Texas Water Development Board

VOLUME 1

2023 REGIONAL FLOOD PLAN
REGION 6
SAN JACINTO

July 2023

PREPARED FOR THE **SAN JACINTO REGIONAL FLOOD PLANNING GROUP**

2023 Amended Regional Flood Plan

Prepared by:

Region 6 San Jacinto Regional Flood Planning Group

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Amendments were made to the Executive Summary, Chapter 4-6, and Chapter 9-10.

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LIST OF ABBREVIATIONS AND DEFINITIONS

Abbreviation	Name	Meaning
ASCE	American Society of Civil Engineers	Organization of professionals in civil engineering. ASCE releases state and national Report Cards for infrastructure examining current conditions and needs.
ACE	Annual Chance Exceedance	The estimated mean probability that a flood event will occur in any given year. For example, the 1.0% ACE has a one percent chance of occurring in any given year. A 1.0% ACE event is sometimes also referred to as a 100-year flood event.
BFE	Base Flood Elevation	Regulatory term meaning the elevation of surface water resulting from a flood that has a 1.0% chance of equaling or exceeding that level in any given year.
BLE	Base Level Engineering	BLE is a high-level process using best available data and automated techniques to produce approximate, regulatory-quality flood hazard extents.
BCA	Benefit Cost Analysis	BCA is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The end result is a Benefit-Cost Ratio.
BCR	Benefit Cost Ratio	Numerical expression of the "cost-effectiveness" of a project, calculated by a project’s total benefits divided by its total costs.
BRIC	Building Resilient Infrastructure and Communities	Federal funding program run by FEMA. This program supports communities as they undertake hazard mitigation projects to reduce risk from natural hazards.
CDC	Centers for Disease Control and Prevention	Federal agency focused on protecting public health including emergency preparedness.
CDBG	Community Development Block Grant	
CRS	Community Rating System	FEMA program to provide incentives for those communities that have gone beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding.
-	Critical Facilities	A critical facility provides services and functions essential to a community, especially during and after a disaster. Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, and similar facilities.
-	Dam Safety Program	The Dam Safety Program monitors and regulates both private and public dams in Texas. The program periodically inspects dams that pose a high or significant hazard.

Abbreviation	Name	Meaning
DCM	Drainage Criteria Manual	A DCM establish the drainage design standards and methods for a community.
EAP	Emergency Action Plan	An EAP is a written document that identifies potential emergency conditions and specifies pre-planned actions to be followed to minimize property damage, potential loss of infrastructure, and potential loss of life.
EPA	Environmental Protection Agency	Federal Agency that monitors environmental conditions including a number of topics related to water.
FEMA	Federal Emergency Management Agency	Federal Agency responsible for emergency management activities before, during, and after disasters. FEMA manages several flood related grant programs and is responsible for the NFIP and maintains FIRM maps.
FAFDS	First American Flood Data Services or Fathom	Flood risk data generated by a large, state-wide model and is based entirely on the expected rainfall in a given area. It is considered the least-accurate of the floodplains available to the Regional Flood Planning Group.
FAQ	Frequently Asked Question	
-	Flood Exposure	For the purposes of flood planning, flood exposure analyses will identify who and what might be harmed by flood including each structure located in flood hazard area.
-	Flood Hazard	For the purposes of flood planning, flood hazard analyses will determine the location, extent, magnitude, and frequency of flooding.
FIF	Flood Infrastructure Fund	Financial assistance program in the form of loans and grants for flood control, flood mitigation, and drainage projects and is administered by the TWDB.
FIRM	Flood Insurance Rate Map	Official map of a community on which FEMA has delineated the Special Flood Hazard Areas (SFHAs), the BFEs, and the food zones applicable to the community.
FIS	Flood Insurance Study	A compilation of flood risk data within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS.
FME	Flood Management Evaluation	A FME is a proposed flood study of a specific, flood-prone area that is needed in order to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs.
FMP	Flood Management Project	A FMP is a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring cost and when implemented will reduce flood risk, mitigate flood hazards to life or property.

Abbreviation	Name	Meaning
FMS	Flood Management Strategy	A FMS is a proposed plan to reduce flood risk or mitigate flood hazards to life or property. FMSs include any proposed action that the RFPG would like to identify, evaluate, and recommend that does not qualify as either a FME or FMP.
-	Flood Readiness and Resilience	Non-structural projects/programs aimed at improving flood preparedness and response to flood events including: plan activation, chain of command, emergency functions, evacuation procedures, flood early warning systems, and/or resilience measures to be implemented to reduce flood damage.
-	Flood Risk	For the purposes of regional flood planning, flood risk analyses will comprise a three-step process of flood hazard, flood exposure, and vulnerability analyses
-	Flood Vulnerability	For the purposes of flood planning, vulnerability analyses will identify vulnerabilities of communities and critical facilities located within the region.
-	Freeboard	An additional amount of height above the BFE used as a factor of safety in determining a structures elevation.
GIS	Graphic Information System	GIS connects data to a map, integrating location data (where things are) with descriptive information (what things are like there).
HGAC	Houston-Galveston Area Council	
HMAP	Hazard Mitigation Action Plan	HMAP reduces loss of life and property by minimizing the impact of disasters. Communities identify natural disaster risks and vulnerabilities in the area.
HMGP	Hazard Mitigation Grant Program	
H&H	Hydrology and Hydraulics	
LOS	Level of Service of Asset	A measure of the level of protection a flood infrastructure asset provides in terms of annual exceedance probability.
LWC	Low Water Crossing	A roadway creek crossing that is subject to frequent inundation during storm events or subject to inundation during a 50% ACE (2-year) storm event. During the first planning cycle, the RFPGs have the flexibility to utilize the community’s discretion to identify a roadway creek crossing as LWC.
MOU	Memorandum of Understanding	

Abbreviation	Name	Meaning
NCEI	National Centers for Environmental Information	
NFHL	National Flood Hazard Layer	NFHL is a geospatial database that contains current effective flood hazard data. FEMA provides the flood hazard data to support the National Flood Insurance Program.
NFIP	National Flood Insurance Program	NFIP is managed by FEMA and provides insurance to help reduce the socio-economic impact of floods.
NOAA	National Oceanic and Atmospheric Administration	Federal Agency that monitors and forecasts weather and climate conditions.
OPC	Opinion of Probable Cost	Planning level cost estimate for flood mitigation actions. Project cost estimates in the 2023 Regional Flood Plan are presented in year 2020 dollars.
PIO	Public Information Officer	
RFPG	Regional Flood Planning Group	The generic term for the planning groups that oversee the regional flood plan development in each region in the State of Texas.
SB	Senate Bill	
SVI	Social Vulnerability Index	SVI ranks each Census tract on 15 social factors that influence a community's ability to prepare for, respond to, and recover from a disaster.
SFHA	Special Flood Hazard Area	Regulatory term for an area having special food, mudflow, or food-related erosion hazards, and shown on an FHBM or FIRM.
TAC	Texas Administrative Code	The development of the regional flood plan must follow specific criteria as outlined in the Texas Administrative Code (TAC). The flood plan requirements may be found at 31TAC, Chapter 361, Subchapter C, Regional Flood Plan Requirements and 31 TAC, Chapter 362, State Flood Planning Guideline Rules, Subchapter A, State Flood Plan Development. These rules contain procedures and guidelines for the development of the regional flood plan.
TCEQ	Texas Commission on Environmental Quality	Environmental agency for the state of Texas responsible for maintaining water quality and availability and the Texas Dam Safety Program.
TDA	Texas Department of Agriculture	

Abbreviation	Name	Meaning
TXDOT	Texas Department of Transportation	
TDEM	Texas Division of Emergency Management	
TFMA	Texas Floodplain Management Association	An organization of professionals involved in floodplain management, flood hazard mitigation, the NFIP, flood preparedness, warning and disaster recovery.
TNRIS	Texas Natural Resources Information System	TNRIS is a division of the TWDB that maintains historic and current geospatial data products.
TSSWCB	Texas State Soil and Water Conservation Board	
TWDB	Texas Water Development Board	Texas Agency with oversight of regional flood plan development.
WSEL	Water Surface Elevation	

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CHAPTER 0. EXECUTIVE SUMMARY

In the wake of historic flooding in Texas, the 86th Texas Legislature passed Senate Bill 8 in 2019 that authorized and established the regional and state flood mitigation planning processes and assigned the responsibility for flood mitigation planning process to the Texas Water Development Board (TWDB). The San Jacinto Regional Flood Planning Group (San Jacinto RFPG) is one of 15 Regional Flood Planning Groups (RFPGs) formed by the TWDB to develop river basin-specific Regional Flood Plans (RFPs). This report presents the Region 6 San Jacinto Regional Flood Plan, which represents the first-ever flood plan for the San Jacinto River basin.

The TWDB will compile these RFPs into a single comprehensive statewide flood plan and will present it to the Legislature in 2024. A summary of major plan milestones is presented in **Table 0-1**. An updated version of each RFP will be due every five years thereafter. In this first planning cycle, the TWDB allocated additional funding to each of the 15 RFPGs to perform additional tasks. These tasks were outside of the original scope of the RFP due in January 2023; thus, they will be part of the Amended Regional Flood Plans which are due in July 2023.

TABLE 0-1: REGIONAL FLOOD PLAN DEADLINES

Plan Deliverable	Deadline
Draft Regional Flood Plan	August 1, 2022
Final Regional Flood Plan	January 10, 2023
Amended Regional Flood Plan	July 14, 2023
State Flood Plan	September 1, 2024

The TWDB has appointed a Regional Flood Planning Group (RFPG) for each major river basin in Texas. The Region 6 RFPG was established by the TWDB on October 1, 2020, to manage the flood mitigation planning efforts for the San Jacinto River basin and is designated as the Region 6 San Jacinto Flood Planning Region (San Jacinto region). The TWDB administers the regional planning process through a contract with the RFPG's sponsor, who is selected by the RFPG. The Region 6 sponsor is the Harris County Engineering Department. The Texas State Legislature also allocated funding to be distributed by the TWDB for the preparation of the RFPs and procurement of technical assistance.

The RFPG's responsibilities include directing the work of their technical consultant, soliciting and considering public input, identifying specific flood risks, and identifying and recommending flood management evaluations, strategies, and projects to reduce risk in their regions. To promote input from diverse perspectives, voting members of the RFPGs represent a wide variety of stakeholders potentially impacted by flooding, including:

- Agricultural Interests
- Counties
- Coastal Communities
- Electric Generating Utilities
- Environmental Interests
- Flood Districts
- Industries
- Municipalities
- Public
- River Authorities
- Small Business
- Upper Watershed
- Water Districts
- Water Utilities

In addition to voting members, non-voting members of the RFPGs increase the diversity of the group for input on the plan and include:

- General Land Office (GLO)
- Gulf Coast Protection District (GCPD)
- Harris-Galveston Subsidence District (HGSD)
- Houston-Galveston Area Council (H-GAC)
- TWDB Region H Regional Water Planning Group
- Texas Commission on Environmental Quality (TCEQ)
- Texas Department of Agriculture (TDA)
- Port of Houston
- Texas Division of Emergency Management (TDEM)
- Texas Department of Transportation (TXDOT)
- Texas Parks and Wildlife Department (TPWD)
- Texas Water Development Board (TWDB)
- Texas State Soil and Water Conservation Board (TSSWCB)
- U.S. Army Corps of Engineers (USACE)

Task 1. Planning Area Description

San Jacinto region includes all or parts of 11 counties and extends from Galveston County in the south to Walker County in the north. The San Jacinto River basin drainage area (San Jacinto region) covers a wide variety of landscapes and communities served by a vast network of natural and constructed flood infrastructure, including approximately 3,700 stream miles of various creeks, bayous, and urban drainage systems as well as thousands of acres of ponds, reservoirs, and wetlands. Land surface elevations across the San Jacinto region range from several feet below sea level in the tidal and coastal region to approximately 400 feet above sea level in northern Walker County. **Figure 0-1** provides an overview of the San Jacinto region.

FIGURE 0-1: SAN JACINTO REGION OVERVIEW

The San Jacinto region encompasses 5,089 square miles, making it the second smallest flood planning region in the state by area. However, the region is the second most populous, with an estimated population in 2020 of 6.4 million. With a population density of 1,200 people per square mile, the San Jacinto region is also the most densely populated region in the state, with double the population density of any other region. The extensive development and proximity to the coast make flooding a particular issue of interest and need; the San Jacinto region has the highest amount of National Flood Insurance Program (NFIP) claims of any region in the state, from 1975 to 2019. Approximately 21% of Texas residents live in the area. It is a geographically diverse region where the needs of rural stakeholders must be balanced with those of rapidly developing urban population centers.

While there are a total of 92 municipalities across the region, most of the population is centered around the Greater Houston Area, as well as communities near the coast. Incorporated major cities are listed in **Table 0-2**.

TABLE 0-2: MAJOR CITIES IN THE SAN JACINTO REGION

City	Population	City	Population
Houston	2,304,600	Conroe	90,000
Pasadena	152,000	Atascocita	88,200
Pearland	125,800	Baytown	83,700
The Woodlands	114,400	Missouri City	74,300
League City	114,400	Galveston	53,700

Source: 2020 Census Redistricting (census.gov)

Most of the region is projected to experience high levels of population growth over the next 30 years, primarily in Montgomery and Harris Counties and in the currently urbanized parts of Galveston County. From 2020 to 2050, the population in the San Jacinto region is expected to grow by 33% to 8,454,389 residents, based on Water User Group and Hydrologic Unit Code (HUC) 8 population projection data provided by the TWDB. One of the largest challenges associated with this growth is determining how to manage development responsibly and continue to preserve the region’s natural resources.

The San Jacinto region has a lengthy history of flooding. For reference, from 1836 to 1936, the region was impacted by at least 16 major flooding events. These numerous flood events have caused billions of dollars in damages and thousands of fatalities. Two flooding events of historic nature bookend the region’s flooding history starting with the Great Galveston Storm of 1900 and more recently with Hurricane Harvey. The Galveston Storm of 1900 is still considered the deadliest natural disaster in American history with a loss of between 6,000 and 12,000 lives. On the more recent side of that timeline, Hurricane Harvey in August of 2017, was the largest known rainfall event ever recorded in United States history resulting in historic flood damages across the entire region.

Task 2. Flood Risk Analysis

The objective of Task 2 is to perform a comprehensive and cohesive flood risk analysis for the region. Flood risks were assessed for the 1.0% annual chance event (ACE) and 0.2% ACE. The ACE references the probablility that a rain event of a certain magnitude will occur within a given year. The analysis was performed for existing conditions of the region, as well as for a future condition scenario that considers changes in flood hazards over a 30-year planning horizon.

The goal of the exposure analysis is to identify who and what might be harmed within the San Jacinto region by flooding. Vulnerability analysis is an assessment of the potential negative impact of the flood hazard to communities and a description of the impacts. This task uses the data from the existing flood exposure analysis to determine the vulnerability of exposed structures and population to flooding. This task helps determine a region-wide evaluation of the risk associated with inundation from existing and future 1.0% and 0.2% ACE floods.

Existing flood hazard was determined based on available floodplain mapping information in the Flood Hazard Quilt provided by the TWDB in the Flood Planning Data Hub website. The feature is predominately Effective FEMA Flood Hazard Data mapping supplemented by some instances of Base Level Engineering (BLE) and FEMA Effective Approximate as shown in **Figure 0-2**. The most updated rainfall data used in flood hazard mapping were TP40, which was originally released in 1960s and, although updated, only accounts for historical storms of record through the early 2010s. Atlas 14 rainfall data, produced by the National Oceanic and Atmospheric Administration (NOAA), are the most recent estimate of rainfall for Texas; it considers historical rainfall records up to and including Hurricane Harvey in 2017. There are significant depth increases in rainfall amounts between the TP40 and Atlas 14 data in the San Jacinto region. As the differences in rainfall amounts are significant, there will be opportunity in future cycles to update the existing flood hazard features mapped to reflect the updated rainfall methodologies used in Atlas 14.

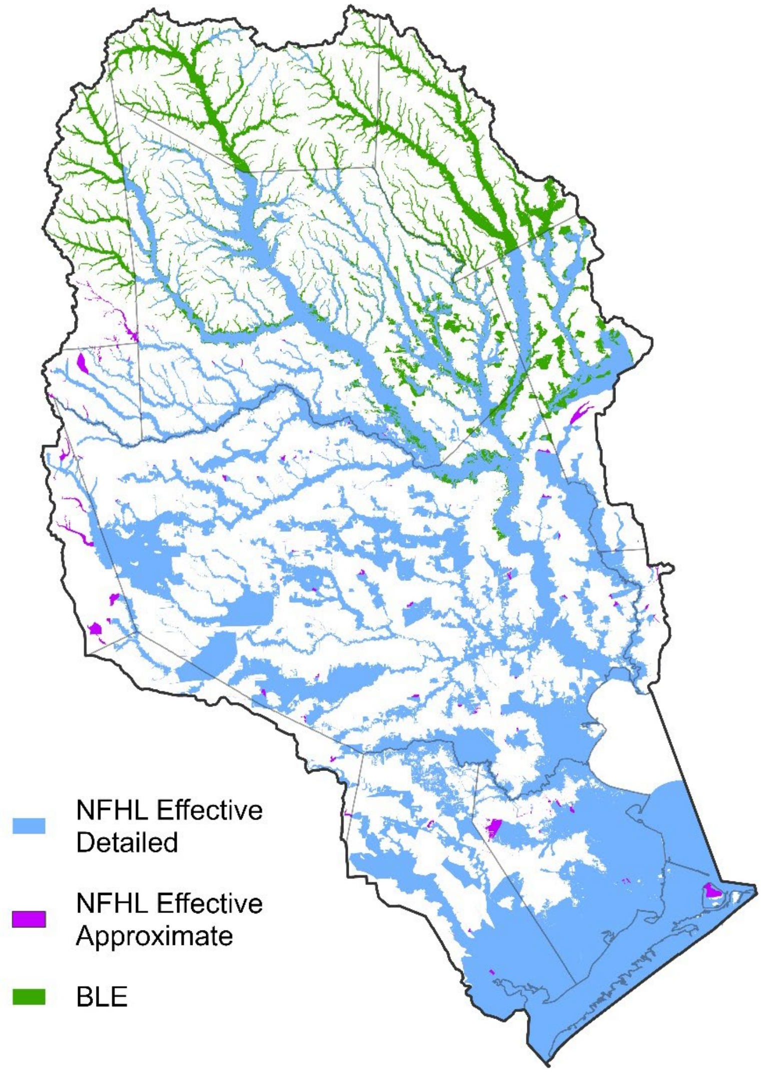

FIGURE 0-2: BEST AVAILABLE FLOOD HAZARD DATA

Task 3. Floodplain Management Practices and Flood Protection Goals

In Texas, authority for enforcing floodplain management regulations lies with local governments such as cities and counties. It is important to note that RFPGs themselves do not have the authority to enact or enforce floodplain management, land use, or other infrastructure design standards. Any standards recommended by the RFPG are aimed at encouraging implementation by local entities in the region with regulatory authority. The RFPG encourages cities and counties without floodplain ordinances or court orders to develop, adopt, implement, and enforce floodplain regulations that at least meet the NFIP minimum standard and, where appropriate, consider adopting higher standards to provide higher levels of protection against loss of life and property due to flooding. Additionally, floodplain management regulatory practices could benefit by being clear, easily interpretable, broadly understood, realistic, and consistently enforced. Doing so would provide forward guidance on new development expectations. The flood management practices and standards recommended by the San Jacinto RFPG are listed in **Table 0-3.**

TABLE 0-3: RECOMMENDED MINIMUM FLOODPLAIN MANAGEMENT STANDARDS

Recommended Minimum Standard	Definition
Participation in the National Flood Insurance Program (NFIP)	• All regulatory entities implement ordinances that meet minimum requirements per the NFIP. • All regulatory entities remain active NFIP participants in good standing. • All regulatory entities are encouraged to participate in the Community Rating System (CRS) Program to reduce flood insurance rate premiums across the region.
Development of No Adverse Impact Policies	• All regulatory entities are encouraged to define a no adverse impact policy. • The no adverse impact policy should be focused on preventing negative impacts. Evaluation of impacts should be completed using best available hydrologic and hydraulic (H&H) modeling, where appropriate.
Establish Minimum Finished Floor Elevations	• All new habitable structures shall have a finished floor elevation established at or above or waterproofed to the FEMA effective 0.2% ACE flood elevation as shown in effective Flood Insurance Studies except in areas designated as coastal flood zones. • Where regulatory mapping has been updated using Atlas 14 rainfall data, all new habitable structures shall have a finished floor elevation established at or above or waterproofed to the FEMA effective 1.0% ACE flood elevation as shown on effective Flood Insurance Studies except in areas designated as coastal flood zones. • In areas designated as coastal flood zones, all new habitable structures shall have a finished floor elevation established at or above or waterproofed to the FEMA effective 1.0% ACE flood elevation as shown on effective FIRMS plus 1 foot of freeboard.
Encourage Use of Best Available Data	• Utilize the latest rainfall data (NOAA Atlas 14) when conducting new analyses, designing drainage infrastructure, or developing regulations and criteria.

Recommended Minimum Standard	Definition
Compensatory Storage Requirements in the 1.0% ACE Floodplain	• Any reduction in floodplain storage or conveyance capacity within the 1.0% ACE regulatory floodplain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction, except in areas identified as coastal flood zones. • A full H&H analysis should be performed to demonstrate that floodplain fill mitigation provided is sufficient.
Compensatory Storage Requirements in the 0.2% ACE Floodplain	• Any reduction in floodplain storage or conveyance capacity within the 0.2% ACE regulatory floodplain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction, except in areas identified as coastal flood zones. • A full H&H analysis should be performed to demonstrate that floodplain fill mitigation provided is sufficient.
Development of Detailed H&H Analysis Criteria/ Requirements	• All regulatory entities develop H&H modeling criteria or requirements. • All regulatory entities identify features of a proposed development that would warrant a full H&H analysis.
Incentivizing the Preservation of the Floodplain	• All regulatory entities are encouraged to explore and develop systems for incentivizing the preservation of the floodplain directly within the regulatory floodplain or within 100 feet of the banks of unstudied streams.

The San Jacinto RFPG discussed potential goals for the regional flood plan over a series of monthly meetings. The adopted goals are listed in **Table 0-4**.

TABLE 0-4: ADOPTED FLOOD MITIGATION AND FLOODPLAIN MANAGEMENT GOALS

Goal ID	Goal	Term of Goal	Target Year	Metric
06000001	There will be 0 flood-related fatalities annually within the San Jacinto region by 2053.	Long Term (30-year)	2053	Number of direct flood-related fatalities.
06000002	Increase the value of state and federal funds awarded within the San Jacinto region by 10%.	Short Term (10-year)	2033	State and federal funds awarded to communities within the San Jacinto region.
06000003	Reduce the miles of major roadways subject to inundation during the 1% ACE by 10% by 2033.	Short Term (10-year)	2033	Number of miles of major thoroughfares subject to 1% ACE flood risk.
06000004	Reduce the miles of major roadways subject to inundation during the 1% ACE event by 25% by 2053.	Long Term (30-year)	2053	Number of miles of major thoroughfares subject to 1% ACE flood risk.
06000005	Increase the number of public entities that invest in stormwater infrastructure and planning by 10% by 2033.	Short Term (10-year)	2033	Number of public entities that dedicate funding towards stormwater infrastructure and planning.
06000006	Increase the number of entities that invest in stormwater infrastructure and planning by 25% by 2053.	Long Term (30-year)	2053	Number of public entities that dedicate funding towards stormwater infrastructure and planning.
06000007	All flood regulatory authorities within the San Jacinto region will adopt standards that equal or exceed minimums recommended by the San Jacinto RFPG in the first cycle of regional flood planning.	Short Term (10-year)	2033	Number of flood regulatory authorities that adopt standards equal to or exceeding recommended minimums by the RFPG in the first cycle.

Goal ID	Goal	Term of Goal	Target Year	Metric
06000008	Improve interjurisdictional coordination through participation in the San Jacinto Regional Flood (SJRF) Planning process. Target to ensure that 50% of identified stakeholders complete the SJRFP stakeholder survey and provide data for inclusion in the RFP by 2033.	Short Term (10-year)	2033	Number of identified stakeholders who submit survey responses or provide data for inclusion in the San Jacinto RFP.
06000009	Improve interjurisdictional coordination through participation in the SJRF Planning process. Target to ensure that 90% of identified stakeholders complete the San Jacinto RFP stakeholder survey and provide data for inclusion in the RFP by 2053.	Long Term (30-year)	2053	Number of identified stakeholders who submit survey responses or provide data for inclusion in the San Jacinto RFP.
06000010	Expand the understanding of flood risk in the San Jacinto region.	Short Term (10-year)	2033	Percentage of the floodplain quilt, by studied stream length, that is based on NOAA Atlas 14 rainfall data.
06000011	Reduce the number of critical facilities subject to inundation during the 1% ACE by 5% by 2033.	Short Term (10-year)	2033	Number of critical facilities subject to 1% ACE flood risk.
06000012	Reduce the number of critical facilities subject to inundation during the 1% ACE by 20% by 2053.	Long Term (30-year)	2053	Number of critical facilities subject to 1% ACE flood risk.
06000013	At least 35% of all flood mitigation strategies (FMSs) and flood mitigation projects (FMPs) identified within the RFP will incorporate nature-based practices by 2033.	Short Term (10-year)	2033	Number of FMSs and FMPs that incorporate nature-based practices as defined within the San Jacinto RFP.
06000014	At least 90% of flood mitigation strategies (FMSs) and flood mitigation projects (FMPs) identified within the regional flood plain will incorporate nature-based practices by 2053.	Long Term (30-year)	2053	Number of FMSs and FMPs that incorporate nature-based practices as defined within the San Jacinto RFP.
06000015	Reduce the number of structures subject to inundation during the 1% ACE by 25% by 2053.	Long Term (30-year)	2053	Number of structures subject to 1% ACE flood risk.

Task 4. Assessment and Identification of Flood Mitigation Needs

The RFPG conducted a flood mitigation needs analysis which considered a variety of criteria including:

- Flood risk exposure to buildings
- Critical infrastructure
- NFIP participation
- Lack of hydrologic and hydraulic models
- Existing flood risk mitigation plans
- Historic flooding reports
- Low water crossings
- Agriculture areas and other resources
- Gaps in flood mapping information
- Emergency need
- Previously identified flood mitigation projects
- Social vulnerability of communities

A scoring methodology was implemented across the entire San Jacinto region based on individual subwatersheds, identified as HUC-12s (Hydrologic Unit Code). Based on guidance from the San Jacinto RFPG, a total of nine data categories with 26 sub-categories were used in the geospatial assessment. A scoring system was determined for each data category based on the statistical distribution of the data, with an effort made to evenly distribute the number of HUCs with each score within a certain category to differentiate HUCs in the identification of higher need areas. A score ranging from one to five points was assigned to each HUC for each subcategory based on the type and distribution of data across all the HUC-12s. Subcategory scores were averaged to get a composite category score for each HUC. The scores for each HUC-12 under each category were then summed to obtain a total score that was used to determine where the greatest flood risk knowledge gaps and areas of greatest known flood risk exist.

The results of this preliminary assessment show that large portions of the San Jacinto region have both inadequate mapping/H&H models and few detailed studies. A large portion of the high knowledge gap area is within Harris County, which reflects older mapping. Harris County Flood Control District (HCFCD) is currently in the process of updating all the floodplain maps within Harris County through the Modeling, Assessment, and Awareness (MAAPnext) project. Adoption of these maps is anticipated to occur prior to the next cycle of regional flood planning. There are also large high knowledge gap areas in the northern portion of the region. This is primarily driven by outdated models and few, if any, master drainage plans (MDPs).

Next, the areas of greatest known flood risk and flood mitigation needs were determined. For each HUC-12 in the San Jacinto region, the scores across the remaining categories were added to obtain a total score. All categories have equal representation in the total score; however, the composite score for Category 1 was weighted 70% for existing conditions and 30% for future conditions.

Finally, potential flood mitigation actions were identified starting with conducting research on stakeholder input and publicly available data. The list of potential FMEs, FMSs, and FMPs is based on contributions from the RFPG and stakeholder outreach. Based on the results of the flood mitigation needs analysis, several sources of data were used to develop a list of 650 potential flood risk reduction actions that may address the San Jacinto region's needs. These actions were then analyzed for feasibility on a variety of factors to determine if they should be included in the final RFP. Once potential flood risk reduction actions were identified, initial classification was completed to sort actions into an appropriate type, broadly categorized into three distinct types, as defined below and outlined in **Figure 0-3**:

- **Flood Management Evaluation (FME)**: a proposed flood study of a specific, flood prone area that is needed in order to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs.
- **Flood Mitigation Project (FMP)**: a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring cost and, when implemented, will reduce flood risk or mitigate flood hazards to life or property.
- **Flood Management Strategy (FMS)**: a proposed plan to reduce flood risk or mitigate flood hazards to life or property.

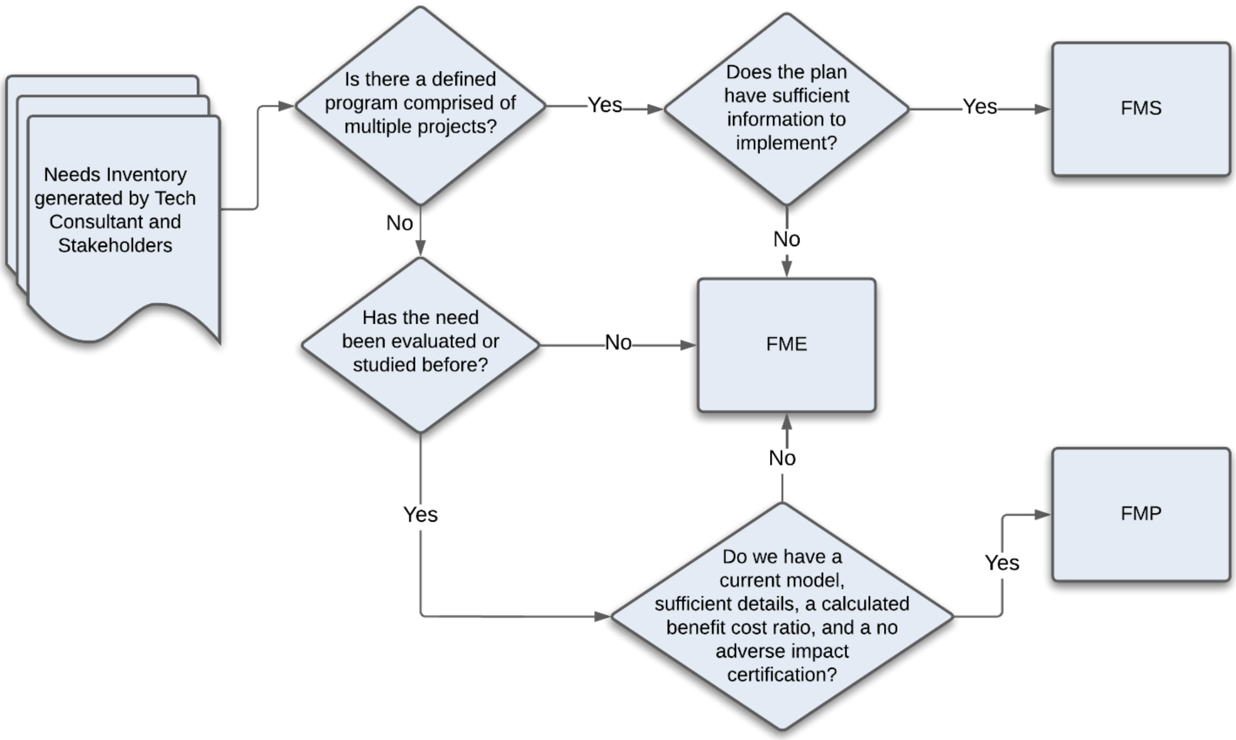

FIGURE 0-3: FLOOD RISK REDUCTION ACTION CLASSIFICATION PROCESS

All FMSs and FMPs must demonstrate that implementation will not negatively affect a neighboring area, based on best available data. Demonstrations of no negative impact must reference 1.0% ACE water surface elevations (WSEs) and peak discharges in pre-project and post-project conditions. Additionally, all FMPs are required to provide a benefit-cost ratio (BCR) which is calculated by dividing the project's total benefits, quantified as a dollar amount, by its total costs. The BCR is a numerical expression of the relative "cost-effectiveness" of a project. A project is generally considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (Federal Emergency Management Agency, 2009). However, a BCR greater than 1.0 is not a requirement for inclusion in the RFP. The lack of a BCR was the only missing requirement of a large group of mitigation actions, which required their classification as an FME.

Task 5. Evaluation and Recommendation of Flood Management Evaluations, Flood Management Strategies, and Associated Flood Mitigation Projects

As part of Task 5, FMEs, FMSs, and FMPs were further evaluated in order to compile the necessary technical data for the RFPG to decide whether to recommend these actions or a subset of these actions. The RFPG considered recommendations on flood mitigation actions through a multi-step process. The general methodology included a screening of all potential flood mitigation actions considering TWDB requirements for inclusion in the RFP. The reasons for not recommending a particular flood mitigation action were clearly documented as part of the evaluation and recommendation process.

FMEs were recommended when additional studies are necessary to adequately evaluate flood prone areas within a region. FMEs include a variety of studies that allow communities to assess flood risk and further define future FMPs and FMSs. Some areas of the region began the regional flood planning process with more flood risk, flood planning, and flood project information than others. The recommended FMEs of areas with less prior information will serve to inform the next planning cycle.

FMSs and FMPs were recommended based upon the identification, analysis, and comparison of alternatives that the RFPG determined to provide measurable reductions in flood impacts in support of the RFPG's specific flood mitigation and floodplain management goals.

The RFPG set criteria to determine which identified potential FMSs and FMPs would be recommended in the RFP to ensure that the recommended FMSs and FMPs are sensible and allowing for efficient resource allocation to implement resulting studies and evaluations. The San Jacinto RFPG considered the following criteria when recommending FMSs and FMPs:

- No adverse impact
- High existing flood need
- Quantifiable flood risk reduction benefits
- Regional benefit (1.0 square mile minimum area)
- Existing flood risk to critical facilities
- Alignment with RFPG goals

The tables below show a summary of recommended FMPs (**Table 0-5**), and the distribution by type of recommended FMSs (**Table 0-6**), and FMEs (**Table 0-7**).

TABLE 0-5: SUMMARY OF RECOMMENDED FLOOD MITIGATION PROJECTS

Structural	FMP Type	Number of Recommended FMPs	Total Cost of Recommended FMPs
Yes	Comprehensive; Master Drainage Plan projects; Coastal	50	$31,683,337,000
No	Preparedness; Improve regulations and permit requirements	20	$1,876,000
	Total	**70**	**$31,685,213,000**

Nonstructural FMPs include property or easement acquisition, elevation of individual structures, flood early warning systems, permit requirements, and other similar projects. When identifying and recommending FMPs, emphasis was placed on mitigation and preparedness. Structural FMPs have the most immediate impact to the region and include actions that mitigate flood risk by constructing projects that reduce the frequency, intensity, and/or height of flood damage. These types of FMPs most frequently involve conveyance improvements combined with regional detention to mitigate any potential negative impacts in the upland regions, and a complex barrier system in the coastal regions.

TABLE 0-6: SUMMARY OF RECOMMENDED FLOOD MITIGATION STRATEGIES

FMS Type	FMS Description	Number of FMSs Recommended	Total Cost of Recommended FMSs
Education and Outreach	Programs or initiatives that aim to educate the public on the hazards and risks of flooding.	15	$5,370,000
Flood Measurement and Warning	Installation of or improvements to rain or stream gauges to monitor water levels and have real-time feedback during flood events.	6	$1,207,720
Infrastructure Projects	Critical maintenance and improvements to existing drainage systems throughout a community.	8	$16,030,000
Property Acquisition and Structural Elevation	Buyouts or elevation of structures with high flood risk or historical flooding impact as well as land preservation and restoration programs.	17	$1,166,975,000
Regulatory and Guidance	Updates or creation of new ordinances, development codes, design standards, or other floodplain management regulations to minimize future flood risk or reduce current flood risk.	10	$5,705,000
Other	Other flood management strategies that do not fit into one of the above categories	9	$4,335,000
	Total	**65**	**$1,199,622,720**

TABLE 0-7: SUMMARY OF RECOMMENDED FLOOD MITIGATION EVALUATIONS

FME Type	FME Description	Number of Recommended FMEs	Total Cost of Recommended FMEs
Watershed Planning	Flood mapping updates; master drainage plans	148	$742,372,000
Project Planning	Updated H&H modeling; Additional engineering analysis	255	$162,955,000
Preparedness	Studies on flood preparedness	1	$20,000
Other	Bayou protection or flood risk management studies	1	$30,000
	Total	**405**	**$905,377,000**

Task 6. Impacts of the Regional Flood Plan

The goal of Task 6 is to summarize the overall impacts of the RFP. This includes potential impacts to areas at risk of flooding, structures and populations in the floodplain, number of low water crossings impacted, impacts to future flood risk, impact to water supply and overall impact on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation. **Table 0-8** summarizes the benefit to people and property expected if the recommended FMPs are implemented.

TABLE 0-8: SUMMARY OF IMPACT ON PEOPLE AND PROPERTY AFTER IMPLEMENTATION OF RFP FLOOD MITIGATION PROJECTS

Annual Chance Exceedance	Flood Exposure Region-wide	Existing Conditions	After Implementation	Reduction in Exposure
0.2%	Total Structures	222,487	100,853	121,634
1.0%	Total Structures	389,734	275,790	113,944
	Residential Structures	329,756	235,276	94,480
	Critical Facilities	6,368	4,039	2,329
	Population	1,063,932	557,091	506,841
	Low Water Crossings (LWCs)	160	138	22

FMPs would reduce the number of structures in the 1.0% ACE floodplain by over 113,000, including 94,000 residential structures. This would reduce flood risk for approximately 505,000 people living within the 1.0% ACE floodplain. An estimated 22 low water crossings would be removed from the 1.0% ACE floodplain, reducing the possibility of road closure occurrences, as well as injuries and fatalities associated with use of the crossings during flood events. It is important to note that specific project modeling used to determine flood risk reduction metrics and the final calculated impacts is different than the existing and future flood risk analyses presented in Task 2.

Impacts to water supply were also evaluated as part of this task. The TWDB established 16 regional water planning areas (RWPA) and appointed members who represent key public interests to the regional water planning groups (RWPG). This grassroots approach allows planning groups to evaluate region-specific risks, uncertainties, and potential water management strategies. Region 6 primarily covers Region H and minimally covers some of Region G (Brazos). None of the recommended flood management actions have an impact on or contribution to water supply.

Task 7. Flood Response Information and Activities

This task provides an overview of flood emergency management and focuses on the preparedness, response, and recovery phases of flood emergencies specific to the San Jacinto region. The summarized information in this chapter relies upon survey responses, discussion with agencies and citizens from the region, and local knowledge of the technical consultants with the idea that the presented flood response information and activities are specific to this region.

The region has robust emergency management protocols in place with well-established regional interagency coordination. Emergency Operating Centers such as that in Harris County have been established to facilitate emergency coordination and better prepare and respond to emergency events, most often activating for predicted or actual regional flooding. Various local, state, and federal entities have also established numerous public alert and response systems that predict and monitor flooding across the region. Public alert systems in the region work to communicate road and channel flooding to broad audiences including key emergency response personnel. In response and recovery operations, local entities in the region provide a wide range of services from high water rescue and traffic control during the event, to high-water mark collection and debris removal after the flood event. Local entities also provide direct assistance to flood victims with actions in the short term such as coordination of temporary housing and then, in the long term, with repair to flood conveyance infrastructure or even facilitating programs for home buyouts.

Task 8. Administrative, Regulatory, and Legislative Recommendations

This task provides an opportunity for the San Jacinto RFPG to make recommendations to the State of Texas to improve floodplain management and mitigation within the San Jacinto region. A total of 24 recommendations were developed and are summarized below.

Legislative Recommendations

1. Provide recurring biennial appropriations to the Flood Infrastructure Fund (FIF) for study, strategy, and project implementation.
2. Provide state incentives for establishment of dedicated drainage funding.
3. Provide counties with legislative authority to establish drainage utilities and assess drainage fees.
4. Enact legislation updating the state building code to, at minimum, the 2015 or 2018 versions of International Building Code (IBC) and International Residential Code as state building standards.

Regulatory and Administrative Recommendations

5. The Texas Department of Transportation (TxDOT) should employ roadway design criteria to require all new and reconstructed state roadways to be designed and constructed, to the extent practicable, at elevations at or above the 1.0% ACE water surface elevation if determined with Atlas-14 rainfall. The 0.2% ACE water surface elevation should be used if other rainfall sources are used to determine elevations.
6. Recommend a statewide building standard that a minimum floor elevation shall have a finished floor elevation established at or waterproofed to the FEMA effective 0.2% annual chance flood elevation as shown on effective Flood Insurance Studies except in areas designated as coastal flood zones or at the 1.0% ACE flood elevation where Atlas 14 has been used.
7. Clarify the process and investment required to take Base Level Engineering (BLE) data to regulatory BLE information on a Flood Insurance Rate Map (FIRM) panel and alternatively, detailed study on a FIRM panel.
8. Establish and fund a levee safety program like the TCEQ dam safety program.
9. Develop model floodplain ordinances for General Law Cities (e.g., building codes, subdivision regulations).

10. Partner with Texas Floodplain Managers Association (TFMA) to promote public education and outreach about flood awareness and flood safety and provide outreach materials to communities. Partnership with Texas Association of Counties to include dedicated outreach to Floodplain Administrators without a technical flooding background (e.g., County Judges).
11. Provide support for ongoing education/training regarding floodplain management in the form of no or low-cost online resources including training modules, webinars, and print resources. Target training for non-technical Flooplain Administrators (e.g., County Judges as FPA).
12. Develop state incentives for local governments to participate in the FEMA National Flood Insurance Program (NFIP) and Community Rating System (CRS) program.
13. Develop a statewide database and tracking system to document flood-related fatalities that are publicly available. This could be an addition to the Flood Plan Data Hub website to capture existing data from TxDOT, NOAA, or others.
14. Assist, via funding, smaller jurisdictions in preparing grant applications or make the application process easier. Provide training for Councils of Governments (COGs) to assist with funding process.
15. Develop a model-based future conditions flood hazard data layer (FHDL) using BLE data and provide it for use by RFPGs and the technical consulting teams during the next flood planning cycle.
16. Reduce or eliminate barriers that prevent jurisdictions from forming effective partnerships to provide regional flood mitigation solutions.
17. Incentivize voluntary buyout programs, turning repetitively flooded properties/neighborhoods into green space, parkland, or any other flood risk mitigation measure as an alternative to large-scale construction projects.
18. Provide training to state agencies, local governments, engineers, planners, and members of RFPGs in the use of natural floodplain preservation/conservation.

Flood Planning Recommendations

19. RFPs are required to provide an indication of whether a flood control solution meets an “emergency need.” Guidance should be provided on what constitutes an “emergency need.”
20. Scoring criteria and methodology for projects that benefit agricultural activities should be updated to allow for these types of projects to compete with urban focused projects.
21. Utilize project scoring that is equitable to project sponsors regardless of their size or population.
22. Utilize project scoring for nature-based solutions that give them a competitive chance compared to non-nature-based projects.
23. Expand consideration and priority for FMEs that establish initial FEMA effective floodplains.
24. Lessen requirements for a project to be considered an FMP.

Task 9. Flood Infrastructure Financing Analysis

A Flood Infrastructure Funding survey was sent to 99 Sponsors with FMEs, FMSs, and FMPs identified in the San Jacinto RFP. Each sponsor was provided the list of mitigation solutions identified under their authority, including project costs, and was asked to provide the level and type of local funding available for the proposed mitigation solutions and the amount of federal and state assistance needed to complete the project. The goal of the survey was to gauge the level and type of local funding region-wide and to then propose the role the state should have in future funding of these solutions. Of the 99 surveys distributed, 17 sponsors responded (17.2%). Although this is only a fraction of the total list of respondents, it does provide the RFPG with useful data in estimating the local funding landscape in the San Jacinto region. For FMEs, FMSs, and FMPs where survey responses were not received, the RFPG estimated 100% of the total project costs are required from state and federal sources.

Based upon the survey results received, there is an estimated $24.8 billion in state and/or federal funding needed to implement the FMEs, FMSs, and FMPs identified in this San Jacinto RFP. This figure is only based upon the mitigation solutions identified and is not sufficient to complete all of the mitigation measures needed to solve all of the region's flooding concerns. Even so, it does provide a valuable tool to evaluate the tremendous funding gap that must be filled to protect the citizens of the San Jacinto region.

Task 10. Public Participation and Plan Adoption

The San Jacinto RFPG has employed multiple methods to engage the public and stakeholders in this initial plan development. The San Jacinto RFPG has given the public access to a survey through their project webpage (www.sanjacintofloodplanning.org). The public also has access to an interactive map hosted on the website where they may identify areas of flood risk in their region and a portal to upload their own data to contribute to the planning process. An interactive data dashboard was also hosted on the website that displayed the GIS data developed during the planning process.

Throughout the planning process, the San Jacinto RFPG held regular Planning Group meetings. Quorum was met at each of these meetings by the voting members with sufficient attendance from the non-voting members and other attendees as well. The San Jacinto RFPG meetings were conducted both online via Zoom and in-person. Frequency of the formal Planning Group meetings averaged almost one per month. All meetings were conducted in accordance with the Texas Open Meetings Act. Public attendance and comments were encouraged at each meeting.

In addition to RFPG meetings, the RFPG met by subcommittee which included the Executive Committee, Technical Committee, and the Public Engagement Committee. The Executive Committee met to take action on items pertaining to the general management of the San Jacinto RFPG while the the Technical Committee met to take action on items pertaining to the technical consultant team's progress on the development of the RFP. The Public Engagement Committee met to take action on items pertaining to best practices for public involvement, engagement, collaboration, and coordination for the San Jacinto RFPG.

On May 18, 2021, the San Jacinto RFPG held a virtual public meeting to gather community concerns to aid with the development of the regional flood plan. This meeting served as the pre-planning meeting and was intended to provide background on formation of RFPGs and the Regional Flood Planning process and gather suggestions and recommendations regarding issues, provisions, projects, and strategies that should be considered in development of the RFP.

On Aug. 31, 2021, the San Jacinto RFPG held a virtual public meeting to provide an overview and update on the San Jacinto RFPG's efforts and identify existing flood risk in the region. This meeting was intended to satisfy the TWDB requirement for a public meeting to identify flood risk in the region.

In May 2022, the San Jacinto RFPG held three open houses on May 24, 26 and 31. To provide equal opportunity for public input, the meetings were hosted in-person and virtually. The meetings were held in different locations within the region so that there was diverse geographic spread. The May 2022 open houses were held to solicit public input and collect further information to be used to develop the draft RFP for the San Jacinto region.

Following submittal of the draft RFP to the TWDB on August 1, 2022, a public comment and review period was initiated. Section 10.F. within Chapter 10 discusses the outreach efforts and public open house meetings held on September 27 and 29 of 2022 to solicit public input on the draft RFP.

Various other public outreach efforts were made including public surveys, website development, professional conference participation, and presentations. The RFP was prepared in accordance with the guidance principles provided by the TWDB. A table is included in Chapter 10 that indicates which portion of the plan addresses each guidance principle.

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INTRODUCTION

In the wake of historic flooding in Texas, the 86th Texas Legislature passed Senate Bill 8 in 2019 that authorized and established regional and state flood mitigation planning processes and assigned the responsibility for flood mitigation planning to the Texas Water Development Board (TWDB). The TWDB has appointed a Regional Flood Planning Group (RFPG) for each of the 15 major river basin in Texas to develop river basin-specific Regional Flood Plans (RFPs). The San Jacinto (RFPG) is one of the RFPGs formed by the TWDB. The RFPGs' responsibilities include directing the work of their technical consultants, soliciting and considering public input, identifying specific flood risks, and identifying and recommending flood management evaluations, strategies, and projects to reduce risk in their regions.

The Region 6 San Jacinto RFPG was established by the TWDB on October 1, 2020, to manage the flood mitigation planning efforts for the San Jacinto River drainage basin which is designated as the Region 6 San Jacinto Flood Planning Region (San Jacinto region). The San Jacinto region covers all of Harris and Montgomery Counties and parts of Walker, Grimes, Waller, Fort Bend, Brazoria, Galveston, Chambers, Liberty and San Jacinto Counties.

Following TWDB directives, this report presents the Region 6 San Jacinto RFP, which represents the first-ever flood plan for the San Jacinto region. The RFP includes chapters that follow the necessary steps for comprehensive flood mitigation analyses and planning for the San Jacinto region.

CHAPTER 1. PLANNING AREA DESCRIPTION

The headwaters of the San Jacinto River begin as two separate, major tributaries – the East Fork and the West Fork. The East Fork begins east of the City of Huntsville in Walker County and meanders south through the Sam Houston National Forest until joining with the West Fork just upstream of Lake Houston. The West Fork begins west of the City of Huntsville and flows southeast until ultimately joining the East Fork in Lake Houston in Harris County. The West Fork is dammed to form Lake Conroe in Montgomery County and southern Walker County. Downstream of Lake Houston, the main stem of the San Jacinto River continues south through the Houston Ship Channel, receiving flow from an intricate system of approximately 20 major watersheds that each drain into 20 major waterways. This system is mostly within Harris County, where there are 2,500 miles of waterways of which only around 800 miles naturally existed when Houston was founded. The rest have been added over the years to improve drainage and allow for development. The system then flows onward to Galveston Bay and ultimately into the Gulf of Mexico. The San Jacinto region (**Figure 1-1**) also includes major watersheds that drain directly to Galveston Bay, including both the Clear Creek and Dickinson Bayou watersheds.

The San Jacinto region drainage area consists of a wide variety of landscapes and communities served by a vast network of natural and constructed drainage infrastructure, including approximate 3,700 stream miles (estimated by TWDB), various tributaries, bayous, and urban drainage systems as well as thousands of acres of ponds, reservoirs, and wetlands. Land surface elevations across the San Jacinto region range from several feet below sea level in the tidal and coastal regions to approximately 400 feet above sea level in northern Walker County.

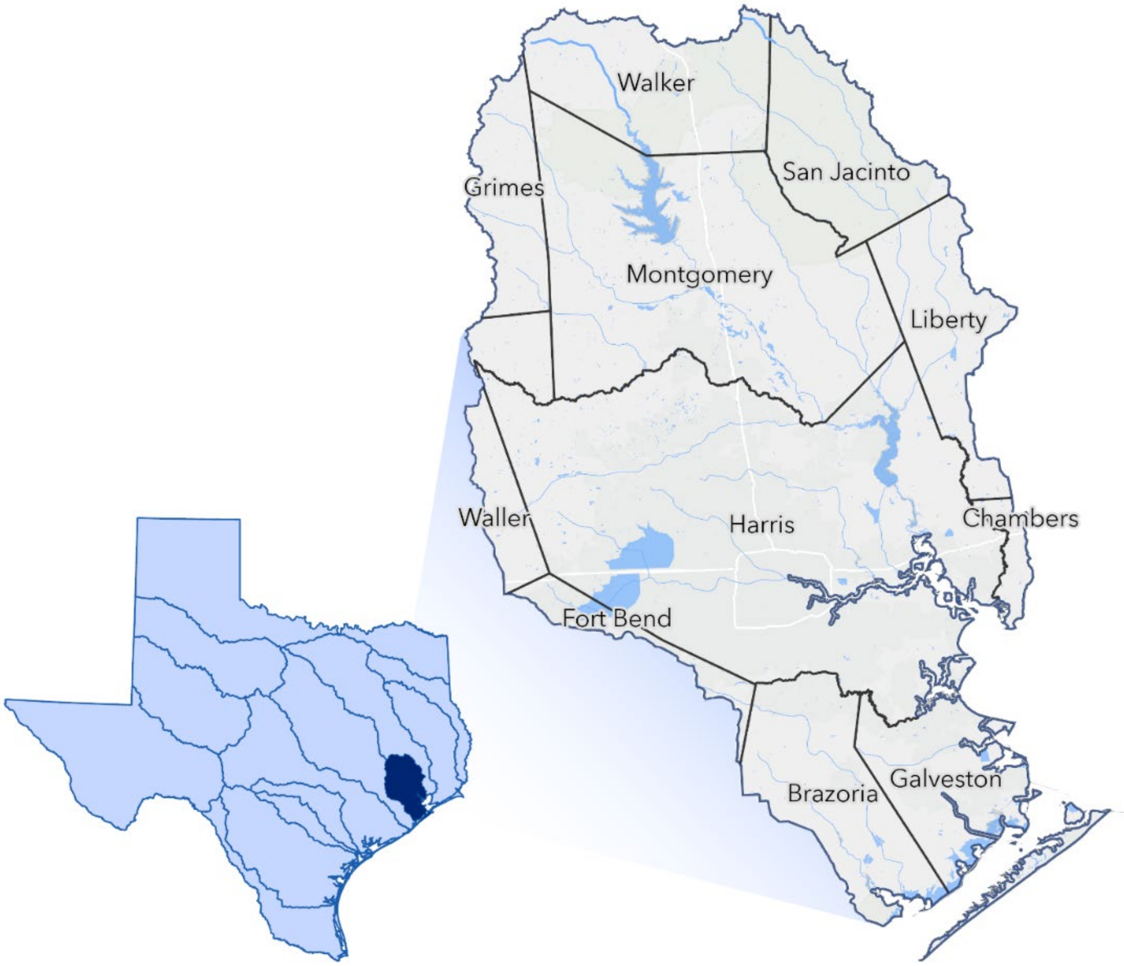

FIGURE 1-1: SAN JACINTO REGION OVERVIEW

The San Jacinto region encompasses 5,089 square miles, making it the second smallest flood mitigation planning region in the state by area. However, the region is the second most populous, with an estimated population in 2020 of 6,360,000. With a population density of 1,200 people per square mile, the San Jacinto region is also the most densely populated region in the state, with double the population density of any other region. Flood risk, from extensive development and proximity to the coast, makeflood mitigation planning a particular issue of interest and need. The San Jacinto region has the highest accumulated value of National Flood Insurance Program (NFIP) claims of any region in the state (1975-2019). According to the TWDB, these NFIP claims total approximately $11.7 billion, nearly $10 billion greater than any other flood planning region in Texas.

The San Jacinto region's climate is characterized by relatively high rainfall and high humidity. Average precipitation reported for the San Jacinto region from the National Oceanic and Atmospheric Administration (NOAA) is approximately 46 inches per year, based on historical rainfall over the past 100 years. Annual precipitation totals vary by a few inches between the northern and southern extents of the region.

Chapter 1.A. Social and Economic Character of the San Jacinto Region

1.A.1. Population and Future Growth

The San Jacinto region is the state's second most populated flood planning region, with an estimated population of 6.4 million in 2020. Approximately 21% of all Texas residents live in the area. It is a geographically diverse region where the needs of rural stakeholders must be balanced with those of rapidly developing urban population centers. Flood risks faced by communities and landowners vary significantly across this region. To better understand the nature of that flood risk, this section discusses the people, type and location of development, economic activities, and sectors at greatest risk of flood impacts.

1.A.1.a. Current Conditions

Most of the population is centered around the Greater Houston Area (Houston, The Woodlands, Sugar Land, Baytown, Conroe), as well as communities near the coast. Incorporated major cities in the San Jacinto region are listed in **Table 1-1.** The population in these cities approximates 3.36 million residents.

TABLE 1-1: MAJOR CITIES IN THE SAN JACINTO REGION

City	Population	City	Population
Houston	2,304,600	Conroe	90,000
Pasadena	152,000	Atascocita	88,200
Pearland	125,800	Baytown	83,700
The Woodlands	114,400	Missouri City	74,300
League City	114,400	Galveston	53,700

Source: 2020 Census Redistricting (census.gov)

1.A.1.b. Economic Activity

The San Jacinto region is a robust major economic center of importance both to the state and nation, with a diversified economic base including service, manufacturing, transportation, energy, and agriculture. The San Jacinto region is home to the nation's fourth-largest city, Houston, located within the Greater Houston Metro Area, where close to 3.2 million workers are employed, according to 2022 Texas Workforce Commission reports. While the Greater Houston Area serves as a hub for much activity, areas outside of the urban core are also major economic contributors.

Major Industries

Petrochemical as well as oil and gas production are dominant industries within the San Jacinto region. Houston is often referenced as the "Energy Capital of the World" and is home to 44 of the 113 publicly traded oil and gas companies in the U.S., accounting for over 42% of the nation's base petrochemical capacity. The region serves as a hub for the processing, manufacturing, and distribution of petrochemical products. The energy industry within the San Jacinto region is greatly supported by the extensive transportation and logistics industry mentioned below.

The transportation and logistics industry also has significant impact within the region. In particular, the Port of Houston is one of the highest ranked U.S. ports in both foreign and domestic waterborne tonnage; the flow of goods through the port is greatly supported by the Gulf Intercoastal Waterway, the Houston Ship Channel, and the expansive and interconnected interstate and highway systems that serve as the logistical backbone of the region.

The service sector holds a prominent role within the San Jacinto region, including but not limited to, industries of accounting, law, banking, computer software, engineering, healthcare, telecommunications, technical services, retail, and accommodation and food services. The service industry sector is the largest industry within the region based on the total number of employees, which exceeds 1.4 million. The San Jacinto region is also home to some of the largest medical facilities in the country, such as the Texas Medical Center in Houston and the University of Texas Medical Branch in Galveston.

The region’s coastal areas also serve a vital economic function. Aside from the inherent benefits of promoting accessibility for the shipping and energy sectors, there is a draw to the region for its natural resources. Approximately eight million people travel to Galveston Island annually for recreational sports, fishing, tourism, and vacation. The coastal region also plays a significant role in the food supply industry via commercial fishing, crabbing, and shrimping. In addition to tourism, the coastal and marine environments are host to multiple top-tier oceanic research facilities and universities.

This wide and vitally important suite of industries is frequently threatened by severe flooding. Major components of the greater region-wide economy that are at critical risk of flooding include major industries along the Houston Ship Channel. Further analysis of the critical infrastructure within the region was performed as a part of Task 2.

Household Income

Along with the large industrial economic characteristics of the region, household income is another factor that is used to evaluate the overall socioeconomic status of the region. Median household incomes can be affected by many factors, including education levels, the opportunity for employment, and location. Median household incomes can also provide a good comparison of income levels across the San Jacinto region. Within the region, the median[1] income by Census tract, $58,935, is slightly below the Texas median of $63,826 and the U.S. median of $64,730.

1.A.1.c. Projected Growth Within the Region

Most of the region is projected to experience high levels of population growth over the next 30 years, primarily in Montgomery and Harris Counties and in the currently urbanized parts of Galveston County. From 2020 to 2050, the population in the San Jacinto region is expected to grow by 33% to 8,454,389 residents, based on Water User Group and Hydrologic Unit Code (HUC) 8 population projection data provided by the TWDB. One of the largest challenges associated with this growth is determining how to manage development responsibly and continue to preserve the region’s natural resources.

1 Median household income by U.S. Census Tract

Urban Population Growth Trends

From 2001 to 2019, approximately 500 square miles of land within the San Jacinto region has been developed into urban use, based on data from the National Land Cover Dataset (NLCD) Land Cover Change Index. More than half of that urbanization occurred in Harris County. Given the expected population growth, it can be assumed that a continued increase in urban development will accompany the projected population growth.

Social Vulnerability Analysis

Disasters impact different people or groups in different ways, ranging from their ability to evacuate an area in harm's way, the likelihood of damage to their homes and properties, and their capacity to marshal the financial resources needed to recover and rebuild after a storm. These factors are evaluated by the U.S. Centers for Disease Control and Prevention (CDC) to determine an area's social vulnerability, which measures a person's or group's capacity to weather, resist, or recover from the impacts of a hazard in the short and long terms. When anticipating the likely extent of damages to a community from catastrophic floods, the social vulnerability analysis first considers "exposure" based on the geographic location of people and property.

Another critical dimension to consider is each community's relative "vulnerability" to floods when they do occur. The overall vulnerability is calculated based on four aspects: socioeconomic status; household composition and disability; minority status and language; and housing type and transportation. The higher the Social Vulnerability Index (SVI), the more vulnerable a community is to a natural disaster; the lower the SVI, the higher the resilience a community has to a natural disaster. SVI values range from 0 to 1. The SVI by census tract within the region ranges from 0.0015 - 0.9900. This wide range of SVI values shows the diversity of the population affected by flood risk within the region. These different communities respond differently to flood disasters, and when flood mitigation policies or standards are being created, each of these communities should be given an equitable consideration. SVI of communities was considered in the vulnerability analysis conducted as part of, and described in, Task 2.

1.A.2. Flood Prone Areas and Flood Risks to Life and Property

As the San Jacinto Regional Flood Planning Group (RFPG) seeks to better manage flood risk to mitigate the loss of life and property from flooding, it is important to establish a baseline of the area's exposure to flood hazards, as well as the vulnerability of communities. A multitude of plans, regulations, and infrastructure are currently in place to address flood hazards in Texas. This planning largely takes place at the local level, with variable standards used by communities and a lack of consistent, available floodplain mapping across the region. This creates significant challenges in quantifying risk.. Flood risks and exposure of life and property to those risks are analyzed and documented further in Chapters 2 and 4.

1.A.2.a. Types of Major Flood Risks

Despite being the second smallest flood planning region in the state by area, the San Jacinto region experiences some of the most complex flood challenges, brought on in part by the variety of flooding sources. Other factors contributing to the complexity of flooding include a range of topography; varying levels of development; intense rainfal;, susceptibility to tropical weather event;, and varying soil types and land cover. The most prevalent flood risk types within the region are riverine, coastal, urban drainage, and compound flooding.

Riverine

Riverine flood risk, or fluvial flood risk, is defined by the *Technical Guidelines for Regional Flood Planning (Exhibit C)* as "flooding caused by bank overtopping when the flow capacity of rivers is exceeded locally. The rising water levels generally originate from high-intensity rainfall creating soil saturation and large volumes of runoff, either locally and/or in upstream watershed areas". Riverine flooding is a prevalent source of risk within the region, and in general is a common type of flood risk in both urban and rural areas throughout the San Jacinto region.

Coastal

According to the *Technical Guidelines*, "coastal flooding occurs when normally dry, low-lying land is flooded by seawater." This flooding is as a result of storm surge, wave action, and various other tidal influences. Wave action can be limited by either water depth or fetch, the distance the wind can affect the water surface. Depth-limited waves can only grow to a size that the depth of water will allow regardless of the fetch. Fetch-limited waves can grow to the size that the wind forces them. Most of Galveston Bay is depth-limited and therefore relieves some risk of wave action flooding. Gulf-abutting portions of the region, such as Galveston Island, are subject to a higher risk from wave action flooding due to the proximity to the Gulf of Mexico. Storm surge is a temporary rise in mean water level due to the pressure and velocity of a storm approaching the coast. This quick rise in water level can inundate structures or allow flood protection features, such as a seawall, to be overtopped by waves that would otherwise be absorbed or deflected. Most of the coastal areas within the region, both the Gulf- and Bay-abutting portions, are at risk of storm surge due to the large expanse of open bay and a deep ship channel.

Urban/Pluvial

Urban flood risk, or pluvial flood risk, is described by the *Technical Guidelines* as flooding caused, "when the inflow of stormwater in urban areas exceeds the capacity of drainage systems to infiltrate stormwater into the soil or to carry it away. The inflow of stormwater results from (a) heavy rainfall, which can collect on the landscape (pluvial flooding) or cause rivers and streams to overflow their banks and inundate surrounding areas; or (b) storm surge or high tides, which push water onto coastal cities." Urban flood risk is prevalent in the Greater Houston Area due to a variety of risk factors including large amounts of impervious area, flat topography, and older, capacity-limited storm sewer infrastructure. As development continues throughout the region, urban flooding will continue to play a prominent role in the overall flood risk to the region.

Compound

Compound flooding is the combined influence of coastal, riverine, and urban drainage flooding. This type of risk is prevalent in the San Jacinto region as there are many areas in the southern/coastal areas with high development that experience significant coastal flooding. Compound flooding occurs where areas experience direct interaction between tidal and riverine risk, such as the Houston Ship Channel, which experiences increases in water surface elevations from both tidal/coastal flooding as well as riverine impacts from upstream tributaries.

Ecological Benefits of Flooding

Flooding is known to have negative impacts on the environment and communities, however there are some ecological benefits that come with natural flooding. These benefits can include replenishing nutrients in the soil; relocating fish and different organisms that live in water bodies; recharging groundwater systems; and filling water supply reservoirs. The nutrients that are provided from flooding improve the soil for agricultural production and efficiency while also improving the health of the fish in the water bodies. This does not necessarily mean that flooding is beneficial for the environment at all times but is important to note there are also benefits provided by natural flooding.

1.A.2.b. Identification of Flood Prone Areas

For the Regional Flood Plan (RFP) analyses, flood prone areas are being considered as known locations that experience flooding outside the extent of the existing Special Flood Hazard Area (SFHA). To adequately grasp the extent of flood prone areas in the region, members of the public and regional stakeholders were provided the opportunity to identify flood prone areas using an online interactive webmap survey, which allowed users to provide input as points and polygons. Responses to the following questions were required for any comment submission on the webmap survey.

1. How often does the location flood?
2. What level of storm intensity causes the area to flood?
3. What appears to be the main cause of the flooding at each location?
4. What is impacted by the flooding?

Additionally, users could provide written comments and attach photos with each submission. The webmap survey was made available for public comment on August 17, 2021. In addition to the survey points and areas collected from the webmap survey, the San Jacinto RFPG also received shared data points from the Texas GLO Combined River Basin Study to help identify areas of flood risk that are not currently reflected in the FEMA-mapped SFHA. These data are important because floodplain mapping only exists where hydrologic and hydraulics (H&H) models have been developed and, therefore, this type of data can help to reveal areas floodplain mapping is missing.

Based on topography and survey response content, several point locations were digitized into polygons to represent areas of likely inundation. The flood prone areas shown within **Figure 1-2** were not assigned a flood frequency value due to the wide variety of responses. For example, some responses identified areas of frequent street ponding, while others identified areas that were inundated during Hurricane Harvey. Since a flood frequency was not estimated for survey responses, the extent of FEMA- delineated flood prone areas will remain unchanged between the existing and future flood hazard analyses. These flood prone areas provide an indication of locations of known, but unquantified, flood risk, but are not comprehensive. This identification process demonstrates the need for improved understanding and public perception of flood risk.

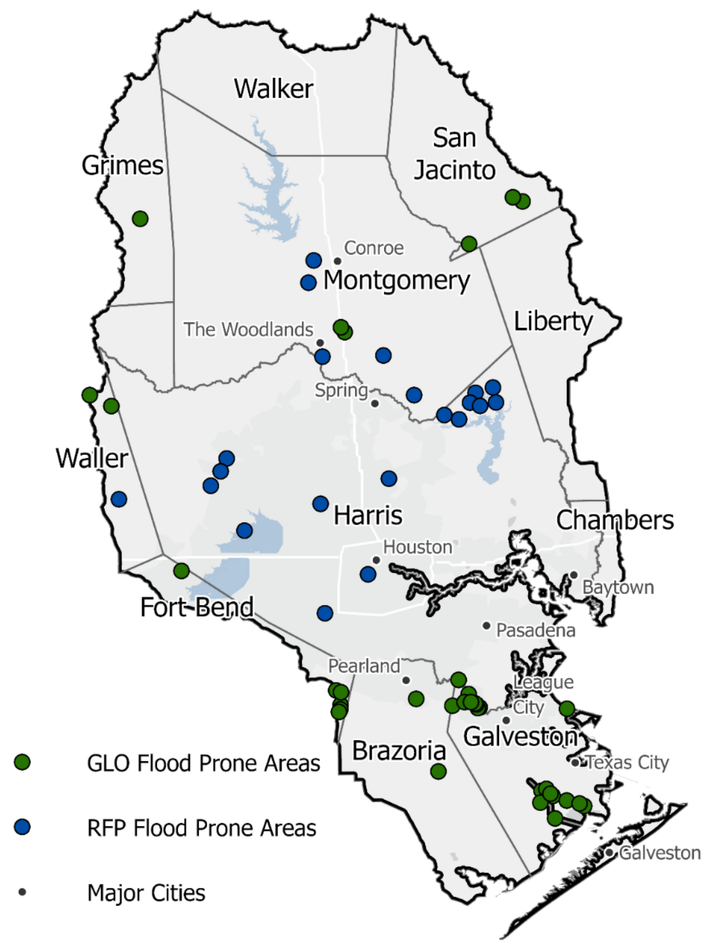

FIGURE 1-2: RECORDED SURVEY DATA

In general, a majority of the RFP reported flood prone areas (blue dots in **Figure 1-2**) were scattered throughout Harris County, south-central Montgomery County, as well as several along the lower West Fork of the San Jacinto River near the Kingwood area. In the flood prone areas received from a Texas Government Land Office (GLO) study (green dots in **Figure 1-2**), a few were located within the northern part of the region near the East Fork of the San Jacinto River as well as farther south in various areas of Galveston and Brazoria Counties. Reports from both GLO and RFP surveys included mentions of flooding associated with various sizes of storm events and natural disasters.

1.A.2.c. Flood-Related Fatalities

One of the potential consequences of flood damage is the loss of human life. This is an issue within the larger context of flood-related risk and is a commonly reported statistic after most hurricanes or flooding-related natural disasters. The organization of flood related fatality data is generally lacking as there is not a unified database of this information; further, the information may be treated as confidential depending on the community. While accurate quantification of flood-related fatalities is challenging, the overall goal of the RFP effort, to reduce the risk to life and property, aligns well with reducing deaths associated with flooding.

1.A.2.d. Critical Assets Subject to Flood Risk

There are several pieces of critical infrastructure at risk of significant impacts from floodwaters. For example, the Houston Ship Channel, a major hub for shipping, transportation, and chemical manufacturing industries, is subject to severe damages from coastal and compound flood risks. Portions of the interstate highway system running through the San Jacinto region are subject to inundation, not only impeding the flow of traffic and major shipping routes but impacting emergency response during a natural disaster. Also, along the coastal portion of the region are large chemical manufacturing facilities that are at great risk to damages by both coastal and riverine flood risk. These are just several of the aspects of critical infrastructure within the San Jacinto region that are at risk of damages and severe consequences from flooding. A more detailed analysis of critical infrastructure that is exposed to flood risk was performed as a part of the Task 2 exposure analysis.

1.A.3. Key Historical Flood Events

The San Jacinto region has a lengthy history of flooding; for example, from 1836 to 1936, the region was impacted by at least 16 major flooding events. These numerous flood events have caused billions of dollars in damages and thousands of fatalities. The following section summarizes the most significant storms in the San Jacinto region's history, as well as programs and management changes implemented in response to flood events. Although this report does not describe in detail the full list of all major flood events within the region, the events presented in this section are intended to provide a concise overview of the character of regional flooding and how these events have shaped the San Jacinto region into a flood-focused community.

1.A.3.a. Great Galveston Storm of 1900

One of the most significant events in the region and nation came at the beginning of the twentieth century. Although the Great Galveston Storm of 1900 took place quite some time before the current level of modern technical data collection (the U.S. Weather Bureau was at that time only approximately a decade old), several sources estimate the Great Galveston Storm of 1900 as the deadliest natural disaster in American history. This Atlantic hurricane, estimated to have been a Category 4 storm with winds of up to 135 miles per hour, destroyed almost 4,000 homes and most of the infrastructure in the City of Galveston. As hurricane information and tracking was not a developed science at the time, the storm was not predicted ahead of time which led to the loss of between 6,000 and 12,000 lives. The lack of communication and organization of emergency protocols was a major contributor to the loss of life. This storm led to greater awareness of the need to organize communication strategies; the importance of tracking and predicting storms; and constructing critical flood mitigation infrastructure. The Galveston Seawall, a product of the response to the Great Galveston Storm of 1900, is still standing and functioning.

1.A.3.b. 1920 - 1930s Storms

The early 1900s contained several significant non-tropical originating storms, such as the 1929 and 1935 events that swept through the San Jacinto region. A significant aspect of these storms was the role that saturated soils played in causing extensive flooding. For example, the May 1929 storm caused significant flooding due to the fact the soils were already saturated, and the bayous were already full from a Gulf storm earlier that April. By the late 1930s, as infrastructure projects around the county began to proliferate, the need for local sponsorship of flood management activities was increasingly recognized. The Texas Legislature responded to these severe flood events by creating local entities with flood management responsibilities. For example, in 1937, the Harris County Flood Control District (HCFCD) was created by the Texas Legislature in response to severe damage from previous events with the intent of taking a systematic and unified approach to mitigating flood risk within Harris County.

1.A.3.c. Tropical Storm Claudette

In July of 1979, Tropical Storm Claudette, an Atlantic originating storm, brought unprecedented rainfall to the San Jacinto region and specifically to the vicinity of the City of Alvin, Texas, which received 42 inches of rain in approximately 24 hours. At the time, this was the record 24-hour precipitation amount for any location within the U.S. The cities of Alvin, Freeport, and others in the surrounding area all received record-breaking amounts of rainfall, resulting in $700 million in total estimated damages across the country.

1.A.3.d. Tropical Storm Allison

Tropical Storm Allison, an Atlantic originating tropical storm, was the next significant event in the region. This storm made landfall twice, first on June 5, 2001, near Galveston, Texas. As the storm moved northward, the Greater Houston Area received from 4 to 10 inches of rainfall across varying parts of the area. Over the following day, the storm dropped 8 to 12 inches of rainfall near the Sugar Land-Stafford area of Fort Bend and Harris Counties. The storm retreated into the Gulf of Mexico, gathering more moisture before proceeding back inland on June 10, 2001. This second landfall, moving at a relatively slow speed across the area, caused significant inundation. Flooding was exacerbated by low rainfall infiltration because soils were already saturated from the first landfall occurrence. During the second landfall, the storm spent a long period of time over the Houston area, causing five of the major bayou systems to experience flooding and all the major interstate systems to close, as well as flooding the entirety of the Texas Medical Center. During the storm’s second landfall, two-thirds of Harris County received more than 10 inches of rain, with some areas receiving more than 20 inches in a span of 10 hours. The storm caused nearly $5 billion in damages and 22 deaths in Harris County alone.

As a result of Tropical Storm Allison, entities within the San Jacinto region moved toward a more holistic approach to flooding. For example, a multi-year initiative called the Tropical Storm Allison Recovery Project (TSARP) was created through the partnership of Federal Emergency Management Agency (FEMA) and the HCFCD. TSARP established a new advanced technical approach to remapping floodplains of local counties and created new and more accurate flood models based on updated land use and topographic data. The lasting and widespread impact of Tropical Storm Allison persuaded officials to adjust their recovery strategies in fundamental ways, creating new programs in the region such as the Voluntary Home Buyout Program which addressed homes that were found to have no other feasible / cost-effective mitigation strategy available to reduce flood risk. Another significant result of Tropical Storm Allison was an increased focus on resiliency built into critical infrastructure within the region. For example, after the Texas Medical Center was severely damaged by Tropical Storm Allison, resiliency became a priority as the area was rebuilt, with changes made successfully reducing the impact that severe flooding can have on Texas Medical Center’s critical infrastructure.

1.A.3.e. Hurricane Ike

Hurricane Ike was the third costliest hurricane in U.S. at the time, with an estimated $27 billion in damages throughout the country, resulting from two component rainfall events in September 2008, the first bringing 6-10 inches of rain, and the second bringing 3-8 inches the following day. The most significant damage resulted from extreme storm surge, with Galveston Island experiencing the highest storm surge recorded since 1915 and 12-17-foot storm surges taking place in parts of both Harris County and Bolivar Peninsula, Galveston County.

1.A.3.f. Memorial Day 2015 Flood

On May 25, 2015, several thunderstorm systems merged and released an average of 5.3 inches of rainfall across Harris County, roughly equating to 162 billion gallons, over a 12-hour period, with some areas in the San Jacinto region recording more than 10 inches. Brays Bayou within the City of Houston received close to 11 inches in three hours. More than 6,000 structures were flooded in Harris County alone, and Brays Bayou recorded record high rainfall amounts. The Memorial Day event caused significant damages due to the soils and infrastructure already being saturated from consistent rainfall from previous weeks.

1.A.3.g. Tax Day 2016 Flood

On April 16 and 17, 2016, severe storms caused approximately 240 billion gallons of water to fall upon Harris County, with an intense amount of rainfall in the northern and western areas of the county. The Upper Cypress Creek, Addicks Reservoir, and Barker Reservoir catchments received approximately 13-17 inches of rain over 12 hours. Both reservoirs recorded record water surface elevation levels. As the bulk of the water volume made its way downstream from the reservoirs and bayous into the downstream bayous (particularly Buffalo Bayou), secondary flooding resulted from the channels experiencing water surfaces up to 6 feet higher than normal reservoir release levels. In Harris County alone, more than 1,800 high-water rescues were executed, and close to 10,000 structures were flooded. A state of emergency was declared in nine counties in the area. Six weeks later, the region received another 8-13 inches of rainfall which caused significant repeated flooding as soils were still saturated and many bayous within Harris County were still holding water from the 2016 Tax Day event.

Both the Memorial Day 2015 and Tax Day 2016 events provided useful data such as high-water marks, stream gauge data, and inundation extents indicated by FEMA NFIP claims. These events are used frequently in the development of H&H models as calibration events within the San Jacinto region.

1.A.3.h. Hurricane Harvey

On August 25, 2017, Hurricane Harvey made landfall near Port Aransas, Texas as a category 4 hurricane that produced substantial rainfall at high rates. As the storm slowed and stalled over Harris County and surrounding areas, it brought continued intense bands of rain, causing flash flooding throughout the entire San Jacinto region. In a four-day period, more than 1 trillion gallons of water fell across Harris County alone. One of the rainfall gauges in Harris County (Clear Creek at I45) reported more than 47 inches of rainfall in four days. Widespread rainfall caused 46% of all the river flow forecasting points in Southeast Texas to reach new record levels during the storm. Hurricane Harvey is estimated to have caused more than $125 billion in damages throughout the country () and caused 68 deaths within Texas, 36 of which were in Harris County. Hurricane Harvey is the second-costliest hurricane in U.S. behind Hurricane Katrina in 2005. The storm highlighted the need for further improvements to floodplain management, disaster recovery, and funding for repairs. In the following September of 2017, the U.S. federal government allocated relief funds through House Resolution 601, which provided "$15.25 billion in FY2017 supplemental appropriations to FEMA, the Small Business Administration (SBA), and the Department of Housing and Urban Development (HUD) for disaster relief requirements, such as response and recovery efforts from Hurricanes Harvey and Irma." This large influx of money into the affected areas has had a significant positive impact on flood infrastructure and flood mitigation projects.

1.A.3.i. Damages, Flood Claims, and Fatalities

The San Jacinto region is regularly impacted by thunderstorms, tropical storms, and hurricanes, which can lead to severe flood events across the entirety of the region. Major storm events and associated FEMA NFIP flood claims, damages, and fatalities are reported in **Table 1-2**. The values displayed in **Table 1-2** only include the San Jacinto region, not for the entire storm area.

TABLE 1-2[2]: REPORTED FLOOD DAMAGES, CLAIMS, AND FATALITIES

Name	Year	Total Flood Damages[3]	No. Flood Claims	No. Fatalities
Great Galveston Storm	1900	Unknown	Unknown	6,000-12,000
May 1929 Storm	1929	$24,000,000	Unknown	Unknown
December 1935 Storm	1935	$65,000,000	Unknown	Unknown
Tropical Storm Claudette	1979	$542,000,000	8,842	Unknown
Hurricane Alicia	1983	$388,000,000	13,497	21
October 1994 Storm	1994	$353,000,000	5,400	17
Tropical Storm Allison	2001	$1,568,000,000	25,906	22
Hurricane Ike	2008	$1,901,000,000	34,471	13
Memorial Day	2015	$454,000,000	5,776	7
Tax Day	2016	$560,000,000	8,155	7
Hurricane Harvey	2017	$8,372,000,000	66,244	49
Tropical Storm Imelda	2019	$432,000,000	7,010	2

Hurricane Harvey was the most destructive recent storm event in the San Jacinto region, as reported by both the number of NFIP claims and the total value of NFIP claims. It should be noted that for all these flood events, the loss of property is higher, as properties without flood insurance at the time of the event are not accounted for in the number of NFIP claims or the total damage value.

In addition to the direct property damage and fatalities associated with hurricanes and flood events, there are also emotional and psychological costs rarely mentioned or quantified regarding these events. All people within the region can be greatly impacted by the results of flooding, including concerns associated with displacement, resource scarcity (such as gas, food, and water), loss of work, lack of mobility, and irreparable damage or destruction to property. Although there is not a clear numerical

[2] Source and Methodology: Various (See Appendix 0-1)

[3] Values in May 2022 dollars

value associated with these types of hardship, the burden and impact upon the community's physical and mental wellbeing will continue to be extremely significant.

1.A.3.j. Disaster Declarations

Formal federal governmental disaster declarations may be issued for any natural event determined to have caused severe damage that goes beyond the capabilities of both state and local governments to respond. Major disaster declarations include key events such as hurricanes, tornadoes, storms, earthquakes, landslides, fires, floods, or explosions. Out of the 63 federally declared disasters within the counties of the San Jacinto region since 1953, 43 are associated with hurricanes, severe storms, coastal storms, or flooding.

1.A.4. Political Subdivisions with Flood-Related Authority

State guidelines define political subdivisions with flood-related authority as cities, counties, districts, or authorities created under Article III, Section 52, or Article XVI, Section 59, of the Texas Constitution, any other political subdivision of the state, any interstate compact commission to which the state is a party, and any nonprofit water supply corporation created and operating under Chapter 67. State law also provides for limited purpose Water Supply and Utility Districts, known variously as Municipal Utility Districts (MUDs), Municipal Water Districts (MWDs), Fresh Water Supply Districts (FWSDs), and Special Utility Districts (SUDs). These districts may be located within or adjacent to cities or counties involved in the reclamation and drainage of their jurisdictional property.

Although a multitude of these entities have the capability to exercise some degree of flood-related authority, many defer to a larger entity such as a county or municipality for regulatory floodplain management purposes. These larger entities often have unified enforceable development codes and floodplain management standards in place. For example, although MUDs and SUDs are considered to be political subdivisions given the above definition, they rarely directly regulate drainage or flooding infrastructure within their jurisdictions. Also, many of these entities have the authority to implement flood-related planning or projects but do not necessarily have the authority to implement or enforce floodplain management practices or standards. Of the political subdivisions, the majority of entities active in flood planning are municipal or county governments, both of which utilize broad authority to set policies mitigating flood risk. The data collection effort for this plan identified 81 municipalities and 11 counties within the region with flood-related authority (**Table 1-3**).

TABLE 1-3: POLITICAL SUBDIVISIONS WITH FLOOD-RELATED AUTHORITY

Type of Political Subdivision	Number of Jurisdictions
Municipality	83
County	11
River Authority	3
Flood District	15
Other	980
Total	**1092**

1.A.5. Extent of Local Regulations and Development Codes

Based on research performed by the San Jacinto RFPG, in conjunction with the San Jacinto RFP Data Collection Survey Tool responses, there are many entities within the San Jacinto region that have regulations and codes in place regarding stormwater management. These measures are often included within local subdivision regulations or drainage criteria manuals. Development regulations and drainage manuals cover standards pertaining to planning and drainage report submissions, right of way and easements, and the completion of H&H studies. Drainage design criteria serve to set the minimum standards for planners, architects, and engineers to follow when preparing plans for construction within the corresponding jurisdictions. These could be for regional entities, municipalities, or counties within the San Jacinto region.

Floodplain Ordinances and Court Orders dictate how development is to occur within (or to avoid) a floodplain. FEMA provides communities with flood hazard information upon which floodplain management regulations are based. Floodplain Ordinances and Court Orders are subject to the NFIP and promote communities taking flood hazards into account when making land use and land management decisions. Ordinances may include references to maps with Base Flood Elevations, freeboard requirements, and flood storage requirements, as well as criteria for land management and use. In addition, communities can regulate development within floodplains with higher or more restrictive standards than those set by the NFIP.

All 11 counties which are wholly or partially within the San Jacinto region include entities with some form of floodplain regulations. Of the 83 municipalities identified during the data collection efforts for San Jacinto RFP development, 74 have some form of floodplain regulations. There are 62 municipalities identified as having higher design requirements than the NFIP requirements. Local regulation and development codes are summarized in **Table 1-4**.

TABLE 1-4: REGIONAL REGULATIONS SUMMARY

Regulation/Code	Municipalities with Regulation/Code
Drainage Criteria Manual	44
Floodplain Regulations	74
NFIP Participation	78
Higher Standards Than NFIP	62

There are also several drainage districts throughout the San Jacinto region. Drainage districts in Brazoria, Fort Bend, Galveston, and Harris Counties all have development regulations and design criteria for their respective jurisdictions.

1.A.6. Agricultural and Natural Resources Most Impacted by Flooding

Flood events can have a detrimental impact on the extensive agricultural and natural resources of the San Jacinto River Basin, which includes more than 3,173 square miles of farming, forestry, and ranch land (**Table 1-5**). Potential impacts to various agricultural sectors are discussed in greater detail in the following subsections. **Table 1-5** has also been provided to show the breakdown of the land use within the San Jacinto region and how the general trend of areas at risk of flooding follows the same trend as the total land use area, showing that no one land type is being disproportionally affected by flooding.

TABLE 1-5: REGIONAL LAND USE SUMMARY

Land Use	Total Area in Region (Sq. Mi.)	Total Area in Region at Risk of Flooding (Sq. Mi.) (According to Existing Flood Hazard Mapping)
Farming	286	124
Forestry	1833	718
Open Water	116	98
Ranching	1054	295
Urban Development	1796	526

1.A.6.a. Farming

Flooding or excess precipitation can impact cropland in various ways, including rapid direct damage to crops or long-term impacts through soil erosion and soil nutrient losses. The severity of the impact flooding has on farming depends on a broad range of factors, including crop type, the timing of storm events relative to planting or crop growth stage, and the wind speed of a storm. Different crops have different resiliencies to excess precipitation and prolonged standing water. Permanent crops, such as fruit trees, tend to be more resilient to excess precipitation and standing water than row crops, such as corn and soybeans. Heavy rain prior to planting could delay planting or prevent planting entirely. Additionally, the stage of growth of a crop influences its susceptibility to damage or loss due to excess water. It should be noted that some degree of flooding may be tolerated or even beneficial for some crops such as rice. However, flooding in excess and sustained conditions do have associated negative long- and short-term impacts. The San Jacinto region has experienced more than $21.4 million in crop losses due to flooding, hurricanes, and tropical storms for years 1989 through 2020.

