862,516	32.5%
South Houston	0	0	0	0	$0	$0	$0	0.0%
Southside Place	0	0	0	0	$0	$0	$0	0.0%
Spring Valley Village	0	0	0	0	$0	$0	$0	0.0%
Stafford (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	0	0	0	0	$0	$0	$0	0.0%
Stafford (total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0%**
Taylor Lake Village	0	0	0	0	$0	$0	$0	0.0%
Tomball (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Waller (Harris Co.)	0	0	0	0	$0	$0	$0	0.0%
Webster	0	0	0	0	$0	$0	$0	0.0%
West University Place	0	0	0	0	$0	$0	$0	0.0%
Unincorporated Harris County	132	11	0	10	$1,730,336	$2,937,138	$4,667,475	0.0%
Total	**59,582**	**8,379**	**462**	**2,937**	**237,701,783**	**135,559,891**	**373,261,674**	**0.0%**

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Flood Risk Assessment

100-Year Coastal

Jurisdiction	Acres of Floodplain	Number of Structures in Floodplain (2)							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	649	55	2	0	0	0	0	0	57
Baytown (Chambers Co.)	0	0	1	0	0	0	0	0	1
Baytown (Total)	**650**	**55**	**3**	**0**	**0**	**0**	**0**	**0**	**58**
Bellaire	0	0	0	0	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0	0	0	0	0
Deer Park	0	0	0	0	0	0	0	0	0
El Lago	0	0	0	0	0	0	0	0	0
Friendswood (Harris Co.)	0	0	0	0	0	0	0	0	0
Friendswood (Galveston Co.)	0	0	0	0	0	0	0	0	0
Friendswood (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Galena Park	0	0	0	0	0	0	0	0	0
Hedwig Village	0	0	0	0	0	0	0	0	0
Hilshire Village	0	0	0	0	0	0	0	0	0
Houston (Harris Co.)	0	0	0	0	0	0	0	0	0
Humble	0	0	0	0	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0	0	0	0	0
Jacinto City	0	0	0	0	0	0	0	0	0
Jersey Village	0	0	0	0	0	0	0	0	0
Katy (Harris Co.)	0	0	0	0	0	0	0	0	0
Katy (Fort Bend Co.)	0	0	0	0	0	0	0	0	0
Katy (Waller Co.)	0	0	0	0	0	0	0	0	0
Katy (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
La Porte	1,354	1,368	39	0	0	1	0	1	1409
League City (Harris Co.)	0	0	0	0	0	0	0	0	0
Missouri City (Harris Co.)	0	0	0	0	0	0	0	0	0
Missouri City (Fort Bend Co.)	0	0	0	0	0	0	0	0	0
Misouri City (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Morgan's Point (Harris Co.)	65	35	0	0	0	0	0	0	35
Nassau Bay	0	0	0	0	0	0	0	0	0
Pasadena	142	127	2	0	0	0	0	0	129
Pearland (Harris Co.)	0	0	0	0	0	0	0	0	0
Piney Point Village	0	0	0	0	0	0	0	0	0
Seabrook (Harris Co.)	1,773	1,226	34	0	2	2	0	0	1264
Shoreacres (Harris Co.)	236	382	1	0	0	0	0	0	383
South Houston	0	0	0	0	0	0	0	0	0
Southside Place	0	0	0	0	0	0	0	0	0
Spring Valley Village	0	0	0	0	0	0	0	0	0
Stafford (Harris Co.)	0	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	0	0	0	0	0	0	0	0	0
Stafford (total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taylor Lake Village	0	0	0	0	0	0	0	0	0
Tomball (Harris Co.)	0	0	0	0	0	0	0	0	0
Waller (Harris Co.)	0	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0	0
West University Place	0	0	0	0	0	0	0	0	0
Unincorporated Harris County	850	6	3	1	0	0	0	0	10
Total	**5,720**	**3,254**	**84**	**1**	**2**	**3**	**0**	**1**	**3,345**

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Flood Risk Assessment

Harvey

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Misouri City (Total)	**74,705**	**24,326**	**23,412**	**12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (total)	**18,312**	**5,055**	**3,967**	**6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated Harris County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,906,224**	**1,379,420**	**1,283,467**	**939,761,939,891**

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(3) Percent of residential buildings exposed multiplied by the Estimated Population.

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Flood Risk Assessment

Harvey

Jurisdiction	Estimated Building Exposure						
	Buildings Exposed (2)	Population Exposed (3)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value Exposed
Baytown (Harris Co.)	7,721	26,909	36.9%	$1,801,715,229	$1,218,149,893	$3,019,865,121	30.0%
Baytown (Chambers Co.)	1,430	4,142	99.9%	$679,197,000	$691,484,000	$1,370,681,000	99.6%
Baytown (Total)	**9,151**	**31,051**	**40.3%**	**2,480,912,229**	**1,909,633,893**	**4,390,546,121**	**38.3%**
Bellaire	2,963	8,754	46.2%	$1,537,023,254	$936,185,007	$2,473,208,261	43.2%
Bunker Hill Village	8	24	0.6%	$4,509,551	$2,254,776	$6,764,327	0.5%
Deer Park	4,352	12,404	36.6%	$1,610,270,240	$1,207,829,185	$2,818,099,425	48.2%
El Lago	550	1,369	50.2%	$135,925,454	$70,225,543	$206,150,997	43.9%
Friendswood (Harris Co.)	1,833	5,992	51.8%	$468,313,627	$250,032,352	$718,345,978	44.0%
Friendswood (Galveston Co.)	2,744	7,923	27.7%	$777,896,214	$463,073,009	$1,240,969,223	27.3%
Friendswood (Total)	**4,577**	**13,915**	**34.6%**	**1,246,209,840**	**713,105,361**	**1,959,315,201**	**31.7%**
Galena Park	1,292	4,200	38.4%	$273,471,336	$211,339,761	$484,811,098	41.1%
Hedwig Village	52	108	4.0%	$55,758,601	$47,726,940	$103,485,541	9.1%
Hilshire Village	234	590	72.0%	$100,895,591	$52,133,982	$153,029,573	73.6%
Houston (Harris Co.)	232,838	892,426	39.2%	$103,604,257,785	$75,397,073,382	$179,001,331,167	36.7%
Humble	2,010	6,692	41.7%	$907,314,897	$822,773,481	$1,730,088,377	37.9%
Hunters Creek Village	307	952	19.5%	$225,499,213	$125,151,041	$350,650,254	19.6%
Jacinto City	1,130	4,056	38.2%	$262,187,581	$195,829,132	$458,016,713	36.3%
Jersey Village	833	2,709	34.0%	$419,346,672	$305,566,424	$724,913,097	31.9%
Katy (Harris Co.)	859	2,779	18.2%	$258,924,431	$191,406,526	$450,330,957	24.1%
Katy (Fort Bend Co.)	278	556	25.7%	$129,380,399	$112,840,525	$242,220,923	18.5%
Katy (Waller Co.)	487	1,806	100.0%	$128,967,000	$75,540,000	$204,507,000	93.4%
Katy (Total)	**1,624**	**5,141**	**26.8%**	**517,271,830**	**379,787,051**	**897,058,880**	**26.4%**
La Porte	5,882	16,159	45.6%	$1,856,961,252	$1,327,117,490	$3,184,078,742	48.4%
League City (Harris Co.)	83	385	19.4%	$73,575,155	$40,699,917	$114,275,072	40.7%
Missouri City (Harris Co.)	507	1,685	26.9%	$165,295,390	$108,632,923	$273,928,313	35.5%
Missouri City (Fort Bend Co.)	5,360	16,309	23.8%	$1,630,922,044	$967,348,395	$2,598,270,439	22.3%
Misouri City (Total)	**5,867**	**17,994**	**24.1%**	**1,796,217,434**	**1,075,981,318**	**2,872,198,752**	**23.2%**
Morgan's Point (Harris Co.)	75	152	44.0%	$112,161,712	$118,710,485	$230,872,197	88.0%
Nassau Bay	600	1,514	37.5%	$426,460,790	$278,060,981	$704,521,771	43.1%
Pasadena	21,148	78,008	50.9%	$7,225,285,050	$5,124,260,122	$12,349,545,173	54.9%
Pearland (Harris Co.)	560	3,602	68.8%	$209,487,505	$131,429,615	$340,917,121	48.1%
Piney Point Village	364	1,051	30.5%	$335,050,052	$173,217,900	$508,267,952	28.0%
Seabrook (Harris Co.)	2,119	6,757	47.3%	$743,094,486	$445,713,030	$1,188,807,516	46.8%
Shoreacres (Harris Co.)	405	995	61.7%	$87,530,932	$43,765,466	$131,296,397	60.2%
South Houston	3,766	13,202	75.1%	$946,441,093	$722,758,722	$1,669,199,815	77.2%
Southside Place	155	590	31.4%	$81,513,528	$40,838,933	$122,352,461	25.9%
Spring Valley Village	508	1,457	33.6%	$259,232,498	$162,775,762	$422,008,260	34.4%
Stafford (Harris Co.)	24	83	27.0%	$4,333,858	$2,166,929	$6,500,787	27.0%
Stafford (Fort Bend Co.)	2,410	8,240	45.8%	$1,600,981,794	$1,413,615,069	$3,014,596,862	49.6%
Stafford (total)	**2,434**	**8,323**	**45.5%**	**1,605,315,651**	**1,415,781,998**	**3,021,097,649**	**49.5%**
Taylor Lake Village	542	1,413	39.0%	$198,938,348	$100,218,234	$299,156,582	43.3%
Tomball (Harris Co.)	714	2,093	17.8%	$379,879,581	$303,540,999	$683,420,581	19.1%
Waller (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Webster	1,042	4,066	36.3%	$1,757,917,918	$1,703,418,723	$3,461,336,641	60.7%
West University Place	1,611	4,553	29.0%	$716,892,600	$368,640,831	$1,085,533,432	29.2%
Unincorporated Harris County	187,650	624,814	32.6%	$61,815,219,668	$41,241,685,716	$103,056,905,383	32.1%
Total	**507,000**	**1,804,422**	**36.8%**	**196,278,058,183**	**138,663,413,445**	**334,941,471,628**	**35.6%**

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Flood Risk Assessment

Harvey

Jurisdiction	Economic Impact							
	Structure Debris (Tons) (4)	Displaced Population (5)	People Requiring Short-Term Shelter (5)	Buildings Impacted (6)	Value Structure in $ Damaged (6)	Value Contents in $ Damaged (6)	Total Value (Structure and Contents in $) Damaged	% of Total Value Damaged
Baytown (Harris Co.)	69,788	14,442	839	7,541	$274,900,831	$257,965,011	$532,865,842	5.3%
Baytown (Chambers Co.)	6,076	2,210	122		$84,087,000	$67,689,000	$151,776,000	11.0%
Baytown (Total)	**75,864**	**16,652**	**961**	**7,541**	**358,987,831**	**325,654,011**	**684,641,842**	**6.0%**
Bellaire	31,038	6,005	236	2,749	$226,553,788	$162,942,481	$389,496,268	6.8%
Bunker Hill Village	725	2	0	7	$649,119	$384,013	$1,033,132	0.1%
Deer Park	40,321	6,186	355	4,272	$294,523,955	$351,535,919	$646,059,874	11.1%
El Lago	5,666	698	44	533	$45,992,568	$28,484,687	$74,477,255	15.9%
Friendswood (Harris Co.)	15,793	3,795	219	1,791	$125,532,540	$75,703,694	$201,236,235	12.3%
Friendswood (Galveston Co.)	33,430	3,445	171	2,581	$241,868,327	$370,418,970	$612,287,297	13.4%
Friendswood (Total)	**49,223**	**7,240**	**390**	**4,372**	**367,400,867**	**446,122,665**	**813,523,532**	**13.2%**
Galena Park	7,245	2,012	85	1,266	$45,644,955	$71,827,129	$117,472,084	10.0%
Hedwig Village	1,949	35	2	50	$7,523,056	$11,421,965	$18,945,021	1.7%
Hilshire Village	4,853	504	30	233	$23,145,425	$13,793,316	$36,938,741	17.8%
Houston (Harris Co.)	2,498,854	494,973	43,606	226,464	$15,166,942,440	$16,692,757,930	$31,859,700,370	6.5%
Humble	32,402	3,421	241	1,979	$149,236,148	$252,134,792	$401,370,940	8.8%
Hunters Creek Village	19,426	337	15	301	$55,298,891	$33,814,581	$89,113,472	5.0%
Jacinto City	6,076	2,126	99	1,099	$33,196,382	$44,021,434	$77,217,816	6.1%
Jersey Village	12,373	1,269	79	804	$50,556,959	$62,283,207	$112,840,166	5.0%
Katy (Harris Co.)	9,652	1,354	78	809	$30,899,187	$42,397,364	$73,296,550	3.9%
Katy (Fort Bend Co.)	998	316	21	276	$17,387,354	$35,482,468	$52,869,822	4.0%
Katy (Waller Co.)	1,256	695	22	519	$11,137,000	$7,108,000	$18,245,000	8.3%
Katy (Total)	**11,906**	**2,365**	**120**	**1,604**	**59,423,541**	**84,987,832**	**144,411,373**	**4.3%**
La Porte	36,693	8,965	430	5,625	$357,286,090	$406,771,718	$764,057,808	11.6%
League City (Harris Co.)	1,554	175	13	78	$20,550,447	$15,898,467	$36,448,913	13.0%
Missouri City (Harris Co.)	7,578	936	52	492	$21,809,153	$26,182,318	$47,991,471	6.2%
Missouri City (Fort Bend Co.)	83,691	8,029	468	5,226	$271,020,640	$196,397,296	$467,417,936	4.0%
Misouri City (Total)	**91,269**	**8,965**	**519**	**5,718**	**292,829,794**	**222,579,614**	**515,409,408**	**4.2%**
Morgan's Point (Harris Co.)	8	103	2	72	$27,028,167	$52,991,596	$80,019,762	30.5%
Nassau Bay	18,187	707	54	493	$98,497,314	$89,298,426	$187,795,740	11.5%
Pasadena	203,119	44,617	3,415	20,712	$1,510,675,754	$1,711,398,856	$3,222,074,610	14.3%
Pearland (Harris Co.)	4,253	2,658	170	556	$81,043,792	$51,063,804	$132,107,596	18.6%
Piney Point Village	23,770	581	34	352	$83,115,164	$51,358,178	$134,473,342	7.4%
Seabrook (Harris Co.)	23,981	3,738	246	1,846	$224,502,653	$173,461,555	$397,964,207	15.7%
Shoreacres (Harris Co.)	9,569	639	20	352	$46,543,471	$23,323,757	$69,867,228	32.0%
South Houston	23,845	10,260	631	3,700	$151,176,978	$210,548,633	$361,725,611	16.7%
Southside Place	2,471	331	15	148	$12,154,983	$7,292,368	$19,447,352	4.1%
Spring Valley Village	10,966	662	33	502	$54,470,533	$46,275,412	$100,745,944	8.2%
Stafford (Harris Co.)	129	49	1	22	$533,097	$314,006	$847,103	3.5%
Stafford (Fort Bend Co.)	24,815	5,561	394	2,373	$204,308,535	$377,201,666	$581,510,201	9.6%
Stafford (total)	**24,945**	**5,610**	**395**	**2,395**	**204,841,632**	**377,515,671**	**582,357,303**	**9.5%**
Taylor Lake Village	13,865	598	27	524	$79,697,682	$43,741,775	$123,439,457	17.9%
Tomball (Harris Co.)	12,877	669	50	705	$94,115,215	$137,435,706	$231,550,922	6.5%
Waller (Harris Co.)	79	0	0	0	$0	$0	$0	0.0%
Webster	13,227	2,028	248	882	$267,698,690	$537,755,351	$805,454,041	14.1%
West University Place	21,786	2,418	50	1,508	$104,258,798	$63,408,814	$167,667,612	4.5%
Unincorporated Harris County	1,947,825	327,218	21,777	180,149	$11,234,253,423	$9,775,522,239	$21,009,775,663	6.5%
Total	**5,367,793**	**983,003**	**75,452**	**488,923**	**32,230,249,878**	**32,913,476,608**	**65,143,726,485**	**6.9%**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.

(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties).

(3) Percent of residential buildings exposed multiplied by the Estimated Population.

(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.

(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.