1.A.6.b. Forestry

Forestry impacts due to flooding are also multifaceted. Flash flooding can bring swiftly moving debris that could physically wound trees, creating conditions for contaminated flood water to introduce diseases. Sustained flooded conditions can also deplete the soil oxygen supply and cause root damage. Floods that occur during the growing season can kill trees much faster than similar conditions during the dormant season. However, flooding can also positively impact forests by clearing weaker trees, spreading seeds, and stimulating the growth of surviving trees. Forested areas can be used as potential natural infrastructure with benefits such as increased storage of runoff during flood events.

1.A.6.c. Ranching

Ranching activities in the region are also impacted by flooding. Livestock can be swept away, drowned, or injured by flash floods. Livestock exposed to contaminated flood waters can experience health issues such as pneumonia or foot rot. Livestock may also be exposed to disease-carrying mosquitoes during flood events. Prolonged flood events and impacts can cause further challenges to the ranching sector by causing delays in building back livestock herds or limiting the availability of accessible and usable forage land. Ranching areas can also be used as potential natural infrastructure with benefits such as increased storage of runoff during flood events.

1.A.7. Existing Flood Planning Documents

The Existing Flood Planning Documents section provides insight into the regulatory and policy environment governing floodplain management in the various jurisdictions of the San Jacinto region, including the most common types of regulation, structural controls, and planning activities. Additional details are provided in the following subsections.

1.A.7.a. Floodplain Ordinances

Floodplain ordinances regulate development and various impacts on a community's floodplain. Many of the municipalities in the San Jacinto region participate in the NFIP. FEMA requires flood control measures and flood prevention standards to be included in local regulations and development codes for program participation. Overall, there are 74 municipalities with floodplain management and flood prevention ordinances in the San Jacinto region. Generally speaking, these ordinances:

- restrict and prohibit land uses that are dangerous;
- control alteration of floodplains, channels, and natural protective barriers;
- describe permitting and variance procedures for land use regulation in relation to flood prevention;
- define the duties of the floodplain administrator;
- specify subdivision and construction standards;
- prescribe penalties for non-compliance to standards; and,
- define overall rules and regulations for flood control and flood hazard reduction.

Some communities have included drainage design manuals and detailed construction standards within their ordinances for flood hazard reduction.

1.A.7.b. Current Local Regulation and Development Codes

Subdivision regulations provide more focused regulation of the design and form of the development elements of a city, such as regulating the platting processes, standards for the design and layout of streets and other types of infrastructure, the design and configuration of parcel boundaries, and standards for protecting natural resources and open space. While both cities and counties have subdivision ordinances, counties in Texas do not have zoning authority.

Many entities within the region specify drainage requirements within their subdivision regulations or associated drainage criteria manuals. These regulations specify detention requirements for new development, require finished floor elevations for buildings, and standard design requirements for drainage infrastructure.

1.A.7.c. Local and Regional Flood Plans

There have been 65 identified flood studies in the San Jacinto region since 2003. These studies range from Hazard Mitigation Plans (HMPs) and Master Drainage Plans (MDPs) for counties and municipalities to larger regional watershed studies. The plans describe the existing flood hazard conditions within the watershed and outline mitigation measures to better respond to flooding events. These include 15 HMPs, 11 Flood Insurance Studies (FISs), 10 Master Drainage Plans (MDPs), and two Base Level Engineering (BLE) studies. There are 27 additional studies that were identified, including drainage analyses and flood planning and risk reduction studies.

Chapter 1.B. Assessment of Flood Infrastructure

The following sections describe the natural and built infrastructure that gives the basin its hydraulic and hydrologic characteristics, which are the primary functions and indicators of how floodwaters move and behave through an area. Flood infrastructure in the San Jacinto region includes both natural areas and built features that are owned and managed by stakeholders ranging from Flood Control Districts to individual farmers and ranchers. This RFP considers both the natural and human-made features that contribute to risk reduction, which may include but are not necessarily limited to:

- rivers, tributaries, and functioning floodplains
- wetlands and marshes
- parks, preserves, and other natural areas
- coastal areas
- vegetated dunes
- levees
- sea barriers, walls, and revetments
- tidal barriers and gates
- stormwater tunnels
- stormwater canals
- dams that provide flood protection
- detention and retention ponds
- weirs
- storm drain system

The TWDB-provided several data sources to assist with the identification of flood management infrastructure at the Flood Data Hub website such as Dams, Levees, Reservoirs, Stream gauges, High Water Marks and Low Water Crossings. There were also several questions posed in the San Jacinto RFP Data Collection Survey Tool that were used to supplement the information provided by existing data sources to create a more complete picture of how communities in the region protect themselves from flood risk.

A comprehensive inventory of existing flood infrastructure is provided in the TWBD-required format as Appendix 1-4. Due to the scale of this assessment, the San Jacinto RFP includes major flood infrastructure such as regional detention facilities but not minor elements such as small private detention ponds serving individual properties. **Map 1**, found in **Appendix 1-1**, depicts the existing flood infrastructure within the San Jacinto region.

1.B.1. Natural Features

1.B.1.a. Rivers, Tributaries and Functioning Floodplains

The San Jacinto region is comprised mainly of the San Jacinto River and its major and minor tributaries, making up a complex network of functioning floodplains. A functioning floodplain is a broad term used to describe a natural area susceptible to flooding that provides a broad range of ecological and hydrological functions, including flood storage, water quality maintenance, and groundwater recharge.

1.B.1.b. Wetlands and Marshes

A wetland is an ecosystem that is flooded by water, either permanently, seasonally, or after discrete rainfall events. Wetlands provide an important ecosystem for aquatic plants and animals, as well as significant flood storage. The natural functions of wetlands within the San Jacinto region are numerous including natural stormwater treatment, biodiversification, oxygen saturation improvements, areas to promote infiltration, and distribution of intensity of floodwaters. The San Jacinto region contains both freshwater and coastal wetlands for a total of 189,000 acres.

1.B.1.c. Parks, Preserves, and Other Natural Areas

Parks and preserves are included in the flood infrastructure assessment because they include provide essential opportunities for infiltration and retention of stormwater during and after a rainfall. These types of natural flood infrastructure are generally located within or adjacent to floodplains throughout the basin to provide flood benefits and flood storage. Higher concentrations of these areas are located along or close to the major rivers. There is a relatively large amount of preserved natural area within the region, notably the Sam Houston National Forest, the Coastal Prairie Conservancy, Lake Houston Wilderness Park, Armand Bayou Nature Center, and various dedicated urban green spaces.

1.B.1.d. Coastal Areas

The San Jacinto region contains and is greatly impacted by coastal areas. There are also somewhat inland areas, areas not directly touching the coast, that see an impact from coastal flooding, such as the Houston Ship Channel and other areas inland within Brazoria, Chambers, Galveston, and Harris Counties. The natural functions of coastal areas, such as dune and bay ecosystems, serve a large ecological and economic benefit. Galveston Island, a barrier island, provides protection to Galveston Bay and land behind it from much of the Gulf of Mexico's wave, current, and tidal action. On Galveston Island, measures are in place to protect the Island and keep the barrier island stable. Measures include dune systems; a seawall along the historically populated portion of the eastern portion of the Island; and beach nourishment of severely eroding Gulf-facing beaches. Galveston Bay is a relatively shallow bay with minimal wave action due to the barrier island, which can reduce the erosive forces on the bay shorelines. Constructed Flood Infrastructure and Structural Protections

A vast number of stormwater features have been constructed across Texas, ranging from major flood control infrastructure such as reservoirs, dams, and levees, to municipal drainage systems made up of constructed channels and ditches, closed storm drain systems, and detention and retention ponds. Each of these elements play an important role in protecting communities within the San Jacinto region from flooding.

1.B.1.e. Dams, Reservoirs, Levees, and Weirs

Reservoirs and their associated dams and weirs in Texas may serve one or more purposes, including recreation, flood risk mitigation, irrigation, water supply, and fire protection. Information on major reservoirs for the San Jacinto RFP analysis was compiled from the TWDB dataset. Of the 17 total reservoirs identified in the TWDB-provided infrastructure dataset, six major reservoirs (**Table 1-6**) were identified in the San Jacinto region. Note that the Addicks and Barker Reservoirs' primary functions are to reduce flood risk, whereas the other reservoirs in **Table 1-6** were constructed to provide other functions, such as water supply.

TABLE 1-6: LIST OF MAJOR RESERVOIRS

Reservoir Name	Impoundment Feature	Location
Addicks Reservoir	Dam	Houston, TX
Barker Reservoir	Dam	Houston, TX
Lake Conroe	Dam	Conroe, TX
Lake Houston	Dam	Houston, TX
Lewis Creek Reservoir	Dam	Willis, TX
Sheldon Reservoir	Dam	Sheldon, TX

Levees are human-made embankments that contain flood flows to a restricted floodplain. Throughout the region, there are roughly 152 miles of levee systems. The prominent levees within the San Jacinto region include a seawall along eastern Galveston Island; levees along Cedar Bayou in Chambers County; the coastal protection levee system around Texas City; two levee systems along Spring Creek and Cypress Creek in northern Harris County near Spring, Texas; and the Lynchburg Pump Station levee along the Harris County Ship Channel.

1.B.1.f. Stormwater Management, Storm Drain and Canal Systems

While it is likely that most communities maintain at least a limited amount of storm drainage infrastructure, there is no publicly available comprehensive dataset of municipal storm drain systems. As a result, the collection of spatial data for the San Jacinto RFP relied on survey responses based on local entity data management. These stormwater management systems contain several elements such as culverts, channels, inlets, canals, detention, and natural functioning drainage systems. During this first cycle of San Jacinto RFP development, limited storm drainage infrastructure geospatial datasets were provided by stakeholders.

1.B.1.g. Detention and Retention Areas

Detention and retention systems are either dry or wet bottom basins, constructed to store and release downstream controlled stormwater runoff. Detention areas located within the San Jacinto region are a common and frequently utilized measure for mitigating and reducing impacts from flooding due to land development, road improvements, and other projects that have the potential to increase stormwater runoff. Detention is often accompanied by channel redesign to ensure the volume, capacity, and timing of releases from the channel have no adverse downstream impacts. Detention basins can vary in size from privately owned impoundments that provide benefit to one property to large regional basins owned and maintained by public entities. However, at municipal and privately owned levels, there are many more instances of detention than listed or provided in the accompanying spatial dataset. There is an increasing trend of constructing wet-bottom detention facilities, meaning a certain volume of water is designed to always stay in the basin. Constructing larger regional-scale detention can lead to reduced design and maintenance costs. As an example, one of the larger detention efforts within the region will add approximately 25,000 acre-feet of detention storage to the Cypress Creek watershed. For comparison, since the inception of HCFCD in 1937, only 62,000 acre-feet of detention storage has been created within Harris County.

1.B.1.h. Coastal Infrastructure

Within the San Jacinto region, the counties of Brazoria, Chambers, Galveston, and Harris either border or are proximate to the Texas coastline. Different portions of the coastline are protected from waves or nominal tidal water levels to varying degrees by seawalls, beach and dune systems, harbors, or other protective elements. The importance of maintaining the uninterrupted function of port, petrochemical operations, and prevalent industries within the coastal areas of the region has historically resulted in investments in protection measures which make those sites and the coastline less susceptible to minor, regular flooding events.

1.B.2. Assessment of Condition and Functionality of Existing Infrastructure

Participants in the San Jacinto RFP data collection effort were able to provide only limited spatial information that could supplement the information provided by the TWDB regarding the condition or functionality of infrastructure, which resulted in **Map 3** (**Appendix 1-3**) not displaying any spatial data. The San Jacinto RFPG intends to incorporate this data in future planning cycles, as the data is made available or provided.

Out of the stakeholders responding to the survey regarding infrastructure status, 56% noted that at least 25% of the infrastructure about which they provided information was considered non-functional[4], and 88% of respondents noted that at least 25% of the infrastructure about which they provided information was deficient[5]. Some of the most common responses regarding the non-functioning and deficient infrastructure were inadequate budget to construct a proper or sufficient system; inadequate budget to maintain the system; uncontrolled erosion or scour; impacts from development;and lack of adequate standards during construction.

4 Non-functional was defined as infrastructure that is not providing its intended or designed level of service.
5 Deficient was defined as infrastructure that is in poor structural or non-structural condition and needs replacement, restoration, or rehabilitation.

1.B.2.a. Dam and Levee Safety

In 2019, the Association of State Dam Safety Officials (ASDSO) estimated the cost to rehabilitate all non-federal dams in Texas at $5 billion. There are currently 182 identified dams within the San Jacinto region. While the dams are located across a wide geographic area, roughly 50% are within Montgomery County. Of the 182 identified dams, approximately 80% are state regulated, and a majority in the region are privately owned. Out of the 182 dams, 70% do not have a condition assessment rating, 15.8% were rated fair, 5.6% were rated poor, 5.6% were rated satisfactory, and 2.8% were rated unsatisfactory. These metrics show that dams within the region are not in the best of condition and are susceptible to further decline, increasing the risk failure.

The Texas City Hurricane Flood Protection and Lynchburg pump station systems were the only levees to receive a performance and potential lost benefit rating according to the U.S. Army Corps of Engineers (USACE) National Levee Database (NLD). The Lynchburg pump station levee system protects a critical pump system that supplies drinking water to the City of Houston. The Lynchburg system has a relatively low associated risk, as the likelihood of failure of the system prior to surge water elevations reaching the top of the levee is low, according to the USACE NLD. The Texas City Hurricane Flood Protection (HFP) system received a high-risk classification due to the system having experienced 100% water loading during Hurricane Ike, and the USACE notes that the wall is likely to fail prior to the system being overtopped. In the event that a failure occurs, there are billions of dollars and thousands of people at high risk.

There are both provisionally accredited levee (PAL) systems and accredited levee systems identified in the region. An accredited levee system designation is given when FEMA has determined that the system meets the design, data, and documentation requirements described in Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44 CFR 65.10) and can be shown on a flood insurance rate map (FIRM) as reducing the base flood hazard. A PAL system is accredited when the system provides a base flood hazard reduction on an effective FIRM and FEMA is awaiting data and/or documentation to show the system is compliant with 44 CFR 65.10. The Texas City systems are recognized as PAL systems, while the Spring Creek and Cypress Creek systems are FEMA accredited levee systems.

1.B.3. Planned Flood Infrastructure Improvements

Planned flood infrastructure projects and studies within the region portray an assessment of current mitigation needs. Stakeholder survey responses were very limited for planned projects. Subsequent outreach and research was conducted by the RFPG. Entities within the San Jacinto region have an extensive list of 514 identified or ongoing projects ranging from land acquisition and buyouts to regional detention and conveyance improvements to coastal protection. These projects include potential local, state, and federal sponsors. **Figure 1-3** shows the breakdown of flood mitigation project types within the region researched and provided via the stakeholder survey. **Map 2**, found in **Appendix 1-2**, depicts the proposed and/or ongoing flood mitigation projects within the San Jacinto region by HUC 8. For a list of identified existing flood projects within the San Jacinto region, refer **Table 2** to **Appendix 1-5**. Task 4 further discusses the recommended projects for the San Jacinto RFP.

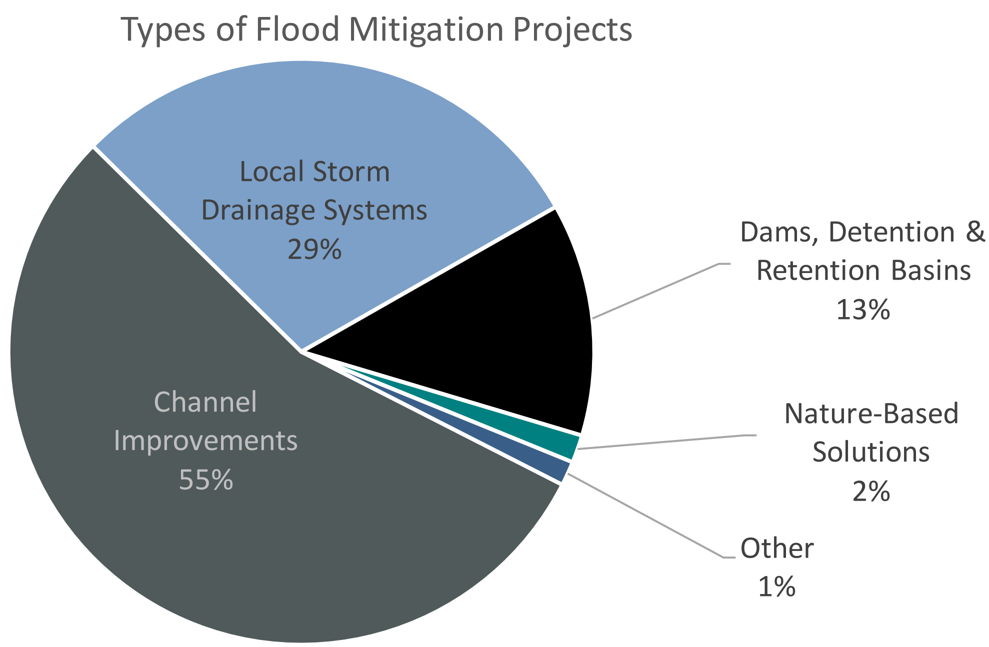

FIGURE 1-3: TYPES OF FLOOD MITIGATION PROJECTS[6]

The most common types of projects in the region are channel improvement projects, which are inclusive of channel repair and channel conveyance improvement projects. The channel repair projects are primarily ones proposed by HCFCD as part of the Harris County 2018 Bond program. The channel conveyance improvements vary in size from several miles of channel widening to shorter sections of channel repair to stabilize banks and restore capacity. The second most common project type includes local storm drainage projects, primarily led by the HCFCD and their local partners. Collected proposed projects involving acquisition, levees, and nature-based solutions were generally limited within the San Jacinto region.

1.B.3.a. Structural Projects Under Construction

The ongoing Harris County 2018 Bond program has projects in different stages of implementation, including 69 active construction projects within the county. Outside of Harris County, information was insufficient to provide a complete understanding of the status of proposed infrastructure projects.

1.B.3.b. Non-structural Flood Mitigation Projects Being Implemented

Projects involving non-structural measures were limited within the region compared to structural projects. Non-structural solutions included flood warning gauges to enhance flood response; voluntaryhome buyout programs in Montgomery County and Harris County; and land acquisition for floodplain preservation within Harris County.

6 The categories with the fewest number of projects have been represented together as an “Other” category, including land acquisition, levees and flood walls, roadway crossing improvements, and coastal projects.

1.B.3.c. Structural and Non-Structural Flood Mitigation Projects with Dedicated Funding and Expected Year of Completion[7]

Although funding for many projects in Harris County is known, the information provided in response to stakeholder outreach for the remainder of the region was insufficient to describe all of the structural and non-structural flood mitigation projects with dedicated funding. However, multiple sources of funding were identified when researching existing projects. These sources are listed in Section 1.B.5.

1.B.3.d. Anticipated Benefits of Planned Infrastructure Improvements

Survey results and initial research of the identified planned projects provided limited information on expected benefits for each project gathered during Task 1. The project benefits vary greatly depending on the type and scale of the drainage improvements. Without greater detail as to the scale, functionality, and complexity of each project, it is difficult to quantify the anticipated benefits. Further collecting and inventorying of this information is planned for future planning cycles and is recommended to be used to determine benefits more accurately.

1.B.4. Summary of Ongoing Study Efforts

Flood studies are important tools to help communities identify flood risk. The input data for these studies is constantly being updated and refined, including information such as rainfall depths, land use, and implemented projects. Ongoing studies can be leveraged in future flood planning efforts to enhance the understanding of existing and future flood hazard within the region.

Base Level Engineering (BLE) studies involve the development of high-level models to estimate flood risk and are led by the TWDB in partnership with FEMA. BLE studies provide additional flood risk information for areas of limited or outdated mapping. Current BLE studies within the region include the West Fork San Jacinto, East Fork San Jacinto, and Spring Creek watersheds.

Other studies include a remapping of Harris County watersheds by FEMA and HCFCD, referenced as the MAAPNext program. This effort utilizes new data, methodologies, and technologies such as NOAA's Atlas 14 rainfall, 2018 LiDAR, and two-dimensional modeling to enhance the understanding of flood risk within the county. FEMA is working to complete the development of data and preliminary maps and will release this information to the public once they are complete, which is currently anticipated to be in 2023.

The Texas GLO's Combined River Basin Study, which covers counties that received a Presidential Disaster Declaration due to the impact of Hurricane Harvey, will result in a detailed assessment of existing flood risk as well as the development of mitigation strategies for each of the regions included in the study. The study's Central region covers the San Jacinto and Brazos River watersheds, including much of the San Jacinto region. Information from this study will be used to support the current and future flood plans for the region. The study will be completed in the summer of 2024.

The TWDB Flood Infrastructure Fund (FIF) provides funding for projects and studies throughout the San Jacinto region. Of the applications received by TWDB for FIF funds for flood planning studies, ten studies

7 "Year Complete" refers to the expected year of completion for a project.

were funded and are ongoing in the region to understand existing flood risk and provide mitigation solutions. These include studies sponsored by the San Jacinto River Authority, the City of Houston, Chambers County, Waller County, and Montgomery County.

Potential funding sources identified for ongoing study efforts in the San Jacinto region identified as part of the San Jacinto RFPG data collection effort include federal, state, and local sources. Federal sources include FEMA through the Flood Mitigation Assistance (FMA) program and Hazard Mitigation Grant Program (HMGP), HUD funding through the Community Development Block Grant Mitigation (CDBG-MIT) and Community Development Block Grant Disaster Recovery (CDBG-DR) programs, the Natural Resources Conservation Service (NRCS), and the USACE. State funding includes the Texas GLO, TWDB FIF program, and Texas Division of Emergency Management (TDEM). Local funding sources include general funds, local bonds, taxes, and stormwater utility fees.

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CHAPTER 2. FLOOD RISK ANALYSES

A critical component in development of the Regional Flood Plan (RFP) was to define a baseline of understanding for flood risk in the San Jacinto region. This chapter documents the effort to define flood risk throughout the San Jacinto region for both existing and future conditions. The flood risk analysis was comprised of three main components:

1. Flood Hazard Analyses - determine the source, location, magnitude, and frequency of flooding;
2. Flood Exposure Analyses - to identify who and what might be harmed within the San Jacinto region; and
3. Vulnerability Analyses - to identify vulnerabilities of communities and critical facilities.

Figure 2-1 demonstrates the main components that drive the flood risk analysis performed for the San Jacinto region.

FIGURE 2-1: FLOOD RISK ANALYSIS COMPONENTS

Chapter 2.A. Existing Condition Flood Risk Analysis

2.A.1. Existing Condition Flood Hazard Analysis

2.A.1.a. Characterization of Existing Condition Floodplains

Existing flood hazard was determined based on available floodplain mapping information in the Flood Hazard Quilt provided by the TWDB in the Flood Planning Data Hub website. The feature is predominately Effective FEMA Flood Hazard Data mapping supplemented by some instances of Base Level Engineering (BLE) and FEMA Effective Approximate modeling. The TWDB has provided data from the First American Foundation Data Service (FAFDS) and cursory floodplain data from Fathom. Neither of these data sets were used in this RFP because the San Jacinto region already has significant coverage of detailed floodplain mapping data. Fathom was not included specifically due to the approximate nature of the data set. The methodology for reconciling overlapping sources of floodplain data is discussed further in the section, **Best Available Existing Flood Hazard Data**.

Of the data available in the TWDB-provided flood quilt, flood hazard mapping included in this planning cycle is based upon TP40 rainfall frequency, depth, and distribution information. TP40 was originally released in the 1960s and updated versions only account for historical storms of record through the early 2010s. Atlas 14, produced by National Oceanic and Atmospheric Administration (NOAA), is the most recent estimate of rainfall frequency for Texas, as it considers historical rainfall records up to and including Hurricane Harvey in 2017. There are significant differences between TP40 and Atlas 14 rainfall amounts as shown in the table below.

As the differences in rainfall amounts, shown in **Table 2-1**, are significant there will be opportunity in future planning cycles to update existing flood hazard features to reflect updated rainfall.

TABLE 2-1: APPROXIMATE RAINFALL DIFFERENCE BETWEEN ATLAS 14 AND TP40

Location	TP40 Rainfall (in)	NOAA Atlas 14 Rainfall (in)
San Jacinto region	11.5-13.5	13.5-20.5

Throughout the San Jacinto region, flood risk data are prevalent, and there is full coverage of available regulatory flood hazard mapping. The main types of flood risk reported in the San Jacinto flood hazard layer are riverine and coastal. However, in future planning cycles of the RFP there is opportunity to include other types of risk such as urban and pluvial flood risk.

As the region is rapidly developing, the regulatory floodplains are updated through the FEMA Letter of Map Change (LOMC) process. Any modifications to the regulatory mapping products used in the existing flood hazard features that became effective after December 2020 have not been included for this first planning cycle. However, data and changes that take place after 2020 can be captured and reflected in future planning cycles. The current risk distribution of 1.0% and 0.2% annual chance events (ACE) within the region can be seen in **Figure 2-2**. Harris, Montgomery, and Galveston Counties have the largest overall areas and floodplain areas within the San Jacinto region.

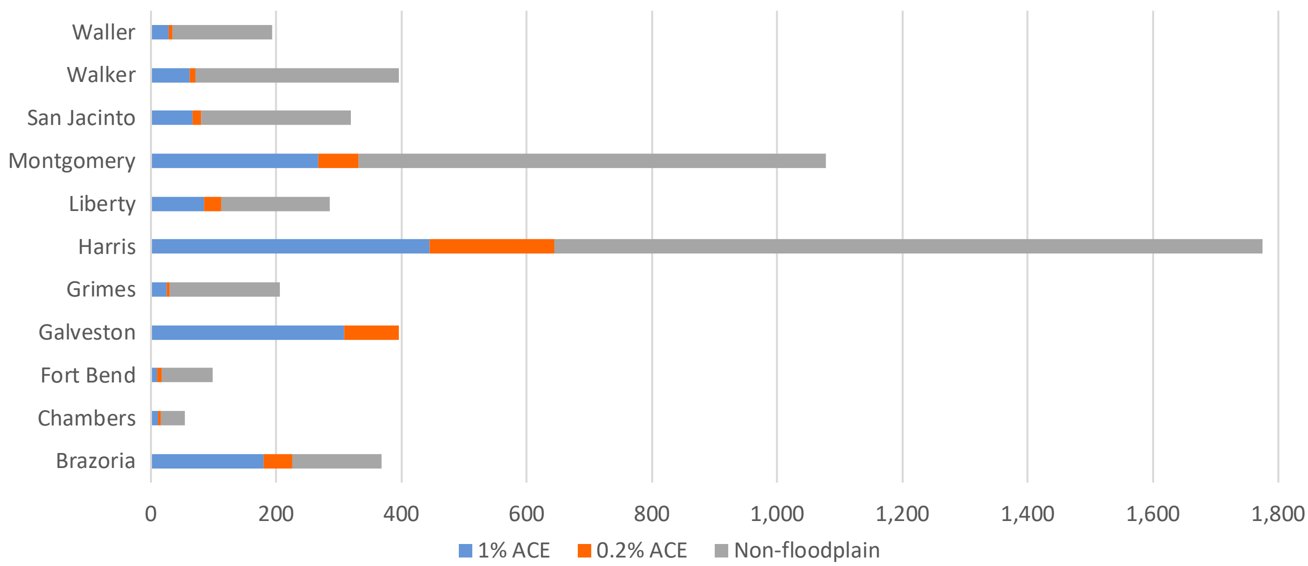

FIGURE 2-2: EXISTING FLOODPLAIN AREA[1] BY COUNTY

1 For the purposes of the graphic, the 0.2% ACE area is not inclusive of the 1.0% ACE area.

2.A.1.b. Existing Hydrology and Hydraulic Model Availability

Hydrology and hydraulics (H&H) modeling is a necessary component in determining how water flows over land and is a crucial element in developing effective and reasonable flood mitigation planning strategies. Hydrology is the scientific study of earth's natural water movement with a focus on how rainfall, infiltration, and evaporation affect the amount of runoff, and hydraulics represents the analysis of the depth and flow of water.

Applied since the 1970s, H&H modeling uses computer software applications that simulate the flow of rainfall runoff over the land to predict the rise in water level in creeks, rivers, and lakes as well as potential flooding extents. H&H modeling simulates flow, frequency, depth, and extent of flooding over land and frequently satisfies regulatory requirements to ensure that natural, agricultural, and social resources are not damaged by flooding induced by development or modifications to natural features.

As previously discussed, the San Jacinto region is a data-rich area with numerous FEMA, BLE, and other detailed H&H modeling efforts. Due to the overall abundance of floodplain data and the short timeframe of the first planning cycle, there were no additional non-regulatory data incorporated. The abundance of available detailed H&H modeling is apparent in **Appendix 2A-5** and in Model Coverage mapping shown in **Appendix 2A-9**. The list of existing H&H models in **Appendix 2A-5** was developed based on known modeling efforts. However, the model coverage shown in **Map 22** of **Appendix 2A-9** is representative of models that have been collected and are publicly available or were submitted by sponsors to the San Jacinto RFPG. Although most of the identified models were available during the development of the RFP and used updated Atlas 14 rainfall, they were not incorporated into this first planning cycle. However, there will be an opportunity to consider incorporating additional non-regulatory data in future planning cycles.

2.A.1.c. Best Available Existing Flood Hazard Data

As defined in the *Technical Guidelines for Regional Flood Planning (Exhibit C)* the RFPGs shall perform existing condition flood hazard analysis to determine the location and magnitude of both the 1.0% annual chance and the 0.2% annual chance flood events. The text below is provided to highlight the process used to create the flood hazard information.

Existing flood hazard was determined based on available floodplain mapping information in the Flood Hazard Quilt provided by the TWDB in the Flood Planning Data Hub website. At locations where mapping information overlapped, the information used followed the hierarchy provided by the TWDB and approved by the San Jacinto RFPG. The hierarchy list is provided below in order of descending data source priority.

1. **FEMA Map Service Center (MSC) (https://msc.fema.gov/portal/home)**
    a. Pending Flood Hazard data[2]
    b. Preliminary Flood Hazard data[3]
    c. Effective Flood Hazard data

2 No Pending Flood Hazard data was used due to Effective Flood Hazard data availability.
3 No Preliminary Flood Hazard data was used due to Effective Flood Hazard data availability.

2. **FEMA/USGS/TWDB Estimated Base Flood Elevation Viewer** (https://webapps.usgs.gov/infrm/estbfe/)
    a. Base Level Engineering (BLE) data
3. **First American Flood Data Services (FAFDS)**
    a. FAFDS data is not incorporated into the San Jacinto region analysis due to the approximate nature of the dataset.
4. **Cursory Floodplain (Fathom 3m) (Provided October 2021)** (https://firststreet.org/flood-factor/)
    a. Cursory Floodplain data is not incorporated into the San Jacinto region analysis due to TWDB's recommendation that the data "may not appropriately depict flood risk associated with: Constructed features that may alter flow patterns (roadways, railroads, urban areas, storm drainage systems, dams, levees, embankments, etc.)." The Cursory Floodplain Data has not been incorporated because the Cursory Floodplain dataset is considered approximate due to the coarse level of detail; intended only to be used in areas where no other data is available; used in areas without constructed drainage features; and the prevalence of comprehensive existing floodplain mapping is available throughout the region.

A region-wide set of maps was developed that depicts the existing flood hazard areas following the described processes and hierarchy of data priority as shown in **Map 4** found in **Appendix 2A-1**. These maps reflect the best-known flood risk data provided by the TWDB in the Flood Planning Data Hub as seen appropriate by the San Jacinto RFPG. **Figure 2-3** shows the overall presence of regulatory mapping within the region. Most of the region is covered by the detailed National Flood Hazard Layer (NFHL) from FEMA Effective Flood Hazard data. FEMA NFHL is the regulatory source for floodplain mapping used in a variety of contexts such as national flood insurance and local development regulations. However, some areas are supplemented by BLE data in the northern part of the region and small areas of NFHL approximate mapping can be found at the upstream tailwater conditions of some reaches. Other detailed H&H mapping exists for various areas within the San Jacinto region and can be incorporated into the existing flood hazard area in future planning cycles.

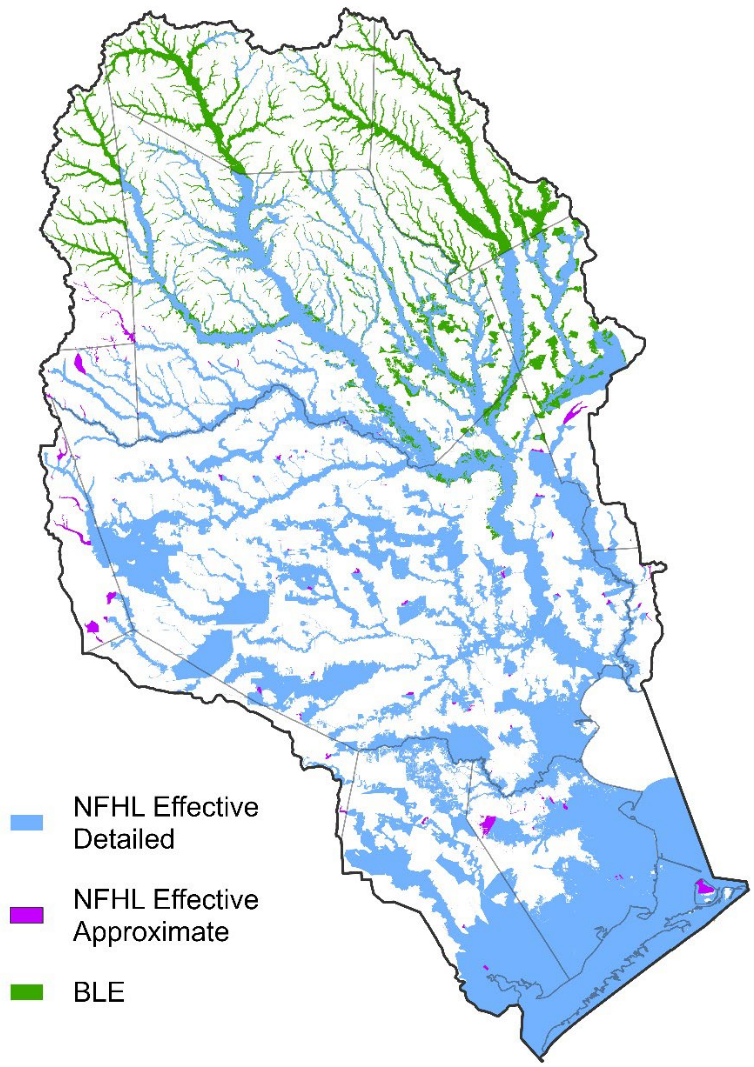

FIGURE 2-3: BEST AVAILABLE FLOOD HAZARD DATA

2.A.1.d. Existing Flood Map Gaps and Flood Prone Areas

Flood Map Gaps

The intent of the gap analysis is to identify areas with an absence of, or outdated, regulatory modeling and mapping. Watersheds with inadequate floodplain mapping information have been classified as map gaps. These watersheds were identified at a Hydrologic Unit Code (HUC) level, which indicates the size of the watershed reflected in a series of digits (HUC12 was used for this analysis). Several datasets were used as references to help inform the gap designations. These include the urban development data from the National Landcover Database, TWDB Flood quilt, and various FEMA Flood Insurance Study (FIS) reports. Due to significant increases in anticipated rainfall depth seen across the entire region due to the NOAA Atlas 14 as shown in **Figure 2-4**, change in rainfall depth was not included as a decision point for Flood Map Gap designations, as the change in rainfall amounts would qualify the whole region as a mapping gap since the effective FEMA mapping does not yet incorporate Atlas 14 rainfall.

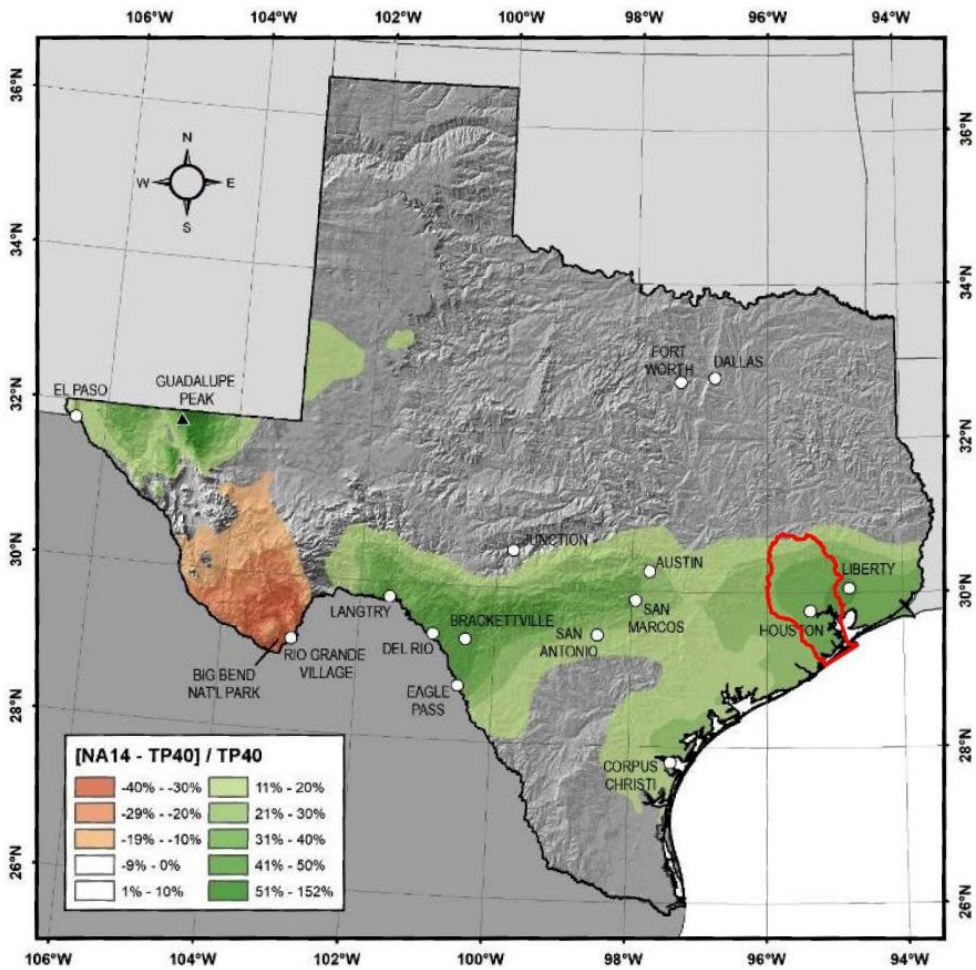

FIGURE 2-4: RAINFALL INCREASE BETWEEN ATLAS 14 AND TP40

In addition, areas with known ongoing mapping efforts, such as areas captured within the Harris County MAAPnext effort or recently completed Master Drainage Plan modeling, were not considered to be gaps as these studies have developed detailed mapping using current methodology (including Atlas 14 rainfall) and are available for incorporation in subsequent flood planning cycles. For the purposes of the mapping gap analysis, inadequate mapping in the San Jacinto region has been defined as:

- Mapping Limited to Main Reach
  - Locations that only have detailed mapping associated with the main stem of the HUC12 but lack detailed mapping along tributaries.
- Outdated Mapping
  - Mapping produced with inputs, such as terrain or percent imperviousness, that no longer reflect current development conditions. The percentage of HUC12 area recently converted to urban development and FIS reports were used to determine whether existing mapping no longer accurately reflects flood risk in each area. Depending on the development percentage either 2010 or 2000 was used as the date cutoff for outdated mapping.

- Areas of Recent Development with only BLE Mapping
    - HUC12s without detailed mapping in areas with recent development or a significant number of roadway stream crossings. BLE mapping provides an insufficient level of detail to adequately capture flood risk in these areas.
- Lacking Effective NFHL Mapping (Only includes Effective Approximate mapping)
    - HUC12s lacking both effective detailed FEMA mapping and BLE mapping.

The gap analysis provides an understanding of the areas of the region that have modeling and mapping needs. Information on the location of flood map gaps is included in **Map 5** found in **Appendix 2A-2**.

Flood Prone Areas

Flood prone areas are being considered as known locations that experience flooding outside the extent of the existing flood hazard area. Members of the public and regional stakeholders were provided the opportunity to identify flood prone areas using an online interactive map where users were allowed to provide input as points and polygons. The following four questions are required for any comment submission on the web map.

1. How often does the location flood?
2. What level of storm intensity causes the area to flood?
3. What appears to be the main cause of the flooding at each location?
4. What is impacted by the flooding?

In **Figure 2-5**, a reported flood prone area shown by the blue rectangle is for the most part outside of the mapped floodplain, as the noted location must be outside the extent of the existing flood hazard to be noted as flood prone. Users were allowed to input data in any location, including areas within the existing floodplain, but only data recorded outside of the known flood hazard area was used in the flood prone area analysis. This data helps inform the San Jacinto RFPG of flood risks that are not reflected in current flood risk mapping.

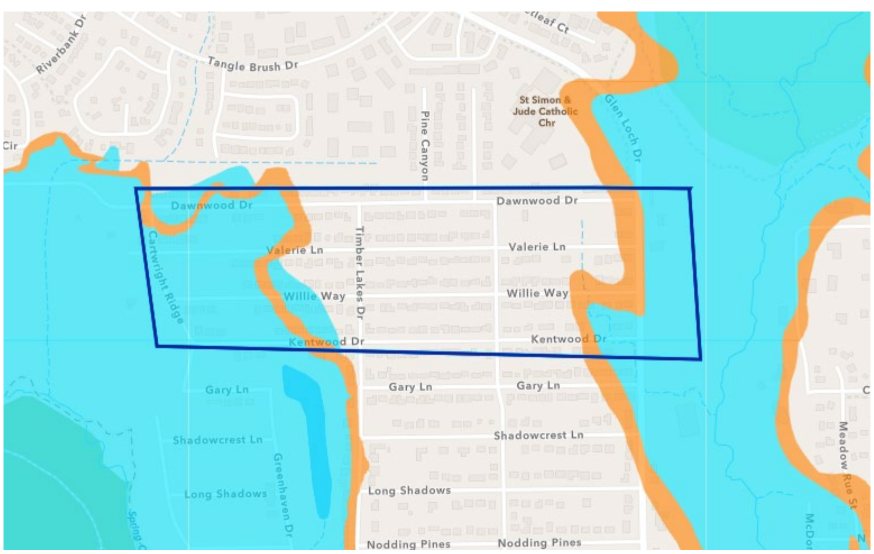

FIGURE 2-5: EXAMPLE FLOOD PRONE AREA - SURVEY RESPONSE

In addition to the polygons and points recorded, the responses to the survey questions were recorded (a received response shown below) and used for planning purposes to help provide more detail into the extent and the perceived cause of the flooding. Additionally, users could provide written comments and attach photos with each submission. As future planning cycles progress, the intent is to continue to engage the public and regional stakeholders to help identify areas that experience flood risk that are not currently being reflected in regulatory risk information.

Example of Received Responses

1. How often does the location flood? *Once in the last five years*
2. What level of storm intensity causes the area to flood? *Only during heavy or prolonged rain events*
3. What appears to be the main cause of the flooding at each location? *Site is too low or too flat*
4. What is impacted by the flooding? *Buildings*
5. Comments: *This area floods every time there is a major flood. Water is up to the roof tops and the homes are cleaned up and rented again. The area has flooded at least 10 times in the last 30 years.*

The online interactive map was made available for public comment on August 17, 2021 and has received 27 total recorded survey responses. The flood prone areas included in the Draft San Jacinto RFP originated from San Jacinto RFPG online webmap survey responses as well as data points shared from the Texas GLO data outreach effort. Based on topography and survey responses, several point locations were digitized into polygons to represent areas of likely inundation. The flood prone areas were included in the Existing and Future Flood Hazard spatial features with a Flood Frequency designated as “Unknown”, per *Technical Guidelines*.

The flood prone areas shown within **Map 5** found in **Appendix 2A-2** were not assigned a flood frequency value due to the wide variety of survey responses received. For example, some responses identified areas of frequent street ponding while others identified areas that were inundated during Hurricane Harvey. Since a flood frequency was not estimated for survey responses, the extent of the delineated flood prone areas remained unchanged between the existing and future flood hazard analyses.

2.A.2. Existing Condition Flood Exposure Analysis

2.A.2.a. Existing Development within the Floodplain

As defined in the *Technical Guidelines*, the goal of the exposure analysis is to identify who and what might be harmed within the region by flooding. The exposure analysis, namely a GIS exercise, was completed by intersecting roadways, agricultural areas, critical facilities, and buildings, with the flood hazard features to determine a region-wide evaluation of the infrastructure prone to risk associated with inundation from the existing and future 0.2% and 1.0% annual chance flood events.

TWDB provided the following datasets that were used in the critical infrastructure dataset: police and fire stations, hospitals, shelters, schools, natural gas pipelines, and electric power transmission. The natural gas pipelines and electric power transmission lines were not included as a part of the critical infrastructure dataset used in the exposure analysis within the San Jacinto region since most of these features within the region were determined to be floodproofed, located well above or below ground, or are not in imminent risk of damage if located spatially within the floodplain.

In addition to the TWDB-provided dataset, the San Jacinto RFPG supplemented the critical infrastructure dataset with water and wastewater treatment plants, correctional facilities, aviation facilities, waste disposal facilities, power generation, and chemical manufacturing and processing facilities. As a result of the exposure analysis, a population estimate was generated to summarize the number of people impacted in the various floodplains. The exposure analysis information was summarized in **Table 3**: Existing Conditions Flood Exposure Summary Table provided as **Appendix 2A-7**.

This exposure information will be used to not only identify areas within the region that have the greatest flood mitigation needs but to serve as a basis of comparison when assessing benefit of potential mitigation projects or strategies. The density of critical features resulting from the exposure analysis is displayed region wide in **Map 6** in **Appendix 2A-3** in the form of a density raster.

2.A.2.b. Potential Flood Mitigation Projects

Every HUC 12 watershed within the San Jacinto region has at least one ongoing project with a project area associated inside the HUC 12 watershed extent. There are approximately 514 ongoing/planned projects within the San Jacinto region aimed at reducing flood risk. Many of these projects are located within Harris County and parts of Brazoria and Galveston Counties. As a general requirement, these projects often have associated model results or post-project inundation mapping; however, post-project inundation mapping was not incorporated for this first planning cycle due to the short timeframe and vast number of projects within the region. These benefits and floodplain modifications will be reflected in future planning cycles as changes to effective FEMA mapping or as time allows for incorporation in future planning cycles.

2.A.2.c. Flood Exposure Due to Existing Levees or Dams

Levees in the San Jacinto Region

Levees are a significant piece of flood reduction infrastructure, totaling more than 152 miles throughout the San Jacinto region. Some of the most notable levees include systems along eastern Galveston Island, along Cedar Bayou in Chambers County, the coastal levee system within Texas City, the two systems in northern Harris County near Spring, Texas along Spring and Cypress Creeks, and the Lynchburg Pump Station along the Harris County Ship Channel. Whereas installation of levees is a common practice where coastal flood risk is prevalent, using levees as an inland riverine flood reduction method is not. However, throughout the region, levees are frequently used for agricultural purposes, but these agriculture levees rarely serve any significant flood protection to property or infrastructure and therefore are not considered as flood infrastructure for this RFP cycle.

Among the levees within the region, both the Texas City systems are recognized as provisionally accredited (PAL), and the Spring Creek and Cypress Creek Systems are FEMA accredited. The details of the accreditation and risk analysis process are defined in section 1.B.3.a. The Lynchburg pump station levee system protects a critical pump system that supplies drinking water to the City of Houston. The Lynchburg system has a relatively low associated risk, as the likelihood of failure of the system prior to surge water elevations overtopping the levee is low according to the USACE National Levee Database.

Although there are water supply and infrastructure consequences of the Lynchburg pump system levee failing, the Lynchburg levee protects one person and $1 million in property value. On the other hand, the Texas City Hurricane Flood Protection (HFP) system received a high-risk classification due to the system experiencing significant water loading during Hurricane Ike; the USACE notes that the system is likely to fail prior to the system being overtopped. As shown in **Table 2-2**, the two levees in Texas City protect a substantial amount of property and number of people, yielding significant flood exposure in the event of a system failure.

Levee Exposure Assessment

The most significant levees and the resources they protect within the region according to the USACE National Levee Database are found in **Table 2-2**. There are other levees within the region that protect millions of dollars worth of property and many people, but the ones included below are seen as the most significant with property value protected at greater than $25 million.

TABLE 2-2: LEVEE EXPOSURE DATA

Levee Name	Location	Length (miles)	Population Protected	Buildings Protected	Property Value Protected	FIRM/ FEMA Status
Gulf Coast Water Authority Reservoir Levee System	Texas City	3.7	11,253	3,406	$2B	Provisionally Accredited (PAL)
Texas City Hurricane Flood Protection	Texas City	22.0	15,370	4,965	$1B	Provisionally Accredited (PAL)
Spring Creek Levee System	Spring	1.2	1,562	399	$300M	Accredited
Cypress Creek System	Spring	0.9	407	177	$47M	Accredited

Dams in the San Jacinto Region

In Texas, the Texas Commission on Environmental Quality (TCEQ) is the regulatory agency responsible for the administration of state dam safety laws. Dams located in Texas have both a size and hazard classification. The size classification is based on the maximum storage in the reservoir as well as the height of water behind the dam and the hazard potential is based on the estimated loss to human life and property damages downstream from the dam would a breach to occur. A dam's hazard classification can be low, significant, or high, based on the downstream risks in the event of a failure. Although the classification data is not released publicly, TCEQ maintains and defines these classifications. Within the San Jacinto region every type of classification for both size and hazard of dams are represented. If the hazard classification is deemed to be significant or high, an emergency action plan (EAP) must be developed by the dam owner. Sixty-four dams within the region have an EAP prepared and 19 possess the associated hazard that warrants an EAP but do not currently have a plan in place.

Dams within the region have various purposes, namely flood protection, water supply, recreation, and irrigation. The only two dams in the region that are intended for flood control purposes are the two federally regulated USACE owned and operated dams at the Addicks and Barker Reservoirs. Addicks and Barker Reservoirs are the only ones in the region that have flood control pools, which are operated by following specific protocols designed to protect downtown Houston from flooding.

Other major reservoirs in the region such as Lake Houston and Lake Conroe have a primary purpose of providing water supply to the region; as such, these reservoirs do not have a dedicated flood pool nor the infrastructure to retain flood flows. Instead, water supply reservoirs such as these are designed to maintain a conservation pool used for water supply, and to serve as a pass-through of flood flows by following protocols that ensure peak reservoir releases do not exceed peak inflows into the reservoir.

Any state-regulated dam classified by the TCEQ or federal dam operated by USACE classified as high hazard must have associated modeling and risk analysis corresponding to various dam breach scenarios. Although this modeling and risk analysis is not readily available to the public and is not currently reflected in FEMA mapping, these types of large-scale risks are being evaluated and considered in the scope of public flood risk.

A critical aspect of dams and reservoirs is a flowage easement which is privately owned land that the dam operator has the right to inundate at any point in time under normal operations. Depending on the community and dam operator, the allowances regarding what can be done with such land, such as building or developing, can be limited. The lack of development in these areas is an appropriate response of land use since the area is likely to experience inundation.

2.A.2.d. Existing Flood Exposure

Harris, Montgomery, and Galveston Counties, are spatially prominent with large relative land areas in the San Jacinto region. These three counties show the highest values for almost every category in the exposure analysis. An important consideration regarding the exposure analysis is that there is no elevation data associated with the flood hazard evaluation, so infrastructure such as elevated roadways and buildings, appear in the exposure analysis to be at risk even if they are properly elevated and are well above the regulatory water surface elevations. This potentially exaggerates the results of the exposure analysis.

Population

The general population of people can be put at risk by flood waters in a multitude of ways, such as while at home, while at work, while commuting, or while traveling to seek shelter. Within the region there are several areas that show significant populations at risk. For example, Harris County tops the list with an estimated 590,000 and 1.3 million people at risk in the 1.0% and 0.2% ACE risk classifications, respectively. Risk in Harris County accounts for approximately three fourths of the region's total population exposed to 0.2% ACE flood risk. These population numbers are based on the TWDB-provided buildings layer population estimates and are not indicative of people who are commuting in and out of these counties. Galveston County has the second highest estimated population exposed to flood risk and Montgomery County has the third highest. The trend in population exposed to flood risk aligns with the fact that the highest population densities in the region are located within these counties.

Structures

While people often shelter in their homes in times of danger and emergency, there is an inherent risk associated with staying at home during a flood event. Most of the structures identified at risk within the flood exposure analyses are residential. For example, in the entire San Jacinto region, out of the roughly 240,000 structures at risk in the 1.0% ACE, approximately 200,000 are classified as residential. Critical facilities and public infrastructure perform essential functions that require enhanced consideration in flood planning. The breakdown of existing structure types within both the 1.0% and 0.2% ACE flood hazard areas can be seen in **Figure 2-6**.

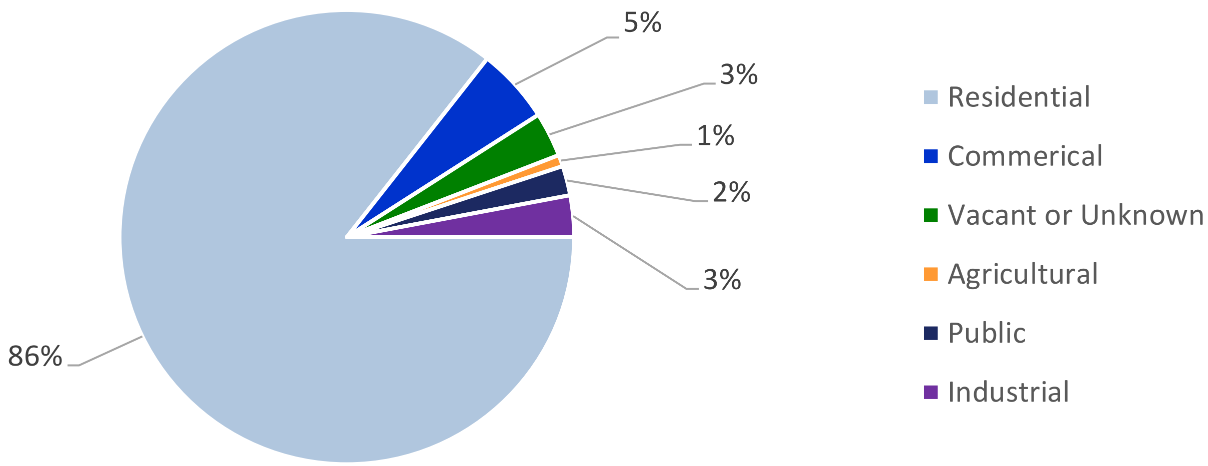

FIGURE 2-6: DISTRIBUTION OF TYPES OF EXISTING STRUCTURES IN THE 1.0% AND 0.2% ACE FLOOD HAZARD AREAS

Galveston County has the second highest number of structures exposed to both riverine flood events, almost doubling that of Montgomery County, which had the third highest number of structures exposed. Out of the estimated 2.1 million structures located within the San Jacinto region (as provided by the TWDB buildings dataset), approximately 25% of the structures are located within the 1.0% and 0.2% ACE floodplains, cumulatively, as shown in **Figure 2-7**.

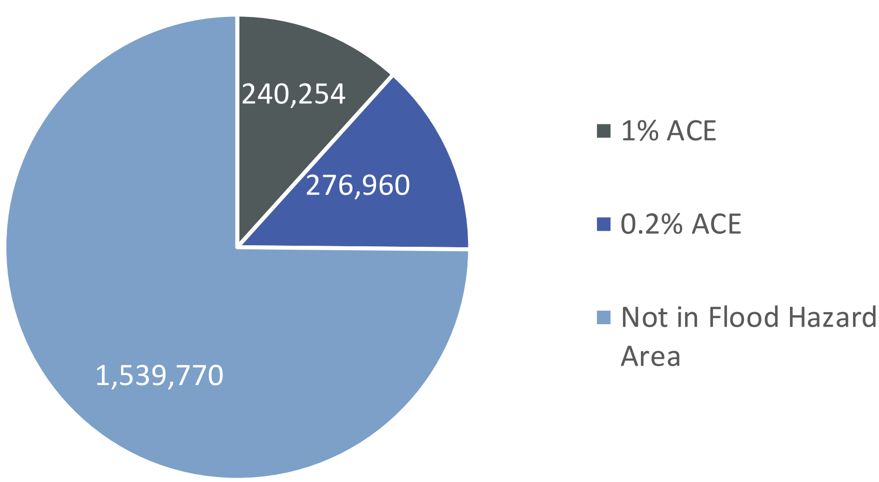

FIGURE 2-7: REGION-WIDE FLOOD HAZARD EXPOSURE OF STRUCTURES TO FLOOD EVENT

In terms of damages to structures resulting from flooding, the San Jacinto region has the highest value of National Flood Insurance Program (NFIP) flood claims in the state of any RFP region. A total of $11.7 billion in damages has been reported during the period 1975-2019, surpassing each of the other regions by nearly $10 billion, with significant damages from storms such as Hurricane Harvey, Tropical Storm Allison, and Hurricane Ike, in addition to those described in Chapter 1. Flooding is a significant issue for many residents of the San Jacinto region.

Critical facilities / Public Infrastructure

Critical facilities have especially high consequences associated with flood risk due to the nature and function of the facilities as they a serve vital function to the well-being of the population. As expected, Harris County tops the list of critical facilities exposed to flood hazards, accounting for more than half of the critical facilities in both 1.0% and 0.2 % ACE as shown in Appendix 2A-8. Galveston County shows the second highest critical facility exposure values; Brazoria County has the third highest number of critical facilities exposed to flood hazards.Roadway crossings and segments

TxDOT roadway data was provided by TWDB and included interstates and highways. Two factors were analyzed for roadways: length of roadway inundated in a flood event and number of road stream crossings. Bridge deck elevation data was not included in the analysis, so all points of intersection between streams and roads were considered in the exposure analysis. At a conceptual level, flood risk associated with flooded roadways is associated with low water crossings; cars floating in more than six inches of water;, or people unable to escape as their car is swept away.

Also, as roadways are shut down due to flooding, this affects the transportation of goods and emergency services along any major throughfare. For example, a large amount of shipping and logistics occur along US Interstate 10 within the region; if any part of it were to become impassable, this would cause significant financial impact and travel delays throughout the region. There are more than 4,000 and 8,000 miles of roadway with associated risk in the 1.0% and 0.2% ACE, respectively. Harris County tops the list for roadways inundated by both storm events; Galveston County has the second highest miles of roadways exposed to flooding; and Montgomery County has the second highest number of roadway stream crossings.

Agricultural Areas

Agricultural area in the region was identified using the 2020 CropScape – Cropland Data Layer produced by USDA National Agricultural Statistics Service. A total of 35 and 51 square miles of agricultural land were exposed region-wide to 1.0% and 0.2% ACE, respectively. Land use categories associated with farming and ranching were included in the exposure analysis as agricultural areas, while fallow or idle cropland and forestry were excluded. Brazoria County had half the agricultural acreage that is exposed to flooding within the entire San Jacinto region. Second was Harris County with Grimes County following with the third most exposed acreage. These ranges serve as an indicator of the variety of land use dynamics within the region. Although agricultural lands are a predominately natural aspect of the landscape and rarely contain large amounts of impervious surface, prolonged and unexpected flooding can cause significant damages for crop quality and yield amounts.

2.A.2.e.Expected Loss of Function

Severe flood events can result in a loss of function for a community's infrastructure which impacts the systems supported by the infrastructure. The impacts can include disruptions to life, business, and public services that can be essential to a community during and after a flood event. Infrastructure that becomes inundated during flooding events is often non-functional during the event and through the recovery process.

A spatial analysis was conducted in GIS using the best available data and the existing conditions floodplain quilt to generate qualitative estimates of expected loss of function to infrastructure for the San Jacinto region. Metrics were developed to get a general understanding of the potential loss of function of structures, transportation, health services, water supply, water treatment, utilities, energy generation, and emergency services during a 1.0% ACE. The table provided in **Appendix 2A-6** summarizes the results of the expected loss of function analysis for each county within the San Jacinto region. The expected loss of function analysis does not consider any hardening, raising, or other methods to protect functionality.

Inundated Structures

Residential structure data used in the San Jacinto region included single-family homes, town homes, mobile homes, as well as multi-family residences like apartments and condominiums. Based on the GIS analysis, an estimated 240,000 residential buildings are in the 1.0% ACE floodplain and have the potential to lose function during and after storm events. Loss of function of residential structures can result in content loss and displacement of residents. Harris County and Galveston County show the highest number of residential structures in the 1.0 % ACE floodplain.

Non-residential inventory data includes agricultural, commercial, industrial, and public buildings. An estimated 40,000 non-residential buildings are within the 1.0% ACE floodplain. These buildings are subject to a potential loss of function during storm events and during the recovery process. Loss of function of non-residential structures can result in content and inventory loss, potential relocation, loss of work, and loss of short-term shelters.

Transportation

Transportation line data (roadways and railroads) from TxDOT was used to estimate road and railways crossings at-risk of flooding. Based on the GIS analysis, approximately 4,350 miles of roadways could experience a loss of function during a 1.0% ACE storm event in the San Jacinto region.

There are approximately 239 low water crossings identified by TWDB in the San Jacinto region. These low water crossings will likely become impassable and result in a loss of function during significant storm events. The impassable roadways can delay emergency responders and strand motorists. During significant storm events, debris buildup can cause loss of stream conveyance at bridges and exacerbate the risk of stream road crossings with higher flood waters and debris overtopping the roadways.

Health and Human Services

Health and human services include hospitals, nursing homes, and other services to enhance the health and well-being of the public. Based on the spatial analysis, twenty hospitals and forty nursing homes or assisted care facilities are located within the existing floodplain. During a flood event, potential loss of function can occur for these services due to their location within the floodplain. Loss of function of health and human services can result in loss of available beds, displacement of patients, and a potential loss in the quality and availability of care. Harris County has the highest number of hospitals and nursing homes within the existing 1.0 % ACE floodplain in the San Jacinto region.

Water Supply

Floods can contaminate water supply sources such as wells, springs, and lakes/ponds through polluted runoff laden with sediment, bacteria, animal waste, pesticides, overflowing wastewater, and industrial waste and chemicals. Drinking water wells have the potential to become contaminated during major flooding events, requiring disinfection and cleanup. Based on TCEQ's Public Water Supply dataset, there are 451 public water supply wells in the San Jacinto River Basin with fifty-six in the floodplain. Therefore, 12% of the public water supply wells in the San Jacinto region are potentially exposed to flood risk. Similar risks for loss of function are expected for private water wells in flood prone areas during flood events.

Water and Wastewater Treatment

Flooding has the potential to impact water and wastewater treatment facilities and reduce the effectiveness of the facilities. Failure of water and wastewater treatment systems due to flooding may consist of direct losses such as equipment damage and/or contamination of pipes as well as indirect impacts such as disruption of clean water supply. In the San Jacinto region, around 800 wastewater outfalls are located within the 1% ACE floodplain. This means that a wastewater treatment facility is likely within the 1% ACE floodplain and is possibly susceptible to exposure and loss of function.

Energy Generation

Potential failure of power generation plants due to flooding can cause direct losses such as equipment damage as well as indirect impacts to surrounding facilities and residences due to loss of power. Eight power plants are located within the 1% ACE floodplain and have the potential to lose function during a flood event.

Emergency Services

Flood events have potential to cause disruption to emergency services causing delays in response times and could hinder access to areas such as shelters or locations in emergencies. Thirty-nine fire stations are located within the floodplainand could experience a loss of function during a flood event. Thirty-eight emergency shelters are within the 1% ACE floodplain which could limit access to those facilities in the event of a flood.

2.A.3. Existing Condition Vulnerability Analysis

Vulnerability is an assessment of the potential negative impact of the flood hazard to communities and a description of the impacts. This task used the data from the existing flood exposure analysis to determine the vulnerability of exposed structures and population to flooding. The existing condition vulnerability analysis used the same base data as the future condition vulnerability analysis. The populations and structures exposed to flood risk were evaluated for vulnerability based on the U.S. Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI). SVI is a ranking of recorded data from the U.S. census analyzed at a census tract level based "on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes." The San Jacinto RFP analysis is using SVI as a metric for vulnerability, which is being linked to resilience given a natural disaster within communities. For the purposes of the first planning cycle, the TWDB recommended that vulnerability, SVI, should be used as an inverse indicator of resiliency, which can be defined as the ability of a community or persons to recover from adverse conditions or situations, such as major flood events.

SVI values are measured from 0 to 1, where zero is the lowest vulnerability to a natural disaster and one is the highest vulnerability. Throughout the San Jacinto region the SVI by census tract ranged from 0.0015-0.9900; this wide range shows the broad diversity of communities and how they can likely respond to flood hazards occuring within the region. These data provide more detail into the communities that are at risk and how they are likely to respond to a disaster given their current resources.

All vulnerability spatial features and required tables were completed in accordance with the *Technical Guidelines* and the *Data Submittal Guidelines for Regional Flood Planning (Exhibit D)* for both the existing and future flood risk. The data generated from the vulnerability analysis are shown in **Map 7** in**Appendix 2A-4**. The average SVI of infrastructure exposed to flood risk as well as exposed critical facilities are presented by county in **Table 3** in **Appendix 2A-7**.

2.A.3.a. Resiliency of Communities

Increasing the overall resiliency of a community goes beyond merely reducing flood risk; there must be a focus on the broader, systemic aspects of the community and their ability to respond, given their current resources and systems. For example, the National Preparedness and Response Science Board describes multiple actions that may be taken, such as promoting access to public health, healthcare, and social services; promoting health and wellness alongside disaster preparedness; and, expanding communication and collaboration among networks of social services, business, academia, etc. The list states that communities can increase resiliency by encouraging at-risk individuals, and the programs that serve them, to take an active and responsible role in facilitating disaster efforts and building social connectedness to built trust amid emergency preparedness efforts. All these efforts, in addition to reducing flood risk, can provide a holistic approach to reducing the impact that flood-related natural disasters have on communities throughout the San Jacinto region.

2.A.3.b. Vulnerability of Critical Facilities

Critical facilities were considered for this analysis to be hospitals, police and fire stations, shelters, schools, water and wastewater treatment Plants, Correctional Facilities, Aviation Facilities, Waste Disposal Facilities, Power Generation, and chemical manufacturing and processing facilities. Water and wastewater treatment plants are considered critical due to their function as well as their proximity to floodplains or bodies of water. Hospitals and shelters are considered, as a part of the exposure analysis, as critical features due to the vital role these facilities play in providing essential services to the region. The rest of the facilities were considered critical in the exposure analysis due to the primary function or necessary service they provide to the San Jacinto region. Out of the 7,620 critical features in the exposure analysis, the average SVI value per structure is 0.58 with a standard deviation of 0.28. These values generally show that the resiliency and vulnerability of critical facilities are greatly varied across the region.

Critical facilities have especially important risks when exposed to floodwaters. For example, during Tropical Storm Allison, the entire Houston Medical Center was devastated by flood waters, causing major losses of data and research and a lengthy loss of care to patients. Aside from the inherent importance of the previously listed features, there are certain features such as the Houston Ship Channel and the corresponding petrochemical production, and the interstate highway system, which include infrastructure that can experience damages from compound flooding, riverine and storm surge. These are critical infrastructure that are subject to more frequent and complex risk associated with compound flooding scenarios as well as severe consequence in the event of damage or inundation.

Beyond the sheer property damage associated with flooding events, there are also the longer-term damages associated with flooding losses that, although not deemed critical from an infrastructure point of view in the exposure analysis, are no less important in the discussion of flood risk. These associated damages include but are not limited to: loss of work, mental health stress and illness, or lack of resources for needed repairs. Based on the SVI metric some of these threats disproportionately affect more vulnerable groups, as communities respond in myriad ways given a hardship such as a flood-related natural disaster.

2.A.4. Summary of Exposure and Vulnerability Analyses

The previous sections presented results of the methodology employed to develop qualitative and quantitative descriptions of the flood threat, exposure, and vulnerability within the San Jacinto region. Based on the exposure analysis within the existing 1.0% and 0.2 % ACE floodplains, there are approximately 500,000 structures, 1.7 million people, and 2,000 square miles of land area exposed to flood risk. These numbers are significant and will only continue to increase with associated increases in population and development within the region. The existing flood risk, exposure, and vulnerability assessment for the San Jacinto region are summarized in the TWDB-required **Table 3** located in **Appendix 2A-7**, providing the results by county of the existing flood exposure and vulnerability analysis as outlined in the *Technical Guidelines* as well as the SVI per structure in the floodplain by county.

A geodatabase with applicable layers as well as associated TWDB-required **Maps 4** through **Map 7** are provided in **Appendix 2A** as PDFs. **Table 2-3** outlines the geodatabase deliverables included in the Draft RFP as well as spatial files and tables. These deliverables align with the TWDB's *Data Submittal Guidelines*.

TABLE 2-3: TASK 2A GEODATABASE LAYERS AND TABLES

Item Name	Description	Feature Class Name	Data Format (Polygon/Line/ Point/GDB Table)
Existing Flood Hazard	Perform existing condition flood hazard analyses to determine the location and magnitude of both 1.0% annual chance and 0.2% annual chance flood events.	ExFldHazard	Polygon
Existing Exposure	Develop high-level, region-wide, and largely GIS-based existing condition flood exposure analyses using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1.0% annual chance and 0.2% annual chance flood events.	ExFldExpPol	Polygon
	Develop high-level, region-wide, and largely GIS-based existing condition flood exposure analyses using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1.0% annual chance and 0.2% annual chance flood events.	ExFldExpLn	Polyline
	Develop high-level, region-wide, and largely GIS-based existing condition flood exposure analyses using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1.0% annual chance and 0.2% annual chance flood events.	ExFldExpPt	Point
	Combine the Exposure Poly, Line, and Point data into a single master layer, also includes vulnerability data.	ExFldExpAll	All

Chapter 2.B. Future Condition Flood Risk Analysis

2.B.1. Future Condition Flood Hazard Analysis

The purpose of Section 2.B. is to present key considerations in the development of future condition flood hazard areas and summarize the methodology utilized to determine the future 1.0% and 0.2% ACE flood hazard areas. For the 2020–2023 planning cycle, the RFPGs were tasked with performing future condition flood analyses to determine the potential extent of both the 1.0% and 0.2% ACE flood hazard based on a 30-year future forecast period. The estimated flood hazard changes would be used solely for the purpose of estimating the general magnitude of potential future increases in flood risk under the equivalent of a "do-nothing" or "no-action" alternative. Within the San Jacinto regional flood planning context, these projections would not be used for developing new regulatory flood hazard maps. Some political entities within the San Jacinto river basin, such as Harris County, have adopted "no-rise/no adverse impact" policies that require new development to offset increases in development impervious area and resulting runoff rates with the addition of detention.

The first step of the task was to identify areas within each FPR where future condition hydrology and hydraulic model results and maps are available and to summarize the relevant information for use in determining future flood hazards. In areas where future condition flood hazard data were not available, the *Technical Guidelines* outlined the following four methods for performing future condition flood hazard identification, summarized in **Table 2-4**.

TABLE 2-4: TWDB FUTURE CONDITIONS FLOOD HAZARD METHODOLOGY

Method	Description	Explanation
1	Increase water surface elevation based on projected percent population increase (as proxy for development of land areas).	Method 1 involves making certain assumptions about development, and then estimating correlations between impervious cover changes and changes to flood elevations. These results would vary based on a watershed's land use, soil type, and topography. The TWDB acknowledges that population increases do not always lead to impervious cover increases, but this simplified approach can be utilized if desired.
2	Utilize the existing condition 0.2% ACE floodplain as a proxy for the future 1.0% ACE extent.	Method 2 utilizes existing modeling and mapping to create the future condition 1.0% ACE flood hazard. However, it does not yield a future 0.2% ACE flood hazard area, so a methodology will need to be determined by the RFPG to determine the future 0.2% flood hazard area. The TWDB notes that this method may be more appropriate in areas with high growth rates that are categorized as urban or suburban.
3	Combine methods 1 and 2 or use an RFPG-proposed method.	Method 3 is a combination of the first two methods, and, as with the other methods, the rational/determination should be well-documented.

Method	Description	Explanation
4	Request TWDB perform a Desktop Analysis.	Method 4 has the TWDB perform a desktop analysis to determine the future condition flood hazard boundaries. This would be primarily utilized in areas where the locations do not have future condition flood hazard data already available.

Additional discussion and supporting information related to Task 2B can be found in the *Task 2B Technical Memorandum* and **Appendix 2B-7**.

2.B.1.a. Characterization of Future Condition Floodplains

Flood hazard within the San Jacinto region can be defined as pluvial, urban, riverine, and coastal. For the purposes of this analysis, only riverine and coastal were considered due to the availability of data for these types of flooding. Changes in flood risk for riverine and coastal flood hazard are dependent on a variety of potential factors. Riverine floodplain boundaries may be influenced by future development, population growth, subsidence, and future rainfall patterns.

In addition to those factors, coastal floodplain boundaries may be affected by a combination of storm intensity, sea level rise (SLR), and coastal erosion. Each of these changes can influence the extent of hurricane or tropical storm surge that reaches inland, inundating communities.

Development and population growth may result in a change of land use and alter existing drainage patterns, which may result in increases in downstream discharge ratesand runoff volumes and in shortened hydrograph timing. Depending on the magnitude of changes, water surface elevations and floodplain widths may increase. Many municipalities and counties in the region have development retention/detention criteria to reduce and mitigate increases in peak stormwater runoff as a result of development.

Subsidence is the gradual lowering of the ground elevation that, in the greater Houston-Galveston region, primarily results from aquifer compaction due to long-term, sustained groundwater extraction. Changes in ground elevations from non-uniform subsidence may result in wider floodplains for the region. Studies are currently underway to understand the impacts of subsidence on existing flooding in the region. Changing regulations are intended to reduce subsidence.

Models that include increased riverine discharges, due to future rainfall patterns, result in changes in water surface elevation and limited changes in inundation extents in areas with steep terrain. Alternatively, in areas with flat terrain, increased flows resultin smaller changes in water surface elevations and larger changes in inundation extents. Since varying terrain is common throughout the region, varying results are seen in floodplain comparisons.

Throughout the San Jacinto region, flood risk data is prevalent and there is substantial coverage of available regulatory flood hazard mapping, with the exceptions listed in Existing Flood Map Gaps and Flood Prone Areas section. The types of risk reported in the flood hazard layer are riverine and coastal. However, in future cycles of the RFP, there may be opportunity to include other types of flood risks, such as urban and pluvial.

Current Land Use and Development Trends Associated with Population Increase

The TWDB's Water User Group projects that within the next 30 years, the population in the Water Planning Region H would increase by 3.5 million residents, equating to an approximate population increase of 37% between 2020 and 2050. Within the San Jacinto region, the population is estimated to increase by 2.0 million, with the majority of growth being in Harris, Montgomery, and Fort Bend Counties.

Land use changes associated with population increases in the San Jacinto region were considered for some of the region based on model availability. Future development land use changes in the northern portion of the watershed (approximately Lake Houston Watershed) were analyzed in the San Jacinto Regional Watershed Master Drainage Plan (SJRMDP; more information on the model can be found in **Appendix 2B-7**). The future conditions models from the SJRMDP included changes in land use based on a 50-year population outlook that accounted for increased impervious cover in anticipated development areas. The future conditions model reflects anticipated changes in population between 2020 and 2070, which are expected to lead to increases in impervious cover and changes in the timing of basin runoff.

An analysis of future development for the southern areas of the San Jacinto region is not included due to the high density of development in Harris and Galveston Counties. While future development may have an impact on runoff, many areas within these zones have already been essentially fully developed. Other factors, such as increase in rainfall, subsidence, and sea level rise will result in more substantial changes to the floodplain extents. These areas also have high standards for development within the floodplain and detention criteria which minimize the impacts from future development.

Sea Level Rise

Along with a growth in population and future rainfall patterns, sea level rise (SLR) was taken into consideration when estimating future flood hazard boundaries. SLR is an ongoing phenomenon where the relative ocean elevation is increasing and encroaching on coastal areas. Historical SLR has been analyzed by the Texas State Climatologist, Dr. Nielsen-Gammon, and his analysis has shown relative SLR increases of approximately 6.59 millimeters per year (0.65 feet in SLR over 30 years) in Galveston Bay at the Pier 21 (Galveston, Texas) measurement station.

Subsidence

Approximately 250 GPS stations are currently monitoring subsidence within the San Jacinto region, operated by the Harris-Galveston Subsidence District (HGSD), Fort Bend Subsidence District (FBSD), University of Houston, Lone Star Groundwater Conservation District (LSGCD), Brazoria County Groundwater Conservation District (BCGCD), Texas Department of Transportation (TxDOT), and other local entities. Much of the subsidence is observed in the northern and southern zones of the region (zones are defined in **Figure 2-11**), and shown in **Figure 2-8**.

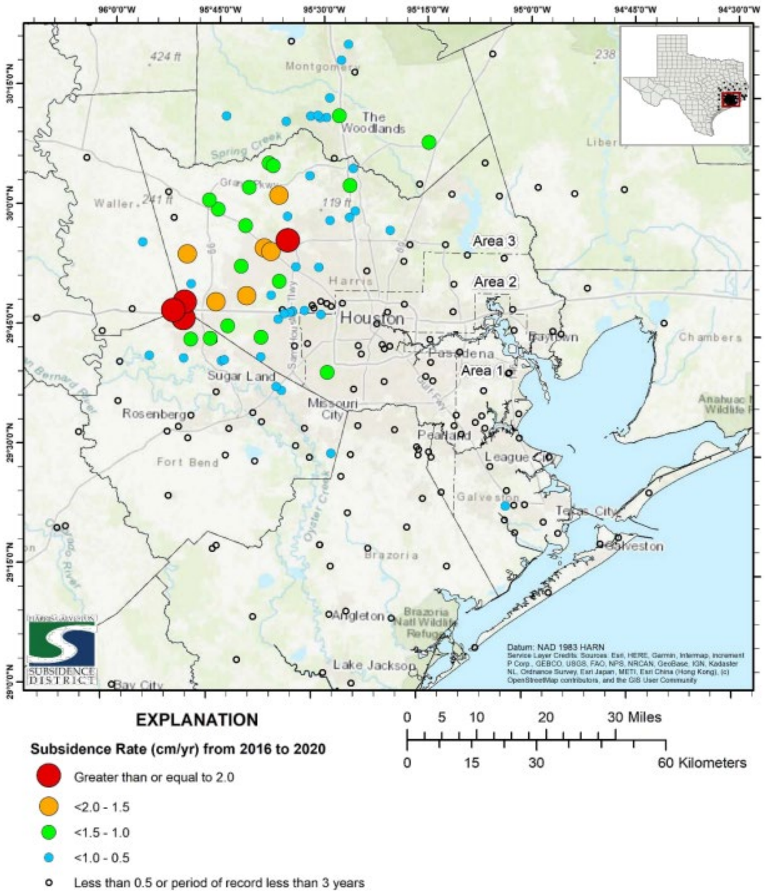

FIGURE 2-8: SUBSIDENCE RATES IN THE SAN JACINTO REGION

Future Rainfall Patterns and Anticipated Changes to Floodplain Functionality

Projected future rainfall patterns can also have an impact on identifying future flood risk. According to the NOAA Atlas 14, Volume 11 Precipitation-Frequency Atlas, the Texas coast saw a 10-15% increase in annual precipitation between 1991 and 2012 compared to the average annual precipitation between 1901 and 1960.

The Office of the Texas State Climatologist provided TWDB with guidance regarding how to incorporate projected future rainfall patterns in its April 16, 2021, report, titled “Climate Change Recommendations for Regional Flood Planning.” The report states that 24-hour, 1.0% ACE rainfall depths increased by approximately 15% between 1960 and 2020. The climatologist coupled historical rainfall data with results from climate models to develop a relationship between extreme rainfall depths and future increases in global temperature. Percent increase in future precipitation was developed for both urbanized and rural watershed conditions. Due to the uncertainty of predicting weather patterns for extreme rainfall events[4], the climatologist provided a minimum and maximum range for estimating future rainfall patterns. The climatologist found even greater uncertainty when analyzing rural areas and large river catchments due to future predicted decreases in soil moisture due to climate change. This led

[4] Typically defined as the 100-year (1% annual chance event) and 500-year (0.2% annual chance event) storms.

to a percent decrease as a minimum value. The report did not mention storm events more frequent than the 1.0% ACE rainfall (for instance, the 10.0% ACE or 4.0% ACE storms), but this information could be available for analysis during future flood planning phases.

Table 2-5 was obtained from the climatologist's report and represents additional changes in rainfall that need to be applied to the Atlas 14 rainfall depths across the entire state.

TABLE 2-5: POTENTIAL CHANGE IN FUTURE RAINFALL

Location	Minimum	Maximum
Urban Areas	12%	20%
Rural Areas / River	-5%	10%

The San Jacinto region includes both urban and rural areas. Therefore, the averaged maximum for urban and rural areas of 16% on top of the Atlas 14 rainfall was used to increase rainfall for any future flood hazard modeling efforts within the region.

Anticipated Sedimentation in Flood Control Structures and Major Geomorphic Changes

Flood control structures prevent floodwaters, either stormwater or coastal water, from inundating vast amounts of land and property. Hydraulic works (levees, flood walls, dams, river diversions, etc.) represent human modification to the flood hazard. In the San Jacinto region, the most prominent flood control structures at a regional scale are levees, dams, and reservoirs.

Sedimentation occurs throughout all flood control structures and is often accounted for during the design of the facility. Sedimentation in water supply reservoirs primarily impacts the conservation pool or water supply available. The TWDB has completed sedimentation studies on both Lake Conroe and Lake Houston to determine the water supply capacity impact of sedimentary accumulation in each lake. These studies show that the sedimentation occurs at the bottom of the reservoir which has minimal impact on the water storage volume; however, sedimentation does have an impact on available firm water yield (water supply) from the reservoir.

Dredging is being conducted in both the Addicks and Barker Reservoirs as well as the West Fork San Jacinto River and East Fork San Jacinto River. These projects aim to remove sediment deposited in Hurricane Harvey while ongoing studies aim to find long-term solutions to mitigate sediment accumulation within these structures.

Sediment deposition in a channel can reduce its cross-section area over time or block storm sewer outfalls from local drainage systems. During high-frequency, low-intensity events, reduced channel conveyance may result in increased water surface elevations. But during low-frequency, high intensity storms, such as the 1.0% ACE, flood flows are typically conveyed by the greater floodplain and reduced channel conveyance may have a limited impact on water surface elevations.

Sediment deposition throughout the San Jacinto region is also dynamic. During flood events, rushing water can scour deposited sediment and transport it downstream. As the flood recedes and waters slow down, sediments from upstream may begin to deposit and can reform the obstruction. This shifting sediment complicates the calculation of water surface elevations during the peak of the flood.

Since additional analysis is needed to understand the impacts of geomorphic changes to the floodplain, this aspect was not included within the future conditions flood hazard layer.

Completion of Proposed or Ongoing Flood Mitigation Projects

There are multiple Flood Mitigation Projects (FMPs) throughout the San Jacinto region that are either under construction or have dedicated construction funding. Additional detail regarding the types of ongoing mitigation projects in the region can be found in Chapter 1. In summary, there are 514 identified or ongoing projects in the region. These include land acquisition, channel conveyance improvements, levees and flood walls, local storm drainage systems, nature-based solutions, dams/retention/detention basins, roadway crossing improvements, and coastal projects.

Although flood mitigation projects impact the floodplains in their localized area, they were not included in the future floodplain analysis. Individual project models would have needed to be compiled, reviewed, and incorporated into the analysis to incorporate into the future condition analysis. In addition, models would have required calibration to ensure that inputs and assumptions were the same throughout the region. This information could be included in the next phase of the RFP as many of the flood mitigation projects are currently under construction and are not included in the future flood hazard analysis.

2.B.1.b. Available Hydrology and Hydraulic Models

Available H&H models containing future flood risk data were compiled and analyzed to understand how future conditions may affect future flood risk. The models collected included those related to the San Jacinto Regional Watershed Master Drainage Plan (SJRMDP), developed in 2020, and the FEMA Effective modeling within Harris County developed in the late 2000s. Results from these models served as a reference to guide the estimation of how future conditions may impact flood hazard elevations and widths.

- SJRMDP – The HCFCD, City of Houston, Montgomery County, and San Jacinto River Authority completed the SJRMDP in 2020 which was a comprehensive plan for all major streams in the upper San Jacinto River basin. The SJRMDP included updated existing conditions H&H models for the main streams within the watershed as well as a high-level analysis of future floodplains as the region continues to grow. The SJRMDP future conditions included changes in land use based on a 50-year population outlook that was accounted for through increased impervious cover in anticipated development areas. The SJRMDP future conditions models reflect anticipated changes in population between 2020 and 2070, which are expected to lead to increases in impervious cover and changes in the timing of basin runoff. While these models were developed for the purpose of high-level planning, they serve as a valuable guide for understanding the potential future flood risk for the basin. The modeling extents of the SJRMDP are shown below in **Figure 2-9**.

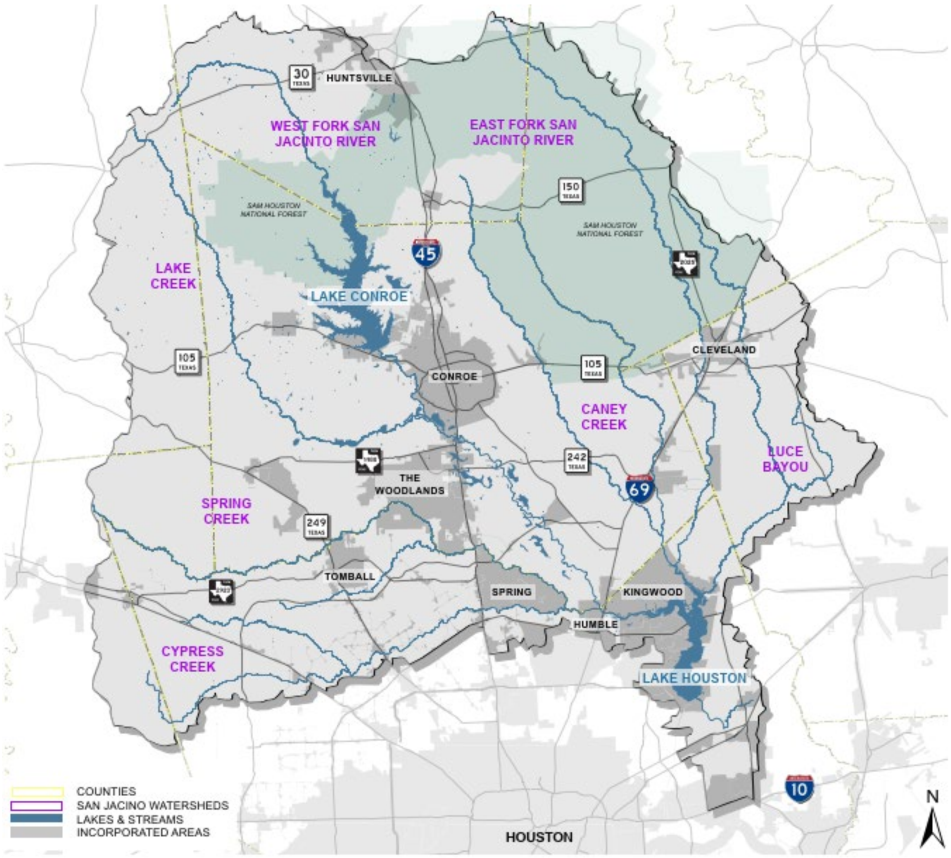

FIGURE 2-9: MODELING EXTENTS OF SJRMDP

- HCFCD FEMA Models – The HCFCD maintains the effective FEMA models for mapped streams within Harris County. The models are open-source and can be obtained from HCFCD's website. These steady state HEC-RAS models were developed in the late 2000s by HCFCD and were calibrated to historical storm events. As part of previous efforts prepared for the HCFCD, Atlas 14 rainfall have been incorporated into several of the HCFCD models, which provided an approximation of flood elevations with future precipitation. This information was used to inform the future flood hazard recommended approach for the RFP. As part of the RFP effort, modifications to the HCFCD models included Atlas 14 precipitation and extrapolated storage-discharge curves to create updated steady state hydraulic models.

2.B.1.c. Determination of Future 1.0% and 0.2% Annual Chance Event Floodplains

The assessment of future flood risk requires the estimation of the extent of the future flood hazard area. The determination of potential increases in the San Jacinto region's future 1.0% and 0.2% ACE flood hazard areas is based on a "do-nothing" or "no-action" scenario for approximately 30 years of continued growth with existing flood regulations and policies. Since there is limited information regarding future flood hazard within the region, the future condition flood hazard layer is based on a horizontal buffer applied tothe existing conditions flood hazard.

Based on review of available information and the categorization of future conditions within the San Jacinto region, future conditions flood hazard considers changes in rainfall, development, subsidence, and sea level rise for this planning cycle. Additional analysis on other contributing factors such as flood mitigation projects and geomorphic changes should be included once this information is available to incorporate. **Figure 2-10** below illustrates how the individual horizontal buffers determined for each of the future condition considerations were combined and applied to generate the future flood hazard.

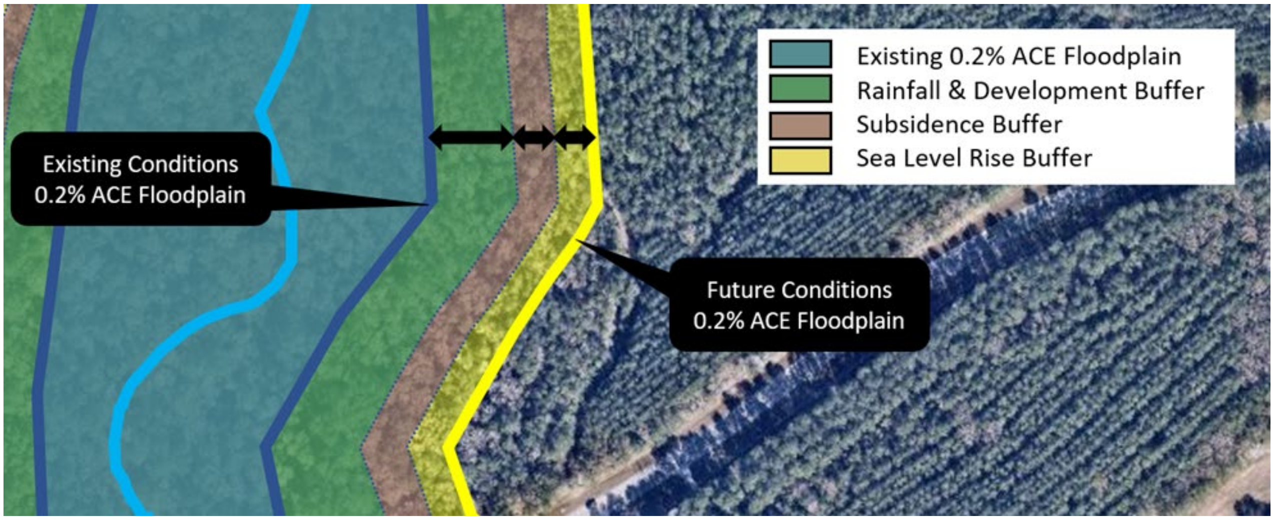

FIGURE 2-10: COMBINED HORIZONTAL BUFFER APPROACH TO FUTURE FLOOD HAZARD

The region was also divided into three different zones to represent varying watershed characteristics and the different driving factors affecting change in flood hazards to estimate future condition flood hazards. The zones were designated as Northern, Southern, and Coastal as shown in **Figure 2-11**.

- The Northern Zone includes the areas within Montgomery, Grimes, Walker, San Jacinto, and small portions of Harris, Liberty, and Waller Counties that drain into Lake Houston. This zone is characterized by rural development that is transforming towards urban development and rolling hill topography which is steeper than the topography in other zones.
- The Southern Zone includes most of Harris County, as well as portions of Chambers, Fort Bend, Liberty, and Waller Counties that drain into the Houston Ship Channel. This zone is characterized by urban development with flat terrain that is mostly influenced by riverine flooding.
- The Coastal Zone includes the areas that drain into Galveston Bay in Brazoria, Galveston, and southern Harris Counties, as well as a portion of Fort Bend and Chambers Counties. This zone is characterized by flat and coastal topography that experiences riverine as well as coastal storm surge flooding.

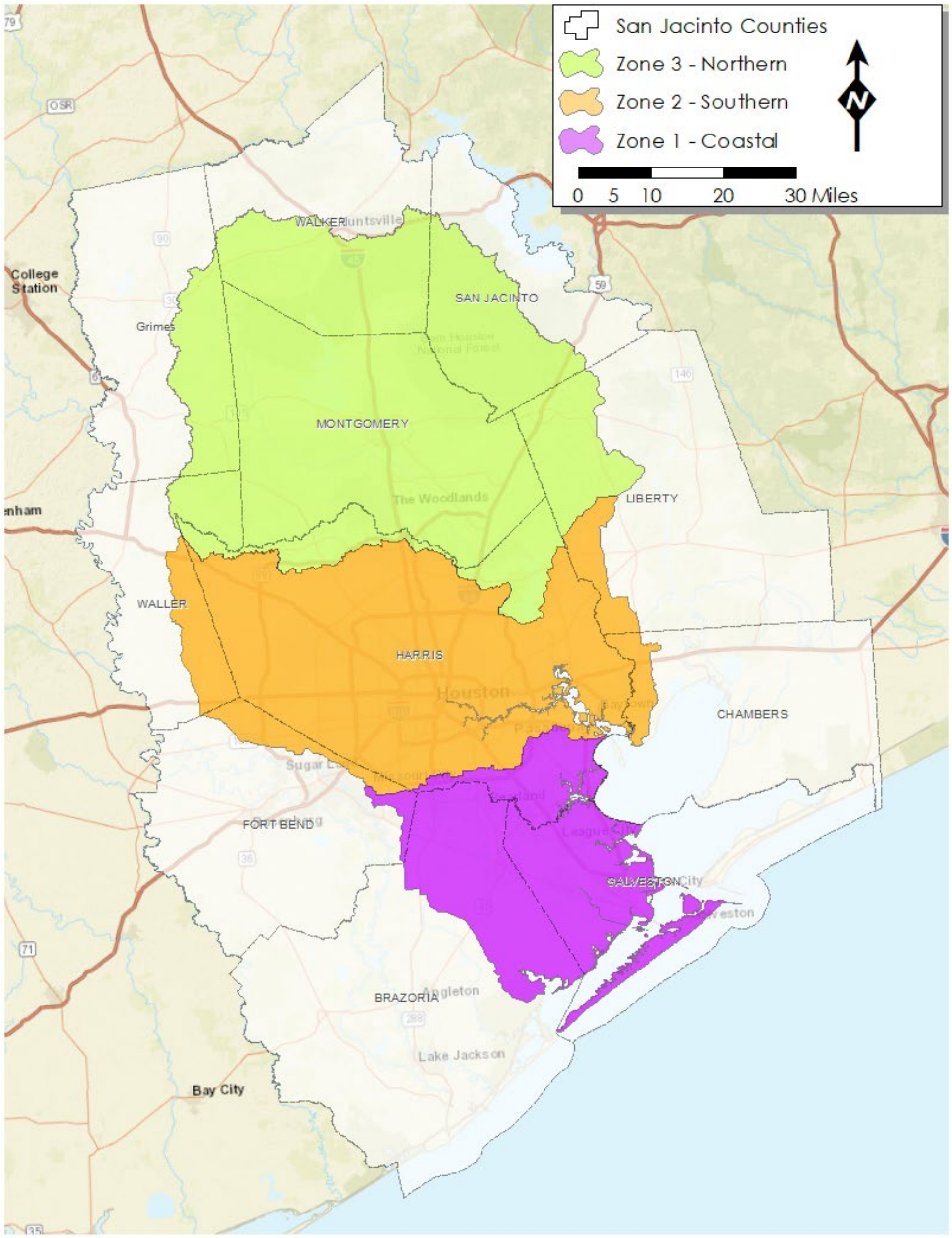

FIGURE 2-11: SAN JACINTO ZONE DESIGNATIONS

Future 1.0% Annual Chance Event Flood Hazard Area

The Method 3 approach as outlined by TWDB in Table 2-4 was followed for developing the future 1.0% ACE flood hazard area. The method involves using the existing 0.2% ACE flood hazard area as an approximation for the future 1.0% ACE flood hazard area.

Unique to the nature of the comprehensive analysis, the SJRMDP included models for future flood hazard 1.0% ACE floodplains for the main tributaries for the upper basin. The modeled future 1.0% ACE flood hazard was compared to the effective 0.2% ACE flood hazard to identify similarities and differences in the floodplains for the Northern Zone.

The Southern and Coastal Zones have similar topography and channel features and therefore are grouped into one analysis. The available effective HCFCD models were updated with higher Atlas 14 rainfall depths to generate estimated future flood hazard water surface elevations for the Southern and Coastal Zones. An analysis of future development is not included for the Southern or Coastal Zones due to the high density of existing development within these zones. While future development may have an impact on runoff, many areas have already been developed. Other factors such as increase in rainfall, subsidence, and sea level rise will result in more substantial changes to the floodplain extents. These zones also have high standards of floodplain development and detention criteria which minimize the impacts of future development.

Future 1.0% ACE Flood Hazard Conclusion – All Zones

The SJRMDP modeling shows that the anticipated future 1.0% ACE flood hazard extents are reasonably consistent with the existing conditions 0.2% flood hazard extents for the Northern Zone. This conclusion was also supported by the HCFCD model future 1.0% and existing 0.2% ACE flood hazard comparison. The differences shown in water surface elevations and flood hazard extents are attributed to different modeling approaches and the approximate nature of the comparison analysis.

The comparisons show that the existing 0.2% ACE flood hazard area can be used as an appropriate estimate of the future 1.0% ACE flood hazard area. Separate approaches for determining the future 1.0% ACE flood hazard area were followed for the Northern, Southern, and Coastal Zones due to the differences in topography and flooding sources. Due to potential land changes due to subsidence and sea level rise, buffers for those two factors were determined separately and applied to the existing 0.2% ACE flood hazard area to create the future 1.0% ACE floodplain extents. The general approach for the future 1.0% ACE flood hazard area is outlined in **Figure 2-12**. The determination of the subsidence and sea level rise buffers is discussed further in subsequent sections.

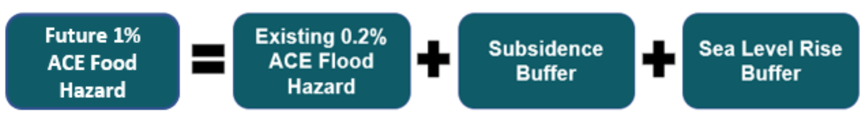

FIGURE 2-12: FUTURE 1.0% ACE FLOOD HAZARD DETERMINATION PROCESS

Future 0.2% Annual Chance Exceedance Flood Hazard Area

The existing available information was reviewed to identify the approach for the future 0.2% ACE flood hazard based on the recommended approaches from the TWDB. As discussed previously, future floodplains will consider increases in rainfall, changes in development, subsidence, and sea level rise. Since future conditions modeling is not widely available for the region, applying a horizontal buffer to existing flood hazard area boundaries is used as a reasonable approach to estimating future flood hazard area widths.

It is noted that floodplain widths are not standard nor typical and depend on numerous variables including topography, development type, stream condition, discharge rates, and downstream conditions. However, the horizontal buffer approach provides reasonable results for the initial planning cycle and can be refined in future studies. In addition, it is noted that not every stream could be analyzed. Watersheds with unique or atypically large floodplains were excluded to prevent data outliers.

Separate approaches for determining the future 0.2% ACE flood hazard area were followed for the Northern, Southern, and Coastal Zones due to the differences in topography and flooding sources. A more detailed discussion of the methodology used is provided in the *Task 2B Technical Memorandum*. The approach for the 0.2% ACE flood hazard area determination is outlined below in **Figure 2-13**.

FIGURE 2-13: FUTURE 0.2% ACE FLOOD HAZARD DETERMINATION PROCESS

Northern Zone – Future 0.2% ACE Development and Rainfall Buffer

Information from the SJRMDP was used to compare the effective floodplain widths to the estimated future floodplain widths to establish the Development and Rainfall Buffer to be used for the future 0.2% ACE floodplain. The model was simulated for both the effective rainfall (pre-Atlas 14) and the TWDB recommended rainfall (Atlas 14 + 15%). The average difference in the 0.2% ACE flood hazard layer top width between the two different rainfall scenarios was calculated for each modeled watershed, and then utilized as a 'Development and Rainfall Patterns Buffer' that could be added to the existing 0.2% ACE floodplain. The horizontal buffer is applied to the floodplain so the calculated values include an increase on both sides of the channel. For example, a 500-foot buffer would be applied as 250 feet on either side of the channel. The results for the Northern Zone are provided below in **Table 2-6**. For reference, the average top width of the existing conditions 1.0% annual chance floodplain of each main stem is also included in the table. Note that all watersheds in the region were not included in the analysis – watersheds with unique or atypically large floodplains were excluded to prevent data outliers.

TABLE 2-6: NORTHERN ZONE 0.2% ACE TOP WIDTH COMPARISON

Channel	Existing Average Width of 1% ACE Floodplain (ft)	Average Difference of 0.2% ACE Flood Hazard Layer Top Width (ft)
Lake Creek	4,134	343
Peach Creek	2,100	488
Willow Creek	2,761	497
Spring Creek	3,335	565
Caney Creek	3,027	612
Recommended Development and Rainfall Patterns Top Width Buffer (Northern Zone)		500

Southern and Coastal Zones – Future 0.2% ACE Development and Rainfall Buffer

Information from available HCFCD models was used to compare the effective 1.0% ACE floodplain widths to the estimated future floodplain widths to establish the Development and Rainfall Buffer to be used for the future 0.2% ACE floodplain. The model was updated with the rainfall values for both the effective rainfall and Atlas 14 rainfall. The average difference in 0.2% ACE flood hazard layer top width between the two different rainfall scenarios for each modeled watershed was calculated, and then utilized as a 'Development and Rainfall Patterns Buffer' that could be added to the existing 0.2% ACE floodplain. The horizontal buffer is applied to the floodplain, so the calculated values include an increase on both sides of the channel. For example, a 500-foot buffer would be applied as 250 feet on either side of the channel. The results for the Southern and Coastal Zones can be seen in **Table 2-7**. For reference, the average top width of the existing conditions 1.0% annual chance floodplain of each main stem is also included in the table. Note that all watersheds in the region were not included in the analysis – watersheds with unique or atypically large floodplains were excluded to prevent data outliers.

TABLE 2-7: SOUTHERN AND COASTAL ZONE 0.2% ACE TOP WIDTH COMPARISON

Channel	Existing Average Width of 1% Floodplain (ft)	Average Difference of 0.2% Flood Hazard Layer Top Width (ft)
Greens Bayou	4,502	701
Buffalo Bayou	1,210	817
White Oak Bayou	2,932	843
Sims Bayou	1,399	1,096
Recommended Development and Rainfall Patterns Top Width Buffer (Southern and Coastal Zones)		850

Future 0.2% ACE Flood Hazard Conclusion – All Zones

The comparisons show that with the addition of a calculated buffer, the existing 0.2% ACE flood hazard area can be used as an appropriate estimate of the future 0.2% ACE flood hazard area. Buffer factors include a development and rainfall patterns buffer as well as sea level rise and subsidence buffers. The buffers for all three factors were determined separately (since they differ between the zones) and applied to the existing 0.2% ACE flood hazard area to create the future 0.2% ACE flood hazard extents.

The flood width boundaries calculated for the Southern and Coastal Zones are much larger than those calculated for the Northern Zone. This is due to the primarily flat topography of the Southern and Coastal watersheds when compared to the Northern Zone watersheds.

Sea Level Rise Buffer

The United States Army Corps of Engineers (USACE) has developed a tool to calculate the approximate SLR for “high”, “intermediate”, and “low” scenarios (**Figure 2-14**). The rate computed for the “high” scenario builds from the most recent Intergovernmental Panel on Climate Change (IPCC) and modified National Research Council (NRC) projections for a high rate of SLR. In Galveston Bay, the approximate “high” SLR projected by USACE over the next 30 years is 1.6 feet. The rate computed for the “intermediate” scenario builds from the most recent IPCC and modified NRC projections for a moderate rate of SLR. In Galveston Bay, the approximate “intermediate” SLR projected by USACE over the next 30 years is 0.85. The rate computed for the “low” scenario builds from historical rates of SLR to determine the low rate of SLR. In Galveston Bay, the approximate “low” SLR projected by USACE over the next 30 years is 0.6 feet. The “intermediate” scenario (0.85 feet of SLR) is the recommended estimation of SLR over the next 30 years.

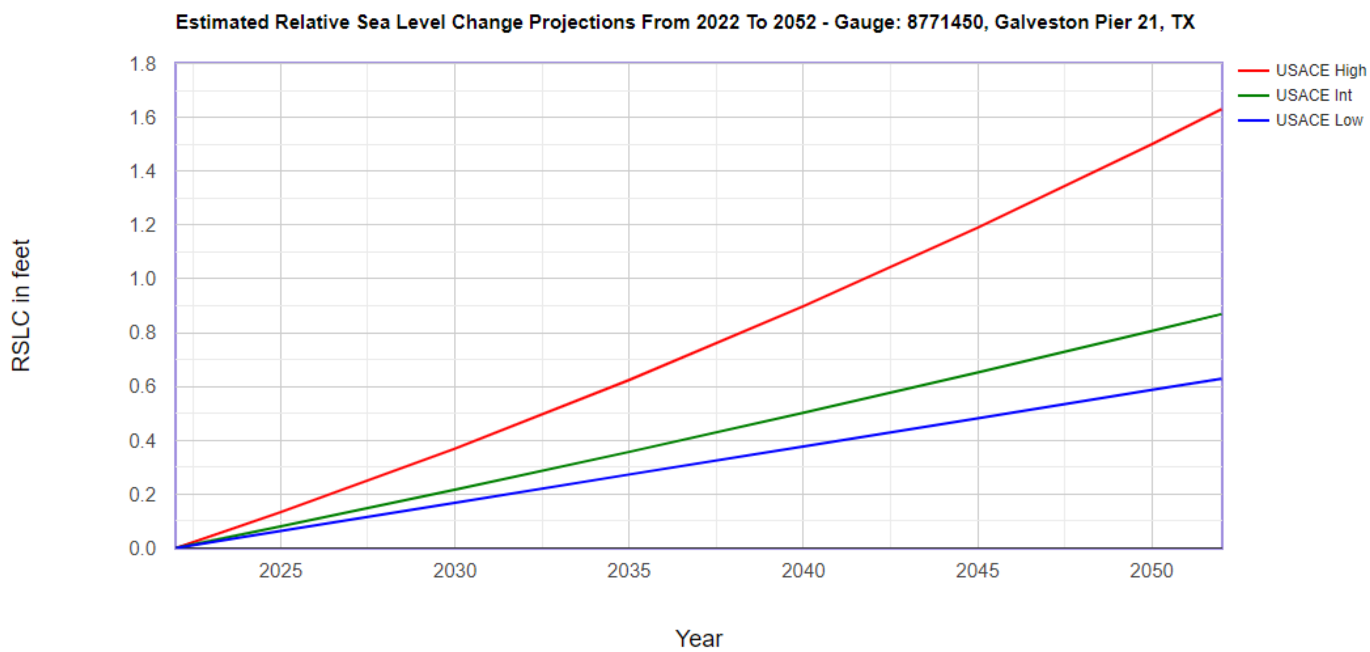

FIGURE 2-14: ESTIMATED SEA LEVEL RISE IN GALVESTON BAY FROM 2022 TO 2052 (USACE 2021)

Using the "intermediate" SLR estimate, a horizontal buffer was determined to approximate the influence of SLR on the future condition coastal flood hazard. From the best available terrain data, transects of the coast were cut to determine the average overland slope in the Southern and Coastal Zones. The average overland slope for sea level rise was limited specifically to the coastal areas and does not include overland slopes further inland.

Using best available terrain data, an average slope was calculated for the coastal areas of the Southern and Coastal Zones (as defined in **Figure 2-11**) of the San Jacinto region. The slope, refined to remove the channel bank slopes, was found for each zone and is detailed **Table 2-8** below. The slope was then translated into a horizontal distance for 0.85 feet of rise to determine the recommended buffer distance accounting for SLR. Ultimately, the recommended buffer for 0.85 feet of SLR was determined to be 315 feet of additional buffer for the Southern Zone and 570 feet for the Coastal Zone to be incorporated in the future flood hazard 1.0% and 0.2% ACE flood hazard layers within the Coastal Zone and applicable portions of the Southern Zone around Galveston Bay. The different buffers provided in **Table 2-8** are applicable to specific zones of the San Jacinto region as defined in **Figure 2-11**.

TABLE 2-8: SEA LEVEL RISE BUFFER ESTIMATE

	San Jacinto River Basin Zone		
	Northern	Southern	Coastal
Estimated Sea Level Rise over 30 years (feet)	N/A	0.85	0.85
Average Overland Slope (%)	N/A	0.27%	0.15%
Estimated Zonal Sea Level Rise Buffer (Feet)	N/A	315	570

Subsidence Buffer

Actual ground level subsidence varies spatially. For the purposes of this study, subsidence is adopted as the average for each regulatory subsidence region defined by the Harris Galveston Subsidence District (HGSD). Future floodplains located in corresponding subsidence regions are assumed to adopt subsidence projections unique to that region. This projection is subsequently transformed into a horizontal buffer added onto the future floodplain. In this study, it is assumed that subsidence projections on a per subsidence region basis experience consistent subsidence rates for both creek bed and floodplain. This is an assumption that errs on the conservative side using available data and for informing future flood risk.

For each zone of the San Jacinto region, an average subsidence rate was calculated using historical rates provided by HGSD and then projected over 30 years to determine an approximate future ground elevation change (HGSD, 2021). An approach, similar to that used for SLR, was utilized to determine the relationship between the vertical change of subsidence and a horizontal distance that would be incorporated into the total buffer distance. Using best available terrain data, an average slope was determined for each zone of the San Jacinto region using a combination of coastal transects and inland cross sections. The slope was then translated into a horizontal distance to determine the recommended buffer distance accounting for subsidence. **Table 2-9** provides a summary of the approximate average subsidence rate, estimated subsidence over 30 years, average slopes calculated, and the estimated buffer distance for each zone. The recommended buffer accounting for future subsidence is 55 feet for the Northern Zone; 340 feet for the Southern Zone; and 80 feet for the Coastal Zone to be incorporated into the future 1.0% and 0.2% ACE flood hazard layer.

TABLE 2-9: SAN JACINTO RIVER BASIN SUBSIDENCE RECOMMENDATION

	San Jacinto River Basin Zone		
	Northern	Southern	Coastal
Approximate Average Subsidence Rate (cm/yr)	-0.86	-1.10	-0.20
Estimated Subsidence over 30 years (feet)	-0.85	-1.08	-0.19
Average Overland Slope (%)	1.62%	0.32%	0.25%
Estimated Zonal Subsidence Buffer (feet)	55	340	80

Future Flood Hazard Buffer Exceptions

The flood hazard area buffers described above were applied across the San Jacinto region to determine the extents of the estimated future 1% ACE and 0.2% ACE floodplains. These buffers were applied to all flood hazard areas except in a few instances where regional, man-made structures influence the flood hazard area. For all areas mentioned, additional analysis should be conducted to understand the implications of future growth and rainfall changes in the region.

Within Harris County there are two accredited levee systems in the Spring Creek and the Cypress Creek watersheds. Since these levees were constructed with freeboard, it is anticipated that the future flood hazard areas would remain within the existing flood hazard areas. Therefore, the floodplains controlled by these levees were clipped to the extent of the existing conditions within the Inverness Forest Levee and Northgate Levee.

Within the San Jacinto region, there are two water supply reservoirs, Lake Houston and Lake Conroe. Lake Houston water surface elevations during flood events are influenced mostly by the large uncontrolled spillway. Therefore, horizontal buffers as described above are applied to the region upstream of Lake Houston. Elevations in Lake Conroe are controlled by operational gates. Due to controlled releases from Lake Conroe, the buffers applied to other areas of the region would not necessarily be representative of future conditions water surface elevations in the lake. Therefore, within the area influenced by the Lake Conroe Dam, the existing condition flood hazard areas were used as the future condition flood hazard areas for both the 1.0% and 0.2% ACE. Additional analysis should be conducted in future planning cycles to better understand potential changes to future floodplains within the influence area of these reservoirs.

Within the region there are also two regional flood control facilities (Addicks and Barker Reservoirs) where water surface elevations are strictly controlled by operational gates. The gated structures allow storm runoff to pass downstream and gate operations are based on reservoir elevations. Therefore, for areas influenced by the Addicks and Barker Reservoirs, the existing conditions flood hazard areas are used as the future conditions flood hazard areas for both the 1.0% and 0.2% ACE. Additional analysis should be conducted in future planning cycles to understand potential changes to future floodplains based on reservoir operations and future inflows.

Summary Future Flood Hazard Delineation

The future 1.0% and 0.2% ACE flood hazard areas were developed following the Method 3 approach (a combination of Methods 1 and 2) from the TWDB's *Technical Guidelines* document. Recommendations were developed for each of the three zones within the San Jacinto FPR to reflect differences in watershed characteristics throughout the region.

Future 1.0% ACE Flood Hazard

- The existing 0.2% ACE flood hazard area was selected to serve as a proxy for the future 1.0% ACE flood hazard area.
- Additional horizontal buffers to account for subsidence and sea level rise were applied to the existing 0.2% ACE flood hazard area boundary.

Future 0.2% ACE Flood Hazard

- The existing 0.2% ACE flood hazard area is buffered by either 500-feet or 850-feet, based on the zone within the region, to reflect the impact of development and future rainfall patterns on the flood hazard area.
- Additional horizontal buffers accounting for subsidence and sea level rise were applied to the existing 0.2% ACE flood hazard area boundary.

Table 2-10 shows the recommended buffer widths utilized to determine the future flood hazard boundaries. Note that the buffers listed represent a total top width buffer and should be divided in half to determine the expansion of the flood hazard boundary from the edge of the floodplain on each side of an associated water feature.

TABLE 2-10: FUTURE FLOOD CONDITIONS FLOOD HAZARD APPROACH

Future Flood Hazard 1.0% Storm Event

Existing 0.2% ACE + Buffer

		Development and Rainfall Patterns Buffer (ft)	Subsidence Buffer (ft)	Sea Level Rise Buffer (ft)	Total Top Width Buffer (ft)
Northern Zone	All	0	55	0	55
Southern Zone	Riverine	0	340	0	340
	Coastal	0	340	315	655
Coastal Zone	Riverine	0	80	0	80
	Coastal	0	80	570	650

Future Flood Hazard 0.2% Storm Event

Existing 0.2% ACE + Buffer

		Development and Rainfall Patterns Buffer (ft)	Subsidence Buffer (ft)	Sea Level Rise Buffer (ft)	Total Top Width Buffer (ft)
Northern Zone	All	500	55	0	555
Southern Zone	Riverine	850	340	0	1,190
	Coastal	850	340	315	1,505
Coastal Zone	Riverine	850	80	0	930
	Coastal	850	80	570	1,500

This methodology and approach were presented to the Technical Committee on February 3, 2022, and gained consensus and approval by the Committee. Approval by the members of the RFPG board was obtained during the March 3, 2022, meeting.

Appendix 2B-1 includes **Map 8** which shows the future condition flood hazard areas for the San Jacinto region. The future conditions risk distribution of 1.0% and 0.2% ACE within the region can be seen in **Figure 2-15**. Harris, Montgomery, Brazoria and Galveston Counties have the largest percentage of overall area in future condition floodplains area within the region.

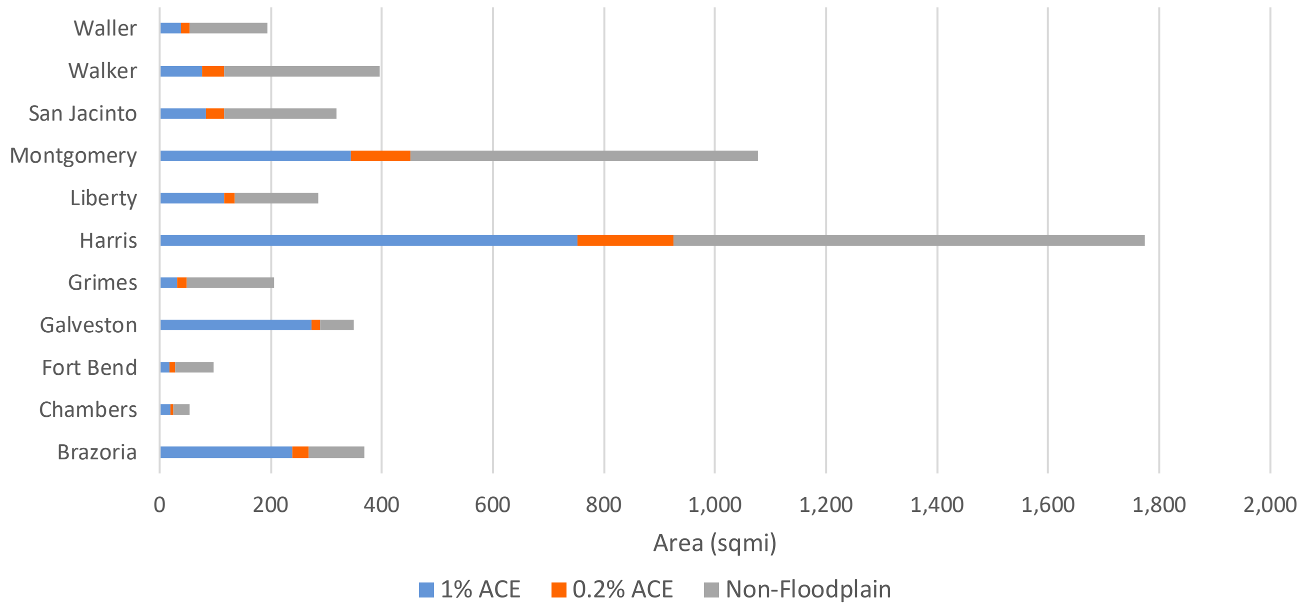

FIGURE 2-15: FUTURE FLOODPLAIN AREA[5] BY COUNTY

2.B.1.d. Flood Map Gaps and Future Flood Prone Areas

Minor Tributaries

Upon determining the buffer, an evaluation was done to apply the buffer across the region. The buffers were generated based on approximate models for the major streams within each zone. Minor tributaries to the streams may vary in characteristics which can affect the flood hazard layer width. Such characteristics include urbanization, topography, channel improvements, and existing channel capacity. While an overall flood hazard buffer applied to each major stream and minor tributary may not most accurately show the future flood hazard, varying tributary buffers would require substantially more information than is currently available or feasible to develop in the first cycle RFP development timeframe. These models would require significant time and effort to create and analyze. Therefore, it was determined that the same flood hazard buffer for the main stems would also be applied to the tributaries. During future RFPs, reviewing the proposed buffer width along tributaries should be explored further. It would provide the most accurate representation of the future flood hazard boundary if additional information for that analysis is developed.

Modeling

One of the issues discussed among the Region 6 membership was the models utilized for future floodplain development. Floodplain extents are good indicators of flood risk. However, flood depth is also critical to understand the risk that flooding poses to residents and property. That information was not available for utilization during this RFP cycle but could be available for future flood planning cycles.

[5] For the purposes of the graphic, the 0.2% ACE area is not inclusive of the 1.0% ACE area.

The unavailability of extensive future flood models and associated mapping data across the region resulted in the future flood hazard mapping assumptions and approaches discussed above. In addition, the same data gaps generally exist for future flood hazard mapping as they do for existing conditions mapping since the existing conditions were used to develop the future extents. The data gaps are shown in **Map 9** in **Appendix 2B-2**.

2.B.1.e. Comparison to Existing Conditions Floodplains

Map 10 in **Appendix 2B-3** depicts the changes in flood hazard areas from existing to future conditions. **Table 2-11** compares the existing and future conditions extents for the entire region.

TABLE 2-11: EXISTING AND FUTURE CONDITIONS FLOOD HAZARD AREA COMPARISON

Annual Chance Storm Event	Existing Conditions (Sq. Mi.)	Future Conditions (Sq. Mi.)	Difference (Sq. Mi.)	Difference (%)
1 % ACE	1,484	1,993	509	+34%
0.2% ACE	1,956	2,457	501	+25%

2.B.2. Future Condition Flood Exposure Analysis

An exposure analysis was performed to identify the population and structures in the region that may be affected during the future 1.0% and 0.2% ACE floods. ArcGIS was utilized to intersect the future flood hazard layer and the features identified by TWDB to determine the affected existing development, critical infrastructure, roadways, and low water crossings at risk of flooding.

2.B.2.a. Existing and Future Development within the Floodplain

The analysis performed for future flood hazard exposure was based on the flood exposure dataset developed as part of Task 2A: Existing Condition Flood Risk Analyses. Future development was not accounted for as part of this analysis due to the complexity and variability with predicting future structure locations as well as current floodplain ordinances within the region that regulate development within existing flood hazard areas. Existing buildings, associated population, roadway crossings, agricultural areas, and other metrics were used in the future flood exposure analysis by intersecting this existing data with the future 1.0% and 0.2% ACE flood hazard areas. Because the future flood hazard layer generally results in larger mapping extents when compared to the existing conditions floodplain quilt, the number of people and structures at risk in the future conditions flood exposure analysis is greater than under the existing conditions analysis.

The types of critical infrastructure considered for the analysis of future flood risk include medical facilities, government buildings, emergency operations and shelters, law enforcement facilities, fire stations, schools, nursing homes, airports, railyards, ports, power generating plants, transmission facilities and water/wastewater treatment plants. To facilitate alignment with concurrent GLO and USACE coastal studies, additional structure types added to the critical infrastructure list include chemical plants, refineries, chemical storage facilities, oil and gas infrastructure and correctional facilities.

2.B.2.b. Proposed and Ongoing Flood Mitigation Projects

The existing conditions flood hazard areas do not include post-ongoing project inundation mapping due to the vast number of projects within the region as well as lack of information on the future condition floodplains. Many of these projects do not have significant impact on the less frequent storm event floodplains such as the 1.0% and 0.2% identified in this analysis. Future projects, such as those recommended in the RFP, should consider the increase in flood risk associated with future condition variables over the life of the respective structures.

2.B.2.c. Future Flood Exposure

The summary of future flood exposure by county can be found in **Table 5**, **Appendix 2B-6**. A map of future flood exposure can be found in **Map 11** in **Appendix 2B-4**. The increase in future flood hazard exposure compared with existing conditions exposure is summarized in **Table 2-12** and **Table 2-13**. As a clarification point, nighttime and daytime populations are included in the tables in the appendix, as well as a third “population” column. That column, also included as a row in **Table 2-12** and **Table 2-13**, is the maximum between the nighttime and daytime values.

TABLE 2-12: SUMMARY OF INCREASED EXPOSURE IN FLOOD HAZARD AREA FOR 1.0% ACE FLOOD RISK IN THE SAN JACINTO REGION

	Existing Conditions	Future Conditions	Increase	% Increase
Population	785,911	2,225,624	1,439,713	183%
Total Structures	240,254	653,872	413,618	172%
Residential Structures	199,918	562,108	362,190	181%
Non-Residential Structures	40,336	91,764	51,428	127%
Critical Facilities	3,411	10,253	6,842	201%
Roadway Crossings	4,257	8,005	3,748	88%
Roadway Segments (miles)	4,350	9,726	5,376	124%
Agricultural Area (sq. mi)	35	56	21	60%

TABLE 2-13: SUMMARY OF INCREASED EXPOSURE IN FLOOD HAZARD AREA FOR 0.2% ACE FLOOD RISK IN THE SAN JACINTO REGION

	Existing Conditions	Future Conditions	Increase	% Increase
Population	1,705,926	2,960,702	1,254,776	74%
Total Structures	517,214	895,112	377,898	73%
Residential Structures	442,768	775,464	332,696	75%
Non-Residential Structures	74,446	119,648	45,202	61%
Critical Facilities	8,091	12,922	4,831	60%
Roadway Crossings	5,208	9,109	3,901	75%
Roadway Segments (miles)	7,984	12,814	4,830	61%
Agricultural Area (sq. mi)	51	66.2	15	30%

Population Totals by County

The population associated with existing structures was not altered for the future exposure analysis. Future development was not accounted for as part of this analysis due to the complexity and variability involved in predicting future structure locations as well as current floodplain ordinances within the region that regulate development within existing flood zones. Existing buildings, and associated population, were used in the future flood exposure analysis by intersecting this existing data with the future 1.0% and 0.2% ACE flood hazard areas.

An estimated 2,225,624 people are anticipated to be located within the future 1.0% ACE flood hazard area, and 2,960,702 people within the future 0.2% ACE flood hazard area. An estimated 1,254,776 people are introduced into future flood prone areas.

Structures

Future flood exposure analysis was performed by overlaying the future flood hazard area developed for the San Jacinto region with the buildings, critical facilities, infrastructure, and agricultural areas that were determined to be in the region. **Table 5**: Future Condition Flood Risk Summary Table in **Appendix 2B-6**shows the total number/area of buildings, critical facilities, and agricultural areas exposed to the future flood hazard areas, summarized by county. A total of 653,872 structures are exposed to the 1.0% ACE flood risk regionwide under future conditions.

While people often shelter at home in times of danger and emergency, there is an inherent risk associated with doing so during a flood event. Most of the structures identified at risk within the flood exposure analyses were residential. Critical facilities and public infrastructure perform essential functions that require enhanced consideration in flood planning. An explanation of critical facilities used in the exposure analysis is provided in Section *Existing Development within the Floodplain.* For example, out of the approximately 654,000structures at risk in the future condition 1.0% ACE in the region, approximately 562,000 are classified as residential. The breakdown of types of structures within either the 1.0% or 0.2% ACE future condition flood hazard areas are shown in **Figure 2-16**.

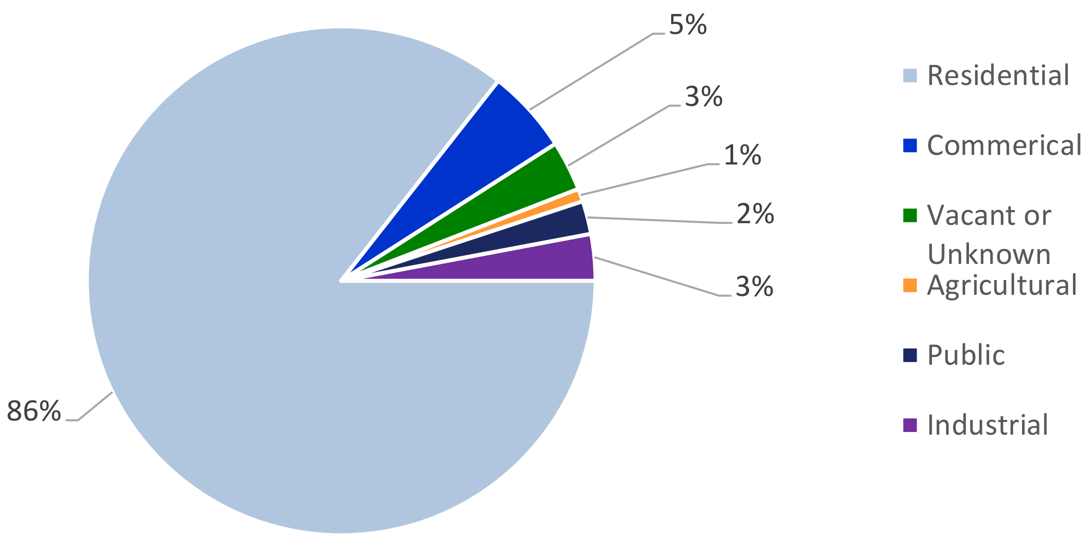

FIGURE 2-16: STRUCTURE TYPE DISTRIBUTION WITHIN FUTURE FLOOD HAZARD AREA

Harris County had the largest number of structures in the future condition floodplains. Similar to the results for the existing condition floodplains, Galveston County had the second highest number of structures within both ACE flood hazard areas. Out of the approximately 2.1 million structures located within the San Jacinto region,as provided by the TWDB buildings dataset, approximately 44% of the structures within the region are located within either the future conditions 1.0% or 0.2% ACE floodplains as shown in **Figure 2-17**.

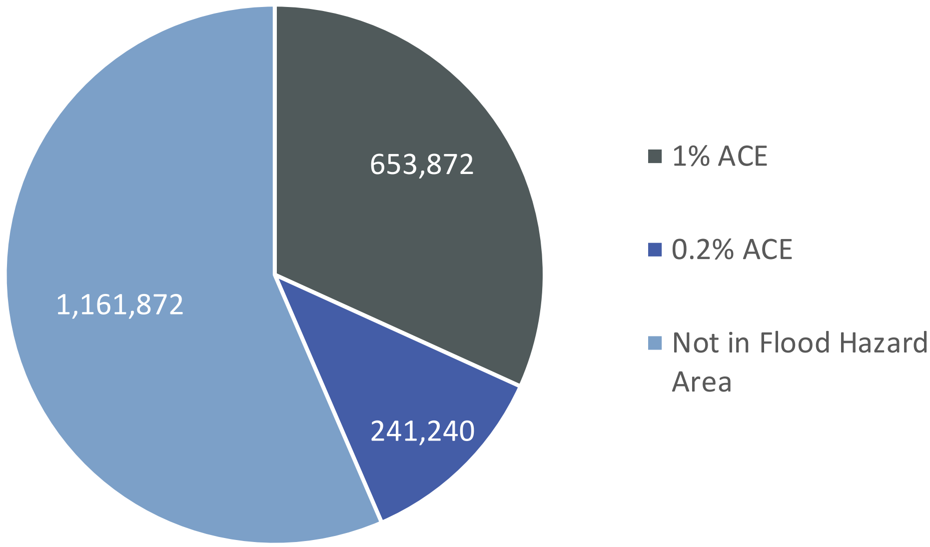

FIGURE 2-17: NUMBER OF STRUCTURES IN THE FUTURE FLOOD HAZARD AREA[6]

Critical Facilities and Public Infrastructure

Critical facilities and public infrastructure were analyzed with the future flood hazard areas to determine future flood risk exposure of these features. No additional features were added to the dataset compiled in the existing conditions flood exposure analysis previously described. An additional 6,842 critical facilities were identified in the future condition1.0% ACE flood risk exposure analysis that were not previously located within in the existing conditions floodplain. Harris County tops the list as shown in **Appendix 2B-8**.

Roadway Crossings and Roadway Segments

The future flood risk exposure analysis for roadways used only the existing roadway data available from TxDOT. Without considering additional future roads, the 1.0% ACE future flood risk exposure resulted in a 47% increase in roadway crossings and 55% increase in miles of inundated roadways. Similar to the existing condition exposure analysis, bridge deck height was not considered in the future condition exposure analysis. Larger flood hazard areas resulted in a significant increase in inundated roadway miles.

[6] Please note that if a structure is included in the 1.0% ACE, it is also included in the 0.2% ACE. When reviewing these counts, numbers should be summed to determine the total number of structures in 0.2% ACE floodplain, contrary to what is shown in Figure 2-17.

Agricultural Area

Agricultural areas in the San Jacinto planning region were also evaluated to determine future flood exposure. The same area classified as agricultural in the existing exposure analysis was used in the future flood risk exposure analysis. Without altering the agricultural land dataset, the 1.0% ACE future flood risk exposure resulted in a 38% increase in inundated agricultural land in the future condition.

2.B.2.d. Flood Prone Areas

Flood prone areas were not changed between existing and proposed future conditions. These areas were provided by residents and the public using the online dashboard; therefore, additional future conditions flood prone areas cannot be known at this time.

2.B.3. Future Condition Vulnerability Analysis

Vulnerability is an assessment of the potential negative impact of the flood hazard to communities and a description of the impacts. This task uses the data from the existing flood exposure analysis to determine the vulnerability of structures and population exposed to flooding. The existing condition vulnerability analysis uses the same data as the future conditions vulnerability analysis. The analysis also utilizes the 2018 Social Vulnerability Index (SVI) data developed by the U.S. Centers for Disease Control and Prevention (CDC). The CDC calculates the SVI at the census tract level within a specified county using 15 social factors such as poverty, housing, ethnicity, and vehicle access. The CDC groups these factors into four related themes: Socioeconomic Status, Household Composition, Race/Ethnicity/Language, and Housing/Transportation. **Figure 2-18** shows the CDC themes used for SVI calculation. Each census tract received a separate ranking for each of the four themes, as well as an overall ranking.

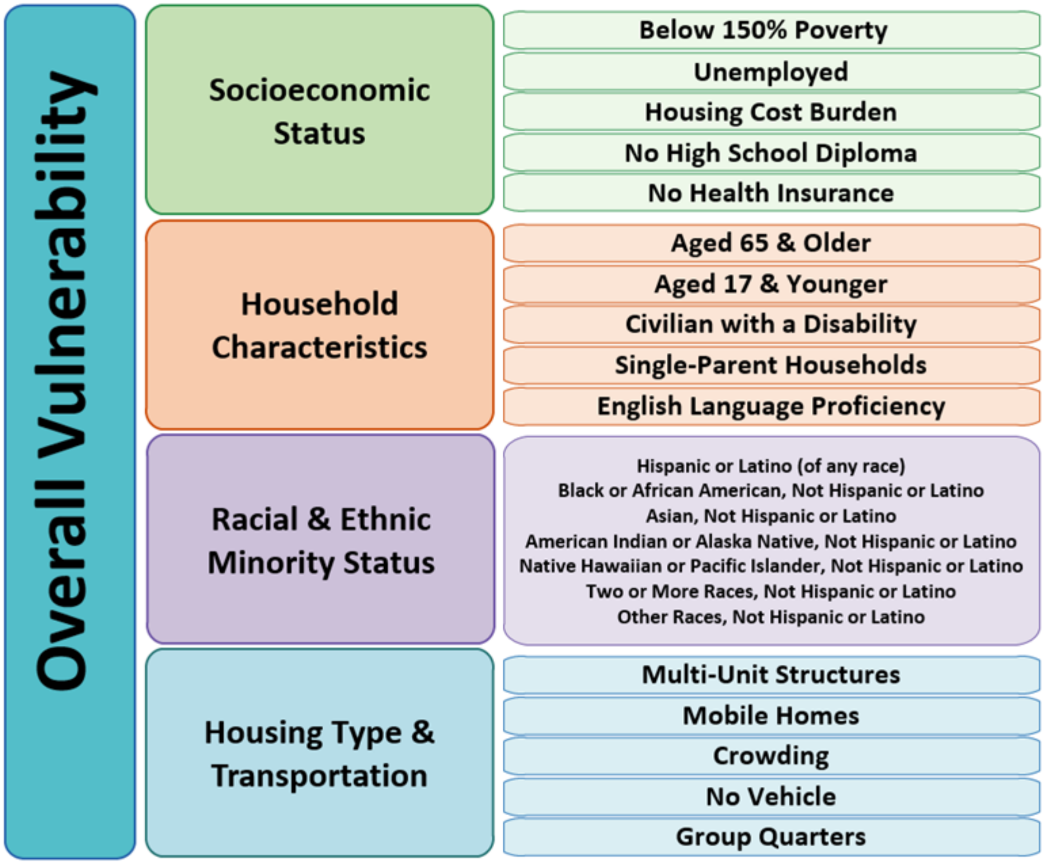

FIGURE 2-18: CDC THEMES FOR SVI CALCULATION

2.B.3.a. Resiliency of Communities

A community's Social Vulnerability score is proportional to a community's susceptibility to risk. Social vulnerability is a consequence-enhancing risk indicator and community risk factor that represents the susceptibility of social groups to the adverse effects of natural hazards like floods, including disproportionate death, injury, loss, or disruption of livelihoods. An SVI score and rating represent the relative level of a community's social vulnerability compared to all other communities, with a higher SVI score indicating higher overall vulnerability.

2.B.3.b. Vulnerability of Critical Facilities

Based on the analysis of future conditions flood exposure data, there is a large increase in critical facilities vulnerable to flooding during the 1.0% and 0.2% ACE storms. In order to protect critical facilities and other infrastructure from flooding in future storm events, mitigation and protection measures should be taken in advance to reduce risk of loss of function during future storm events. **Map 11** in **Appendix 2B-4** depicts the future condtions flood exposure of critical facilties in the San Jacinto region.

2.B.4. Summary of Exposure and Vulnerability Analyses

The future floodplains include 172% more structures and 183% more people potentially impacted than existing conditions while just adding 40% more land area. As mentioned previously, no additional structures or population were added under future conditions to reflect future development or population growth. Actual future flood risk would be higher when considering new structures that would be constructed and growth in population, which would increase flood risk beyond just the expansion of flood hazard areas under future condition scenarios.

The future flood risk, exposure, and vulnerability assessment for the San Jacinto region are summarized in TWDB-required **Table 5** located in **Appendix 2B-6**, providing the results per county of the future flood exposure and vulnerability analysis as outlined in the *Technical Guidelines* for Regional Flood Planning.

A geodatabase with applicable layers as well as associated TWDB-required **Maps 8** through **Map 12** are provided in **Appendix 2B-1** through **Appendix 2B-5**. **Table 2-14** below outlines the geodatabase deliverables included in this RFP as well as spatial files and tables. These deliverables align with the TWDB's *Data Submittal Guidelines*.

TABLE 2-14: TASK 2B GEODATABASE LAYERS AND TABLES

Item Name	Description	Feature Class Name	Data Format (Polygon/Line/ Point/GDB Table)
Future Flood Hazard	Perform future condition flood hazard analyses to determine the location and magnitude of both 1.0% ACE and 0.2% ACE floods.	FutFldHazard	Polygon
Future Exposure	Develop high-level, region-wide, and largely GIS-based future condition flood exposure analyses using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1.0% ACE and 0.2% ACE floods.	FutFldExpPol	Polygon
	Develop high-level, region-wide, and largely GIS-based future condition flood exposure analyses using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1.0% ACE and 0.2% ACE floods.	FutFldExpLn	Polyline
	Develop high-level, region-wide, and largely GIS-based future condition flood exposure analyses using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1.0% ACE and 0.2% ACE floods.	FutFldExpPt	Point
	Combines the Exposure Poly, Line, and Point data into a single master layer, also includes Vulnerability data	FutFldExpAll	All

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CHAPTER 3. FLOODPLAIN MANAGEMENT PRACTICES AND FLOOD PROTECTION GOALS

The overarching goal of all RFPs must be "to protect against the loss of life and property" as set forth in the Guidance Principles, 31 TAC §362.3. This includes the need to:

1. Identify and reduce the risk and impact to life and property that already exists, and
2. Avoid increasing or creating new flood risk by addressing future development within the areas known to have existing or future flood risk.

The San Jacinto Regional Flood Planning Group (RFPG) was tasked with evaluating and recommending floodplain management practices, Task 3A, and flood protection goals, Task 3B, within the region. This chapter describes the processes undertaken by the RFPG to achieve these tasks and summarizes the outcomes of this task.

Chapter 3.A. Evaluation and Recommendations on Floodplain Management Practices

Floodplain management practices are crucial to accomplishing these objectives at regional and local levels. Institutional support for floodplain management comes in multiple forms from the state and local level. Local institutional support includes adequate budgeting for the floodplain administration office, general support from governing boards, departmental support from local public works and finance. Regional and state institutional support comes in the form of agency cooperation, guidance and information sharing, technical guidance on complex matters and general political support. External professional support for floodplain management practices typically comes in the form of professional engineers, surveyors, insurance professionals, environmental planners, and technicians. These subject matter experts are often relied on to provide the technical materials and understanding to properly complete floodplain development permit applications and execute their requirements. The relative number and availability of qualified professionals plays an important role in the efficiency of regulatory compliance.

Floodplain management is defined in Title 31 Texas Administrative Code §361.10 as, "The operation of an overall program of corrective and preventative measures for reducing flood damage." The nature and implementation of floodplain management practices vary across the region. The following sections will provide a qualitative assessment of regional trends of existing floodplain management practices within the San Jacinto region.

3.A.1. Existing Floodplain Management Practices

Existing floodplain management practices for regulatory entities within the region, specifically municipalities and counties, were collected and assessed. For the purpose of this chapter, floodplain management practices refer to the ordinances and regulations enacted by regulatory entities in order to manage flooding in their respective communities. Floodplain management documents available via open-source search were first collected. Parallel to this effort, a web-based survey was sent out to each regulatory entity in the region to gather additional information. A high-level summary of existing floodplain management practices is included in **Table 6** in **Appendix 3A-1**. Values for entities were classified as “Unknown” if data were not provided through the survey or data could not be found online. **Figure 3-1** summarizes the classification distribution of floodplain management practices in the region. There are numerous other non-regulatory entities with flood-related authority throughout the San Jacinto region including flood districts and river authorities that often provide technical support to municipalities and counties. Although contributions from these flood-related authorities were considered when evaluating floodplain management practices across the region and are included in **Appendix 3A-1**, they were not included in **Figure 3-1**.

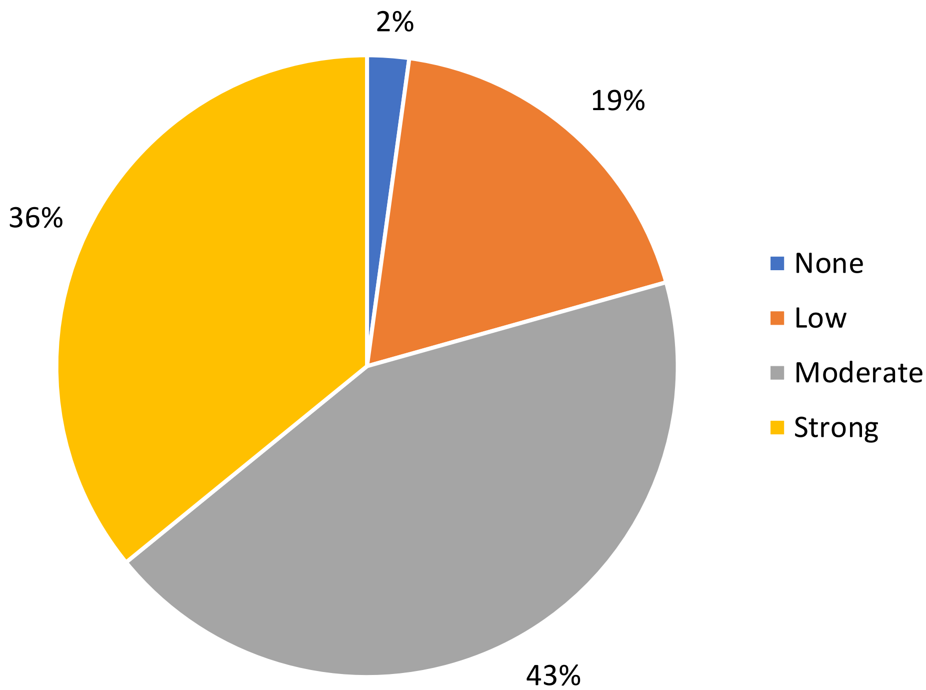

FIGURE 3-1: LEVEL OF FLOODPLAIN MANAGEMENT PRACTICES

The Federal Emergency Management Agency (FEMA) establishes Base Flood Elevations (BFEs) and Special Flood Hazard Areas (SFHAs) along rivers, creeks and large tributaries that are shown on Flood Insurance Rate Maps (FIRMs) and are adopted by municipalities and counties. FIRMs define the geographic area for which local floodplain regulations are applicable. They are developed by FEMA via a discovery process that includes input from hydrologic and hydraulic analyses as well as local stakeholders. The most important geographic zones defined on FIRMs are Special Flood Hazard Areas (SFHAs), floodways, and, to a lesser extent, 0.2% ACE areas designated as shaded Zone X. Other designations and zones are also defined on FIRMs, such as coastal zones and jurisdictional boundaries. The geographic accuracy of zones defined on FIRMs, or the degree to which FIRMs accurately reflect flood risk is dependent on changes in land use or rainfall pattern after the published date. Communities use the FIRM, BFE, and SFHA data in their floodplain permitting processes as a requirement for participating in the NFIP. Insurance agents use FIRMs to determine if flood insurance is required for a property. Flood insurance rates are determined for individual properties based on their location in the SFHA.

To participate in the NFIP, a community must adopt minimum standards that are outlined in Title 44 of the Code of Federal Regulations 44 CFR § 60.3. **Map 13** in **Appendix 3A-2** demonstrates the widespread coverage of floodplain management practices throughout the region that meet or exceed NFIP minimum standards. NFIP participation provides residents of a community the eligibility to purchase flood insurance as well as makes the community eligible for disaster assistance following a flood event. FEMA maintains records of community eligibility, in the form of a publicly available report, the Community Status Book and suspends communities that fail to meet the minimum requirements. The Community Status Book , consulted on May 9, 2022 indicated that all of the counties and the majority of municipalities within the San Jacinto region actively participate in the NFIP. There are two municipalities that are listed as non-participants which are the City of North Cleveland and the City of Todd Mission. However, it is noted that the City of Todd Mission recently updated its floodplain ordinances to meet NFIP minimum requirements. It is also noted that the City of Plantersville, recently incorporated in May 2017, was not listed in the Community Status Book.

Municipalities and counties have the authority to establish their own policies, standards, and practices to manage land use and permitting within associated legal jurisdictions and when developed properties utilize infrastructure that is owned and operated by these regulatory entities. Regulatory entities have the responsibility and authority to permit development that is reasonably safe from flooding. They can adopt and enforce higher standards than the FEMA NFIP minimum standards to better protect people and property from flooding. FEMA supports entities who choose to establish higher standards to better protect life and property, which many entities throughout the San Jacinto region have implemented.

The ability and terms via which regulatory entities enforce floodplain ordinances or regulations is typically codified in sections documenting specific penalties for noncompliance. Specific penalties codified in adopted regulations implies an understanding, preparation, and support from local officials, administrative boards, and code enforcement. Regulatory entities were sent web-based surveys to gather information regarding the level of enforcement of local floodplain regulations. No responses were received describing level of enforcement.

3.A.1.a. Low Floodplain Management Practices

Entities were considered to have “low” floodplain management practices if current ordinances or regulations met the minimum requirements per the NFIP. Approximately 19% of regulatory entities within the Region have “low” floodplain management practices. A designation of ‘None’ was assigned to entities from which no data were obtained through the methods discussed above or were lacking a flood damage prevention ordinance (FDPO).

Floodplain management criteria for flood prone areas minimum requirements per Title 44 of the Code of Federal Regulations 44 CFR § 60.3 are listed at the end of this section and summarized below.

- Require permits for all proposed construction in the community to determine whether construction is proposed within flood prone areas
- Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding:

  - If a proposed building site is in a flood prone area, all new construction and substantial improvements shall be designed to adequately prevent flotation or collapse and be constructed with materials resistant to flood damage
- Review subdivision proposals to determine whether such a proposal will be reasonably safe from flooding:
  - If a subdivision proposal is in a flood prone area, any such proposal shall be reviewed to assure that all such proposals are consistent with the need to minimize flood damage within the flood prone area and
    - All public utilities and facilities, such as sewer, gas, electrical, and water systems are located and constructed to minimize or eliminate flood damage;
    - Adequate drainage is provided to reduce exposure to flood hazards
- Adopt and enforce a FDPO
- Require new or substantially improved homes and manufactured homes to be elevated above the BFE
- Require elevation certificates to ensure compliance
- Conduct field inspections, cite violations, resolve noncompliance issues, and consider and manage variances
- Require within flood prone areas new and replacement water supply systems to be designed to minimize or eliminate infiltration of flood waters into the system
- Require within flood prone areas new and replacement sanitary sewage systems to be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the systems into flood waters and onsite waste disposal systems to be located to avoid impairment to them or contamination from them during flood events

3.A.1.b. Moderate Floodplain Management Practices

Entities were designated as having a “moderate” level of floodplain management practices if current regulations exceeded the minimum requirements of the NFIP. Some of these higher standards include detention requirements; compensatory fill requirements in the 1.0% ACE regulatory floodplain; and requirements that minimum finished floor elevations of new habitable structures exceed the BFE. Most entities within the San Jacinto region fall within this category of floodplain management practice.

Although these entities have chosen to exceed NFIP minimums, current standards implemented by these entities do not address updated best available rainfall data published in 2018, NOAA Atlas 14 rainfall data.

3.A.1.c. Strong Floodplain Management Practices

Entities were designated as having a “strong” level of floodplain management practices if the entity currently regulated to the effective 0.2% ACE regulatory floodplain or had adopted NOAA Atlas 14 rainfall data. Within the San Jacinto region, the effective 0.2% ACE rainfall is widely considered to be a proxy for the Atlas 14 1.0% ACE rainfall. Approximately 36% of regulatory entities within the region have "strong" floodplain management practices. Regulations implemented by these entities include requiring compensatory floodplain fill mitigation for fill placed within the effective 0.2% ACE floodplain as well as requiring that finished floor elevations of new habitable structures be built above the 0.2% ACE floodplain elevation.

Regulatory entities with "strong" floodplain management practices have chosen to implement regulations that go well beyond NFIP minimum requirements and demonstrate some of the strongest floodplain management practices in the state.

3.A.2. Impacts of Floodplain Management Practices on Population and Property

Communities in the San Jacinto region have incrementally improved floodplain and development regulations since the 1980s. Because these regulations are targeted at new development, there is typically a delay between when floodplain management practices are implemented and when the benefits of those practices may be realized and quantified. An analysis of flooded structures within Harris County occurred after Hurricane Harvey in August of 2017. What was notable regarding the analysis was that, although 75,000 homes were built in unincorporated Harris County since 2009, only 467, or 0.6% of those 75,000 homes, flooded during Hurricane Harvey. The year 2009 was when HCFCD effected significant updates to its hydrologic and hydraulic analysis criteria and impacted the safety of structures. None of the 467 flooded homes were substantially damaged. For context, it is estimated that roughly 154,000 homes flooded within Harris County as a result of Hurricane Harvey, amounting to between 9% and 12% of the total number of buildings in the county. Improved floodplain management and development regulations have directly benefited communities within Harris County and the San Jacinto region.

The implementation of floodplain management practices is the first line of defense to avoiding increasing flood risk or creating new flood risk and can yield significant returns on investment. A study by the National Institute of Building Sciences published in 2019 concluded that investment in updating building codes and improving development regulations can result in major savings, as much as $7 dollars for every $1 invested, in avoided fatalities, damages, and other indirect costs associated with riverine flooding, such as diverted resources required to facilitate the recovery process and the interruption to business. Improving floodplain management practices and elevating minimum standards within a region present some of the lowest cost, proactive solutions to protecting both existing and future populations from worsening flood risk.

3.A.3. Recommendation of Minimum Floodplain Management Standards

The San Jacinto RFPG is required to consider the possibility of <u>recommending</u> and/or <u>adopting</u> region-wide minimum standards, landuse practices, or economic development practices and strategies that should be implemented by flood-related authorities to manage flood risk in the region. <u>Recommending</u> minimum standards encourages entities with flood-related authority to implement standards that meet or exceed those minimum standards. <u>Adopting</u> minimum standards requires entities to meet or exceed the minimum standards adopted by the RFPG as a pre-requisite for Flood Management Strategies

(FMSs), Flood Management Evaluations (FMEs), and Flood Mitigation Projects (FMPs) sponsored by that entity to be included in the RFP. Funding programs administered by the TWDB will require that activities be recommended in the RFP to be eligible for future financial assistance.

Due to the already wide-spread active participation in the NFIP by communities within the San Jacinto region, discussion on minimum standards was focused on higher standards. The Technical Committee considered information collected regarding the prevalence, regional coverage, and type of higher standards currently implemented across the region at a meeting held on March 31, 2022. The Technical Committee developed a preliminary list of floodplain management standards for consideration by the RFPG at the following meeting held on April 14, 2022. Input from the RFPG at the April meeting centered on ensuring that there was adequate flexibility incorporated into the identified standards to allow entities to adopt regulations that best suited both the needs of their community as well as current staffing capability. Discussion also focused on incorporation of exceptions to minimum standards that considered the unique concerns of coastal flood zones.

The minimum standards listed in **Table 3-1** were recommended by the RFPG at a meeting held on May 12, 2022. Given the abbreviated schedule of the first cycle of regional flood planning, there would not be opportunity for entities to take action to implement those minimum standards were the San Jacinto RFPG to choose to adopt standards. If the San Jacinto RFPG were to choose to adopt standards, only entities that already have regulations in place that meet or exceed those standards would be eligible for future funding through programs administered by the TWDB. Therefore, the San Jacinto RFPG specifically chose to recommend standards as opposed to adopting them so as to not limit the funding eligibility of entities within the region.

TABLE 3-1: RECOMMENDED MINIMUM FLOODPLAIN MANAGEMENT STANDARDS

Recommended Minimum Standard	Definition
Participation in the National Flood Insurance Program (NFIP)	• All regulatory entities to implement ordinances that meet minimum requirements per the NFIP • All regulatory entities to remain active NFIP participants in good standing • All regulatory entities are encouraged to participate in the Community Rating System (CRS) Program to reduce flood insurance rate premiums across the region.
Development of No Adverse Impact Policies	• All regulatory entities are encouraged to define a no adverse impact policy. • The no adverse impact policy should be focused on preventing negative impacts. Evaluation of impacts should be completed using best available hydrologic and hydraulic modeling, where appropriate.

Recommended Minimum Standard	Definition
Establish Minimum Finished Floor Elevations	• All new habitable structures shall have a finished floor elevation established at or above or waterproofed to the FEMA effective 0.2% ACE flood elevation as shown on effective FIRMs except in areas designated as coastal flood zones. • Where regulatory mapping has been updated using Atlas 14 rainfall data, all new habitable structures shall have a finished floor elevation established at or above or waterproofed to the FEMA effective 1.0% ACE flood elevation as shown on effective FIRMs except in areas designated as coastal flood zones. • In areas designated as coastal flood zones, all new habitable structures shall have a finished floor elevation established at or above or waterproofed to the FEMA effective 1.0% ACE flood elevation as shown on effective FIRMS plus 1 foot of freeboard.
Encourage Use of Best Available Data	• Utilize the latest rainfall data, NOAA Atlas 14 rainfall data, when conducting new analyses, designing drainage infrastructure, or developing regulations and criteria.
Compensatory Storage Requirements in the 1.0% ACE Floodplain	• Any reduction in floodplain storage or conveyance capacity within the 1.0% ACE regulatory floodplain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction, except in areas identified as coastal flood zones. • A full hydrologic and hydraulic analysis should be performed to demonstrate that floodplain fill mitigation provided is sufficient.
Compensatory Storage Requirements in the 0.2% ACE Floodplain	• Any reduction in floodplain storage or conveyance capacity within the 0.2% ACE regulatory floodplain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction, except in areas identified as coastal flood zones. • A full hydrologic and hydraulic analysis should be performed to demonstrate that floodplain fill mitigation provided is sufficient.
Development of Detailed Hydrologic and Hydraulic Analysis Criteria/Requirements	• All regulatory entities to develop hydrologic and hydraulic modeling criteria or requirements. • All regulatory entities to identify features of a proposed development that would warrant a full hydrologic and hydraulic analysis.
Incentivizing the Preservation of the Floodplain	• All regulatory entities are encouraged to explore and develop systems for incentivizing the preservation of the floodplain directly within the regulatory floodplain or within 100 feet of the banks of unstudied streams.

Chapter 3.B. Flood Mitigation and Floodplain Management Goals

The objective of Task 3B is to define and select a series of goals that will serve as the drivers of the regional flood planning effort. The RFPG must identify goals that are specific and achievable and, when implemented, will demonstrate progress toward the overarching goal for the statewide planning effort. Per TWDB requirements and guidelines, the goals selected by the RFPG must include the information listed below:

- Description of the goal
- Term of the goal set at 10 years (short-term) or 30 years (long-term)
- Extent or geographic area to which the goal applies
- Residual risk that remains after the goal is met
- Measurement method that will be used to measure goal attainment
- Association with overarching goal categories.

3.B.1. Development of Flood Mitigation and Floodplain Management Goals

The goals were developed by both the San Jacinto RFPG Technical Committee and the full RFPG. Throughout the goal development process, the Technical Committee, RFPG members, and members of the public were able to provide feedback and comments during multiple public meetings and to the technical consultant between public meetings. Results of the public survey, held in the Fall of 2021, presented to and for consideration by the RFPG when developing goals are shown in **Figure 3-2**.

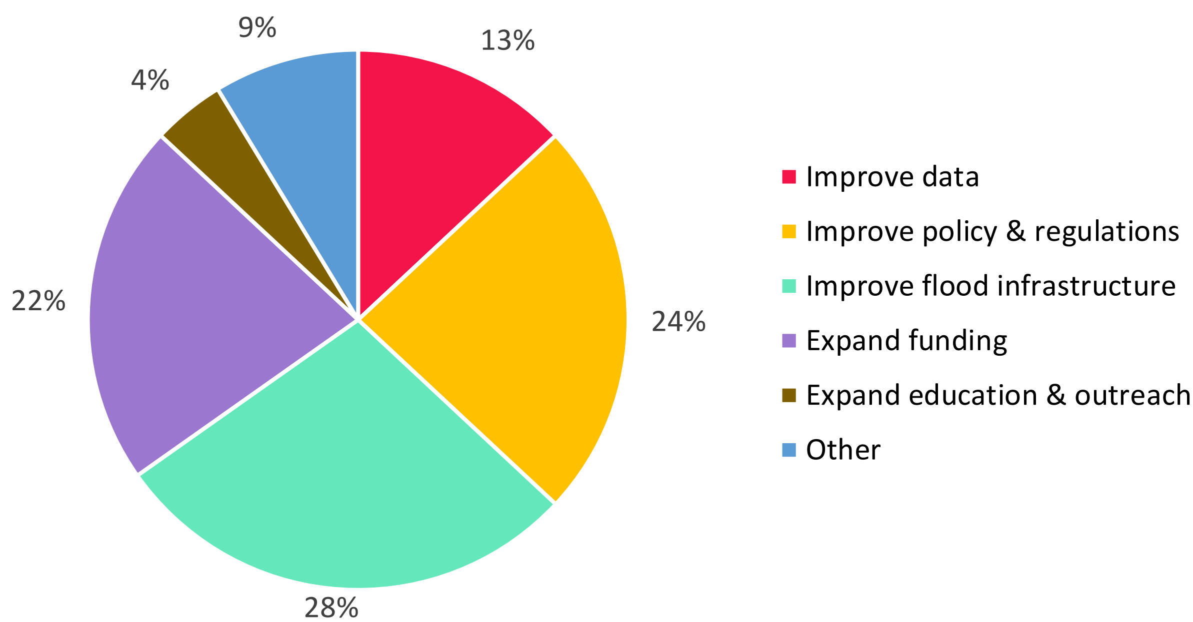

FIGURE 3-2: PUBLIC SURVEY RESULTS DETAILING HIGHEST PRIORITY GOAL CATEGORIES

During the August 2021 Technical Committee and September 2021 RFPG meetings, live polling was used during the meeting to focus the direction of the draft goals and to identify which goal categories were of the highest importance. Each group member was asked “Which RFPG goal category should be the most important for the San Jacinto region, based on assigned weight out of 100 points.” The results of the poll are shown in the **Figure 3-3**. RFPG live polling and public survey results were fairly consistent. It should be noted that the public survey did not include separate categories for protecting life safety and property as potential answer choices.

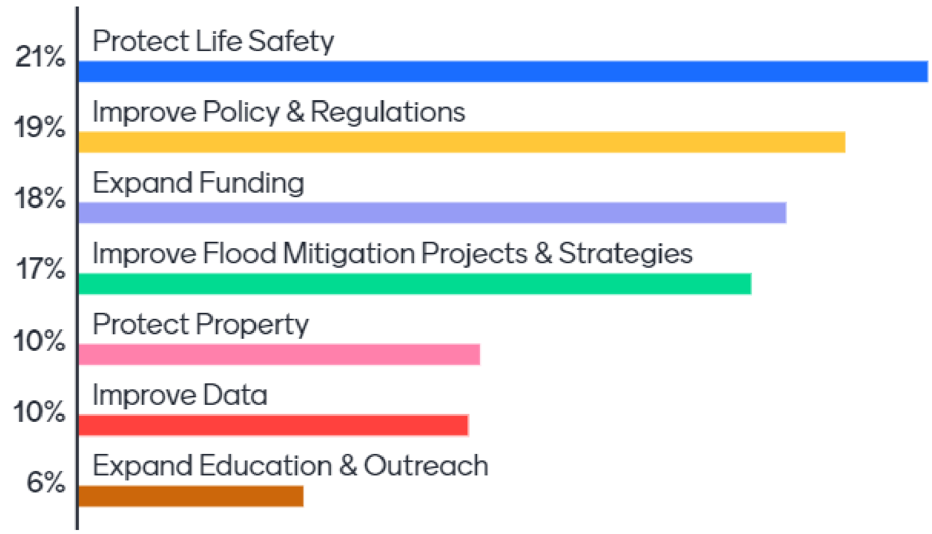

FIGURE 3-3: RFPG PRIORITIZATION OF GOAL CATEGORIES FROM LIVE POLLING

The poll also gave the RFPG the opportunity to rank specific goal topics within each of the broader categories based on importance. The subgoals are more specific and guide ways in which the larger goal categories can be achieved. For example, under the “Protect Life Safety” goal category, the presented subgoals included “reducing the number of flood related deaths” and “improving emergency access and response”. Using the goal category and subgoal ranking, an overall weighted ranking was calculated for each subgoal. The process of polling the RFPG and calculating the weighted ranking value for the subgoals helped narrow and establish a slate of draft goals.

3.B.2. Adoption of Flood Mitigation and Floodplain Management Goals

The RFPG utilized the assessment of current floodplain management and land use practices from Task 3A, as well as the existing and future condition flood risk analyses from Task 2, to guide the development of the goals for the region. The RFPG began discussion to identify and refine goals categories at the RFPG meeting on September 9, 2021. Draft goals were presented at the subsequent RFPG meeting on October 14, 2021 where significant discussion centered around data availability and the development of SMART, specific, measurable, achievable, relevant, and time-bound, goals.

After careful consideration, the San Jacinto RFPG adopted the flood mitigation and floodplain management goals listed in **Appendix 3B-1**. An abbreviated list of adopted goals is provided in **Table 3-2**. These specific goals were reviewed and approved by the San Jacinto RFPG during a meeting held on November 18, 2021.

3.B.3. Transformed and Residual Risk

Flood risk will be reduced by the implementation of the actions and construction of the projects necessary to achieve the identified goals. However, the San Jacinto RFPG acknowledges that it is not possible to protect against all potential flood risk. The RFPG has determined the residual and transformed flood risk remaining in the San Jacinto region after each goal is achieved. Residual risk is defined as the risk remaining after the execution of a flood mitigation action, while transformed risk is defined by U.S. Army Corps of Engineers (USACE) as the change in the nature of flood risk for some areas that is associated with the presence of flood hazard reduction infrastructure. For example, a community within the region could choose to construct new flood infrastructure that protects buildings up to the 1% ACE flood elevation. However, the residual risk associated with this action would be that the new infrastructure does not protect buildings for events that exceed the 1% ACE. Using the same scenario, while the new flood infrastructure helps mitigate the flood risk previously posed by the 1% ACE, the risk is now "transformed" into a risk of structural failure of the flood infrastructure, whether it be by a larger storm event or lack of future maintenance.The risk intended to be addressed by the adopted goal combined with the residual and transformed risk represents the totality of flood risk faced in the San Jacinto region. An explanation of residual risk and the measurement method that will be used to determine the progress towards achieving each adopted goal are listed in **Appendix 3B-1**.

3.B.4. Goals as a Guide for the Regional Flood Plan

The selected specific goals will guide the development of the FMSs, FMEs, and FMPs for the San Jacinto region. They build upon TWDB regional flood planning guidance and provide a comprehensive framework for future strategy development focused on reducing flood risk to people and property, while not negatively affecting neighboring areas.

An abbreviated list of adopted RFP goals is provided in **Table 3-2**. The complete description of adopted goals by the RFPG are included in **Appendix 3B-1**.

TABLE 3-2: ADOPTED FLOOD PROTECTION GOALS

Goal ID	Goal	Term of Goal	Target Year	Metric
06000001	There will be 0 flood-related fatalities annually within the San Jacinto region by 2053.	Long Term (30-year)	2053	Number of direct flood-related fatalities
06000002	Increase the value of state and federal funds awarded within the San Jacinto region by 10%.	Short Term (10-year)	2033	State and federal funds awarded to communities within the San Jacinto region
06000003	Reduce the miles of major roadways subject to inundation during the 1% ACE flood by 10% by 2033.	Short Term (10-year)	2033	Number of miles of major thoroughfares subject to 1% ACE flood risk
06000004	Reduce the miles of major roadways subject to inundation during the 1% ACE flood by 25% by 2053.	Long Term (30-year)	2053	Number of miles of major thoroughfares subject to 1% ACE flood risk

Goal ID	Goal	Term of Goal	Target Year	Metric
06000005	Increase the number of public entities that invest in stormwater infrastructure and planning by 10% by 2033.	Short Term (10-year)	2033	Number of public entities that dedicate funding towards stormwater infrastructure and planning
06000006	Increase the number of public entities that invest in stormwater infrastructure and planning by 25% by 2053.	Long Term (30-year)	2053	Number of public entities that dedicate funding towards stormwater infrastructure and planning
06000007	All flood regulatory authorities within the region will adopt standards equal to or exceeding minimums as recommended by the San Jacinto RFPG in the first cycle of regional flood planning.	Short Term (10-year)	2033	Number of flood regulatory authorities that adopt standards equal to or exceeding recommended minimums by the RFPG in the first cycle
06000008	Improve interjurisdictional coordination through participation in the San Jacinto regional flood planning process. Target to ensure that 50% of identified stakeholders complete the San Jacinto RFP stakeholder survey and provide data for inclusion in the RFP by 2033.	Short Term (10-year)	2033	Number of identified stakeholders who submit survey responses or provide data for inclusion in the San Jacinto RFP
06000009	Improve interjurisdictional coordination through participation in the San Jacinto regional flood planning process. Target to ensure that 90% of identified stakeholders complete the San Jacinto RFP stakeholder survey and provide data for inclusion in the RFP by 2053.	Long Term (30-year)	2053	Number of identified stakeholders who submit survey responses or provide data for inclusion in the San Jacinto RFP
06000010	Expand the understanding of flood risk in the San Jacinto region.	Short Term (10-year)	2033	Percentage of the floodplain quilt, by studied stream length, that is based on NOAA Atlas 14 rainfall data
06000011	Reduce the number of critical facilities subject to inundation during the 1% ACE by 5% by 2033.	Short Term (10-year)	2033	Number of critical facilities subject to 1% ACE flood risk
06000012	Reduce the number of critical facilities subject to inundation during the 1% ACE by 20% by 2053.	Long Term (30-year)	2053	Number of critical facilities subject to 1% ACE flood risk

Goal ID	Goal	Term of Goal	Target Year	Metric
06000013	At least 35% of all flood mitigation strategies (FMSs) and flood mitigation projects (FMPs) identified within the RFP will incorporate nature-based practices by 2033.	Short Term (10-year)	2033	Number of FMSs and FMPs that incorporate nature-based practices as defined within the San Jacinto RFP
06000014	At least 90% of flood mitigation strategies (FMSs) and flood mitigation projects (FMPs) identified within the RFP will incorporate nature-based practices by 2053.	Long Term (30-year)	2053	Number of FMSs and FMPs that incorporate nature-based practices as defined within the San Jacinto RFP
06000015	Reduce the number of structures subject to inundation during the 1% ACE by 25% by 2053.	Long Term (30-year)	2053	Number of structures subject to 1% ACE flood risk

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CHAPTER 4. ASSESSMENT AND IDENTIFICATION OF FLOOD MITIGATION NEEDS

Chapter 4.A. Flood Mitigation Needs Analysis

This section of the chapter describes the process adopted by the San Jacinto RFPG to conduct the Flood Mitigation Needs Analysis, Task 4A, which involves a high-level assessment of the San Jacinto region with the goal of identifying areas with the greatest flood risk knowledge gaps and greatest known flood risk and mitigation needs. Guidance from the Texas Water Development Board (TWDB) *Technical Guidelines for Regional Flood Planning (Exhibit C)* indicates that the gaps in flood risk information should be of “flood prone areas with poorly defined or inadequate flood risk information to the extent that it would prevent the RFPG from identifying potentially feasible FMSs and/or FMPs to mitigate flood risks.” The guidance for areas of greatest flood risk indicate that ongoing and planned flood risk reduction projects with funding should be considered when determining areas of greatest need. The results of Task 4A help guide the subsequent Task 4B effort of identifying FMEs, FMPs, and FMSs. **Table 4-1** provides a summary of the *Technical Guidelines* factors that were considered in Task 4A.

TABLE 4-1: TWDB GUIDANCE AND FACTORS TO CONSIDER IN TASK 4A

Guidance	Factors to Consider
1. Most prone to flooding that threatens life and property	• Existing Conditions and Future Conditions • Area in the existing 0.2% ACE floodplain • Structures within 0.2% ACE floodplain • Agricultural areas within 0.2% ACE floodplain • Quantity of roadway miles • Number of roadway water crossings • Number of critical facilities in 0.2% ACE floodplain
2. Locations, extent and performance of current floodplain management and land use policies and infrastructure	• Community participation in NFIP • Presence of a city and/or county Drainage Criteria Manual • Presence of Higher Floodplain Standards • Community's CRS Score
3. Inadequate inundation mapping 4. Lack of hydrologic and hydraulic (H&H) models	• No BLE or Zone A FEMA floodplain mapping • Presence of Atlas 14 rainfall data • Age of maps
5. Emergency need	• FEMA-designated Repetitive Loss/Severe Repetitive Loss structures • Critical facilities within the exiting 0.2% ACE floodplain • Hurricane Evacuation Routes
6. Existing modeling analyses and flood risk mitigation plans	• Presence of Master Drainage Plans, including watershed-wide Master Drainage Plans
7. Previously identified and evaluated flood mitigation projects	• This guidance was not included as part of the scoring criteria – more detail can be found in the text below
8. Historic flooding events	• Number of FEMA claims • Claim property damage
9. Previously implemented flood mitigation projects	• Number of active construction projects
10. Additional other factors deemed relevant by RFPG	• Social Vulnerability Index (SVI) • Nighttime population density

4.A.1. Process and Scoring Criteria

Task 4A utilized compiled data from Tasks 1 through 3 to conduct a geospatial assessment of the region by assigning scoring based on calculated metrics associated with the factors listed in **Table 4-1**. Note that one category of factors (previously identified and evaluated flood mitigation projects) was excluded from the analysis. This category of factors focused on plans/studies that are not implemented or funded. These types of projects do not capture flood risk knowledge gaps or risks.

The geospatial assessment was performed at a HUC-12 watershed level of detail, which is consistent with the minimum watershed size as specified in the *Technical Guidelines*. A Hydrologic Unit Code (HUC) is a unique identification code assigned to watersheds in the United States. As watersheds are subdivided into smaller watersheds, the number of digits used to identify them gets longer. The smallest unit of division used to identify a watershed is 12 digits, also referred to as a HUC-12. The San Jacinto region has a total of 108 HUC-12 watersheds, with an average size of 49 square miles.

Due to the topography of the region, the HUC-12 boundaries in the southern (coastal) zone of the region are much larger than those in the northern part of the region. Four of the 108 HUC-12 boundaries have an average area of 272 square miles, while the remaining 104 HUCs have an average area of 41 square miles. As a result, the average HUC area is skewed, which will lead to uneven results on the distribution of flood risk and knowledge gaps. To address this concern, the four large HUC-12 boundaries were divided further using local watershed boundaries. The result was a total of 115 watersheds, with an average area of 64 square miles.

Based on guidance from the RFPG, a total of nine data categories with 26 subcategories were used in the geospatial assessment. A scoring system was determined for each data category based on the statistical distribution of the data, with an effort made to evenly distribute the number of HUCs with each score within a certain category to differentiate HUCs in the identification of higher need areas. The process followed for the analysis was:

1. Intersect the selected data with HUC boundaries to get a count of number of items per HUC.
2. Subdivide the data results to fall into different scores. The scores were created to have similar amounts of HUCs within each scoring value. However, some scoring 'buckets' have large ranges. This was necessary to keep the number of HUCs within each 'bucket' as even as possible. For an example of this approach, see the number of structures in the floodplain calculated in **Table 4-3**.
3. The categories were assigned a score. A higher score indicates higher risk or knowledge gaps and that more attention or funding should be dedicated to that HUC.
4. For categories with more than one factor included, an average score was calculated to determine the overall resulting category score for each HUC.
5. The process was repeated for all categories.
6. Relevant categories were summed to create an overall score for each HUC in both the flood risk and flood risk knowledge gap calculations based on the breakdown in **Table 4-2**.