(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Flood Risk Assessment

Harvey

Jurisdiction	Acres of Floodplain	Number of Structures in Floodplain (2)							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	0	7,026	660	7	2	20	3	3	7721
Baytown (Chambers Co.)	0	1,279	56	84	3	7	0	1	1430
Baytown (Total)	**0**	**8,305**	**716**	**91**	**5**	**27**	**3**	**4**	**9,151**
Bellaire	0	2,911	46	0	2	3	0	1	2963
Bunker Hill Village	0	8	0	0	0	0	0	0	8
Deer Park	0	3,866	419	48	2	13	0	4	4352
El Lago	0	541	6	0	0	2	1	0	550
Friendswood (Harris Co.)	0	1,801	32	0	0	0	0	0	1833
Friendswood (Galveston Co.)	0	2,657	85	0	2	0	0	0	2744
Friendswood (Total)	**0**	**4,458**	**117**	**0**	**2**	**0**	**0**	**0**	**4,577**
Galena Park	0	1,165	101	4	0	8	0	14	1292
Hedwig Village	0	33	18	0	1	0	0	0	52
Hilshire Village	0	224	8	0	0	0	0	2	234
Houston (Harris Co.)	0	213,169	17,982	789	56	592	35	215	232838
Humble	0	1,660	311	29	4	5	1	0	2010
Hunters Creek Village	0	302	2	0	0	2	0	1	307
Jacinto City	0	1,048	77	0	0	4	1	0	1130
Jersey Village	0	799	33	0	0	1	0	0	833
Katy (Harris Co.)	0	716	135	3	0	2	3	0	859
Katy (Fort Bend Co.)	0	141	132	0	3	2	0	0	278
Katy (Waller Co.)	0	444	29	10	4	0	0	0	487
Katy (Total)	**0**	**1,301**	**296**	**13**	**7**	**4**	**3**	**0**	**1,624**
La Porte	0	5,231	618	13	1	13	1	5	5882
League City (Harris Co.)	0	75	7	0	0	1	0	0	83
Missouri City (Harris Co.)	0	490	17	0	0	0	0	0	507
Missouri City (Fort Bend Co.)	0	5,145	184	7	22	2	0	0	5360
Misouri City (Total)	**0**	**5,635**	**201**	**7**	**22**	**2**	**0**	**0**	**5,867**
Morgan's Point (Harris Co.)	0	66	6	3	0	0	0	0	75
Nassau Bay	0	564	36	0	0	0	0	0	600
Pasadena	0	18,903	2,104	65	6	49	4	17	21148
Pearland (Harris Co.)	0	544	13	3	0	0	0	0	560
Piney Point Village	0	362	1	0	0	1	0	0	364
Seabrook (Harris Co.)	0	1,941	171	2	2	2	1	0	2119
Shoreacres (Harris Co.)	0	405	0	0	0	0	0	0	405
South Houston	0	3,041	676	23	0	23	1	2	3766
Southside Place	0	154	1	0	0	0	0	0	155
Spring Valley Village	0	493	15	0	0	0	0	0	508
Stafford (Harris Co.)	0	24	0	0	0	0	0	0	24
Stafford (Fort Bend Co.)	0	1,775	612	16	2	5	0	0	2410
Stafford (total)	**0**	**1,799**	**612**	**16**	**2**	**5**	**0**	**0**	**2,434**
Taylor Lake Village	0	540	2	0	0	0	0	0	542
Tomball (Harris Co.)	0	522	177	4	3	3	1	4	714
Waller (Harris Co.)	0	0	0	0	0	0	0	0	0
Webster	0	644	381	2	7	5	1	2	1042
West University Place	0	1,588	20	0	1	2	0	0	1611
Unincorporated Harris County	0	176,871	9,444	890	71	244	35	95	187650
Total	**0**	**467,995**	**35,309**	**2,009**	**196**	**1,031**	**91**	**369**	**507,000**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.

(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties).

(3) Percent of residential buildings exposed multiplied by the Estimated Population.

(4) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03.

(5) Calculated using a Census block level, general building stock (GBS) analysis in Hazus 4.2 SP03, and adjusted to reflect the estimated population.

(6) Calculated using a user-defined (UDF) analysis (Harris, Fort Bend, Galveston) or a general building stock (GBS) analysis (Chambers, Waller) in Hazus 4.2 SP03.

Hurricane Risk Assessment

20-Year Probabilistic

Jurisdiction	Estimated Exposure				
	Estimated Population (1)	% Population Exposed	Total Number of Buildings (2)	Total Building Value (Structure and contents in $) (2)	% of Total Value Exposed
Baytown (Harris Co.)	72,879	100%	20,718	$10,081,462,691	100%
Baytown (Chambers Co.)	4,145	100%	1,440	$1,376,644,000	100%
Baytown (Total)	**77,024**	**100%**	**22,158**	**$11,458,106,691**	**100%**
Bellaire	18,966	100%	6,503	$5,726,227,131	100%
Bunker Hill Village	3,982	100%	1,303	$1,322,346,729	100%
Deer Park	33,931	100%	11,370	$5,845,168,035	100%
El Lago	2,727	100%	1,107	$469,295,696	100%
Friendswood (Harris Co.)	11,575	100%	3,570	$1,631,453,165	100%
Friendswood (Galveston Co.)	28,606	100%	9,959	$4,553,773,509	100%
Friendswood (Total)	**40,181**	**100%**	**13,529**	**$6,185,226,675**	**100%**
Galena Park	10,931	100%	3,288	$1,178,706,765	100%
Hedwig Village	2,669	100%	909	$1,142,111,969	100%
Hilshire Village	819	100%	321	$207,926,478	100%
Houston (Harris Co.)	2,278,069	100%	592,166	$487,379,428,234	100%
Humble	16,041	100%	4,890	$4,570,456,883	100%
Hunters Creek Village	4,891	100%	1,572	$1,787,651,957	100%
Jacinto City	10,625	100%	2,986	$1,261,111,221	100%
Jersey Village	7,962	100%	2,527	$2,275,428,136	100%
Katy (Harris Co.)	15,251	100%	4,249	$1,865,017,616	100%
Katy (Fort Bend Co.)	2,159	100%	811	$1,312,561,128	100%
Katy (Waller Co.)	1,806	100%	492	$218,939,000	100%
Katy (Total)	**3,965**	**100%**	**1,303**	**$1,531,500,128**	**100%**
La Porte	35,423	100%	12,427	$6,575,613,440	100%
League City (Harris Co.)	1,984	100%	394	$280,449,911	100%
Missouri City (Harris Co.)	6,273	100%	1,876	$770,837,732	100%
Missouri City (Fort Bend Co.)	68,432	100%	22,450	$11,627,868,465	100%
Missouri City (Total)	**74,705**	**100%**	**24,326**	**$12,398,706,197**	**100%**
Morgan's Point (Harris Co.)	345	100%	160	$262,314,866	100%
Nassau Bay	4,037	100%	1,574	$1,635,924,802	100%
Pasadena	153,219	100%	40,639	$22,505,882,445	100%
Pearland (Harris Co.)	5,237	100%	834	$709,046,327	100%
Piney Point Village	3,449	100%	1,195	$1,817,131,583	100%
Seabrook (Harris Co.)	14,291	100%	4,390	$2,537,671,414	100%
Shoreacres (Harris Co.)	1,611	100%	657	$218,188,519	100%
South Houston	17,583	100%	5,001	$2,162,541,092	100%
Southside Place	1,881	100%	508	$471,918,214	100%
Spring Valley Village	4,333	100%	1,509	$1,227,871,955	100%
Stafford (Harris Co.)	309	100%	89	$24,088,003	100%
Stafford (Fort Bend Co.)	18,003	100%	4,966	$6,078,341,979	100%
Stafford (Total)	**18,312**	**100%**	**5,055**	**$6,102,429,982**	**100%**
Taylor Lake Village	3,625	100%	1,390	$690,404,692	100%
Tomball (Harris Co.)	11,761	100%	3,649	$3,569,286,191	100%
Waller (Harris Co.)	600	100%	261	$221,680,638	100%
Webster	11,201	100%	2,387	$5,700,342,104	100%
West University Place	15,676	100%	5,525	$3,722,134,705	100%
Unincorporated County	1,914,463	100%	573,070	$321,033,774,612	100%
TOTAL	**4,821,770**	100%	**1,355,132**	**928,049,024,035**	100%

Hurricane Risk Assessment

20-Year Probabilistic

Jurisdiction	Economic Impact						
	Structure Debris (Tons) (3)	Number of Displaced Households (3)	People Requiring Short-Term Shelter (3)	Value Structure in $ Damaged (3)	Value Contents in $ Damaged (3)	Total Value (Structure and Contents in $) Damaged (3)	% of Total Value Damaged
Baytown (Harris Co.)	22,903.85	207	156	$133,033,569	$25,474,750	$158,508,319	1.6%
Baytown (Chambers Co.)	26.51	0	0	$309,292	$35,302	$344,594	0.0%
Baytown (Total)	**22,930.36**	**207**	**156**	**$133,342,861**	**$25,510,052**	**$158,852,913**	**1.4%**
Bellaire	173.44	0	0	$2,406,753	$465,291	$2,872,044	0.1%
Bunker Hill Village	12.27	0	0	$611,593	$216,738	$828,331	0.1%
Deer Park	5,526.94	24	15	$32,574,719	$4,044,435	$36,619,153	0.6%
El Lago	883.92	12	6	$5,363,374	$668,911	$6,032,284	1.3%
Friendswood (Harris Co.)	626.12	3	2	$4,845,261	$681,267	$5,526,528	0.3%
Friendswood (Galveston Co.)	1,938.94	0	0	$14,127,381	$2,045,501	$16,172,882	0.4%
Friendswood (Total)	**2,565.06**	**3**	**2**	**$18,972,641**	**$2,726,768**	**$21,699,410**	**0.4%**
Galena Park	375.53	0	0	$2,258,047	$233,956	$2,492,003	0.2%
Hedwig Village	29.65	0	0	$326,695	$86,918	$413,613	0.0%
Hilshire Village	6.71	0	0	$116,848	$36,451	$153,299	0.1%
Houston (Harris Co.)	83,624.88	275	185	$552,491,545	$76,827,480	$629,319,025	0.1%
Humble	2,696.22	12	10	$16,894,683	$3,758,583	$20,653,266	0.5%
Hunters Creek Village	57.07	0	0	$1,214,141	$383,767	$1,597,908	0.1%
Jacinto City	492.55	1	1	$2,858,554	$282,910	$3,141,464	0.2%
Jersey Village	98.93	0	0	$765,475	$123,738	$889,214	0.0%
Katy (Harris Co.)	0.00	0	0	$0	$0	$0	0.0%
Katy (Fort Bend Co.)	28.16	0	0	$126,832	$652	$127,484	0.0%
Katy (Waller Co.)	4.18	0	0	$59,124	$1,725	$60,848	0.0%
Katy (Total)	**32.34**	**0**	**0**	**$185,956**	**$2,377**	**$188,333**	**0.0%**
La Porte	6,919.62	35	20	$40,938,745	$7,319,684	$48,258,429	0.7%
League City (Harris Co.)	118.63	0	0	$847,187	$127,283	$974,470	0.3%
Missouri City (Harris Co.)	3.65	0	0	$65,416	$917	$66,333	0.0%
Missouri City (Fort Bend Co.)	2,996.30	0	0	$21,086,591	$379,807	$21,466,399	0.2%
Missouri City (Total)	**2,999.95**	**0**	**0**	**$21,152,007**	**$380,725**	**$21,532,732**	**0.2%**
Morgan's Point (Harris Co.)	156.15	0	0	$967,823	$239,518	$1,207,341	0.5%
Nassau Bay	2,753.26	24	10	$15,576,398	$1,750,533	$17,326,930	1.1%
Pasadena	17,161.20	102	82	$101,370,307	$11,530,631	$112,900,938	0.5%
Pearland (Harris Co.)	101.04	0	0	$1,082,637	$154,430	$1,237,067	0.2%
Piney Point Village	14.00	0	0	$869,824	$322,686	$1,192,510	0.1%
Seabrook (Harris Co.)	4,463.91	41	21	$27,072,611	$4,205,378	$31,277,990	1.2%
Shoreacres (Harris Co.)	617.48	5	2	$3,774,960	$827,442	$4,602,402	2.1%
South Houston	888.94	3	3	$5,099,679	$445,054	$5,544,733	0.3%
Southside Place	18.06	0	0	$267,562	$35,405	$302,967	0.1%
Spring Valley Village	39.58	0	0	$688,696	$214,725	$903,420	0.1%
Stafford (Harris Co.)	0.13	0	0	$781	$11	$792	0.0%
Stafford (Fort Bend Co.)	1,126.61	1	1	$4,953,705	$237,402	$5,191,108	0.1%
Stafford (Total)	**1,126.75**	**1**	**1**	**$4,954,486**	**$237,414**	**$5,191,900**	**0.1%**
Taylor Lake Village	1,176.73	12	6	$7,785,089	$1,502,025	$9,287,114	1.3%
Tomball (Harris Co.)	193.32	0	0	$1,472,824	$327,539	$1,800,363	0.1%
Waller (Harris Co.)	2.40	0	0	$32,621	$4,632	$37,253	0.0%
Webster	3,604.46	25	14	$19,461,323	$2,153,484	$21,614,807	0.4%
West University Place	179.17	0	0	$3,173,812	$510,566	$3,684,378	0.1%
Unincorporated County	81,266.17	301	232	$595,516,966	$122,319,996	$717,836,962	0.2%
TOTAL	**243,307**	**1,083**	**767**	**1,622,489,443**	**269,977,524**	**1,892,466,967**	**0.2%**

Hurricane Risk Assessment

100-Year Probabilistic

Jurisdiction	Estimated Exposure				
	Estimated Population (1)	% Population Exposed	Total Number of Buildings (2)	Total Building Value (Structure and contents in $) (2)	% of Total Value Exposed
Baytown (Harris Co.)	72,879	100%	20,718	$10,081,462,691	100%
Baytown (Chambers Co.)	4,145	100%	1,440	$1,376,644,000	100%
Baytown (Total)	**77,024**	**100%**	**22,158**	**$11,458,106,691**	**100%**
Bellaire	18,966	100%	6,503	$5,726,227,131	100%
Bunker Hill Village	3,982	100%	1,303	$1,322,346,729	100%
Deer Park	33,931	100%	11,370	$5,845,168,035	100%
El Lago	2,727	100%	1,107	$469,295,696	100%
Friendswood (Harris Co.)	11,575	100%	3,570	$1,631,453,165	100%
Friendswood (Galveston Co.)	28,606	100%	9,959	$4,553,773,509	100%
Friendswood (Total)	**40,181**	**100%**	**13,529**	**$6,185,226,675**	**100%**
Galena Park	10,931	100%	3,288	$1,178,706,765	100%
Hedwig Village	2,669	100%	909	$1,142,111,969	100%
Hilshire Village	819	100%	321	$207,926,478	100%
Houston (Harris Co.)	2,278,069	100%	592,166	$487,379,428,234	100%
Humble	16,041	100%	4,890	$4,570,456,883	100%
Hunters Creek Village	4,891	100%	1,572	$1,787,651,957	100%
Jacinto City	10,625	100%	2,986	$1,261,111,221	100%
Jersey Village	7,962	100%	2,527	$2,275,428,136	100%
Katy (Harris Co.)	15,251	100%	4,249	$1,865,017,616	100%
Katy (Fort Bend Co.)	2,159	100%	811	$1,312,561,128	100%
Katy (Waller Co.)	1,806	100%	492	$218,939,000	100%
Katy (Total)	**3,965**	**100%**	**1,303**	**$1,531,500,128**	**100%**
La Porte	35,423	100%	12,427	$6,575,613,440	100%
League City (Harris Co.)	1,984	100%	394	$280,449,911	100%
Missouri City (Harris Co.)	6,273	100%	1,876	$770,837,732	100%
Missouri City (Fort Bend Co.)	68,432	100%	22,450	$11,627,868,465	100%
Missouri City (Total)	**74,705**	**100%**	**24,326**	**$12,398,706,197**	**100%**
Morgan's Point (Harris Co.)	345	100%	160	$262,314,866	100%
Nassau Bay	4,037	100%	1,574	$1,635,924,802	100%
Pasadena	153,219	100%	40,639	$22,505,882,445	100%
Pearland (Harris Co.)	5,237	100%	834	$709,046,327	100%
Piney Point Village	3,449	100%	1,195	$1,817,131,583	100%
Seabrook (Harris Co.)	14,291	100%	4,390	$2,537,671,414	100%
Shoreacres (Harris Co.)	1,611	100%	657	$218,188,519	100%
South Houston	17,583	100%	5,001	$2,162,541,092	100%
Southside Place	1,881	100%	508	$471,918,214	100%
Spring Valley Village	4,333	100%	1,509	$1,227,871,955	100%
Stafford (Harris Co.)	309	100%	89	$24,088,003	100%
Stafford (Fort Bend Co.)	18,003	100%	4,966	$6,078,341,979	100%
Stafford (Total)	**18,312**	**100%**	**5,055**	**$6,102,429,982**	**100%**
Taylor Lake Village	3,625	100%	1,390	$690,404,692	100%
Tomball (Harris Co.)	11,761	100%	3,649	$3,569,286,191	100%
Waller (Harris Co.)	600	100%	261	$221,680,638	100%
Webster	11,201	100%	2,387	$5,700,342,104	100%
West University Place	15,676	100%	5,525	$3,722,134,705	100%
Unincorporated County	1,914,463	100%	573,070	$321,033,774,612	100%
TOTAL	**4,821,770**	100%	**1,355,132**	**928,049,024,035**	100%

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
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(3) Calculated using a Census tract level, general building stock (GBS) analysis in Hazus 4.2 SP03.

Hurricane Risk Assessment

100-Year Probabilistic

Jurisdiction	Economic Impact						
	Structure Debris (Tons) (3)	Number of Displaced Households (3)	People Requiring Short-Term Shelter (3)	Value Structure in $ Damaged (3)	Value Contents in $ Damaged (3)	Total Value (Structure and Contents in $) Damaged (3)	% of Total Value Damaged
Baytown (Harris Co.)	104,934.58	2,067	1,630	$702,129,625	$256,564,752	$958,694,377	9.5%
Baytown (Chambers Co.)	606.50	7	4	$5,368,827	$2,225,540	$7,594,366	0.6%
Baytown (Total)	**105,541.08**	**2,074**	**1,635**	**$707,498,451**	**$258,790,292**	**$966,288,743**	**8.4%**
Bellaire	9,187.67	24	12	$67,873,600	$14,125,519	$81,999,118	1.4%
Bunker Hill Village	1,743.50	4	2	$17,689,265	$5,928,609	$23,617,874	1.8%
Deer Park	53,622.13	799	492	$364,557,451	$139,584,238	$504,141,689	8.6%
El Lago	7,396.75	172	86	$52,630,448	$19,214,257	$71,844,705	15.3%
Friendswood (Harris Co.)	14,366.24	240	135	$96,478,672	$32,728,351	$129,207,023	7.9%
Friendswood (Galveston Co.)	28,914.35	269	145	$178,778,369	$59,102,013	$237,880,381	5.2%
Friendswood (Total)	**43,280.59**	**509**	**281**	**$275,257,041**	**$91,830,363**	**$367,087,404**	**5.9%**
Galena Park	4,171.52	52	57	$27,265,313	$10,685,635	$37,950,947	3.2%
Hedwig Village	1,746.75	7	4	$11,625,419	$2,422,305	$14,047,724	1.2%
Hilshire Village	283.65	1	0	$2,230,264	$606,611	$2,836,875	1.4%
Houston (Harris Co.)	1,205,561.75	14,442	10,363	$7,590,932,495	$1,747,832,737	$9,338,765,232	1.9%
Humble	4,563.05	26	21	$27,589,267	$6,173,044	$33,762,310	0.7%
Hunters Creek Village	2,633.33	5	3	$24,514,917	$7,335,870	$31,850,788	1.8%
Jacinto City	4,399.68	53	58	$27,914,926	$9,191,107	$37,106,033	2.9%
Jersey Village	2,233.39	17	10	$14,073,056	$1,971,084	$16,044,140	0.7%
Katy (Harris Co.)	796.53	1	1	$5,863,175	$934,195	$6,797,371	0.4%
Katy (Fort Bend Co.)	235.24	4	2	$1,003,613	$132,443	$1,136,056	0.1%
Katy (Waller Co.)	110.43	1	0	$893,836	$306,298	$1,200,134	0.5%
Katy (Total)	**345.67**	**4**	**3**	**$1,897,449**	**$438,741**	**$2,336,190**	**0.2%**
La Porte	70,441.58	1,256	766	$526,991,078	$241,796,193	$768,787,272	11.7%
League City (Harris Co.)	2,489.47	32	16	$17,413,312	$6,163,651	$23,576,964	8.4%
Missouri City (Harris Co.)	1,048.75	9	8	$6,094,387	$792,072	$6,886,459	0.9%
Missouri City (Fort Bend Co.)	39,577.47	221	153	$208,556,424	$47,550,248	$256,106,672	2.2%
Missouri City (Total)	**40,626.22**	**230**	**160**	**$214,650,812**	**$48,342,320**	**$262,993,131**	**2.1%**
Morgan's Point (Harris Co.)	1,481.39	13	9	$13,527,268	$7,372,100	$20,899,368	8.0%
Nassau Bay	20,723.39	373	156	$154,678,593	$59,092,066	$213,770,659	13.1%
Pasadena	175,082.39	3,132	2,475	$1,203,242,990	$422,128,451	$1,625,371,441	7.2%
Pearland (Harris Co.)	3,564.77	24	17	$23,433,183	$7,611,481	$31,044,664	4.4%
Piney Point Village	2,256.56	3	2	$23,775,724	$7,930,276	$31,706,000	1.7%
Seabrook (Harris Co.)	38,076.39	750	386	$271,888,968	$105,408,806	$377,297,774	14.9%
Shoreacres (Harris Co.)	5,501.65	140	74	$36,022,372	$14,813,092	$50,835,463	23.3%
South Houston	11,515.04	197	213	$74,889,121	$24,560,900	$99,450,021	4.6%
Southside Place	824.82	4	2	$6,264,670	$1,233,392	$7,498,062	1.6%
Spring Valley Village	1,676.34	4	3	$13,172,638	$3,579,298	$16,751,936	1.4%
Stafford (Harris Co.)	25.24	0	0	$145,781	$18,145	$163,925	0.7%
Stafford (Fort Bend Co.)	14,498.34	91	58	$72,100,002	$16,382,311	$88,482,313	1.5%
Stafford (Total)	**14,523.57**	**91**	**58**	**$72,245,783**	**$16,400,456**	**$88,646,238**	**1.5%**
Taylor Lake Village	11,665.22	201	103	$84,073,727	$33,824,948	$117,898,675	17.1%
Tomball (Harris Co.)	797.59	1	1	$5,464,927	$941,787	$6,406,714	0.2%
Waller (Harris Co.)	75.67	0	0	$551,352	$59,472	$610,824	0.3%
Webster	39,159.58	674	370	$324,261,293	$139,372,781	$463,634,074	8.1%
West University Place	7,500.92	26	14	$59,985,101	$13,666,584	$73,651,685	2.0%
Unincorporated County	430,158.74	3,452	2,715	$2,933,228,680	$815,981,053	$3,749,209,732	1.2%
TOTAL	**2,325,648**	**28,793**	**20,567**	**15,279,174,125**	**4,287,343,716**	**19,566,517,841**	2.1%

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(3) Calculated using a Census tract level, general building stock (GBS) analysis in Hazus 4.2 SP03.

Hurricane Risk Assessment

Alicia

Jurisdiction	Estimated Exposure				
	Estimated Population (1)	% Population Exposed	Total Number of Buildings (2)	Total Building Value (Structure and contents in $) (2)	% of Total Value Exposed
Baytown (Harris Co.)	72,879	100%	20,718	$10,081,462,691	100%
Baytown (Chambers Co.)	4,145	100%	1,440	$1,376,644,000	100%
Baytown (Total)	**77,024**	**100%**	**22,158**	**$11,458,106,691**	**100%**
Bellaire	18,966	100%	6,503	$5,726,227,131	100%
Bunker Hill Village	3,982	100%	1,303	$1,322,346,729	100%
Deer Park	33,931	100%	11,370	$5,845,168,035	100%
El Lago	2,727	100%	1,107	$469,295,696	100%
Friendswood (Harris Co.)	11,575	100%	3,570	$1,631,453,165	100%
Friendswood (Galveston Co.)	28,606	100%	9,959	$4,553,773,509	100%
Friendswood (Total)	**40,181**	**100%**	**13,529**	**$6,185,226,675**	**100%**
Galena Park	10,931	100%	3,288	$1,178,706,765	100%
Hedwig Village	2,669	100%	909	$1,142,111,969	100%
Hilshire Village	819	100%	321	$207,926,478	100%
Houston (Harris Co.)	2,278,069	100%	592,166	$487,379,428,234	100%
Humble	16,041	100%	4,890	$4,570,456,883	100%
Hunters Creek Village	4,891	100%	1,572	$1,787,651,957	100%
Jacinto City	10,625	100%	2,986	$1,261,111,221	100%
Jersey Village	7,962	100%	2,527	$2,275,428,136	100%
Katy (Harris Co.)	15,251	100%	4,249	$1,865,017,616	100%
Katy (Fort Bend Co.)	2,159	100%	811	$1,312,561,128	100%
Katy (Waller Co.)	1,806	100%	492	$218,939,000	100%
Katy (Total)	**3,965**	**100%**	**1,303**	**$1,531,500,128**	**100%**
La Porte	35,423	100%	12,427	$6,575,613,440	100%
League City (Harris Co.)	1,984	100%	394	$280,449,911	100%
Missouri City (Harris Co.)	6,273	100%	1,876	$770,837,732	100%
Missouri City (Fort Bend Co.)	68,432	100%	22,450	$11,627,868,465	100%
Missouri City (Total)	**74,705**	**100%**	**24,326**	**$12,398,706,197**	**100%**
Morgan's Point (Harris Co.)	345	100%	160	$262,314,866	100%
Nassau Bay	4,037	100%	1,574	$1,635,924,802	100%
Pasadena	153,219	100%	40,639	$22,505,882,445	100%
Pearland (Harris Co.)	5,237	100%	834	$709,046,327	100%
Piney Point Village	3,449	100%	1,195	$1,817,131,583	100%
Seabrook (Harris Co.)	14,291	100%	4,390	$2,537,671,414	100%
Shoreacres (Harris Co.)	1,611	100%	657	$218,188,519	100%
South Houston	17,583	100%	5,001	$2,162,541,092	100%
Southside Place	1,881	100%	508	$471,918,214	100%
Spring Valley Village	4,333	100%	1,509	$1,227,871,955	100%
Stafford (Harris Co.)	309	100%	89	$24,088,003	100%
Stafford (Fort Bend Co.)	18,003	100%	4,966	$6,078,341,979	100%
Stafford (Total)	**18,312**	**100%**	**5,055**	**$6,102,429,982**	**100%**
Taylor Lake Village	3,625	100%	1,390	$690,404,692	100%
Tomball (Harris Co.)	11,761	100%	3,649	$3,569,286,191	100%
Waller (Harris Co.)	600	100%	261	$221,680,638	100%
Webster	11,201	100%	2,387	$5,700,342,104	100%
West University Place	15,676	100%	5,525	$3,722,134,705	100%
Unincorporated County	1,914,463	100%	573,070	$321,033,774,612	100%
TOTAL	**4,821,770**	100%	**1,355,132**	**928,049,024,035**	100%

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(3) Calculated using a Census tract level, general building stock (GBS) analysis in Hazus 4.2 SP03.

Hurricane Risk Assessment

Alicia

Jurisdiction	Economic Impact						
	Structure Debris (x Tons) (3)	Number of Displaced Households (3)	People Requiring Short-Term Shelter (3)	Value Structure in $ Damaged (3)	Value Contents in $ Damaged (3)	Total Value (Structure and Contents in $) Damaged (3)	% of Total Value Damaged
Baytown (Harris Co.)	15,301.04	113	86	$87,550,431	$13,537,135	$101,087,567	1.0%
Baytown (Chambers Co.)	98.90	0	0	$829,921	$153,476	$983,397	0.1%
Baytown (Total)	**15,399.93**	**114**	**86**	**$88,380,352**	**$13,690,611**	**$102,070,963**	**0.9%**
Bellaire	6,449.15	12	5	$48,142,317	$8,442,681	$56,584,998	1.0%
Bunker Hill Village	1,510.56	3	1	$15,682,418	$5,102,406	$20,784,824	1.6%
Deer Park	8,543.49	48	30	$49,393,142	$8,045,862	$57,439,004	1.0%
El Lago	1,206.53	17	9	$7,380,687	$1,136,284	$8,516,971	1.8%
Friendswood (Harris Co.)	3,541.00	33	19	$21,649,813	$4,360,022	$26,009,836	1.6%
Friendswood (Galveston Co.)	10,307.68	44	23	$59,364,627	$13,817,125	$73,181,752	1.6%
Friendswood (Total)	**13,848.68**	**77**	**42**	**$81,014,441**	**$18,177,147**	**$99,191,588**	**1.6%**
Galena Park	1,099.23	6	6	$6,142,036	$1,237,697	$7,379,733	0.6%
Hedwig Village	1,521.32	5	3	$10,118,851	$2,011,618	$12,130,470	1.1%
Hilshire Village	224.72	0	0	$1,830,433	$469,359	$2,299,792	1.1%
Houston (Harris Co.)	757,640.68	7,069	4,922	$4,462,908,346	$687,639,674	$5,150,548,021	1.1%
Humble	4,542.53	24	19	$27,331,813	$6,122,075	$33,453,889	0.7%
Hunters Creek Village	1,984.38	3	2	$19,175,882	$5,421,506	$24,597,388	1.4%
Jacinto City	1,337.34	6	7	$7,380,630	$1,310,661	$8,691,291	0.7%
Jersey Village	2,565.05	21	12	$15,999,893	$2,304,562	$18,304,455	0.8%
Katy (Harris Co.)	1,646.66	5	4	$10,470,861	$1,821,151	$12,292,012	0.7%
Katy (Fort Bend Co.)	134.62	2	1	$548,851	$46,374	$595,225	0.0%
Katy (Waller Co.)	35.85	0	0	$295,376	$54,318	$349,694	0.2%
Katy (Total)	**170.47**	**2**	**1**	**$844,227**	**$100,693**	**$944,919**	**0.1%**
La Porte	9,018.65	54	34	$53,991,120	$11,229,379	$65,220,499	1.0%
League City (Harris Co.)	576.64	4	2	$3,567,213	$743,328	$4,310,541	1.5%
Missouri City (Harris Co.)	1,130.67	9	8	$6,558,252	$900,285	$7,458,537	1.0%
Missouri City (Fort Bend Co.)	16,714.04	45	31	$83,981,946	$10,138,257	$94,120,203	0.8%
Missouri City (Total)	**17,844.71**	**54**	**39**	**$90,540,198**	**$11,038,542**	**$101,578,740**	**0.8%**
Morgan's Point (Harris Co.)	164.44	0	0	$1,025,942	$266,170	$1,292,112	0.5%
Nassau Bay	5,570.64	60	25	$33,055,603	$5,588,015	$38,643,618	2.4%
Pasadena	37,254.64	342	288	$215,614,242	$34,815,402	$250,429,643	1.1%
Pearland (Harris Co.)	1,243.89	4	3	$7,714,684	$1,649,895	$9,364,579	1.3%
Piney Point Village	1,830.78	2	1	$19,622,526	$6,361,302	$25,983,828	1.4%
Seabrook (Harris Co.)	6,160.72	64	32	$37,700,143	$6,858,551	$44,558,694	1.8%
Shoreacres (Harris Co.)	711.41	6	3	$4,354,322	$1,015,127	$5,369,449	2.5%
South Houston	3,234.77	31	33	$17,866,251	$2,972,671	$20,838,921	1.0%
Southside Place	552.34	2	1	$4,179,657	$651,629	$4,831,286	1.0%
Spring Valley Village	1,328.69	3	2	$10,813,106	$2,769,882	$13,582,988	1.1%
Stafford (Harris Co.)	30.09	0	0	$177,330	$26,882	$204,212	0.8%
Stafford (Fort Bend Co.)	6,468.57	28	17	$28,671,624	$3,695,436	$32,367,061	0.5%
Stafford (Total)	**6,498.66**	**28**	**17**	**$28,848,954**	**$3,722,319**	**$32,571,272**	**0.5%**
Taylor Lake Village	1,862.10	20	10	$11,936,896	$2,663,855	$14,600,751	2.1%
Tomball (Harris Co.)	2,539.66	12	7	$15,041,278	$2,911,143	$17,952,421	0.5%
Waller (Harris Co.)	260.93	0	0	$1,580,438	$269,938	$1,850,375	0.8%
Webster	9,612.97	98	53	$58,019,942	$10,531,088	$68,551,029	1.2%
West University Place	4,621.98	10	5	$37,845,806	$7,023,021	$44,868,827	1.2%
Unincorporated County	345,295.31	1,662	1,220	$2,209,444,864	$410,580,584	$2,620,025,448	0.8%
TOTAL	**1,275,875**	**9,867**	**6,925**	**7,714,959,513**	**1,286,695,827**	**9,001,655,339**	1.0%

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(3) Calculated using a Census tract level, general building stock (GBS) analysis in Hazus 4.2 SP03.