TABLE 4-2: CATEGORY FACTORS FOR FLOOD RISK KNOWLEDGE GAPS AND KNOWN FLOOD RISK

Category	Knowledge Gap	Flood Risk Need
1		X
2		X
3 and 4	X	
5		X
6	X	
7	N/A	N/A
8		X
9		X
10		X

A score ranging from one to five points was assigned to each HUC watershed for each subcategory based on the type and distribution of data across all the HUC-12 watersheds. Subcategory scores were averaged to get a composite category score for each HUC. The scores for each HUC-12 under each category were then summed to obtain a total score that was used to determine where the greatest flood risk knowledge gaps and areas of greatest known flood risk exist. Further documentation of scoring methodology is provided in the sections below.

The following sections provide descriptions of all factors used in the Task 4A assessment and an explanation of how each category or subcategory was scored. Note that the objective of Task 4A is to understand the general magnitude of need based on all factors that are present within a given HUC-12 watershed, but not necessarily to focus on the relative contribution of each category to the total score. Therefore, no weighting factors were applied to any specific category, although some weighting was applied to subcategories within a category as noted below.

4.A.1.a. Areas Most Prone to Flooding that Threatens Life and Property (Category 1)

Compared to other flood planning regions, the San Jacinto region has more complete mapping coverage based on more detailed and newer flood risk information. A significant remapping effort was undertaken by the HCFCD, whose jurisdiction covers a significant portion of the region. Since the mapping for Harris County, corresponding to the Central Zone for the San Jacinto region, is in the process of being updated, consideration was given to both existing and future conditions for the determination of areas most prone to flooding that threaten life and property. To calculate total points for this category, the points assigned based on existing floodplain mapping were weighted at 70% while the points assigned based on future floodplain mapping were weighted at 30%. Note that the depth of flooding was not modeled and therefore not utilized for the analysis; instead, only floodplain extents or areas were utilized.

A total of six subcategories contributed to the total points for this category. Calculated metrics and assigned points related to existing conditions were referenced as Category 1A while those related to future conditions were referencedas Category 1B. Scoring criteria for this category is shown in **Table 4-3,** Existing Conditions, and **Table 4-4,** Future Conditions. The points from the six subcategories were averaged to get the total scores for Categories 1A and 1B.

Areas Within the Floodplain

The total area within the existing and future 0.2% ACE floodplains was determined in Tasks 2A and 2B, respectively. The total area within each 0.2% ACE floodplain was calculated for each HUC-12 and used to assign points for this subcategory.

Number of Structures in the Floodplain

The building footprints dataset was provided by the TWDB on the Data Hub. This dataset was utilized in Task 2A to determine the total number of buildings in the existing 0.2% ACE floodplain. A similar exercise was performed to determine structures within the future 0.2% ACE floodplain by intersecting existing structures with the future conditions floodplains delineated in Task 2B. For Task 4A, points were assigned for this subcategory based on the count of existing buildings within each 0.2% ACE floodplain for each HUC-12 watershed.

For this analysis, if a structure were located within the existing 0.2% ACE floodplain extent, it was counted without consideration of the structure elevation. Furthermore, no additional building footprints were added under future conditions due to the challenge and time required to determine the number and location of future buildings; the existing building footprints dataset was also used to determine structure count based on the future floodplain extents. Consideration of structure elevations and change in number of structures between existing and future conditions could be evaluated in future flood planning cycles.

Agricultural Areas

Agricultural areas have been defined for this task as land used for farming. The agricultural areas dataset was provided by the TWDB on the Data Hub. This dataset was utilized in Task 2A to determine the total number of agricultural area (square miles) within the existing 0.2% ACE floodplain. A similar exercise was performed to determine future impacted agricultural areas within the 0.2% ACE floodplain by intersecting existing agricultural areas with the future conditions 0.2% ACE floodplains delineated in Task 2B. For Task 4A, points were assigned for this subcategory based on the square miles of total impacted agricultural area for each HUC-12 watershed.

For this analysis, no additional agricultural areas were added under future conditions; the existing agricultural areas dataset was used to determine areas based on the future floodplain extent. Consideration of future agricultural areas could be evaluated in future flood planning cycles.

Quantity of Roadway Miles

The roadway segments dataset was provided by the TWDB on the Data Hub website. This dataset was utilized in Task 2A to determine the total number of roadway miles in the existing 0.2% ACE floodplain. A similar exercise was performed to determine roadway miles within the future 0.2% ACE floodplain by intersecting existing roadways within the future conditions floodplain delineated in Task 2B. For Task 4A, points were assigned for this subcategory based on the count of roadway miles within the 0.2% ACE floodplain for each HUC-12 watershed.

For this analysis, if a roadway intersected the existing 0.2% ACE floodplain, it was counted without consideration of roadway elevation due to a lack of consistent topographic data and the time required to extract roadway elevation information. Consideration of roadway elevation could be evaluated in future flood planning cycles. Furthermore, no additional roadways were added under future conditions; the existing roadway dataset was also used to determine roadway miles based on the future floodplain extent.

Number of Roadway Crossings

Low water crossings were identified in Task 1 and were downloaded from the TWDB Data Hub website. This dataset was utilized in Task 2A to determine the total number of roadway crossings in the existing 0.2% ACE floodplain . A similar exercise was performed to determine low water crossings within the future 0.2% ACE floodplain by intersecting number of existing low water crossings within the future conditions floodplain delineated in Task 2B. For Task 4A, the count of low water crossings within the 0.2% ACE floodplain for each HUC-12 watershed was used to assign points for this subcategory.

For this analysis, no low water crossings were added under future conditions. Consideration of future low water crossings could be evaluated in future flood planning cycles.

Critical Facilities

Critical facilities include but are not limited to fire stations, hospitals, shelters, schools, water and wastewater treatment plants, correctional facilities, aviation facilities, waste disposal facilities, power generation, and chemical manufacturing and processing facilities.

The critical facilities footprints dataset was provided by the TWDB on the Data Hub website. This dataset was utilized in Task 2A to determine the total number of critical facilities in the existing 0.2% ACE floodplain. A similar exercise was performed to determine critical facilities within the future 0.2% ACE floodplain by intersecting existing critical facilities with the future conditions floodplains delineated in Task 2B. For Task 4A, points were assigned for this subcategory based on the count of existing critical facilities within the 0.2% ACE floodplain for each HUC-12 watershed.

For this analysis, if a critical facility were located within the existing 0.2% ACE floodplain, it was counted without consideration of the structure elevation. Furthermore, no critical facility footprints were added under future conditions; the existing critical facility footprints dataset was also used to determine a facilities count based on the future floodplain extents. Consideration of structure elevations and change in number of critical facilities between existing and future conditions could be evaluated in future flood planning cycles.

TABLE 4-3: TASK 4A SCORING CRITERIA – CATEGORY 1A: EXISTING CONDITIONS

Score (points)		1	2	3	4	5
Area within the Floodplain (Square Miles)	Range	0-60	60.01-75	75.01-95	95.01-112	112.01+
	Number of Occurrences	23	23	23	24	22
Number of Structures in the Floodplain	Range	1-86	87-700	701-2560	2561-4950	4951+
	Number of Occurrences	23	23	23	23	23
Agricultural Areas in Flood Prone Areas (Square Miles)	Range	0-0.017	0.0171-0.046	0.0461-0.093	0.0931-0.39	0.0391+
	Number of Occurrences	23	24	23	23	22
Quantity of Roadway Miles	Range	0-5	5.01-16	16.01-45	45.01-85	85.01+
	Number of Occurrences	24	23	23	22	23
Number of Roadway Crossings	Range	1-14	15-22	23-38	39-55	56+
	Number of Occurrences	22	23	23	23	24
Number of Critical Facilities in Flood Prone Areas	Range	0	1-8	9-27	28-120	121+
	Number of Occurrences	44	17	18	18	18

TABLE 4-4: TASK 4A SCORING CRITERIA – CATEGORY 1B: FUTURE CONDITIONS

Score (points)		1	2	3	4	5
Area within the Floodplain (Square Miles)	Range	0-73	73.1-88	88.1-112	112.1-133	133.1+
	Number of Occurrences	23	23	22	23	24
Number of Structures in the Floodplain	Range	1-280	281-1650	1651-5050	5051-11500	11501+
	Number of Occurrences	23	23	23	23	23
Agricultural Areas in Flood Prone Areas (Square Miles)	Range	0.001-0.032	0.0321-0.066	0.0661-0.13	0.131-0.53	0.531+
	Number of Occurrences	22	24	24	23	22
Quantity of Roadway Miles	Range	1-11	11.1-35	35.1-80	80.1-140	170.1+
	Number of Occurrences	24	22	24	24	21
Number of Roadway Crossings	Range	0	1-25	26-53	54-92	93+
	Number of Occurrences	0	29	27	29	30
Number of Critical Facilities in Flood Prone Areas	Range	0	1-13	14-42	43-165	166+
	Number of Occurrences	34	20	19	20	22

4.A.1.b. Current Floodplain Management and Land Use Policies and Infrastructure (Category 2)

Communities Participating in the NFIP

Communities participating in the NFIP were identified in Task 1 and Task 3. The scores were calculated by utilizing the percentage of an NFIP-participating community area in each HUC watershed boundary. Scoring criteria for this category is shown in **Table 4-5**.

Communities with a Drainage Criteria Manual

Communities can regulate development utilizing drainage criteria manuals. These manuals are tools that can regulate detention and local drainage infrastructure. A list of drainage criteria manuals for the counties and communities within the San Jacinto region was compiled in ArcGIS, and then overlaid with the HUC watershed boundaries. For this exercise, the documentation needed to explicitly be labeled as a Drainage Criteria Manual for the documentation to be considered.

Scores were given based on the presence of a drainage criteria manual for the city and county (a score of one point), the presence of the manual for the city or the county (a score of three points), or if neither the county nor community had a drainage criteria manual (a score of five points). Scoring criteria for this category is shown in **Table 4-5**.

Communities with Higher Floodplain Standards

When regulating development in a floodplain, communities can utilize higher floodplain standards than NFIP minimum standards to help reduce the risk of flooding. Higher standards are indicated by additional guidance documents and stricter requirements for new developments or significant redevelopment, such as requiring higher finished floor elevations. Communities with higher floodplain standards were identified utilizing the survey responses compiled in Task 1. Scores were determined based on the percentage of the HUC watershed that was covered by a community having higher floodplain standards. Scoring criteria for this category is shown in **Table 4-5**.

Communities CRS Score

Communities with a Community Rating System (CRS) score were identified using publicly available data from FEMA. A CRS score indicates that a community has adopted higher standards for floodplain management than the basic requirements for participation in the NFIP and is granted a discount on flood insurance premiums. The scores for this category were based on the CRS score received from FEMA, ranked such that a lower CRS score garnered fewer points than a higher CRS score, in line with FEMA scoring requirements. Where HUC boundaries contained multiple CRS-participating communities, the score was calculated utilizing a weighted average of CRS score based upon the communities' area within a HUC watershed. Non-participating communities were given a score of 10, which is the default value that FEMA utilizes. Scoring criteria for this category is shown in **Table 4-5**.

TABLE 4-5: TASK 4A SCORING CRITERIA – CATEGORY 2

Score (points)		1	2	3	4	5
Communities Participating in NFIP	Range	>90%	50-90%	20-50%	0.1-20%	0%
	Number of Occurrences	30	15	17	30	23
Communities with a Drainage Criteria Manual	Range	County AND City		County OR City		Neither
	Number of Occurrences	4		97		14
Communities with Higher Floodplain Standards	Range	>90%	50-90%	20-50%	0-20%	0%
	Number of Occurrences	30	15	16	26	28
Communities CRS Score	Range	<6	6-7	7-8	8-10	10
	Number of Occurrences	10	14	13	25	53

The points from the four subcategories were averaged to get the total score for Category 2.

4.A.1.c. Areas Identified as Flood Map Gaps and Areas Without Hydrologic and Hydraulic Models (Category 3 and 4)

The analyses for mapping and modeling were combined for the purpose of Task 4A. It was assumed that areas with maps would have associated H&H models that would correlate in accuracy and age to the mapping level of detail and effective date. For the scores within this category, regulatory FEMA maps were used, rather than watershed study or master drainage plan maps. The analysis was based on the most predominant map type and age within each HUC-12 watershed based on the following scale in order of least accurate to most detailed and current regulatory flood mapping:

- No mapping
- Zone A (approximate limits and no base flood elevations)
- Pre-2008 (pre-LiDAR data)
- Base Level Engineering (BLE – created with updated topography but using approximate methods)
- 2008 – 2018 Maps (Previous LiDAR dataset)
- 2018 Maps (using Newest LiDAR and Atlas 14 rainfall data)

The breakdown was created based primarily on the age of terrain data along with level of mapping study detail (for example, Zone AE versus Zone A on FIRMs). Scoring criteria for this category is shown in **Table 4-6**. Note that no HUC-12 watersheds in the San Jacinto region had Zone A flood maps or no maps available.

It is also important to note that much of Harris County had high scores reflecting older mapping information. HCFCD recently finished the development of updated floodplain modeling and mapping for the entire Harris County. These models and maps are currently undergoing review by FEMA and are expected to be preliminarily released in 2023. For the Task 4A assessment, only modeling and mapping available to the public and agencies today was considered. Future regional flood planning cycles will likely be able to incorporate the new maps, thus updating the Category 3 and 4 score for the HUC-12 watersheds within Harris County.

TABLE 4-6: TASK 4A SCORING CRITERIA – CATEGORIES 3 AND 4

Score (points)		0	1	2	3	4	5
Map Description	Range	2018 or Newer	2008-2018	BLE	Pre-2008 Maps	Zone A Maps	No Map
	Number of Occurrences	12	34	31	38	0	0

4.A.1.d. Areas with Emergency Needs (Category 5)

With input from the RFPG, the following subcategories were included in the Task 4A emergency needs assessment:

- FEMA Repetitive Loss (RL)/Severe Repetitive Loss (SRL) data
- Critical facilities within the existing 0.2% ACE floodplain
- Hurricane evacuation routes, calculated in miles

The FEMA RL/SRL data was taken from publicly available FEMA data for events from 2009 – 2015, the most recent year available. The data was overlaid with the HUC-12 boundaries to determine the number of structures that suffered damage during historical storm events within each HUC-12 watershed.

Critical facilities include but are not limited to fire stations, hospitals, shelters, schools, water and wastewater treatment plans, correctional facilities, aviation facilities, waste disposal facilities, power generation, and chemical manufacturing and processing facilities.

The critical facilities footprints dataset was provided by the TWDB on the Data Hub website. This dataset was utilized in Task 2A to determine the total number of critical facilities in the existing 0.2% ACE floodplain. A similar exercise was performed to determine critical facilities within the future 0.2% ACE floodplain by intersecting existing critical facilities with the future conditions floodplains delineated in Task 2B. For Task 4A, points were assigned for this subcategory based on the count of existing buildings within the 0.2% ACE floodplain for each HUC-12.

For this analysis, if a critical facility was located within the existing 0.2% ACE floodplain extents, it was counted without consideration of the structure elevation. Furthermore, no critical facility footprints were added under future conditions; the existing critical facility footprints dataset was also used to determine facilities count based on the future floodplain extents. Consideration of structure elevations and change in number of critical facilities between existing and future conditions could be evaluated in future flood planning cycles.

Hurricane evacuation route data was downloaded from the Houston-Galveston Area Council (H-GAC) website. The routes were overlaid with the existing conditions 0.2% ACE floodplain that was created during Task 2A to calculate miles of evacuation routes within each HUC-12 watershed.

Scoring criteria for this category is shown in **Table 4-7**. The points from the three subcategories were averaged to get the total score for Category 5.

TABLE 4-7: TASK 4A SCORING CRITERIA – CATEGORY 5

Score (points)		1	2	3	4	5
FEMA RL/SRL	Range	0	1-15	16-80	81-800	801+
	Number of Occurrences	78	10	10	8	9
Critical Facilities	Range	0	1-8	9-27	28-120	121+
	Number of Occurrences	44	17	18	18	18
Miles of Hurricane Evacuation Routes	Range	0	0.01-0.50	0.51-1.4	1.41-3.3	3.31+
	Number of Occurrences	61	13	13	14	14

During a RFPG meeting, one suggestion was to track where emergency services personnel or vehicles have trouble reaching people in a time of need. However, this approach was not considered further in this cycle due to a lack of data. Additional research could be performed perhaps in the survey responses, in future flood planning cycles.

4.A.1.e. Existing Modeling Analyses and Flood Risk Mitigation Plans (Category 6)

To score this category, Master Drainage Plans (MDPs) were compiled for the region and associated with their corresponding entity such as a city or county. MDPs provide additional information based on detailed modeling analysis and floodplain mapping, including infrastructure level of service, local drainage information, mitigation alternatives, and implementation and policy plans. MDPs and other similar watershed-wide planning studies, such as the Watershed Planning Studies completed by HCFCD, were spatially analyzed in ArcGIS and overlaid with HUC-12 watershed boundaries to determine the number of MDP or watershed planning studies within each HUC-12.

Hazard Mitigation Action Plans (HMAPs) were available for all counties in the San Jacinto region. Therefore, this metric was not included in the assessment since it does not provide any differentiation regarding flood risk within the region.

The scoring for this category was established so that a HUC-12 watershed with no detailed studies has a higher score to indicate a greater need for additional detailed studies. Scoring criteria for this category is shown in **Table 4-8**.

TABLE 4-8: TASK 4A SCORING CRITERIA – CATEGORY 6

Score (points)		1	2	3	4	5
Detailed Studies	Range	4+	3	2	1	0
	Number of Occurrences	23	13	37	37	5

4.A.1.f. Already Identified and Evaluated Flood Mitigation Projects (Category 7)

The purpose of this scoring category was to identify plans and studies that are not implemented or funded within the region. Upon evaluation, the RFPG determined that the proposed projects do not reflect the knowledge gaps nor the area of greatest needs. These projects were important in subsequent tasks, Tasks 4.B and 5, but would not be useful in determining need or knowledge gaps in the region. Therefore, this category was not evaluated for Task 4A.

4.A.1.g. Historic Flooding Events (Category 8)

Number of FEMA Claims

To summarize flooding history in the San Jacinto region, redacted flood claims from 1975 – 2022 were obtained in tabular form to remove any associated street addresses while still allowing use of the flood claim information. The provided data were overlaid with census tract data to determine the general location of the flood claims and the census tracts were intersected with HUC-12 watershed boundaries. The number of claims was then divided between watersheds based upon the area of intersected census tracts. This subcategory had points assigned based on the count of claims within each HUC-12 watershed. Scoring criteria for this category is shown in **Table 4-9**.

Damage Amount of FEMA Claims

The FEMA redacted flood claim information noted in the previous section was also used to evaluate claims paid. The claim amounts were converted to 2021 dollars for equitable comparison using the Bureau of Labor Statistics Consumer Price Index and the duration between the year when the flood claim was made and the baseline year of 2021.

The FEMA damage amounts were calculated using the same methodology used for determining the number of FEMA claims, by overlaying the data with census tract data with the HUC boundaries. For Task 4A, this subcategory had points assigned based on the total dollar amount of claim payouts within each HUC-12 watershed. Scoring criteria for this category is shown in **Table 4-9**.

TABLE 4-9: TASK 4A SCORING CRITERIA – CATEGORY 8

Score (points)		1	2	3	4	5
Number of FEMA Claims	Range	<14	15-180	181-870	871-2800	2800+
	Number of Occurrences	23	23	23	23	23
Claim Payout	Range	<$2.5M	$2.5M-$39.5M	$39.5M-$180.5M	$180.5M-$683M	$683M+
	Number of Occurrences	22	24	23	23	23

The points from the two subcategories were averaged to get the total score for Category 8.

4.A.1.h. Already Implemented Flood Mitigation Projects (Category 9)

Ongoing construction projects that are being implemented were considered for this subcategory. Based on input from the RFPG or other publicly available information, a list of active construction projects was identified. Most of these projects were HCFCD 2018 Flood Bond projects. The list of projects was created by cross-referencing bond project status lists with HCFCD's website. An ArcGIS shapefile was created which contained the general locations of these construction projects, associated with approximate boundaries such as for a city or watershed and intersected with the HUC-12 watershed boundaries to determine if construction projects were present within a HUC-12. The magnitude of a project, such as flood reduction amounts, was not included in the category due to variations in project calculations among projects. In future flood planning cycles, the magnitude of the project could also be considered.

The scoring for this category was established so that a HUC-12 watershed with no active construction projects has a higher score and projects should be recommended for implementation to reduce future flood risk. Scoring criteria for this category is shown in **Table 4-10**.

TABLE 4-10: TASK 4A SCORING CRITERIA – CATEGORY 9

Score (points)		1	5
Active Construction Projects	Range	Ongoing flood mitigation project present	No ongoing flood mitigation projects
	Number of Occurrences	19	96

4.A.1.i. Other Factors - Social Vulnerability Index (SVI) and Population Density (Category 10)

Social Vulnerability Index (SVI) relates to the potential negative effects on communities caused by external stresses on human health, which include natural or human-caused disasters such as floods and disease outbreaks. In the context of Task 4A, SVI is being used as a metric for assessing the vulnerability of communities. The CDC calculates the SVI at the census tract level within a specified county using 15 social factors including poverty, housing, ethnicity, and vehicle access. SVI is ranked on a scale of 0 to 1. Communities on the lower end of the score range have access to more resources and can recover more quickly after a natural disaster.

To support Task 2, the TWDB provided a regionwide building footprints feature class which contained SVI values provided by the CDC appended to each building record within the dataset. For Task 4A, the SVI values within these building records were spatially associated to a specific HUC-12 watershed and then an average SVI per HUC-12 was calculated. Points were assigned for this subcategory to reflect that higher SVI values correlate with a higher flood risk mitigation need, since high SVI areas tend to have greater difficulty recovering from natural disasters.

The RFPG requested that consideration of the impact of flooding on residents be included. Therefore, nighttime population density was added as a subcategory. The population values were obtained from the TWDB during Task 1. They were overlaid with the existing floodplains created in Task 2A. The total impacted population values in the existing 0.2% ACE floodplain using HUC-12 watershed population density were used to assign points. Scoring criteria for this category is shown in **Table 4-11**. The points from the two subcategories were averaged to get the total score for Category 10.

TABLE 4-11: TASK 4A SCORING CRITERIA – CATEGORY 10

Score (points)		1	2	3	4	5
SVI (Range of 0 to 1)	Range	0.01-0.27	0.271-0.385	0.3851-0.50	0.51-0.60	0.61+
	Number of Occurrences	22	22	24	22	25
Nighttime Population Density (people per square mile)	Range	1-55	56-200	201-670	671-2300	2301+
	Number of Occurrences	23	23	23	23	23

4.A.2. Analysis Results

The HUC scoring methodology described above was implemented across the entire San Jacinto region to address the two goals of Task 4A. The first goal is to identify areas where the greatest flood risk knowledge gaps exist. The Flood Map Gap/Hydrologic and Hydraulic Modeling (Category 3/4) and Existing Modeling Analysis (Category 6) categories were selected as the basis for identifying these areas. To create the flood risk knowledge gap maps, the points from Categories 3/4 and 6 were added for each HUC. The resulting scores are illustrated in **Map 14**, with areas of the most flood risk knowledge gaps shown in red, as shown in **Figure 4-1**.

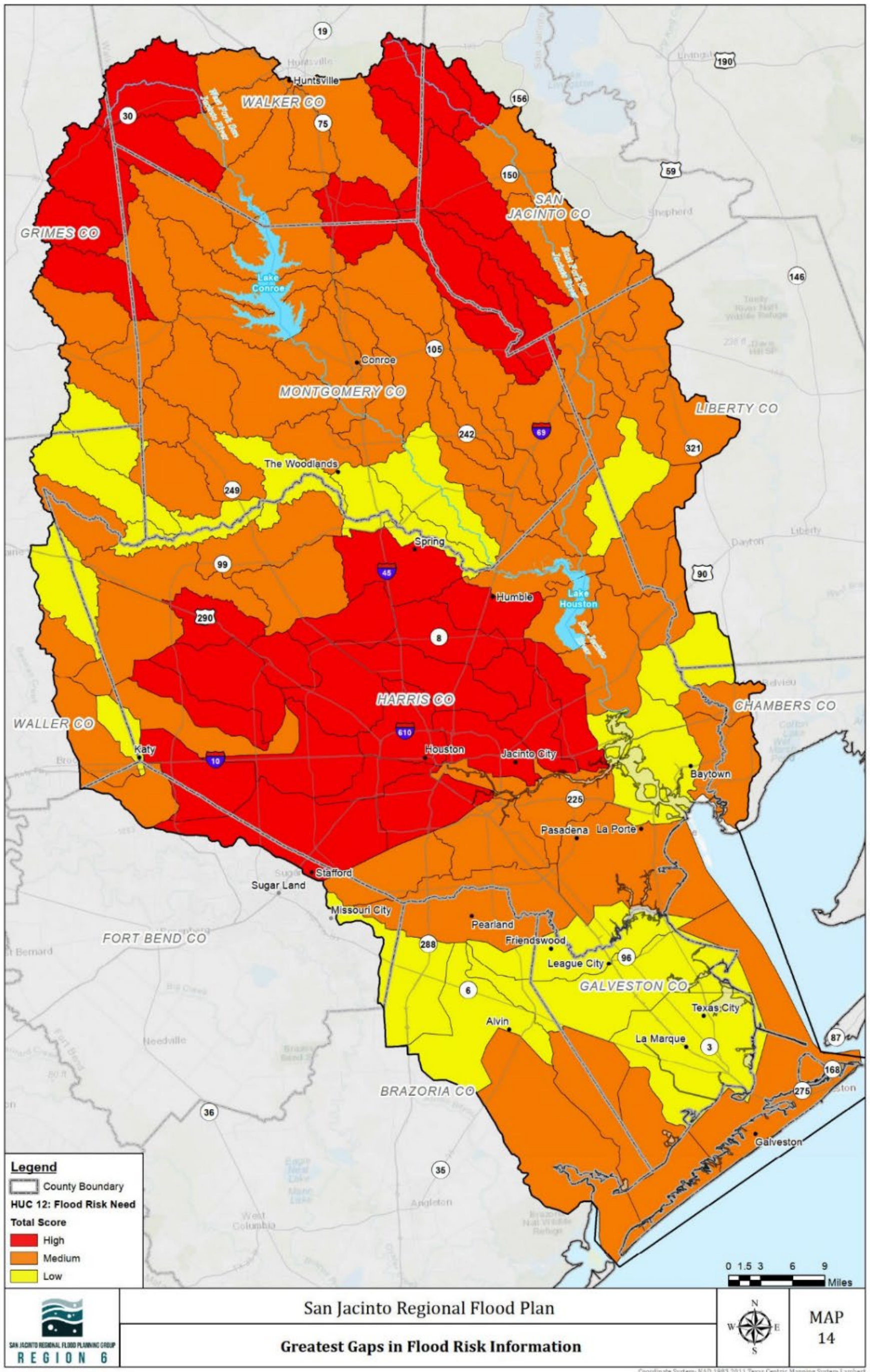

FIGURE 4-1: FLOOD RISK KNOWLEDGE GAPS MAP

The results of this preliminary assessment show that large portions of the San Jacinto region have both inadequate mapping/hydrologic and hydraulic models and few detailed studies. A large portion of the high knowledge gap area is in Harris County, which reflects older mapping. HCFCD is currently in the process of updating all the floodplain maps within Harris County through the Modeling, Assessment, and Awareness (MAAPnext) project. Adoption of these maps is anticipated to occur prior to the next cycle of regional flood planning. There are also high knowledge gap areas in the northern portion of the region. This is primarily driven by outdated models and few, if any, MDPs.

The second goal is to determine the areas of greatest known flood risk and flood mitigation needs. For each HUC-12 watershed in the San Jacinto region, the scores across the remaining categories were added to obtain a total score. All categories have equal representation in the total score; however, the composite score for Category 1 was weighted 70% for existing conditions and 30% for future conditions. The resulting scores are illustrated in **Map 15**, with areas of the greatest known flood risk and flood mitigation needs shown in red, as shown in **Figure 4-2**. It is important to note the fact that a HUC-12 watershed that resulted in a low score does not necessarily mean that there is no flood risk in this area, only that flood risk is lower when compared to other watersheds in the San Jacinto region.

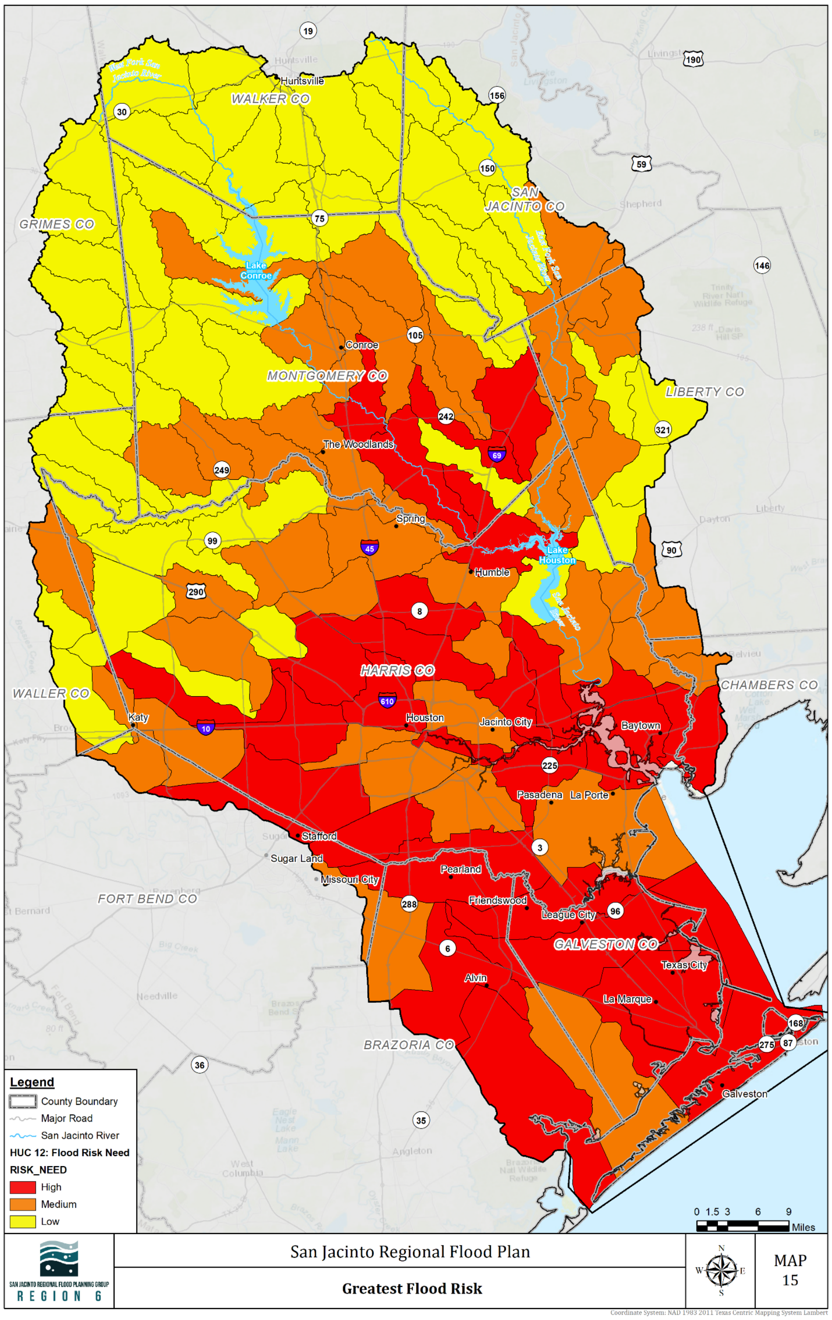

FIGURE 4-2: KNOWN FLOOD RISK MAP

HUC-12 watersheds determined by this analysis to have high flood risk are distributed throughout the San Jacinto region, especially in the middle and southern portions of the region. This includes large portions of the City of Houston, as well as the Cities of Pearland, League City, Texas City, and Galveston. Harris, Brazoria, and Galveston Counties are among the areas determined to have the highest flood risk.

Each of these areas tend to score high from a combination of risk factors. For instance, areas in Harris County score high due to the higher population and number of buildings and critical facilities in the floodplain as well as magnitude of flood claims. Watersheds in the southern (coastal) portions of the region also score high due to the vast areas of floodplains present in those areas.

Ultimately, the results of Task 4A assisted the RFPG with subsequent efforts in addressing flood risk knowledge gaps and high flood risk mitigation needs. **Map 14** identifies areas with high flood knowledge gap scores in the San Jacinto region where watershed planning and flood mapping update FMEs should be added as part of Task 4B. **Map 15** identifies areas where the RFPG should strive to identify and implement FMSs and FMPs to reduce the known flood risks within those areas. Additional FMEs added as part of Task 4B for high flood risk areas include completion of Master Drainage Plans with the goal of identifying future FMSs and FMPs.

Chapter 4.B. Identification and Evaluation of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects

4.B.1. Process to Identify Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs)

The first step in identifying potential FMEs and potentially feasible FMSs and FMPs began with conducting research on stakeholder input and publicly available data. The list of potentially feasible FMSs and FMPs is based on contributions from the RFPG, stakeholder outreach, and from sources such as:

- Previous flood studies
- Master Drainage plans
- Capital Improvement Plans (CIPs)
- Hazard Mitigation Plans (HMPs)
- Bond programs
- Flood Infrastructure Fund (FIF) Applications
- Community Development Block Grant Mitigation Program (CDBG-MIT) Applications
- Building Resilient Infrastructure and Communities (BRIC) Applications
- Other references as applicable.

The Flood Mitigation Needs Analysis performed in Task 4A was used to supplement the actions identified in the public information research. Generally, Task 4A guided the evaluation of potential actions by highlighting:

- The areas with the greatest gaps in flood risk knowledge that should be considered for potential FMEs.
- The areas of greatest known flood risk and flood mitigation needs that should be considered for implementation of potentially feasible FMSs and FMPs.

Potential FMEs were added to the list based on the outcome of the evaluation performed in Task 4A. Flood remapping FMEs were added in areas with high flood knowledge gap scores. Master Drainage Plans (MDPs) FMEs were added in areas with a high known flood risk score.

4.B.2. Evaluation of Potentially Feasible FMEs, FMSs, and FMPs

After conducting an initial search, approximately 650 potential actions were identified from various sources. In general, actions identified that were not related to flooding or flood risk were omitted from further consideration in the assessment. Actions that were related to flooding, storms or hazard preparedness were included but those actions that lacked resulting flood risk mitigation were classified as infeasible. Most examples of actions considered infeasible were those that were solely for maintenance, environmental features, or which would provide no known flood risk reduction benefit.

The secondary criterion for evaluating the feasibility of an identified FME, FMS, and FMP was whether the action had a broad/undefined scope or was lacking in sufficient detail. The level of detail required to be considered feasible was defined by the FME/FMS/FMP table requirements outlined in the *Technical Guidelines.* For example, actions are required to have a brief description and a potential sponsor entity as well as other required data.

The third criterion for evaluating the feasibility of an identified action involved considering whether the size of the proposed action was appropriate for inclusion in the RFP. Actions with a contributing drainage area less than or equal to one square mile were generally considered infeasible in accordance with the *Technical Guidelines*. However, a small number of actions were included with a drainage area less than one square mile if they were submitted directly by a sponsor for consideration. Sometimes extreme event overflows, which are not considered in drainage area delineations, can govern flood risk in these smaller areas. Elevated tailwater conditions in receiving streams of large drainage areas can also be an important flood risk factor for smaller areas.

4.B.3. Classification of Potential FMEs and Potentially Feasible FMSs and FMPs

Once potential flood risk reduction actions were identified, initial classification was completed to sort actions into an appropriate category. The *Scope of Work* and *Technical Guidelines* require FMSs and FMPs to be developed at a sufficient level of detail, meaning no negative impact, quantitative reporting of estimated benefits, detailed H&H modeling, developed benefit cost ratio (BCR), etc., to be included in the RFP. Generally, FMEs will be recommended for remaining areas with potential flood risk and exposure that do not have a corresponding flood risk reduction action or for FMSs and FMPs that do not meet requirements for inclusion. The classification process shown below in **Figure 4-3** was developed based on the requirements in the *Scope of Work* and *Technical Guidelines* and was discussed by the Technical Committee and approved by the RFPG at the meeting held on October 14, 2021. As additional data are collected from regional stakeholders and through efforts made possible by the additional funding allocation, classifications may be subject to change.

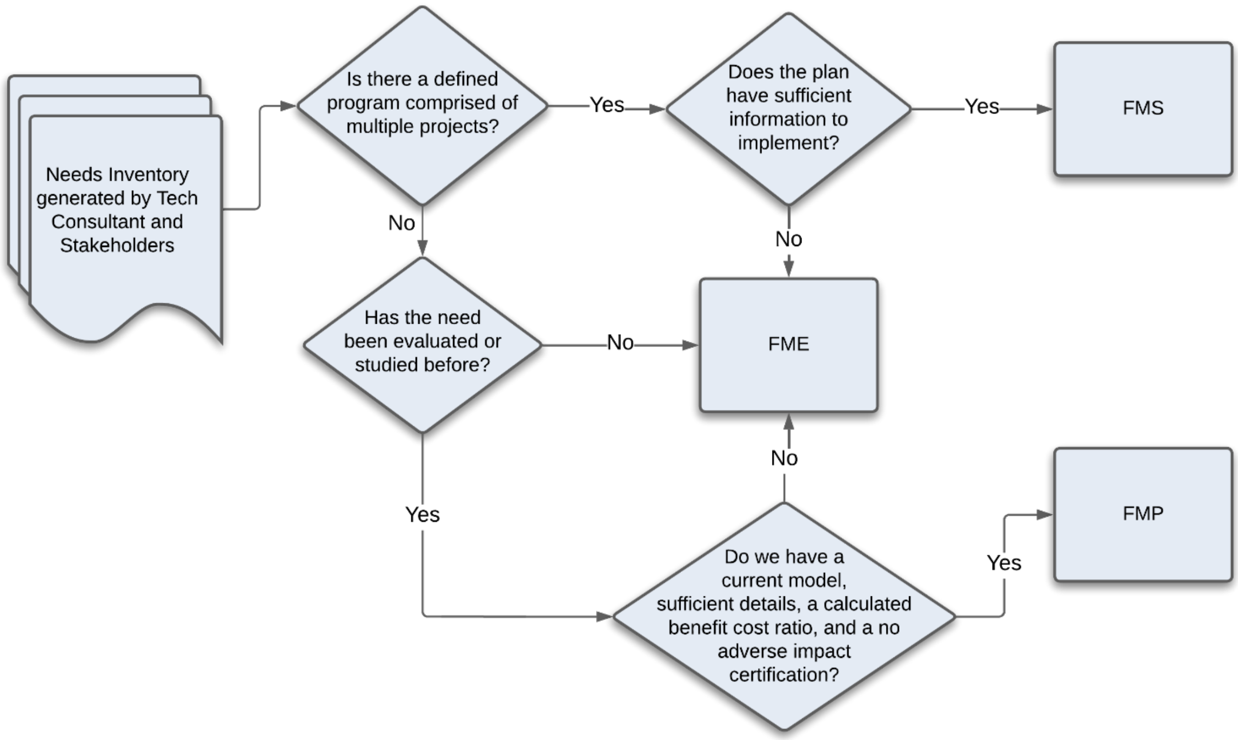

FIGURE 4-3: FLOOD RISK REDUCTION ACTION CLASSIFICATION PROCESS

All recommended actions meet the requirements outlined in the *Technical Guidelines*. However, some potential actions that meet these baseline requirements may not be appropriate for recommendation. While this is not a comprehensive list, some potential reasons a project may not be recommended in Task 5 include:

- Action does not align with the flood mitigation goal(s) adopted by the San Jacinto region and/or the guidelines and principles set forth by the state.
- Action duplicates the benefits of other included or recommended action(s).
- Action cannot obtain a Memorandum of Understanding or other form of concurrence from entities with oversight, stakeholders, or entities with the potential for adverse impact.
- Action does not demonstrate a sensible benefit-cost ratio or other similar metrics.
- Public input regarding the action demonstrates a need for further evaluation or consensus building with regional stakeholders.
- Action does not receive a simple majority vote from a quorum of the RFPG members.

4.B.3.a. FMP Types

The FMP category includes many types of flood risk mitigation projects designed to address specific known flood risk needs. A FMP is a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring costs and, when implemented, will reduce flood risk and mitigate flood hazards to life or property. For the San Jacinto region, 73 projects were identified by the RFPG and are summarized in **Table 4-12** based on the FMP type. These projects included regional detention facilities, channel improvement projects, coastal protection systems, and non-structural flood preparedness enhancements. Potential FMPs are shown on **Map 17**, **Appendix 4-2,** and summarized in **Table 13**, **Appendix 4-5**.

TABLE 4-12: FMP TYPES AND GENERAL DESCRIPTION

FMP Type		Description	Total FMPs Identified
Structural	Regional Detention	Detention ponds intended to mitigate flooding by reducing peak flow rates for multiple sites or large regions.	14
Structural	Regional Channel Improvements	Channel improvements intended to mitigate flooding by lowering the water surface elevation for multiple sites or large regions.	3
Structural	Coastal Protections	Projects intended to prevent coastal erosion and mitigate coastal storm surge risk such as flood gates, sea wall improvements, and ecosystem restoration.	2
Structural	Infrastructure Improvements	Improvements to flood mitigation infrastructure including storm drain improvements and detention ponds intended to mitigate flooding in individual neighborhoods.	7
Structural	Comprehensive Regional Improvements	A combination of individual flood risk reduction projects intended to work together to mitigate flood risk.	25
Non-Structural	Flood Preparedness	Projects intended to mitigate flood risk through improved flood management regulations and ordinances.	21
Non-Structural	Other	Other flood mitigation projects that do not fit into one of the above categories.	1
		Total	**73**

4.B.3.b. FMS Types

The FMS category includes a wide range of flood mitigation and floodplain management efforts that do not classify as projects or evaluations. Identified strategies included flood awareness, public education, flood warning system improvements, property acquisition, and hardening/maintenance of infrastructure. The majority of FMSs include public education and outreach as well as property acquisition and structural elevation. The RFPG identified 66 FMSs for the San Jacinto region, which are summarized by type in **Table 4-13**. Potential FMSs are shown on **Map 18**, **Appendix 4-3** and summarized in **Table 14**, **Appendix 4-6**.

TABLE 4-13: FMS TYPES AND GENERAL DESCRIPTION

FMS Type	Description	Total FMSs Identified
Education and Outreach	Programs or initiatives that aim to educate the public on the hazards and risks of flooding.	15
Flood Measurement and Warning	Installation of or improvements to rain or stream gauges to monitor water levels and have real-time feedback during flood events.	6
Infrastructure Projects	Critical maintenance and improvements to existing drainage systems throughout a community.	8
Property Acquisition and Structural Elevation	Buyouts or elevation of structures with high flood risk or historical flooding impact as well as land preservation and restoration programs.	18
Regulatory and Guidance	Updates or creation of new ordinances, development codes, design standards, or other floodplain management regulations to minimize future flood risk or reduce current flood risk.	10
Other	Other flood management strategies that do not fit into the one of the above categories.	9
	Total	**66**

4.B.3.c. FME Types

The FME category includes a variety of studies that allow communities to assess flood risk and further define future FMPs and FMSs. The majority of recommended FMEs were based on input from sponsors on future studies or evaluations needed to progress flood mitigation solutions from concept to reality as well as to develop more accurate flood risk information that would inform future project identification and prioritization. Other FMEs were identified based on the findings of Task 4A, which involved a high-level assessment of the San Jacinto region based on multiple risk factors with the goal of identifying areas with the greatest gaps in flood risk information and areas of greatest known flood risk and mitigation needs. Watershed studies that included flood mapping updates were proposed for areas of high knowledge gap scores while Master Drainage Plans were proposed for areas of high known flood risk. As a result, 82 additional Watershed Planning FMEs were added to the plan which included Master Drainage Plans and flood mapping update efforts.

For FMEs that overlap with exisiting BLE models, flood mapping provided by BLE is approximate in nature - the data source does not consider watershed-specific H&H models incorporated in the data and does not account for structures such as roadway crossings. It is the purpose of the FMEs identified to conduct modeling that will be more detailed in scope than what has been conducted for BLE studies. For FMEs identified in areas that have FIF or GLO studies, there is potential for the FME itself to identify alternatives that had initially not been examined in the FIF/GLO studies. Additionally, FIF, BLE, and GLO focus on riverine flood studies, whereas some identified FMEs pertain to urban flooding.

The RFPG identified 462 FMEs for the San Jacinto region which are summarized by type in **Table 4-14**. Of these, 108 FMEs require only a benefit-cost analysis to complete and potentially elevate to an FMP. Those 108 FMEs were primarily Preliminary Engineering Project Planning. This information could be calculated or obtained from the sponsor in subsequent amendments or planning cycles and elevated to an FMP. Recommended FMEs are shown on **Map 16 in Appendix 4-1,** and listed in **Table 12 in Appendix 4-4**.

TABLE 4-14: FME TYPES AND GENERAL DESCRIPTION

FME Type	FME Sub-Type	Description	Total FMEs Identified
Watershed Planning	Master Drainage Plans	An assessment of a watershed or community to estimate flood risk and recommend flood management and flood mitigation projects.	80
	Regional Watershed Studies	An assessment of a watershed with the intent to develop better flood risk information which can include both regulatory and non-regulatory flood risk mapping.	70
Engineering Project Planning	Feasibility Assessment	Develop flood mitigation project alternatives for a discrete high flood risk area, estimate construction costs for alternatives, and determine flood reduction benefit for alternatives. Evaluation may require creation of H&H modeling.	58
	Preliminary Engineering	Further evaluate an identified potential FMP to refine and validate constructions costs and flood reduction benefits. Evaluation may require the creation or updating of H&H modeling.	245
	Update H&H Modeling	Updates or refinement of previously created models that support a potential flood mitigation project to include the best available data.	6
Studies on Flood Preparedness		Analysis to determine community risk and enhance preparedness in event of infrastructure failure or severe flooding event.	1
Other		Other flood management evaluations that do not fit into one of the above categories.	2
		Total	**462**

4.B.3.d. No Negative Impact

All FMSs and FMPs must demonstrate that implementation will not negatively affect a neighboring area, based on best available data. Demonstrations of no negative impact must reference 1.0% ACE water surface elevations (WSEs) and peak discharges in pre-project and post-project conditions. The criteria listed below do not have any regulatory implications at a local, state, or federal level due to the approximate nature of flood planning. For the purposes of flood planning effort, a determination of no negative impact can be established if a project or strategy does not increase flood risk of infrastructure such as residential and commercial buildings and structures. Additionally, all the following TWDB requirements should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.
3. Maximum increase of 1D WSEs must round to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section.
4. Maximum increase of 2D WSEs must round to 0.3 feet (< 0.35ft) measured at each computational cell.
5. Maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

Non-structural FMPs and FMSs can be determined to have no negative impact on neighboring areas by default. These projects do not propose physical changes to the floodplain and resulting flood hazard areas, which eliminates the potential for increases in 1.0% ACE discharges or WSEs. In the San Jacinto region, nonstrucural FMSs focused on increasing public awareness work to mitigate flood risk by enabling individuals to make well-informed decisions during flood events. Additionally, non-structural FMPs, aimed to improve regulations and permit requirements, can strengthen resilience before disaster strikes. These types of projects can reduce flood risk over time by ensuring that all new construction and significant remodels are built according to modern best practices including ensuring no negative impacts.

Similarly, a significant portion of FMSs can also be determined to have no negative impact on neighboring areas without a detailed supporting analysis due to being non-structural in nature. These types of FMSs include:

- Education and Outreach
- Flood Measurement and Warning
- Property Acquisition and Structural Elevation
- Regulatory and Guidance
- Other, includes maintenance, restoration, land use policies, sign installation, etc.

For structural FMPs and FMSs, signed and sealed reports were checked for certified statements that the associated project or strategy would not cause negative impacts upstream, downstream, or within the project area in events up to and including the 1.0% ACE. As structural FMSs and FMPs progress, further evaluation of adverse impacts and mitigation solutions to avoid any impacts are required as further development continues.

4.B.3.e. Estimated Benefits of FMPs, FMSs, and FMEs

Benefits for FMPs, FMSs, and FMEs include quantifiable flood risk reduction; outreach to the communities regarding flood risk; and additional identification of flood risk within the region. These benefits directly correspond to accomplishing the 15 regional flood planning goals outlined in Chapter 3. Examples of goals include expanding the understanding of flood risk in the San Jacinto region, Goal ID 06000010, incorporating nature-based practices, Goal ID 06000013, and reducing the number of structures subject to inundation during the 1% ACE storm, Goal ID 06000015. Where feasible, benefits were tabulated using geospatial data provided by project sponsors and the TWDB.

FMPs

Estimated benefits for FMPs were geospatially determined using provided hydrologic and hydraulic models or obtained from resultant model output or tabular summaries contained within source documentation. The existing and proposed condition floodplains for the 1.0% and 0.2% ACE floodplains were used to estimate the associated flood risk reduction for the project based on the following metrics:

- Reduction in residential structures flood risk
- Reduction in residential population flood risk
- Reduction critical facilities flood risk
- Reduction in flooded low water crossings
- Reduction in acres of agricultural areas
- Reduction in length of road overtopped

Estimates in reduction in fatalities or injuries upon project completion was not evaluated due to limited documentation for these metrics. However, these values could be reviewed further and provided in future planning cycles.

FMSs

FMSs provide widespread benefit to the associated area by updating floodplain management regulations to increase community resilience, informing the public regarding flood risk reduction challenges and a holistic vision for solutions, and implementing regional infrastructure improvements. These benefits, while impactful, are often not quantified due to the high-level nature of the strategies. Therefore, quantitative evaluation of the flood risk and flood risk reduction uniformly for all FMSs was not feasible and was instead performed just for FMPs.

FMEs

The FMEs provide a roadmap for further defining and implementing future projects and strategies that will lead to flood risk reduction throughout the region. FMEs range from high-level regional planning studies to detailed benefit cost analyses on specific projects. Benefits of completing the recommended FMEs include the development of more accurate flood risk maps for areas with limited or outdated information, the evaluation of flood risk reduction alternatives, and determination of additional information required to transition FMEs to FMPs.

4.B.3.f. Estimated Costs of FMPs, FMSs, and FMEs

Cost for FMPs, FMSs, and FMEs provide the RFPG guidance for implementation of the associated project, strategy or evaluation.

FMPs

Cost estimates for FMPs were obtained from the associated engineering report or plan documentation for the project. Costs were adjusted to account for inflation and other changes in price of labor and commodities that had taken place since the publication date of the information. All FMP costs were converted to 2020 dollars to provide a consistent baseline for comparison.

Recurring costs were also calculated for FMPs to account for monetary and maintenance costs associated with the structural or non-structural project. Debt service is related to the cost required to pay for the interest expense of any potential loan. This may be required for projects locally funded that would require loans or interests. For most of the construction projects, operations and maintenance will be required to keep the project functioning as designed such as inspection, mowing, and clearing. The yearly operations and maintenance were assumed to be 1.0% of the total construction budget. This was based on an analysis of a sample project that determined that 1.0% was a conservative estimate for the FMPs.

FMSs

Most of the identified FMS cost estimates were obtained from the available Hazard Mitigation Plan for the entity. Strategies without associated costs were estimated based on professional experience on similar work.

FMEs

FME costs were obtained from available documentation or were calculated based on anticipated effort of the evaluation. Following TWDB guidance, the cost estimates included the following major components:

- Associated non-engineering studies, planning studies
- Engineering/technical/feasibility studies
- Surveying; geotechnical; testing

FME costs were determined based on key parameters including FME sub-type, study area size, and estimated project construction cost. If the associated documentation did not include study costs, FME cost was estimated based on the following approach:

- For Watershed Planning and Flood Preparedness FMEs, a cost-to-study area relationship was developed based on previous project experience completing similar types of projects. This relationship was used to estimate the potential study cost based on the area delineated for the study including the contributing watershed.
- Costs for Preliminary Engineering FMEs were estimated based on the scope and type of project being evaluated. These evaluations have been identified in previous modeling but require additional vetting through a preliminary engineering report. The study cost was estimated as a percentage of the project construction cost provided in supporting documentation. As with typical engineering costs, the percentage of the cost decreased as the overall project cost increased.
- Preliminary engineering evaluations that did not have an associated construction cost within source material were classified as Feasibility Assessments. Feasibility Assessment FME costs were estimated based on the study area using the cost-to-study area developed for the watershed planning studies.
- Benefit-Cost Analysis projects were included as Preliminary Engineering evaluations but only required a benefit-cost analysis to be re-classified as FMPs. These were assigned a value of $30,000.

The estimated costs associated with each FME depends on broad, high-level assumptions. All costs were rounded to the nearest $10,000 since these are mostly regional studies. The FME costs estimated as part of this plan are for high-level planning purposes only and should be evaluated further prior to implementation.

4.B.3.g. Benefit-Cost Ratio for FMPs

Benefit-Cost Analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The end result is a Benefit-Cost Ratio (BCR), which is calculated by dividing the project’s total benefits, quantified as a dollar amount, by its total costs. The BCR is a numerical expression of the relative "cost-effectiveness" of a project. A project is generally considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (Federal Emergency Management Agency, 2009). However, a BCR greater than 1.0 is not a requirement for inclusion in the RFP. It is recognized that requiring a BCR greater than 1.0 primarily measures physical risk to property while neglecting the long-term, intangible social costs incurred by vulnerable communities. Requiring a BCR of greater than 1.0 can result in higher-property-value communities receiving a disproportionate share of mitigation infrastructure. Therefore the RFPG can decide to recommend a project with a lower BCR and to compete for funding based on a set of other criteria to be established by the TWDB.

For structural FMPs, a BCR that had been previously calculated in an engineering report or study was utilized for the FMP analysis. In the San Jacinto region, non-structural FMPs primarily focused on improving regulations and permit requirements. Regulation improvements average a BCR range between 4.0 - 11.0, depending on the type of regulatory adoptions made (National Institute of Building Services, 2019). In the San Jacinto region, non-structural FMPs that did not have a previously calculated BCR from reports or studies have been assigned a default BCR of 5.0.

4.B.3.h. Emergency Need of FMPs, FMEs, and FMSs

The term "emergency need" can be interpreted in multiple ways, and each RFPG has been tasked with defining the term for their individual flood planning region. The definition of emergency need varied for FMPs, FMEs, and FMSs as described below.

FMPs that met the definition of emergency need were those that removed or reduced critical infrastructure from severe flood events. Critical infrastructure included facilities such as police and fire stations, hospitals, and emergency shelters. Removal of these facilities was calculated geospatially as described previously and any project that removed at least one critical facility was considered an emergency need.

Emergency need for FMEs was defined as those that would update regional flood maps with NOAA's Atlas 14 rainfall data, which corresponds to one of the RFPG goals. Flood maps are a great asset to communities, who can use them to evaluate their flood risk and more effectively plan for flood risk mitigation. Providing accurate maps based on the best available information will assist communities and their residents in increasing their knowledge of flood risks.

Emergency need for FMSs was defined as strategies that would increase the resiliency of critical infrastructure, such as retrofits, as well as property acquisition and structural elevation strategies to reduce the number of structures and properties that are at risk of flooding, including those that have severe repetitive and repetitive losses.

4.B.3.i. Funding Sources

There is a wide range of funding mechanisms available for the identified FMPs, FMSs, and FMEs including local, state, and federal sources. Different sources can be used for the individual projects based on grant and funding requirements and matched to stretch the available local funding for projects.

- Local – Municipalities can establish a stormwater utility which can be used to generate revenue to provide for and maintain stormwater services. Stormwater utilities are typically used to fund local maintenance projects making this funding source suitable FMPs, FMSs, and FMEs. Local communities also can issue bonds for developing and implementing flood related projects.
- State – The TWDB provides financial assistance for a variety of flood related projects, evaluations, and studies including through the Flood Infrastructure Fund (FIF) and Clean Water State Revolving Fund (CWSRF). Historically, regional solutions have been given priority for the FIF. The CWSRF is mostly oriented toward mitigation activities. Since both programs

appropriate funding from planning level activities to construction, they are suitable mechanisms for FMEs, FMSs, and FMPs.

- Federal – The FEMA Flood Mitigation Assistance (FMA) appropriates funds to applications from applicants with FEMA-approved HMAPs to support activities that mitigate severe repetitive loss. Additionally, the HUD Community Disaster Block Grant was created in 2018 to fund activities to reduce future losses in areas affected by qualifying disasters. Lastly, the FEMA BRIC program provides funding to applicants with FEMA-approved HMAPs for a broad range of activities. Since all these programs prioritize flood hazard reduction, each could be used for the identified FMPs, FMSs, and FMEs.

Further details on funding opportunities and the anticipated funding sources for the recommended actions are included in Chapter 9.

4.B.3.j. Considerations of Residual Risk

While it is not possible to protect against all potential flood risks, the evaluation of FMPs considered their associated residual, post-project and future risks including the risk of potential catastrophic failure and the potential for future increases to these risks due to lack of maintenance. For more details regarding an approach for considering residual risks and TWDB's proposed scoring guidelines, please see the *Technical Guidelines* for RFP.

Flood risk is often reduced by the construction of flood mitigation structures but, as a result, may also be 'transformed' into a different type of risk, for example, in the form of risk from structural failure of that mitigation infrastructure, such as in the case of dams or levees.

Residual risks by nature have a low probability of occurrence. However, keeping it low requires continuing maintenance of FMPs and effective emergency services for preparedness, response, and recovery as a holistic approach.

In order to determine the residual risk of the FMPs, each project description was reviewed to determine what type of project it is, for instance, a detention/retention basin, channel or capacity improvements, public outreach, structural, codes/ordinances revision, etc. Residual risks were determined for each category. For example, several types of projects require maintenance/upkeep, and others do not reduce the risk of flooding for every storm event. Residual risks are listed for each FMP in **Appendix 4-5**.

4.B.3.k. Implementation Issues of FMPs

Project implementation issues include different conflicts such as right-of-way, permitting, acquisitions, relocations, utility or transportation conflicts, environmental concerns, and other issues that could arise before an FMP can be fully constructed. These planning efforts cannot uncover every obstacle or challenge associated with each FMP, however general issues were identified based on the best available data for the projects to document the most probable implementation issues. These implementation issues are critical to identifying, documenting, and managing the feasibility of the projects while allowing for sufficient planning to manage these potential issues. The identified potential implementation issues are listed below:

- Right-of-Way
- Permitting
- Acquisitions
- Environmental Concerns
- Utility Relocations
- Transportation Conflicts

4.B.3.l. Contributions to Water Supply

A review of all feasible FMPs and FMSs found that none would provide any contributions to water supply. For an action to be considered to have contribution to water supply, it must be measurable. While some FMPs and FMSs are likely to provide indirect water supply benefits through environmental features such as wet bottom detention, none of these actions would be measurable.

4.B.3.m. Flood Mitigation or Floodplain Management Goals

The evaluation of potential FMPs, FMEs, and FMSs included the association of the RFPG-approved flood management and mitigation goals as described in Chapter 3B. The association allows the alignment of the regional goals to the included projects and project tracking to monitor success of the plan.

4.B.3.n. Other Benefits

Projects may have an additional benefit aside from flood mitigation. These other benefits include public uplift, public education, low impact development features, and environmental benefits. Each FMP and FMS was analyzed to determine if any other benefit was captured and could be included as a benefit.

Public uplift refers to the uplift of the amenities that many people of the public may use in their daily lives. For example, if a project includes the reconstruction of a bridge or sidewalk, then it would be placed into this category since there is improvement to something that is available and usable to the public. More examples would be improving a driveway from having to relocate a certain utility or the creation of a park that is also used as a detention basin. These kinds of improvements not only benefit by mitigating the flood risk but also bring an additional benefit of uplifting the community amenities.

Certain projects do not necessarily have a structural benefit to mitigate flood risk. These projects may pertain to the education of the public regarding flooding to mitigate their flood risk. These things include informing the public on what actions to take during a flood, places to avoid, and projects that are in the Study and Design stages. These measures are taken to ensure that in the event of a flood, the public has the information to guide them to safety.

Low Impact Development (LID) is a stormwater and land-use management strategy that provides features with a low impact to the environment. The LID strategies and techniques are used to manage stormwater in a sustainable and cost-effective manner.

A project may have an additional benefit such as an environmental benefit. An environmental benefit can include actions that help to restore the natural environment. This includes habitat restoration, preservation of ecosystems and wildlife, natural environment improvements, and creation of green spaces. For a project to have an environmental benefit, it should have aspects of the project that improve or restore the natural environment.

4.B.3.o. FMEs Elevated to FMPs as part of Task 12

The objective of Task 12, as described by the TWDB, was to identify FMEs to recommend as additional potentially feasible FMPs. A prioritization framework was developed to assist the RFPG with prioritizing of FMEs evaluated during Task 12. A technical memorandum documenting the prioritization framework is provided as **Appendix 4-7**.

As part of the Task 12 effort, 13 FMEs were evaluated to develop necessary data to elevate to FMPs. The FMEs elevated are provided in **Table 4-15**. These FMEs were primarily the development of benefit-cost analyses (BCA). Documentation of each of the analyses are provided in **Appendix 5-4**.

TABLE 4-155: FMES ELEVATED TO FMPS

Project Name	FME ID	New FMP ID
Rivershire West – Grand Lake Creek	061000453	063000453
37th Street, Galveston, Drainage Project	061000311	063000311
Goose Creek Flood Risk Reduction Phase 1, 2, & 3	061000334	063000334
White Oak Bayou – Woodland Trails Stormwater Detention Basin	061000344	063000344
Willow Creek – M120 Detention/Preservation Site	061000339	063000339
Fort Bend County Willow Fork Channel Improvements	061000318	TBD
City of Friendswood – Inline & Offline Detention	061000424	063000424
Addicks Reservoir Channel Improvements, Bypass Channel, and Detention Basin along South Mayde Creek	061000315	063000472
Mary's Creek Improvements	061000063	TBD
Brays Bayou – Keegans Bayou Flood Risk Reduction	061000328	063000328
Blalock Road Drainage Improvement Project	061000327	063000327
G103-38-00 Kingwood Diversion Ditch	061000360	063000360
Danubina Drainage Improvements	061000422	063000422

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CHAPTER 5. RECOMMENDATION OF FLOOD MANAGEMENT EVALUATIONS AND FLOOD MANAGEMENT STRATEGIES AND ASSOCIATED FLOOD MITIGATION PROJECTS

The goal of Task 5 is for the San Jacinto RFPG to FMPs, FMSs, and FMEs for inclusion in the RFP. While Chapter 4 details the process to identify the areas with the greatest flood risk evaluation needs, greatest flood mitigation needs, as well as potentially feasible FMPs, FMSs, and FMEs, Chapter 5 outlines the actions that are recommended. The actions recommended by the San Jacinto RFPG are not necessarily anticipated to be performed during the same regional flood planning cycle through which they are identified.

Chapter 5.A. RFPG Evaluation and Recommendation

The San Jacinto RFPG considered recommendations on flood mitigation actions beginning at the San Jacinto RFPG meeting on April 14, 2022, where major considerations and screening criteria, detailed in subsequent sections, were presented to the San Jacinto RFPG. At the following San Jacinto RFPG meeting, held on May 12, 2022, the San Jacinto RFPG was provided with an interactive GIS dashboard to facilitate review of identified FMPs, FMSs, and FMEs. Comments were received and addressed on identified actions following the May San Jacinto RFPG meeting. Ahead of the San Jacinto RFPG meeting held on June 9, 2022, both an updated list and a one-page summary report of each identified action were provided to the group for review.

At the meeting on June 9, 2022, the San Jacinto RFPG unanimously approved the list of actions for recommendation in the RFP pending any direct disapproval from regional sponsors following the vote. It was clarified by the San Jacinto RFPG at this meeting that the vote to recommend these actions does not remove the need for these actions to meet other applicable regulations or criteria. Since the June meeting, 4 FMEs and 2 FMPS have been redefined as “not recommended” by the San Jacinto RFPG. The FMPs now considered “not recommended” were due to those projects yielding no direct flood risk reduction or not containing a BCR. The FMEs no longer recommended were due to being out of the San Jacinto region bounds; being included in other regions; having already proceeded with an evaluation; or being a duplicate within the list. The complete table of recommended actions can be found for FMEs, FMPs, and FMSs in **Appendix 5-6**, **Appendix 5-7**, and **Appendix 5-8**, respectively. Recommendation by the San Jacinto RFPG also does not serve as a specific endorsement of the actions, but rather, as a recommendation that the actions be eligible for future funding through the TWDB.

Chapter 5.B. Sponsor Outreach

The lists of identified FMEs, FMSs, and FMPs documented in Chapter 4 were largely collected using publicly available reports such as Hazard Mitigation Plans, Master Drainage Plans, and Flood Protection Plans. The compiled list of all identified FMEs, FMPs, and FMSs can be found in **Appendix 4-4**, **4-5**, and **4-6**, respectively. Specific evaluations, strategies, and projects identified in these reports were included to be able to collect a broad sample of potentially feasible actions that represented the needs identified by entities across the region. An initial effort to reach out directly to potential sponsors was targeted at those sponsors with the most identified FMEs, FMSs, and FMPs. Several outreach efforts were successful in that sponsors were able to confirm interest in identified actions, clarify details, provide supporting data, or identify which actions may have already been funded and should not be considered for recommendation.

Due to the amount of analysis necessary to populate required details for actions in the plan, a cut-off date of April 14, 2022, was communicated to entities and community officials through monthly emails sent to the San Jacinto RFPG email distribution list. The email distribution list developed included contacts for entities and community officials from across the region and utilized applicable contacts collected through the ongoing General Land Office's Combined River Basin Flood Study (Central Region). Members of the public were also able to register for this distribution list through the San Jacinto RFPG website.

Given that this is the first regional flood planning cycle and that many entities within the region are unfamiliar with the implications of this planning effort, that flood mitigation actions must be recommended in the RFP to be eligible for future state funding assistance through the TWDB, the San Jacinto RFPG decided that an affirmative willingness to sponsor a given action would not be a prerequisite for inclusion in the plan. This approach was adopted because:

1. It provides a comprehensive representation of flood mitigation and study needs in the region.
2. It increases the funding opportunities available to entities in the region.
3. It does not oblige entities identified as sponsors to take action and it does not require any financial commitment on behalf of the sponsor.

Following recommendation of the list of FMEs, FMSs, and FMPs at the San Jacinto RFPG meeting held on June 9, 2022, all sponsors received a table of actions recommended in the plan along with one-page summary reports including details of each action recommended in the plan for their review. They were also provided a survey meant to collect information on sponsor funding and potential funding sources for actions listed in the plan. Following the survey response an additional 21 FMEs were redefined as no longer recommended by the San Jacinto RFPG. Four FMEs were redefined as recommended FMPs as sufficient additional information was received from the sponsor to elevate the projects. The results of this survey are documented in Chapter 9.

Chapter 5.C. Flood Management Evaluations (FMEs)

5.C.1. Summary of Approach to Recommending FMEs

The San Jacinto RFPG evaluated the identified potential FMEs and recommended all FMEs that met TWDB requirements and addressed the significant need for better understanding of flood risk and implementation of specific flood risk mitigation solutions within the San Jacinto region. Recommended FMEs were required to demonstrate an alignment with at least one regional floodplain management and flood mitigation goal developed in Task 3., Each recommended FME that would also likely result in identification of potentially feasible FMSs and FMPs. These FMEs would, at a minimum, identify and investigate one solution to mitigate for floods associated with a 1.0% ACE. Given the relatively high number of identified FMEs in the region, not all FMEs may be completed during the same planning cycle as they are recommended. Based on these TWDB requirements, the San Jacinto RFPG identified and recommended four types of FMEs: Watershed Planning, Engineering Project Planning, Flood Preparedness, and Other.

The majority of recommended FMEs were based on input from sponsors relating to future studies or evaluations needed to progress conceptual flood mitigation solutions as well as develop more accurate flood risk information with which to inform future project identification and prioritization. Other FMEs were identified based on the findings of Task 4A, which involved a high-level assessment of the San Jacinto region based on multiple risk factors with the goal of identifying areas with the greatest gaps in flood risk information and areas of greatest known flood risk and mitigation needs. The HUC-12 watersheds determined to have high flood risk are distributed throughout the San Jacinto region, especially in the middle and southern portions of the region. This includes large portions of the City of Houston, as well as the Cities of Pearland, League City, Texas City, and Galveston. Harris, Brazoria, and Galveston Counties are among the areas determined to have the highest flood risk. Watershed studies that included flood mapping updates were proposed for areas of high knowledge gap scores, shown in **Map 14** in Section 4.A.2 as Figure 4-1 while Master Drainage Plans were proposed for areas of high known flood risk, shown in **Map 15** in Section 4.A.2 as Figure 4-2.

The primary reason for not recommending an FME was based on sponsor input. An FME was not recommended if a sponsor indicated that the proposed study is currently in progress, has been completed, or was no longer a priority. In some cases, multiple FMEs were combined into a single FME for recommendation due to their overlapping scope and the proximity of study areas.

Specific project recommendations identified from these FMEs cannot be defined at this time, but the goal of completing these FMEs is to identify feasible FMPs that meet TWDB requirements. Some FMEs do not directly result in identification of FMPs but instead develop the supporting data such as floodplain mapping. The FMEs will involve additional planning, H&H modeling, and analysis to assess flood risk reduction effectiveness, identify potential impacts, and tabulate benefits for the 1.0% ACE, at a minimum.

There are a number of recommended FMEs that extend beyond the San Jacinto region boundary. In these instances, the total cost of FMEs was split between the San Jacinto and neighboring flood planning regions based on area of the study located within each region. Splitting costs prevents the potential for duplication within the State Flood Plan.

For FMEs that overlap with existing BLE models, refer to section 4.B.3.c, for clarification on how FMEs differentiate from existing BLE models.

There are also several instances where proposed FMEs are within areas that have ongoing FIF Category 1 studies. In these cases, coordination between the proposed FMEs and ongoing studies could provide additional data necessary to complete the studies. Some FIF projects also state within the scope of work that they are complimentary to ongoing flood planning and can provide additional, critical data and tools to allow for a more regional approach to flood mitigation. The results and findings of any Category 1 FIF study will be utilized during the scoping and execution of any overlapping FME.

A total of 462 potential FMEs were identified and evaluated by the San Jacinto RFPG. Of these identified FMEs, 405 were recommended, representing a combined total of approximately $905 million of flood management evaluation needs across the San Jacinto region. The number and types of projects recommended by the San Jacinto RFPG are summarized in **Table 5-1**.

TABLE 5-1: SUMMARY OF RECOMMENDED FLOOD MITIGATION EVALUATIONS

FME Type	FME Description	Number of Identified FMEs	Number of Recommended FMEs	Total Cost of Recommended FMEs
Watershed Planning	Flood mapping updates; Master Drainage Plans	150	148	$742,372,000
Project Planning	Updated H&H modeling; Additional engineering analysis	309	255	$162,955,000
Preparedness	Studies on flood preparedness	1	1	$20,000
Other	Bayou protection or flood risk management studies	2	1	$30,000
	Total	**462**	**405**	**$905,377,000**

Recommended FMEs are illustrated in **Map 19** of **Appendix 5-1**. The full list of FMEs and supporting technical data is provided in **Table 15** of **Appendix 5-6**. A one-page report summary for each recommended FME is included in **Appendix 5-5C**. The recommended FMEs encompass study areas across 10 counties, providing complete coverage of the region. Overall, the completion of these FMEs will represent significant progress in the identification of future FMPs that will lead to drainage infrastructure improvements and flood risk reduction throughout the San Jacinto region.

Chapter 5.D. Flood Mitigation Projects (FMPs)

5.D.1. Summary and Approach in Recommending FMPs

For consideration as an FMP, a project must be defined in a sufficient level of detail to meet the technical requirements of the flood planning project *Scope of Work* and the associated *Technical Guidelines for Regional Flood Planning (Exhibit C)* developed by the TWDB. In summary, the San Jacinto RFPG must be able to demonstrate that each recommended FMP meets the following TWDB requirements:

1. Supports at least one regional floodplain management and flood mitigation goal.
2. The primary purpose is mitigation (response and recovery projects are not eligible for inclusion in the RFP).
3. The FMP is a discrete project (not an entire capital program or drainage master plan).
4. Implementation of the FMP results in:
    a. Quantifiable flood risk reduction benefits

b. No negative impacts to adjacent or downstream properties A No Negative Impact determination is required.

c. No negative impacts to an entity's water supply

d. No overallocation of a water source based on the water availability allocations in the most recently adopted State Water Plan.

In addition, the TWDB recommends that, at a minimum, FMPs should mitigate flood events associated with the 1.0% ACE. However, the San Jacinto RFPG can document the reasons that an FMP that does not mitigate to the 1.0% ACE is still a recommended FMP.

The quantifiable risk reduction benefits are discussed in the individual FMP descriptions within this chapter. The risk reduction benefits are also summarized in the FMP one-page summaries located in **Appendix 5-5A**. The no negative impact determination requirement is discussed in **Chapter 4, Section 4.B.3.d**., A detailed explanation can be found in **Chapter 6, Section 6.A.6.d**., regarding how the recommended FMPs affect water supply.

Updated construction cost estimates and estimates of project benefits must also be available to define a BCR for each recommended FMP. The TWDB recommends that proposed projects have a BCR greater than 1.0, but the San Jacinto RFPG may recommend FMPs with a BCR lower than 1.0 with proper justification.

The San Jacinto RFPG also considered non-structural FMPs primarily focused on improving regulations and permit requirements. These FMPs involved updating or improving regulations and permit requirements which can significantly reduce flood risk in the long term. Regulation improvements average a BCR range between 4.0 - 11.0, depending on the type of regulatory adoptions made (National Institute of Building Services, 2019). The most conservative BCR, specific to riverine flooding, was a 5.0 for constructing new buildings with adopted 2015 International Wildland-Urban Interface Codes. In the San Jacinto region, non-structural FMPs that improve regulations and permit requirements have been assigned a BCR of 5.0.

All potentially feasible FMPs that had the necessary data and detailed H&H modeling results available to populate these technical requirements were considered for recommendation by the San Jacinto RFPG. Pertinent details about the FMP evaluation are provided in the following section.

5.D.2. FMP Evaluation

5.D.2.a. Initial Evaluation

Each FMP was evaluated to ensure that it would support at least one of the regional floodplain management and flood mitigation goals established in Chapter 3. Based on a review of the supporting studies and H&H models, the region determined that the primary purpose for each FMP is flood mitigation, the FMP is a discrete project, and the FMP does not have any anticipated impacts to water supply or water availability allocations as established in the most recently adopted SWP. An overall summary of water supply impacts, overall flood risk benefits, and other impacts of recommended FMPs are included in Chapter 6.

5.D.2.b. No Negative Impacts Determination

Each identified FMP must demonstrate that no negative impacts on a neighboring area would result from its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. Using best available data, the increase in flood risk is measured by the 1% ACE water surface elevation and peak discharge. According to the *Technical Guidelines* it is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be sufficient to demonstrate proposed project conditions are equal to or less than the existing conditions.

These conditions were evaluated for each potentially feasible FMP based on currently available regional planning level data. However, the local sponsor will be ultimately responsible for proving the final project design has no negative flood impacts prior to initiating construction.

For the purposes of flood planning effort, a determination of no negative impact can be established if stormwater does not increase inundation of infrastructure, such as residential and commercial buildings and structures. Addtionally, the following requirements, per the *Technical Guidelines*, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.
3. Maximum increase of 1D WSEs must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.
4. Maximum increase of 2D WSEs must round to 0.3 feet (<0.35 ft) measured at each computation cell.
5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (subbasins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

If negative impacts are identified, mitigation measures may be utilized to alleviate such impacts. Projects with design level mitigation measures already identified may be included in the RFP and could be finalized at a later stage to conform to the “No Negative Impact” requirements prior to funding or execution of a project.

Furthermore, the RFPG has flexibility to consider and accept additional “negative impact” for requirements 1 through 5 based on engineer’s professional judgment and analysis given any affected stakeholders are informed and accept the impacts. This should be well-documented and consistent across the entire region. However, flexibility regarding negative impact remains subject to TWDB review.

A comparative assessment of pre-and post-project conditions for the 1% ACE was performed for each potentially feasible FMP based on their associated H&H models. The floodplain boundary extents, resulting WSEs, and peak discharge values were compared at pertinent locations to determine if the FMP conforms to the no negative impact requirements.

5.D.2.c. Benefit Cost Analysis

BCA is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. The result is a BCR, which is calculated by dividing the project's total benefits, quantified as a dollar amount, by its total costs. The BCR is a numerical expression of the relative "cost effectiveness" of a project. A project is generally considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (Federal Emergency Management Agency, 2009). However, a BCR greater than 1.0 is not a requirement for inclusion in the RFP. The RFPG can decide to recommend a project with a lower BCR with appropriate justification.

TWDB funded and guided development of a BCA input spreadsheet that is used in conjunction with the FEMA BCA Toolkit 6.0 for use in any project without an existing BCR. The process makes several generalizing assumptions, including (AECOM, 2022):

- 7% discount rate
- Annual inflation is ~2%
- Each residence houses 3 people (including 2 workers)
- The per diem for displaced residents is $240/day per household (this includes 1 hotel room and meals for 3 people)
- Residential square footage based on house size:
    - Small = 1,000
    - Average = 2,500
    - Large = 5,000
- Each commercial building employs 10 people
- Commercial property value is $100/square foot

For projects using the TWDB BCA method, construction cost estimates were escalated to 2020 dollars using the Consumer Cost Index (CCI). Benefits to structures, roadways, and other infrastructure were taken directly from model results or reports and applied to the BCA spreadsheet as directed. Existing BCRs were used where possible with some modifications to meet the flood planning guidelines. BCR calculations are available as part of the supporting technical memoranda for each project included in **Appendix E-3**.

5.D.3. Description of Recommended FMPs

A total of 73 potential FMPs were identified and evaluated by the San Jacinto RFPG. Of these, 70 FMPs were recommended for inclusion in the RFP. The two FMPs that were excluded were due to yielding no direct flood risk reduction benefits and having no BCR. The FMPs recommended consist of both structural and non-structural projects. The recommended FMPs represent a combined cost of $32 billion in flood management project needs across the San Jacinto region.

Table 5-2 summarizes the types of FMPs, the number of FMPs for each type, and the total cost of the recommended FMPs. The full list of recommended FMPs and supporting data are included in **Table 16** in **Appendix 5-7**. Recommended FMPs are shown on **Map 20**, **Appendix 5-2**. A one-page report summary of each recommended FMP is included in **Appendix 5-5**.

TABLE 5-2: SUMMARY OF RECOMMENDED FLOOD MITIGATION PROJECTS

Structural	FMP Type	Number of Identified FMPs	Number of Recommended FMPs	Total Cost of Recommended FMPs
Yes	Comprehensive; Master Drainage Plan projects	51	50	$31,683,377,000
No	Preparedness; Improve regulations and permit requirements; Other	22	20	$1,876,000
	Total	**73**	**70**	**$31,685,213,000**

5.D.4. Summary of Recommended Non-structural FMPs

Non-structural FMPs include property or easement acquisition, elevation of individual structures, Flood Early Warning Systems, and other similar projects. When identifying and recommending FMPs, emphasis was placed on mitigation and preparedness. **Figure 5-1** shows the distribution of recommended non-structural flood mitigation projects. By quantity, most recommended non-structural FMPs are categorized as preparedness. Reference material for the non-structural FMPs can be found in **Appendix 5-4A**.

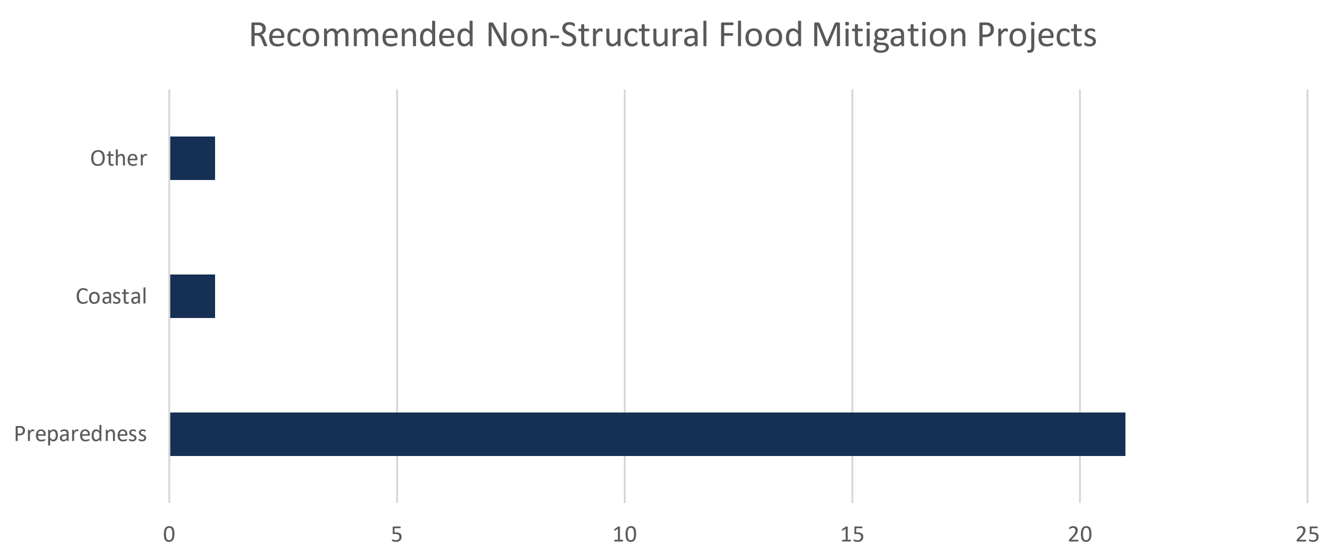


FIGURE 5-1: DISTRIBUTION OF RECOMMENDED NON-STRUCTURAL FLOOD MITIGATION PROJECT BY TYPE

5.D.5. Recommended Structural FMPs

A total of 50 structural FMPs were recommended by the San Jacinto RFPG. The follwing sections detail each project's various components, H&H modeling, cost, benefit, and any other pertinent information. For a summary and additional information on these project refer to the one-page summaries attached in the **Appendix 5-5**.

5.D.5.a. League City Projects

Lower Clear Creek and Dickinson Bayou Flood Mitigation Plan (063000026)

This project was developed as part of a comprehensive flood mitigation plan for the Lower Clear Creek and Dickinson Bayou Watersheds with a focus on the riverine impacts along the main channel of each waterway. The flood mitigation plan focused on mitigating the risk of extreme events similar to Hurricane Harvey, Tropical Storm Allison, and other large tropical storms, as well as flood damages from smaller more frequent storms. The targeted reduction in flood depths was set as multiple feet of reduction at Interstate 45 (I-45) during a 1.0% ACE storm.

League City led the engagement of numerous stakeholders along Dickinson Bayou to fund Phases 1 through 3 of the study that recommended this project. League City also entered into an agreement to receive Planning Assistance to States (PAS) funding from the United States Army Corps of Engineers (USACE) under the authority provided by Section 22 of the Water Resources Development Act of 1974 (PL 93-251), as amended. USACE Galveston District provided in-kind services and was engaged in all aspects of the project including technical reviews and a downstream boundary condition analysis accounting for storm surge and future sea level rise. Key planning partners and study contributors included:

1. League City
2. USACE
3. Harris County Flood Control District (HCFCD)
4. Galveston County
5. City of Friendswood
6. Galveston County Consolidated Drainage District

This project is supported by state-of-the-art H&H models, leveraging current NOAA Atlas 14 rainfall data, 2018 LiDAR data, and a 1D/2D unsteady-state modeling approach. Existing and future conditions flood risks were evaluated based on Atlas 14 storm events. The recommended project was selected from a total of 3 combinations of alternatives that were evaluated along Clear Creek.

The recommended project is outlined as "Alternative 3: Detention + Conveyance + I-45 Tunnel" in the supporting report. Six individual components make up this overall recommendation, as shown in **Figure 5-2** below:

1. Friendswood Detention Basin
2. Timber Creek Golf Course Detention Basin
3. Channel Benching Above Ordinary High Water Mark (OHWM) – FM 1959 to Bay Area Blvd.
4. 40-Foot Diameter Tunnel Diversion from I-45 to Galveston Bay
5. SH 3 and UPRR Capacity Improvements
6. FM 270 Auxiliary Opening

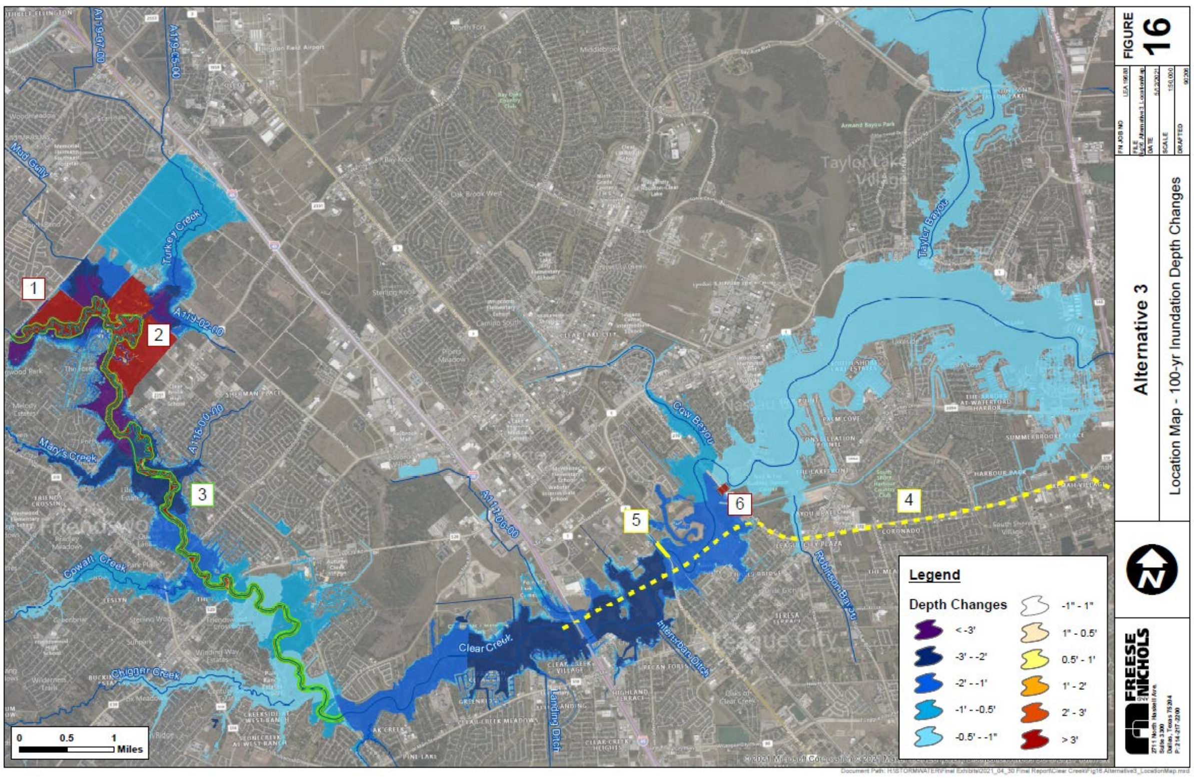


FIGURE 5-2: ALTERNATIVE 3 LOCATION AND INUNDATION DEPTH CHANGE MAP

The 40-foot I-45 to Galveston Bay tunnel was retained based on an efficiency analysis of various tunnel configurations. This alternative provides significant benefits, with water surface elevation reductions of over seven feet in the 1.0% ACE storm immediately downstream of FM 1959. This project also provides notable water surface elevation reductions in the vicinity of I-45, with reductions exceeding two feet in the 1.0% ACE storm. Clear Creek through Clear Lake benefits from water being diverted by the tunnel out of Clear Creek and bypassing the Lake down to Galveston Bay.