Wildfire Risk Assessment

Ignition Density Very High (3)

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.) (see Note 1)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**$11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**$6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Missouri City (Total)	**74,705**	**24,326**	**23,412**	**$12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (Total)	**18,312**	**5,055**	**3,967**	**$6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,896,475**	**1,379,458**	**1,284,371**	**940,447,730,231**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density Very High (3)

Jurisdiction	Estimated Exposure						
	Estimated Buildings Exposed (2)	Population Exposed (4)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value
Baytown (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Baytown (Chambers Co.) (see Note 1)	0	0	0.0%	$0	$0	$0	0.0%
Baytown (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Bellaire	0	0	0.0%	$0	$0	$0	0.0%
Bunker Hill Village	0	0	0.0%	$0	$0	$0	0.0%
Deer Park	0	0	0.0%	$0	$0	$0	0.0%
El Lago	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Galveston Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Galena Park	0	0	0.0%	$0	$0	$0	0.0%
Hedwig Village	0	0	0.0%	$0	$0	$0	0.0%
Hilshire Village	0	0	0.0%	$0	$0	$0	0.0%
Houston (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Humble	0	0	0.0%	$0	$0	$0	0.0%
Hunters Creek Village	0	0	0.0%	$0	$0	$0	0.0%
Jacinto City	0	0	0.0%	$0	$0	$0	0.0%
Jersey Village	0	0	0.0%	$0	$0	$0	0.0%
Katy (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Waller Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
La Porte	0	0	0.0%	$0	$0	$0	0.0%
League City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Morgan's Point (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Nassau Bay	0	0	0.0%	$0	$0	$0	0.0%
Pasadena	0	0	0.0%	$0	$0	$0	0.0%
Pearland (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Piney Point Village	0	0	0.0%	$0	$0	$0	0.0%
Seabrook (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Shoreacres (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
South Houston	0	0	0.0%	$0	$0	$0	0.0%
Southside Place	0	0	0.0%	$0	$0	$0	0.0%
Spring Valley Village	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Taylor Lake Village	0	0	0.0%	$0	$0	$0	0.0%
Tomball (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Waller (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Webster	0	0	0.0%	$0	$0	$0	0.0%
West University Place	0	0	0.0%	$0	$0	$0	0.0%
Unincorporated County	1,243	4,384	0.2%	$549,809,652	$275,178,423	$824,988,075	0.3%
Total	**1,243**	**4,384**	**0.1%**	**549,809,652**	**275,178,423**	**824,988,075**	**0.1%**

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(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density Very High (3)

Jurisdiction	Number of Structures in Ignition Denisty Very High ` (2)							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	0	0	0	0	0	0	0	0
Baytown (Chambers Co.) (see Note 1)	0	0	0	0	0	0	0	0
Baytown (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Bellaire	0	0	0	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0	0	0	0
Deer Park	0	0	0	0	0	0	0	0
El Lago	0	0	0	0	0	0	0	0
Friendswood (Harris Co.)	0	0	0	0	0	0	0	0
Friendswood (Galveston Co.)	0	0	0	0	0	0	0	0
Friendswood (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Galena Park	0	0	0	0	0	0	0	0
Hedwig Village	0	0	0	0	0	0	0	0
Hilshire Village	0	0	0	0	0	0	0	0
Houston (Harris Co.)	0	0	0	0	0	0	0	0
Humble	0	0	0	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0	0	0	0
Jacinto City	0	0	0	0	0	0	0	0
Jersey Village	0	0	0	0	0	0	0	0
Katy (Harris Co.)	0	0	0	0	0	0	0	0
Katy (Fort Bend Co.)	0	0	0	0	0	0	0	0
Katy (Waller Co.)	0	0	0	0	0	0	0	0
Katy (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
La Porte	0	0	0	0	0	0	0	0
League City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Fort Bend Co.)	0	0	0	0	0	0	0	0
Missouri City (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Morgan's Point (Harris Co.)	0	0	0	0	0	0	0	0
Nassau Bay	0	0	0	0	0	0	0	0
Pasadena	0	0	0	0	0	0	0	0
Pearland (Harris Co.)	0	0	0	0	0	0	0	0
Piney Point Village	0	0	0	0	0	0	0	0
Seabrook (Harris Co.)	0	0	0	0	0	0	0	0
Shoreacres (Harris Co.)	0	0	0	0	0	0	0	0
South Houston	0	0	0	0	0	0	0	0
Southside Place	0	0	0	0	0	0	0	0
Spring Valley Village	0	0	0	0	0	0	0	0
Stafford (Harris Co.)	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	0	0	0	0	0	0	0	0
Stafford (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taylor Lake Village	0	0	0	0	0	0	0	0
Tomball (Harris Co.)	0	0	0	0	0	0	0	0
Waller (Harris Co.)	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
West University Place	0	0	0	0	0	0	0	0
Unincorporated County	1,241	2	0	0	0	0	0	1,243
Total	**1,241**	**2**	**0**	**0**	**0**	**0**	**0**	**1,243**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
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(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density High (3)

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.) (see Note 1)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**$11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**$6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Missouri City (Total)	**74,705**	**24,326**	**23,412**	**$12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (Total)	**18,312**	**5,055**	**3,967**	**$6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,896,475**	**1,379,458**	**1,284,371**	**940,447,730,231**

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(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density High (3)

Jurisdiction	Estimated Exposure						
	Estimated Buildings Exposed (2)	Population Exposed (4)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value
Baytown (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Baytown (Chambers Co.) (see Note 1)	0	0	0.0%	$0	$0	$0	0.0%
Baytown (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Bellaire	0	0	0.0%	$0	$0	$0	0.0%
Bunker Hill Village	0	0	0.0%	$0	$0	$0	0.0%
Deer Park	0	0	0.0%	$0	$0	$0	0.0%
El Lago	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Galveston Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Galena Park	0	0	0.0%	$0	$0	$0	0.0%
Hedwig Village	0	0	0.0%	$0	$0	$0	0.0%
Hilshire Village	0	0	0.0%	$0	$0	$0	0.0%
Houston (Harris Co.)	58	230	0.0%	$114,414,888	$76,478,429	$190,893,317	0.0%
Humble	0	0	0.0%	$0	$0	$0	0.0%
Hunters Creek Village	0	0	0.0%	$0	$0	$0	0.0%
Jacinto City	0	0	0.0%	$0	$0	$0	0.0%
Jersey Village	0	0	0.0%	$0	$0	$0	0.0%
Katy (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Waller Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Total)	**0**	**0**	**0.0%**	**0**	**0**	**0**	**0.0%**
La Porte	0	0	0.0%	$0	$0	$0	0.0%
League City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Morgan's Point (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Nassau Bay	0	0	0.0%	$0	$0	$0	0.0%
Pasadena	0	0	0.0%	$0	$0	$0	0.0%
Pearland (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Piney Point Village	0	0	0.0%	$0	$0	$0	0.0%
Seabrook (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Shoreacres (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
South Houston	0	0	0.0%	$0	$0	$0	0.0%
Southside Place	0	0	0.0%	$0	$0	$0	0.0%
Spring Valley Village	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Taylor Lake Village	0	0	0.0%	$0	$0	$0	0.0%
Tomball (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Waller (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Webster	0	0	0.0%	$0	$0	$0	0.0%
West University Place	0	0	0.0%	$0	$0	$0	0.0%
Unincorporated County	1,943	6,765	0.4%	$975,127,683	$511,462,353	$1,486,590,036	0.5%
Total	**2,001**	**6,995**	**0.1%**	**1,089,542,571**	**587,940,782**	**1,677,483,353**	**0.2%**

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(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density High (3)

Jurisdiction	Number of Structures in Ignition Denisty High (2)							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	0	0	0	0	0	0	0	0
Baytown (Chambers Co.) (see Note 1)	0	0	0	0	0	0	0	0
Baytown (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Bellaire	0	0	0	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0	0	0	0
Deer Park	0	0	0	0	0	0	0	0
El Lago	0	0	0	0	0	0	0	0
Friendswood (Harris Co.)	0	0	0	0	0	0	0	0
Friendswood (Galveston Co.)	0	0	0	0	0	0	0	0
Friendswood (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Galena Park	0	0	0	0	0	0	0	0
Hedwig Village	0	0	0	0	0	0	0	0
Hilshire Village	0	0	0	0	0	0	0	0
Houston (Harris Co.)	55	3	0	0	0	0	0	58
Humble	0	0	0	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0	0	0	0
Jacinto City	0	0	0	0	0	0	0	0
Jersey Village	0	0	0	0	0	0	0	0
Katy (Harris Co.)	0	0	0	0	0	0	0	0
Katy (Fort Bend Co.)	0	0	0	0	0	0	0	0
Katy (Waller Co.)	0	0	0	0	0	0	0	0
Katy (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
La Porte	0	0	0	0	0	0	0	0
League City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Fort Bend Co.)	0	0	0	0	0	0	0	0
Missouri City (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Morgan's Point (Harris Co.)	0	0	0	0	0	0	0	0
Nassau Bay	0	0	0	0	0	0	0	0
Pasadena	0	0	0	0	0	0	0	0
Pearland (Harris Co.)	0	0	0	0	0	0	0	0
Piney Point Village	0	0	0	0	0	0	0	0
Seabrook (Harris Co.)	0	0	0	0	0	0	0	0
Shoreacres (Harris Co.)	0	0	0	0	0	0	0	0
South Houston	0	0	0	0	0	0	0	0
Southside Place	0	0	0	0	0	0	0	0
Spring Valley Village	0	0	0	0	0	0	0	0
Stafford (Harris Co.)	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	0	0	0	0	0	0	0	0
Stafford (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taylor Lake Village	0	0	0	0	0	0	0	0
Tomball (Harris Co.)	0	0	0	0	0	0	0	0
Waller (Harris Co.)	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
West University Place	0	0	0	0	0	0	0	0
Unincorporated County	1,915	24	0	1	2	1	0	1,943
Total	**1,970**	**27**	**0**	**1**	**2**	**1**	**0**	**2,001**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density Moderate (3)

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.) (see Note 1)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**$11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Friendswood (Total)	**40,181**	**13,529**	**13,072**	**$6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Missouri City (Total)	**74,705**	**24,326**	**23,412**	**$12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (Total)	**18,312**	**5,055**	**3,967**	**$6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,896,475**	**1,379,458**	**1,284,371**	**940,447,730,231**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)
(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density Moderate (3)

Jurisdiction	Estimated Exposure						
	Estimated Buildings Exposed (2)	Population Exposed (4)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value
Baytown (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Baytown (Chambers Co.) (see Note 1)	0	0	0.0%	$0	$0	$0	0.0%
Baytown (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Bellaire	0	0	0.0%	$0	$0	$0	0.0%
Bunker Hill Village	0	0	0.0%	$0	$0	$0	0.0%
Deer Park	0	0	0.0%	$0	$0	$0	0.0%
El Lago	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Galveston Co.)	0	0	0.0%	$0	$0	$0	0.0%
Friendswood (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Galena Park	0	0	0.0%	$0	$0	$0	0.0%
Hedwig Village	0	0	0.0%	$0	$0	$0	0.0%
Hilshire Village	0	0	0.0%	$0	$0	$0	0.0%
Houston (Harris Co.)	283	1,143	0.1%	$238,324,746	$273,121,095	$511,445,841	0.1%
Humble	0	0	0.0%	$0	$0	$0	0.0%
Hunters Creek Village	0	0	0.0%	$0	$0	$0	0.0%
Jacinto City	0	0	0.0%	$0	$0	$0	0.0%
Jersey Village	0	0	0.0%	$0	$0	$0	0.0%
Katy (Harris Co.)	27	105	0.7%	$5,206,717	$2,603,358	$7,810,075	0.4%
Katy (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Waller Co.)	0	0	0.0%	$0	$0	$0	0.0%
Katy (Total)	**27**	**105**	**0.5%**	**5,206,717**	**2,603,358**	**7,810,075**	**0.2%**
La Porte	0	0	0.0%	$0	$0	$0	0.0%
League City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Missouri City (Fort Bend Co.)	151	472	0.7%	$37,514,402	$19,009,393	$56,523,794	0.5%
Missouri City (Total)	**151**	**472**	**0.6%**	**$37,514,402**	**$19,009,393**	**$56,523,794**	**0.5%**
Morgan's Point (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Nassau Bay	0	0	0.0%	$0	$0	$0	0.0%
Pasadena	0	0	0.0%	$0	$0	$0	0.0%
Pearland (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Piney Point Village	0	0	0.0%	$0	$0	$0	0.0%
Seabrook (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Shoreacres (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
South Houston	0	0	0.0%	$0	$0	$0	0.0%
Southside Place	0	0	0.0%	$0	$0	$0	0.0%
Spring Valley Village	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Fort Bend Co.)	0	0	0.0%	$0	$0	$0	0.0%
Stafford (Total)	**0**	**0**	**0.0%**	**$0**	**$0**	**$0**	**0.0%**
Taylor Lake Village	0	0	0.0%	$0	$0	$0	0.0%
Tomball (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Waller (Harris Co.)	0	0	0.0%	$0	$0	$0	0.0%
Webster	0	0	0.0%	$0	$0	$0	0.0%
West University Place	0	0	0.0%	$0	$0	$0	0.0%
Unincorporated County	7,037	23,520	1.2%	$3,536,400,752	$2,346,687,845	$5,883,088,597	1.8%
Total	**7,649**	**25,712**	**0.5%**	**3,854,961,018**	**2,660,431,084**	**6,515,392,102**	**0.7%**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
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(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Ignition Density Moderate (3)

Jurisdiction	Number of Structures in Ignition Density Moderate (2)							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	0	0	0	0	0	0	0	0
Baytown (Chambers Co.) (see Note 1)	0	0	0	0	0	0	0	0
Baytown (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Bellaire	0	0	0	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0	0	0	0
Deer Park	0	0	0	0	0	0	0	0
El Lago	0	0	0	0	0	0	0	0
Friendswood (Harris Co.)	0	0	0	0	0	0	0	0
Friendswood (Galveston Co.)	0	0	0	0	0	0	0	0
Friendswood (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Galena Park	0	0	0	0	0	0	0	0
Hedwig Village	0	0	0	0	0	0	0	0
Hilshire Village	0	0	0	0	0	0	0	0
Houston (Harris Co.)	273	10	0	0	0	0	0	283
Humble	0	0	0	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0	0	0	0
Jacinto City	0	0	0	0	0	0	0	0
Jersey Village	0	0	0	0	0	0	0	0
Katy (Harris Co.)	27	0	0	0	0	0	0	27
Katy (Fort Bend Co.)	0	0	0	0	0	0	0	0
Katy (Waller Co.)	0	0	0	0	0	0	0	0
Katy (Total)	**27**	**0**	**0**	**0**	**0**	**0**	**0**	**27**
La Porte	0	0	0	0	0	0	0	0
League City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Harris Co.)	0	0	0	0	0	0	0	0
Missouri City (Fort Bend Co.)	149	2	0	0	0	0	0	151
Missouri City (Total)	**149**	**2**	**0**	**0**	**0**	**0**	**0**	**151**
Morgan's Point (Harris Co.)	0	0	0	0	0	0	0	0
Nassau Bay	0	0	0	0	0	0	0	0
Pasadena	0	0	0	0	0	0	0	0
Pearland (Harris Co.)	0	0	0	0	0	0	0	0
Piney Point Village	0	0	0	0	0	0	0	0
Seabrook (Harris Co.)	0	0	0	0	0	0	0	0
Shoreacres (Harris Co.)	0	0	0	0	0	0	0	0
South Houston	0	0	0	0	0	0	0	0
Southside Place	0	0	0	0	0	0	0	0
Spring Valley Village	0	0	0	0	0	0	0	0
Stafford (Harris Co.)	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	0	0	0	0	0	0	0	0
Stafford (Total)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Taylor Lake Village	0	0	0	0	0	0	0	0
Tomball (Harris Co.)	0	0	0	0	0	0	0	0
Waller (Harris Co.)	0	0	0	0	0	0	0	0
Webster	0	0	0	0	0	0	0	0
West University Place	0	0	0	0	0	0	0	0
Unincorporated County	6,658	307	36	17	16	0	3	7,037
Total	**7,256**	**321**	**36**	**17**	**16**	**0**	**3**	**7,649**

(1) U.S. Census Bureau 2018 estimated population downloaded from the The County Information Program, Texas Association of Counties website in July 2019.
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(3) Wildfire ignition density data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).
(4) Percent of residential buildings exposed multiplied by the Estimated Population.
NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown due to the census block aggregation level of the general building stock data. The majority of Chambers County portion of Baytown is in the low ignition density category

Wildfire Risk Assessment

Wildfire Threat (Low) (3)

Jurisdiction	Estimated Population (1)	Total Number of Buildings (2)	Total Number of Residential Buildings (2)	Total Building Value (Structure and contents in $) (2)
Baytown (Harris Co.)	72,879	20,718	19,029	$10,081,462,691
Baytown (Chambers Co.) (see Note 1)	4,145	1,440	1,280	$1,376,644,000
Baytown (Total)	**77,024**	**22,158**	**20,309**	**11,458,106,691**
Bellaire	18,966	6,503	6,307	$5,726,227,131
Bunker Hill Village	3,982	1,303	1,302	$1,322,346,729
Deer Park	33,931	11,370	10,575	$5,845,168,035
El Lago	2,727	1,107	1,078	$469,295,696
Friendswood (Harris Co.)	11,575	3,570	3,479	$1,631,453,165
Friendswood (Galveston Co.)	28,606	9,959	9,593	$4,553,773,509
Firendswood (Total)	**40,181**	**13,529**	**13,072**	**6,185,226,675**
Galena Park	10,931	3,288	3,032	$1,178,706,765
Hedwig Village	2,669	909	818	$1,142,111,969
Hilshire Village	819	321	311	$207,926,478
Houston (Harris Co.)	2,278,069	592,166	544,150	$487,379,428,234
Humble	16,041	4,890	3,979	$4,570,456,883
Hunters Creek Village	4,891	1,572	1,552	$1,787,651,957
Jacinto City	10,625	2,986	2,745	$1,261,111,221
Jersey Village	7,962	2,527	2,348	$2,275,428,136
Katy (Harris Co.)	15,251	4,249	3,929	$1,865,017,616
Katy (Fort Bend Co.)	2,159	811	548	$1,312,561,128
Katy (Waller Co.) (see Note 1)	1,806	492	444	$218,939,000
Katy (Total)	**19,216**	**5,552**	**4,921**	**3,396,517,744**
La Porte	35,423	12,427	11,467	$6,575,613,440
League City (Harris Co.)	1,984	394	386	$280,449,911
Missouri City (Harris Co.)	6,273	1,876	1,824	$770,837,732
Missouri City (Fort Bend Co.)	68,432	22,450	21,588	$11,627,868,465
Missouri City (Total)	**74,705**	**24,326**	**23,412**	**12,398,706,197**
Morgan's Point (Harris Co.)	345	160	150	$262,314,866
Nassau Bay	4,037	1,574	1,504	$1,635,924,802
Pasadena	153,219	40,639	37,128	$22,505,882,445
Pearland (Harris Co.)	5,237	834	791	$709,046,327
Piney Point Village	3,449	1,195	1,188	$1,817,131,583
Seabrook (Harris Co.)	14,291	4,390	4,105	$2,537,671,414
Shoreacres (Harris Co.)	1,611	657	656	$218,188,519
South Houston	17,583	5,001	4,050	$2,162,541,092
Southside Place	1,881	508	491	$471,918,214
Spring Valley Village	4,333	1,509	1,466	$1,227,871,955
Stafford (Harris Co.)	309	89	89	$24,088,003
Stafford (Fort Bend Co.)	18,003	4,966	3,878	$6,078,341,979
Stafford (Total)	**18,312**	**5,055**	**3,967**	**6,102,429,982**
Taylor Lake Village	3,625	1,390	1,385	$690,404,692
Tomball (Harris Co.)	11,761	3,649	2,933	$3,569,286,191
Waller (Harris Co.)	600	261	197	$221,680,638
Webster	11,201	2,387	1,774	$5,700,342,104
West University Place	15,676	5,525	5,468	$3,722,134,705
Unincorporated County	1,914,463	573,070	541,942	$321,033,774,612
Total	**4,821,770**	**1,355,132**	**1,260,959**	**928,049,024,035**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)

(3) Wildfire theat data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).

(4) Percent of residential buildings exposed multiplied by the Estimated Population.

NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown and the Waller County portion of Katy due to the census block aggregation level of the general building stock data.

Wildfire Risk Assessment

Wildfire Threat (Low) (3)

Jurisdiction	Wildfire Threat Low Category (3)						
	Estimated Exposure						
	Estimated Buildings Exposed (2)	Population Exposed (4)	% of Population Exposed	Value Structure in $ Exposed (2)	Value Contents in $ Exposed (2)	Value (Structure and contents in $) Exposed (2)	% of Total Value
Baytown (Harris Co.)	4,229	15,032	20.63%	1,530,877,041	1,054,985,188	2,585,862,229	25.64967%
Baytown (Chambers Co.) (see Note 1)	0	0	0.00%	0	0	0	0.00000%
Baytown (Total)	**4,229**	**15,032**	**19.52%**	**1,530,877,041**	**1,054,985,188**	**2,585,862,229**	**22.56797%**
Bellaire	0	0	0.00%	0	0	0	0.00000%
Bunker Hill Village	0	0	0.00%	0	0	0	0.00000%
Deer Park	2,825	8,291	24.43%	978,373,551	750,187,869	1,728,561,420	29.57248%
El Lago	0	0	0.00%	0	0	0	0.00000%
Friendswood (Harris Co.)	2,357	7,556	65.28%	824,156,730	459,945,000	1,284,101,730	78.70908%
Friendswood (Galveston Co.)	5,597	16,177	56.55%	1,619,592,482	977,291,751	2,596,884,233	57.02708%
Firendswood (Total)	**7,954**	**23,733**	**59.07%**	**2,443,749,211**	**1,437,236,751**	**3,880,985,962**	**62.74606%**
Galena Park	896	3,129	28.63%	141,477,599	89,991,264	231,468,862	19.63753%
Hedwig Village	0	0	0.00%	0	0	0	0.00000%
Hilshire Village	0	0	0.00%	0	0	0	0.00000%
Houston (Harris Co.)	62,572	244,879	10.75%	26,184,617,819	18,328,243,169	44,512,860,989	9.13310%
Humble	3,337	11,631	72.51%	1,516,854,784	1,236,413,838	2,753,268,622	60.24056%
Hunters Creek Village	0	0	0.00%	0	0	0	0.00000%
Jacinto City	839	3,201	30.13%	114,069,755	62,099,041	176,168,797	13.96933%
Jersey Village	0	0	0.00%	0	0	0	0.00000%
Katy (Harris Co.)	2,754	10,201	66.89%	712,531,972	434,657,892	1,147,189,864	61.51094%
Katy (Fort Bend Co.)	761	2,037	94.34%	503,071,470	415,172,391	918,243,861	69.95818%
Katy (Waller Co.) (see Note 1)	0	0	0.00%	0	0	0	0.00000%
Katy (Total)	**3,515**	**12,238**	**63.69%**	**1,215,603,442**	**849,830,283**	**2,065,433,725**	**60.81033%**
La Porte	3,510	9,684	27.34%	1,459,984,403	1,133,722,938	2,593,707,341	39.44434%
League City (Harris Co.)	377	1,897	95.60%	178,502,383	93,163,532	271,665,914	96.86789%
Missouri City (Harris Co.)	192	592	9.43%	66,697,572	45,426,030	112,123,603	14.54568%
Missouri City (Fort Bend Co.)	7,769	23,495	34.33%	2,668,983,839	1,792,075,609	4,461,059,448	38.36524%
Missouri City (Total)	**7,961**	**24,087**	**32.24%**	**2,735,681,411**	**1,837,501,639**	**4,573,183,051**	**36.88436%**
Morgan's Point (Harris Co.)	0	0	0.00%	0	0	0	0.00000%
Nassau Bay	52	140	3.46%	17,154,404	8,577,202	25,731,607	1.57291%
Pasadena	4,326	16,879	11.02%	2,218,801,361	1,572,321,647	3,791,123,008	16.84503%
Pearland (Harris Co.)	617	3,814	72.82%	321,467,557	260,146,487	581,614,044	82.02765%
Piney Point Village	0	0	0.00%	0	0	0	0.00000%
Seabrook (Harris Co.)	902	2,883	20.17%	362,010,837	228,125,154	590,135,992	23.25502%
Shoreacres (Harris Co.)	274	673	41.77%	65,256,637	32,628,319	97,884,956	44.86256%
South Houston	0	0	0.00%	0	0	0	0.00000%
Southside Place	0	0	0.00%	0	0	0	0.00000%
Spring Valley Village	0	0	0.00%	0	0	0	0.00000%
Stafford (Harris Co.)	0	0	0.00%	0	0	0	0.00000%
Stafford (Fort Bend Co.)	361	1,156	6.42%	181,202,243	154,820,661	336,022,904	5.52820%
Stafford (Total)	**361**	**1,156**	**6.31%**	**181,202,243**	**154,820,661**	**336,022,904**	**5.50638%**
Taylor Lake Village	353	921	25.42%	119,767,995	59,965,638	179,733,633	26.03308%
Tomball (Harris Co.)	2,687	9,110	77.46%	1,438,945,986	1,297,330,273	2,736,276,259	76.66172%
Waller (Harris Co.)	258	597	99.49%	121,767,177	81,449,232	203,216,409	91.67080%
Webster	824	4,180	37.32%	690,744,797	537,107,039	1,227,851,836	21.53997%
West University Place	0	0	0.00%	0	0	0	0.00000%
Unincorporated County	224,708	754,948	39.43%	75,262,423,020	47,772,123,054	123,034,546,074	38.32449%
Total	**333,377**	**1,153,102**	**23.91%**	**119,299,333,414**	**78,877,970,218**	**198,177,303,632**	**21.35418%**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)

(3) Wildfire theat data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).

(4) Percent of residential buildings exposed multiplied by the Estimated Population.

NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown and the Waller County portion of Katy due to the census block aggregation level of the general building stock data.

Wildfire Risk Assessment

Wildfire Threat (Low) (3)

Jurisdiction	Number of Structures inWildfire Threat Low Category (2)							
	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Baytown (Harris Co.)	3,925	287	2	3	9	1	2	4,229
Baytown (Chambers Co.) (see Note 1)	0	0	0	0	0	0	0	0
Baytown (Total)	**3,925**	**287**	**2**	**3**	**9**	**1**	**2**	**4,229**
Bellaire	0	0	0	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0	0	0	0
Deer Park	2,584	192	45	0	2	0	2	2,825
El Lago	0	0	0	0	0	0	0	0
Friendswood (Harris Co.)	2,271	84	1	0	1	0	0	2,357
Friendswood (Galveston Co.)	5,425	162	1	9	0	0	0	5,597
Firendswood (Total)	**7,696**	**246**	**2**	**9**	**1**	**0**	**0**	**7,954**
Galena Park	868	19	2	0	3	0	4	896
Hedwig Village	0	0	0	0	0	0	0	0
Hilshire Village	0	0	0	0	0	0	0	0
Houston (Harris Co.)	58,493	3,636	246	32	113	14	38	62,572
Humble	2,885	399	35	3	13	1	1	3,337
Hunters Creek Village	0	0	0	0	0	0	0	0
Jacinto City	827	10	0	0	2	0	0	839
Jersey Village	0	0	0	0	0	0	0	0
Katy (Harris Co.)	2,628	114	3	1	6	2	0	2,754
Katy (Fort Bend Co.)	517	224	0	17	3	0	0	761
Katy (Waller Co.) (see Note 1)	0	0	0	0	0	0	0	0
Katy (Total)	**3,145**	**338**	**3**	**18**	**9**	**2**	**0**	**3,515**
La Porte	3,135	338	27	3	4	0	3	3,510
League City (Harris Co.)	369	7	0	0	1	0	0	377
Missouri City (Harris Co.)	172	20	0	0	0	0	0	192
Missouri City (Fort Bend Co.)	7,412	305	22	26	4	0	0	7,769
Missouri City (Total)	**7,584**	**325**	**22**	**26**	**4**	**0**	**0**	**7,961**
Morgan's Point (Harris Co.)	0	0	0	0	0	0	0	0
Nassau Bay	52	0	0	0	0	0	0	52
Pasadena	4,090	200	29	0	5	2	0	4,326
Pearland (Harris Co.)	576	29	12	0	0	0	0	617
Piney Point Village	0	0	0	0	0	0	0	0
Seabrook (Harris Co.)	828	73	0	1	0	0	0	902
Shoreacres (Harris Co.)	274	0	0	0	0	0	0	274
South Houston	0	0	0	0	0	0	0	0
Southside Place	0	0	0	0	0	0	0	0
Spring Valley Village	0	0	0	0	0	0	0	0
Stafford (Harris Co.)	0	0	0	0	0	0	0	0
Stafford (Fort Bend Co.)	249	103	5	2	2	0	0	361
Stafford (Total)	**249**	**103**	**5**	**2**	**2**	**0**	**0**	**361**
Taylor Lake Village	352	1	0	0	0	0	0	353
Tomball (Harris Co.)	2,272	369	26	1	10	0	9	2,687
Waller (Harris Co.)	196	61	0	0	0	1	0	258
Webster	662	153	2	6	1	0	0	824
West University Place	0	0	0	0	0	0	0	0
Unincorporated County	213,709	9,658	808	108	272	38	115	224,708
Total	**314,771**	**16,444**	**1,266**	**212**	**451**	**59**	**174**	**333,377**

(1) U.S. Census Bureau 2018 estimated population

(2) Values based off of Harris Central Appraisal District data (2019), Fort Bend Central Appraisal District data (2018), Galveston Central Appraisal District data (2018), and Hazus v4.2 SP03 default general building stock data (Chambers and Waller counties)

(3) Wildfire theat data downloaded from Texas Wildfire Risk Assessment Portal (TxWrap).

(4) Percent of residential buildings exposed multiplied by the Estimated Population.

NOTE: Unable to determine the building exposure for the Chambers County portion of Baytown and the Waller County portion of Katy due to the census block aggregation level of the general building stock data.

REPETITIVE LOSS PROPERTY ANALYSIS

Jurisdiction	Total	Residential	Non-Residential	Total Loss Count	Total Paid
Baytown	0	0	0	0	$0
Bellaire	183	172	11	461	$28,688,973
Bunker Hill Village	53	53	0	144	$5,894,567
Deer Park	0	0	0	0	$0
El Lago	43	38	5	153	$8,757,473
Friendswood	327	321	6	1,300	$66,481,807
Galena Park	12	12	0	41	$1,076,001
Hedwig Village	22	22	0	63	$2,447,266
Hilshire Village	1	1	0	3	$211,347
Houston	9,434	8,846	588	29,913	$1,746,534,815
Humble	48	34	14	141	$9,084,232
Hunters Creek Village	30	29	1	78	$4,415,659
Jacinto City	15	12	3	37	$1,564,940
Jersey Village	155	152	3	479	$32,557,871
Katy	80	73	7	166	$16,064,196
La Porte	307	294	13	961	$32,160,805
League City	366	357	9	1,104	$40,462,256
Missouri City	48	48	0	150	$2,565,113
Morgan's Point	1	1	0	2	$14,838
Nassau Bay	160	158	2	570	$38,725,382
Pasadena	402	376	26	1,712	$61,282,112
Pearland	316	303	13	1,155	$43,188,700
Piney Point Village	52	50	2	159	$11,299,283
Seabrook	209	160	49	704	$31,270,532
Shoreacres	117	115	2	341	$18,914,506
South Houston	65	62	3	269	$8,799,970
Southside Place	2	2	0	6	$262,448
Spring Valley Village	7	7	0	19	$797,236
Stafford	11	10	1	24	$409,970
Taylor Lake Village	81	81	0	335	$12,236,042
Tomball	14	10	4	63	$2,171,228
Waller	8	8	0	23	$466,225
Webster	25	17	8	85	$4,170,330
West University Place	35	33	2	99	$3,293,435
Unincorporated Harris County	5,316	5,139	177	16,480	$868,276,283
Total	**17,945**	**16,996**	**949**	**57,240**	**$3,104,545,841**

Repetitive loss data as of 2/28/2018. Data provided by the Harris County Flood Control District (HCFCD).

Data includes repetitive loss properties in counties adjacent to Harris County for jurisdictions that are in multiple counties including Harris County.

Note 1: 366 properties of the 17,945 properties in the HCFCD dataset were not geocoded. It could not be determined if these properties are located in the FEMA 100-year or Hurricane Harvey flood zones.

REPETITIVE LOSS PROPERTY ANALYSIS

Jurisdiction	Mitigated	Non-Mitigated	Insured	Insured SDF	Not Insured
Baytown	0	0	0	0	0
Bellaire	10	173	144	3	36
Bunker Hill Village	4	49	19	3	31
Deer Park	0	0	0	0	0
El Lago	12	31	18	1	24
Friendswood	119	208	117	20	190
Galena Park	0	12	7	2	3
Hedwig Village	1	21	10	1	11
Hilshire Village	0	1	1	0	0
Houston	859	8,575	5,501	699	3,234
Humble	1	47	19	3	26
Hunters Creek Village	3	27	17	2	11
Jacinto City	2	13	4	0	11
Jersey Village	4	151	85	33	37
Katy	0	80	77	0	3
La Porte	57	250	121	12	174
League City	84	282	223	6	137
Missouri City	2	46	19	4	25
Morgan's Point	0	1	0	0	1
Nassau Bay	17	143	104	18	38
Pasadena	94	308	98	16	288
Pearland	85	231	113	26	177
Piney Point Village	0	52	29	5	18
Seabrook	90	119	104	8	97
Shoreacres	47	70	57	7	53
South Houston	0	65	30	3	32
Southside Place	1	1	1	0	1
Spring Valley Village	1	6	3	0	4
Stafford	0	11	3	0	8
Taylor Lake Village	26	55	41	10	30
Tomball	2	12	5	0	9
Waller	0	8	7	0	1
Webster	1	24	11	5	9
West University Place	1	34	19	1	15
Unincorporated Harris County	1,102	4,214	2,663	264	2,389
Total	**2,625**	**15,320**	**9,670**	**1,152**	**7,123**

Repetitive loss data as of 2/28/2018. Data provided by the Harris County Flood Control District (HCFCD).

Data includes repetitive loss properties in counties adjacent to Harris County for jurisdictions that are in multiple counties including Harris County.

Note 1: 366 properties of the 17,945 properties in the HCFCD dataset were not geocoded. It could not be determined if these properties are located in the FEMA 100-year or Hurricane Harvey flood zones.

REPETITIVE LOSS PROPERTY ANALYSIS

Jurisdiction	In FEMA 100-year Zone (note 1)	In Hurricane Harvey Flood Zone (note 1)
Baytown	0	0
Bellaire	168	153
Bunker Hill Village	1	5
Deer Park	0	0
El Lago	24	16
Friendswood	190	274
Galena Park	1	9
Hedwig Village	0	4
Hilshire Village	1	1
Houston	5,423	6,971
Humble	16	31
Hunters Creek Village	11	15
Jacinto City	0	11
Jersey Village	143	57
Katy	42	53
La Porte	132	170
League City	106	286
Missouri City	0	35
Morgan's Point	1	0
Nassau Bay	149	114
Pasadena	133	262
Pearland	206	244
Piney Point Village	17	31
Seabrook	198	136
Shoreacres	114	65
South Houston	25	51
Southside Place	2	2
Spring Valley Village	1	0
Stafford	0	9
Taylor Lake Village	70	57
Tomball	1	6
Waller	7	3
Webster	10	16
West University Place	24	17
Unincorporated Harris County	3,020	3,869
Total	**10,236**	**12,973**

Repetitive loss data as of 2/28/2018. Data provided by the Harris County Flood Control District (HCFCD).

Data includes repetitive loss properties in counties adjacent to Harris County for jurisdictions that are in multiple counties including Harris County.

Note 1: 366 properties of the 17,945 properties in the HCFCD dataset were not geocoded. It could not be determined if these properties are located in the FEMA 100-year or Hurricane Harvey flood zones.