This project was found to meet no adverse impact requirements and is supported in the report, "Lower Clear Creek and Dickinson Bayou Flood Mitigation Plan," dated June 2021. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4B**. Further no adverse impact documentation is supported with an associated model (ID 060000000027).

5.D.5.b. San Jacinto River Master Drainage Plan Projects

The following projects were developed as part of the San Jacinto River Regional Watershed Master Drainage Plan (SJMDP). In the wake of Hurricane Harvey, HCFCD, the San Jacinto River Authority (SJRA), Montgomery County (MOCO), and the City of Houston recognized the need for flooding mitigation strategies along the San Jacinto River. The SJMDP evaluated the existing conditions in the basin and developed a comprehensive flood mitigation plan. From the SJMDP, sixteen structural flood mitigation alternatives were recommended for future development. These 16 structural alternatives have been grouped into the following 6 FMPs.

Several agencies or communities were identified as potential partners that could provide assistance in the implementation of the projects. The following sponsor/funding agencies have been identified for all of the following projects: SJRA, TWDB, GLO, and the USACE.

These projects are supported by H&H models leveraging Atlas 14 rainfall data. The models utilized Digital Elevation Models (DEM) developed from regional 2018 LiDAR and other sources to cover the extent of the San Jacinto River watershed. Major watersheds within the San Jacinto River basin were modeled individually and then combined into one comprehensive model. In the SJMDP, each individual segment was modeled to determine the benefits on the watershed as a whole. However, the evaluation of the specific project segment was not conducted. The SJMDP project team, instead, assessed benefits throughout the entire watershed. This approach was taken to account for an alternative having the potential to benefit structures downstream of the primary benefit area. Assessing benefits throughout the entire watershed also was deemed appropriate due to the channelization alternatives requiring a separate upstream detention project. Each FMP that stems from the SJMDP, that involves channelization, has also been paired with detention alternatives or has been recommended to be completed subsequent or in conjunction to an upstream detention alternative. For further details on the modeling approach used by the SJMDP project team, please refer to the report in **Appendix 5-4C**.

These projects were found to meet no adverse impact requirements as documented in the SJMDP report. This study was based on best available information, was certified by professional engineers. Further no adverse impact documentation is supported with associated models (ID 060000000026).

The BCR was determined for each individual alternative considered in the SJMDP. The BCR was also provided in an estimated range and developed using spreadsheet calculations that follow the same principles as FEMA's BCA toolkit. Since most SJMDP FMPs involve multiple alternatives, the BCR was determined by the San Jacinto RFPG through a weighted average using the highest cost from the range provided with the corresponding BCR for all alternatives recommended in each SJMDP FMP. FMPs in the SJMDP were grouped based on guidance provided in the report, which can be referenced in **Appendix 5-4C**.

SJMDP Caney Creek - Channelization with Detention (063000058)

This project includes three structural mitigation projects along Caney Creek and has combined two detention projects. Some of the detention project volume is needed for mitigation of the channelization projects while the remaining volume provides flood risk reduction as well. These projects can be implemented separately if needed however, in general, to avoid negative impacts, detention must be constructed first. These projects are highlighted in **Figure 5-3**, which include:

1. Detention at FM 1097

2. Detention at SH105
3. Channelization at I-69

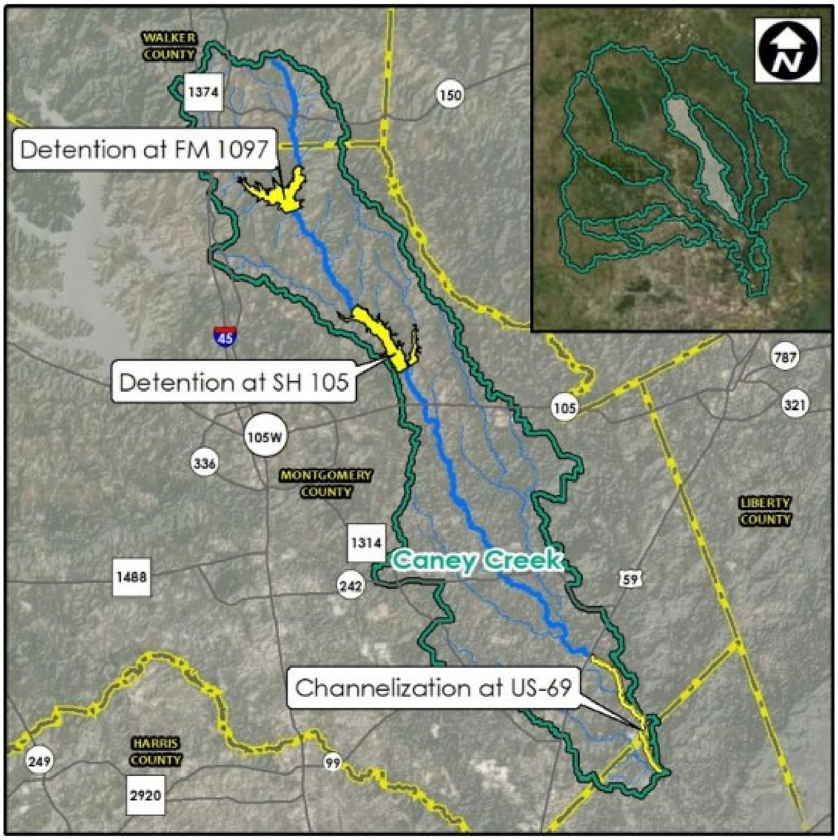


FIGURE 5-3: SJMDP CANEY CREEK PROJECT AREA

In addition to the sponsors mentioned in the SJMDP summary above in 5.D.5.b., the TxDOT is an identified as a potential sponsor/funding agency. Upon the completion of this project, an agency will also need to be determined to own and maintain the detention basins.

The project aims to reduce flooding along Caney Creek by implementing two dry dam detention facilities to impound stream flow during flood events along with channelization near the confluence of the East Fork of the San Jacinto River. The channelization increases conveyance and requires a separate upstream detention project. The channelization must be constructed with detention at FM 1097 or detention at SH105 to capture runoff from Caney Creek. The dry dam detention facility at FM 1097 includes a 1.2-mile-long earthen impoundment that would provide 13,900 acre-feet of storage capacity, while the dry dam at SH 105 includes a 0.8-mile-long earthen impoundment with 28,090 acre-feet of storage below the 1% ACE WSE. The channelization at I-69 includes 700-foot-wide benching for a 7.8-mile-long stretch from 0.5 mile downstream of I-69 to the confluence of the East Fork of the San Jacinto River. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

SJMDP East Fork San Jacinto River – Detention (063000059)

This project includes a structural mitigation alternative along the East Fork of the San Jacinto River, through the construction of Winters Bayou Dry Dam Detention Basin, highlighted in **Figure 5-4**.

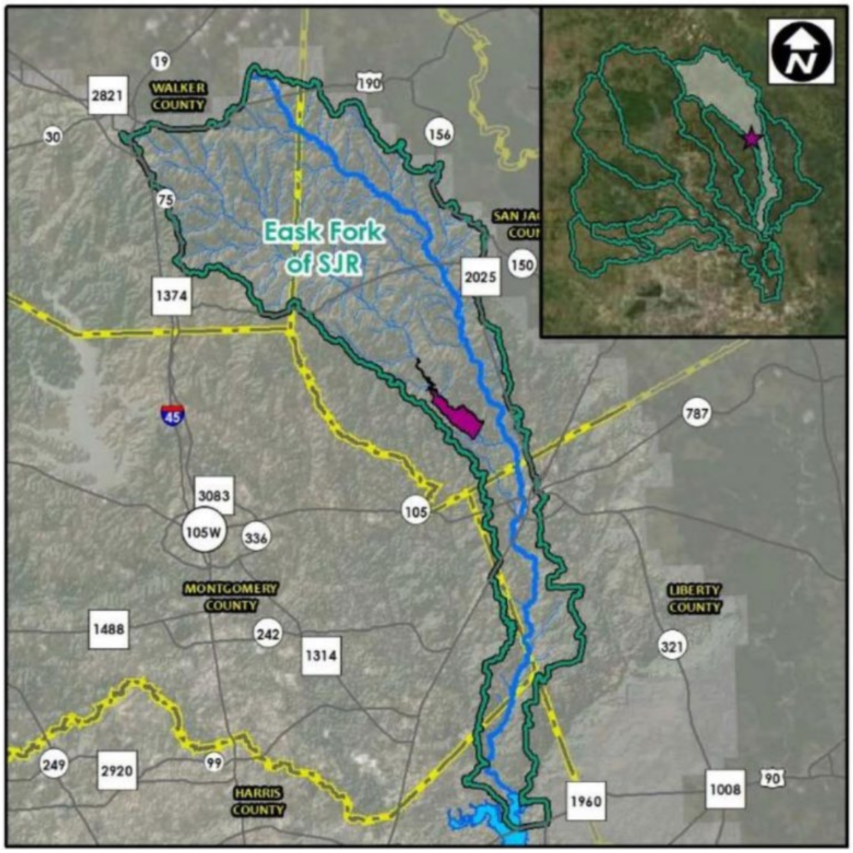


FIGURE 5-4: SJMDP EAST FORK WINTERS BAYOU PROJECT AREA

In addition to the sponsors mentioned in the SJMDP summary above in 5.D.5.b., the following are other identified potential sponsors/funding agencies: San Jacinto County, TxDOT, U.S. Department of Agriculture (USDA), Burlington Northern Santa Fe (BNSF) Railroad, and Union Pacific Railroad (UPRR). Upon the completion of this project, an agency will also need to be determined to own and maintain the detention basin.

This detention project aims to reduce flooding along the East Fork of the San Jacinto River by implementing a dry dam facility that impounds stream flow during flood events. Out of several potential detention locations this site was chosen based on the ability to reduce flows, its limited existing development, and the large impact Winters Bayou has on the water surface and flow of the East Fork. The dry dam detention facility includes a 1.60-mile-long earthen impoundment that captures runoff from Winters Bayou. The flow control structure consists of a 48-ft tall dam with 5 – 10’x10’ reinforced concrete blocks directly connected into a secondary (300’) tiered dual spillway. The amount of material required to construct such a system would entail close to 1.3 million cubic meters of materials to create approximately 45,055 acre-ft of storage capacity below the 1% ACE WSE, spanning an area of 2,479 acres. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

SJMDP Lake Creek – Detention (063000060)

This project includes three structural mitigation alternatives along Lake Creek which consist of detention projects. The detention volume created by these projects have the potential to provide mitigation volume to channel conveyance projects in other watersheds. These projects are highlighted in **Figure 5-5**, which include:

1. Caney Creek Detention
2. Little Caney Creek Detention
3. Garrett's Creek detention

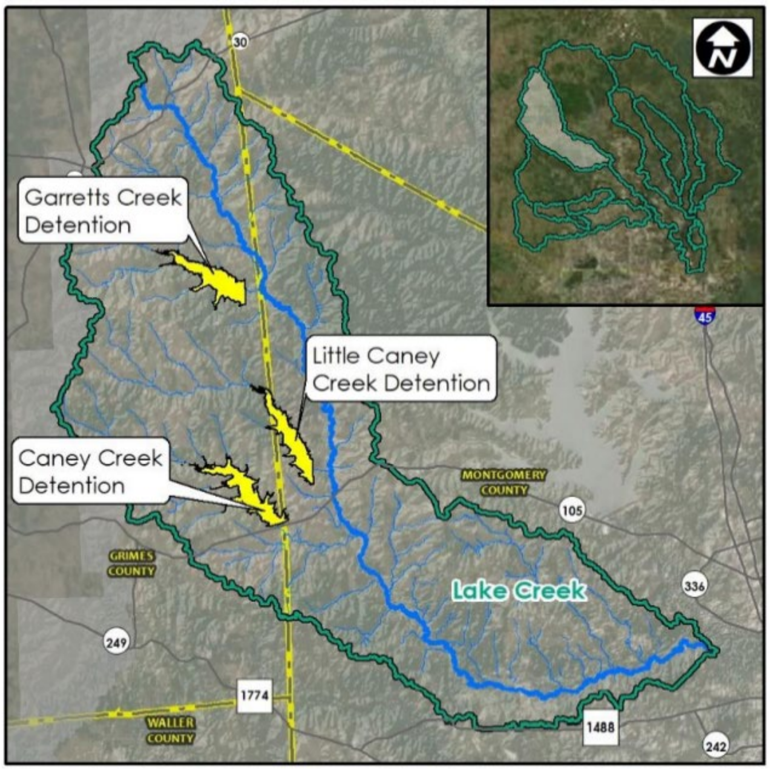


FIGURE 5-5: SJMDP LAKE CREEK PROJECT AREA

In addition to the sponsors mentioned in the SJMDP summary above, Grimes County and TxDOT are other additional identified potential sponsors/funding agencies. Upon the completion of this project, an agency will also need to be determined to own and maintain the detention basins.

The project aims to reduce flooding along Lake Creek by implementing three dry dam detention facilities to impound stream flow during flood events. The Caney Creek Detention consists of a dry dam detention facility approximately 0.3 miles upstream of SH 105 on Caney Creek. This dry dam detention facility includes a 0.76-mile-long earthen impoundment that would provide 19,750 acre-feet of storage capacity with a maximum dam height of 52 ft. Little Caney Creek Detention, which is located approximately 1.1 miles upstream of Lake Creek on Little Caney Creek, West of FM 1486, is a dry dam detention facility. The facility includes a 0.83-mile-long earthen impoundment that would provide 17,500 acre-feet of storage with a maximum dam height of 51 ft. Garrett's Creek Detention also consists of a dry dam detention facility, which is located 0.7 miles upstream of Lake Creek on Garrett's Creek. The facility includes a 1.2-mile-long earthen impoundment that would provide 16,850 acre-feet of storage below the 1% ACE WSE with a maximum dam height of 43 ft. All detention basins contain a primary outfall consisting of 3-5'x5' reinforced concrete block and a secondary spillway approximately 200 ft in length; however, Garrett's Creek secondary spillway has approximately 100 ft in length. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

SJMDP Peach Creek - Channelization with Detention (063000061)

This project includes three structural mitigation alternatives along Peach Creek and has combined two detention projects to mitigate the channelization project. These projects are highlighted in **Figure 5-6**, which include:

1. Detention at Walker Creek
2. Detention at SH 105
3. Channelization at I-69 (I-59)

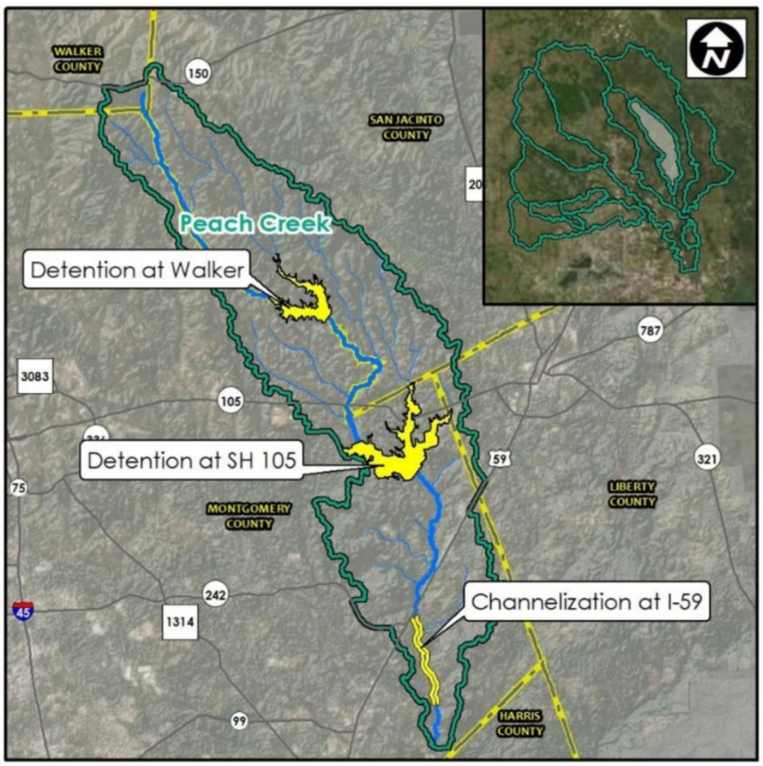


FIGURE 5-6: SJMDP PEACH CREEK PROJECT AREA

In addition to the sponsors mentioned in the SJMDP summary above, the following are other identified potential sponsors/funding agencies: San Jacinto County and TxDOT. Upon the completion of this project, an agency will also need to be determined to own and maintain the detention basins.

The goal of these projects is to reduce flooding in the Peach Creek watershed by combining the benefits of two dams with channelization of the main stem of Peach Creek. The Walker Creek detention project is a dry dam project that is modeled to reduce WSEs from the 1.0% ACE down to the 10.0% ACE level. The Walker Creek detention facility occupies close to 1,200 acres of land at the 1.0% ACE WSE and would hold close to 36,000 acre-feet of water volume. Similarly, to the Walker Creek detention facility, further downstream on Peach Creek, the SH 105 detention shows an WSEL reduction from the 1.0% ACE down to the 4.0% ACE, occupying approximately 3,000 acres of area and 36,000 acre-feet of volume at 1.0% ACE WSE. And the furthest downstream, the channelization of Peach Creek at I-69 increases the conveyance capacity of this section of channel. This project contains 4.3 miles of channelization with 800-feet of benching, ultimately reducing the immediate downstream WSEL from a 1.0% ACE to that of the 4.0% ACE level. The three projects show an average WSEL reduction of approximately 1.2” in the 1.0% ACE WSE in the section of channel from I-69 to the confluence of the East Fork. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

SJMDP Spring Creek - Channelization with detention (063000062)

This project includes four structural mitigation alternatives along Spring Creek and has combined two detention projects (Birch Creek and Walnut Creek Detention) to mitigate for the channelization projects. These projects are highlighted in **Figure 5-7**, which include:

1. Walnut Creek Detention
2. Birch Creek Detention
3. Woodlands Channel (200-ft)
4. I-45 Channelization

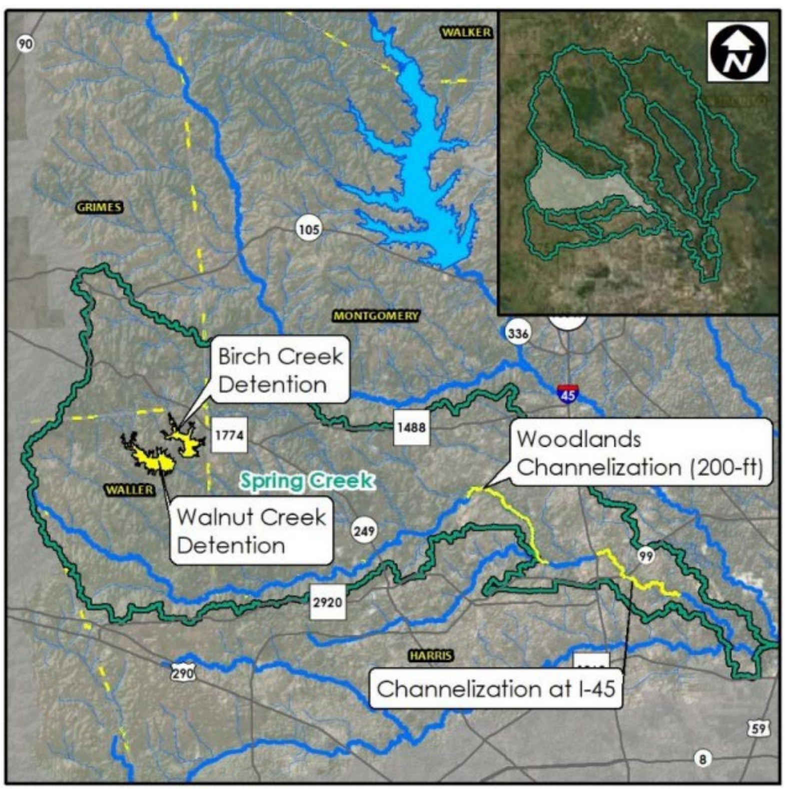


FIGURE 5-7: SJMDP SPRING CREEK PROJECT AREA

In addition to the sponsors mentioned in the SJMDP summary above, the following are other identified potential sponsors/funding agencies: Waller County, Harris County, City of Tomball, The Woodlands Township, Municipal Utility District 386 (MUD 386), Woodlands Water Agency (WWA), and Federal Emergency Management Agency (FEMA)and TxDOT. Upon the completion of this project, an agency will also need to be determined to own and maintain the detention basins.

The project aims to reduce flooding along Spring Creek by implementing two dry dam detention facilities to impound stream flow during flood events and a total of 15.7 miles of channelization downstream of I-45 and through the Woodlands. The channelization increases conveyance requiring construction of a separate upstream detention project first. The Walnut Creek Detention consists of a dry dam detention facility approximately 12 miles upstream of Spring Creek on Walnut Creek. This dry dam detention facilities includes a 1.2-mile-long earthen impoundment that would provide 12,159 acre-feet of storage capacity below the 1% ACE WSE with a maximum dam height of 46 ft. Walnut Creek also contains contain a primary outfall consisting of 2-4’x4’ RCBC and a secondary spillway approximately 200 ft in length. Birch Creek Detention, which is located approximately 12 miles upstream of Spring Creek on Birch Creek, also consists of a dry dam detention facility. The facility includes a 0.7-mile-long earthen impoundment that would provide 7,731 acre-feet of storage below the 1% ACE WSE, a maximum dam height of 41 ft, and a primary outfall consisting of 2-4’x3’ RCBC and a secondary spillway approximately 200 ft in length. The proposed Woodlands Channelization improvement is located upstream of Kuykendahl Road and downstream of Willow Creek confluence on Spring Creek. This improvement consists of 8.8 miles of channelization with 200-foot-wide benching and 7,200 acre-feet of required mitigation storage. The I-45 channelization is located from I-45 to approximately 4 miles downstream of Riley Fuzzel Road on Spring Creek. This improvement consists of 6.9 miles of channelization with 300-foot-wide benching and requires 8,000 acre-feet of mitigation storage. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

SJMDP West Fork San Jacinto River - Benching and Channelization (063000064)

This project includes two structural mitigation alternatives along the West Fork of the San Jacinto River. This project is expected to be conducted after or in conjunction with the detention projects on Lake Creek or Spring Creek which will mitigate negative impacts from the channelization. These projects are highlighted in **Figure 5-8**, which include:

1. HW 242 Channelization
2. Kingwood Benching

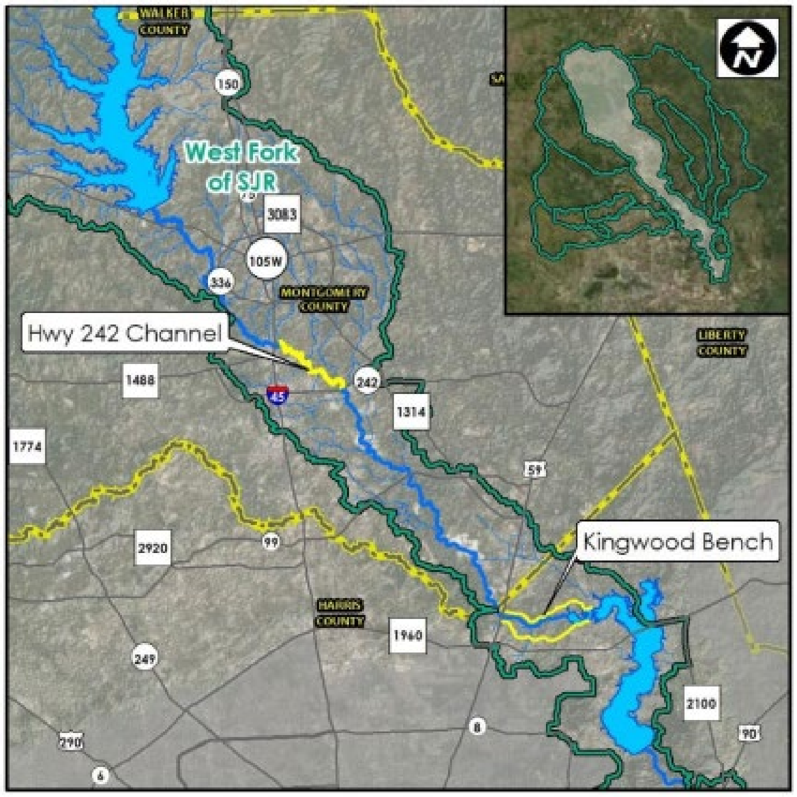


FIGURE 5-8: SJMDP WEST FORK PROJECT AREA

In addition to the sponsors mentioned in the SJMDP summary above in 5.D.5.b., Harris County is another identified potential sponsor/funding agency.

The project aims to reduce flooding along West Fork of San Jacinto River through 5.7 miles of channelization and 5 miles of channel benching. This project must also be conducted after or in conjunction with detention on Lake Creek or Spring Creek to mitigate for potential adverse impacts. The goal of the Highway 242 channelization is to reduce flooding by widening a 5.7-mile-long stretch to increase conveyance capacity of the West Fork to lower the WSE, which would also require 12,400 acre-feet of mitigation storage. Improvements are planned to widen the West Fork to 750-feet with a 2-foot bench above the stream bed. The Kingwood Bench portion of the project will also increase conveyance capacity of West Fork, involves widening a 5-mile-long channelized stretch with 3,500-feet wide of benching. This project would require 923 acre-feet of mitigation storage. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

5.D.5.c. Gulf Coast Protection District

Galveston Bay Surge Protection Coastal Storm Risk Management (063000127)

Identified in the Coastal Texas Protection and Restoration Feasibility Study, or Texas Coastal Study (2021), the Galveston Bay Surge Protection Coastal Storm Risk Management project includes various features along Galveston Island and Bolivar Peninsula, across the Bolivar Roads, and in Galveston Bay itself. The project is highlighted below in **Figure 5-9.** The goals of this study, between the USACE and the

GLO, are to promote a resilient and sustainable economy by reducing the risk of storm damage to residential structures, industries, and businesses critical to the nation's economy. The objectives of the project are:

1. Reduce risk to human life from storm surge impacts along the Texas coast;
2. Reduce economic damage from coastal storm surge to business, residents, and infrastructure along the Texas coast;
3. Enhance energy security and reduce economic impacts of petrochemical supply-chain related interruption due to storm surge impacts;
4. Reduce risks to critical facilities (e.g., medical centers, ship channels, schools, transportation, etc.) from storm surge impact;
5. Manage regional sediment, including beneficial use of dredged material from navigation and other operations to contribute to storm surge reduction where feasible;
6. Increase the resilience of existing hurricane risk reduction systems from sea level rise and storm surge impacts; and
7. Enhance and restore coastal landforms that contribute to storm surge attenuation where feasible.

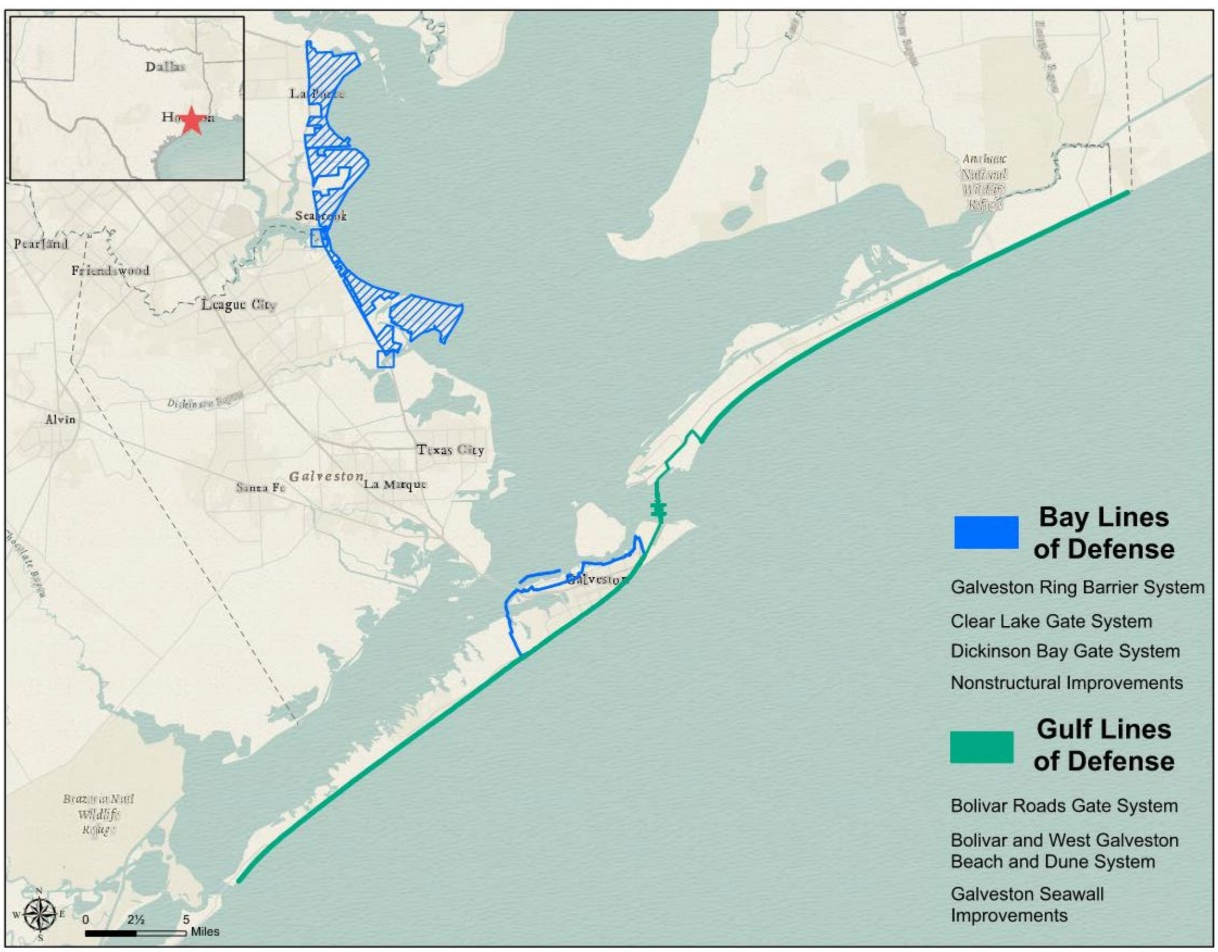


FIGURE 5-9: GALVESTON BAY SURGE PROTECTION PROJECT AREA

The Galveston Bay Storm Surge Barrier System can be split into two zones: Gulf Defenses and Bay Defenses. The Gulf Defenses include:

1. **The Bolivar Roads Gate System**: across the entrance to the Houston Ship Channel, Galveston Ship Channel, and Texas City Ship Channel, between Bolivar Peninsula and Galveston Island;
2. **West Galveston and Bolivar Peninsula Beach and Dune System**: 43 miles of beach and dune segments on Bolivar Peninsula and West Galveston Island that work with the Bolivar Roads Gate System to form a continuous line of defense against Gulf of Mexico storm surge, preventing or reducing storm surge volumes that would enter the Bay system; and
3. **Galveston Seawall Improvements**: improvements to the existing 10-mile Seawall on Galveston Island to complete the continuous line of defense against Gulf surge.

The Bay Defenses include:

4. **Galveston Ring Barrier System (GRBS)**: An 18-mile GRBS that impedes Bay waters from flooding neighborhoods, businesses, and critical health facilities within the City of Galveston;
5. **Clear Lake Gate System and Pump Station:** A surge gate at Clear Lake that would reduce surge volumes that push into neighborhoods in the Clear Lake area;
6. **Dickinson Bay Gate System and Pump Station:** A surge gate at Dickinson Bay that would reduce surge volumes that push into neighborhoods in the low-lying areas along Dickinson Bayou; and
7. **Nonstructural Improvements**: Complementary non-structural measures to further reduce Bay-surge risks along the western perimeter of Galveston Bay.

The modeling and analysis, performed by Mott MacDonald, consisted of the Clear Creek, Dickinson Bayou, and Galveston watersheds. The Clear Creek watershed had previously developed, calibrated, and well-documented H&H models, in HEC-HMS and HEC-RAS, respectively, and an effort was made to alter those models as little as possible due to their documented accuracy. The Dickinson Bayou watershed model was developed from available data and generating and calibrating 24 sub-watersheds. The Dickinson Bayou watershed model was developed using the represents 1979 topography, not current data. It is highly recommended for the next level of analysis to conduct a topographic data collection campaign. The Galveston watershed was modeled using the EPA model for H&H.

Reference material for this project can be found in **Appendix 5-4D**. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

5.D.5.d. City of Houston Projects

These project applications were developed by the City of Houston in areas that are identified as frequently flooded. The projects are included in the City of Houston's Capital Improvement Program. There are four FMEs that have been elevated to FMPs based on additional information provided by the City of Houston. The four structural projects are paired with detention alternatives to ensure no negative impact as result of these flood mitigation solutions.

A BCA was developed based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0 and MH-HAZUS. Each of the projects had a BCA report associated with it. The results of these reports concluded with a BCR for each project which is reported below. For a summary of each FMP, refer to the one-page summary attached in **Appendix 5-5**.

City of Houston Fifth Ward Area Flood Mitigation (063000417)

The City of Houston Fifth Ward Area Flood Mitigation Project was identified as an area of need under the City's Capital Improvement Projects program. Within the Greater Fifth Ward Super Neighborhood in downtown Houston, several areas of concern were identified as requiring drainage updates and/or street repairs. Drainage studies were performed for each of these areas, but an overall solution was not possible on an individual project basis. Therefore, this project combines those areas into what is now referenced as the Greater Fifth Ward Drainage Master Plan. The project area is located northeast of downtown Houston. The area is primarily residential, comprised of single-family homes. The majority of drainage systems in the project location are comprised of concrete curb and gutter streets with underground storm sewer systems, but there are also a few areas with asphalt streets and roadside ditches. Buffalo Bayou (HCFCD Unit #W100-00-00) serves as the primary outfall location at three different locations. The project area is shown in **Figure 5-10**.

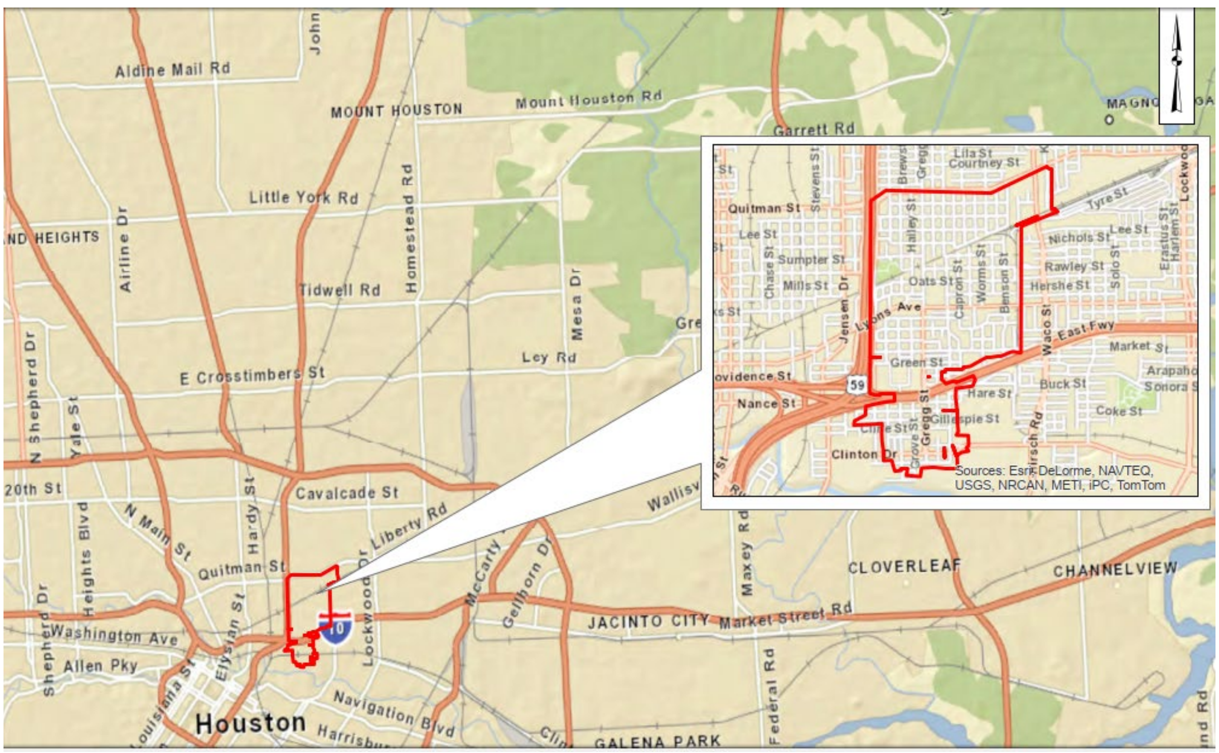


FIGURE 5-10: FIFTH WARD PROJECT AREA

The proposed project addresses the extreme event sheet flow deficiencies and uses a continuous trunkline throughout the entire project area. The proposed storm drain system will have sufficient capacity to convey the 50% ACE rainfall and keep the extreme event contained within the ROW along the proposed storm sewer trunkline. The proposed storm sewer trunkline will provide relief necessary for the undersized pipes in the north side of the project area. The roadways required to be reconstructed to install the proposed storm sewer will be replaced with equivalent sections to the existing condition.

This project was found to meet no adverse impact requirements and is supported in the report, "Fifth Ward Master Drainage Plan Technical Memorandum" dated October 2020. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4E**.

The calculated BCR of the project was found to be 1.87. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

City of Houston Port Area Flood Mitigation (063000418)

The City of Houston Port Area Flood Mitigation Project, also called "Pleasantville", was identified as an area of need under the City's Capital Improvement Projects program. The project area is west of 610 East, south of Market Street Road, east of Pearl Street and north of Clinton Drive. The project area is shown in **Figure 5-11**. The existing storm sewer system was constructed in the 1960s and 1970s. Several drainage improvements were constructed in 2016 and 2017. These improvements provide relief from flooding for residents within the Pleasantville area. However, additional improvements are necessary to provide flood relief to the area.

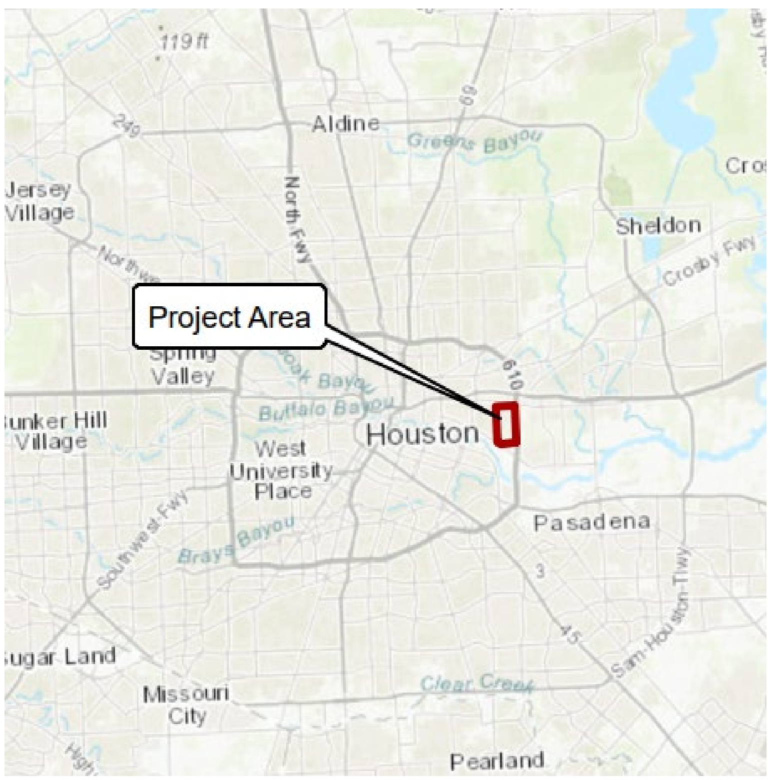


FIGURE 5-11: PLEASANTVILLE PROJECT AREA

The project includes storm sewer improvements on nearly every street in the Pleasantville neighborhood to improve conveyance and reduce ponding and flood risk.

This project was found to meet no adverse impact requirements and is supported in the report, "Pleasantville Detention Analysis," dated April 2020. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4F**.

The proposed flood control and drainage improvements in the Pleasantville neighborhood reduce ponding on major streets, increasing the number of lane miles that are passable during major events. The calculated BCR of the project was found to be 0.30. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

City of Houston Kashmere Gardens Area Flood Mitigation (063000434)

The City of Houston Kashmere Gardens Area Flood Mitigation Project was identified as an area of need under the City's Capital Improvement Projects program. The project is located within the historic Kashmere Gardens, which is located just south of North 610 Loop and east of US-59 in Houston, Texas. The study area is bounded by an industrial area to the east, a Union Pacific rail corridor to the south, Schrum Gully, H112-00-00, to the west and Huntington Bayou, H100-00-00 to the north. The existing land use is mainly single-family residential lots and commercial developments. An outline of the proposed project area is shown in **Figure 5-12**.

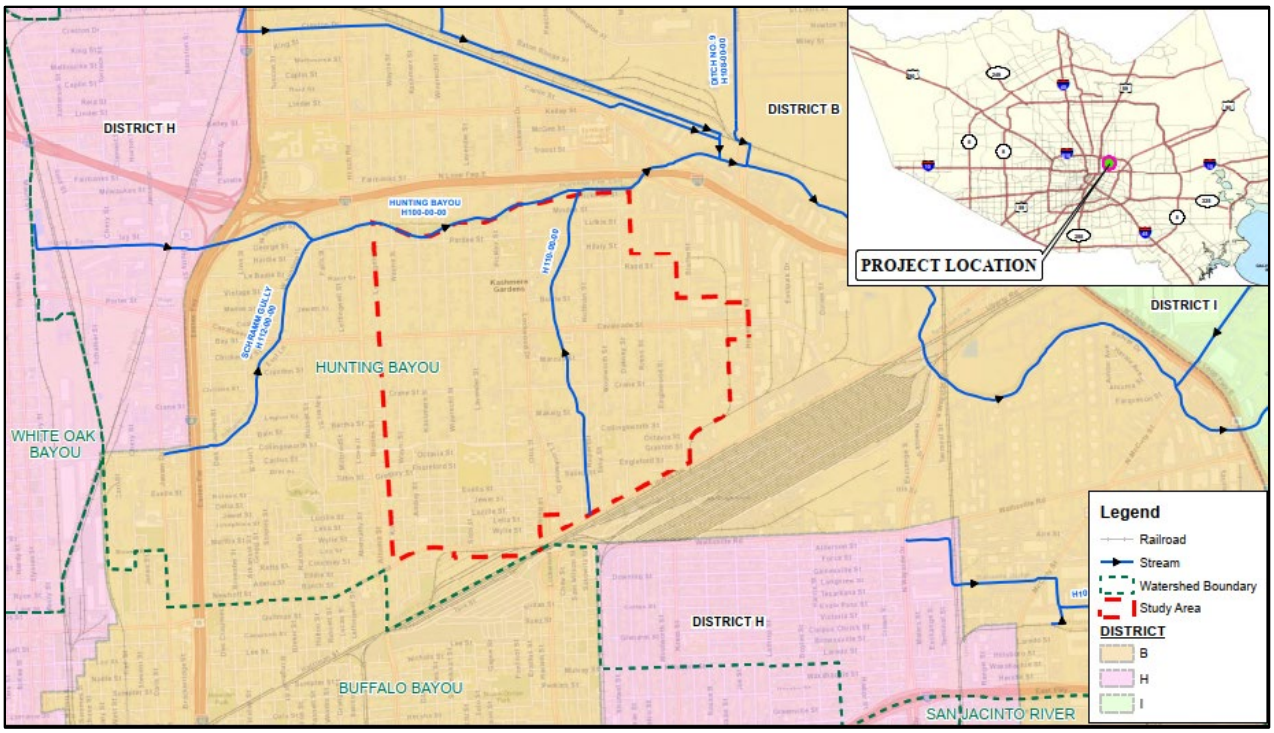


FIGURE 5-12: KASHMERE GARDENS STUDY AREA

The existing drainage system within the project area consists of storm sewer lines, roadside ditches, and channels. The project area is located within the Hunting Bayou watershed. Hunting Bayou and its tributaries, H110-00-00, serve as outfalls for the local drainage systems. Channel H110-00-00 divides the study area into two parts.

During intense rainfall events, Hunting Bayou has historically come out of banks and flooded existing structures along the bayou within the proposed project limits. The existing storm sewer lines also have limited capacity, which potentially contributed to the widespread flooding in the neighborhood in the past. The HCFCD is in the final stages of completing improvements to Hunting Bayou, which will reduce WSEs in the bayou.

This project was found to meet no adverse impact requirements and is supported in the report, "Houston Kashmere Gardens Area Flood Mitigation Project Technical Memorandum," dated October 2020. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4G**.

The proposed drainage improvements include proposing new storm sewer trunklines, a detention pond, regrading roadside ditches, driveway culvert replacement, inlet replacement and constructing green stormwater infrastructure. The proposed improvements will increase the size of the existing storm sewer lines, which will reduce the risk of excessive street ponding and structural flooding. The calculated BCR of the project was found to be 1.09. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

City of Houston Sunnyside Area Flood Mitigation (063000468)

The City of Houston Sunnyside Area Flood Mitigation Project was identified as an area of need under the City's Capital Improvement Projects program. The neighborhood includes approximately 5,000 acres of development within the southern portion of the City of Houston. The project area is roughly bounded by Loop 610 South on the north, State Highway 288 on the west, Mykawa Road on the east and Sims Bayou on the south. An outline of the proposed project area is shown in **Figure 5-13.**

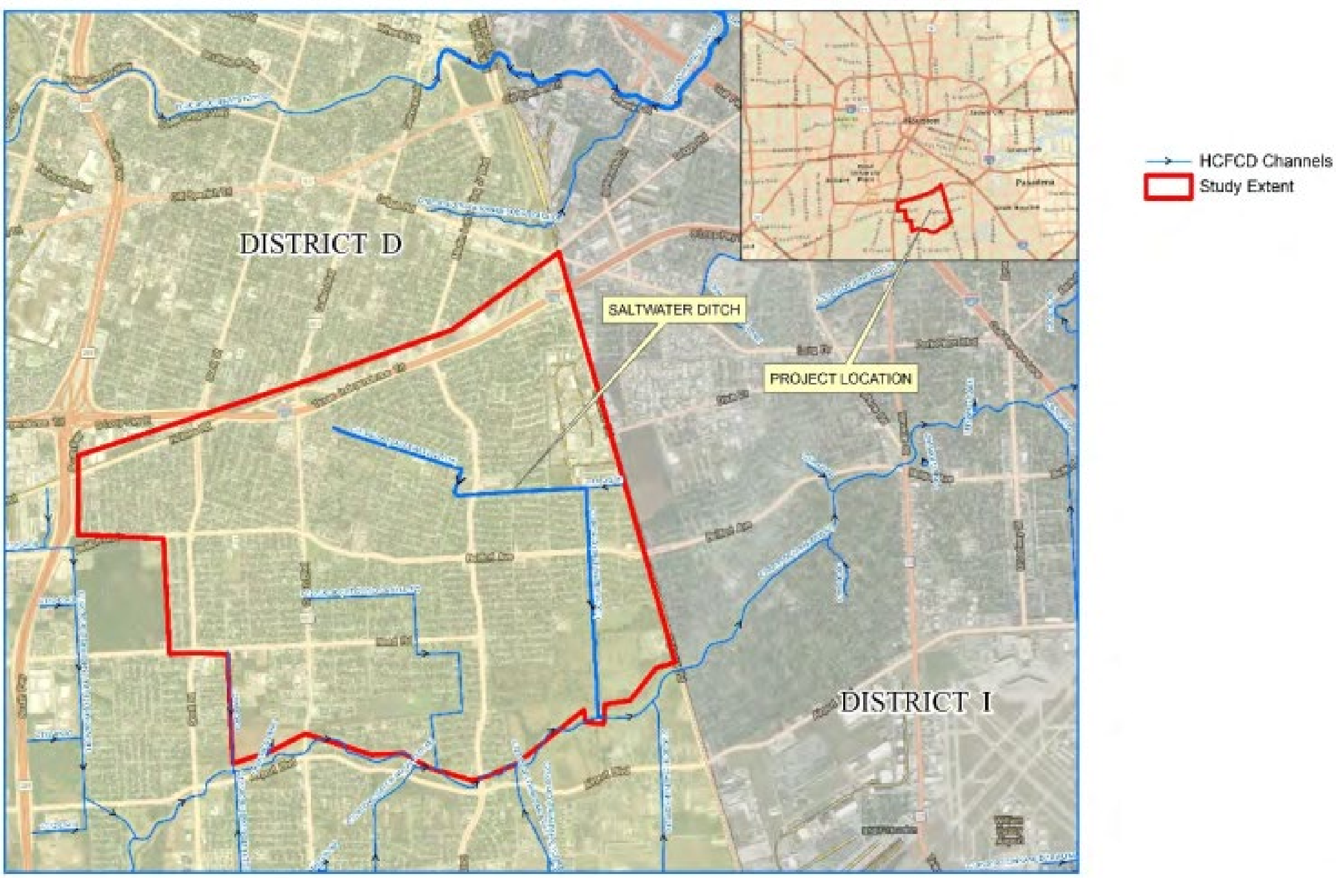


FIGURE 5-13: SUNNYSIDE PROJECT AREA

A large majority of the project area is located within the Sims Bayou watershed, while a small portion of the area drains to the Loop 610 drainage system and then into HCFCD Unit D105-00-00 and ultimately Brays Bayou. The portion of the project area within the Sims Bayou watershed is drained via underground storm sewer or roadside ditches to one of three tributaries of Sims Bayou: 1) HCFCD Unit C118-00-00 ,Salt Water Ditch; 2) HCFCD Unit C122-00-00; and 3) HCFCD Unit C128-00-00.

The neighborhood is mainly single-family residential development with some commercial development along major thoroughfares.Local schools are also located within the project area.

This project was found to meet no adverse impact requirements and is supported in the report, "City of Houston Drainage Pre-Engineering Services for Storm Water Improvements Work Order #9 – South Park/Sunnyside Drainage Analysis," dated October 2020. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4H**.

The proposed drainage improvements include proposing new storm sewer trunklines and networks, detention ponds, inlet replacement, green stormwater infrastructure, and channel improvements at Salt Water Ditch. The proposed improvements will increase the size of the existing storm sewer lines, which will reduce the risk of excessive street ponding and structural flooding. The calculated BCR of the project was found to be 1.20. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

5.D.5.e. City of Galveston Projects

Galveston 37th Street (063000311)

This project was developed in fiscal year 2019 as part of the City of Galveston's three-year storm sewer rehabilitation and inspection program which was intended to inspect, remove debris, and rehabilitate the city's existing drainage system to increase capacity and reduce flooding during tidal events, tropical storms, and hurricanes. The primary goal of the project was to improve the accessibility of roadways during heavy rainfall events, specifically along the Harborside Drive evacuation route during pre-storm flood events. **Figure 5-14** shows the benefit area and evacuation routes benefited.

FIGURE 5-14: 37TH STREET PROJECT AREA EVACUATION ROUTES

Hydraulic results were provided in raster format for the 20%, 10% and 1% ACE for both pre-project conditions. The post-project conditions were assumed to have no impacts for the purpose of the benefit cost analysis (BCA). The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The benefits considered in the analysis include the reduction in damages to residential structures, commercial structures, and flooded street impacts. The BCA Input Tool was modified to allow for more than 100 structures to be included in the analysis. The BCA Input Tool was used in conjunction with the FEMA BCA Toolkit v6.0.0. Flooded street impacts used in the analysis were developed within the TWDB-developed BCA Input Tool. The final BCR with standard benefits was determined to be 0.1. No other benefits,i.e., recreation, roadway, etc., were analyzed during this analysis. Despite the relatively low BCR, this project was ultimately chosen for recommendation in the RFP due to its focus on improving access to evacuation routes.

This project was found to meet no adverse impact requirements and is supported in the report, “Engineer’s Justification Statement for the 37th Street Drainage Project; CDBG-MIT Hurricane Harvey State Mitigation Competition,” dated October 2020. This study was based on best available information and is included in **Appendix 5-4I**.

For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

5.D.5.f. City of Friendswood Projects

Friendswood - Inline & Offline Detention (063000424)

The City of Friendswood evaluated flood mitigation projects, including channel improvements and detention basins, to reduce damage from increasingly frequent and heavy rainfall events. The flood mitigation project is developed to protect against flooding from Clear Creek. The recommended project combines the construction of two new detention ponds, the expansion of an existing detention basin, and the terracing of two sections of the creek. These five project components are highlighted in **Figure 5-15**, and include:

- FM 1959 Detention Basin : 1,700 ac.ft of storage capacity located along the left bank of Clear Creek just downstream of FM 1959
- Whitcomb Detention Basin: 340 ac.ft of storage capacity located along the left bank of Clear Creek downstream of FM 528
- Whitcomb Terracing: Grading up to 400 ft wide, along 5,300 LF of the left bank of Clear Creek
- Blackhawk Detention Basin: Expansion of the existing 5 acre detention pond to include 200 ac.ft of additional storage capacity; located on the north side of the Blackhawk Regional Waste Water Treatment Plant.
- Blackhawk Terracing: Grading up to 250 ft wide, along 3,000 LF of the left bank of Clear Creek.

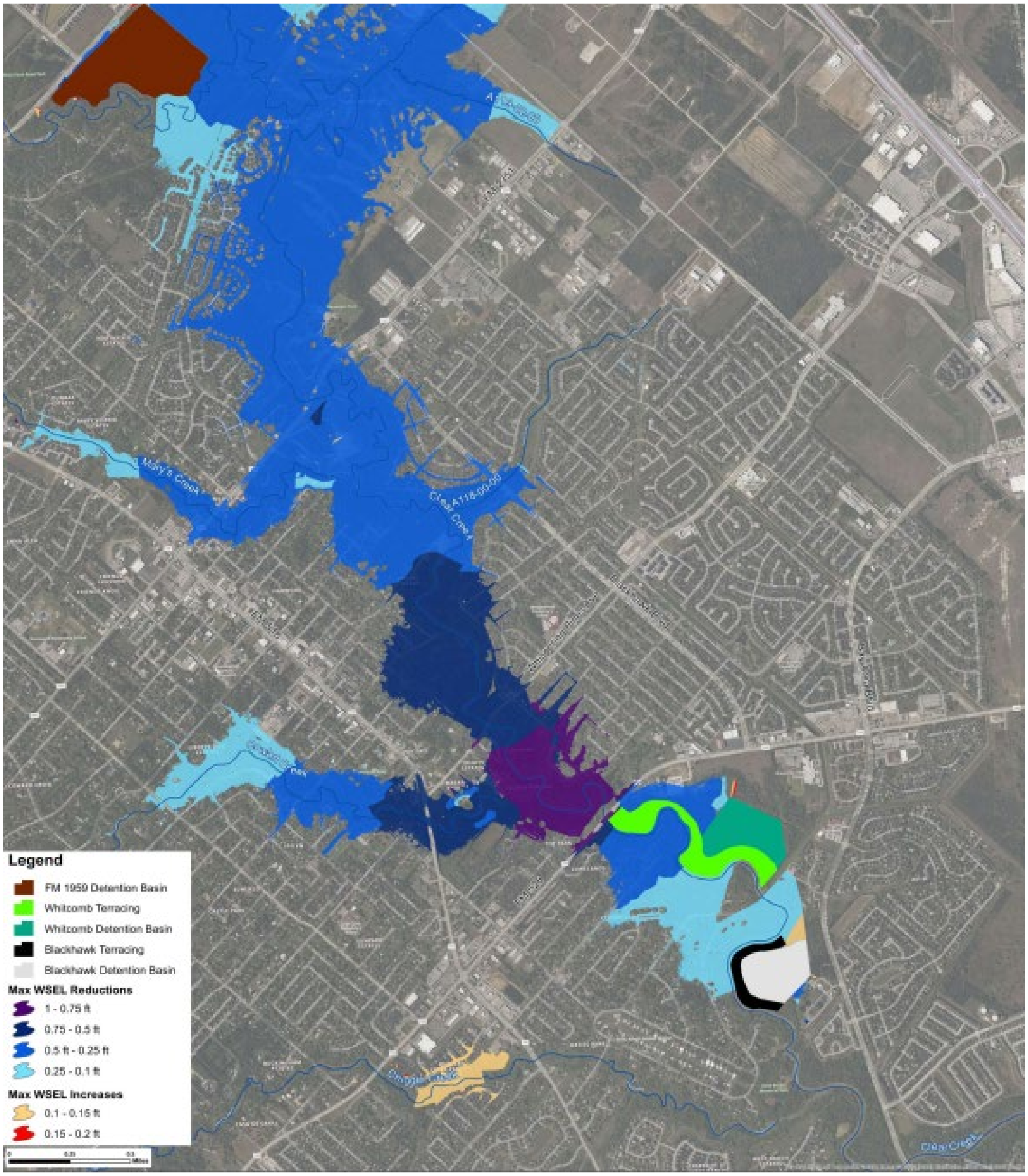


FIGURE 5-15: FRIENDSWOOD PROJECT AREA

This flood mitigation project was developed using a model created as part of the Lower Clear Creek and Dickinson Bayou Flood Mitigation Study, 2021. The model leverages current NOAA Atlas 14 rainfall data and 2018 LiDAR data, along with as-built drawings and survey data for the structures. Project benefits and impacts were assessed using the Future Conditions, 1% ACE storm.

The BCA for this project was completed using a modified TWDB BCA input tool and FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.03. Environmental benefits were also analyzed apart of the BCA. More details on the methodology used for the BCA are provided in **Appendix 5-4AJ**.

The project was found to meet no adverse impact requirements. For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

The modeled project reflects a concept-level analysis that was based on rudimentary grading extents. Although this level of detail is adequate to evaluate the general efficacy of a proposed project in providing flood risk mitigation, the preliminary modeling that was performed will need to be refined in the future once the grading and the intake structure components of the detention basins have been designed to determine the actual project benefits and potential adverse impacts. Based on the scope of this modeling effort, the benefit and negative impacts analysis was limited to maximum WSEs during the Future Conditions, 1% ACE storm.

5.D.5.g. Harris County Flood Control District Projects

Keegans Bayou Flood Risk Reduction Project (063000328)

This project was developed as part of a flood risk reduction project to identify projects to reduce riverine flood risk. Keegans Bayou is a tributary of Brays Bayou, encompassing about 19 square miles, and is primarily a residential area with some commercial and industrial development. The proposed project improvements include widening sections of the Keegans Bayou main channel with a total detention volume of 2,257 acre-feet. The project could significantly increase the conveyance capacity of Keegans Bayou and provide the required detention to offset impacts from peak flow increases due to the improved conveyance capacity. **Figure 5-16** shows the location of the proposed project.

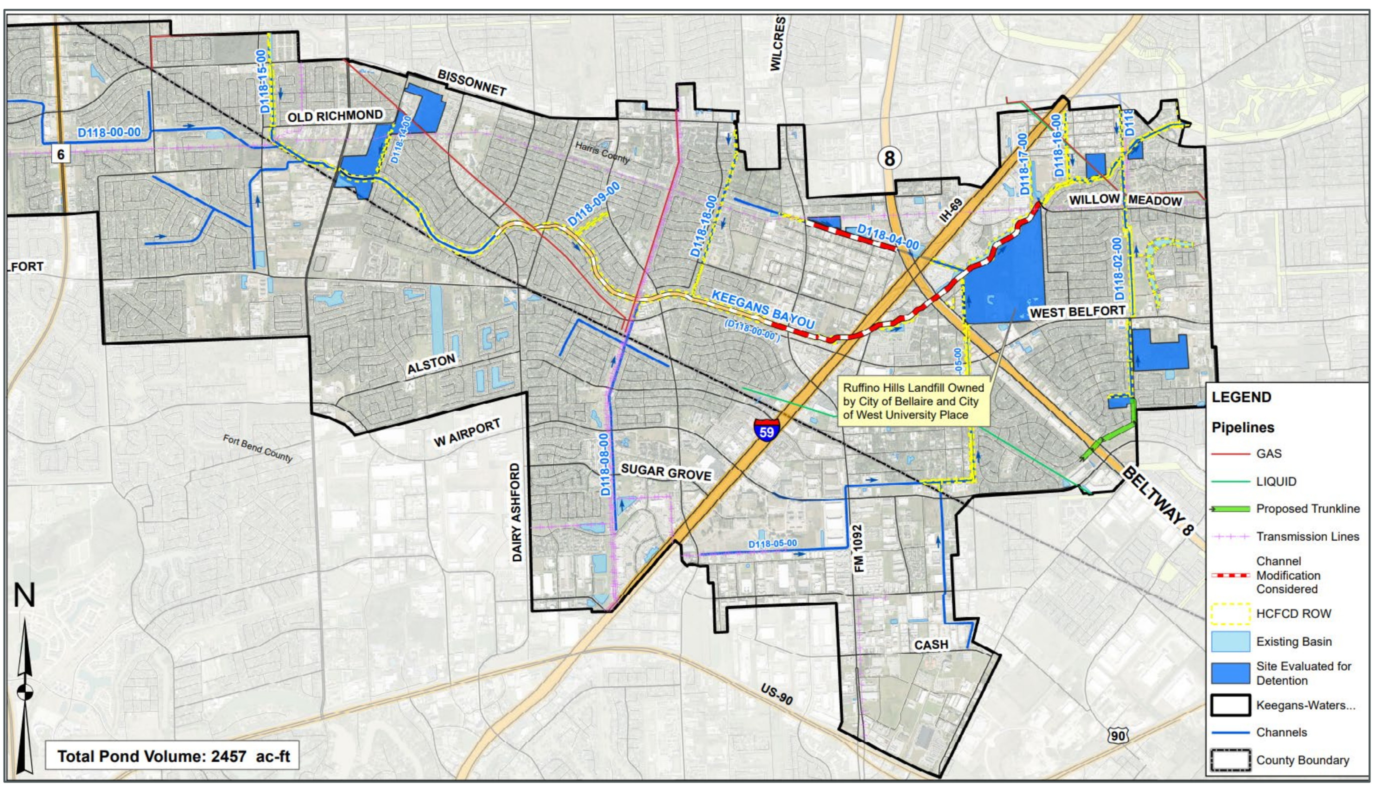


FIGURE 5-16: KEEGANS BAYOU FLOOD RISK REDUCTION PROJECT AREA

The project reduces flood risk through the construction of detention storage. Based on the hydraulic analysis conducted for project development, the project removes many structures from potential flood damage for the analyzed storm events.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 1% ACE, 2% ACE, and 10% ACE for both pre-project and post-project conditions. The BCR performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.94. Other benefits were analyzed including residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4K**.

The project report, "Keegans Bayou Feasibility Study Plan Final Report," dated August 2021, states that the implementation of detention basins and channel improvements will decrease WSEs and peak discharges for the analyzed storm events. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Goose Creek Flood Risk Reduction Project (063000334)

This project was developed as part of a comprehensive watershed evaluation of Goose Creek to identify projects to reduce riverine flood risk. The primary goal of the project was to create a high-level watershed plan to identify strategies for mitigation of existing flooding problems and to address improved drainage infrastructure required for future development. The project includes three phases of development. Phase 1 includes a regional detention basin and channel improvements along two segments of Goose Creek for a total length of 1.65 miles. Phase 2 includes a regional detention basin and channel improvements along a one-mile segment of Goose Creek. Phase 3 includes local channel and crossing improvements along two Goose Creek tributaries,HCFCD Unit ID. O117-00-00 and O126-00-00. **Figure 5-17** shows the project area as well as the different components of the project.

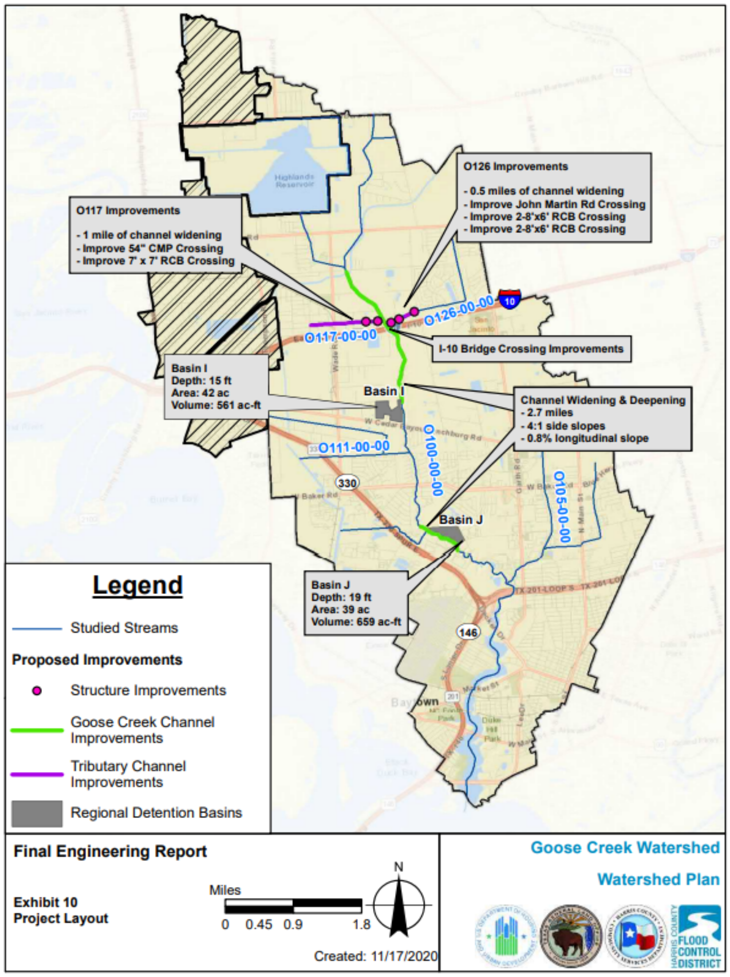


FIGURE 5-17: GOOSE CREEK FLOOD RISK REDUCTION PROJECT AREA

The project reduces flood risk by improving channel conveyance and providing detention storage. Based on the hydraulic analysis conducted for the project development, the project removes many structures from potential flood damage for all analyzed storm events.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. The BCA performed was based on the results under a process developed by the San Jacinto RFPG. The BCAfor this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.48. No other benefits,i.e., recreation, roadway, etc., were analyzed during this analysis. More details on the methodology used for the BCA are provided in **Appendix 5-4L**.

The report, "Final Engineering Report for the Goose Creek Watershed Planning Project," dated March 2021, states that the project's inclusion of detention throughout the watershed mitigates any adverse impacts caused by increased channel conveyance from channel improvements. Using these statements along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Kingwood Diversion Ditch (063000360)

This project was developed as part of a conceptual watershed evaluation of the Kingwood Area to identify projects to reduce riverine flood risk. The Kingwood Diversion Ditch, HCFCD Unit G103-38-00, is a previously constructed man-made ditch designed to alleviate flooding on Bens Branch,HCFCD Unit G103-33-00, through diversion of excess flow around Kingwood to the West Fork of the San Jacinto River. The proposed improvements include the construction of a concrete control structure, channel modifications, bridge improvements, and detention. **Figure 5-18** shows the location of the proposed project.

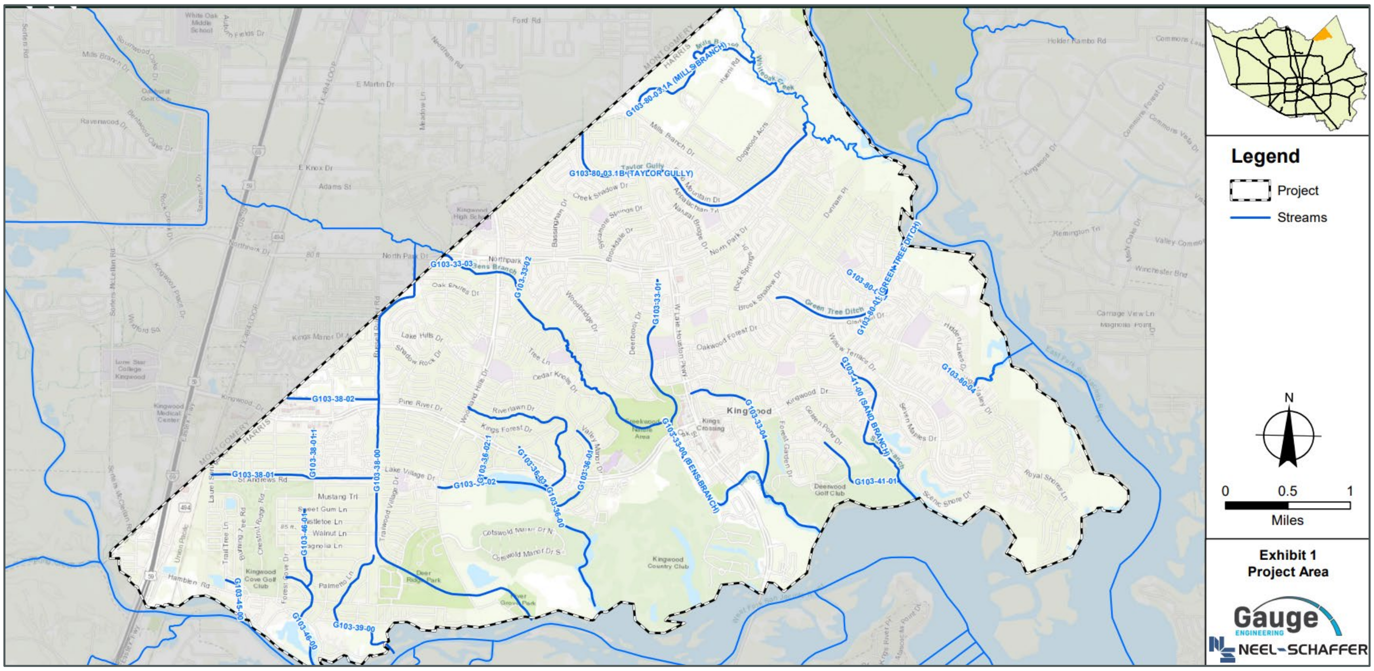


FIGURE 5-18: KINGWOOD DIVERSION DITCH PROJECT AREA

The project reduces flood risk through the construction of detention storage. Based on the hydraulic analysis conducted for the project development, the project removes structures from potential flood damage for the analyzed storm events.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 1% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final benefit-cost ratio (BCR) with standard benefits was determined to be 0.03. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4M**.

The project report, “Kingwood Drainage Study” dated July 2020, includes documentation of no adverse impact and shows that WSEs decrease throughout the project area. Using this information along with HCFCD’s no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one page summary attached in **Appendix 5-5**.

Design and Construction of Genoa Red Bluff Detention Basins (63000319)

The Genoa Red Bluff stormwater detention basin project involves the construction of three detention basins along Spring Gully, HCFCD Unit B109-00-00, to address repetitive structural flooding within the Armand Bayou watershed. The basins are located west of Spring Gully and near the intersection of Genoa Red Bluff Road and Fairmont Parkway. The northern and southern detention basin are separated by Genoa Red Bluff Road and provide a combined detention storage of approximately 1,350 ac-ft. The three detention basins are shown in **Figure 5-19**.

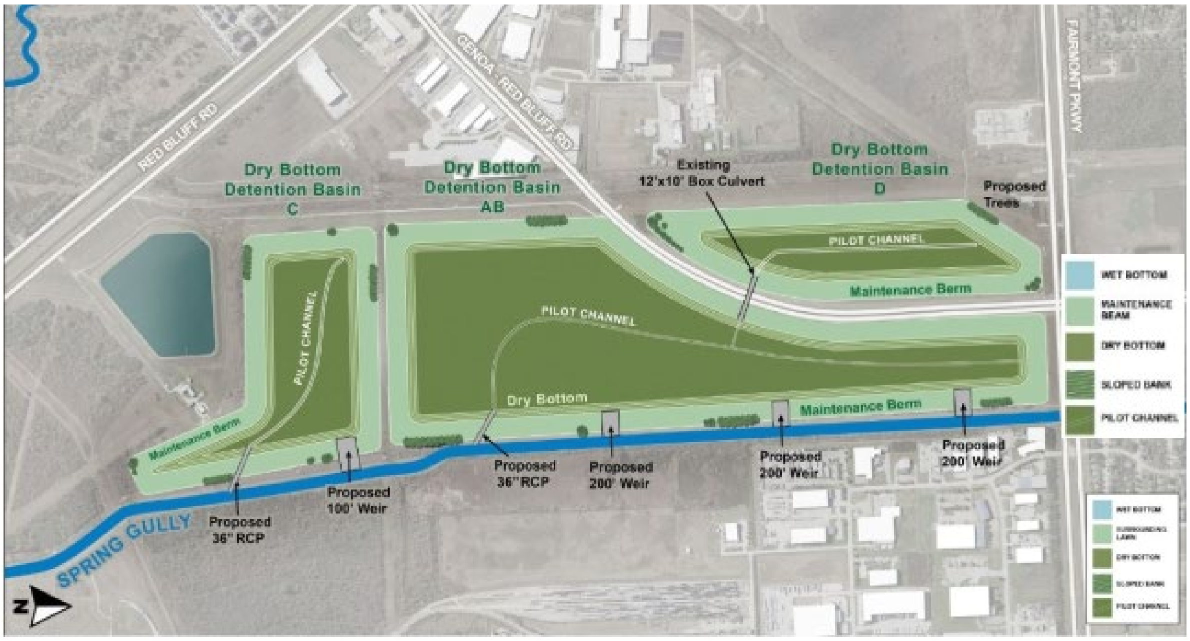


FIGURE 5-19: GENOA RED BLUFF DETENTION BASINS

The H&H modeling completed to support this project utilized Atlas 14 rainfall data to evaluate detention basin alternatives. A BCA was completed utilizing the TWDB BCA Input Tool and FEMA BCA Toolkit. The BCR for the project was 0.01. The methodology used to calculate the BCA can be found in **Appendix 5-4N.**

This project was found to meet no adverse impact requirements and is supported in the report, "Phase 2 Genoa Red Bluff Stormwater Detention Basins Preliminary Engineering Report," dated December 2022. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000319).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Cypress Creek Program Detention Basin Implementation Plan (63000357)

The Cypress Creek Watershed and Major Tributaries Regional Drainage Plan Update was completed in Februrary 2020, and determined that a primary flooding source along Cypress Creek tributaries is elevated WSEs from backwater from the Cypress Creek mainstem. The Implementation Plan, completed in November 2021, evaluated 49 original detention basin sites and ultimately recommended approximately 12,800 ac-ft of detention storage along Cypress Creek provided by 22 detention basins throughout the watershed. The detention basins are shown in **Figure 5-20**.

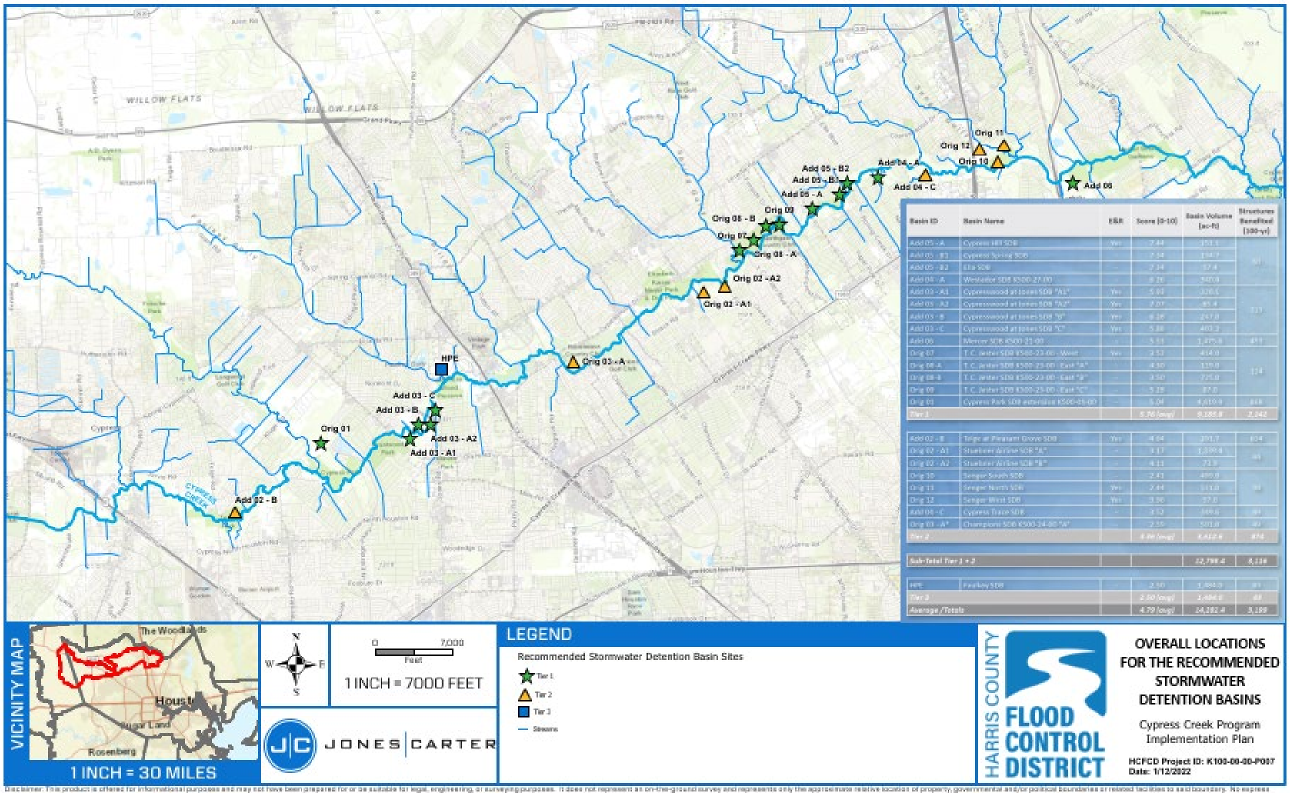


FIGURE 5-20: RECOMMENDED CYPRESS CREEK STORMWATER DETENTION BASINS

The H&H modeling completed to support this project utilized Atlas 14 rainfall data and HEC-RAS to evaluate detention basin alternatives. Future conditions were accounted for in the updated hydrologic modeling to reflect increased runoff volume due to future development. A BCA was completed utilizing the TWDB BCA Input Tool and FEMA BCA Toolkit that determined the BCR for the project was 0.28. The methodology used to perform the BCA is included in **Appendix 5-4O**.

This project was found to meet no adverse impact requirements and is supported in the report, "Cypress Creek Program Implementation Plan (K100-00-00-P007)" dated November 2021 December 2022. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000357).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Design and Construction of Aldine Westfield North Detention Basin (63000396)

The Aldine Westfield North Detention Basin is a wet detention basin proposed as part of the Halls Bayou Watershed Risk Reduction Phase Study completed in 2021. The basin is being constructed in two phases; Phase 1 is currently under construction and Phase 2 involves the ultimate basin expansion and is the focus of this FMP. The basin is located east of P118-21-00, west of Aldine Westfield Road, south of Isom Street, and north of Halls Bayou (HCFCD Unit P118-00-00), as shown in **Figure 5-21**.

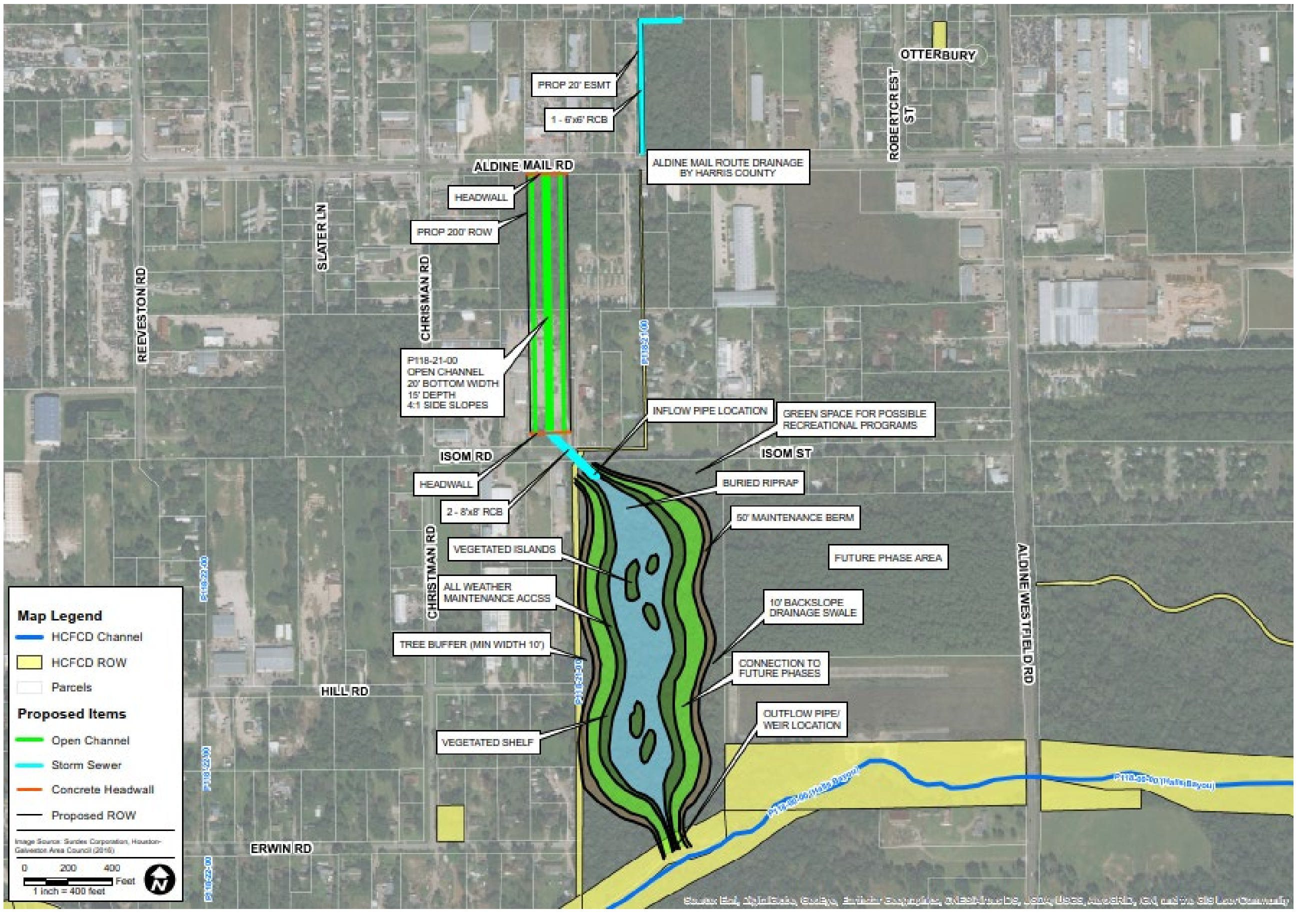


FIGURE 5-21: ALDINE WESTFIELD NORTH DETENTION BASIN

The detention basin is part of an overall flood risk reduction solution that also includes the installation of box culverts and channel improvements upstream to convey flow more effectively to the basin. Box culverts north of Aldine Mail Route Road will convey stormwater from an improved roadway and surrounding neighborhoods. Channel improvements along P118-21-00 currently under construction consist of a grass-lined channel with a 20-foot bottom width and a depth of 15 feet that eventually drains south through new dual 8' x 8' RCBs into the detention basin.

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and HEC-RAS to evaluate a series of drainage improvement alternatives. A BCA was completed utilizing the TWDB BCA Input Tool and FEMA BCA Toolkit that determined the BCR for the project was 0.24 or 0.50 when other benefits such as environmental benefits are taken into account. The methodology used to perform the BCA is documented in **Appendix 5-4P**.

This project was found to meet no adverse impact requirements and is supported in the report, “Excavation of Detention Basins and Channel Conveyance Improvements in P118-21-00: Preliminary Engineering Report” dated December 2019. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000396).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Design and Construction of P118-23-00 Drainage Improvements (63000397)

Drainage improvements to P118-23-00, a tributary to Halls Bayou, include the construction of detention basins along P118-23-00 and concrete-lining P118-23-02. Three detention basins are located between Gulf Bank Road and Carby Road and provide a combined 142 ac-ft of detention storage. An additional detention basin is located at the confluence of P118-23-00 and Halls Bayou, which provides 158 ac-ft of detention storage. Channel improvements along P118-23-02 consist of a concrete-lined channel with a lower rectangular section (15-foot bottom width and 4-foot depth) and a trapezoidal section above. The drainage improvements are shown in **Figure 5-22**.