ALL CRITICAL FACILITIES, BY JURISDICTION

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	15	4	7	29	11
Bellaire	6	2	1	10	6
Bunker Hill Village	2	0	0	2	0
Deer Park	10	4	2	34	1
El Lago	2	0	1	0	0
Friendswood	3	5	5	2	1
Galena Park	6	3	2	13	1
Hedwig Village	1	2	1	2	0
Hilshire Village	1	0	0	0	0
Houston	492	133	471	1,180	249
Humble	4	5	9	21	10
Hunters Creek Village	1	0	0	1	0
Jacinto City	2	2	1	3	1
Jersey Village	1	3	1	10	0
Katy	4	2	3	11	3
La Porte	8	4	6	29	1
League City	0	7	7	1	0
Missouri City	0	5	0	2	1
Morgan's Point	0	1	0	6	1
Nassau Bay	0	5	1	1	1
Pasadena	39	11	59	60	13
Pearland	0	3	2	2	0
Piney Point Village	2	1	0	2	0
Seabrook	2	2	6	6	0
Shoreacres	1	4	0	0	0
South Houston	6	2	3	16	0
Southside Place	0	1	1	1	0
Spring Valley Village	0	2	1	2	1
Stafford	2	3	1	0	0
Taylor Lake Village	0	1	0	2	0
Tomball	6	4	5	13	14
Waller	1	2	1	0	0
Webster	2	4	2	12	11
West University Place	1	2	1	1	1
Unincorporated County	561	83	483	1,216	94
Total	**1,181**	**312**	**1,083**	**2,690**	**421**

ALL CRITICAL FACILITIES,

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	72	22	3	**163**
Bellaire	10	1	1	**37**
Bunker Hill Village	5	1	0	**10**
Deer Park	22	10	2	**85**
El Lago	0	0	1	**4**
Friendswood	0	2	1	**19**
Galena Park	9	14	1	**49**
Hedwig Village	1	2	0	**9**
Hilshire Village	4	0	0	**5**
Houston	1,822	1,083	74	**5,504**
Humble	40	7	1	**97**
Hunters Creek Village	1	2	0	**5**
Jacinto City	7	5	0	**21**
Jersey Village	2	10	2	**29**
Katy	11	1	0	**35**
La Porte	30	32	2	**112**
League City	2	0	1	**18**
Missouri City	1	6	4	**19**
Morgan's Point	0	0	1	**9**
Nassau Bay	3	0	3	**14**
Pasadena	82	87	5	**356**
Pearland	2	3	1	**13**
Piney Point Village	5	3	1	**14**
Seabrook	6	4	1	**27**
Shoreacres	0	2	0	**7**
South Houston	7	11	1	**46**
Southside Place	0	1	0	**4**
Spring Valley Village	4	2	0	**12**
Stafford	0	0	0	**6**
Taylor Lake Village	1	0	0	**4**
Tomball	11	2	1	**56**
Waller	2	1	0	**7**
Webster	19	5	1	**56**
West University Place	6	2	1	**15**
Unincorporated County	717	714	681	**4,549**
Total	**2,904**	**2,035**	**790**	**11,416**

Lake Conroe Dam Failure

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	0	0	0	0	0
Bellaire	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0
Deer Park	0	0	0	0	0
El Lago	0	0	0	0	0
Friendswood	0	0	0	0	0
Galena Park	0	0	0	0	0
Hedwig Village	0	0	0	0	0
Hilshire Village	0	0	0	0	0
Houston	3	2	12	7	4
Humble	1	0	1	4	1
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	0	0	0	0
Jersey Village	0	0	0	0	0
Katy	0	0	0	0	0
La Porte	0	0	0	0	0
League City	0	0	0	0	0
Missouri City	0	0	0	0	0
Morgan's Point	0	0	0	0	0
Nassau Bay	0	0	0	0	0
Pasadena	0	0	0	0	0
Pearland	0	0	0	0	0
Piney Point Village	0	0	0	0	0
Seabrook	0	0	0	0	0
Shoreacres	0	0	0	0	0
South Houston	0	0	0	0	0
Southside Place	0	0	0	0	0
Spring Valley Village	0	0	0	0	0
Stafford	0	0	0	0	0
Taylor Lake Village	0	0	0	0	0
Tomball	0	0	0	0	0
Waller	0	0	0	0	0
Webster	0	0	0	0	0
West University Place	0	0	0	0	0
Unincorporated County	1	1	24	13	0
Total	**5**	**3**	**37**	**24**	**5**

Lake Conroe Dam Failure

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	0	0	0	**0**
Bellaire	0	0	0	**0**
Bunker Hill Village	0	0	0	**0**
Deer Park	0	0	0	**0**
El Lago	0	0	0	**0**
Friendswood	0	0	0	**0**
Galena Park	0	0	0	**0**
Hedwig Village	0	0	0	**0**
Hilshire Village	0	0	0	**0**
Houston	2	19	4	**53**
Humble	5	3	0	**15**
Hunters Creek Village	0	0	0	**0**
Jacinto City	0	0	0	**0**
Jersey Village	0	0	0	**0**
Katy	0	0	0	**0**
La Porte	0	0	0	**0**
League City	0	0	0	**0**
Missouri City	0	0	0	**0**
Morgan's Point	0	0	0	**0**
Nassau Bay	0	0	0	**0**
Pasadena	0	0	0	**0**
Pearland	0	0	0	**0**
Piney Point Village	0	0	0	**0**
Seabrook	0	0	0	**0**
Shoreacres	0	0	0	**0**
South Houston	0	0	0	**0**
Southside Place	0	0	0	**0**
Spring Valley Village	0	0	0	**0**
Stafford	0	0	0	**0**
Taylor Lake Village	0	0	0	**0**
Tomball	0	0	0	**0**
Waller	0	0	0	**0**
Webster	0	0	0	**0**
West University Place	0	0	0	**0**
Unincorporated County	1	13	12	**65**
Total	**8**	**35**	**16**	**133**

1% Annual Chance Flood

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	0	0	0	3	0
Bellaire	5	2	1	7	5
Bunker Hill Village	0	0	0	0	0
Deer Park	0	0	0	11	0
El Lago	0	0	1	0	0
Friendswood	1	0	1	0	0
Galena Park	0	1	0	2	0
Hedwig Village	0	0	0	0	0
Hilshire Village	0	0	0	0	0
Houston	62	15	117	156	38
Humble	0	0	0	1	0
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	0	0	1	0
Jersey Village	1	0	0	0	0
Katy	0	1	0	0	1
La Porte	1	0	3	2	0
League City	0	0	3	0	0
Missouri City	0	0	0	0	0
Morgan's Point	0	0	0	0	0
Nassau Bay	0	2	0	0	0
Pasadena	3	1	30	11	2
Pearland	0	1	2	1	0
Piney Point Village	0	0	0	0	0
Seabrook	2	1	6	5	0
Shoreacres	1	4	0	0	0
South Houston	2	0	1	8	0
Southside Place	0	1	1	1	0
Spring Valley Village	0	0	0	0	0
Stafford	0	0	0	0	0
Taylor Lake Village	0	0	0	0	0
Tomball	0	0	0	0	0
Waller	0	0	0	0	0
Webster	0	0	0	0	2
West University Place	1	0	0	0	0
Unincorporated County	37	11	123	182	4
Total	**116**	**40**	**289**	**391**	**52**

1% Annual Chance Flood

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	4	18	3	**28**
Bellaire	9	1	1	**31**
Bunker Hill Village	0	0	0	**0**
Deer Park	3	6	0	**20**
El Lago	0	0	0	**1**
Friendswood	0	2	0	**4**
Galena Park	0	6	1	**10**
Hedwig Village	0	0	0	**0**
Hilshire Village	0	0	0	**0**
Houston	230	648	23	**1,289**
Humble	1	2	0	**4**
Hunters Creek Village	0	2	0	**2**
Jacinto City	0	3	0	**4**
Jersey Village	1	7	1	**10**
Katy	0	1	0	**3**
La Porte	4	24	0	**34**
League City	2	0	0	**5**
Missouri City	0	3	0	**3**
Morgan's Point	0	0	0	**0**
Nassau Bay	3	0	1	**6**
Pasadena	8	70	1	**126**
Pearland	2	3	0	**9**
Piney Point Village	0	2	0	**2**
Seabrook	3	4	1	**22**
Shoreacres	0	2	0	**7**
South Houston	3	11	0	**25**
Southside Place	0	1	0	**4**
Spring Valley Village	0	2	0	**2**
Stafford	0	0	0	**0**
Taylor Lake Village	1	0	0	**1**
Tomball	0	0	0	**0**
Waller	0	1	0	**1**
Webster	1	2	0	**5**
West University Place	0	0	0	**1**
Unincorporated County	76	373	156	**962**
Total	**351**	**1,194**	**188**	**2,621**

Harvey Inundation Area

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	7	3	2	14	4
Bellaire	4	0	0	8	2
Bunker Hill Village	0	0	0	1	0
Deer Park	8	3	2	18	1
El Lago	1	0	0	0	0
Friendswood	1	1	1	0	1
Galena Park	6	1	2	2	1
Hedwig Village	1	2	1	1	0
Hilshire Village	1	0	0	0	0
Houston	241	43	259	600	104
Humble	0	0	3	8	5
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	2	0	2	1
Jersey Village	0	2	0	5	0
Katy	2	1	0	8	1
La Porte	7	4	5	15	1
League City	0	3	6	1	0
Missouri City	0	1	0	2	1
Morgan's Point	0	1	0	4	1
Nassau Bay	0	2	1	1	0
Pasadena	29	8	35	35	5
Pearland	0	1	1	1	0
Piney Point Village	1	0	0	2	0
Seabrook	2	1	6	6	0
Shoreacres	1	4	0	0	0
South Houston	5	2	3	14	0
Southside Place	0	0	1	0	0
Spring Valley Village	0	0	0	0	0
Stafford	2	1	0	0	0
Taylor Lake Village	0	0	0	1	0
Tomball	1	2	2	4	3
Waller	0	0	0	0	0
Webster	1	3	1	7	8
West University Place	1	2	1	0	0
Unincorporated County	203	31	205	577	35
Total	**525**	**124**	**537**	**1,337**	**174**

Harvey Inundation Area

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	43	17	1	**91**
Bellaire	2	0	1	**17**
Bunker Hill Village	0	0	0	**1**
Deer Park	18	8	0	**58**
El Lago	0	0	0	**1**
Friendswood	0	2	0	**6**
Galena Park	6	9	1	**28**
Hedwig Village	0	2	0	**7**
Hilshire Village	3	0	0	**4**
Houston	962	845	32	**3,086**
Humble	20	5	0	**41**
Hunters Creek Village	1	1	0	**2**
Jacinto City	3	5	0	**13**
Jersey Village	1	9	1	**18**
Katy	4	1	0	**17**
La Porte	21	22	1	**76**
League City	2	0	0	**12**
Missouri City	0	5	3	**12**
Morgan's Point	0	0	1	**7**
Nassau Bay	2	0	2	**8**
Pasadena	50	72	4	**238**
Pearland	2	3	0	**8**
Piney Point Village	3	3	1	**10**
Seabrook	3	3	1	**22**
Shoreacres	0	2	0	**7**
South Houston	6	11	0	**41**
Southside Place	0	1	0	**2**
Spring Valley Village	2	2	0	**4**
Stafford	0	0	0	**3**
Taylor Lake Village	1	0	0	**2**
Tomball	2	2	1	**17**
Waller	0	1	0	**1**
Webster	12	5	0	**37**
West University Place	3	2	0	**9**
Unincorporated County	306	475	349	**2,181**
Total	**1,478**	**1,513**	**399**	**6,087**

Wildfire Ignition Density
Very High

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	0	0	0	0	0
Bellaire	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0
Deer Park	0	0	0	0	0
El Lago	0	0	0	0	0
Friendswood	0	0	0	0	0
Galena Park	0	0	0	0	0
Hedwig Village	0	0	0	0	0
Hilshire Village	0	0	0	0	0
Houston	0	0	0	0	0
Humble	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	0	0	0	0
Jersey Village	0	0	0	0	0
Katy	0	0	0	0	0
La Porte	0	0	0	0	0
League City	0	0	0	0	0
Missouri City	0	0	0	0	0
Morgan's Point	0	0	0	0	0
Nassau Bay	0	0	0	0	0
Pasadena	0	0	0	0	0
Pearland	0	0	0	0	0
Piney Point Village	0	0	0	0	0
Seabrook	0	0	0	0	0
Shoreacres	0	0	0	0	0
South Houston	0	0	0	0	0
Southside Place	0	0	0	0	0
Spring Valley Village	0	0	0	0	0
Stafford	0	0	0	0	0
Taylor Lake Village	0	0	0	0	0
Tomball	0	0	0	0	0
Waller	0	0	0	0	0
Webster	0	0	0	0	0
West University Place	0	0	0	0	0
Unincorporated County	0	0	0	1	0
Total	**0**	**0**	**0**	**1**	**0**

Wildfire Ignition Density
Very High

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	0	0	0	**0**
Bellaire	0	0	0	**0**
Bunker Hill Village	0	0	0	**0**
Deer Park	0	0	0	**0**
El Lago	0	0	0	**0**
Friendswood	0	0	0	**0**
Galena Park	0	0	0	**0**
Hedwig Village	0	0	0	**0**
Hilshire Village	0	0	0	**0**
Houston	0	0	0	**0**
Humble	0	0	0	**0**
Hunters Creek Village	0	0	0	**0**
Jacinto City	0	0	0	**0**
Jersey Village	0	0	0	**0**
Katy	0	0	0	**0**
La Porte	0	0	0	**0**
League City	0	0	0	**0**
Missouri City	0	0	0	**0**
Morgan's Point	0	0	0	**0**
Nassau Bay	0	0	0	**0**
Pasadena	0	0	0	**0**
Pearland	0	0	0	**0**
Piney Point Village	0	0	0	**0**
Seabrook	0	0	0	**0**
Shoreacres	0	0	0	**0**
South Houston	0	0	0	**0**
Southside Place	0	0	0	**0**
Spring Valley Village	0	0	0	**0**
Stafford	0	0	0	**0**
Taylor Lake Village	0	0	0	**0**
Tomball	0	0	0	**0**
Waller	0	0	0	**0**
Webster	0	0	0	**0**
West University Place	0	0	0	**0**
Unincorporated County	0	0	1	**2**
Total	**0**	**0**	**1**	**2**

Wildfire Ignition Density
High

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	0	0	0	0	0
Bellaire	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0
Deer Park	0	0	0	0	0
El Lago	0	0	0	0	0
Friendswood	0	0	0	0	0
Galena Park	0	0	0	0	0
Hedwig Village	0	0	0	0	0
Hilshire Village	0	0	0	0	0
Houston	0	0	0	0	0
Humble	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	0	0	0	0
Jersey Village	0	0	0	0	0
Katy	0	0	0	0	0
La Porte	0	0	0	0	0
League City	0	0	0	0	0
Missouri City	0	0	0	0	0
Morgan's Point	0	0	0	0	0
Nassau Bay	0	0	0	0	0
Pasadena	0	0	0	0	0
Pearland	0	0	0	0	0
Piney Point Village	0	0	0	0	0
Seabrook	0	0	0	0	0
Shoreacres	0	0	0	0	0
South Houston	0	0	0	0	0
Southside Place	0	0	0	0	0
Spring Valley Village	0	0	0	0	0
Stafford	0	0	0	0	0
Taylor Lake Village	0	0	0	0	0
Tomball	0	0	0	0	0
Waller	0	0	0	0	0
Webster	0	0	0	0	0
West University Place	0	0	0	0	0
Unincorporated County	2	0	2	1	0
Total	**2**	**0**	**2**	**1**	**0**

Wildfire Ignition Density
High

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	0	0	0	**0**
Bellaire	0	0	0	**0**
Bunker Hill Village	0	0	0	**0**
Deer Park	0	0	0	**0**
El Lago	0	0	0	**0**
Friendswood	0	0	0	**0**
Galena Park	0	0	0	**0**
Hedwig Village	0	0	0	**0**
Hilshire Village	0	0	0	**0**
Houston	0	0	0	**0**
Humble	0	0	0	**0**
Hunters Creek Village	0	0	0	**0**
Jacinto City	0	0	0	**0**
Jersey Village	0	0	0	**0**
Katy	0	0	0	**0**
La Porte	0	0	0	**0**
League City	0	0	0	**0**
Missouri City	0	0	0	**0**
Morgan's Point	0	0	0	**0**
Nassau Bay	0	0	0	**0**
Pasadena	0	0	0	**0**
Pearland	0	0	0	**0**
Piney Point Village	0	0	0	**0**
Seabrook	0	0	0	**0**
Shoreacres	0	0	0	**0**
South Houston	0	0	0	**0**
Southside Place	0	0	0	**0**
Spring Valley Village	0	0	0	**0**
Stafford	0	0	0	**0**
Taylor Lake Village	0	0	0	**0**
Tomball	0	0	0	**0**
Waller	0	0	0	**0**
Webster	0	0	0	**0**
West University Place	0	0	0	**0**
Unincorporated County	0	0	1	**6**
Total	**0**	**0**	**1**	**6**

Wildfire Ignition Density
Moderate

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	0	0	0	0	0
Bellaire	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0
Deer Park	0	0	0	0	0
El Lago	0	0	0	0	0
Friendswood	0	0	0	0	0
Galena Park	0	0	0	0	0
Hedwig Village	0	0	0	0	0
Hilshire Village	0	0	0	0	0
Houston	0	0	0	1	0
Humble	0	0	0	0	0
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	0	0	0	0
Jersey Village	0	0	0	0	0
Katy	0	0	0	0	0
La Porte	0	0	0	0	0
League City	0	0	0	0	0
Missouri City	0	0	0	0	0
Morgan's Point	0	0	0	0	0
Nassau Bay	0	0	0	0	0
Pasadena	0	0	0	0	0
Pearland	0	0	0	0	0
Piney Point Village	0	0	0	0	0
Seabrook	0	0	0	0	0
Shoreacres	0	0	0	0	0
South Houston	0	0	0	0	0
Southside Place	0	0	0	0	0
Spring Valley Village	0	0	0	0	0
Stafford	0	0	0	0	0
Taylor Lake Village	0	0	0	0	0
Tomball	0	0	0	0	0
Waller	0	0	0	0	0
Webster	0	0	0	0	0
West University Place	0	0	0	0	0
Unincorporated County	11	0	0	13	1
Total	**11**	**0**	**0**	**14**	**1**

Wildfire Ignition Density
Moderate

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	0	0	0	**0**
Bellaire	0	0	0	**0**
Bunker Hill Village	0	0	0	**0**
Deer Park	0	0	0	**0**
El Lago	0	0	0	**0**
Friendswood	0	0	0	**0**
Galena Park	0	0	0	**0**
Hedwig Village	0	0	0	**0**
Hilshire Village	0	0	0	**0**
Houston	0	0	0	**1**
Humble	0	0	0	**0**
Hunters Creek Village	0	0	0	**0**
Jacinto City	0	0	0	**0**
Jersey Village	0	0	0	**0**
Katy	0	0	0	**0**
La Porte	0	0	0	**0**
League City	0	0	0	**0**
Missouri City	0	0	0	**0**
Morgan's Point	0	0	0	**0**
Nassau Bay	0	0	0	**0**
Pasadena	0	0	0	**0**
Pearland	0	0	1	**1**
Piney Point Village	0	0	0	**0**
Seabrook	0	0	0	**0**
Shoreacres	0	0	0	**0**
South Houston	0	0	0	**0**
Southside Place	0	0	0	**0**
Spring Valley Village	0	0	0	**0**
Stafford	0	0	0	**0**
Taylor Lake Village	0	0	0	**0**
Tomball	0	0	0	**0**
Waller	0	0	0	**0**
Webster	0	0	0	**0**
West University Place	0	0	0	**0**
Unincorporated County	3	0	12	**40**
Total	**3**	**0**	**13**	**42**

Wildfire Threat - Low

Planning Unit	Education Facilities	Emergency Services	Government Facilities	Hazardous Material Sites	Health and Medical Facilities
Baytown	5	1	0	6	0
Bellaire	0	0	0	0	0
Bunker Hill Village	0	0	0	0	0
Deer Park	2	0	0	9	0
El Lago	0	0	0	0	0
Friendswood	1	3	5	2	1
Galena Park	1	0	0	2	0
Hedwig Village	0	0	0	0	0
Hilshire Village	0	0	0	0	0
Houston	49	21	115	206	13
Humble	3	2	7	15	6
Hunters Creek Village	0	0	0	0	0
Jacinto City	0	0	0	1	0
Jersey Village	0	0	0	0	0
Katy	3	1	3	8	1
La Porte	6	2	0	14	0
League City	0	4	7	1	0
Missouri City	0	2	0	1	0
Morgan's Point	0	0	0	1	0
Nassau Bay	0	0	0	0	0
Pasadena	2	2	25	16	3
Pearland	0	3	2	2	0
Piney Point Village	0	0	0	0	0
Seabrook	0	1	0	2	0
Shoreacres	1	2	0	0	0
South Houston	0	0	0	0	0
Southside Place	0	0	0	0	0
Spring Valley Village	0	0	0	0	0
Stafford	1	2	1	0	0
Taylor Lake Village	0	0	0	0	0
Tomball	5	1	1	10	10
Waller	1	1	1	0	0
Webster	0	0	0	3	1
West University Place	0	0	0	0	0
Unincorporated County	224	28	311	500	32
Total	**304**	**76**	**478**	**799**	**67**

Wildfire Threat - Low

Planning Unit	Historical and Cultural Sites	Transportation Systems	Utility Systems	Total
Baytown	11	9	0	**32**
Bellaire	0	0	0	**0**
Bunker Hill Village	0	0	0	**0**
Deer Park	2	2	0	**15**
El Lago	0	0	0	**0**
Friendswood	0	2	1	**15**
Galena Park	1	5	0	**9**
Hedwig Village	0	0	0	**0**
Hilshire Village	0	0	0	**0**
Houston	153	191	26	**774**
Humble	12	7	0	**52**
Hunters Creek Village	0	0	0	**0**
Jacinto City	2	5	0	**8**
Jersey Village	0	0	0	**0**
Katy	6	1	0	**23**
La Porte	8	18	2	**50**
League City	2	0	1	**15**
Missouri City	1	1	1	**6**
Morgan's Point	0	0	0	**1**
Nassau Bay	0	0	1	**1**
Pasadena	6	20	1	**75**
Pearland	2	3	0	**12**
Piney Point Village	0	0	0	**0**
Seabrook	0	1	0	**4**
Shoreacres	0	2	0	**5**
South Houston	0	0	0	**0**
Southside Place	0	0	0	**0**
Spring Valley Village	0	0	0	**0**
Stafford	0	0	0	**4**
Taylor Lake Village	1	0	0	**1**
Tomball	6	2	1	**36**
Waller	2	1	0	**6**
Webster	3	3	1	**11**
West University Place	0	0	0	**0**
Unincorporated County	274	320	312	**2,001**
Total	**492**	**593**	**347**	**3,156**

Appendix D. Detailed Planning Area Flood History

D. Detailed Planning Area Flood History

Area Affected	Date	Deaths	Property Damage	Details
Widespread	09/1900	6,000 to 8,000 region-wide	$40,000,000	The Galveston Hurricane of 1900 struck on August 27, causing widespread flooding in Harris County well into the month of September.
Harris County, Houston	1907	0	N/A	A major storm floods much of Houston and Harris County.
Harris County, especially the Buffalo, White Oak, Brays and Greens Bayou areas	12/1913	0	N/A	A major Brazos River storm spread to Harris County, heavily impacting the entire area. Many citizens were evacuated.
Harris County, Houston	08/1915	0	$56,000,000	Another Galveston-area hurricane caused major damage throughout Harris County. Buffalo Bayou and widespread areas of Houston experienced heavy flooding.
Harris County, Houston, County-wide	04/1929	0	N/A	An enormous gulf storm with a duration of 14 hours descended on Harris County and specifically Houston. Many areas of the county reported rainfall close to 10 inches. Extensive damage was sustained by businesses and residences in almost all areas of the county. All bayous are reported to have been out of their banks.
Harris County	05/1929	0	N/A	Still recovering from the prior month's flooding, the Harris County area was hit by another major storm. Structural damage, heavy street flooding and widespread crop damage was reported. The San Jacinto River was reported to be 30 feet above normal.
Harris County	05/1930	0	N/A	A large rainstorm cell remained stationary over Harris County for three days. Rainfall amounts were reported to be as high as 12.5 inches in some areas. The average rainfall amount for the entire area was eight inches.
Harris County, especially Freeport	08/1932	40	N/A	A hurricane severely impacted Freeport. Widespread flooding occurred on all bayous throughout Harris County.
Harris County, Houston	12/1935	0	N/A	A massive storm inundated Houston and Harris County. Buffalo Bayou was reported to be 52 feet above normal. The overwhelming devastation lead to the creation of the Harris County Flood Control District in 1937.
Northeast Harris County	11/1940	0	10,000 head of cattle lost	Heavy rains lasted for five days in northeast Harris County.
Harris County	07/1943	0	$16,500,000	A hurricane near Galveston caused extensive flooding in Harris County.
Harris County	10/1943	0	N/A	A hurricane near Freeport flooded more than 11,000 residences, 7 in Harris County.

Area Affected	Date	Deaths	Property Damage	Details
Harris County	08/1945	0	N/A	A hurricane affecting the area produced the heaviest rainfall previously recorded in Harris County: over 15 inches in 24 hours. Flooding was reported on all bayous and streams.
Harris County, especially the Greens Bayou and Baytown areas	02/1950	0	N/A	A thunderstorm preceded a cold front resulting in Greens Bayou running out of its banks. Area residents were evacuated from the area. Baytown reported flooding as well.
Northern County Harris	05/1955	0	N/A	A major thunderstorm hits the northern portion of Harris County. Residential flooding was reported in the area.
Harris County	06/1957	0	N/A	Hurricane Audrey crossed the Louisiana/ Texas coast, causing flooding in Harris County.
Houston	10/1959	0	N/A	A thunderstorm with heavy rains flooded more than 100 residences in the Houston area.
Harris County, especially the Cypress Creek, Spring Creek and San Jacinto River areas	06/1960	0	N/A	A thunderstorm inundated many areas throughout Harris County. Over 200 families were evacuated.
Southern Harris County	09/1961	34 in Texas	$300,000,000 region-wide	Hurricane Carla pounded the Gulf Coast, taking 34 lives. Heavy flooding was reported in southern Harris County.
Harris County	02/1969	0	$3,300,000	A thunderstorm, preceding a cold front, caused the flooding of 250 area residences and businesses.
Northern Harris County	03/1972	0	N/A	A thunderstorm, preceding a cold front, caused the flooding of much of northern Harris County. Over 700 families were evacuated.
Harris County	06/1973	10	$50,000,000	A major storm hit Harris County, bringing 10 to 15 inches of rain. Sims and Greens bayous are reported out of banks.
Harris County, especially Alvin, and surrounding area	07/1979	0	$700,000,000 region-wide	Tropical Storm Claudette brought record rainfall amounts to the area. Forty-three inches of rain within a 24-hour period fell in Alvin – a standing U.S. record.
Harris County	05/1983	0	$14,000,000	A large thunderstorm flooded areas along several creeks and bayous.
Harris County and surrounding area	08/1983	0	$1 billion region-wide	Hurricane Alicia struck Galveston and Harris County. Most of the damage was caused by wind.
Harris County, especially downtown Houston and Brays Bayou	09/1983	0	$38,000,000	Nine inches of rain fell south of downtown Houston. More than 1,000 residences were flooded along Brays Bayou.
Harris County	05/1989	0	N/A	A major storm delivered seven to 14 inches of rain over much of Harris County. More than 1,400 residences were flooded.
Harris County	06/1989	0	N/A	A tropical storm named Allison dropped six to 12 inches of rain over portions of Harris County. Nearly 1,100 residences were flooded.
Harris County, especially I-10	03/1992	0	N/A	A major storm flooded more than 1,500 residences and businesses. Many bayous flooded out of banks. Much of Interstate 10 was under water.
Austin, Brazoria, Chambers, Colorado, Fort Bend, Galveston, Harris,	10/16/1994 - 10/18/1994	17	$900,000,000	A major storm inundated southeast Texas, with four to 29 inches of rain falling on Harris County within a three-day period.

Area Affected	Date	Deaths	Property Damage	Details
Liberty, Matagorda, Montgomery, Walker, Waller, Wharton				More than 13,000 people had to be evacuated during the floods and more than 3,400 residences in 90 subdivisions were damaged in Harris County. An estimated 22,000 residences were damaged region-wide.
Harris, Houston, Pasadena	09/18/1996	0	$1,500,000	Widespread street flooding in downtown Houston and Pasadena. Homes and businesses in Pasadena were flooded.
Harris, Houston	09/27/1996	0	$0	Street flooding in NE Houston.
Southeast Harris County	01/27/1997	0	$0	Widespread street flooding.
Harris, Houston	03/12/1997	0	$130,000	Training rains caused street flooding in south and southwest Houston. Training rains caused significant flooding throughout the Houston metropolitan area. Many bayous/streams were overbanks for much of the day. Widespread street flooding. Portions of I-10 were shut down from 8 AM to 2 PM due to high waters.
Harris, Houston	04/04/1997	0	$0	Street flooding in Houston.
Harris, County-Wide Houston, Jamaica Beach, Nassau Bay, Seabrook, Galveston	04/25/1997	0	$250,000	A strong easterly fetch off the Gulf produced coastal flooding along the upper Texas coast from April 25th-27th. The most extensive flooding/damage occurred from High Island to Jamaica Beach along the Gulf and the western shore of Galveston Bay. Tides ran between 2-4 feet above astronomically predicted levels. Beach erosion, road damage, and foundation damage were common especially in Galveston County due to the high waters. In Seabrook (Harris County), high waters on Toddville road made its way into approximately 12 homes and voluntary evacuation of the immediate bayfront was requested. Many residents lost fishing piers adjacent to their lots. Nassau Bay (Harris County), also reported roads flooded along the waterfront. 5-7" rainfall caused street, bayou, and creek flooding.
Harris, Houston	05/21/1997	1	$50,000	Street flooding in west Houston from 6-8" training rains. An elderly man drove into a flooded underpass (about 8 ft deep) where he drowned.
Harris, Houston	05/24/1997	0	$250,000	Severe flooding in Houston. Fifty to 75 homes received flood damage.
Harris, Houston	05/30/1997	0	$15,000	Street flooding due to 3- to 5-inch rains. Approximately 6 homes sustained water damage
Harris, Webster	11/28/1997	0	$3,000	High water on feeder road at I-45 & Nasa Rd 1.
Harris, County-Wide, Humble, Houston	12/20/1997	0	$20,000	Street flooding in Humble. Magnolia Bar & Grill (SW Houston) roof collapsed due to heavy rain.
Harris, Pasadena	01/04/1998	0	$3,000	Red Bluff in Pasadena flooded, feeder roads near Almeda Mall flooded
Harris, Bellaire	01/06/1998	0	$5,000	Street flooding.
Harris, Pasadena	01/21/1998	0	$5,000	Street flooding across the area, especially in the Pasadena area.
Harris, County-Wide	09/11/1998	0	$0	Flooding from T.S. Frances. Damage included in previous report.
Harris County, especially White Oak Bayou and other bayous	09/1998	0	N/A	Tropical Storm Frances caused extensive flooding along White Oak Bayou and other bayous, causing flood damage to more than 1,300 residences.
Harris, Baytown	09/14/1998	0	$5,000	High water on Desee Rd, Sterling Rd, and Main St.
Harris	10/04/1998	0	$5,000	Feeder roads flooded along I-45 in southern parts of the county.

Area Affected	Date	Deaths	Property Damage	Details
Austin, Brazoria, Brazos, Chambers, Colorado, Fort Bend, Grimes, Harris, Jackson, Liberty, Madison, Matagorda, Montgomery, Waller, Wharton, Humble, County-Wide	10/17/1998-10/18/1998	8	$418,000	Many areas received in excess of 10 inches of rainfall. Three hundred and fifty to 375 homes were impacted region-wide: four were destroyed, 143 sustained major damage, and 209 received minor damage. Hundreds of livestock were lost and 7,500 acres of cropland were damaged. Most of the damage within Harris County occurred in the northern portion of the county.
Austin, Brazoria, Brazos, Colorado, Fort Bend, Harris, Jackson, Liberty, Madison, Matagorda, Montgomery, Polk, San Jacinto, Walker, Waller, Wharton	11/12/1998-11/14/1998	0	$239,000	Rainfall amounts across the area averaged five to seven inches, with large areas receiving seven to nine inches. Isolated locations received more than 10 inches of rain. Homes flooded in several communities. Most of the damage within Harris County occurred in the northern portion of the county.
Harris, Bellaire	03/19/1999	0	$300,000	Widespread flooding in southwest Houston. Numerous streets in the Bellaire area were flooded. Several on-ramps to U.S. 59, Loop 610, and U.S. 90, as well as the intersection of I-10 and Beltway 8, were impassable due to high water.
Harris	04/02/2000	0	$50,000	Significant over curb flooding in the Silverstone and Creekstone subdivisions along Mason Rd. An upper level disturbance spawned a large cluster of thunderstorms over the southern half of southeast Texas in the early morning of April 2nd. Harris, Liberty, and Montgomery counties were hardest hit with widespread reports of large hail, downburst wind damage and flooding.
Harris, Liberty	05/19/2000	0	$10,400,000	Major flooding on Greens, Airtex, Rankin, and Aldine-Westfield Roads in Harris County. Four homes were damaged.
Brazoria, Galveston, Harris	09/13/2000	0	$350,000	No specific details available for Harris County.
Harris, Houston	03/28/2001	0	$35,000	Flooding on Interstate 10 between Washington Street and Interstate 610. Flooding on Milam and Travis Streets in downtown Houston.
Harris County, Houston	06/2001	22	$5,000,000	Referred to as "The Great Flood of 2001," Tropical Storm Allison hit Harris County and Houston with a double punch, beginning June 5 and dealing a final blow three days later as the storm moved back into the Gulf of Mexico. The second pass produced extraordinary rainfall amounts northeast of downtown Houston. The Texas Medical Center was shutdown and the north portion of downtown Houston was decimated. Two million people were simultaneously affected by the storm. More than 70,000 residences were flooded.
Brazoria, Fort Bend, Galveston, Harris	08/28/2001-08/31/2001	0	$1,463,000	Heavy rainfall caused street flooding and water in some homes. Some roads were closed.
Harris, Houston, Pasadena	04/08/2002		$70,000	There was extensive street flooding and road closures in Pasadena, along Red Bluff, along State Highway 225, and at Spencer Highway. Street flooding 2 to 3 feet deep was reported at Dixie Farm Road and Beamer, and around San Jacinto College South located on Beamer.