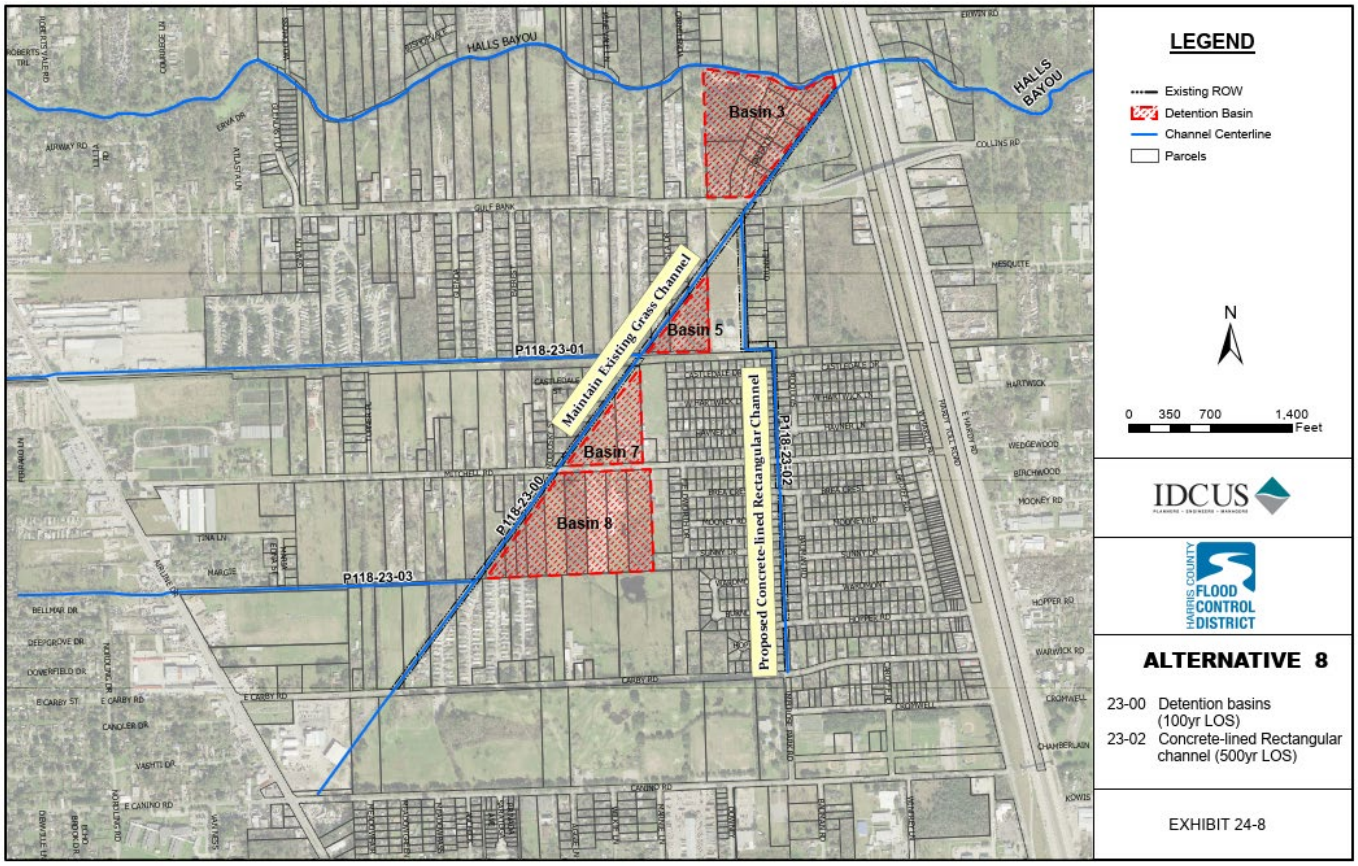


FIGURE 5-22: RECOMMENDED P118-23-00 DRAINAGE IMPROVEMENTS

The project reduces flood risk by adding detention storage and improving the P118-23-02 channel. The recommended alternative increases the Level of Service to the 1% AEP event for P118-23-00 and the 0.2% AEP event for P118-23-02.

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and HEC-HMS/HEC-RAS. The H&H modeling used to perform the alternative analysis was based on the Halls Bayou Watershed Flood Risk Reduction Phasing Study.

A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit that determined the BCR for the project was 0.48 when other social and environmental benefits are taken into account. The methodology used to perform the BCA is documented in **Appendix 5-4Q**.

This project was found to meet no adverse impact requirements and is supported in the report, "Halls Bayou Tributaries P118-230-00 and P118-23-02 Alternatives Analysis" dated February 2020. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000397).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Design and Construction of P118-25-00 & P118-25-01 Drainage Improvements (63000399)

Drainage improvements to P118-25-00 and P118-25-01, both tributaries of Halls Bayou, include the construction of a detention basin, widening of existing channels, and an extension of P118-25-01. The detention basin is located near the intersection of Sellers Road and Aldine Mail Route Road and provides 46 ac-ft of detention storage. A widened channel along P118-25-00 and P118-25-01 consists of a grass-lined channel (25-foot bottom width and 8-foot depth) to provide increased conveyance capacity. Furthermore, the P118-25-01 channel is extended roughly 2,500 feet to Hollyvale Road. In addition, structural improvements to the P118-25-01 culvert crossing Aldine Mail Route Road and a temporary sheet piling restrictor upstream of Hill Road needed to avoid adverse increases downstream were proposed. The drainage improvements are shown in **Figure 5-23**.

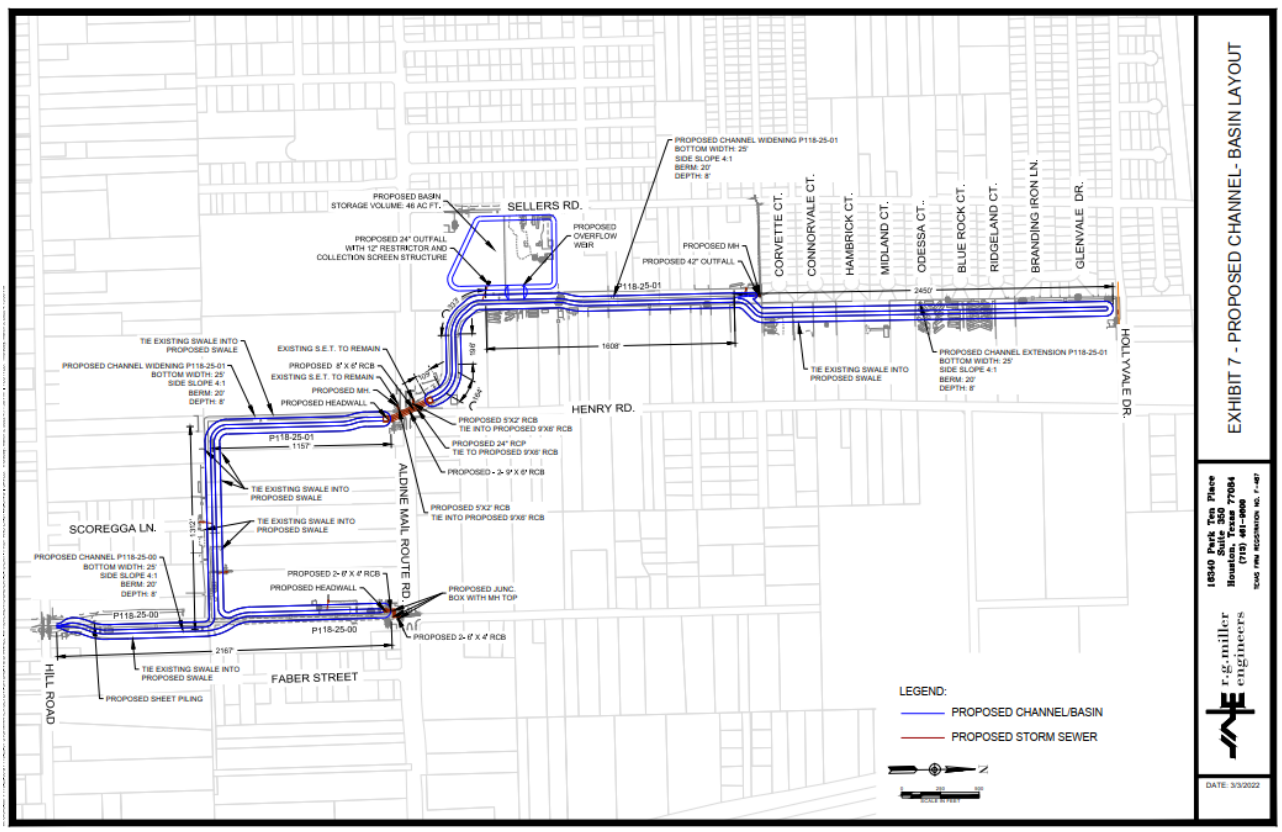


FIGURE 5-23: RECOMMENDED P118-25-00 & P118-25-01 DRAINAGE IMPROVEMENTS

The project reduces flood risk by adding detention storage and improving channel conveyance. The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and HEC-RAS. The H&H modeling used to perform the alternative analysis was based on the Halls Bayou Watershed Flood Risk

Reduction Phasing Study. A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit that determined the BCR for the project was 0.96 when other social and environmental benefits are taken into account. The methodology used to perform the BCA is documented in **Appendix 5-4R**.

This project was found to meet no adverse impact requirements and is supported in the report, "P118-25-00 and Tributaries Conveyance and Detention Improvements Preliminary Engineering Report" dated April 2022. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000399).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Design and Construction of P118-27-00 Drainage Improvements (63000400)

Drainage improvements to P118-27-00, a tributary of Halls Bayou, include the construction of a detention basin and channel improvements. The detention basin is located near the intersection of confluence of P118-27-00 and Halls Bayou and provides 85 ac-ft of detention storage. Approximately 3,000 feet of P118-27-00 will be improved from the existing concrete-lined channel section to the Pin Oak Mobile Home Community. The improved channel will be concrete-lined with a 6-foot bottom width. In addition, structural improvements to the Gulf Bank Road culverts are proposed that will replace the existing dual 60-inch RCPs with dual 10' x 8' RCBs.

The project reduces flood risk by providing a 1% AEP event Level of Service for P118-27-00 and adding detention storage. The drainage improvements are shown in **Figure 5-24**.

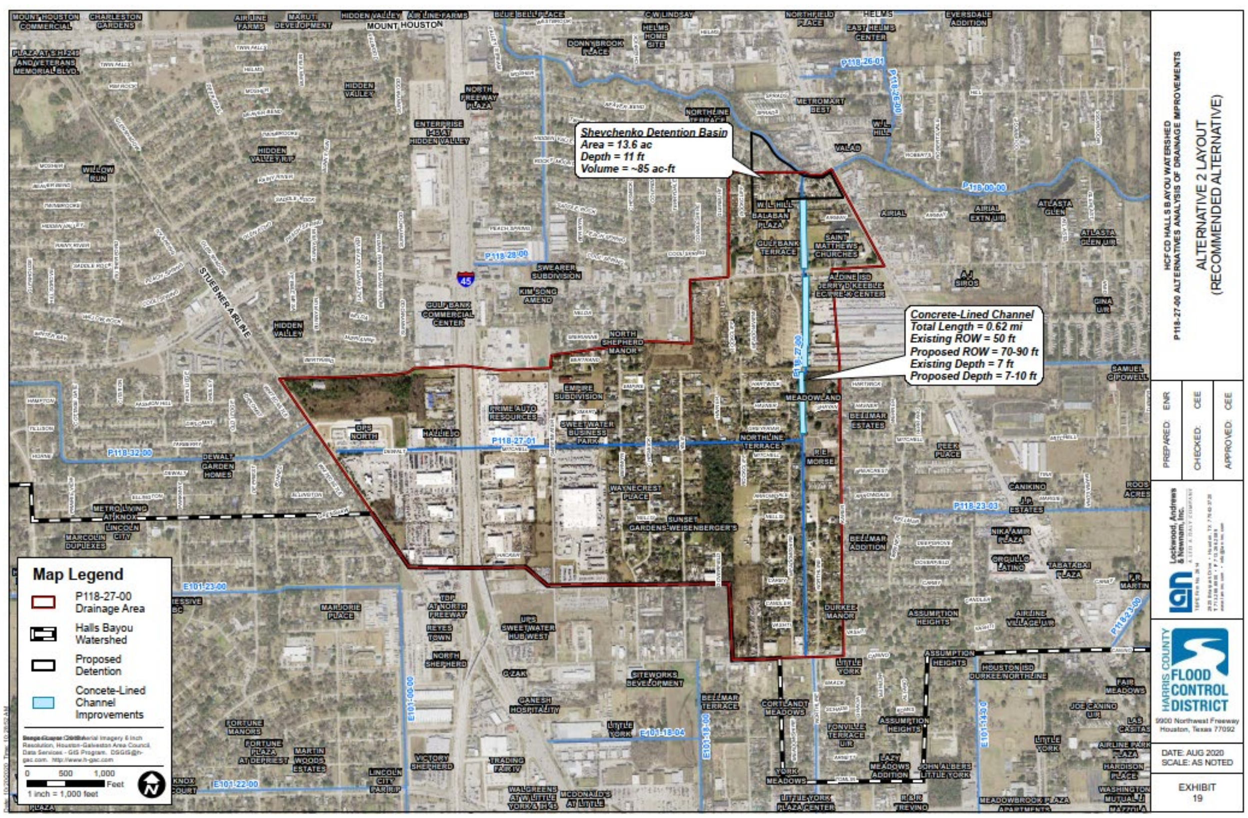


FIGURE 5-24: RECOMMENDED P118-27-00 DRAINAGE IMPROVEMENTS

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and HEC-RAS to evaluate drainage improvement alternatives. The H&H modeling used to perform the alternative analysis was based on the Halls Bayou Watershed Flood Risk Reduction Phasing Study and included two different tailwater condition scenarios. A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit that determined the BCR for the project was 1.51 when social and environmental benefits are taken into account. The methodology used to perform the BCA is documented in **Appendix 5-4S**.

This project was found to meet no adverse impact requirements and is supported in the report, "Halls Bayou Tributary Unit No. P118-27-00 Alternatives Analysis Summary Report" dated December 2020. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000400).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Mainstem Evaluation Projects – Veterans Memorial (2018 Bond Project C-41) (63000469)

The Veterans Memorial Detention Basins are comprised of three basins identified as Veterans Memorial A, B and C. For the purposes of the San Jacinto Regional Flood Plan, Harris County Flood Control District selected Basin A for study and inclusion in the plan. Basin A provides approximately 460 acre-feet of storage within the Halls Bayou watershed. The basin reduces maximum water surface elevations in the 100-year and 500-year storm events. In addition, the proposed storage is essential for future channel improvements along Halls Bayou and its surrounding tributaries. The drainage improvements are shown in **Figure 5-25**.

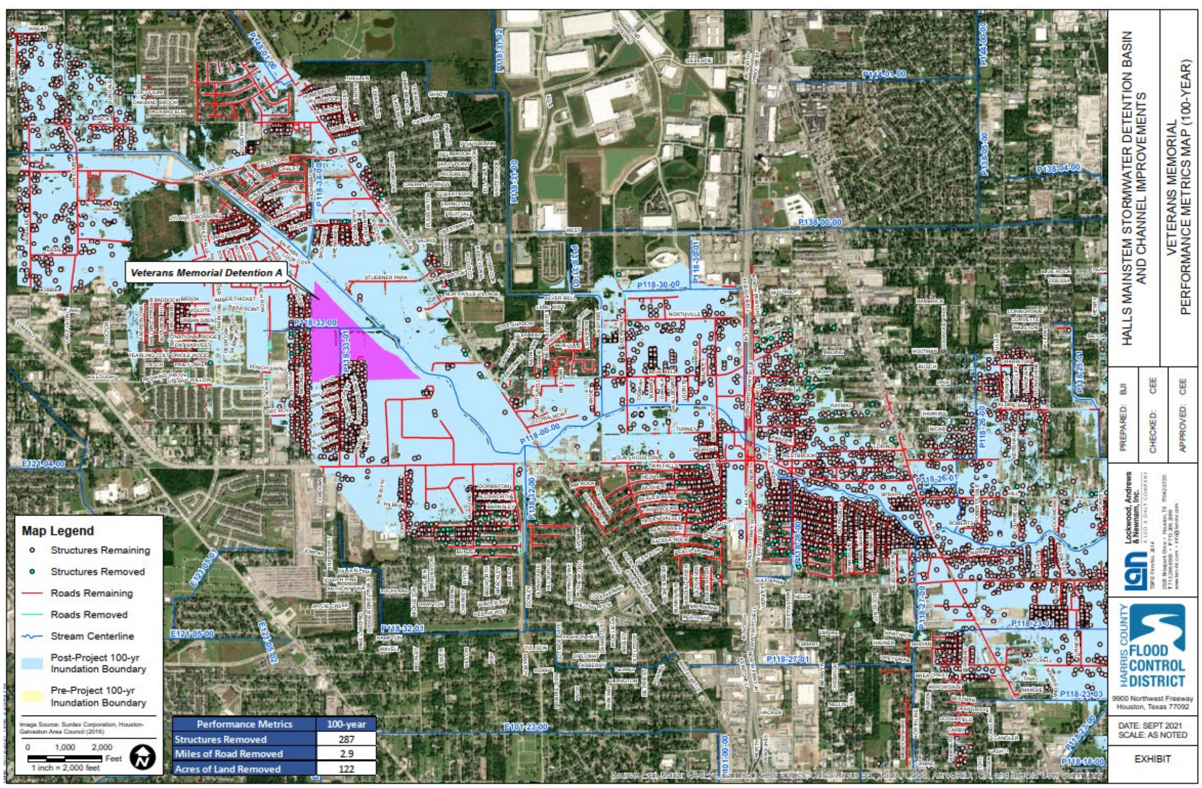


FIGURE 5-25: VETERANS MEMORIAL BASIN A

The hydraulic and hydrologic modeling completed to support this project utilizes Atlas 14 rainfall and HEC-RAS. A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit v6.0.0. that determined the BCR for the project was 0.49. The methodology used to perform the BCA is documented in **Appendix 5-4AS.**

This project was found to meet no adverse impact requirements and is supported in the memorandum "Veterans Memorial Detention Basin" dated September 2021. This study was based off best available information. Further no adverse impact documentation is supported with an associated model (ID 060000000469).

Design and Construction of P118-26-00 Drainage Improvements (63000470)

Drainage improvements to P118-26-00, a tributary of Halls Bayou, include the construction of detention basins and conversion of an open channel to storm sewer. Installation of new storm sewer (triple 9' x 9' RCBs) was recommended to increase the conveyance capacity within the limited existing HCFCD ROW upstream of Helms Road. The detention basins are located east of P118-26-00 north and south of Helms Road and provide approximately 170 ac-ft of detention storage. In addition, a flow restrictor is recommended to prevent adverse impacts to Halls Bayou from the increased conveyance of P118-26-00. The drainage improvements are shown in **Figure 5-26**.

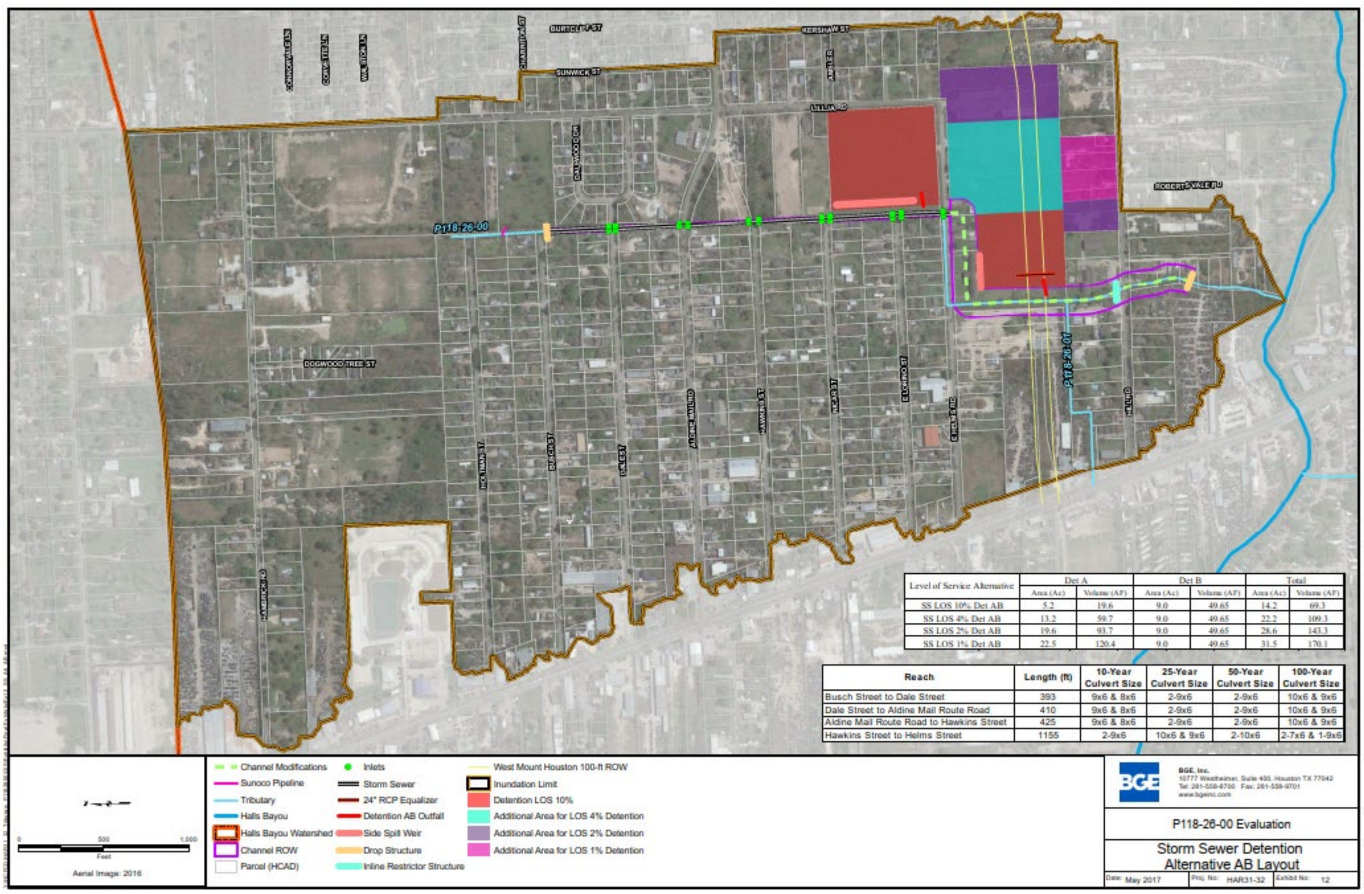


FIGURE 5-26: RECOMMENDED P118-26-00 DRAINAGE IMPROVEMENTS

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data. A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit v6.0.0. that determined the BCR for the project was 2.34, when social and environmental benefits are taken into account. The methodology used to perform the BCA is documented in **Appendix 5-4T.**

This project was found to meet no adverse impact requirements and is supported in the report, "P118-26-00 Evaluation Report for Flood Damage Reduction," dated May 2017. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4**. Further no adverse impact documentation is supported with an associated model (ID 060000000470).

Design and Construction of Parker Road Drainage Improvements (63000471)

The Parker Road drainage improvements consists of four detention basins and channel improvemnts along Halls Bayou (P118-00-00). The basins provide approximatley 602 ac-ft of detention storage and are located on both sides of Halls Bayou north and south of Parker Road. In addition, channel widening is proposed in the vicinity of the detention basins to further reduce WSEs and increase the channel Level of Service to the 0.2% AEP event for the improved segment of Halls Bayou. The drainage improvements are shown in **Figure 5-27**.

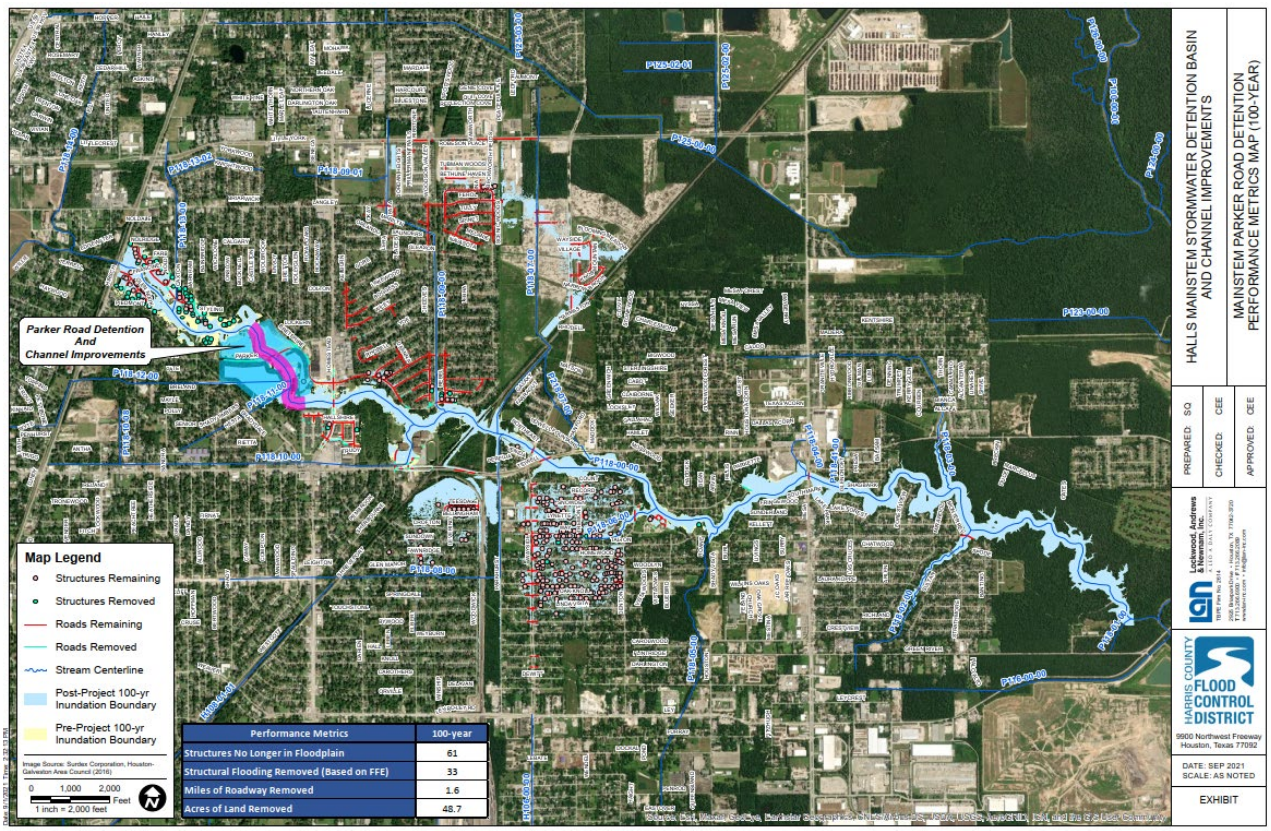


FIGURE 5-27: RECOMMENDED PARKER ROAD DRAINAGE IMPROVEMENTS

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and HEC-RAS. A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit that determined the BCR for the project was 0.18 when social and environmental benefits are taken into account. The methodology used to perform the BCA is documented in **Appendix 5-4U**.

This project was found to meet no adverse impact requirements and is supported in the report dated June 2021. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000471).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Design and Construction of Upper South Mayde Creek Detention Basins (63000472)

This project consists of a series of regional detention basins located in the upstream portion of South Mayde Creek to reduce flood risk by lowering peak channel flows and WSEs. The recommended Alternative 4 includes seven detention basins (Basins E1N, E1S, E2, W1, W2, W3, and W4). These basins provide roughly 854 ac-ft of detention storage.

Based on recent HCFCD ROW acquisition, Alternative 5 (Basins W2, W3, and W4) was recommended as a short-term solution until remaining ROW acquisition is completed and funding becomes available. These three detention basins provide approximately 226 ac-ft of detention storage. The Alternative 5 basins are the focus of this FMP.

The detention basins are located north of the intersection of Clay Road and south of Stockdick School Road on either side of both the Grand Parkway (SH 99) and South Mayde Creek. The detention basins are shown in **Figure 5-28**.

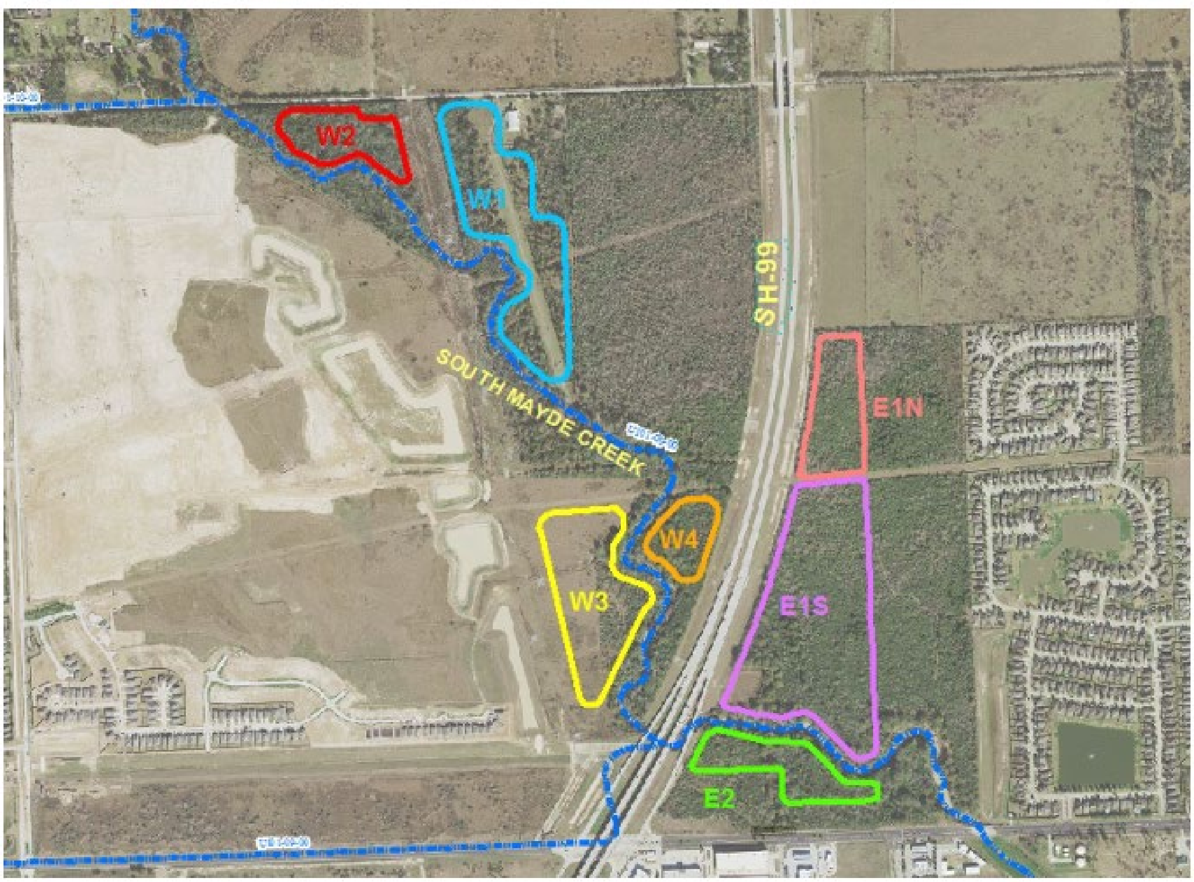


FIGURE 5-28: SOUTH MAYDE CREEK GRAND PARKWAY DETENTION BASINS

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and HEC-RAS. A BCA was completed utilizing the TWDB BCA Input Tool and the FEMA BCA Toolkit that determined the BCR for the project was 0.18. The methodology used to perform the BCA is documented in **Appendix 5-4V**.

This project was found to meet no adverse impact requirements and is supported in the report, "South Mayde Creek Grand Parkway at Clay Stormwater Detention Basin Preliminary Engineering Report" dated June 2021. This study was based on best available information, was certified by a professional engineer. Further no impact documentation is supported with an associated model (ID 060000000472).

For a summary and additional information on this project refer to the one-page summary attached in **Appendix 5-5**.

Design and Construction of Little York Stormwater Detention Basin (63000473)

The Little York stormwater detention basin will be a regional detention basin located along the north and south overbanks of Langham Creek, north of West Little York Road and West of Highway 6. The basins are within the Addicks Reservoir watershed. The proposed project will consist of three detention basin cells. The goal of the project was aimed at mitigating the peak discharges associated with new upstream developments within Langham Creek as shown in **Figure 5-29**.

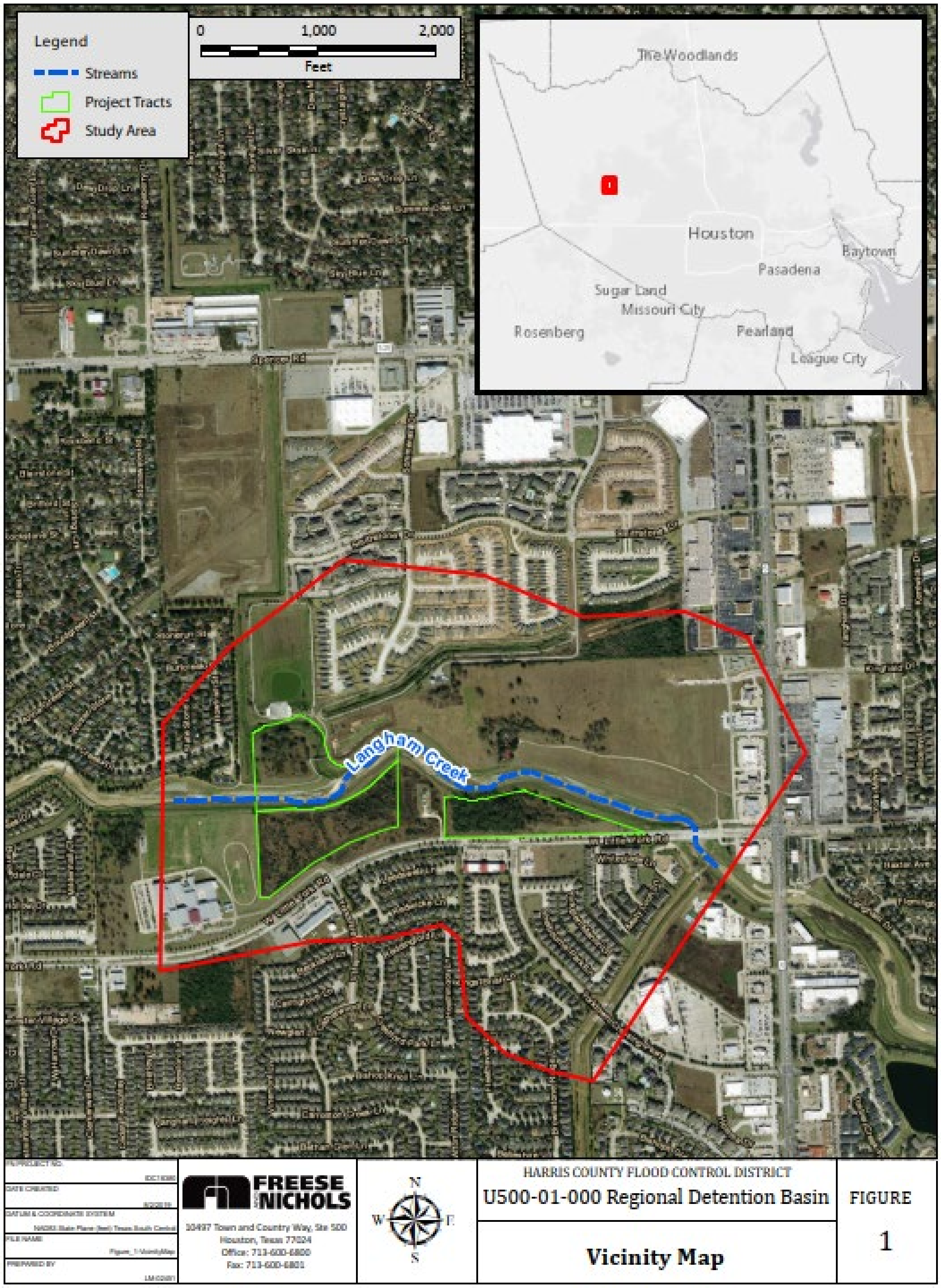


FIGURE 5-29: LITTLE YORK DETENTION BASIN

The project reduces flood risk by adding detention. Based on various forms of hydraulic analysis, the project reduces ponding for multiple structures (residential and commercial) during the 100-year storm event.

As mentioned above were the tools and approach used to create a BCR, which concluded a 0.05 for this project. More details on the methodology used in the BCA can be provided in **Appendix 5-4W**.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data and HEC-RAS. Hydraulic results were provided in raster format for both the 1.0% and 0.2% ACE for both pre-project and post-project conditions. The analysis of benefit and flood risk reduction provided and performed for this FMP were based on the above-mentioned raster results under a process developed by the San Jacinto RFPG.

This project was found to meet no adverse impact requirements and is supported in the report, "Drainage Impact Analysis for U500-01-00-E001 Regional Detention Basin Along Langham Creek (U100-00-00)" dated January 2020. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4**. Further no adverse impact documentation is supported with an associated model (ID 060000000473).

Main Stem Evaluation Projects – Hahl Basin (63000475)

The Hahl North basin is a proposed dry-bottom detention basins and associated channel widening project in the Halls Bayou watershed. This project is bounded by P118-21-00 to the east, Hardy Toll Road to the west, Hill Road to the north, and Halls Bayou to the south. This basin provides additional storage along Halls Bayou and the surrounding tributaries. Although benefits to this project are small, this project could be utilized in conjunction with other projects in Halls Bayou to reduce flood risks. The goal of the project was aimed at mitigating the risk of riverine flooding in the northern area of Harris County as shown in **Figure 5-30**.

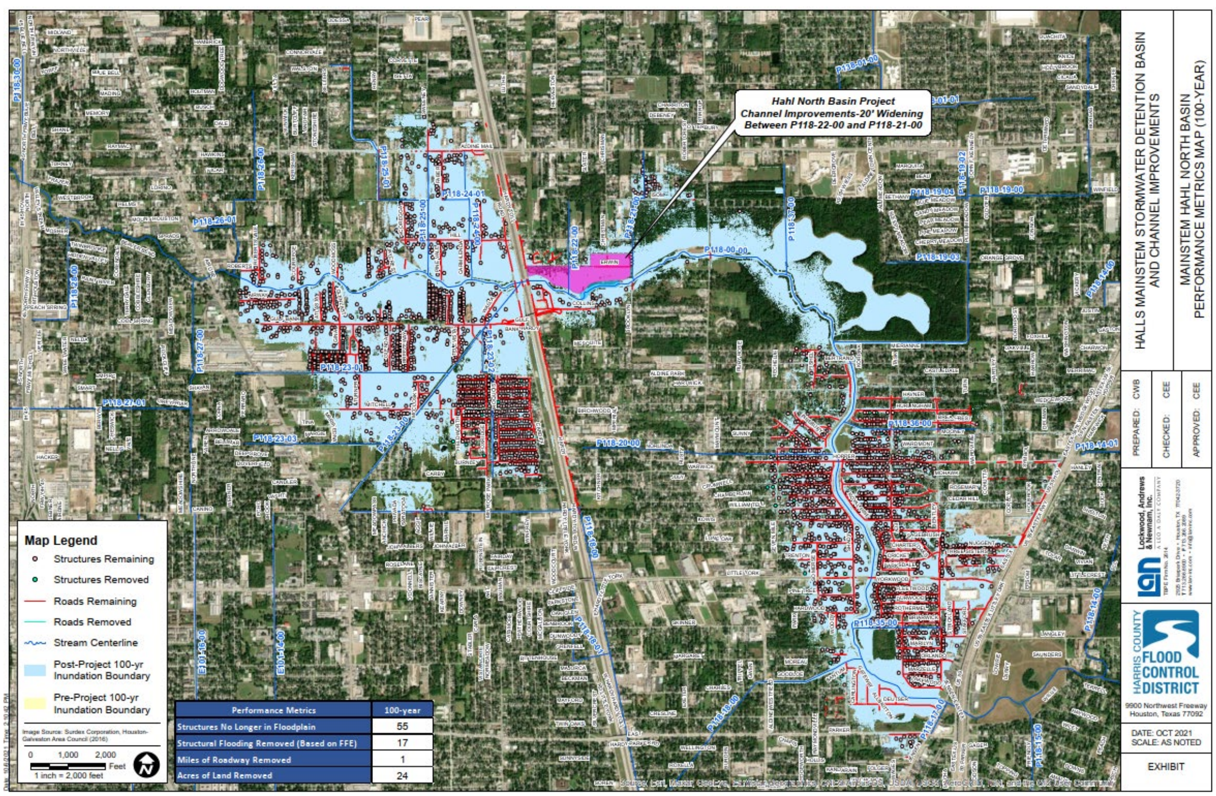


FIGURE 5-30: HAHL NORTH BASIN

As mentioned above were the tools and approach used to create a BCR, which concluded a 0.21 for this project. More details on the methodology used in the BCA can be provided in **Appendix 5-4X**.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data and HEC-RAS. Hydraulic results were provided in raster format for both the 1.0% and 0.2% ACE for both pre-project and post-project conditions. The analysis of benefit and flood risk reduction provided and performed for this FMP were based on the above-mentioned raster results under a process developed by the San Jacinto RFPG.

This project was found to meet no adverse impact requirements and is supported in the memorandum, “Hall North Detention Basin” dated September 2021. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000475).

Cypress Creek Watershed Major Tributaries Regional Drainage Plan Update (063000476)

The Cypress Creek Watershed Major Tributaries Regional Drainage Plan Update was completed in an effort to evaluate the benefits for proposed detention improvements within Cypress Creek based on updated HCFCD criteria. The update specifically focused on Alternative 1 Basins K500-01 and Stuebner Airline Road (HCFCD 2018 Bond Projects CI-36 and CI-20). The project is composed of various stormwater detention basins to reduce flood risk in the area. The project is generally located along Cypress Creek at North Eldridge Parkway and Stuebner Airline Roads. The goal of the project was aimed at mitigating the risk of riverine flooding in the northwestern area of Harris County as shown in **Figure 5-31**.

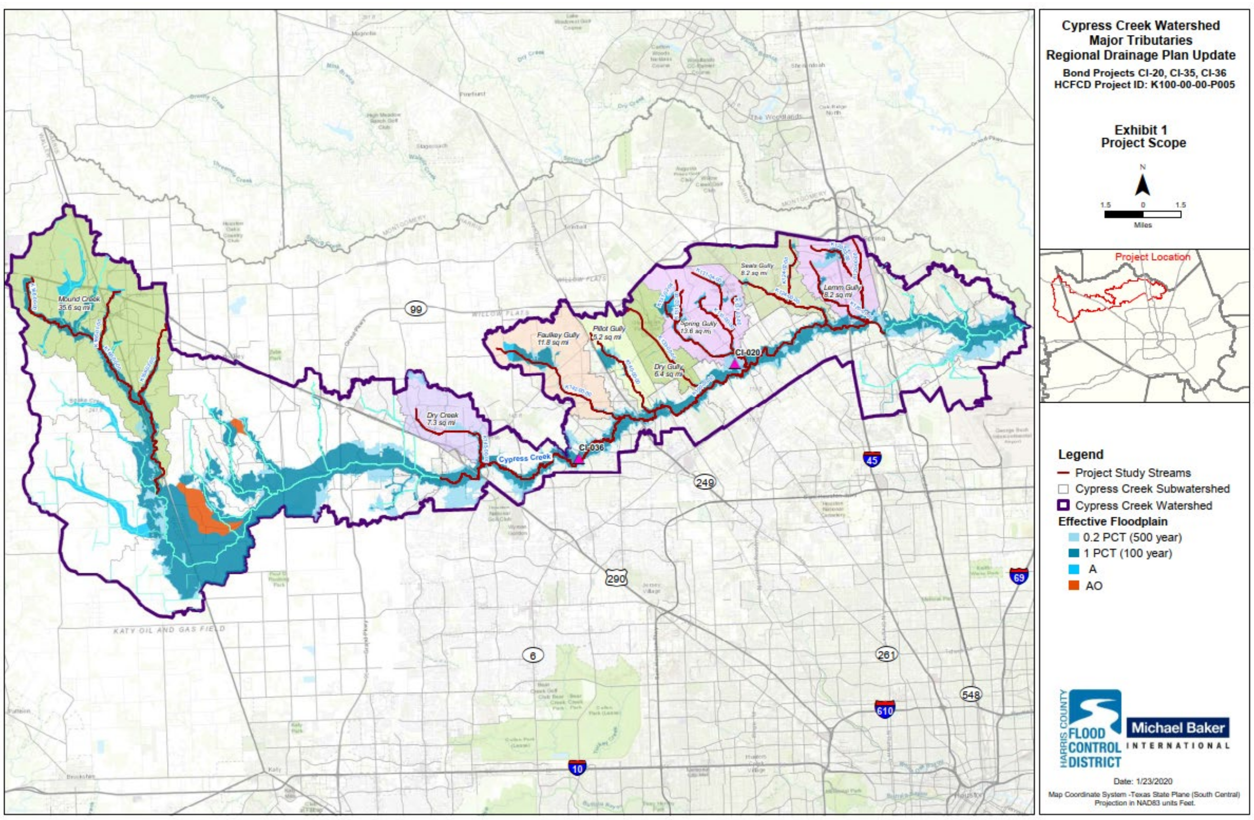


FIGURE 5-31: CYPRESS CREEK REGIONAL DRAINAGE PLAN UPDATE

As mentioned above were the tools and approach used to create a BCR, which concluded a 0.39 for this project. More details on the methodology used in the BCA can be provided in **Appendix 5-4Y**.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for both the 1.0% and 0.2% ACE for both pre-project and post-project conditions. The analysis of benefit and flood risk reduction provided and performed for this FMP were based on the referenced raster results under a process developed by the San Jacinto RFPG.

This project was found to meet no adverse impact requirements and is supported in the report, “Cypress Creek Watershed Major Tributaries Regional Drainage Plan Update,” dated February 2020. This study was based on best available information, was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 060000000476).

Lower South Mayde Creek Conveyance Improvements (063000315)

South Mayde Creek is a major tributary to the Addicks Reservoir located in western Harris County. The South Mayde Creek watershed has experienced repeated structural and roadway flooding over the past decade. The channel transitions from an engineered channel upstream of Greenhouse Road to a heavily vegetated channel downstream with a significantly reduced conveyance capacity. This reduced capacity along with a hydraulic restriction at the Greenhouse Road bridge results in higher WSEs throughout the lower portion of South Mayde Creek that leads to flooding of the adjacent neighborhoods and flooding of key roadways that impact local mobility. The project includes the following drainage improvements:

- Channel benching within the existing Right-of-Way between Fry Road and Greenhouse Road to increase the conveyance capacity of the channel and reduce WSEs;
- Construction of a new bypass channel incorporating Natural Stable Channel Design features between Greenhouse Road and Barker Cypress Road to more effectively convey water east into Addicks Reservoir; and,
- Construction of two upstream regional detention basins, the Sprint Sand & Clay southern basin and the Original Sandpit northern basin, to mitigate for peak flow increases due to the channel improvements and bypass channel.

The Sprint Sand & Clay basin is located south of South Mayde Creek between Raintree Village Drive and Fry Road and will provide roughly 579 ac-ft of detention storage. The Original Sandpit basin is also located south of South Mayde Creek farther upstream between Raintree Village Drive and Morton Road and will provide 404 ac-ft of detention storage.

These improvements can be implemented separately with each providing incremental benefits, although a phased implementation plan was developed based on permitting/mitigation strategy and available funding. Mitigation for the conveyance improvements is provided by two upstream regional detention basins that when combined with the conveyance improvements form a comprehensive flood risk reduction solution. The project improvements are shown in **Figure 5-32**.

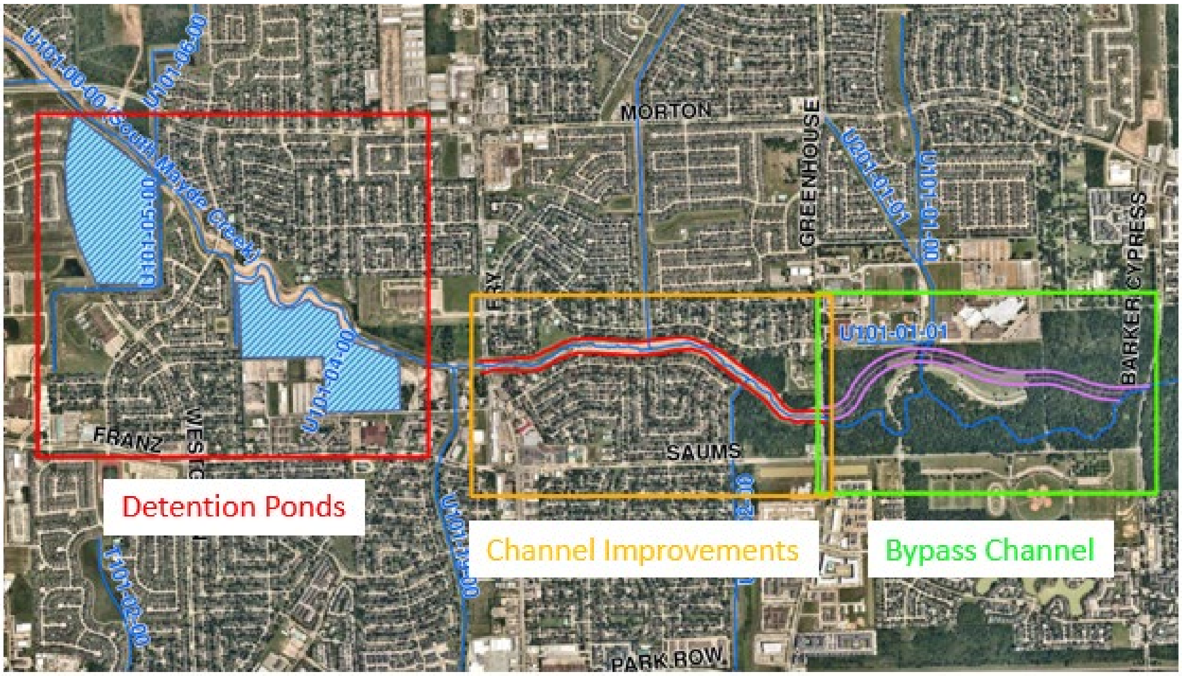


FIGURE 5-32: LOWER SOUTH MAYDE CREEK PROJECT COMPONENTS

This project is expected to reduce structural and roadway flooding in the surrounding areas by lowering peak flow rates within the channel and decreasing WSEs along South Mayde Creek. The calculated BCR of the project was found to be 0.73, documentation on the methodology used to calculate the BCA can be found in **Appendix 5-4Z**.

HCFCD is the project sponsor with the USACE being a key stakeholder since the bypass channel would be constructed within the Addicks Reservoir federal property boundary. HCFCD would be responsible for continued maintenance of the drainage infrastructure.

The project will be mitigated with two regional detention basins upstream of the proposed conveyance improvements. The project was found to meet no adverse impact requirements and is supported in the report, "Lower South Mayde Creek (U101-00-00) Bypass Channel and Channel Improvements Preliminary Engineering Report," dated September 2020. This study was based on best available information and was certified by a professional engineer. Further no adverse impact documentation is supported with an associated model (ID 06000000315). For a summary and additional information on this project refer to the one-page summary in **Appendix 5-5**.

White Oak Bayou – Woodland Trails Stormwater Detention Basin (063000344)

This project was developed as part of a comprehensive watershed evaluation of White Oak Bayou to identify projects to reduce riverine flood risk. The proposed project objective is to reduce the existing flood risk along the White Oak Bayou mainstem by lowering peak flows and WSEs. The proposed project includes an approximate 1,924 acre-feet detention basin with amenity features potentially including a hike and bike trail, recreational park, and a natural vegetated shelf comprised of native plant life. **Figure 5-33** shows the location of the proposed project.

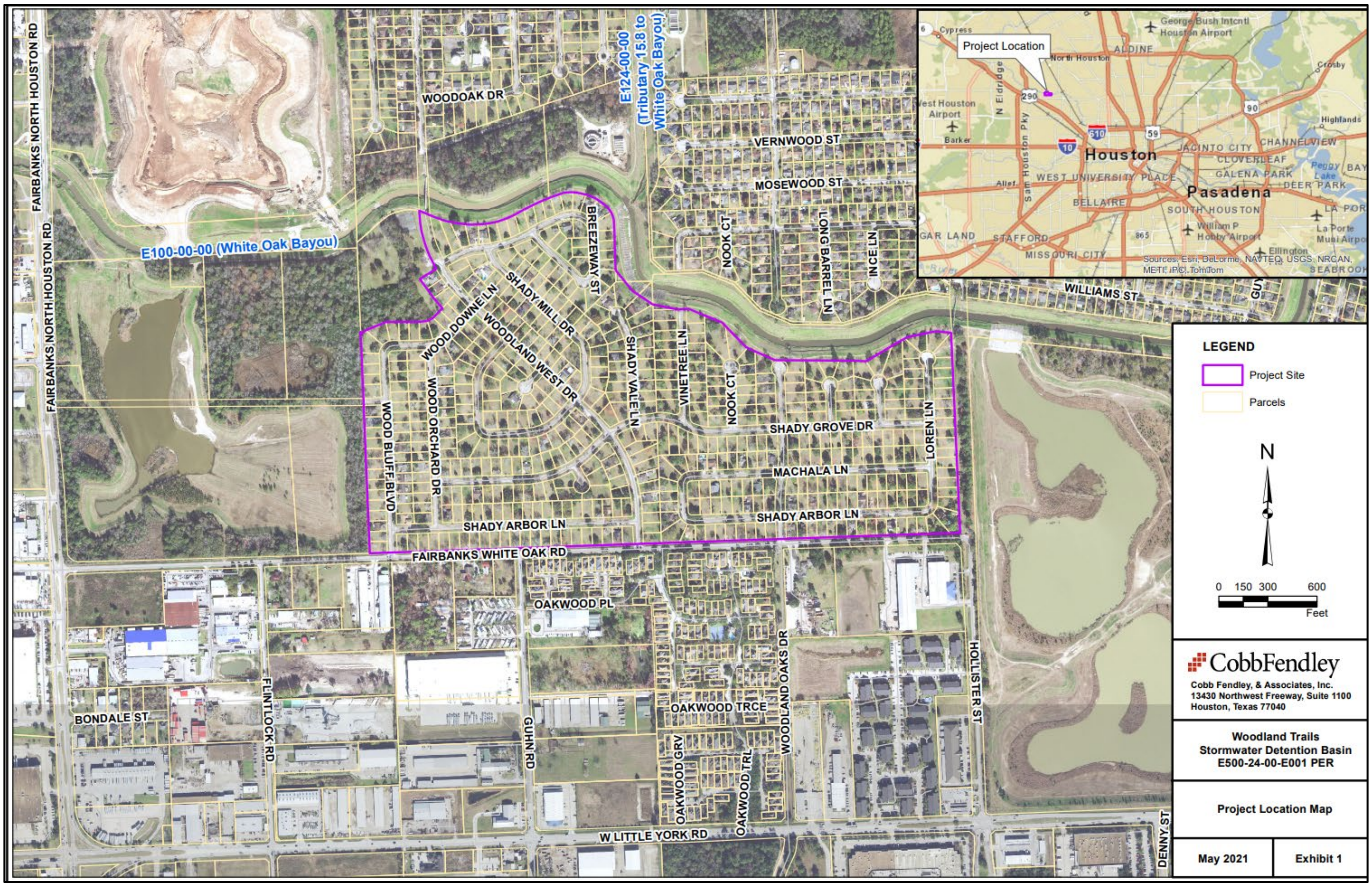


FIGURE 5-33: WOODLAND TRAILS STORMWATER DETENTION BASIN PROJECT AREA

The project reduces flood risk through the construction of detention storage for a total estimated cost of $43 million. Based on the hydraulic analysis conducted for the project development, the project removes many structures from potential flood damage for all analyzed storm events.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 0.2%, 1%, and 10% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 1.89. No other benefits, i.e., recreation, roadway, etc. were analyzed during this analysis. More details on the methodology used for the BCA are provided in **Appendix 5-4AA**.

The hydraulic modeling for the proposed detention basin showed no adverse impacts between the existing and proposed conditions results. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Willow Creek – M120 Detention and Preservation Project (063000339)

This project was developed as part of a comprehensive watershed evaluation of Willow Creek to identify projects to reduce riverine flood risk. The proposed project objectives are to reduce flows and flood levels in Willow Creek, preserve quality of existing riparian forest and habitat, create passive and/or active recreation opportunities, and provide for potential partial mitigation of future improvements to Willow Creek. The proposed project includes a 1,640 ac-ft detention basin and 85 acres of floodplain preservation area. **Figure 5-34** shows the location of the proposed project.

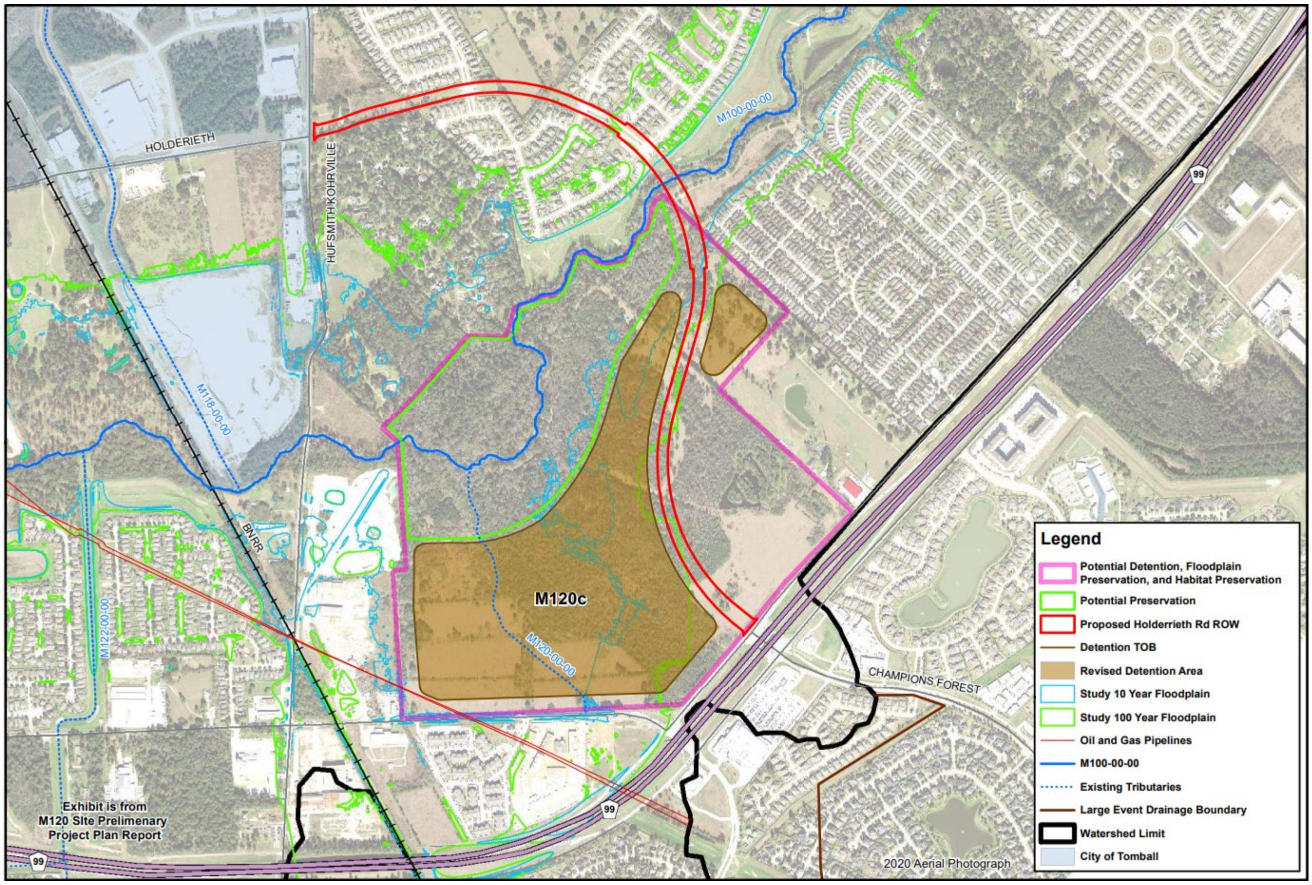


FIGURE 5-34: M120 DETENTION AND PRESERVATION PROJECT AREA

The project reduces flood risk through the construction of detention storage. Based on the hydraulic analysis conducted for the project development, the project removes many structures from potential flood damage for all analyzed storm events.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 0.2%, 1%, and 10% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.80. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4AB**.

The hydraulic modeling for the proposed detention basin showed no adverse impacts between the existing and proposed conditions results. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

P118-E006 (Hardy West) (2018 Bond Project C-41) (063000477)

This project was developed as part of an alternative analysis study of the Hardy West area to improve drainage conditions along Halls Bayou and to mitigate flood risks in the contributing drainage area. The proposed improvement includes two detention ponds to provide approximately 400 ac-ft of additional storage volume in this area. **Figure 5-35**, shows the location of the proposed project.

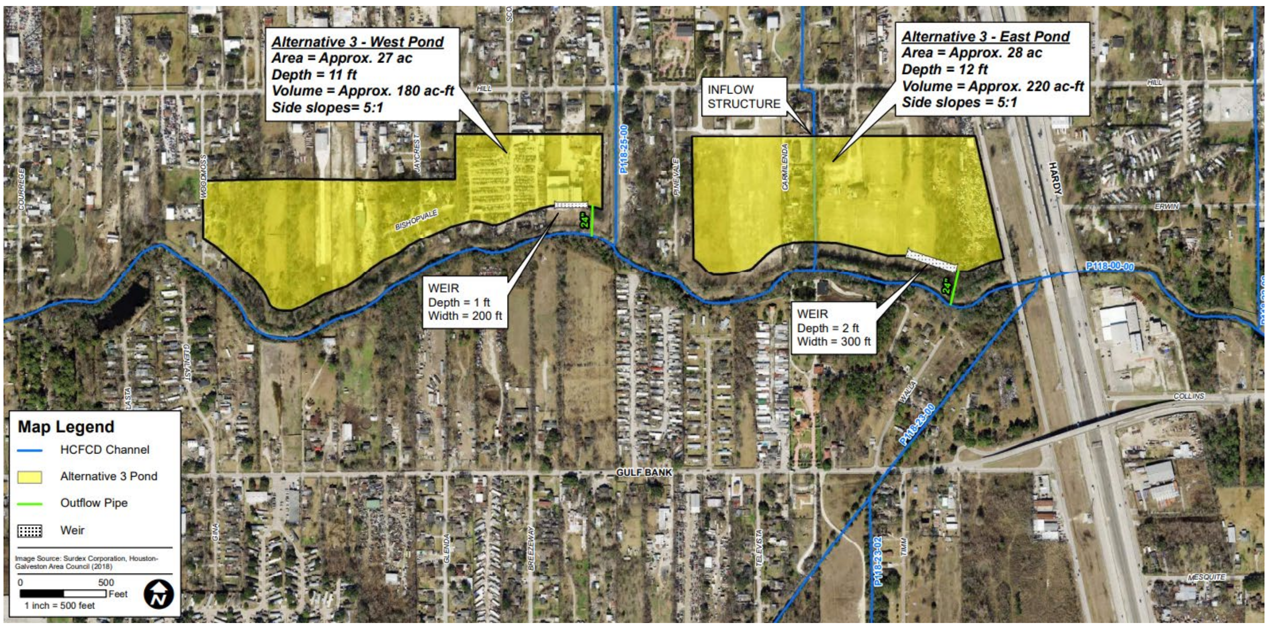


FIGURE 5-35: HARDY WEST DETENTION PONDS

The project reduces flood risk through the construction of detention storage. Based on the hydraulic analysis conducted for the project development, the project removes 41 structures and 0.8 miles of roadway from potential flood damage in the 0.2% ACE flood.

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data, based on Harris County Hydrologic Region 2. The project also provides 0.2% ACE results to approximate Atlas 14 1.0% ACE conditions. Hydraulic results were provided in raster format for the 1% and 0.2% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.38. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4AC.**

The project report developed for this project includes documentation of no adverse impact. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one page summary attached in **Appendix 5-5**.

Design and Construction of Dinner Creek Stormwater Detention Basin (2018 Bond Project C-38) (063000313)

This project was developed as part of a conceptual design for improvements to Stormwater Detention Basins HCFCD Unit No. U510-1-00 located In Cypress, Texas, along Dinner Creek, a tributary to Langham Creek. The proposed improvements include expanding the existing basin to create four individual wet bottoms basins. **Figure 5-36** displays the project area.

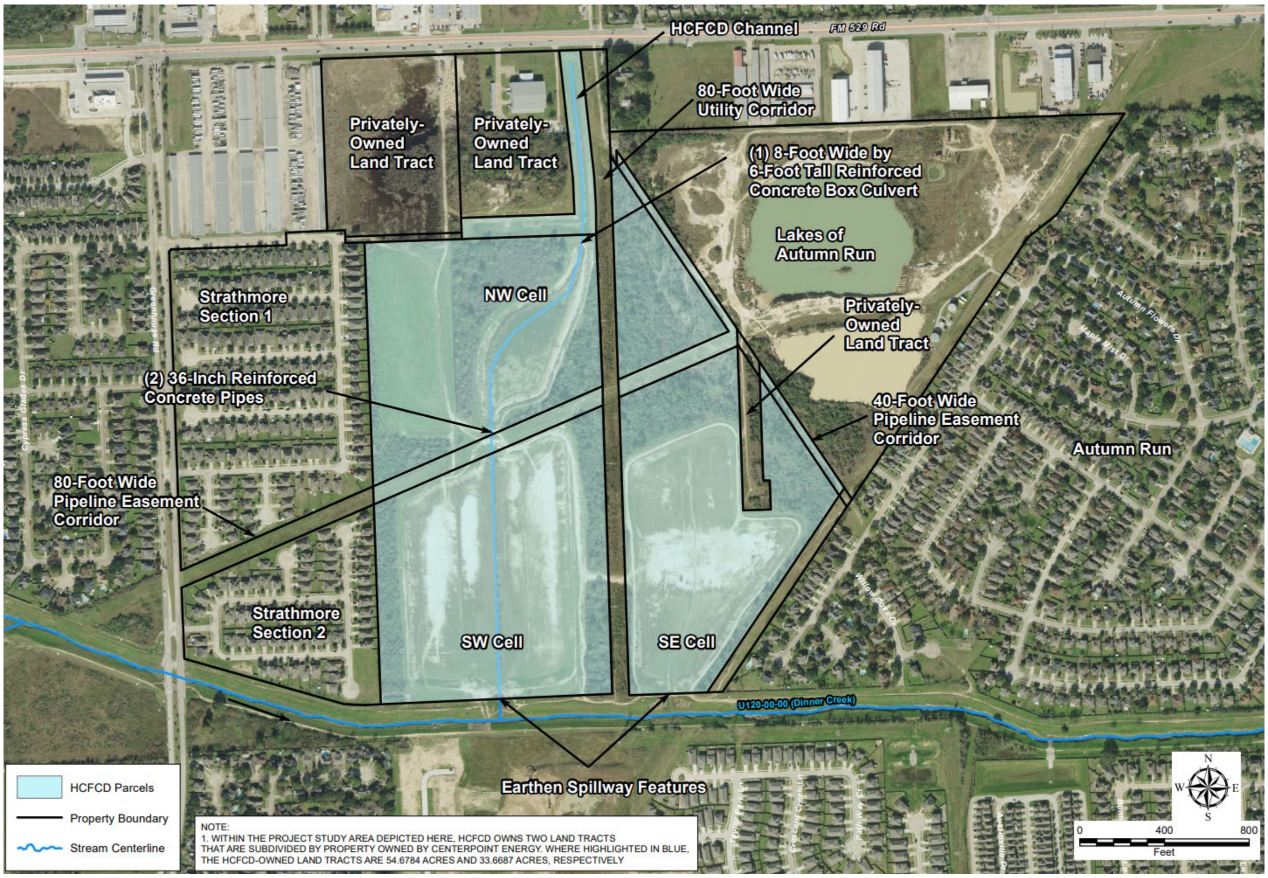


FIGURE 5-36: DINNER CREEK STORMWATER DETENTION BASIN OVERVIEW OF PROJECT AREA

The project would remove the 1% ACE floodplain from the impacted multi-family structures downstream, achieving a 1% ACE of service within Dinner Creek and Langham Creek downstream of U520-01-00, as well as providing volume dedicated to retention.

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data and provides 500-year results to approximate Atlas 14 100-year event conditions. Hydraulic results were provided in raster format for the 1% and 0.2% ACE for both pre-project and post-project conditions.

The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.04. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4AD**.

The project report developed for this project includes documentation of no adverse impact. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5.**

Poor Farm Ditch (063000186)

This project was developed as part of a conceptual design for improvements to Poor Farm Ditch, HCFCD Unit No. D111-00-00, located between Bellaire and University Boulevards. The proposed improvements include a trapezoidal channel with reinforced concrete slope pavement anchored by permanent soil nails extending to the proposed 40-feet of HCFCD right-of-way. **Figure 5-37** displays the project area.

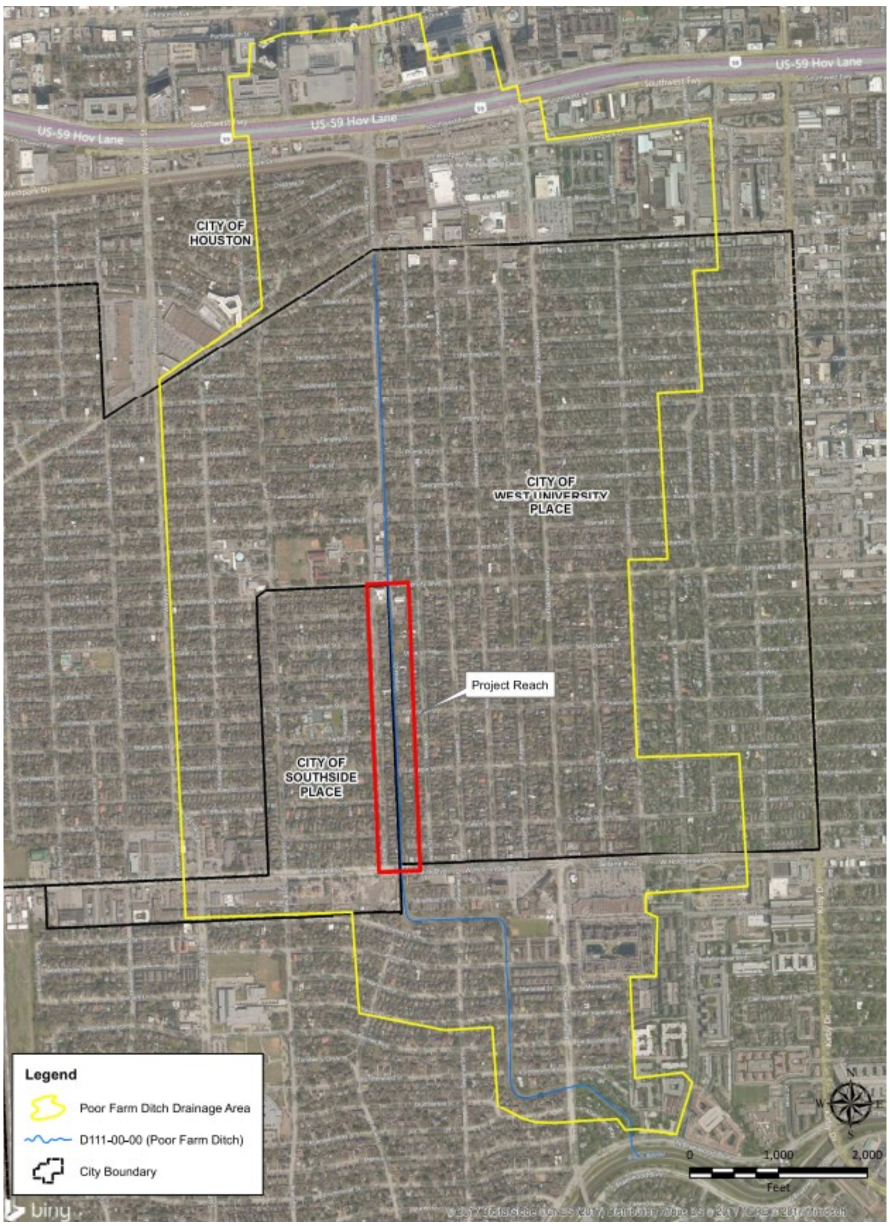


FIGURE 5-37: POOR FARM DITCH PROJECT AREA

The project ranked highest amongst the evaluated alternatives due to the decreases in WSEs when compared to both the effective model and corrected effective model for all storm events; having lowest cost for items associated with the design configuration; and having the least impact of construction activities to nearby residencies.

The H&H modeling completed to support this project utilizes pre-Atlas 14 rainfall data data, as the PER was developed prior to the Atlas-14 rainfall data release (2018). Hydraulic results were provided in raster format for the 1% and 0.2% ACE for both pre-project and post-project conditions.

The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 1.23. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4AT.**

The project report developed for this project includes documentation of no adverse impact. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Armand Bayou – Conveyance Improvements along B500-04-00-E004 and Channel Conveyance Improvements along B115-00-00 (063000321)

This project was developed as part of the Armand Bayou Watershed Planning Project to reduce the risk of flooding within the Armand Bayou watershed. The proposed project involves the optimization and expansion of an existing regional stormwater detention basin, the Red Bluff Stormwater Detention Basin (B500-04-00), and channel improvements to HCFCD Channel B115-00-00. These proposed improvements are set to alleviate historical and potential future riverine flooding within the Armand Bayou Watershed. **Figure 5-38** shows the location of the proposed project.

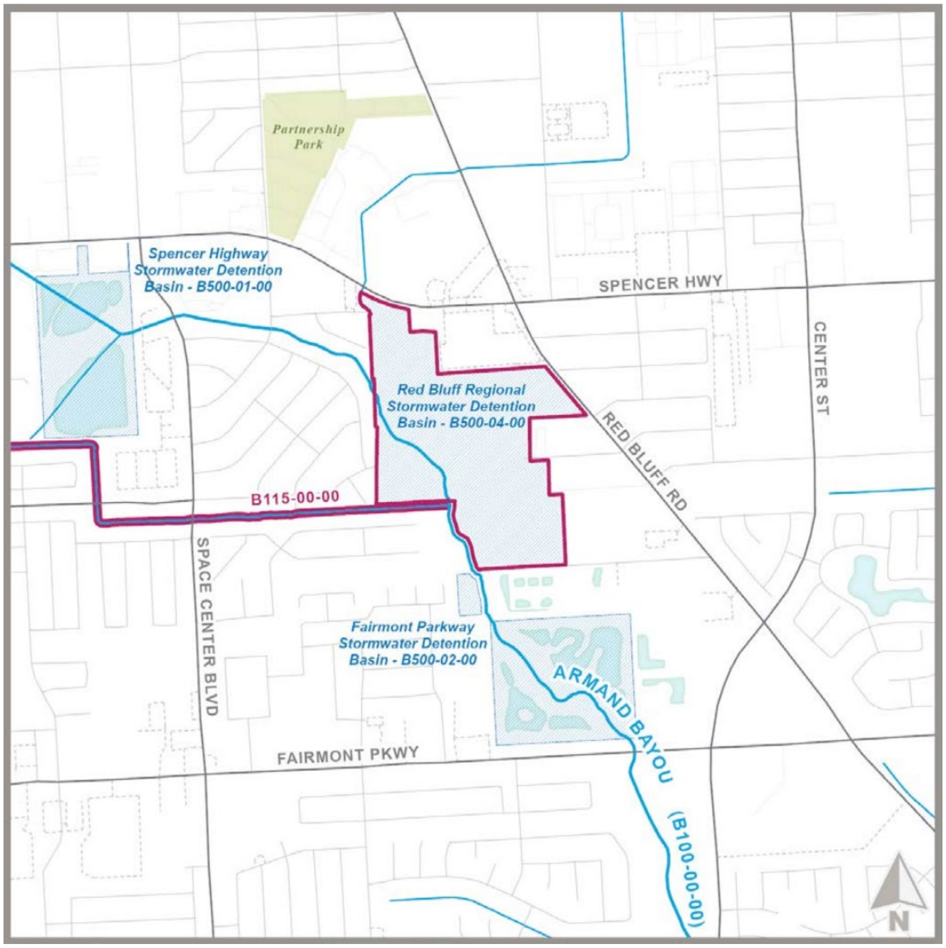


FIGURE 5-38: B500-04-00 CONVEYANCE IMPROVEMENTS AND B115-00-00 CHANNEL CONVEYANCE IMPROVEMENTS PROJECT LOCATION

Based on the hydraulic analysis conducted for the project development, the project reduces the risk of flooding for many structures including residential, commercial, and industrial structures for the storm events analyzed.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data in the HEC-HMS hydrologic model and HEC-RAS hydraulic model. Hydraulic results were provided in raster format for the 1%, 4%, and 10% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.81. No other benefits were analyzed as part of the BCA. More details on the methodology used for the BCA are provided in **Appendix 5-4AE**.

The HEC-RAS hydraulic modeling for the proposed improvements showed no adverse impacts between the existing and proposed conditions results. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Clear Creek Mid Reach Project (063000474)

This project was developed as part of the 2012 General Reevaluation Report (GRR) for the Clear Creek Federal Study and refined as part of the Preliminary Engineering Design (PED) phase of the project. The project includes channel improvements to the Clear Creek mainstem, Mary's Creek, and Turkey Creek along with approximately 4,000 acre-feet of detention volume provided by a combination of proposed detention basins within the Clear Creek watershed. **Figure 5-39** shows an overview of the Clear Creek Watershed.

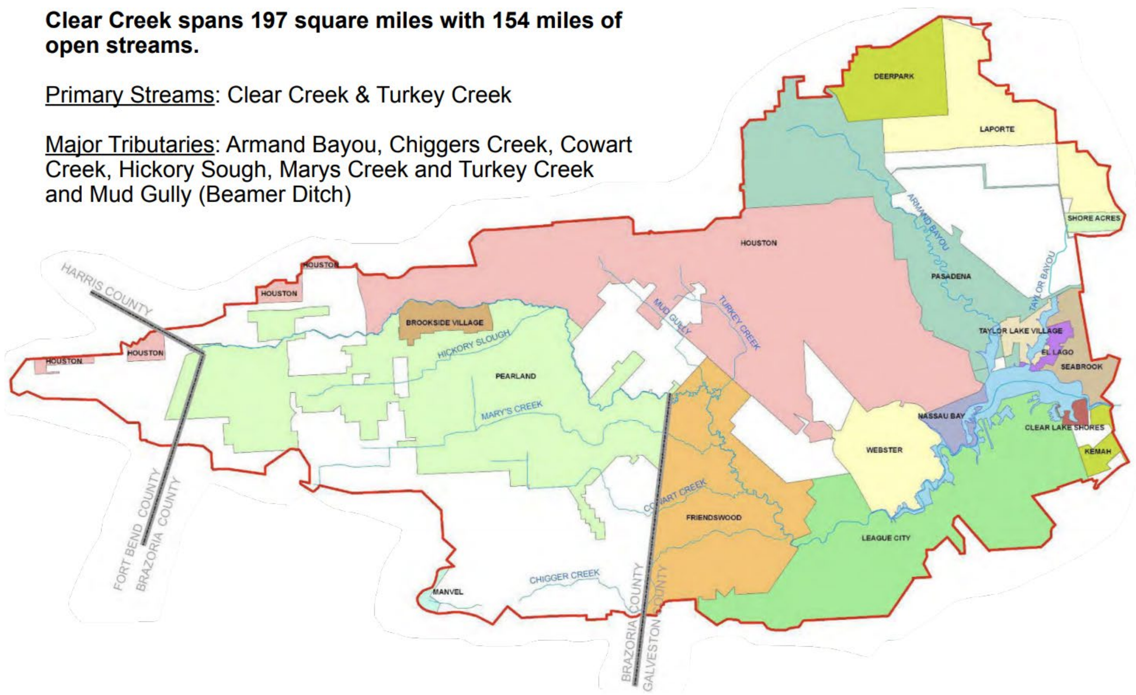


FIGURE 5-39: CLEAR CREEK WATERSHED OVERVIEW

Based on the hydraulic analysis conducted for the project development, the project reduces the risk of flooding for many structures including residential, commercial, and industrial structures for the storm events analyzed.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 0.2% and 1% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.54. No other benefits were analyzed as part of the BCA. The BCA results can be found in **Appendix 5-4AF**.

This project was found to meet no adverse impact requirements and is supported in the report, "Clear Creek Flood Risk Management (Federal Project) Pre-Construction Engineering and Design (PED) Recommendation" dated February 2023. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4AH**. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Carpenters Bayou – Mainstem Channel Modifications and Detention (063000402)

This project was developed as part of a comprehensive watershed evaluation for the Carpenters Bayou watershed. The Carpenters Bayou watershed is a developed and flood prone watershed vulnerable to extreme rainfall, nuisance flooding, and some storm surge from a tidally influenced outfall. The project includes approximately two miles of channel improvements to the Carpenters Bayou mainstem, a short segment of channel improvements to Carpenters Bayou tributary N109-00-00, and an approximate 182 acre-feet stormwater detention facility for mitigation of downstream impacts. **Figure 5-40** shows the location of the proposed project.

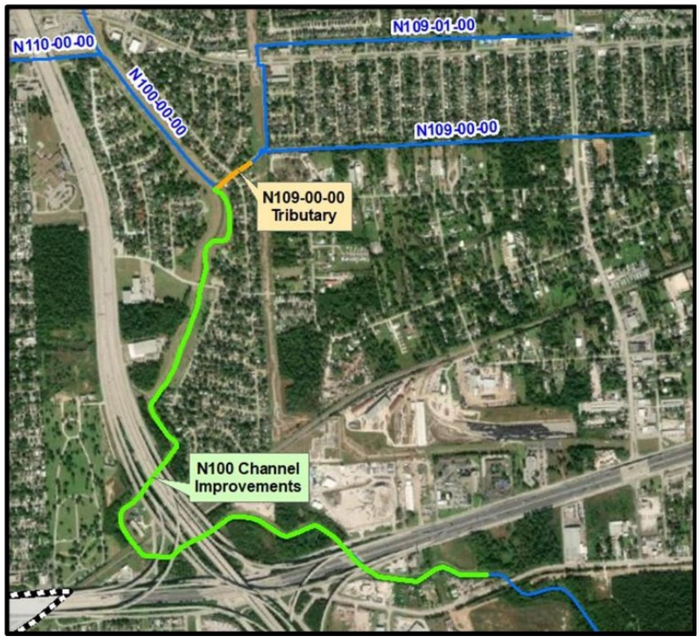


FIGURE 5-40: CARPENTERS BAYOU MAINSTEM CHANNEL MODIFICATION AND DETENTION PROJECT LOCATION

Based on the hydraulic analysis conducted for the project development, the project reduces the risk of flooding for many structures including residential, commercial, and industrial structures for the storm events analyzed.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 0.2% and 1% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.46. No other benefits were analyzed as part of the BCA. More details on the methodology used for the BCA are provided in **Appendix 5-4AG**.

This project was found to meet no adverse impact requirements and is supported in the report, "The Carpenters Bayou Watershed Planning Project: Final Engineering Report," dated March 2021. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4AG**. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one page summary attached in **Appendix 5-5**.

White Oak Bayou – E116 Tributary Modifications and Detention (063000389)

The White Oak Bayou E116 Tributary Modifications and Detention project was developed as part of the White Oak Bayou Tributary Planning Project. The proposed project was developed to reduce flood damage and decrease riverine and urban flood risk. The project includes channel improvements, upsizing of culverts, siltation removal, a stormwater detention basin, local drainage system improvements, and micro-detention basins within selected roadway medians. **Figure 5-41** shows the location of the proposed project.

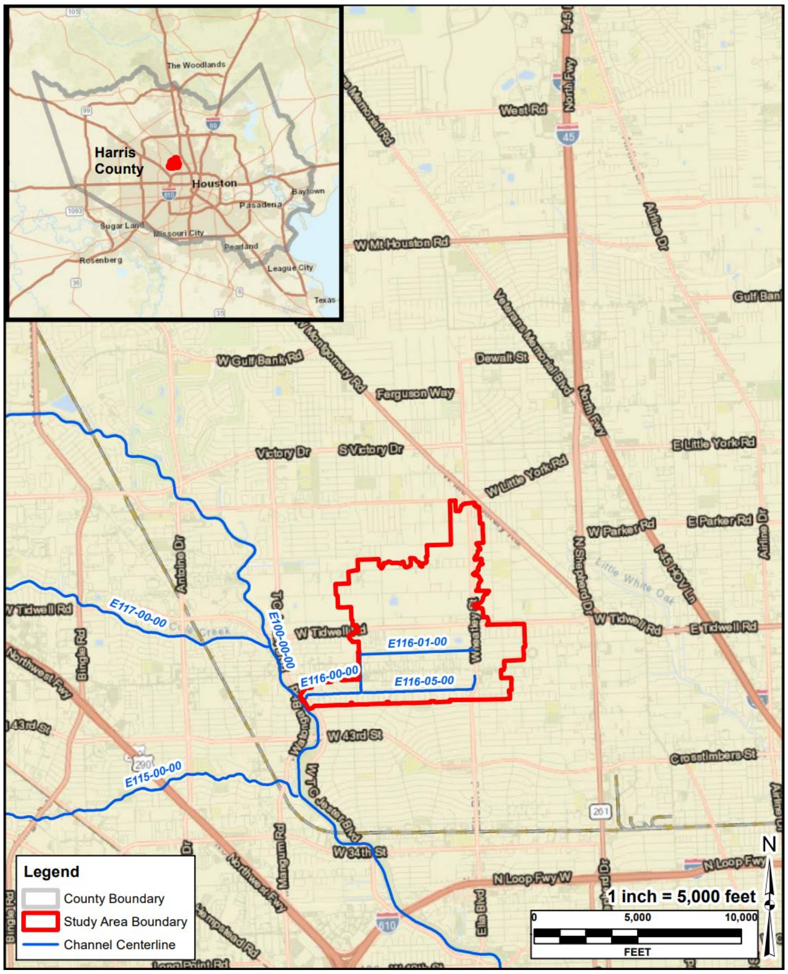


FIGURE 5-41: E116 TRIBUTARY MODIFICATION AND DETENTION PROJECT LOCATION

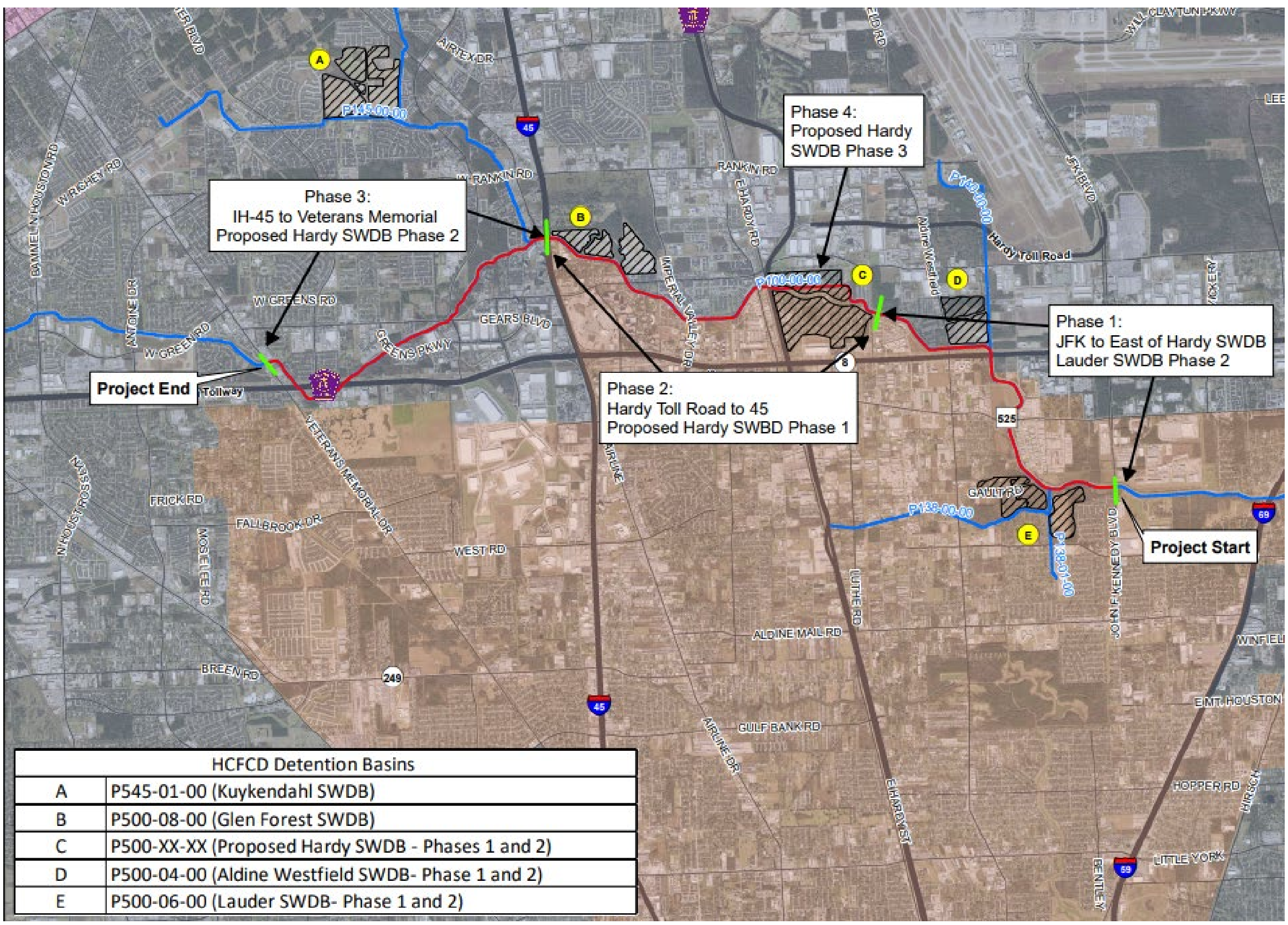
Based on the hydraulic analysis conducted for the project development, the project reduces the risk of flooding for many structures including residential, commercial, and industrial structures for the storm events analyzed.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 1%, 2%, 4%, and 10% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 1.47. No other benefits were analyzed as part of the BCA.

This project was found to meet no adverse impact requirements and is supported in the report, "E116-00-00 Flood Reduction Feasibility Study: Final Engineering Report," dated August 2022. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4AH**. Using this information along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

Greens Mid-Reach (063000167)

The Greens-Mid Reach project was developed as part of a comprehensive study of Greens Bayou watershed, specifically to identify recommendations within the mid-reach. The goal of this project was to identify project alternatives and ultimately present recommendations to reduce WSEs within Greens Bayou watershed, specifically within the mid-reach. The project includes a phased project encompassing five total stormwater detention basins, with one, the Hardy stormwater basin, to include recreational amenities and stormwater quality features, with channel conveyance improvements throughout the mid-reach. **Figure 5-42**, highlights the proposed project along with the recommended phased approach.



HCFCD Detention Basins	
A	P545-01-00 (Kuykendahl SWDB)
B	P500-08-00 (Glen Forest SWDB)
C	P500-XX-XX (Proposed Hardy SWDB - Phases 1 and 2)
D	P500-04-00 (Aldine Westfield SWDB- Phase 1 and 2)
E	P500-06-00 (Lauder SWDB- Phase 1 and 2)

FIGURE 5-42: GREENS MID-REACH PHASED APPROACH

The project reduces flood risk by improving channel conveyance and providing detention storage. The H&H modeling completed to support this project utilizes Atlas 14 rainfall data. Hydraulic results were provided in raster format for the 0.2% and 1% ACE for both pre-project and post-project conditions. The BCA performed was based on the raster results under a process developed by the San Jacinto RFPG. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.24. No other benefits, i.e., recreation, roadway, etc., were analyzed during this analysis. More details on the methodology used for the BCA are provided in **Appendix 5-4AI**.

The Final Engineering Report developed for this project states that the project's inclusion of detention throughout the watershed offset potential adverse impacts caused by channel conveyance improvements. Using these statements along with HCFCD's no adverse impact operating policies, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

CDBG-MIT Projects

These project applications were developed and submitted to compete for funding from the Community Development Block Grant Mitigation – Hurricane Harvey (CDBG-MIT) that Congress appropriated in February of 2018. To be considered, the projects must be for mitigation activities for qualifying disasters which included Hurricane Harvey. The applications were submitted by HCFCD in partnership with Harris County Engineering in 2020 and subsequently were not selected for funding; however, the criteria and data required for consideration by the CDBG-MIT grant makes these projects well suited for consideration as recommended FMPs to the San Jacinto RFP.

There are 20 structural projects paired with detention alternatives to ensure no negative impact as result of these flood mitigation solutions. These structural projects were grouped into 5 recommended FMPs that aim to provide flood risk reduction benefits. These projects are also a part of a locally adopted plan, the HCFCD 2018 bond program for flood risk reduction, where Harris County voters approved $2.5 billion in bonds to finance flood damage reduction projects. This bond program included an expectation for and will require partnership funding to complete to further leverage the flood risk reduction goals of the program.

A BCA was developed based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0 and MH-HAZUS. These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and MH-HAZUS were applied using a combination of geospatial and tabular analysis tools to utilize spatially variable modeled WSE data more efficiently and to incorporate detailed information at an individual structure level. The result concluded with a BCR for each project which is reported below. Also reported are the unique methodologies used to determine flood risk reduction benefits determined by the San Jacinto RFPG. For a summary of each FMP, refer to the one-page summary attached in **Appendix 5-5**.

Brays Bayou CDBG-MIT Application Projects (063000027)

The Brays Bayou Mitigation Project is a joint effort between HCFCD and the City of Houston. The project is composed of various drainage and flood control improvements including improved channel conveyance and stormwater detention basins. Collectively, the components of this project are referenced as improvements to Bintliff Ditch, HCFCD Channel D133-00-00, and the Sharpstown area. The project is generally located west of IH-610 between Brays Bayou to the south, Harwin to the north, and east of Fondren Road. The area is a mix of single-family residential, institutional, commercial and multi-family parcels. The existing drainage system in the area is primarily curb and gutter with some open ditch streets. Bintliff Ditch drains from north to south and outfalls into Brays Bayou. There is significant ponding throughout the study area with flood losses closer to Brays Bayou and along Bintliff Ditch. The goal of the project was to mitigate the risk of riverine flooding in this southwestern portion of Harris County as shown in **Figure 5-43**.

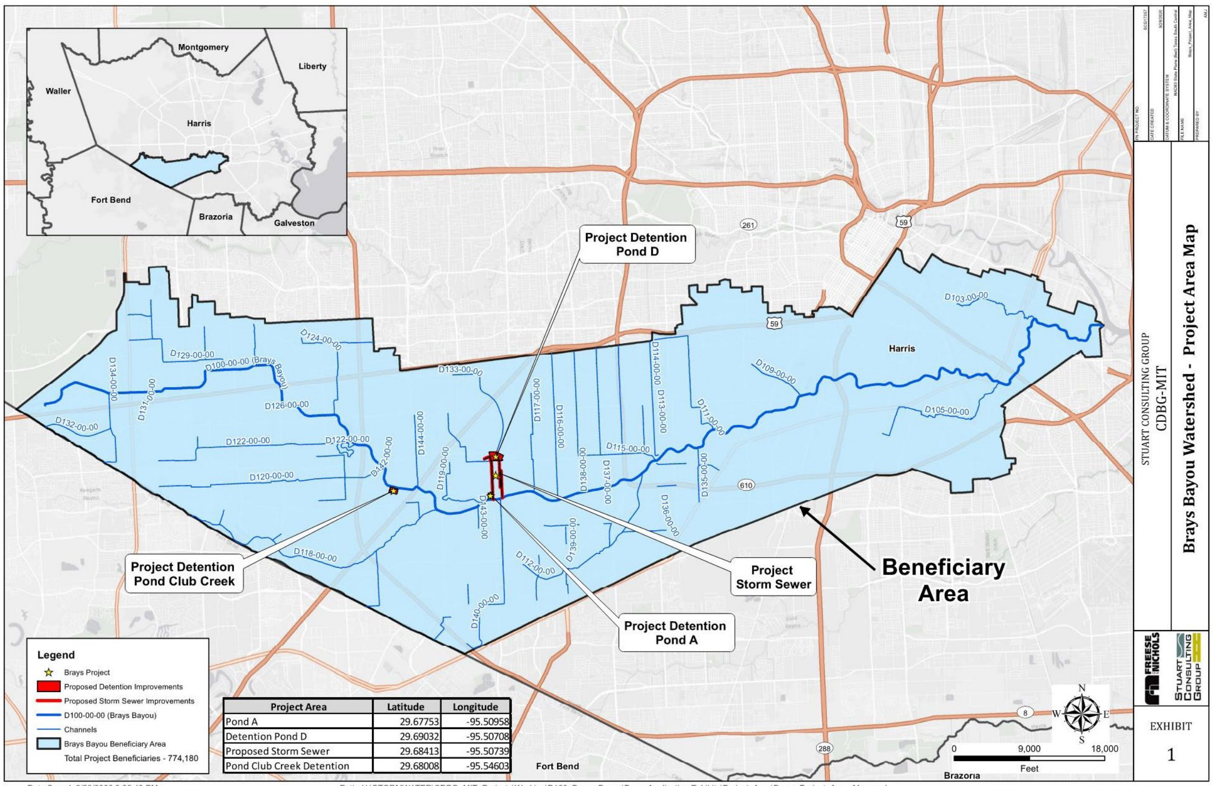


FIGURE 5-43: BRAYS BAYOU WATERSHED CDBG-MIT APPLICATION PROJECT AREA

The project reduces flood risk by improving storm sewer conveyance and adding detention storage. Based on various forms of hydraulic analysis, the project reduces ponding in approximately 10 miles of streets and removes many structures from possible flood damages throughout the project extents. In addition to the direct flood reduction benefits, Lift Station #31, which was significantly damaged during Hurricane Harvey, sees a reduction in flood risk.

The tools and approach used to create a BCR are previously discussed; the BCR is 0.13 for this project. Although the BCR is not greater than 1.0, the project demonstrates that 57.5% of the beneficiaries of Brays Bayou Watershed mitigation project are low-to moderate-income persons. More details on the methodology used in the BCA can be provided in **Appendix 5-4AJ**.

The H&H modeling completed to support this project utilizes Atlas 14 rainfall data and Storm Water Management Model (SWMM). This project was found to meet no adverse impact requirements and is supported in the report, “Sharpstown Master Drainage Plan,” dated August 2020. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4AL**. Further, no adverse impact documentation is supported with an associated model (ID 060000000030).

It is important to note that this project will complement the ongoing USACE-supported Project Brays with overall water surface elevation reductions along the tributary channel. Project Brays is a joint effort program led by HCFCD and the USACE, along with several local stakeholders. The program consists of over 75 projects throughout 31 miles of Brays Bayou to reduce flood risk, increase greenspace, and provide amenities for the community.

Sims Bayou CDBG-MIT Application Projects (063000037)

A suite of structural mitigation measures makes up the Sims Bayou Watershed Mitigation CDBG-MIT application, all of which work to reduce localized and regional flooding for subdivisions and businesses during hurricanes, tropical storms, and intense rainfall events within Sims Bayou. These types of significant rainfall events cause the local drainage and flood control systems to be overwhelmed, resulting in riverine and urban flooding. The Sims Bayou Watershed Mitigation Project entails three (3) individual activities shown in **Figure 5-44**:

1. South Post Oak Stormwater detention basin (SWDB) and channel conveyance improvements (C147);
2. South Shaver SWDB (C506-01-E0003); and,
3. Salt Water Ditch SWDB and channel conveyance improvements (C118).

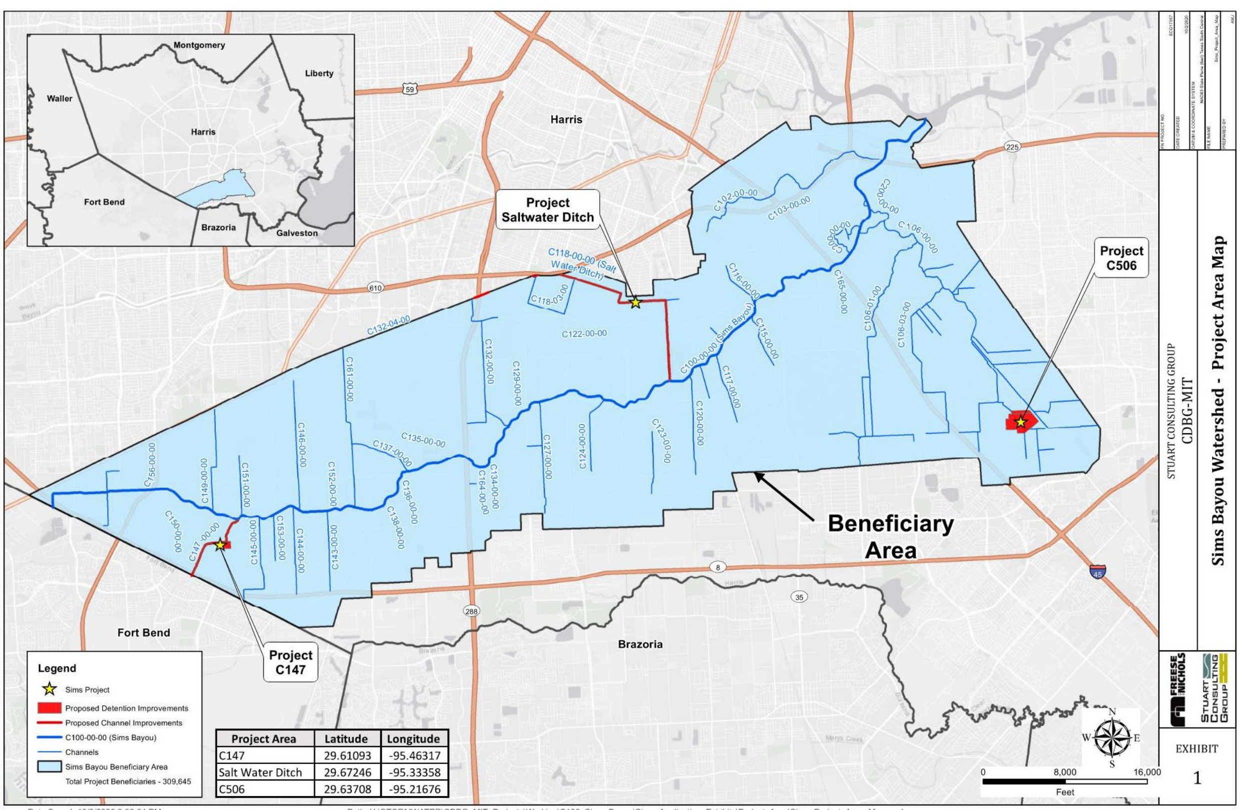


FIGURE 5-44: SIMS BAYOU WATERSHED CDBG-MIT APPLICATION PROJECT AREA

The South Post Oak SWDB and channel conveyance Improvements consists of widening 7,000 feet of channel C147-00-00 from Sims Bayou to the C147-02-00 diversion channel. There are several bridge structures along this reach that will be replaced as a part of the project. The project also seeks to mitigate impacts from channel conveyance improvements by increasing the volume of the C457-01 detention basin. Since completion of this application, the project has advanced through Preliminary Engineering, yielding 30% complete engineering plans. Additionally, some excavation has already been performed on the detention pond as part of an agreement with a nearby landowner.

The South Shaver Detention Basin (C506) is aimed at maximizing the detention volume within the property owned by HCFCD to construct a 96-acre detention basin. Control structures at the discharge of the basin will limit the flow leaving the basin to help attenuate peak flows within the surrounding flood control channels.

The objective of the Saltwater Ditch improvements along C118-00-00 is to maximize the stormwater conveyance capacity by converting the existing drainage ditch into multiple barrels of steel reinforced polyethylene (SRPE) storm sewer. The finished project will achieve a 10% ACE level of service, a significant improvement over the existing 50% ACE level performance. To mitigate the increased runoff volume generated by the project, a detention pond will also be constructed.

The tools and approach used to create a BCR are previously discussed; the BCR is 1.8 for this project. More details on the methodology used in the BCA can be provided in **Appendix 5-4AK**.

All three projects were modeled utilizing locally-required methodologies and the latest versions of HEC-RAS at the time of starting modeling activities. Atlas 14 rainfall data was not utilized but, rather, TP40 rainfall was used, upon which current FEMA mapping is based. The sponsor’s policy at the time was to focus on the 0.2% ACE rainfall event as a reasonable proxy for 1.0% ACE Atlas 14 rainfall until new FEMA maps, based on Atlas 14 rainfall data, were available.

Recent correspondence with the project sponsor indicates that funding and progress will be made during the upcoming flood planning cycle timeline for the project components South Shaver SWDB and South Post Oak Stormwater Detention project. No progress has been made on funding the Saltwater Ditch Improvments along C118-00-00. Future update cycles of the plan will confirm if additional funding may be needed to update this FMP.

No negative impact from this project was assumed, including the 0.2% ACE event, as the project sponsor, HCFCD, enforces a strict no adverse impact policy. This conclusion is further supported in the report, “Feasibility Study for Flood Damage Reduction to Salt Water Ditch,” dated February 2016. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4**. Further no adverse impact documentation is supported with an associated model (ID 060000000033).

Halls Bayou CDGB MIT Application 1 Projects (063000040)

The projects in this application are designed to provide watershed-wide flood risk reduction measures in Halls Bayou, as shown in **Figure 5-45**. The Halls Bayou watershed is a historically underserved area of north Harris County. Projects in this application are sponsored by HCFCD and include improvements in both conveyance and detention on both the mainstem and tributaries of Halls Bayou. Listed below are the five projects submitted as part of the CDBG-MIT grant application in the Halls Bayou watershed:

1. **C-28:** Channel conveyance improvements on Tributaries P118-25-00 and P118-25-01;
2. **C-30:** Channel conveyance improvements on Tributary P118-27-00;
3. **C-23:** Channel conveyance improvements on Tributary P118-08-00;
4. **C-41 Hardy West:** Stormwater detention improvements in the vicinity of Hardy West; and,
5. **C-41 Mainstem:** Main stem channel conveyance improvements upstream of Keith Weiss Park and downstream of Hooper Road; stormwater detention improvements in the vicinity of P118-21-Phase II

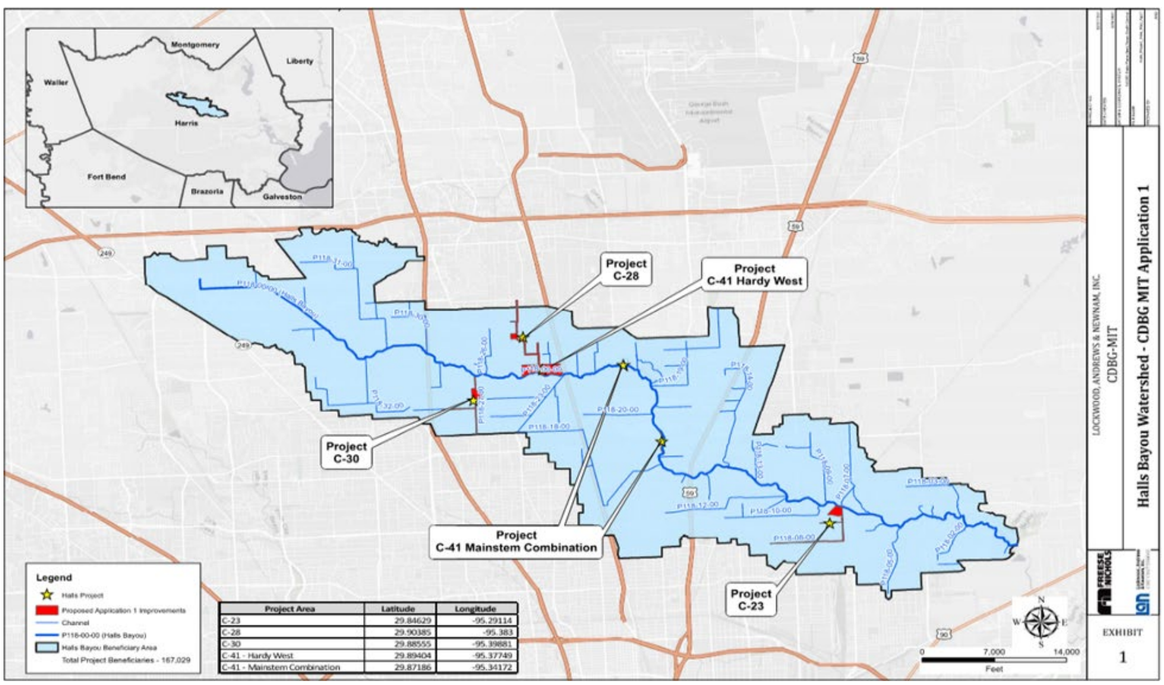


FIGURE 5-45: HALLS BAYOU CDBG-MIT APPLICATION PROJECT AREA

All projects were modeled utilizing locally required methodologies and the latest versions of HEC-RAS at the time of starting modeling activities. Atlas 14 rainfall data was not utilized but, rather, TP40 rainfall was used, upon which current FEMA mapping is based. The sponsor's policy at the time was to focus on the using the 0.2% ACE rainfall event as a reasonable proxy for an Atlas 14 1.0% ACE rainfall event until new FEMA maps, based on Atlas 14 rainfall data, were available. No negative impact from this project was assumed, including the 0.2% ACE storm, since the project sponsor HCFCD enforces a strict no adverse impact policy. Ultimately, the H&H modeling results were provided to the Technical Team by the stakeholder as individual raster coverages for both the pre-project and post-project 1.0% and 0.2% ACE conditions.

A BCR was developed as part of the grant application process which produced a 1.46 for this project. It is important to note that the Halls Bayou Watershed CDBG-MIT Application 1 covered project will provide many community benefits for which an economic value could not be quantified as part of this analysis. More details on the methodology used in the BCA can be provided in **Appendix 5-4AL**.

This project was found to meet no adverse impact requirements and is supported with certified reports on each individual project. These studies were based on best available information and were certified by professional engineers. These reports are included in **Appendix 5-4AL**. Further, no adverse impact documentation is supported with an associated model (ID 060000000029).

According to the project sponsor, a component of this plan, C-28, channel conveyance improvements on Tributaries P118-25-00 and P118-25-01, has likely received funding and could potentially move into design and construction soon. The RFPG will monitor the progress of this project and the plan will be updated accordingly.

White Oak Bayou CDBG MIT Application Projects (063000046)

This CDBG-MIT grant application is located in the White Oak Bayou Watershed and is made up of five (5) individual structural flood risk reduction measures that consist of regional channel and detention projects including Kolbe Road, Barwood, E132-00-00, Tower Oaks, and Little White Oak Bayous. This flood and drainage activity improves drainage at neighborhood and regional levels by making improvements to subdivisions within the White Oak Bayou watershed and to the E132-00-00 and Little White Oak Bayou channels, as shown in **Figure 5-46**. The proposed improvements sponsored by HCFCD and supported by Harris County Engineering include:

1. Kolbe Road Drainage Improvements: addition of storm sewers under the existing roadside ditches throughout the project site. The storm sewer redirects a portion of drainage area from Cypress North Houston to now drain to HCFCD channel E133-01-00. The change in flows requires detention to mitigate any adverse impact;, therefore, right-of-way (ROW) acquisition is included in the project requirements.
2. Barwood: approximately 1,300 linear feet (LF) of 48-inch new RCP installed along N Eldridge Road, connecting to the intersecting, existing lines. A 25.0 ac-ft detention pond to the north of Advance Drive, connecting to the existing system with approximately 220 LF of 48-inch RCP, would be created to offset negative impacts to the increased storm sewer capacity. Approximately 2,500 LF of 48-inch RCP; 1,600 LF of 54-inch RCP; and 860 LF of 72-inch RCP would be added to replace 4,960 LF of existing RCP storm sewer.
3. E132-00-00: includes enclosing a portion of the upstream channel, modifying the width of the remaining channel, and acquiring right-of-way (ROW) for additional detention storage volume or channel widening.
4. Tower Oaks Meadows: proposed improvements involve building storm sewers ranging in size from 24’ circular RCP to dual 9’X4’ reinforced concrete box culverts. Also proposed is converting roadways to curb and gutter streets where storm sewer improvements are proposed, as well as re-grading existing roadside ditches.

5. Little White Oak: involves channel widening 8,700 feet of Little White Oak Bayou (HCFCD Unit No. E101-00-00) from Tidwell Road, upstream, to Crosstimbers Street, downstream, along with constructing two detention basins and additional in-line storage.

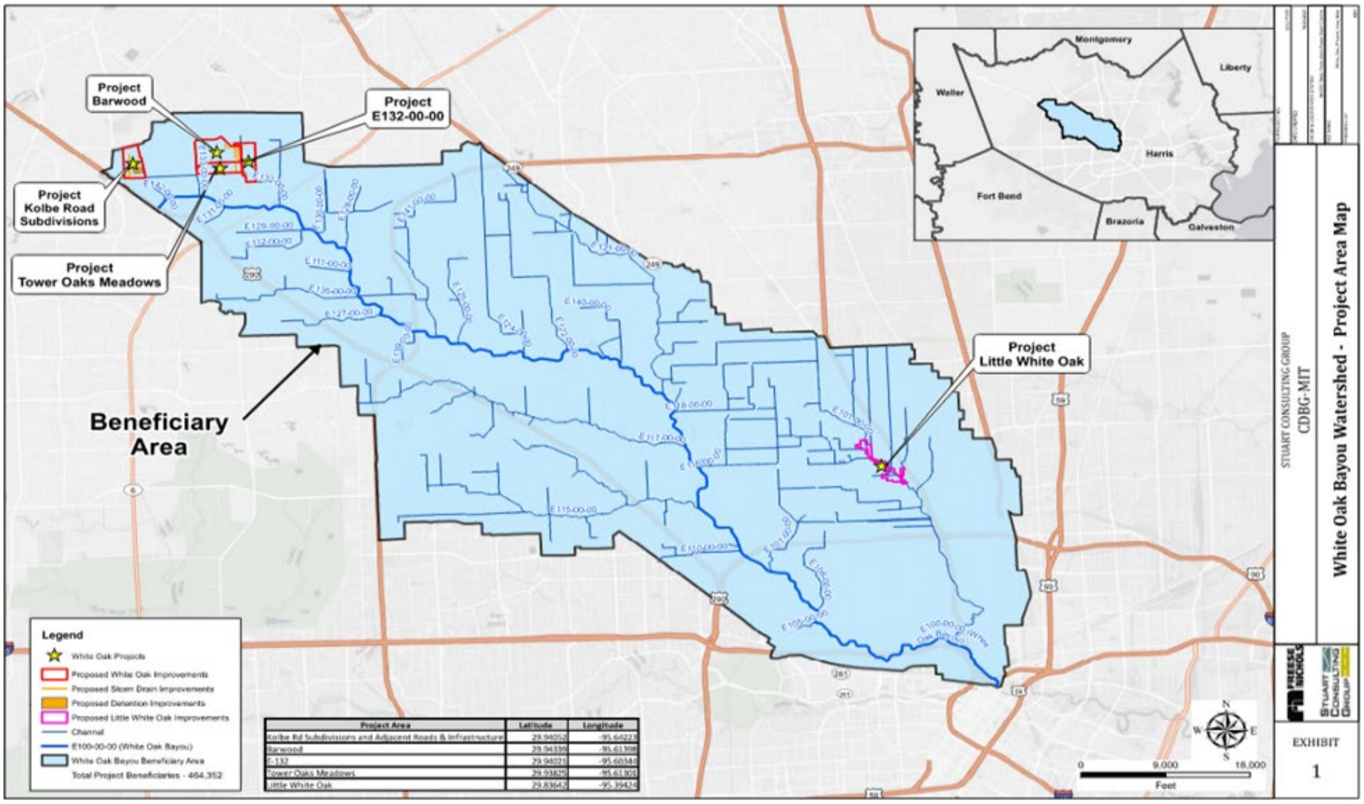


FIGURE 5-46: WHITE OAK BAYOU WATERSHED CDBG-MIT APPLICATION PROJECT AREA

All projects were modeled utilizing locally required methodologies and criteria established by the project sponsor including a strict requirement of no adverse impact. Of the five different projects included, the San Jacinto RFPG only received an H&H model for the Little White Oak project. All other projects utilized the XPSWMM program and a summary of their results was received in spreadsheet format. These projects utilized 2008 and 2018 LiDAR as a basis for modeling and mitigates impacts up to 0.2% ACE TP40 event and/or 0. 1.0% ACE Atlas 14 event. While the TP40 rainfall is not considered the best available for the region, a TP40 0.2% ACE event is reasonably close to the 1.0% ACE Atlas 14 event to serve as a stand-in.

A BCA was developed as part of the grant application process which found a 0.80 BCR for this project. It is important to note that the White Oak Bayou Watershed Mitigation Project will provide many community benefits for which an economic value could not be quantified as part of this analysis. More details on the methodology used in the BCA can be provided in **Appendix 5-4AM**.

Since this project was first included in the regional flood plan, the project cosponsor Harris County Engineering, has made significant progress on the components Kolbe Road Drainage Improvments, Barwood, E132-00-00, and Tower Oaks Meadows. Funding is not longer needed for these compontents of this poject. The most signficant component of the overall project, Little White Oak, has made no signficant progress and full funding is still needed.

No negative impact from this project was assumed up to and including the 0.2% ACE event as the project sponsor HCFCD enforces a strict no negative impact policy. This conclusion is supported by engineering judgment provided in the memo, "Little White Oak Bayou CDBG-MIT Project, Project Background and Certification of No Adverse Impact," dated November 28, 2022. While the modeling provided did not strictly meet the "no adverse impact" criterion, in an engineers' opinion, the design can be reoptimized for assurance of no negative impact. This study was based on best available information, was certified by a professional engineer, and is included in **Appendix 5-4M**.

5.D.5.h. City of Baytown

Danubina Drainage Improvement Project (063000422)

This project was developed as part of an infrastructure watershed evaluation of the Danubina Area to identify projects to reduce excessive flooding during frequent storm events. The storm sewer system for Danubina Street was identified as a critical system due to excessive flooding during frequent storm events. The proposed project objective is to mitigate flooding during more frequent rainfall events while reducing flooding risks for the 1% ACE. The improvements include improving the Hull Gully channel, detention, and storm sewer improvements along Hunnicutt Street. **Figure 5-47** shows the location of the proposed project.

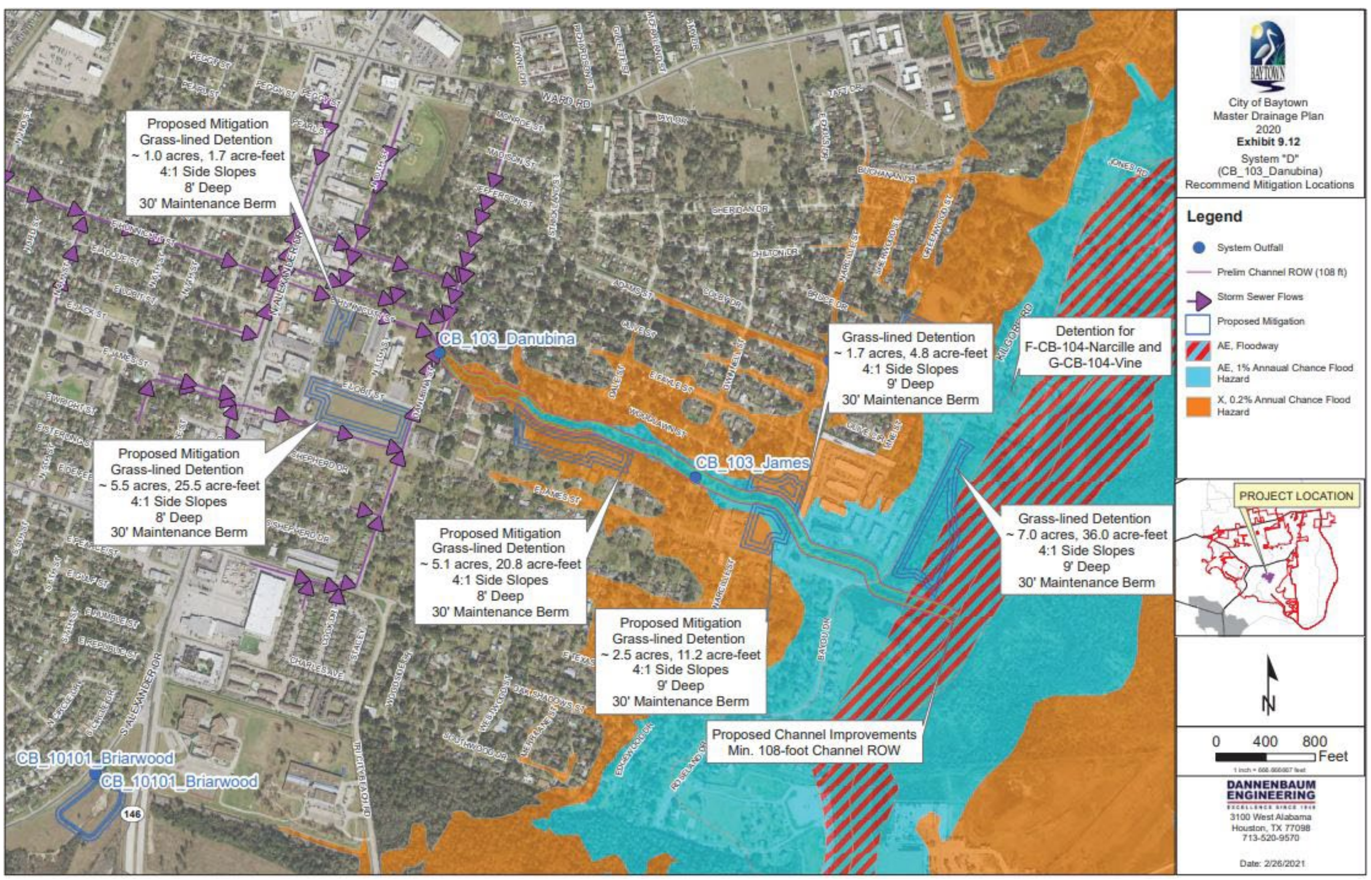


FIGURE 5-47: DANUBINA DRAINAGE IMPROVEMENT PROJECT AREA

Based on the hydraulic analysis conducted for the project development, the project removes structures from potential flood damage for the analyzed storm events.

The hydrologic results were provided in raster format for the 1%, 10%, and 20% AEP for both pre-project and post-project conditions. The BCA performed was based on the raster provided by the City of Baytown and completed by Dannenbaum Engineering Corporation. The BCA for this project was completed using the FEMA BCA Tool Version 6.0. The final BCR with standard benefits was determined to be 0.96. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4AN**.

The project report, "City of Baytown Master Drainage Plan Volume 2: Storm Sewer System Analysis," dated March 2021, includes documentation of no adverse impact and shows that WSEs decrease throughout the project area. Based on this information, the project will cause no negative impacts. For a summary and additional information on this project, refer to the one-page summary attached in **Appendix 5-5**.

5.D.5.i. City of Pearland

Mary's Creek Conveyance Improvements (0630000056)

Mary's Creek is a major channel draining the City of Pearland that discharges into Clear Creek. The existing channel has a low conveyance capacity that results in water overtopping the banks and flooding surrounding areas. In addition, existing structures create hydraulic restrictions along the channel that contribute to the overall flood risk. The project includes the following drainage improvements:

- Channel widening between the B129-01-00 confluence and Airline Drive to increase the conveyance capacity of the channel and reduce WSEs;
- Bridge/culvert replacements to remove hydraulic restrictions along the channel; and,
- Construction of detention basins to mitigate for peak flow increases due to the channel improvements.

These improvements can be implemented separately with each providing incremental benefits, although a phased implementation plan was developed for overall drainage improvements along Mary's Creek based on permitting/mitigation strategy and available funding. When implemented, these improvements will provide a 4% ACE Level of Service for the channel. The project improvements are shown in **Figure 5-48**.

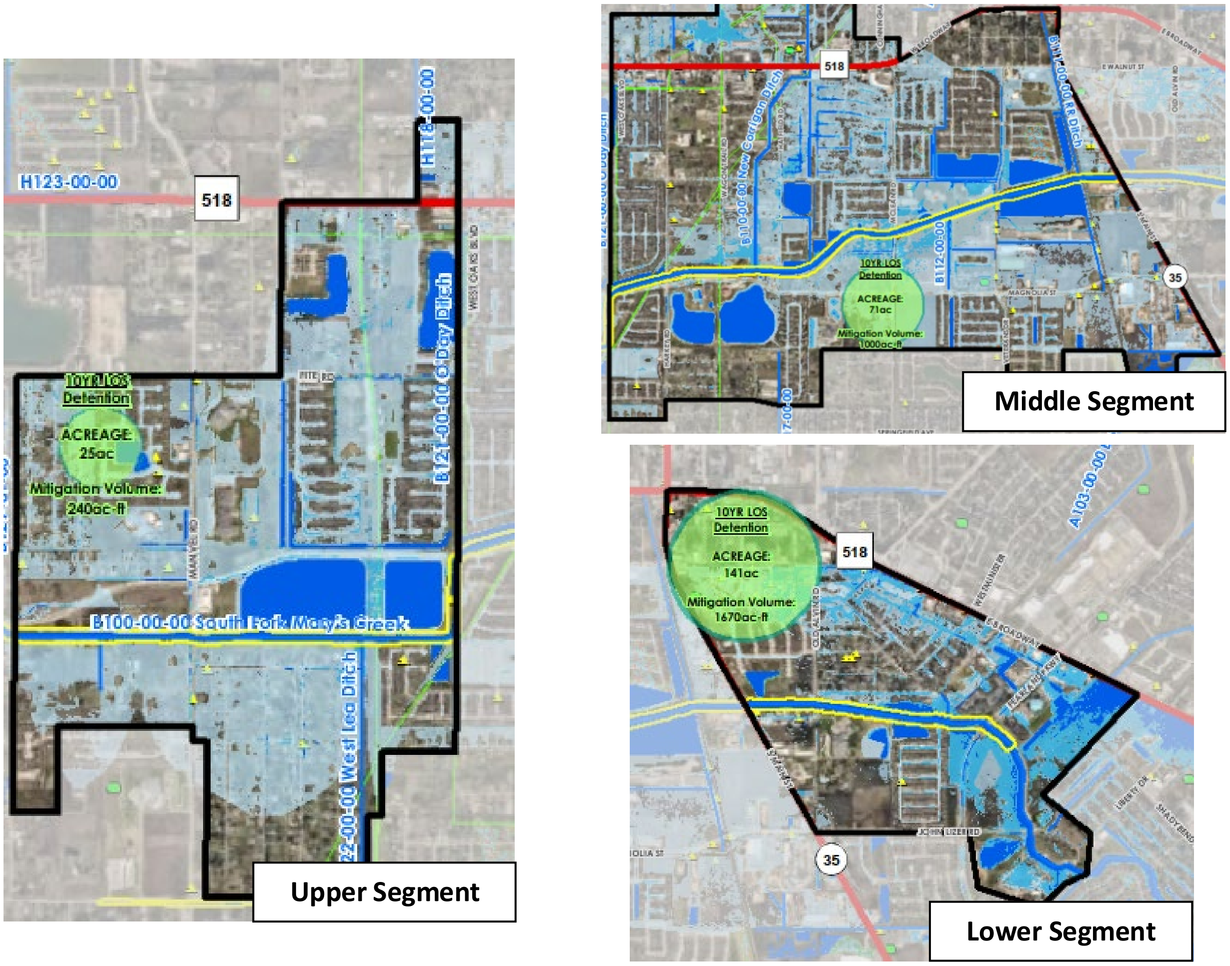


FIGURE 5-48: MARY'S CREEK COMPONENTS

This project provides benefits by reducing structural flooding along Mary's Creek and within the surrounding residential areas and roadways in the 1% ACE. The calculated BCR of the project was found to be 0.16. The methodology used to perform the BCA can be found in **Appendix 5-4AO**.

The City of Pearland is the project sponsor with Brazoria County Drainage District #4 serving as a key stakeholder. Pearland would be responsible for continued maintenance of the drainage infrastructure. For a summary and additional information on this project refer to the one-page summary in **Appendix 5-5**.

The project will include mitigation for the conveyance improvements by creating multiple detention basins along the length of improved channel. This project was found to meet no adverse impact requirements and is supported by an engineer's signed and sealed report. This information is provided in the July 2019 reports titled "Master Drainage Plan Update: Final Report" and "Master Drainage Plan Update: Implementation Plan."

5.D.5.j. City of Piney Point Village

Blalock Road Drainage Improvements (063000327)

The Blalock Road Drainage Improvements Project is located on the west side of the City of Piney Point Village along South Piney Point Road and Blalock Road. The proposed project consists of drainage improvements along Blalock Road drainage system starting near Taylorcrest Road and continuing downstream along Blalock Road outfalling into drainage system improvements completed in 2016 at the Blalock Road and Memorial Drive intersection.

The proposed drainage improvements project will replace an undersized drainage system on Blalock Road, tie into drainage improvements in which the Piney Point has previously invested on South Piney Point Road, and provide improvements to a drainage area that frequently experiences flooding in large rain events. The project improvement area is shown in **Figure 5-49**.

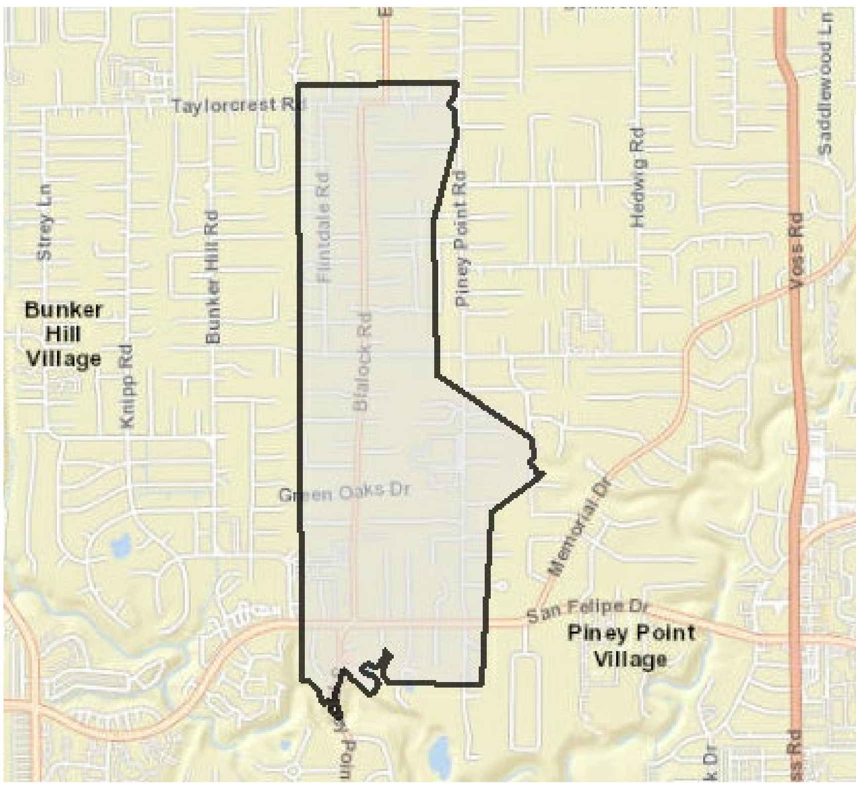


FIGURE 5-49: BLALOCK DRAINAGE IMPROVEMENTS PROJECT AREA

This project will utilize a restrictor on the storm drain system to provide no adverse hydraulic impact to Buffalo Bayou. The project was found to meet no adverse impact requirements and is supported in the memorandum, “Blalock Road Drainage Improvements,” dated October 2020. The benefit and adverse impacts analysis was completed for the 50%, 10%, 4%, and 1% ACE storms.

The methodology used to perform the BCA can be found in **Appendix 5-4AP**.

The City of Piney Point Village is the project sponsor. Piney Point Village would be responsible for continued maintenance of the drainage infrastructure. For a summary and additional information on this project refer to the one-page summary in **Appendix 5-5**.

5.D.5.k. City of Conroe

Rivershire West – Alligator Creek and Grand Lake Watersheds (063000453)

The Rivershire neighborhood in the southern part of Conroe, north of Loop 336, experiences flooding due to an undersized drainage system and overflow from Alligator Creek in large storm events. The overflow is unable to be effectively conveyed through the drainage system and inundates large portions of the Rivershire neighborhood. The Rivershire West project includes a combination of the following improvements:

- Channel benching ranging in size from 200’ to 250’ along Alligator Creek to increase the conveyance capacity of the channel and reduce the overflow into the Rivershire neighborhood;
- Bridge Improvements along Sergent ED Holcomb Boulevard and Loop 336 to reduce hydraulic restrictions at the bridge crossing;
- 3-foot floodwall on the south side of Gladstell Street to prevent overflow from Alligator Creek draining through the Rivershire neighborhood; and,
- Local drainage improvements within the Rivershire neighborhood including roadside ditch re-grading, culvert replacement, and construction of new grass swales to convey local flows to the Grand Lake channel.

These improvements can be implemented separately with each providing incremental benefits. This proposed FMP discharges directly to the West Fork of the San Jacinto River and, while flow is minorly increased from the local watershed, the project will not create a negative impact per City of Conroe and TWDB requirements due to the West Fork’s large watershed and control of the base flood elevations. The project details are shown in **Figure 5-50**.

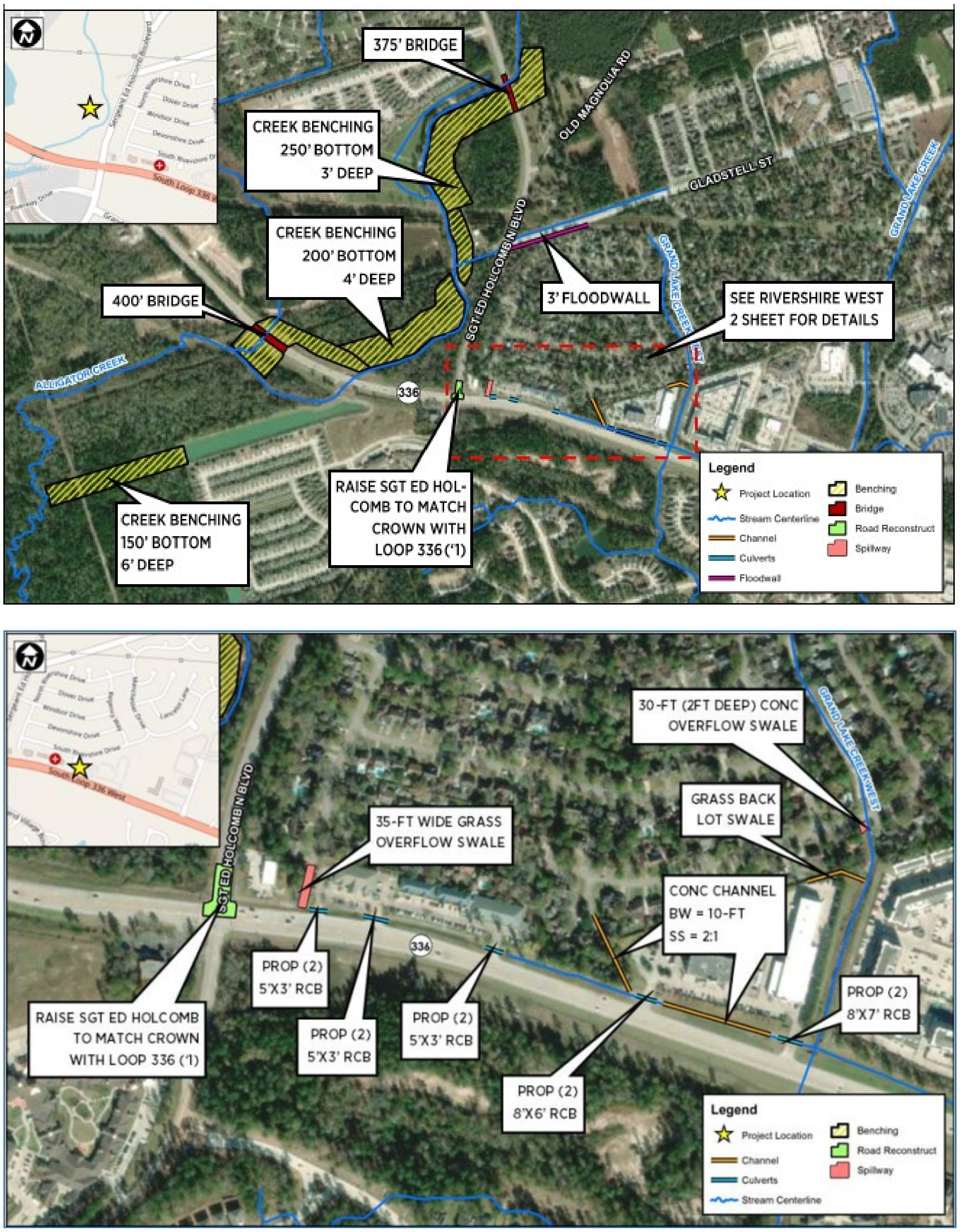


FIGURE 5-50: RIVERSHIRE WEST PROJECT AREA

This project provides benefits by reducing structural flooding within the Rivershire neighborhood for the 1% ACE as well as reducing roadway flooding along Loop 336, Gladstell Street, and Sergeant ED Holcomb Boulevard. The calculated BCR of the project was found to be 0.11. The methodology used to perform the BCA can be found in **Appendix 5-4AQ**.

Along with the City of Conroe, TxDOT is an additional potential project sponsor for the bridge improvement along Loop 336. The City of Conroe would be responsible for continued maintenance of the drainage infrastructure. For a summary and additional information on this project refer to the one-page summary in **Appendix 5-5**.

5.D.5.l. Coastal Prairie Conservancy Projects

Warren Lake and Dam (063000320)

The Coastal Prairie Conservancy proposes to retrofit and enhance the existing Warren Lake dam, create a wetlands complex, and restore tallgrass prairie surrounding the lake and wetlands. **Figure 5-51**, shows the project area.

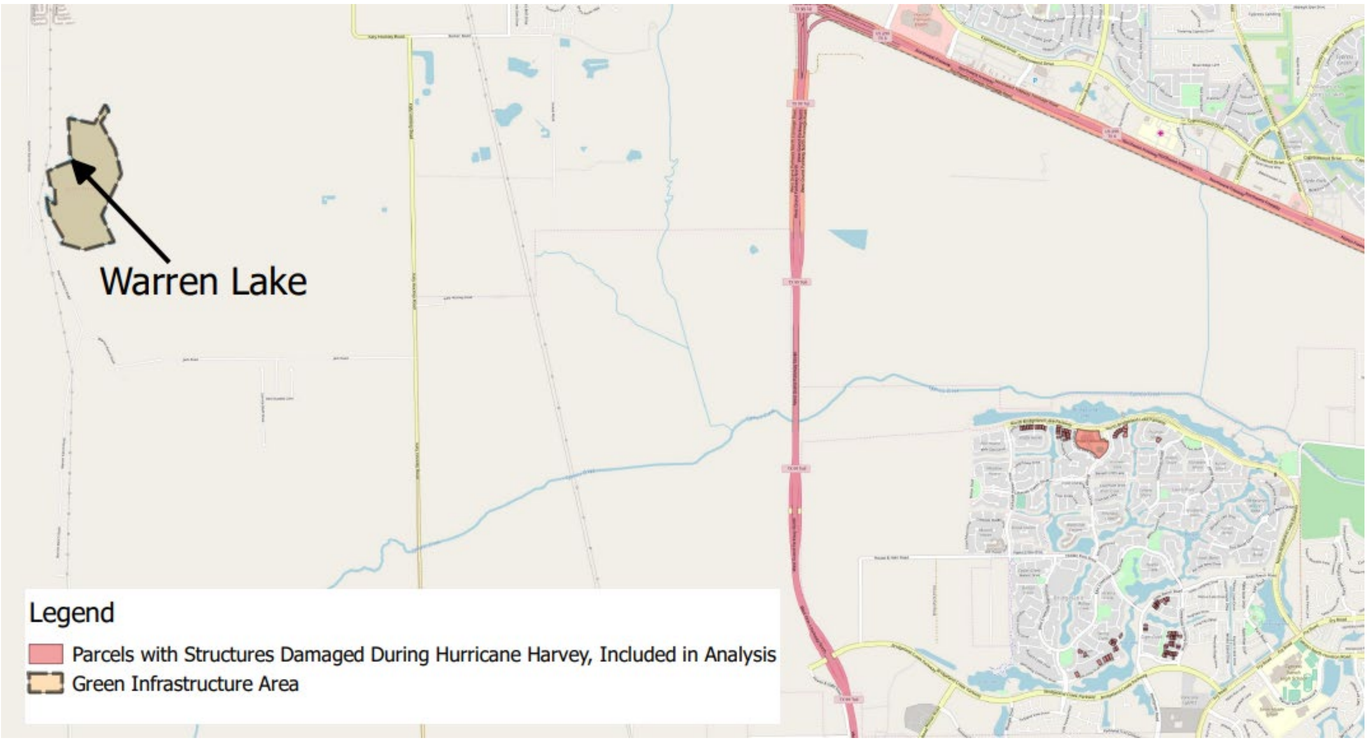


FIGURE 5-51: WARREN LAKE LOCATION

This detention basin, incorporating green infrastructure, will increase the level of protection provided downstream by increasing the flood water capacity of the lake and surrounding land, adding approximately 856 acre-feet of storage during rainfall events. The final BCRwith standard benefits was determined to be 4.45. Other benefits were analyzed including environmental benefits and residual value of investments. More details on the methodology used for the BCA are provided in **Appendix 5-4R**. The report developed for this project includes documentation of no adverse impact.

5.D.6. No Adverse Impact Summary

Each recommended structural FMP demonstrated that no negative impacts on the surrounding area would result from its implementation. **Table 5-3** summarizes the supporting documentation for each FMP. A detailed summary of no adverse impact documentation can be found in **Appendix 5-9**.

TABLE 5-3: SUMMARY OF NO ADVERSE IMPACT DOCUMENTATION

FMP ID	FMP Name	No Adverse Impact Documentation
63000026	Lower Clear Creek and Dickinson Bayou Flood Mitigation Plan	Certified Engineering Statement (Appendix 5-4B) & Model (ID 060000000027)
63000058	SJMDP Caney Creek - Channelization with Detention	Certified Engineering Statement (Appendix 5-4C) & Model (ID 060000000026)
63000059	SJMDP East Fork San Jacinto River – Detention	Certified Engineering Statement (Appendix 5-4C) & Model (ID 060000000026)
63000060	SJMDP Lake Creek – Detention	Certified Engineering Statement (Appendix 5-4C) & Model (ID 060000000026)
63000061	SJMDP Peach Creek - Channelization with Detention	Certified Engineering Statement (Appendix 5-4C) & Model (ID 060000000026)
63000062	SJMDP Spring Creek - Channelization with Detention	Certified Engineering Statement (Appendix 5-4C) & Model (ID 060000000026)
63000064	SJMDP West Fork San Jacinto River - Benching and Channelization	Certified Engineering Statement (Appendix 5-4C) & Model (ID 060000000026)
63000127	Galveston Bay Surge Protection Coastal Storm Risk Management	Statement of Engineering Judgement (Appendix 5-4D)
63000417	City of Houston Fifth Ward Area Flood Mitigation (063000417)	Certified Engineering Statement (Appendix 5-4E)
63000418	City of Houston Port Area Flood Mitigation	Certified Engineering Statement (Appendix 5-4F)
63000434	City of Houston Kashmere Gardens Area Flood Mitigation	Certified Engineering Statement (Appendix 5-4G)
63000468	City of Houston Sunnyside Area Flood Mitigation	Certified Engineering Statement (Appendix 5-4H)
63000311	Galveston 37th Street	Certified Engineering Statement (Appendix 5-4I)
63000424	Friendswood - Inline & Offline Detention	Certified Engineering Statement & Model (ID 060000000090)
63000328	Keegans Bayou Flood Risk Reduction Project	Certified Engineering Statement (Appendix 5-4K)
63000334	Goose Creek Flood Risk Reduction Project	Certified Engineering Statement (Appendix 5-4L)
63000360	Kingwood Diversion Ditch	Certified Engineering Statement (Appendix 5-4M)
63000315	Design and Construction of Lower South Mayde Creek Detention Basins	Certified Engineering Statement & Model (ID 060000000312)
63000319	Design and Construction of Genoa Red Bluff Detention Basins	Certified Engineering Statement & Model (ID 060000000319)
63000357	Cypress Creek Program Detention Basin Implementation Plan	Certified Engineering Statement & Model (ID 060000000357)

FMP ID	FMP Name	No Adverse Impact Documentation
63000396	Design and Construction of Aldine Westfield North Detention Basin	Certified Engineering Statement & Model (ID 060000000396)
63000397	Design and Construction of P118-23-00 Drainage Improvements	Certified Engineering Statement & Model (ID 060000000397)
63000399	Design and Construction of P118-25-00 & P118-25-01 Drainage Improvements	Certified Engineering Statement & Model (ID 060000000399)
63000400	Design and Construction of P118-27-00 Drainage Improvements	Certified Engineering Statement & Model (ID 060000000400)
63000470	Design and Construction of P118-26-00 Design and Construction of P118-26-00 Drainage Improvements	Certified Engineering Statement & Model (ID 060000000470)
63000471	Design and Construction of Parker Road Drainage Improvements	Certified Engineering Statement & Model (ID 060000000471)
63000472	Design and Construction of Upper South Mayde Creek Detention Basins	Certified Engineering Statement & Model (ID 060000000472)
63000473	Design and Construction of Little York Stormwater Detention Basin	Certified Engineering Statement & Model (ID 060000000473)
63000475	Main Stem Evaluation Projects – Hahl Basin	Certified Engineering Statement & Model (ID 060000000475)
63000476	Cypress Creek Watershed Major Tributaries Regional Drainage Plan Update	Certified Engineering Statement & Model (ID 060000000476)
63000315	Lower South Mayde Creek Conveyance Improvements	Certified Engineering Statement (Appendix 5-4Z)
63000344	White Oak Bayou – Woodland Trails Stormwater Detention Basin	Certified Engineering Statement & Model (ID 060000000344)
63000339	Willow Creek – M120 Detention and Preservation Project	Certified Engineering Statement (Appendix 5-4AB) & Model (ID 060000000050)
63000477	P118-E006 (Hardy West) (2018 Bond Project C-41)	Certified Engineering Statement
63000313	Design and Construction of Dinner Creek Stormwater Detention Basin (2018 Bond Project C-38)	Certified Engineering Statement
63000186	Poor Farm Ditch	Certified Engineering Statement
63000321	Armand Bayou – Conveyance Improvements along B500-04-00-E004 and Channel Conveyance Improvements along B115-00-00	Certified Engineering Statement & Model (ID 60000000321)
63000474	Clear Creek Mid Reach Project	Certified Engineering Statement

FMP ID	FMP Name	No Adverse Impact Documentation
63000402	Carpenters Bayou – Mainstem Channel Modifications and Detention	Certified Engineering Statement (Appendix 5-4AG)
63000389	White Oak Bayou – E116 Tributary Modifications and Detention	Certified Engineering Statement (Appendix 5-4AH)
63000167	Greens Mid-Reach	Certified Engineering Statement (Appendix 5-4AK) & Model (ID 060000000037)
63000027	Brays Bayou CDBG-MIT Application Projects	Certified Engineering Statement (Appendix 5-4AJ) & Model (ID 060000000030)
63000037	Sims Bayou CDBG-MIT Application Projects	Certified Engineering Statement (Appendix 5-4AK) & Model (ID 060000000033)
63000040	Halls Bayou CDGB MIT Application 1 Projects	Certified Engineering Statement (Appendix 5-4AL & Model (ID 060000000029)
63000046	White Oak Bayou CDBG MIT Application Projects	Statement of Engineering Judgement (Appendix 5-4AM)
63000422	Danubina Drainage Improvement Project	Certified Engineering Statement
63000056	Mary's Creek Conveyance Improvements	Certified Engineering Statement (Appendix 5-4AO) & Model (ID 063000063)
63000327	Blalock Road Drainage Improvements	Certified Engineering Statement & Model (ID 060000000327)
63000453	Rivershire West – Alligator Creek and Grand Lake Watersheds	Certified Engineering Statement & Model (ID 060000000453)
63000320	Warren Lake and Dam	Certified Engineering Statement (Appendix 5-4AR)

Chapter 5.E. Flood Management Strategies (FMSs)

5.E.1. Summary and Approach in Recommending FMSs

The San Jacinto region identified several FMSs to recommend for inclusion in the RFP. An FMS is a proposed plan to reduce flood risk or mitigate flood hazards to life or property. These strategies are broader in application than the level of detailed analysis necessary for an FME or FMP. For consideration as an FMS, strategies should adhere to requirements included in the project *Scope of Work* and the associated *Technical Guidelines* developed by the TWDB. The San Jacinto RFPG shall recommend FMSs that meet the following TWDB requirements:

1. Support at least one regional floodplain management and flood mitigation goal.
2. Provide mitigation for flood events and measurable reductions in flood impacts in support of the RFPG's specific flood mitigation and/or floodplain management goals.
3. Should not negatively affect a neighboring area or an entity's water supply.
4. If the FMS contributes to water supply, the FMS may not result in an overallocation of a water source based on the water availability allocations in the most recently adopted State Water Plan.

TWDB recommends that, at a minimum, the FMSs should mitigate for the 1.0% ACE flood where feasible. Where mitigation for 1.0% ACE is not feasible, FMSs that mitigate for more frequent events can be included as recommended FMSs.

In addition, each potentially feasible FMS should demonstrate no negative impact to surrounding areas due to its implementation. Each of the recommended FMSs for the region are anticipated to have no adverse impacts from flooding or to the water supply based on the available data for each FMS.

Some of the recommended FMSs were combined into a single FMS for recommendation due to similarity with other FMSs. These FMSs included mitigation of repetitive flood losses and retrofitting of public buildings and critical infrastructure that were determined to be a better fit at a county-wide scale.

5.E.2. Description and Summary of Recommended FMSs

A total of 66 FMSs were collected through stakeholder outreach and publicly available documentation such as Hazard Mitigation Plans. Of these, 65 FMSs were recommended for inclusion in the RFP. Generally, these FMSs are city-wide and county-wide strategies. The FMSs represent a combined cost of $1.2 billion and support several of the regional floodplain management and flood mitigation goals described in Chapter 3.

Table 5-4 summarizes the types of FMSs, the number of FMSs for each type, and the total cost of the recommended FMSs. Recommended FMSs are illustrated in **Map 21** in **Appendix 5-3**. The full list of FMSs and supporting data is included in **Table 17** in **Appendix 5-8**. A one-page report summary of each recommended FMS is included in **Appendix 5-5B**.

TABLE 5-4: SUMMARY OF RECOMMENDED FLOOD MITIGATION STRATEGIES

FMS Type	FMS Description	# of Potential FMSs Identified	# of FMSs Recommended	Total Cost of Recommended FMSs
Education and Outreach	Programs or initiatives that aim to educate the public on the hazards and risks of flooding.	15	15	$5,370,000
Flood Measurement and Warning	Installation of or improvements to rain or stream gauges to monitor water levels and have real-time feedback during flood events.	6	6	$1,207,720
Infrastructure Projects	Critical maintenance and improvements to existing drainage systems throughout a community.	8	8	$16,030,000
Property Acquisition and Structural Elevation	Buyouts or elevation of structures with high flood risk or historical flooding impact as well as land preservation and restoration programs.	18	17	$1,166,975,000
Regulatory and Guidance	Updates or creation of new ordinances, development codes, design standards, or other floodplain management regulations to minimize future flood risk or reduce current flood risk.	10	10	$5,705,000
Other	Other flood management strategies that do not fit into the one of the above categories	9	9	$4,335,000
	Total	**66**	**65**	**$1,199,622,720**

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CHAPTER 6. IMPACT AND CONTRIBUTION OF THE REGIONAL FLOOD PLAN

The RFPG was tasked with summarizing the impacts and contributions the RFP is expected to have when the plan is implemented as recommended. The following sections describe the impacts and contributions of this plan to both flood risk and water supply. Implementation of the plan as recommended assumes that all FMPs, FMSs, and FMEs are fully funded and completed.

Chapter 6.A. Summary of Flood Risk Reduction

The goal of Task 6A is to summarize the relative reduction in flood risk that implementation of the RFP would achieve within the region regarding life, injuries, and property. This includes documenting the overall impacts of the RFP on flood risk to structures,populations, and critical facilities in the floodplain, and on number of low water crossings. In addition to flood risk, project and policy implementation impacts to the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation were also considered. Task 6A documents the findings of the RFPG from the assessment of RFP impacts. Impacts to water supply are discussed in Task 6B.

Completion of Task 6A includes the following specific items:

1. A region-wide summary of the relative reduction in flood risk that implementation of the RFP would achieve within the San Jacinto region to life, injuries, and property.
2. A statement that the FMPs in the plan, when implemented, will not negatively affect neighboring areas located within or outside of the FPR.
3. A general description of the types of potential positive and negative socioeconomic or recreational impacts of the recommended FMSs and FMPs within the flood planning region.
4. A general description of the overall impacts of the recommended FMPs and FMSs in the RFP on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

As discussed in Chapters 2 and 4A, the San Jacinto region is subject to extensive flooding and high flood risk due to a high degree of urbanization; generally flat and low-lying landscape; exposure to extreme rainfall events; and the effect of coastal flooding on a significant portion of the region. Approximately 37% of the region was classified as having a high data knowledge gap while approximately 18% of the region was classified as having high known flood risk. The recommended FMPs, FMSs, and FMEs will address portions of the region that have outdated flood mapping, inadequate identification of high flood risk areas, and limited development of specific flood mitigation solutions for funding and construction. While FMPs, FMSs, and FMEs mitigate flood risk in different ways, the combined effect of all these recommended actions will reduce flood risk, encourage more sustainable development, and protect life and property throughout the region.

Quantitative flood risk reduction data are available to assess impact through several metrics for FMPs, while an assessment of FMS and FME impact depends more on a qualitative consideration of multiple factors. The impacts will generally be determined based on before-and-after RFP implementation comparisons of the same types of information provided under Task 2, Existing Flood Risk and Future

Flood Risk Analyses. These two comparisons may, for example, also indicate a percent change in flood risk faced by various elements, including critical infrastructure. These comparisons, one comparison for a 1.0% ACE and another for a 0.2% ACE should illustrate both how much the region's existing flood risk will be reduced through implementation of the plan, as well as, how much future flood risk will be avoided through implementation of the RFP, including recommended changes/improvements to the region's floodplain management policies.

6.A.1. FMPs

A total of 70 FMPs have been recommended by the RFPG, grouped into the following general categories:

- Flood Preparedness
- Regional Channel Improvements
- Regional Detention
- Comprehensive Regional Improvements
- Infrastructure Improvements
- Coastal Protection
- Other

Channel improvements and regional detention, along with comprehensive regional projects that combine individual mitigation measures, represent the majority of the recommended FMPs. Channel improvements lower peak water surface elevations, reducing the magnitude, duration, and frequency of flooding. Regional detention basins mitigate increased peak flow rates to ensure that flood risk reduction is achieved in a manner that does not transfer risk to surrounding people or properties. FMPs that involve flood preparedness, which include improvements to stormwater regulations, permit requirements and land use ordinances to address hazard prone areas, were also recommended. The majority of these preparedness FMPs are located in the southern half of the San Jacinto region. **Table 6-1** and **Table 6-2** summarize the benefit to people and property expected if the recommended FMPs are implemented.

TABLE 6-1: SUMMARY OF IMPACT ON PEOPLE AND PROPERTY AFTER IMPLEMENTATION OF REGIONAL FLOOD PLAN FLOOD MITIGATION PROJECTS

Flood Exposure Region-wide	Existing Conditions 1.0% ACE	After Implementation 1.0% ACE	Reduction in Exposure 1.0% ACE
Total Structures	389,734	275,790	113,944
Residential Structures	329,756	235,276	94,480
Critical Facilities	6,368	4,039	2,329
Population	1,063,932	557,091	506,841
Low Water Crossings (LWCs)	160	138	22

TABLE 6-2: SUMMARY OF IMPACT ON PEOPLE AND PROPERTY AFTER IMPLEMENTATION OF REGIONAL FLOOD PLAN FLOOD MITIGATION PROJECTS[1]

Flood Exposure Region-wide	Existing Conditions 0.2% ACE	After Implementation 0.2% ACE	Reduction in Exposure 0.2% ACE
Total Structures	222,487	100,853	121,634

FMPs would reduce the number of structures in the 1.0% ACE floodplain by over 100,000, including 94,000 residential structures. This would reduce flood risk for approximately 509,000 people living within the 1.0% ACE floodplain. An estimated 22 low water crossings would be removed from the 1.0% ACE floodplain, reducing the possibility of road closure occurrences, as well as reducing injuries and fatalities associated with use of the crossings during flood events. It is important to note that specific project modeling used to determine flood risk reduction metrics and the final calculated impacts is different than the existing and future flood risk analyses presented in Chapter 2.

6.A.2. FMSs

A total of 65 FMSs have been recommended by the RFPG, grouped into the following general categories:

- Education and Outreach
- Property Acquisition and Structural Elevation
- Infrastructure Projects
- Regulatory and Guidance
- Flood Measurement and Warning
- Flood Preparedness
- Other

Approximately half of the FMSs involve public education and outreach efforts or relate to property acquisition and structural elevation. Property acquisition and structural elevation FMSs remove structures from future flooding or reduce the exposure of structures to flood risk. Public outreach campaigns provide valuable information on observed flooding and known high risk flooding areas and provide feedback on the development of specific, local flood mitigation measures. Public outreach facilitates community engagement to collectively address flooding and builds support for the implementation of individual flood mitigation projects.

Traditional infrastructure projects reduce peak flow rates and lower water surface elevations but require ongoing maintenance to support effectiveness and functionality of drainage systems. Nature-based projects provide natural flood mitigation by conserving floodplain land for agricultural use and native landscapes such as grasslands and wetlands. Regulatory and guidance FMSs play an important role in long-term risk reduction by improving stormwater regulations and floodplain management practices. Flood warning systems alert the public about impending dangerous conditions that can minimize injury

[1] Note that not all of the calculated values for the 1.0% ACE floodplain were required for the 0.2% ACE floodplain. Therefore, only the impact on the total number of structures in the 0.2% ACE floodplain is shown in Table 6-2.

and protect life by encouraging people to avoid flooded roads, seek appropriate shelter, and receive status updates on current weather and flooding conditions.

6.A.3. FMEs

A total of 405 FMEs have been recommended by the RFPG, grouped into the following general categories:

- Engineering Project Planning
- Watershed Planning
- Flood Preparedness Studies
- Other

The FMEs consist primarily of project planning with the goal of further refining and evaluating flood risk reduction solutions to finalize individual project recommendations and provide the necessary supporting cost and benefit information. Additional analyses and evaluation of structural and non-structural flood risk reduction solutions are recommended in areas determined to have higher flood risk need, evaluated during Task 4A, to facilitate the development of specific FMPs. The completion of watershed studies and Flood Insurance Study (FIS) updates provide more accurate floodplain modeling and mapping that facilitates the identification of high flood risk areas and the evaluation of flood mitigation measures from a holistic and conceptual perspective.

Updated floodplain modeling and mapping represents the critically important first step in reducing flood risk. While Harris County is in the process of developing updated flood mapping through the Modeling, Assessment, and Awareness (MAAPnext) project, other counties in the region will benefit from mapping updates. More accurate flood maps allow for risk avoidance, more effective floodplain management regulations, and more strategic planning for stormwater management and flood risk reduction that accommodates long-term development. Watershed planning also supports the prioritization of need areas based on a combination of factors, such as historical flood impacts, predicted flooding, and other socioeconomic factors, to highlight areas where FMPs should be focused to maximize the benefits of projects. Planning at the watershed level encourages complementary projects that reduce risk while avoiding adverse impacts. These FMEs help deliver cost-effective project recommendations that allow for a more equitable and beneficial allocation of limited resources.

Project planning FMEs result in the identification of future FMPs that directly contribute to reduced structural flooding, increased resilience of critical facilities, and increased mobility throughout the entire region. These types of projects affect both regional and local drainage systems, highlighting the two-pronged approach many entities within the region have taken towards flood risk reduction. Many of the FMEs involve drainage improvements aimed at addressing flooding within urbanized areas by improving an entire drainage system's functionality and effectiveness. This involves local drainage improvements at the neighborhood level to reduce street ponding as well as major storm sewer or channel improvements to enhance drainage into receiving waterways. Removing hydraulic restrictions, increasing conveyance capacity, reducing head loss, and addressing long-term maintenance issues all contribute to more effective drainage systems with runoff being conveyed safely away from homes and businesses.

The large number of FMEs highlights the extensive work previously done throughout the region to assess flood risk and identify effective and practical solutions. Additional work is needed to transform flood mitigation measures into constructed solutions that will have a direct impact on the safety and protection of lives and property. Recommended FMEs include 108 Master Drainage Plans and 8 new County FIS updates that, upon completion, will contribute significantly to more accurate flood risk information and empower communities to better regulate floodplain development and identify effective and practical solutions to mitigation flood risk.

Until the FMEs are completed, their specific benefits cannot be quantified; however, within the region, approximately 654,000 structures are currently in the 1.0% ACE floodplain and 895,000 are in the 0.2% ACE floodplain. These structures house approximately 2.23 million and 2.96 million people, respectively. Additionally, many more people are exposed to flood risk as they travel across flooded roadways. These FMEs will help reduce the risks to these people and help prevent people from becoming exposed to the 1.0% and 0.2% ACE flood risk due to expansion of the floodplain and uncontrolled development.

Completion of the recommended FMEs represents significant progress in addressing flood data knowledge gaps and high flood risk areas. Updated flood mapping is proposed for all counties within the San Jacinto region except for Harris County, where flood mapping is currently being updatedand Fort Bend County, whose area consists of just 2% of the San Jacinto region. Flood mapping update FMEs will provide more accurate flood risk information for approximately 63% of the region and directly address the 37% of the region classified as having a high data knowledge gap. The study area of Master Drainage Plan FMEs encompass roughly 31% of the region and directly address the 18% of the region classified as having high known flood risk. While any mitigation measure will not fully resolve flood risk, these numbers reflect the potential positive impact in terms of flood risk reduction benefit of FMEs in the San Jacinto region.

6.A.4. FMP No Adverse Impact

FMPs that consist of channel widening and storm sewer system improvements have the potential to increase flows which could result in water surface elevation increases downstream. To ensure that there will be no negative impacts to surrounding areas or receiving waterways, mitigation measures such as detention basins have typically been included as part of the projects.

The assessment of no adverse impact on surrounding areas or neighboring regions was performed based on currently available regional flood planning data. Sufficient mitigation will be confirmed during the design phase once project funding is obtained. Each local sponsor will be ultimately responsible for proving that the final project design has no negative flood impact prior to initiating construction. The recommended FMPs, as currently proposed, will not negatively affect neighboring areas located within or outside of the San Jacinto region.

6.A.5. Socioeconomic and Recreational Benefits

6.A.5.a. Socioeconomic Impact

Socioeconomic status plays a major role in the response to and the recovery from flood events. Flooding not only results in damaged property and infrastructure, but also has an adverse effect on the livelihoods and well-being of impacted citizens. Socioeconomically disadvantaged areas often have limited resources, making recovery from flooding events challenging with a disproportionate impact on populations of these areas. Implementing flood mitigation measures in disadvantaged areas can bring relief to repeatedly impacted residents and businesses, leading to a more financially stable and positive community outlook. Consideration should be given to promoting equitable flood risk reduction and ensuring that areas with different socioeconomic status have similar access to effective drainage infrastructure and benefit from ongoing efforts to reduce flood risk.

The implementation of the recommended FMPs has the potential to reduce socioeconomic disparity regarding flood risk by promoting flood mitigation measures in areas that may have lower benefit cost ratios or include more vulnerable or disadvantaged populations. The San Jacinto region is characterized by a wide range of socioeconomic status and includes areas characterized by both low and high Social Vulnerability Index (SVI) rankings. SVI rankings range from 0 (lower social vulnerability) to 1 (higher social vulnerability) and are typically categorized into quartiles that represent low, low-to-moderate, moderate-to-high, and high social vulnerability. Approximately 44% of the area, ,225 out of 5,070 square miles, within the San Jacinto region encompasses locations with an SVI of 0.50 or higher representing moderate-to-high and high social vulnerability. Similarly, roughly 27% of the entire region, 1,391 out of 5,070 square miles, contains at least 50% of the population classified as Low-to-Moderate Income (LMI), another indicator of social disparity.

FMPs

Positive and negative socioeconomic impacts of the recommended FMPs are described below:

Positive Impact

- Flood risk is reduced in more vulnerable communities where recovery can be more difficult and financially challenging.
- Reduced flooding improves mobility and reduces interruption of people’s lives and work routines, creating a more resilient and connected community.

Negative Impact

- Implementation of projects can create community disruption.
- Acquiring the necessary right of way (ROW) for projects can displace people and negatively affect tax base and community well-being.

FMSs

Positive and negative socioeconomic impacts of the recommended FMSs are described below:

Positive Impact

- Flood risk is reduced in more vulnerable communities where recovery can be more difficult and financially challenging.
- Mobility improves and reduces interruption of people’s lives and work routines, creating a more resilient and connected community.

- Strategies facilitate removal of structures and people from flood risk exposure.
- Vulnerable communities are protected through smart planning and flood awareness education.
- People are empowered to prepare for flooding, evacuate, and recover from damage.
- Strategies provide a consistent regulatory framework across the San Jacinto region to further encourage sustainable development and growth opportunities that minimizes flood risk.
- Strategies communicate a dedicated, collective effort to address flooding within impacted communities.

Negative Impact

- Increases The regulatory burden for communities can be increased, which can increase cost and permitting effort for development.
- Strategies can increase workload for public agencies.
- Implementation of some FMSs can lead to blight in certain areas, if not handled appropriately.
- Implementation of some FMSs could disproportionally affect vulnerable communities.

6.A.5.b. Recreational Impact

Recreational opportunities are a major contributing factor to quality of life. The San Jacinto region encompasses a wide range of natural and man-made recreational areas such as forests, lakes, streams, parks, and trail systems. The implementation of FMPs and FMSs provides the chance to simultaneously build other community amenities and preserve open space to further enhance recreation, while mitigating flood risk.Many project sponsors, such as the HCFCD, are actively exploring ways to partner with other sponsors to combine flood mitigation projects with public amenities, delivering bothflood risk reduction solutions and environmental and recreational benefits.

Over the past decade there has been a renewed focus on providing the public with recreational opportunities through the creation of parks, urban green spaces, and multi-use trail systems. Many local entities within the San Jacinto region, such as Harris County and the Houston Parks Board, are actively working to build these recreational facilities either through their own planned projects or partnerships with other agencies. While there is continued pressure from the public to mitigate flood risk, community groups are also advocating for the increased use of nature-based solutions and emphasizing the ability to have a single project serve a flood control purpose as well as provide supplementary benefits.

FMPs

Positive and negative recreational impacts of the recommended FMPs are described below:

Positive Impact

- More opportunities are created to promote positive physical and mental health.
- Project value is enhanced from providing multi-use projects that support more livable and integrated communities.

Negative Impact

- Additional green space and parks require funding and staff for operation and maintenance.
- Recreational areas can be subject to safety issues and accumulate trash/debris.
- Effort is required to properly design recreational features and integrate them with flood mitigation projects.

FMSs

Positive and negative recreational impacts of the recommended FMSs are described below:

Positive Impact

- More opportunities are created to promote positive physical and mental health. Strategies for flood risk reduction can incorporate nature-based solutions for more recreational opportunities.
- Strategies can provide land for new recreational areas through floodplain preservation and buyout programs.

Negative Impact

- Additional green space and parks require funding and staffing for operation and maintenance.
- Recreational areas can be subject to safety issues and accumulate trash/debris.

6.A.6. Other Impact Considerations

6.A.6.a. Environmental

The implementation of FMPs, such as channel widening and detention basin construction projects, has the potential to negatively impact wetlands and threatened and endangered species, and reduce the functionality of natural areas. The design and construction of FMPs should be performed in a manner that avoids or minimizes environmental impacts. Proper permitting is required from local, state, and federal agencies to ensure compliance with applicable regulations. Consideration should be given to avoiding environmentally sensitive areas to reduce environmental impact and maintaining the undisturbed condition and existing drainage of natural areas.

Flood risk reduction that results from the implementation of FMPs would reduce the discharge of potentially hazardous materials from flooded structures. The FMPs would also reduce the generation of debris from damaged areas due to a lower magnitude and frequency of flooding. The identification and removal of designatied repetitive loss and severe repetitive loss structures, sponsored by the Cities of Galveston, Manvel, Pearland, and League City, will provide a positive environmental impact through reduced structural flooding. Similar efforts are ongoing in Harris, Galveston, and Brazoria Counties. The Harris County voluntary buyout program sponsored by the HCFCD is another FMS expected to significant benefit this heavily urbanized part of the region that is subject to frequent and widespread flooding.

Non-structural FMSs protect riparian areas from development, which maintains the environmental and flood control value of these areas, along with providing water quality, erosion, and sedimentation benefits. Floodplain preservation also has the potential to impact the natural resources of the floodplain by removing the land from potential development. Land restoration and preservation efforts by Brazoria County and the Coastal Prairie Conservancy, focused on the upper Barker Reservoir and Mound Creek, will provide multiple environmental benefits while also contributing to flood mitigation.

6.A.6.b. Agricultural

Land acquisition for structural FMPs and FMSs could result in a reduction of land area available for agricultural use although some FMSs, such as those related to floodplain preservation, could lead to maintaining or even increasing the amount of agricultural land within the region. Less frequent and severe flooding resulting from the implementation of FMPs and FMSs could increase the productivity of these areas and also minimizes harmful environmental impacts.

Recommended FMPs and FMSs are predominately located in more urbanized areas where agricultural land comprises generally less than 5% of the total FMP or FMS study area; therefore, no significant impact to agriculture is anticipated. The removal of 4,788 acres of agricultural land from the 1.0% ACE floodplain is expected due to the implementation of the recommended FMPs.

6.A.6.c. Water Quality

The release of contaminants, accumulation of trash, and nutrient runoff from agricultural lands are examples of actions that negatively affect water quality. Many structural FMPs are required to incorporate water quality into their design that will directly improve water quality, such as installing trash racks or prepackaged stormwater treatment devices.

Lowering water surface elevations will reduce inundation of critical utility facilities, such as water and wastewater treatment facilities, and lower the likelihood of untreated water being released into the environment. The implementation of the recommended FMPs will remove 2,332 critical facilities from the 1.0% ACE floodplain. Floodproofing/hardening buildings and public utilities further lowers the risk of structural flooding and the release of contaminants. Extended residence time within detention basins also contribute to water quality benefits by trapping bacteria and pollutant carrying sediments in the basin rather than releasing them downstream. Reduction of flooded agricultural land mitigates high nutrient runoff, introduction of bacteria/contaminants, and presence of low dissolved oxygen, anoxic, conditions that are detrimental to aquatic life and harmful to human health.

Some FMSs involve maintenance of drainage systems that consist of clearing debris, sediment, and excess vegetation which improve water quality by minimizing stagnant water and reducing trapped trash/debris. Floodplain preservation creates natural habitat with native vegetation that promotes the natural circulation and treatment of water. Regulations and ordinances also play an important role in the improvement of water quality by emphasizing the proactive prevention of pollution at the source.

6.A.6.d. Erosion and Sedimentation

Erosion and sediment control measures that limit high velocities and protect the functional of drainage infrastructure should be incorporated into the design and construction of FMPs. Ongoing maintenance of constructed projects will be required to address long-term sedimentation which reduces the conveyance capacity of storm sewers and channels.

The approaches included in the recommended FMSs have the potential to reduce erosion by enhancing the regulation of development in flood prone areas. In addition, certain FMSs are focused on the maintenance of existing drainage systems that involve removing sediment and repairing areas where erosion is observed. Protection of undisturbed areas (floodplain preservation) or returning flood impacted properties to a natural state also reduces erosion and sedimentation by reintroducing natural drainage and ecological processes. Public awareness campaigns can also be beneficial to alert businesses and residents of the causes and consequences of erosion and sedimentation.

6.A.6.e. Navigation

The primary navigable channel within the San Jacinto region is the Houston Ship Channel, which serves a critical transportation route for numerous industrial and petrochemical facilities located adjacent to the channel. The Houston Ship Channel drains into Galveston Bay and provides a direct connection to the Gulf of Mexico. Maintenance is regularly performed for the Houston Ship Channel to maintain navigation in support of the Houston maritime shipping industry.

The Coastal Texas Study FMP includes several significant structural improvements within Galveston Bay, Clear Creek, and Dickinson Bayou aimed at increasing coastal protection and reducing flood risk throughout the region. It is assumed that the design and construction of the associated features will be done in a manner that accounts for navigation considerations and strives tp preserve navigation to the greatest extent possible . While this FMP will affect navigation, it is not anticipated that any adverse impact will occur.

The majority of the FMSs are related to floodplain management guidelines and public flood awareness and education. No FMSs are associated with major structural mitigation measures that would impede or improve navigation within the region; therefore, no impact from FMSs on navigable waters is anticipated.

6.A.7. Impact of Regional Flood Planning Goals

Regional flood planning goals were established by the San Jacinto RFPG as a part of Task 3. While the goals include short-term and long-term objectives, Task 3 establishes a long-term vision for target metrics that subsequent planning cycles should achieve.