Area Affected	Date	Deaths	Property Damage	Details
Brazoria, Galveston, Harris	08/15/2002	0	$325,000	Numerous roads in Harris County were flooded.
Harris, Houston, Bellaire, Jersey Village	08/22/2002	0	$10,000	Flooding from Bellaire to Jersey Village.
Harris, Pasadena, Deer Park	09/08/2002	0	$15,000	Flooding in Pasadena and Deer Park; many roads closed.
Harris, Houston	09/19/2002	0	$55,000	Many roads under water and impassable especially north of downtown Houston and near the west loop.
Brazoria, Galveston, Harris, Houston	10/24/2002	0	$250,000	No specific details available for Harris County.
Fort Bend, Harris, Liberty, Houston	10/28/2002	0	$775,000	Widespread flooding across Harris County, resulting in many streets becoming impassable.
Harris, Houston	12/04/2002	0	$10,000	Flooding in the Southwest Freeway and Hillcroft areas.
Harris, Pasadena	08/31/2003	0	$3,000	Flooding in Pasadena.
Harris and surrounding area	11/17/2003	1	$3,000,000	As much as nine inches of rain fell in the area causing several spots of localized flooding. Additionally, 13 tornados were reported. A total of 24 tornados touched down during this 15 hour period of severe weather in southeastern Texas on November 17, 2003. In addition to these tornados, a major flood developed over Harris and surrounding counties during the middle of this tornadic outbreak. Over 300 homes, along with hundreds of vehicles, were flooded.
Harris, Houston, Memorial Village (The Villages), Pasadena	05/01/2004	0	$3,000	Southbound feeder of I-45 flooded at West Gulfbank; flooding also observed in and around Memorial Village and Pasadena.
Harris, Houston	05/13/2004	0	$7,000	Street flooding in and around Kingwood.
Harris, Houston	6/13/2004	0	$50,000	Numerous reports of street flooding in downtown Houston and the Medical Center area.
Harris, Houston, Westfield	11/22/2004	0	$15,000	Flooding reported between the Interstate 45 northbound feeder and FM 1960. Clay Road covered with a foot and a half of water and impassable.
Harris, Houston, Aldine	05/29/2005	0	$10,000	Flooding reported between the Interstate 45 northbound feeder and FM 1960. Clay Road covered with a foot and a half of water and impassable.
Harris, Houston	7/14/2005	0	$115,000	Flash flooding along Interstate 10 and also in and around Downtown Houston. Ten homes and two apartments in the Cloverleaf area had flood damage.
Harris, Houston, Clear Lake area	12/14/2005	0	$40,000	Flooding in and around the Houston area from 3.50 to 4.00 inches of rain. Water was up to one foot deep in Clear Lake area.
Harris	6/19/2006	0	$3,300,000	Approximately 3,370 homes were flooded. Homes along these bayous and creeks had flood water in them from 2 to 8 inches to as high as 18 to 20 inches.
Harris	6/22/2006	0	$200,000	40 vehicles were flooded.
Harris, Houston, Seabrook	10/16/2006	4	$750,000	Heavy rain caused widespread county and metro flooding of numerous roads. There were approximately 125 flooded homes and 92 flooded apartment units. There were four directly related drowning fatalities during this episode. Toddville Road in Seabrook was flooded.

Area Affected	Date	Deaths	Property Damage	Details
Harris, Tomball, Baytown	10/26/2006	0	$150,000	Flooded furniture store with six inches of water. Few Tomball area businesses and homes were reported flooded. Houston Flood Control District rain gauges were measuring near 4-inch per hour rainfall rates. Training thunderstorms moving across eastern Texas created flooding problems as the ground was already saturated from earlier month and morning rainfall. Flood waters entered five homes.
Harris, Houston, Cypress, Spring Valley Village, Aldine, Southside Place	5/10/2007	0	$650,000	Brickhouse Gully exceeded its banks. Total flooded northern Houston metro home count for the event was between 70 to 90 homes.
Harris, Houston, Hedwig Village, Cypress	05/30/2007	0	$0	High water over Flintdale Street causing the road to close. Metro traffic reported several cars underwater at Old Greenhouse Road and Kieth Harrow Boulevard near Bear Creek.
Harris, Houston	07/06/2007	0	$50,000	Numerous reports of street flooding around Houston metro. Reports of flooding at the intersection of Mesa Road and the Sam Houston Parkway. Flooding also reported around downtown Houston and northward up Interstate 45 toward the West Mont Houston area, where various roads were closed due to high water making them impassable.
Harris, Deer Park, Pasadena, La Porte, Clear Lake.	8/16/2007	3	$750,000	Numerous roads flooded and impassable across the eastern half of Harris County. Flooding in Deer Park, with two feet of water reported over portions of East Boulevard. Pasadena area flooding, as well as Beltway 8 exits being closed due to high water. House flooding also occurred in Pasadena. At least a dozen schools, majority of these being in East Houston, received water damage. There were reports of Vince Bayou exceeding its banks. Homes and businesses were also flooded in the La Porte area where some structures were inundated with more than a foot of water. There were three fatalities. Two men died when heavy rainfall collapsed the roof of a grocery store in Clear Lake. A third fatality occurred when an eighteen-wheeler was accidentally driven into a 26 foot deep flooded retention pond in La Porte.
Harris, Houston, Humble	10/15/2007	0	$5,000	Flooding caused numerous road closures north of Houston. Road closures were reported along FM 1960 and the Cypress Creek area.
Harris, Houston, Clear Lake, Shoreacres, Taylor Lake Village, Seabrook, County-wide	09/12-14/008	25	$3,000,000,000	Storm tide ranged from 10 to 15 feet above mean sea level along the Galveston Bay, Clear Lake and associated tributaries which caused major flooding of coastal areas. Number of injuries unknown. Shoreacres, Clear Lake Shores, Seabrook, and Taylor Lake Village were among the hard hit areas. There were at least 25 fatalities indirectly related to Ike.
Harris, Houston, Aldine, Humble	10/15/2008	0	$20,000	Flash flooding occurred from east southeast of the Aldine area northeastward toward Humble. Several vehicles were partially submerged in the flood waters.

Area Affected	Date	Deaths	Property Damage	Details
Harris, Houston, Jersey Village, Houston Heights, La Porte, Pasadena, Webster and Hobby	4/18/2009	5	$3,500,000	Heavy rainfall produced totals of 8 to 10 inches. Numerous roads were closed in areas of the county. More than 350 homes were flooded due to the heavy rains and flooding along bayous. In some areas residential streets were reported to have more than one foot of standing water. In the northern part of the county five children were killed after the car they were riding in inadvertently drove into a drainage ditch that was filled with nine feet of water from the heavy rainfall. Two adults and one child were able to escape the floodwaters, but the five younger children, all under 7 years old, were not able to escape. Numerous roads were closed in areas of the county, including Jersey Village, Houston Heights, La Porte, Pasadena, Webster, and near the Houston Hobby airport.
Harris, Friendswood, Baytown	4/24/2009	0	$1,000,000	Slow moving thunderstorms across the southern portion of Harris County produced widespread flooding and road closures. The heaviest rainfall fell along a line from Friendswood to Baytown, with totals of 7 to 8 inches during a 6 hour period. Many secondary roads along Interstate 45 became impassable for most of the evening. Forty to fifty homes received water damage from this event.
Harris, Bellaire, Missouri City,	4/28/2009	1	$15,000,000	A large, slow moving thunderstorm produced widespread heavy rainfall across western portions of Harris County during the early morning hours. Many roads including portions of U.S. 59, Interstate 10 West, Beltway 8 West, and the 610 Loop were impassable for most of the morning rush hour, with numerous cars becoming stranded by high water. One fatality occurred when a vehicle was swept into the drainage system near the Katy Freeway (Interstate 10 W) and Beltway 8. In addition to the major disruption to the morning commute, over 2,100 homes received some amount of water intrusion from this event. This ranks as the fourth largest number of homes flooded in a single event for Harris County.
Harris, Pasadena, Baytown, La Porte, Nassau Bay, Clear Lake, Friendswood	10/22/2009	0	$4,000	A line of thunderstorms associated with a slow moving cold front trained over a line from Friendswood to Pasadena to Baytown producing some localized flash flooding.
Harris, Houston	10/29/2009	0	$16,000	A broken line of strong to severe thunderstorms developed west of the Houston metro area during the afternoon and moved eastward causing several reports of flash flooding and a few wind damage reports.
Harris, Houston	05/14/2010	0	$5,000	Interstate 45 feeder roads were impassable due to high water over the roadway. One fatality occurred when a vehicle drove off the feeder road and into a retention pond. This occurred on the 6900 block of Interstate 45 between West Little York and West Parker Road.
Harris, Houston	07/02/2010	0	$1,750,000	Heavy rainfall caused flooding of 40 homes in Harris County along Halls, Hunting, and Little White Oak bayous.
Harris, Houston	01/09/2012	0	$20,000	Flash flooding lead to numerous high water rescues in and around the Houston area, especially across the southwest area.
Harris, Houston	01/25/2012	0	$25,000	Numerous roads in and around the Houston area were closed due to heavy rains and flooding.

Area Affected	Date	Deaths	Property Damage	Details
Harris, Houston	05/12/2012	0	$40,000	Rainfall totals of between five to ten inches produced widespread flooding. Street flooding was severe enough to force numerous road closures from northwestern Fort Bend County eastward into northern Galveston County. Homes and businesses flooded along Keegans Bayou from below Wilcrest Road to above Beltway 8. Thirteen to fifteen businesses flooded on the western bank of Keegans Bayou along West Bellfort Road between U.S. 59 and Wilcrest. This flooding was a direct result of the bayou over- topping its banks by 2 to 3 feet. Based on high water marks left on the Wilcrest bridge at least 1 foot of water was flowing over the top of the bridge deck. 1 house flooded along Keegans Bayou between Beltway 8 and U.S. 59 from local run-off then from the bayou when it rose above bank full.
Harris, Houston	07/12/2012		$512,000	A stationary front focused thunderstorm development over the area on July 12 and 13 producing heavy rainfall and flooding. Water was reported in 71 homes in Harris County and 234 homes in Montgomery County. Spring, Willow and Little Cypress Creek watersheds were impacted.
Harris County, Houston	04/27/2013	0	$3,000,000	Heavy rain caused the flooding of numerous roads, that became impassable, across southwestern Harris County into eastern Fort Bend County. There were 98 homes and 2 businesses that were flooded. The majority of the flooded homes were in the Westbury area. Widespread significant street flooding occurred along U.S. Highway 59, the south 610 loop, and State Highway 288.
Harris, Houston	05/10/2013	0	$750,000	Clusters and lines of storms produced hail and flooding. In addition several homes and one individual were struck by lightning. There were numerous reports of flooding around the greater Houston metropolitan area.
Harris, Houston, Jersey Village	09/20/2013	0	$75,000	Heavy rain occurred over western Houston that lead to flash flooding. There were numerous stalled cars in high water near the Highway 290 and 610 loop intersection and also along Chimney Rock road just south of Highway 59. Harris County Flood Control District rain gauges measured between 4 to 5 inches over those areas.
Harris, Houston	10/31/2013	0	$0	A slow-moving storm system and associated frontal boundary generated heavy rainfall that led to flooding across portions of southeast Texas, especially in and around the Houston and Galveston areas.
Harris, Houston, Tomball	05/26 - 27/2014	0	$0	A shortwave disturbance produced slow moving clusters of thunderstorms that tracked north and east from the Gulf Coast the afternoon of May 26th and 27th.
Harris, Houston	05/28/2014	0	$0	A shortwave disturbance passing around a southeastern Oklahoma-centered upper low initiated regional severe thunderstorms.
Harris County	07/03/2014	0	$5,000	Heavy rainfall from this activity caused street flooding on the west side of Houston. Heavy rain caused several streets to flood in and around the Spring Branch area.
Harris, Houston, Pasadena	08/01/2014	0	$100,000	Heavy rain caused flooding to enter homes in the Aldine Bender area. There were several flooded roadways in and around the northern Houston area, generally located inside the Sam Houston Beltway. Some notable one hour rainfall rates were 4.16 inches at Greens Bayou and Highway 59 and 3.96 inches at Jefferson and Highway 59.

Area Affected	Date	Deaths	Property Damage	Details
Harris, Houston	09/16/2014	0	$0	A highly moist air mass streaming in from a Pacific moisture plume, along with southwestern disturbances originating from western Pacific Hurricane Odile, initiated numerous areas of rain with embedded thunderstorms. Localized cells produced high rainfall rates over Houston that caused urban flooding.
Harris, Sugar Land, Houston, Cypress, Hillshire Village, The Village area, Stafford, Hunters Creek Village	09/18/2014	0	$25,000	Numerous locations from the Cypress area to the Sugar Land area to the Houston area were flooded, including the corner of Westheimer Road and Fountain View Drive, George Bush State Park in the Cinco Ranch area, the Cypress area, the left exit lane of 610 South Loop West, parts of Eldridge Parkway, portions of Hidalgo Street near the Galleria area, parts of the Fairwood subdivision, the intersection of Bering Drive and Richmond Avenue, the Interstate 610 East Loop and Clinton Drive, Old Katy Road near the Hillshire Village area, and the 13600 block of FM 1092 near Stafford. The heavy rainfall did cause an old oak tree to collapse in Hunters Creek Village.
Harris, Houston, Katy, Bellaire	09/19/2014	0	$1,000	Flooding was reported from just east of the Katy area to the Bellaire area. Flooded areas included Saums Road near the intersection of both Barker Cypress Road and Greenhouse Road, the intersection of Fondren Road and Bissonnet Street, the Cullen Park area, the Avenue D area between First Street and Sixth Street, the intersection of Gerrner Road and U.S. Highway 59, and Richmond Avenue in the Galleria area.
Houston, Bellaire, Pasadena, La Porte	04/17/2015	0	$300,000	There were numerous reports of flooded roadways and stranded vehicles in high water in and around the city of Houston, Bellaire, Pasadena, La Porte and the Clear Lake/Webster areas. There were fire department high water rescues over the southeastern sector of the county. Impassable roads due to high flood waters include, but are not limited to, South Shepard Street, West Alabama Street, Westheimer Street, Bellaire Blvd, Spur 527 off of Highway 59, Scarsdale Blvd in Pasadena and southbound feeder roads of I-45 around Hobby Airport. There was water in a home off of Scarsdale Blvd in Pasadena. There were approximately 40 flooded homes in the town of La Porte.
Webster	5/12/2015	1	$800,000	Widespread street flooding occurred throughout the Webster area with 50 to 100 stranded or flooded vehicles. There was water in cars at a dealership at the intersection of El Dorado Blvd and Interstate 45. High water rescues were conducted in the Clear Lake area. There was one fatality when a male was swept away during one of the rescues. Flooding was reported at the Green Oaks Apartments at the intersection of Highway 3 and Pineloch Drive. There was a furniture store roof collapse due to the weight of the water.

Area Affected	Date	Deaths	Property Damage	Details
Houston, Orr	10/31/2015	2	$1,000,000	There was widespread flooding across the city of Houston and surrounding areas. The worst flooding occurred across eastern and southern Houston and towns north and east of the city. Numerous roadways were flooded including all main lanes of Highway 288 north of Brays Bayou. High rainfall rates caused Brays Bayou to go out of banks and inundate the Lawndale Wayside part of eastern Houston. Four to five feet of water flowed over North Macgregor Way between Merry Lane and Wildwood Way. High water rescues were conducted by the fire department with a half a foot of water entering Fire Station 26 in southeast Houston near Telephone and Bellfort Streets. Highway 59 at Will Clayton Parkway south of Humble was impassable due to high water. Approximately 40 homes were flooded in the Cloverleaf subdivision near Interstate 10 and Beltway 8. Hunting Bayou went out of banks and flooded neighboring homes. High water rescues were performed on Autumnwood and Wood Shadows Drives near Hunting Bayou. A shopping district and surrounding parking lots were flooded in the Crosby and Barrett areas.
Countywide	04/18/2016	7	$35,000,000	Heavy rain caused extensive flooding especially over western half of the county where 10 to 15 inches of rain fell in less than a 12-hour period. An estimated 40,000 vehicles and 10,000 homes were flooded. Seven people in Harris County drowned in their vehicles when they drove into flooded roadways. There were numerous high-water rescues.
Hurricane Harvey	08/26/2017	36	$10 Billion	Harvey made landfall as a category 4 hurricane near Rockport, Texas during the evening of August 25th. The storm then weakened to a tropical storm and slowed, looping back and tracking over SE Texas then back over the Gulf of Mexico making a second landfall along the Louisiana coast during the early morning hours of August 30th. Over that 5 day period over Southeast Texas TS Harvey produced catastrophic flooding with a large area of 30 to 60 inches of rain, 23 tornados, tropical storm force winds and a moderate storm surge near Matagorda Bay. In some of the heavier bands rain fell at a rate of over 5 inches per hour. This copious record amount of rain over a led to catastrophic flooding. Thousands of homes, businesses, and roads were flooded due to flash flooding and sheet flow from long duration intense rain. Main stem rivers and adjoining tributaries, creeks and bayous reached full capacity and came out of their banks and this also contributed to the massive flooding across southeastern Texas.
TOTAL		**215[a]**	**$16,211,752,000**	

Appendix E. Plan Adoption Resolutions from Planning Partners

PLAN ADOPTION RESOLUTIONS FROM PLANNING PARTNERS

To Be Provided With Final Draft