Some of the RFPG goals, such as increasing stormwater infrastructure investment or increasing use of nature-based solutions, as examples, are not easily represented by specific FMPs or FMSs but rather provide a general framework for developing, recommending, and implementing future flood mitigation and management measures. While FMPs primarily address goals related to reduction in existing flooded infrastructure, FMSs incorporate many nonstructural approaches to reducing long-term flood risk in a sustainable and comprehensive way through partnerships, effective planning, and collaboration between stakeholders and the public.

Regulation of development, implementation of higher standards, and use of best available data are all interdependent strategies for avoiding potential increases in flood risk over time. Higher standards, as discussed in the *Technical Guidelines for Regional Flood Planning*, can include freeboard requirements, detention requirements, or fill restrictions. Higher standards provide a factor of safety to account for future uncertainty in identified flood risk. Baseline minimum standards should be set through NFIP participation, uponwhich higher standards can be built.

Chapter 6.B. Contributions to and Impacts on Water Supply Development and the State Water Plan

In response to the 1950's drought, the TWDB was established in 1957 to prepare a comprehensive long-term plan for the development, conservation, and management of the state's water resources. The current SWP, 2022 State Water Plan – Water for Texas, was produced by the TWDB and based on approved regional water plans (RWPs) in accordance with Senate Bill (SB) 1, enacted in 1997 by the 75th Texas Legislature. As stated in SB1, Section 16.053.a, the purpose of the regional water planning effort is to:

"…provide for the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of that particular region."

The TWDB established 16 regional water planning areas (RWPA) and appointed members who represent key public interests to the regional water planning groups (RWPG). This grassroots approach allows planning groups to evaluate region-specific risks, uncertainties, and potential water management strategies. Region 6 primarily covers Region H and minimally covers some of Region G, in Grimes County, as shown in **Figure 6-1**.

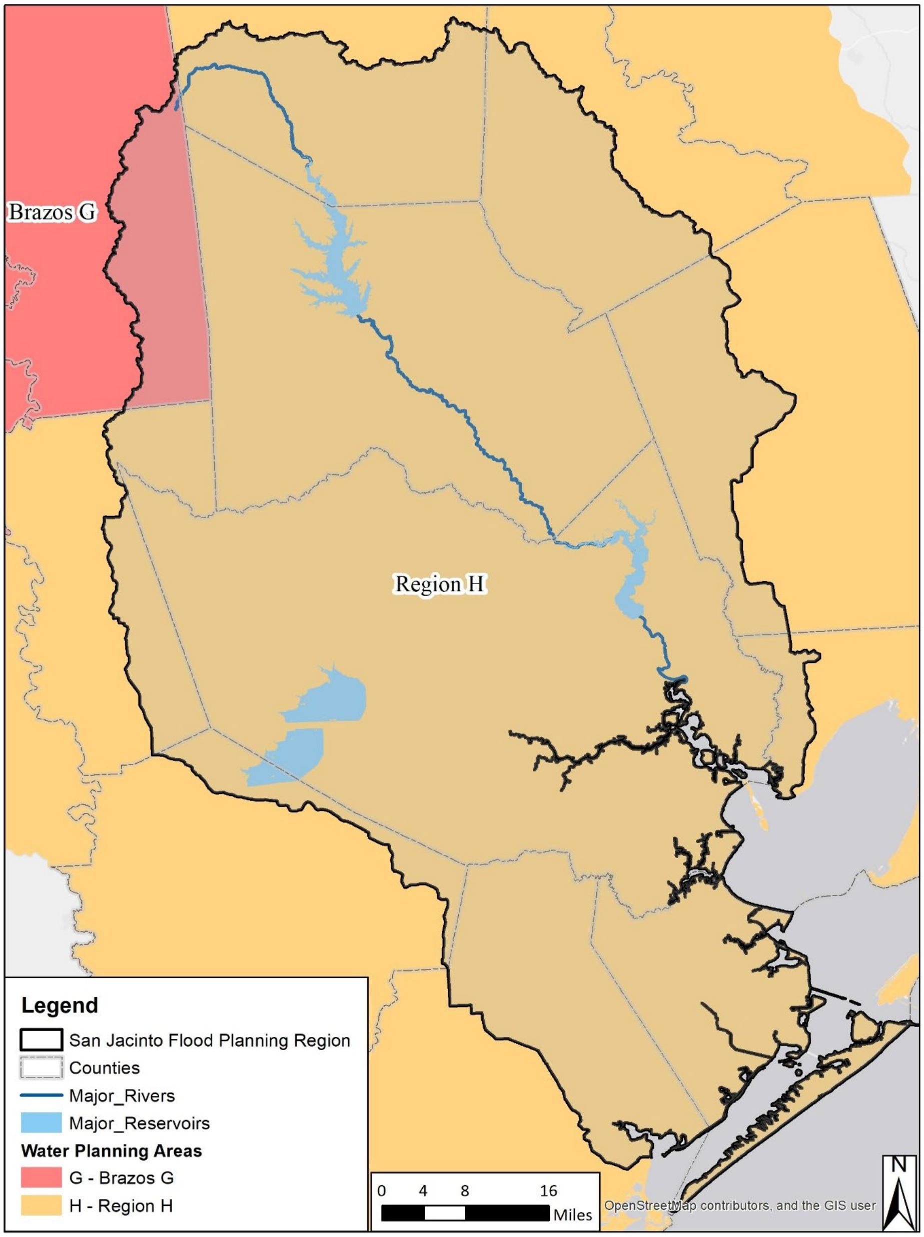

FIGURE 6-1: REGION 6 WITH ASSOCIATED WATER PLANNING AREAS

The goal of Task 6B is to evaluate potential impacts of the RFP on water supply development and the SWP. This chapter describes the processes undertaken by the San Jacinto RFPG to achieve these tasks and summarizes the outcomes of this effort.

This effort included:

- a region-wide summary and description of the contribution that the RFP would have on water supply development, including a list of specific FMSs and FMPs that would measurably impact water supply; and,
- a description of any anticipated impacts that the RFP FMSs and FMPs may have on water supply, water availability, or projects in the SWP.

6.B.1. Contribution of the Regional Flood Plan on Water Supply Development

RFPGs must list recommended FMSs or FMPs that, if implemented, would measurably contribute to water supply such as:

1. involves directly increasing water supply volume available during drought of record which requires both availability increase and directly connecting supply to specific water user group(s);
2. directly benefits water availability;
3. indirectly benefits water availability; and
4. has no anticipated impact on the water supply.

Examples of FMSs and FMPs that could measurably contribute to water supply include directly or indirectly recharging aquifers. Additionally, large detention structures could potentially be modified to include a water supply component for irrigation or other needs. Another example could be the implementation of stormwater management ordinances that manage flooding but could also include a water supply aspect of beneficial reuse for irrigation purposes. Finally, while not generating a measurable water supply increase, green infrastructure, natural channel design, stormwater detention, low impact development, and other measures can help mitigate flood flows and at the same time protect water quality. These measures can help manage downstream water treatment costs and benefit rate payers.

Many FMSs and FMPs could potentially be applicable to water supply through the implementation of various environmental enhancements inherent within their design. The most common example of this feature is construction of wet bottom detention and natural channel design both of which can serve to improve water quality and therefore potentially reduce downstream treatment costs. However, this strategy would not have any direct or measurable impact on water supply. As noted in **Table 16** and **Table 17** in **Appendices 5-7** and **5-8**, there are no recommended FMSs or FMPs that would measurably contribute to water supply.

6.B.2. Anticipated Impacts to the State Water Plan

Additionally, RFPGs must also list recommended FMSs or FMPs that if implemented would negatively impact and/or measurably reduce:

1. water availability volumes that are the basis for the most recently adopted State Water Plan; and,
2. water supply volumes, if implemented.

An example of an FMS or FMP that could measurably reduce water availability involves reallocating a portion of reservoir storage that is currently designated for water supply purposes to be used for flood storage instead. There are no such recommended actions related to reservoirs for Region 6. Additionally, land use changes over time could potentially reduce groundwater availability due to less naturally occurring aquifer recharge. An FMS that preserves open space or limits additional impervious cover could help maintain aquifer recharge.

As noted in **Table 13** and **Table 14** in **Appendices 5-7** and **5-8**), there are no recommended FMSs or FMPs in the San Jacinto RFP that would measurably contribute or have a negative impact and/or measurably reduce water supply in any of the RWPAs.

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CHAPTER 7. FLOOD RESPONSE INFORMATION AND ACTIVITIES

The San Jacinto region experiences a variety of flooding types as well as responses to floodevents. This chapter summarizes the activities within the region to prepare for, respond to, and recover from flood events. Information in this section was collected from survey responses, previous studies and plans, and discussions with agencies within the region.

There are several types of flooding that impact residents and communities within the San Jacinto region, ranging from tropical cyclones from the Gulf of Mexico to frontal thunderstorms from northern Texas.

- Coastal flooding may occur due to an occurrence such as waves, tide, storm surge, or heavy rainfall from tropical storms. Coastal flooding tends to be the most extreme when the storm surge is high. Coastal flooding may also occur due to higher than average, king or seasonal tides or tsunamis. Notable coastal events in recent years that impacted the San Jacinto region include Hurricane Nicholas (2021), Tropical Storm Beta (2020), Tropical Storm Imelda (2019), Hurricane Harvey (2017), Hurricane Ike (2008), and Tropical Storm Allison (2001).
- Riverine floods occur when excess rainfall within a watershed causes overtopping of a riverbank. This rainfall can be caused by both frontal thunderstorms as well as effects from coastal events. This overtopping then spills the water into floodplains.
- Pluvial floods happen when there is flooding independent from a river due to excessive rainfall on internal drainage systems such as storm sewers, ditches, or overland sheet flow. The most common example of this is when urban drainage systems are overwhelmed, and the excess water floods into the streets.
- Flash floods are caused by heavy rainfall over a relatively short period. The flood water can be very powerful making it extremely dangerous.

Emergency preparedness is necessary for each of these flooding scenarios to assist communities and people in disaster response. There are four phases in emergency management[1] shown in **Figure 7-1**.

FIGURE 7-1: THE FOUR PHASES OF EMERGENCY MANAGEMENT

- **Flood Mitigation:** The implementation of both structural and non-structural solutions, to reduce flood risk and protect against the loss of life and property.

[1] Federal Emergency Management Agency, 1998, IS-010 Emergency Management Institute: Animals in Disaster, Module A: Awareness and Preparedness, Washington, DC, 185pp. Accessed on 2/24/2021 at https://training.fema.gov/emiweb/downloads/is10comp.pd

- **Flood Preparedness:** Actions, aside from mitigation, that are taken before flood events to prepare for flood response.
- **Flood Response:** Actions taken during and in the immediate aftermath of a flood event.
- **Flood Recovery:** Actions taken after a flood event involving repairs or other actions necessary to return to pre-event conditions.

Flood mitigation is the most important step in flood plan development, and efforts to identify potential flood mitigation strategies, evaluations, and projects for the San Jacinto region are described in Chapters 4 and 5. When implemented, these studies and projects will reduce flood risk for the region and, depending on the project, may also improve communication of the risk to the public. Flood preparedness, response, and recovery are the focus of this chapter.

Chapter 7.A. Summary of Emergency Management for the San Jacinto Region

Entities throughout the region have differing approaches to emergency response based on their existing capabilities and responsibilities as well as individual community needs. Each entity has methods of communicating flood preparedness awareness to the public, responding to flood emergencies, and coordinating recovery activities. Existing flood response information was collected through the survey[2], discussions with local entities, emergency action plans of entities in the San Jacinto region, and available studies.

7.A.1. Preparation

Preparation includes actions taken by both citizens and the government to prepare for a flood disaster event. Preparation may occur minutes, days, or years prior to an event and ranges from emergency plan development to public education. The list below summarizes various preparations within the San Jacinto region:

- Agencies perform tabletop exercises which are informal discussion-based sessions where teams practice roles and responsibilities during an emergency by walking through example scenarios. Many agencies conduct flood response scenarios with their various departments annually.
- Agencies identify critical infrastructure prior to disaster events and the potential level of inundation that may occur. This information is used to prepare staff as well as emergency responders for the flooding potential.
- Varying agencies have documented emergency action plans (EAP) that provide the process for responding to flooding events. These plans specify relevant roles and responsibilities as well as action items for agency personnel. **Figure 7-2** depicts the operational plan prepared by the Galveston County Health District, as an example.

2 In order to help facilitate gathering the most accurate information for the Region, a Data Collection Survey Tool was set up for response from municipalities throughout the region. Please see Chapter 1 for more information.

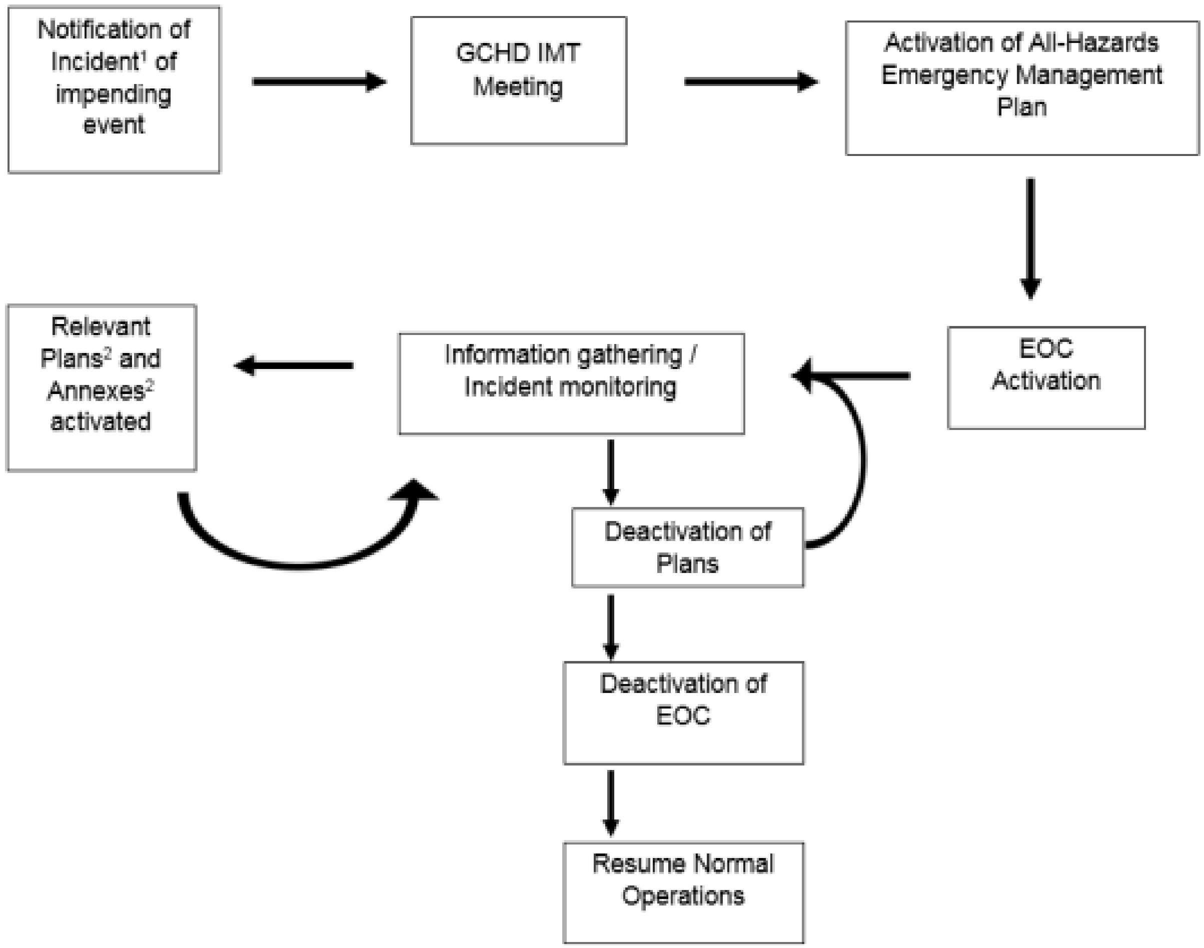

FIGURE 7-2: GALVESTON COUNTY HEALTH DISTRICT EAP

- Some communities open designated shelters during flood events and provide training to both volunteers and staff assigned to each shelter.
- Agencies develop and store pre-scripted messages that can be used during flood events to alert and inform the public.
- Communities provide public education and outreach regarding emergency preparedness and local warning systems. An example is the Galveston County Disaster Guide shown in **Figure 7-3**. This and other documents provide local government contact information, steps for evacuation, and guides for developing an individual disaster plan.

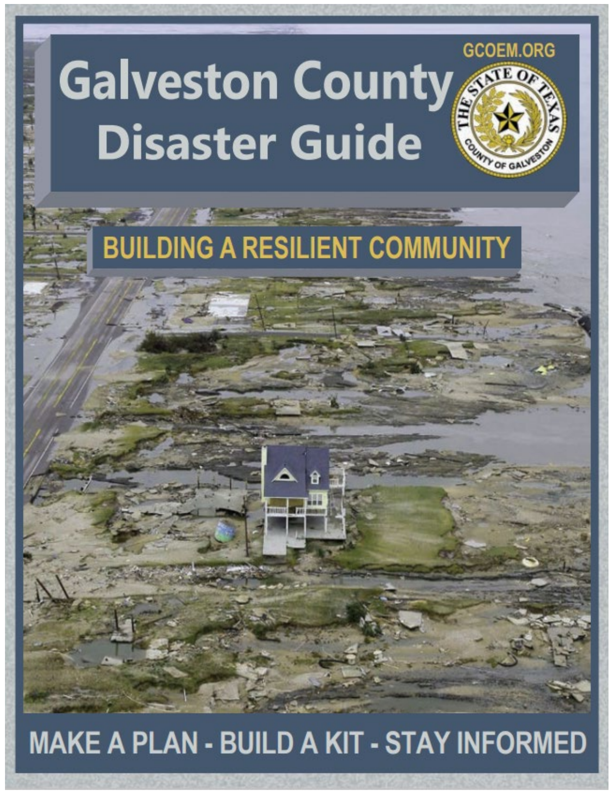

FIGURE 7-3: GALVESTON COUNTY DISASTER GUIDE

- When preparing for disasters, communities identify and monitor areas of known flood risk during storm events and stage evacuations and rescues as needed. These areas are located through available flood mapping, as well as historical accounts. Communities also identify areas and individuals with functional needs that may need additional assistance.
- Communities perform damage assessments post-disaster and train staff on the assessment process so that personnel are ready to be deployed following the event.
- Cities and agencies procure debris removal contracts and have contractors on-call when needed. Debris on roads affects mobility for emergency crews and the public returning home after the event, and, therefore, must be cleared.
- Agencies develop public listservers to distribute information regarding the event to individuals who sign up for the information.
- Communites will educate the public regarding the importance of purchasing flood insurance from the NFIP.
- Some communities have purchased high water rescue vehicles that are used in disaster response efforts.
- The Houston-Galveston Area Council (H-GAC) has prepared a hurricane evacuation route map that various emergency managers across the region use. The map, shown in **Figure 7-4**, also shows evacuation corridors and connections as well as the four zones used for mass evacuation by zip code.

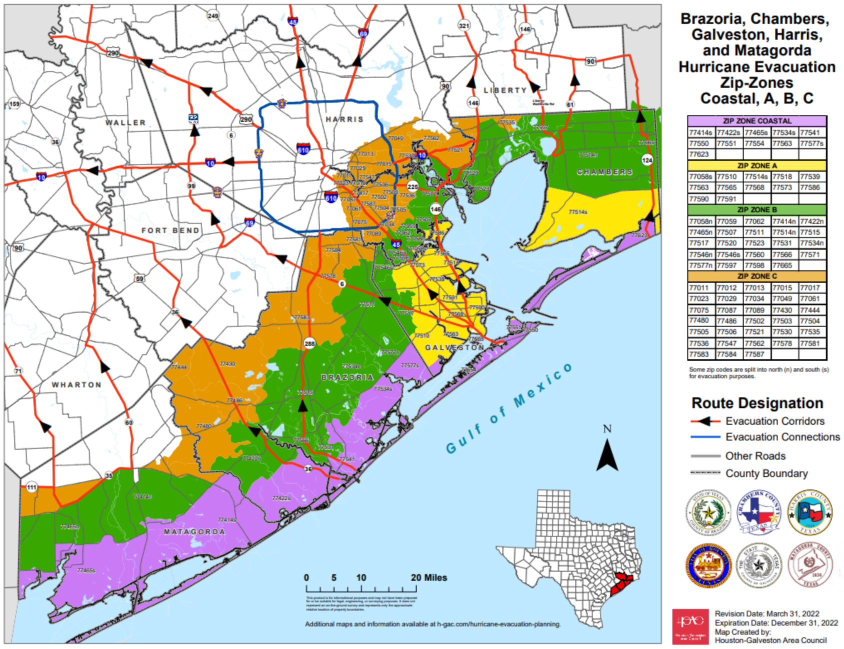

FIGURE 7-4: HGAC HURRICANE EVACUATION ROUTES AND ZONES

7.A.2. Response

Flood response actions occur during and after a storm event as floodwaters rise and fall within the region. Response actions require cooperation among various agencies and residents of the region for successful coordination. Actions include public and interagency communication, alerts, and agency response. The following sections summarize various flood response actions within the San Jacinto region:

7.A.2.a. Public Communication

Public communication activities are the most common activities undertaken by emergency response agencies within the region. Various public communication activities include:

- Reverse 911 notifications are used by various entities to send alerts directly to citizens’ phones based on a geographic area. These alerts can include information regarding weather watches and warnings, as well as flooded areas to avoid.
- Many entities use social media posts on platforms including Facebook, Twitter, YouTube, and LinkedIn.
- Local news media is used to communicate critical information quickly and effectively to residents throughout the region.
- Agencies update their websites to provide the status of current conditions and how to request assistance.
- Radio stations KTRH 740 AM and KUHF 88.7 FM serve as the Emergency Alert Systems (EAS) for the San Jacinto region and will send out weather and flooding alerts as requested by the National Weather Service and other agencies.

- CodeRED Community Emergency Alert system is used by several communities to alert residents and businesses of critical situations. The system is geography based and sends out messages to anyone registered and located within the region via text messages, phone calls, and emails.
- Some emergency response agencies use a direct hotline for the public to call and receive information or have call-takers available to answer questions.
- Press releases are developed, distributed to news media and other pertinent agencies, and posted on social media regarding current status of infrastructure.

7.A.2.b. Interagency Coordination

In addition to communicating with members of the public, communication between emergency response agencies is critical during flood events. There are many ways that interagency coordination is performed by agencies within the region, including:

- Emergency coordinators contact each other via phones or radio to communicate information regarding infrastructure status and flood-related issues. They also use these channels to request additional assistance when needed.
- City departments, such as police and fire, as well as other emergency response agencies, use radio systems as they are more reliable than cellular service during major events. The Government Emergency Telecommunications Services (GETS) is part of the Department of Health and Safety Office of Emergency Communications and allows authorized users to utilize public landline networks during emergencies.
- Emergency Operation Centers (EOC) are established and include personnel from various jurisdictions and agencies for direct communication and coordination. **Figure 7-5** shows the Harris County EOC.

FIGURE 7-5: HARRIS COUNTY EMERGENCY OPERATION CENTER

- Agencies use WebEOC® which is designed to bring real-time crisis information management to local, state, and federal EOCs. Agencies can log on and coordinate with each other through this network.
- County sheriff's officesand fire and police departments are used for information dissemination to the public and for coordinating evacuations.
- Agencies and communities participate in regional coordination calls with federal agencies such as the National Weather Service, National Hurricane Center, and FEMA.
- Agencies coordinate with critical care facilities such as hospitals and nursing homes regarding potential flooding in the area and coordinate assistance.
- Agencies and communities conduct news conferences to inform the public.

7.A.2.c. Flood Alerts

Flood Alerts are more direct ways of disseminating critical information to the public and affected agencies during a flood event. Alert methods vary across agencies but include:

- Emergency management personnel monitor and alert emergency response agencies responsible for closing flooded roadways. Staff are also assigned to monitor roadways that typically flood.
- Communities and agencies monitor National Weather Service broadcasts for flood alerts and react accordingly.
- Some emergency response agencies monitor the West Gulf River Forecast Center flow and stage predictions. Some agencies also will provide information to the Center for its use in developing predictions. The predictions indicate potential peak river stages which assist emergency response agencies to make decisions regarding evacuations and issue public alerts. **Figure 7-6** shows a forecast of stage and flow predictions for Peach Creek, as an example.

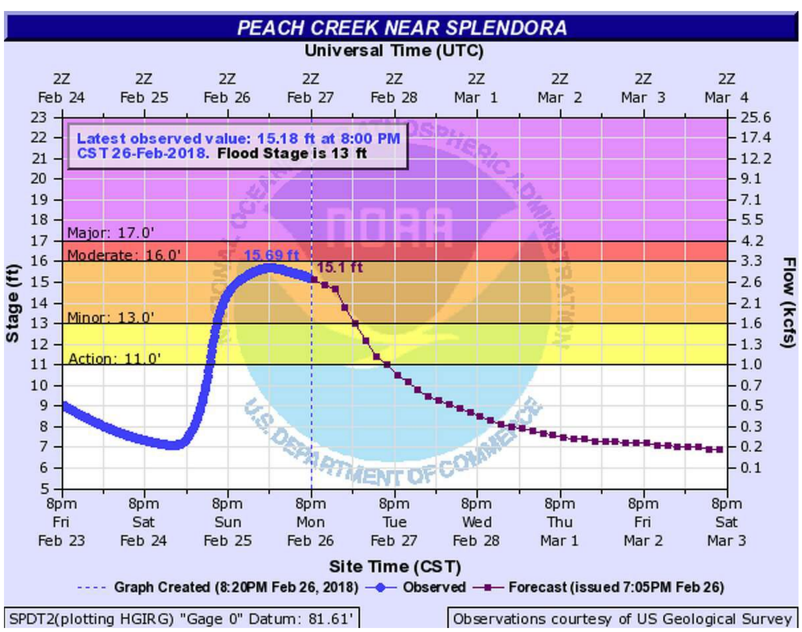

FIGURE 7-6: PEACH CREEK RIVER FORECAST CENTER STAGE AND FLOW PREDICTIONS

- Many rural emergency response agencies communicate with TxDOT regarding the status of state-maintained roadways and alert the public of potential route closures due to flooding.
- Local public school district bus drivers provide valuable information regarding flooded roadways within the school district boundaries that local entities can use to re-route traffic and close roads.
- Some communities have purchased proprietary subscription services that provide detailed weather forecasting information.
- Communities review the Houston Transtar (https://www.houstontranstar.org/) webpage (screenshot in **Figure 7-7**) for information regarding weather, alerts, and traffic conditions.

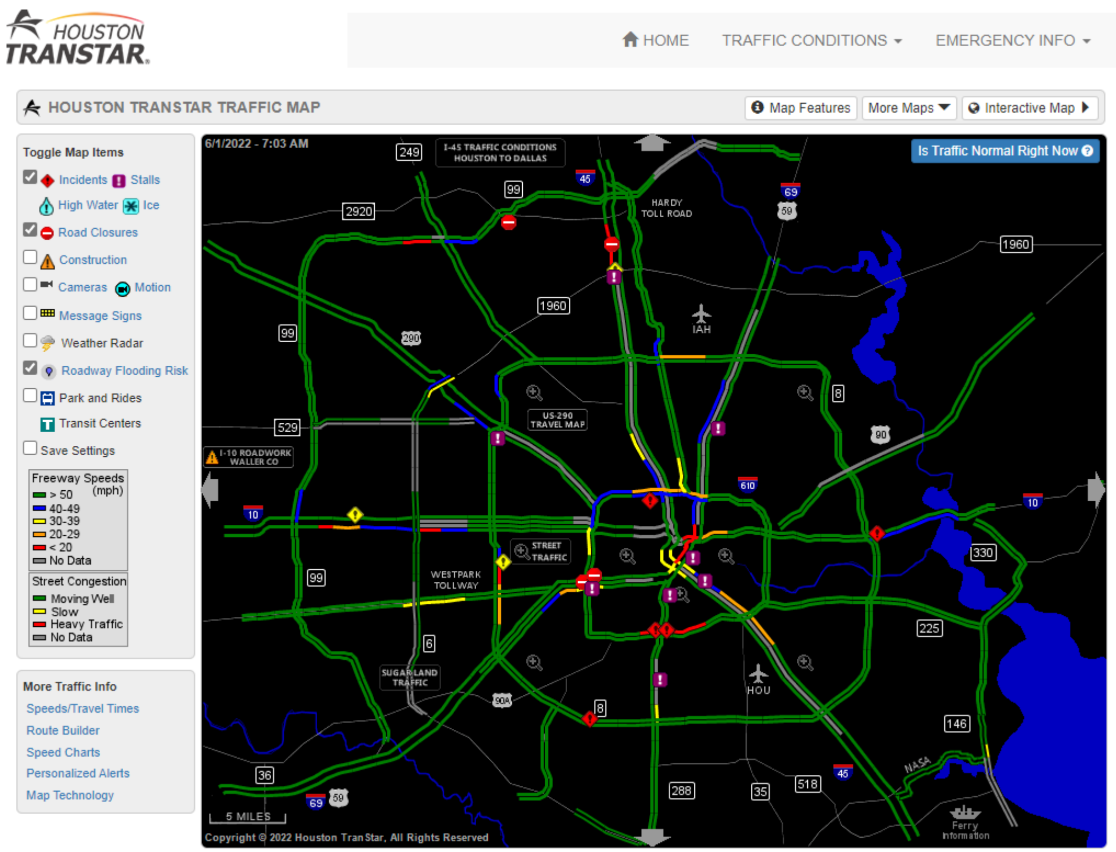

FIGURE 7-7: HOUSTON TRANSTAR WEBMAP

- The Harris County Flood Warning System (harriscountyfws.org) includes real-time information regarding rainfall, bayou stage, and potential inundation in Harris County and some of the surrounding watersheds as shown in **Figure 7-8**. The website also offers text notifications regarding flood gauge status to which the public can subscribe to receive real-time alerts for potential flooding.

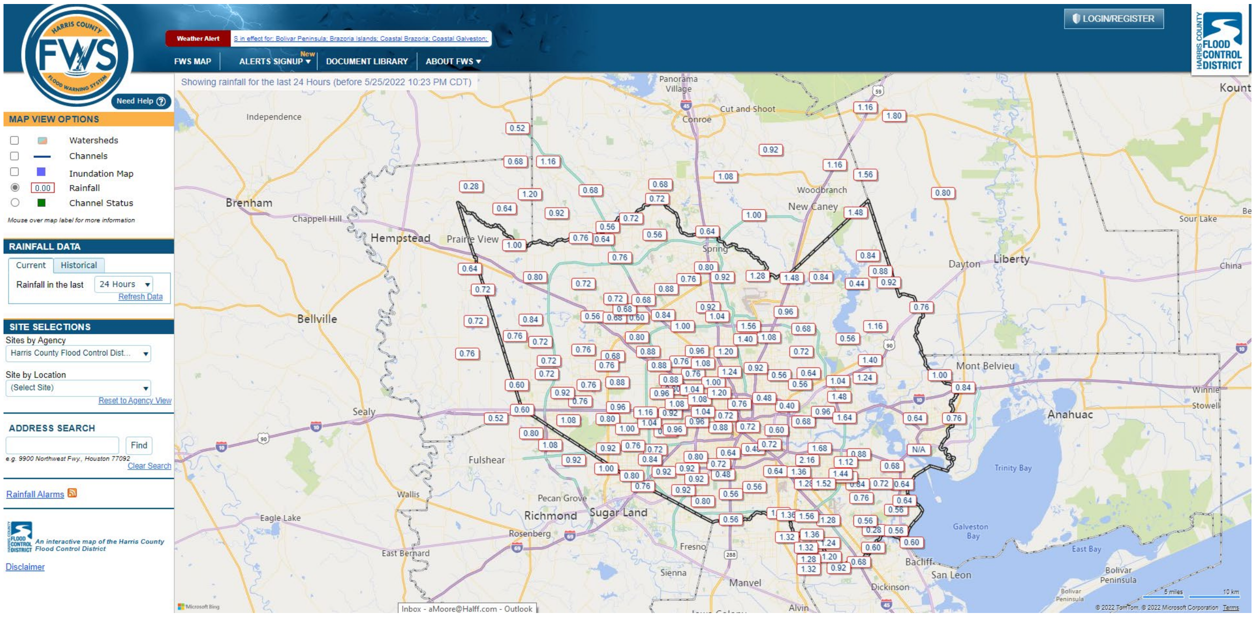

FIGURE 7-8: HARRIS COUNTY FLOOD WARNING SYSTEM WEBSITE

7.A.2.d. Agency Response

Agency response during flood events is critical for protection of life and property as well as to prepare for future flood responses. Typical flood response activities undertaken by various agencies in the San Jacinto region include:

- Closing flooded facilities including roadways, lakes, and recreational facilities to protect the public from encountering high water, debris, and other dangers;
- Opening and staffing shelters for evacuees;
- Issuing evacuation orders for coastal areas according to established evacuation protocol and maps;
- Providing high water rescue efforts, as needed;
- Collecting and distributing food, clothing, first aid, and other essential goods to evacuees and flood damage victims;
- Providing traffic control during evacuations;Managing rumors by providing public information via social media and websites;Collecting high water marks and recording flow information from the event; and,Deploying drones for a variety of flood response and traffic monitoring during disaster events.

7.A.3. Recovery

Recovery from flood events can be a long process as homes, roads, and facilities are repaired and rebuilt. Recovery includes local agencies' conducting damage assessments for both private and public structures, coordination with federal disaster relief agencies, assistance to victims via temporary housing, and providing information regarding recovery efforts. The list below summarizes various flood recovery actions within the San Jacinto region:

- Providing the public with information related to flood insurance and the recovery process;
- Performing damage assessments for both infrastructure and structures and identifying unsafe structures and roadways;
- Removing debris from roadways and public areas and dispositing at pre-determined debris collection points;
- Providing traffic control when affected individuals begin returning to previously flooded areas;
- Assisting residents with temporary housing, if available;
- Demobilizing shelters and mass-care facilities and returning facilities to their normal post recovery use;
- Managing home buyout programs for frequently flooded properties;
- Regularly communicating with disaster victims;
- Compiling records of the disaster event, including observations and documentation of flooding locations, magnitude, and duration;
- Reviewing and updating building code requirements;
- Preparing after-action plans for flooding and other disasters; and,
- Coordinating with local businesses and industries to provide necessary materials to citizens to assist in the rebuilding process.

Chapter 7.B. Relevant Entities in the Region

Preparedness, response, and recovery involves a multitude of local community agencies, as well as state and federal agencies, each tasked with differing roles and responsibilities. Listed below are the various contributing entities and partners.

7.B.1. Local Communities

- Cities, or municipalities, are generally responsible for local response, recovery, and preparedness for flood disaster events. There are 81 cities within the San Jacinto region with populations ranging from a few thousand to several million. Response for cities includes emergency responders such as fire, police, and health/safety personnel for emergency alerts and rescues during events. Public works departments manage utilities including operating back-up generators for water supply and sewage treatment plants and their associated infrastructure, among other tasks. Road and maintenance crews monitor road conditions and close roadways to prevent vehicles from encountering high water. City officials also update their citizens through social media posts and public alerts before, during, and after events.

- There are 11 counties within the San Jacinto region. During flood events, county governments provide the public with critical information, close flooded roadways, perform high water rescues, and coordinate emergency operations.
- The Houston-Galveston Area Council (HGAC) is a regional organization that supports coordination among local governments, mainly to cities and counties, and seeks to provide cooperative planning, coordination, and technical assistance on issues of mutual concern across jurisdictional lines. HGAC serves as a resource for flood data, flood planning, and flood management information.
- The HCFCD mobilizes the Flood Watch team during flood events. District personnel monitor the District's extensive network of rainfall and streamflow gauges to provide accurate information to local officials and the public. Personnel conduct visual surveys and collect physical stream flow data during the flood event, when possible, to verify gauge information. District personnel also participate in the Harris County emergency operations center, providing timely information to emergency management officials, the media, and the public. After flood events, the District is active in debris removal, emergency repairs and maintenance activities, and many other tasks.
- Drainage districts are special-purpose districts established to own and maintain drainage infrastructure within their jurisdictions. After flood disasters, districts may remove debris and sediment within channels to restore conveyance.
- Dams and levees are owned and operated by individuals, private and public organizations, or governmental entities. The responsibility for maintaining a safe dam or levee rests with the owner. A failure resulting in an uncontrolled release can have devastating effects on persons and property downstream. Dam and levee owners are a critical part of the flood response planning process to ensure a collaborative and cohesive plan.

7.B.2. State Agencies

- The TWDB provides to the region planning assistance, data collection and dissemination, technical assistance, and financial assistance services before, during, and after flood disasters.
- The Texas Division of Emergency Management (TDEM), a division of the Texas Department of Public Safety (DPS), is charged with coordinating state and local responses to natural disasters and other emergencies in Texas. TDEM is intended to ensure that the state and local governments respond to and recover from emergencies and disasters and implement plans and programs to help prevent or lessen the impact of emergencies and disasters. There are six TDEM regions within Texas. They serve as the Division's field response personnel stationed throughout the state. They have a dual role as they carry out emergency preparedness activities and coordinate emergency response operations. In their preparedness role, they assist local officials in emergency planning, training, and exercises, and developing emergency teams and facilities. They also teach a wide variety of emergency management courses. In their response role, they deploy to incident sites to assess damages, identify urgent needs, advise local officials regarding state assistance, and coordinate the deployment of state emergency resources to assist local emergency responders. The San Jacinto region is in TDEM Region 2.

- The Texas Department of Transportation (TxDOT) is the state's primary transportation agency. TxDOT can perform road closures and provide real-time road closure and low water crossing information during and after a flood event.
- River authorities are public agencies established by the state legislature and given authority to develop and manage the waters of the state within their jurisdictions. The San Jacinto region includes the San Jacinto River Authority which has the power to conserve, store, control, preserve, utilize, and distribute the waters of a designated geographic region for the benefit of the public.
- Agriculture Extension Agents are employed by land-grant universities and serve citizens as experts or teachers on the topic of agriculture. Ag Extension Agents provide valuable information specific to agricultural entities on preparation for and recovery from flood events. The San Jacinto region has a significant agricultural footprint including farming, forestry, and ranching, which makes working closely with Agriculture Extension Agents crucial to preventing, and recovering from, flood losses.
- The Texas A&M Engineering Extension Service (TEEX) is a state extension agency that offers training programs and provides technical assistance to public safety workers.

7.B.3. Federal Agencies

- The Federal Emergency Management Agency (FEMA), initially created in 1977, is an agency of the United States Department of Homeland Security (DHS). While on-the-ground support of disaster recovery efforts is a major part of FEMA's charter, the agency provides state and local governments with experts in specialized fields, funding for rebuilding efforts, and relief funds for infrastructure by directing individuals to access low-interest loans and grants, sometimes in conjunction with the Small Business Administration. In addition, FEMA provides funds for the training of response personnel throughout the nation and its territories as part of the agency's preparedness effort.
- The National Oceanic and Atmospheric Administration (NOAA) is a federal scientific and regulatory agency within the United States Department of Commerce that forecasts weather, monitors oceanic and atmospheric conditions, charts the seas, among other duties. In addition to forecasting potential storm events, NOAA's National Center for Environmental Information (NCEI) provides historical data that can help communities determine their future probability of flood events and is key in the planning and disaster mitigation process.
- The U.S. Army Corps of Engineers (USACE) is an important part of the nation's military. The agency is responsible for a wide range of efforts in the nation, including addressing safety issues related to waterways, dams, and canals and also environmental protection, emergency relief, hydroelectric power, among other missions. The USACE is composed of several divisions with the San Jacinto region being in the Southwest Division and the Galveston and Fort Worth Districts.
- The National Weather Service (NWS) provides weather data, water, and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy. The NWS provides flash flood indicators through

watches, warnings, and emergency notices. Daily river forecasts are issued by the NWS West Gulf River Forecast Center using hydrologic models based on rainfall, soil characteristics, precipitation forecasts, and several other variables. These forecasts benefit a wide range of users, including those in agriculture, hydroelectric dam operation, and water supply sectors. The forecasts provide essential information on river levels and conditions, in anticipation of flood events.

- The U.S. Geological Survey (USGS) is the sole science agency for the U.S. Department of the Interior that collects, monitors, and analyzes information regarding natural resources conditions. Within the San Jacinto River Basin, the USGS has a network of gauges that monitor and measure stream flow, stage, and water quality information for streams. The USGS also performs high water mark surveys post-event to understand the extent of flooding in the future events. This information is used by emergency managers to understand current stream conditions, as well as assist in future preditions of where streams may overtop their banks.

Chapter 7.C. Plans to be Considered

7.C.1. State and Regional Plans

The State of Texas provides an updated Texas Hazard Mitigation Plan to FEMA every three years and, as a result, is eligible to receive Hazard Mitigation Assistance (HMA) funding to help both state and local communities achieve flood mitigation goals. The State Hazard Mitigation Plan is an effective instrument to reduce losses by reducing the impact of disasters upon people and property. Although mitigation efforts cannot completely eliminate the impacts of disastrous events, the hazard mitigation plan intends to reduce the impacts of hazardous events to the greatest extent possible.

The plan evaluates, profiles, and ranks natural and human-caused hazards affecting Texas as determined by the frequency of the event, economic impact, deaths, and injuries. The plan assesses hazard risk, reviews current state and local hazard mitigation and climate adaptation capabilities, develops strategies, and identifies potential actions by state agencies and other entities to address needs.

7.C.2. Local Plans

In 2021 the San Jacinto RFPG requested copies of local emergency management and emergency response plans that are publicly available. Some emergency plans are protected by law and are not available to the public. These include Emergency Operation Plans or Emergency Action Plans for high hazard or private dams. In addition to the plans provided by local entities, Emergency Management Plans, Hazard Mitigation Plans, and other regional and local flood planning studies from counties and local entities were obtained.

An Emergency Management Plan is a course of action developed to mitigate the damage of potential events that could endanger an organization's ability to function. Such a plan includes measures that provide for the safety of the public, entity personnel and, if possible, property and facilities.

Entities across the San Jacinto region have numerous plans and regulations in place that provide a framework that guide a communities' actions to implement mitigation and preparedness actions. Having an up-to-date Hazard Mitigation Plan is key in assessing risk and in developing mitigation actions, or projects. **Table 7-1** shows that all of the counties in the region have Hazard Mitigation Plans, with 10 out of 11 county plans currently approved by FEMA. Grimes County is currently developing its plan.

TABLE 7-1: HAZARD MITIGATION PLAN SUMMARY

Jurisdiction	Year of HMAP
Brazoria County	2017
Chambers County	2017
Fort Bend County	2018
Galveston County	2017
Grimes County	2013*
Harris County	2020
Liberty County	2017
Montgomery County	2017
San Jacinto County	2017
Walker County	2017
Waller County	2017

**Denotes in progress*

The San Jacinto region's ability to prepare, respond, recover, and mitigate disaster events is affected by many factors. With a clear understanding of the plans that guide community and county actions, a recognition of the entities with whom coordination is key, and knowledge of the actions identified to promote resiliency, the region can be better equipped to implement sound measures for preparedness, response, and recovery.

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CHAPTER 8. ADMINISTRATION, REGULATORY, AND LEGISLATIVE RECOMMENDATIONS

As part of the process of developing the RFP, the San Jacinto RFPG is directed to develop and include recommendations for legislative, regulatory, and administrative improvements that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation. The TWDB asks for:

- Legislative recommendations that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation;
- Other regulatory or administrative recommendations that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation;
- Any other recommendations that the RFPG believes are needed and desirable to achieve its regional flood mitigation and floodplain management goals; and
- Recommendations regarding potential, new revenue-raising opportunities, including potential new municipal drainage utilities or regional flood authorities, that could fund the development, operation, and maintenance of floodplain management or flood mitigation activities in the region.

These recommendations may address items that benefit and/or can be implemented at the local, regional, or state level. Recommendations, in general, are anticipated to be aimed at supporting flood risk reduction and supporting implementation of the regional flood plans, including exploring innovative ways of funding flood risk reduction activities. Recommendations include suggested changes to the flood planning process for the TWDB to consider when implementing the next cycle of regional and state flood planning.

Recommendations in this chapter were developed with input from various sources including RFPG meeting discussions and direct RFPG Technical Committee input. Recommendations were based on observations and lessons learned while developing this plan. The recommendations in this chapter were reviewed by the San Jacinto RFPG and approved at a meeting held on July 14, 2022. These recommendations are categorized into three major classifications based on the path that would be required to enact them: legislative, regulatory and administrative, and flood planning recommendations. It is recognized that legislative recommendations are the most difficult to enact but, at the same time, they are potentially the most impactful actions to flood risk reduction. The next classification, regulatory and administrative recommendations, can be enacted typically by state level agencies such as TxDOT and are considered to take somewhat less effort and time to enact while still providing very impactful improvements to flood risk policy across the state.

Recommendations regarding the last category, the flood planning process itself, were developed after review of proposed project scoring guidelines and data requirements detailed in the *Technical Guidelines*. The proposed project scoring system will be used by the TWDB to rank FMPs. Many of the recommendations in this category are focused on developing scoring criteria that are equitable to all community types and sizes. Scoring that automatically disadvantages a community due to its size or population, for example, should not be used.

Chapter 8.A. Legislative Recommendations

Recommendations in this section contain measures that would require action by the Texas Legislature. These actions involve updates to existing laws, authorities granted to counties and other entities, and new or additional funding appropriations. **Table 8-1** offers legislative recommendations and discussion that the RFPG considers necessary to further floodplain management and flood mitigation planning and implementation.

TABLE 8-1: LEGISLATIVE RECOMMENDATIONS

	Recommendation	Discussion
1	Provide recurring biennial appropriations to the Flood Infrastructure Fund (FIF) for study, strategy, and project implementation.	Passed by the Legislature and approved by Texas voters through a constitutional amendment, the FIF program provides financial assistance in the form of loans and grants for flood control, flood mitigation, and drainage projects. The program provided an infusion of funding when passed into law in 2019 but additional funds were not added in the subsequent legislative session. Setting a regular appropriation of funds is necessary to help communities to better plan for future applications and to encourage them to develop projects and mitigation measures for consideration.
2	Provide state incentives for establishment of dedicated drainage funding.	State law provides municipalities with the authority to establish local drainage utilities. Having a stable and predictable source of funding is conducive to both long-range planning and the timely development and implementation of flood risk reduction projects. Absent the creation of a drainage utility, local governments typically rely on federal partners to fund floodplain management and regulatory programs or utilize general tax revenues and/or municipal bonds secured and serviced with local tax revenues. The state should incentivize local communities to invest and plan for participation in, and funding of, dedicated drainage projects rather than rely solely on federal funding.

	Recommendation	Discussion
3	Provide counties with legislative authority to establish drainage utilities and assess drainage fees.	State law provides municipalities in Texas the authority to implement governing ordinances within their jurisdictions including the establishment of drainage utilities or the assessment of drainage fees. This same authority is not currently granted to unincorporated areas of counties. These funds create a direct and reliable source of revenue to assist in the implementation and long-term maintenance and repair of drainage and flood risk reduction projects. Without the establishment of a utility or fee, governing entities must typically rely on federal partner funding, tapping into general funds, and/or issuing bonds. Any new drainage authority granted to unincorporated counties should not conflict with Municipal Utility Districts' (MUDs) authority. The goals of the State Flood Plan would be fostered if counties with governance over unincorporated areas were granted the authority to establish drainage utilities or drainage fees for those unincorporated areas.
4	Enact legislation updating the state building code to, at minimum, the 2015 or 2018 versions of International Building Code (IBC) and International Residential Code (IRC) as State building standards. Updates should occur biennially during the regular legislative session to comply with the current IBC and any future updates.	Without a mandatory state building code, local entities in Texas do not score competitively for some federal funding programs, such as FEMA's Building Resilient Infrastructure and Communities (BRIC) Grant. Updating building codes is also one of the most cost efficient and effective long-term mitigation measures that can be implemented.

Chapter 8.B. Regulatory and Administrative Recommendations

Some recommendations from the RFPG can be implemented under prior legislative action and can be enacted via existing authorities granted to state agencies. **Table 8-2** offers recommendations and discussion that the RFPG considers necessary to further floodplain management and flood mitigation planning and implementation that require regulatory and/or administrative action at the state level.

TABLE 8-2: REGULATORY AND ADMINISTRATIVE RECOMMENDATIONS

	Recommendation	Discussion
5	The TxDOT should employ roadway design criteria to require all new and reconstructed state roadways to be designed and constructed, to the extent practicable, at elevations at or above the 1.0% ACE WSE if determined with Atlas 14 rainfall. The 0.2% ACE WSE should be used to determine elevation if Atlas 14 has not yet been adopted. TxDOT should also consider future conditions, such as urbanization and climate variability, in its roadway design criteria for drainage and flood risk reduction.	TxDOT is not a participant in the NFIP and does not in all cases design roadways in a manner consistent with minimum NFIP requirements. It is recognized that, by their nature, it is often not feasible or practicable to design and construct roadways to provide a level of flood protection equivalent to or greater than the 1.0% ACE storm. However, as a matter of policy and practice, TxDOT should strive to meet this standard, especially for critical infrastructure such as evacuation and emergency routes. By not acting on this recommendation, newly built transportation infrastructure could be at risk of extreme event flooding.
6	Recommend a statewide building standard of a minimum finished floor elevation to be established at or waterproofed to the FEMA effective 0.2% ACE flood elevation as shown on effective Flood Insurance Studies except in areas designated as coastal flood zones or at the 1.0% ACE flood elevation where Atlas 14 has been adopted.	The TWDB should encourage and incentivize higher building standards than those minimally required by federal regulations. This is especially true on minimum base flood elevations (BFEs) where recent events of historic flooding and updated rainfall totals, by the National Oceanic and Atmospheric Administration Atlas 14, have revealed how much BFEs change over time. New studies occurring across the state now expect to see increases of BFEs once the new Atlas 14 data are incorporated into models and maps. Jurisdictions that have required a freeboard over the current BFE have mitigated the risk of these increasing BFEs.
7	Clarify the process and investment required to take Base Level Engineering (BLE) data to regulatory BFE information on a Flood Insurance Rate Map (FIRM) panel and alternatively, detailed study on a FIRM panel.	BLE is an efficient modeling and mapping approach that aims to provide technically credible flood hazard data at various geographic scales such as community, county, watershed, and/or state level. Currently the state and FEMA are heavily investing in BLE studies across the state and there is a need to clearly communicate to local jurisdictions how to make this data regulatory or, if desired, improve upon it to make it eligible for incorporation into a detailed study on a FIRM. The steps for both paths remain unclear to many local jurisdictions and this large investment could be further leveraged.

	Recommendation	Discussion
8	Establish and fund a levee safety program similar to the Texas Commission on Environmental Quality (TCEQ) dam safety program.	The TCEQ currently has in place a program that monitors and regulates certain dams across the state. The program calls for periodic inspections of dams that fall under its jurisdiction and pose a high or significant hazard. Recommendations are made to dam owners to help them maintain safe facilities. Levees, on the other hand, are not subject to a similar safety program despite posing a similar risk during flooding events.
9	Develop model floodplain ordinances for General Law Cities (e.g., building codes, subdivision regulations).	General Law Cities are smaller cities, generally having populations under 5,000 people, which include a large number of the communities throughout Texas. They have limited regulatory powers based on what state statutes direct or permit them to do. Typical ordinance language used by larger Home Rule Cities may not always be applicable for use in General Law cities. Model ordinances should be developed by the TWDB that consider the specific limitations of General Law Cities.
10	Partner with Texas Floodplain Managers Association (TFMA) to promote public education and outreach about flood awareness and flood safety and provide outreach materials to communities. Partner with Texas Association of Counties to include dedicated outreach to Floodplain Administrators lacking technical flooding background (e.g., County Judges who serve as Floodplain Administrators may not have the necessary technical background).	The TWDB should partner with floodplain management organizations such as TFMA to develop and promote public flood risk education and outreach materials. Public outreach that provides opportunities for flood risk education and awareness helps to support public safety and flood mitigation measures in a variety of ways. A well-informed public can make better informed personal choices regarding issues that involve flood risk and also will be more likely to support public policies and mitigation measures to reduce that risk. These outreach materials and education can reach an even wider audience by partnering with organizations like Texas Association of Counties that have broader reaches to smaller communities and those that may not have dedicated Floodplain Administrators with technical backgrounds.

	Recommendation	Discussion
11	Provide support for ongoing education/training regarding floodplain management in the form of no or low-cost online resources including training modules, webinars, and print resources. Target training for non-technical Floodplain Administrators (e.g., County Judges who serve as Floodplain Administrators may not have the necessary technical background).	Floodplain Administrators, especially in smaller Texas communities, are often responsible for a much wider field of responsibilities than just floodplain management, as often is the case with County Judges. Also, these individuals may not have a technical background or be well versed in floodplain management practices. Providing support in the form of no or low-cost educational training including webinars and print resources tailored toward non-technical audiences would help to make effective floodplain management more prevalent across the state.
12	Develop state incentives for local governments to participate in the FEMA NFIP and CRS program.	The NFIP is a vital tool that works with communities required to adopt and enforce floodplain management regulations that help mitigate flooding effects. The CRS is a voluntary incentive program that recognizes and encourages community floodplain management practices that exceed the minimum requirements of the NFIP. These programs are essential to achieving the goals of the State Flood Plan and state-led incentives that encourage and assist communities in participation are recommended.
13	Develop a statewide database and tracking system to document flood-related fatalities that are publicly available. This could be an addition to the Flood Plan Data Hub website to capture existing data from TxDOT, NOAA, and others.	Fatalities have historically occurred during extreme flood events throughout the state's and region's history. To limit these fatalities, a statewide database and tracking system with appropriate privacy restrictions could serve to aid in future project planning and regulatory decision making. Additionally, it could help with future outreach and educational efforts that serve to break the cycle of actions taken during storm events that frequently lead to these outcomes. An example is the importance of avoiding driving through flood waters. This effort could be an addition to the Flood Plan Data Hub website to capture existing data from TxDOT, NOAA, and others.

	Recommendation	Discussion
14	Assist, via funding, smaller jurisdictions in preparing grant and loan applications or make the application process easier. Provide training for Councils of Governments (COGs) to assist with funding process.	Developing applications for project funding can be a difficult task, especially for smaller jurisdictions with limited experience and access to funding to obtain expert assistance. Simplifying applications and making funding available specifically for application development would serve to make the process more accessible across the state and help close knowledge gaps. Additionally, developing resources at the COG level that would provide training to smaller communities regarding how to fully develop funding applications would provide further benefits and help to ensure opportunities to pursue funding to all.
15	Develop a model-based future conditions flood hazard data layer using BLE data and provide it for use by RFPGs and the technical consulting teams during the next flood planning cycle.	Guidance and investment for the development of future conditions flood hazard and land use data should be improved and standardized across flood planning regions. The state's and FEMA's investment in BLE data throughout the state, along with existing FEMA RiskMAP data, provide an opportunity for standard guidance to be developed for future condition flood hazard data that would be applicable eventually in most parts of the state.
16	Reduce or eliminate barriers that prevent jurisdictions from forming effective partnerships to provide regional flood mitigation solutions.	Flood risk does not recognize jurisdictional boundaries, yet many flood mitigation programs have requirements that can often prevent multiple jurisdictions from working together. For example, if a primary sponsor meets all administrative requirements but additional jurisdictions do not, this could jeopardize state funding eligibility. The process should still allow regional flooding solutions in this situation to remain eligible for state funding either through a waiver process or an update to current policy. Flood mitigation studies and solutions at the scale of Regional Flood Planning are rarely exclusive to a single jurisdiction, therefore interjurisdictional collaboration should be encouraged, and policies updated to better allow for it.

	Recommendation	Discussion
17	Incentivize voluntary buyout programs, turning repetitively flooded properties/neighborhoods into green space, parkland, or any other flood risk mitigation measure as a potential alternative to large-scale flood mitigation construction projects.	Buyout programs have the distinction of being one of the only flood mitigation programs that leave no residual risk for the households they serve. Buyouts can also serve adjacent populations further by reclaiming environmentally beneficial floodplain land or providing a location for other community needs such as parkland. Many communities however are not supportive of buyouts, typically due to loss of tax revenue and other unintended consequences. Incentives should be developed to encourage this type of permanent flood mitigation and offset some of these consequences, especially in areas where structural mitigation projects cannot meaningfully reduce flood risk.
18	Provide training to state agencies, local governments, engineers, planners, and members of RFPGs in the use of natural floodplain preservation/conservation.	Natural floodplains provide flood risk reduction benefits by slowing runoff and storing flood water. They also provide other benefits of considerable economic, social, and environmental value that are often overlooked when local land-use decisions are made. Training and education opportunities would help policy makers to better understand the benefits of natural floodplains and conservation when making decisions regarding land use or mitigation projects.

Chapter 8.C. Flood Planning Recommendations

This section contains recommendations to the flood planning process for the TWDB to consider when implementing the next cycle of regional and state flood planning. **Table 8-3** contains recommendations to the flood planning process.

TABLE 8-3: FLOOD PLANNING RECOMMENDATIONS

	Recommendation	Discussion
19	Regional flood plans are required to provide an indication of whether a flood control solution meets an "emergency need." Guidance should be provided on what constitutes an emergency need.	Regional flood plans are required to provide an indication of whether a flood control solution meets an "emergency need," however no further guidance or definitions are provided by the TWDB. Uncertainty remains whether "emergency need" references infrastructure facing imminent failure and/or flood risk that poses hazards to emergency services or otherwise. How individual RFPGs determine whether a project meets an "emergency need" is likely to vary greatly. To encourage consistency across all regional flood plans, further guidance, definition, and/or criteria should be provided on what constitutes an "emergency need."
20	Scoring criteria and methodology for projects that benefit agricultural activities should be updated to allow for these types of projects to compete with urban focused projects.	The scoring or award of funding for projects that benefit agricultural activities based on a traditional benefit-cost ratio will not feasibly allow for these projects to compete against more urban projects with higher value infrastructure or damage. Protection of agricultural land use can also help to maintain their use as beneficial floodplains. Guidance should be developed and provided on a TWDB-preferred methodology to account for benefits to agricultural areas and activities and include consideration of agricultural benefits when ranking projects in the State Flood Plan.
21	Utilize project scoring that is equitable to project sponsors regardless of their size or population.	Scoring and awarding of projects should not be affected by a community's overall population or size. Certain proposed scoring guidelines include metrics that would automatically give larger communities the lowest score possible since it would divide the benefits by total population. Scoring metrics should not be included that automatically disadvantage project sponsors because they are large in area or population.

	Recommendation	Discussion
22	Utilize project scoring for nature-based solutions that give them a competitive chance compared to non-nature-based projects.	The formula for scoring nature-based solutions should not be based on nature-based project costs as a percentage of overall costs as nature-based projects are almost always more cost efficient than large, gray infrastructure projects. This disparity will also put them at a disadvantage. An alternative suggestion is to determine the overall value of the project and the way the project functions in terms of the nature-based aspects and their relationship to the value and function of the overall project. Specific examples could be helpful in describing the scoring (for instance, preservation of an existing natural stream and wetlands would score 10; a newly constructed retention pond with natural vegetation that functions like a natural area would score slightly less; etc.). The goal is to develop stand-alone metrics for nature-based projects.
23	Expand consideration and priority for FMEs that establish initial FEMA effective floodplains.	Development of high-quality FEMA floodplain maps is a key component in a successful flood mitigation strategy. It provides many tools used to regulate flood risk and typically grants local communities additional authority. One key feature is the automatic establishment of BFEs which, in addition to reducing future flood risk, would allow communities to better consider floodplain management practices and identify FMPs.
24	Lessen requirements for a project to be considered an FMP.	The San Jacinto RFPG pulled together many planning level studies that are ready for design and construction. A majority of these projects were missing a BCA due to local preference to not disadvantage lower income communities. Even though models were available and all other strict criteria were met, such as meeting a no negative impact requirement, these projects were all designated as FMEs due to the BCA requirements. It is also well understood that early in final design, many of these requirements can be fulfilled. Consideration should be given to well-developed projects that may be lacking a single, non-critical item that can easily be fulfilled early in the design process.

Implementation of these recommendations will help to support flood risk reduction and support implementation of the RFPs, including providing innovative ways of funding flood risk reduction activities.

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CHAPTER 9. FLOOD INFRASTRUCTURE FINANCING ANALYSIS

The objective of this task is to report on how sponsors of the recommended FMSs, FMPs, and FMEs included in this RFP propose to finance projects, in accordance with TAC 361.44. As part of this effort, a survey was collected from potential sponsors regarding available funding sources and required state/federal funding. The following sections of this chapter will:

- Cite the known available sources of funding at the local, state and federal level in Section 9.A.
- Summarize the feedback from the sponsor funding survey in Section 9.B.
- Discuss proposals for the State's role in funding for the FMSs, FMPs, and FMEs covered by this Plan in Section 9.C.

Chapter 9.A. Sources of Funding

This RFP contemplates and proposes a wide and comprehensive array of flood mitigation solutions to serve the communities within the San Jacinto region. In many cases, the magnitude and scope of these mitigation solutions exceed the funding capacity of local governments, regional authorities, and other political subdivisions in the San Jacinto region. Although this section does cite several potential local funding strategies below, it is necessary to identify potential sources for funding assistance at the state and federal level. This section will explore known sources of potential state and federal assistance, and the unique eligibility requirements and funding priorities associated with each program. As specific FMSs, FMPs, and FMEs are advanced, this chapter may be utilized to identify assistance programs that best fit the mitigation solution.

Many state and federal programs explored below provide assistance to local sponsors in the form of grants, but some offer low-interest or 0% interest loans. Also, the funding frequency varies, with some programs following an annual or semi-annual funding cycle, some by special appropriation, and some only being triggered following a federally declared disaster. It is important to note that although this chapter presents a variety of potential funding sources, summarized in **Table 9-1**, the field of federal and state assistance programs is always evolving with new programs and new priorities emerging each year.

TABLE 9-1: SUMMARY OF FEDERAL AND STATE FUNDING SOURCES

Primary Federal/State Funding Agency	Program Name	Grant/ Loan/Both	Post Disaster	Cost Share (Fed or State / Local)	BCA Required
Texas Water Development Board	Texas Water Development Fund (DFund)	Loan	No	None	No
Texas Water Development Board	Flood Infrastructure Fund (FIF)	Both	No	Varies	Yes[9]

Primary Federal/State Funding Agency	Program Name	Grant/ Loan/Both	Post Disaster	Cost Share (Fed or State / Local)	BCA Required
Texas Water Development Board	Clean Water State Revolving Fund (CWSRF)	Loan	No	None	No
Texas State Soil and Water Conservation Board	Operations & Maintenance Grant Program	Grant	No	90/10	No
Texas State Soil and Water Conservation Board	Structural Repair Grant Program	Grant	No	Varies 95-98.25/1.75-5	No
Housing & Urban Development	Community Development Block Grant – Disaster Recovery (CDBG-DR)	Grant	Yes	100/0	No
Housing & Urban Development	Community Development Block Grant – Mitigation (CDBG-MIT)	Grant	Yes	99/1[1]	Maybe[2]
Housing & Urban Development	Rural Texas Community Development Block Grants Program (TxCDBG)	Grant	No	100/0	No
Housing & Urban Development	Community Development Block Grant – Entitlement Program	Grant	No	100/0	No
Federal Emergency Management Agency	Hazard Mitigation Grant Program (HMGP)	Grant	Yes	75/25	Yes
Federal Emergency Management Agency	Public Assistance (PA)	Grant	Yes	75/25 (90/10)[5]	Yes

Primary Federal/State Funding Agency	Program Name	Grant/ Loan/Both	Post Disaster	Cost Share (Fed or State / Local)	BCA Required
Federal Emergency Management Agency	Building Resilient Infrastructure and Communities (BRIC)	Grant	No	75/25 (90/10)[7]	Yes
Federal Emergency Management Agency	Flood Mitigation Assistance (FMA)	Grant	No	75/25	Yes
Federal Emergency Management Agency	Coordinating Technical Partners (CTP)	Grant	No	100/0	No
Federal Emergency Management Agency	Rehabilitation of High Hazard Potential Dams	Grant	No	65/35	No
Federal Emergency Management Agency	Safeguarding Tomorrow Through Ongoing Risk Mitigation Act	TBD	No	TBD	TBD
Natural Resources Conservation Service	Emergency Watershed Protection Program (EWP)	Grant	Yes	75/25 (90/10)[5]	No
Natural Resources Conservation Service	Watershed and Flood Prevention Operations (WFPO)	Grant	No	Varies	Indirect[3]
Natural Resources Conservation Service	Watershed Rehabilitation	Grant	No	65/35	Indirect[3]
Natural Resources Conservation Service	Wetland Reserve Easement Program	Grant	No	Varies	No

Primary Federal/State Funding Agency	Program Name	Grant/ Loan/Both	Post Disaster	Cost Share (Fed or State / Local)	BCA Required
US Army Corps of Engineers	Continuing Authorities Program	Grant	No	Varies 50-75/25-50	Indirect[3]
US Economic Development Administration	Various	Grant	Yes/No[6]	Varies 50-80/20-50	No
US Congress	Community Project Funding	Grant	No	75/25[4]	Maybe[8]
US Congress	Water Resources Development Act (WRDA)	Grant	No	Varies	Indirect[3]

1. *CDBG-MIT does not have a statutory cost share requirement, but in scoring applications, preference is given to projects with at least 1% local contribution.*
2. *CDBG-MIT only requires a BCA for covered projects with cost over $100M, CDBG funds over $50M.*
3. *These programs don't require a BCA at application but may require coordination between applicant and funding agency to populate BCA in development of the project.*
4. *CPF cost share may vary based upon the federal program that is used for disbursement of funds.*
5. *For FEMA PA, either the President or Congress may approve a federal/non-federal cost share of 90/10 for select severe disasters. NRCS EWP typically follows the cost share FEMA sets.*
6. *EDA provides assistance through various initiatives, some tied to disaster supplementals, some through other means.*
7. *FEMA BRIC standard cost share is 75/25, but small and impoverished communitites may receive 90/10.*
8. *BCA may not be required depending on what phase of project is appropriate for using Environmental Infrastructure through Community Project Funding.*
9. *BCRs are not required to be provided for eligible studies that are aimed at identifying potential projects. Nor are BCRs required for Flood Early Warning Systems or Flood Response Plans.*

9.A.1. Local Funding

It is widely accepted that flood risk mitigation is an important funding priority for a community, especially in the San Jacinto region. However, many communities, especially smaller, rural, or disadvantaged communities often face the challenge of limited local resources. Difficult decisions must be made regarding allocation of the limited local funding that is available across all of the community's needs, sometimes leaving insufficient funding available for flood mitigation activities. Unlike other forms of infrastructure, flood mitigation measures do not typically generate revenue, further complicating the approach to funding. Through the RFPG's survey outreach efforts, the RFPG aimed to identify local funding strategies that are already in place. More specific details regarding the survey results are provided in Section 9.B below, but this section will explore the available local funding options available to sponsors.

9.A.1.a. General Fund

The most basic source of local funding is an entitiy's general fund, which is typically financed through tax revenue (sales, property, hotel, etc.). However, the general fund is usually in high demand and is used to operate basic community services (fire, police, administration, sanitation, utilities, etc.). With limited revenues and multiple budgetary demands, the general fund is not a reliable source for financing meaningful flood mitigation strategies in many counties and municipalities. Although communities can increase revenue through higher tax rates, voters in the San Jacinto region often reject tax increases.

9.A.1.b. Usage or Impact Fees

One tool that many communities have employed to generate funding at the local level is a usage fee. For flood-related funding, this would take the form of a drainage/stormwater fee or a development impact fee. A community could assess a fee for existing and/or new users that discharge stormwater into the existing community drainage system, typically based on the rate of discharge. Another option would be to assess impact fees as part of the community permitting process during development based upon the expected stormwater runoff from the developed property. Critics of this type of funding source may claim that it restricts developer investment in a community, but usage/impact fees are typically a more palatable source of revenue than taxes since they are fundamentally based upon the level to which a user impacts the community's stormwater system.

9.A.1.c. Debt and Bonds

Another local funding tool is generating capital by issuing debt, typically in the form of bonds. Bonds are often repaid through dedicated revenue generated by taxes or fees. In Texas, issuing bonds is governed at the state level by Texas Bond Review Board.

9.A.1.d. Special Districts

One final option for local funding is to establish a special district to provide specific services to the community contained within the district. These can take various forms, but in this region they are most often called Municipal Utility Districts (MUD), Flood Control Districts (FCD), Drainage Districts (DD), and Water Control and Improvement Districts (WCID). One of the biggest benefits of special districts is that they are typically focused on a single service, such as flood mitigation, which allows the local county or municipal government to attend to other important community needs. There are many rules and laws governing each type of district, depending on whether the district is created at the state, county or city level. Often these districts are supported by taxes or user fees, but some may have the ability to issue debt through bonds.

Each of these local funding options have their own benefits and constraints. However, even with these options, the total flood mitigation need surpasses the total local funding available for most of the communities in the San Jacinto region. Therefore, communities are forced to explore additional funding at the state and federal level.

9.A.2. State Funding

Texas has taken great strides, especially in recent years, to provide meaningful flood mitigation assistance to its residents. Following Hurricane Harvey, the 86th Texas Legislature passed Senate Bill 7 in 2019, which established multiple state funding sources for flood control initiatives. In addition, many of the federal programs outlined in Section 9.A.3 involve close coordination with a partner state agency to manage and administer funds at the state level. Most flood mitigation programs in Texas operate through one of the following state agencies:

- Texas Water Development Board (TWDB)
- Texas Division of Emergency Management (TDEM)
- Texas State Soil and Water Conservation Board (TSSWCB)

Below, this plan will explore the state-level programs available to local communities for assistance in combating flood risks. It should be noted that these programs are not available to individual residents, but local governments and agencies may apply on behalf of their communities.

9.A.2.a. TWDB Flood Infrastructure Fund (FIF)

Established by Senate Bill 7 in 2019 and subsequently approved by voters, the FIF program provides critical financial assistance for flood control, flood mitigation and drainage projects. FIF rules allow for a wide range of flood projects, including structural and nonstructural projects as well as nature-based solutions. Examples include, but are not limited to:

- Planning Phase and Preliminary engineering
- Feasibility, Design, and H&H studies
- Drainage infrastructure
- Flood control or mitigation infrastructure
- Retention/Detention basins
- Nonstructural flood mitigation
- Levees and pump stations
- Restoration of floodplains, wetlands, etc.
- Natural erosion and runoff control
- Warning systems and stream gauges

Type of Financial Assistance

The FIF program provides financial assistance in the form of grants and 0% interest loans. FIF assistance can also be used to meet non-federal cost share requirements for federal awards or flood-related activities, such as FEMA PA or HMGP.

Funding Priorities

The FIF program includes 4 categories that focus on different priorities:

- Category 1 – Flood protection planning for watersheds.
- Category 2 - Planning, acquisition, design, construction, rehabilitation.
- Category 3 – Federal award matching funds.
- Category 4 - Measures immediately effective at protecting life and property.

Under the scoring criteria published by TWDB, additional points are awarded to projects that:

- Will provide benefits to multiple applicants.
- Will be completed quickly, less than 18 months, or less than 36 months.
- Benefit a rural applicant.
- Provide water supply benefits.
- Fulfill an urgent or immediate need.

Cost Share Requirements

The FIF program grant funding percentages will vary by project based upon FIF scoring criteria and available funding. Any project costs beyond the awarded grant percentage will be considered local share. Recipients may either use their own available funds or borrow FIF funds at low or no interest for any portion of the required local cost share not provided through the FIF grant funds.

Funding Frequency

The FIF Program was funded by special appropriation from the Texas state legislature in 2019. Additional appropriations will be required to continue this program.

Benefit Cost Analysis (BCA)

Before program funding is authorized, applicants must be able to demonstrate a BCR greater than 1.0. TWDB may accept a project with a BCR less than 1.0 in select cases, if sufficient justification can be provided. FIF does not require the use of any specific BCA tools, but does refer applicants to FEMA and USACE tools. Additionally, FIF exempts the following projects from BCR thresholds:

- Studies that are aimed at identifying potential projects;
- Flood early warning systems; and
- Flood response plans.

9.A.2.b. TWDB Clean Water State Revolving Fund (CWSRF) Loan Program

The CWSRF assists communities with a wide range of wastewater, stormwater, reuse, and other pollution control projects. Streamlining of the program provides year-round funding as projects are included in the CWSRF Intended Use Plan. Through fiscal year 2022, the program has committed approximately $11 billion for projects across Texas.

Generally, the CWSRF is intended to provide assistance with planning, design, acquisition, and construction of:

- Wastewater treatment facilities.
- Wastewater recycling and reuse facilities, including “purple pipe” distribution systems.
- Nonpotable reuse.
- Wastewater collection systems.
- Existing wastewater facilities.
- Stormwater control.
- Nonpoint source pollution control projects, such as correction of failing on-site systems and wetlands restoration.
- Estuary management projects identified in either the Galveston Bay or Coastal Bend Estuary Management Plans.

Type of Financial Assistance

The CWSRF program provides assistance through low interest loans with up to a 30-year repayment period. Principal forgiveness is available on a limited basis to eligible disadvantaged communities, small/rural disadvantaged communities, very small systems, green projects, emergency preparedness, and urgent need projects. In Texas, the CWSRF is administered by TWDB. The initial maximum funding limit is $44 million per project.

Funding Priorities

The CWSRF heavily emphasizes pollution mitigation and groundwater quality benefits. Flood mitigation projects that also demonstrate some level of pollution mitigation or groundwater quality benefit should be considered for possible funding assistance under this program. Additionally, projects must be consistent with the current TWDB State Water Plan.

Cost Share Requirements

As a loan program, there are no cost share requirements for the CWSRF.

Funding Frequency

The CWSRF is funded by federal grants from the Environmental Protection Agency (EPA) to state agencies to capitalize the loans and then are continuously funded by the program's interest and loan repayments.

Benefit Cost Analysis (BCA)

The TWDB CWSRF program does not require any benefit cost analysis from local sponsors.

9.A.2.c. TWDB Texas Water Development Fund (DFund)

The Dfund is a flexible program at the State level that can provide assistance to local communities for a variety of water supply, conservation, water quality, flood control, wastewater, and municipal solid waste initiatives. The types of flood control projects that are eligible under this program include:

- Construction of storm water retention basins.
- Enlargement of stream channels.
- Modification or reconstruction of bridges.
- Acquisition of floodplain land for use in public open space.
- Relocation of residents from a floodplain.
- Public beach re-nourishment.
- Flood warning systems.
- Control of coastal erosion.
- Development of flood management plans.

Type of Financial Assistance

The DFund program provides assistance through low interest loans, typically far below market rates, with terms of up to 30 years. There is no programmatic maximum funding limit, but assistance is limited by the total state program funding.

Funding Priorities

The DFund focuses on providing funding for planning, design, acquisition, and construction of projects noted previously. Projects must be consistent with the current TWDB State Water Plan. Entities receiving assistance greater than $500,000 must adopt a water conservation and drought contingency plan.

Cost Share Requirements

As a loan program, there are no cost share requirements for the DFund.

Funding Frequency

The DFund is funded directly by the Texas Legislature. Applications for loans are accepted throughout the year.

Benefit Cost Analysis (BCA)

The DFund does not require any benefit cost analysis from local sponsors.

9.A.2.d. Texas Division of Emergency Management (TDEM)

As the state agency responsible for emergency preparedness, response, and recovery, TDEM is a critical component in the flood risk reduction process. For many of the programs funded by FEMA, TDEM serves as the Applicant, receiving the direct Federal funds and administering the grants from application to closeout. For the HMGP program, outlined in Section 9.A.3.e below, TDEM is responsible for selecting the projects for funding, pending approval by FEMA.

9.A.3. Texas State Soil and Water Conservation Board (TSSWCB) Operations and Maintenance (O&M) Grant Program

The TSSWCB's O&M Program provides necessary state-level support to local sponsors and Soil and Water Conservation Districts (SWCDs) for operation and maintenance costs associated with dams originally constructed with assistance from the United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS). Even though this program provides critical financial assistance through 90/10 cost share grants, it is only designed to help maintain existing dam infrastructure, not to construct new flood mitigation measures or improve existing flood control structures.

9.A.3.a. TSSWCB Structural Repair Grant Program

The TSSWCB's Structural Repair Grant Program provides state assistance for dam repair and to upgrade projects. Funds through this program can also be used as local match funding for the grants received through the NRCS Dam Rehabilitation Program and Emergency Watershed Protection Program (EWP).

Type of Financial Assistance

This program provides assistance through grants.

Funding Priorities

This program prioritizes repairs and upgrades to existing dams that pose a threat to life and property.

Cost Share Requirements

This program provides a state cost share of 95% for allowable dam repair activities and 98.25% of dam upgrade projects. Grant funds can be leveraged toward local cost share requirements of specific NRCS grant programs.

Funding Frequency

The program is funded directly by the Texas Legislature, most recently through supplemental appropriations approved in 2019.

Benefit Cost Analysis (BCA)

The program does not require any benefit cost analysis from local sponsors

9.A.4. Federal Funding

Even with the local and state funding sources outlined above, it would not be possible to complete many of the FMEs, FMSs and FMPs included in the RFP without assistance from the federal level. This section explores available funding programs through a variety of federal departments and agencies. It is important to note that many of these programs involve at least one state agency as a partner for administration of the funding. **Table 9-2** summarizes the list of programs with Federal sponsoring agency and the state partner agency, where applicable.

TABLE 9-2: FEDERAL FUNDING SOURCES WITH SPONSOR AGENCY AND STATE AFFILIATE

Federal Sponsoring Agency	Program Name	State-Affiliated Agency
Housing & Urban Development	Community Development Block Grant - Disaster Recovery (CDBG-DR)	General Land Office
Housing & Urban Development	Community Development Block Grant – Mitigation (CDBG-MIT)	General Land Office
Housing & Urban Development	Rural Texas Community Development Block Grants Program (TxCDBG)	Texas Department of Agriculture
Housing & Urban Development	Community Development Block Grant - Entitlement Program	N/A
Federal Emergency Management Agency	Hazard Mitigation Grant Program (HMGP)	Texas Division of Emergency Management
Federal Emergency Management Agency	Public Assistance (PA)	Texas Division of Emergency Management
Federal Emergency Management Agency	Building Resilient Infrastructure and Communities (BRIC)	Texas Division of Emergency Management
Federal Emergency Management Agency	Flood Mitigation Assistance (FMA)	Texas Water Development Board

Federal Sponsoring Agency	Program Name	State-Affiliated Agency
Federal Emergency Management Agency	Coordinating Technical Partners (CTP)	-
Federal Emergency Management Agency	Rehabilitation of High Hazard Potential Dams	Texas Commission on Environmental Quality
Federal Emergency Management Agency	Safeguarding Tomorrow Through Ongoing Risk Mitigation Act	-
Natural Resources Conservation Service	Emergency Watershed Protection Program (EWP)	-
Natural Resources Conservation Service	Watershed and Flood Prevention Operations (WFPO)	-
Natural Resources Conservation Service	Watershed Rehabilitation	Texas State Soil and Water Conservation Board
Natural Resources Conservation Service	Wetland Reserve Easement Program	-
US Army Corps of Engineers	Continuing Authorities Program	-
Environmental Protection Agency	Clean Water State Revolving Fund	Texas Water Development Board
US Economic Development Administration	Various	Regional Councils
US Congress	Community Project Funding	Varies
US Congress	Water Resources Development Act (WRDA)	Varies

9.A.4.a. HUD Community Development Block Grant-Disaster Recovery (CDBG-DR)

The CDBG-DR program, through the United States Department of Housing and Urban Development (HUD), is a long-standing federal program that provides grants to rebuild flood-impacted areas and provide crucial seed money to start the recovery process. These flexible grants help cities, counties, and states recover from presidentially declared disasters, especially in low-income areas, subject to availability of supplemental appropriations. Since CDBG-DR assistance may fund a broad range of recovery activities, HUD can help communities and neighborhoods that otherwise might not recover due to limited resources. This program is popular due to its favorable local cost share requirements and the potential to apply grant funds toward local cost share under other federal assistance programs. In Texas, CDBG-DR grants are administered at the state level through the Texas General Land Office (GLO). The GLO is responsible for establishing an Action Plan to set specific criteria for scoring and selection of potential projects for funding, and then for project selection/award, and oversight through the closeout of the grants.

Type of Financial Assistance

The CDBG-DR program provides assistance in the form of grants administered through the GLO.

Funding Priorities

Assistance provided under the CDBG-DR program must achieve at least one of the program's National Objectives which are explored in greater detail below:

- Low- to Moderate-Income (LMI).
- Slum/Blight.
- Urgent Need.

Although some mitigation solutions may be funded under the Urgent Need National Objective, it is anticipated that the LMI National Objective will need to be met to qualify for funding assistance for the majority of the FMSs, FMPs, and FMEs covered by this RFP.

Cost Share Requirements

CDBG-DR does not require that the grantee meet a cost share requirement. 100% of the funding may be utilized for any eligible activity. Additionally, CDBG-DR funds may be used to satisfy the cost-share requirements of the FEMA Public Assistance (PA) Program. This includes developing joint implementation guidance that outlines a flexible approach to using HUD CDBG-DR funding for the PA local cost-share requirements, flexible match.

The flexible match concept allows CDBG-DR funding to be applied to distinct facilities or sites within a PA project. Applying the flexible match concept reduces the number of sites that must meet both FEMA PA and CDBG-DR requirements. While all the sites and facilities must comply with FEMA PA requirements, only the CDBG-DR-assisted portion of the project must comply with CDBG-DR requirements.

Funding Frequency

The CDBG-DR is funded with special appropriations by Congress following a federally declared natural disaster. Unlike other recovery assistance programs administered by FEMA and the U.S. Small Business Administration (SBA), CDBG-DR assistance is not permanently authorized. After Congress appropriates funding to the CDBG-DR program, HUD formally announces the CDBG-DR awards and publishes rules for the awards in a Federal Register notice.

Benefit Cost Analysis (BCA)

The CDBG-DR program does not have a BCA requirement.

9.A.4.b. HUD Community Development Block Grant-MIT (CDBG-MIT)

Recently, HUD established this new CDBG program to enable communities to proactively implement innovative climate adaptation solutions that will make their communities more resilient and equitable following federally declared disasters. As mitigation is the primary National Objective for CDBG-MIT activities, eligible activities are those that increase resilience to future disasters and reduce or eliminate the long-term risks of loss of life, injury, damage to and loss of property, and suffering and hardship. Although this program was only created in 2018, it may present a strategic source of funding for the FMSs, FMPs, and FMEs covered by this RFP following future disasters.

Type of Financial Assistance

The CDBG-MIT program provides assistance in the form of grants administered through the GLO.

Funding Priorities

As with CDBG-DR, the CDBG-MIT program heavily emphasizes benefits to LMI households, with a requirement that at least 50% of the program funds be used for LMI benefits. Generally, at least fifty-one percent (51%) of the beneficiaries are low- and moderate-income persons However, the CDBG-MIT differs from CDBG-DR with the following changes in National Objectives. The Slum/Blight objective does not apply under CDBG-MIT and, in its place, a new national objective titled Urgent Need Mitigation (UNM) was adopted. UNM requires that grantees identify how their proposed use of CDBG-MIT funds will accomplish the following:

- Address the current and future risks as identified in the Mitigation Needs Assessment of most impacted and distressed areas, and yield a community development benefit.
- Will result in a measurable and verifiable reduction in the risk of loss of life and property.

Cost Share Requirements

CDBG-MIT does not require that the grantee meet a cost share requirement. 100% of the funding may be utilized for any eligible mitigation activity. However, depending on the funding prioritizations set by GLO, projects may have a higher chance of funding if the applicant demonstrates local match funding of at least 1%.

Funding Frequency

The CDBG-MIT is funded by special appropriation of Congress following a federally declared natural disaster. Like the CDBG-DR program, CDBG-MIT is not permanently authorized and only receives funding through Congressional appropriation.

Benefit Cost Analysis (BCA)

For projects under $100 million there is no BCA requirement. For projects over $100 million, “covered projects”, CDBG-MIT requires that applicants demonstrate a BCR >1.0. Although use of FEMA’s BCA Toolkit is highly encouraged for generating the BCR, alternative methodologies may be employed by an applicant, as long as the that BCA accounts for economic development, community development, and other social/community benefits or costs.

9.A.4.c. Rural Texas Community Development Block Grant Program (TxCDBG)

HUD provides funding directly to the State for the TxCDBG program to provide assistance to small, rural cities with populations less than 50,000 and to counties that have a non-metropolitan population, as defined by the US Census, under 200,000. Recipients are not eligible for direct funding from HUD through the Entitlement Program. See Section 9.A.3.d below. In Texas, this program is administered by the Texas Department of Agriculture (TDA).

Type of Financial Assistance

The TxCDBG provides assistance through grants.

Funding Priorities

The TxCDBG program follows the same national objectives as CDBG-DR, but most projects fulfill HUD's first national objective, by benefiting at least 51% LMI persons. Although funding under this program is heavily focused on community-building and housing activities, it may be possible to utilize funding for select flood mitigation activities if significant LMI benefit is achieved and applicants can demonstrate how the proposed mitigation helps to rehabilitate an affected community.

Cost Share Requirements

The TxCDBG program does not have a cost share requirement.

Funding Frequency

This TxCDBG program is funded annually by appropriation from Congress.

Benefit Cost Analysis (BCA)

The TxCDBG program does not have a BCA requirement.

9.A.4.d. HUD Community Development Block Grant (CDBG) Entitlement Program

HUD awards assistance through this program to entitlement jurisdictions or cities, with populations of 50,000 or more, and counties with populations of 200,000 or more.

Type of Financial Assistance

The CDBG Entitlement Program awards assistance in the form of grants.

Funding Priorities

This program follows the same funding priorities as TxCDBG in the previous section.

Cost Share Requirements

The CDBG Entitlement program does not have a cost share requirement.

Funding Frequency

This CDBG Entitlement program is funded annually by appropriation from Congress.

Benefit Cost Analysis (BCA)

The CDBG Entitlement program does not have a BCA requirement.

9.A.4.e. FEMA Hazard Mitigation Grant Program (HMGP)

The HMGP through the Federal Emergency Management Agency (FEMA) provides funding to state, local, tribal and territorial governments so they can develop hazard mitigation plans and rebuild in a way that reduces, or mitigates, future disaster losses in their communities. Following federally declared disasters, FEMA awards HMGP funding to affected states on a sliding scale based on the percentage of funds spent on public and individual assistance for the disaster. In Texas, funds are administered by the Texas Division of Emergency Management (TDEM) and awarded to eligible agencies through evaluation of competitive applications. State, local, territorial, and tribal agencies may receive funding under this program to implement mitigation strategies, construct mitigation measures, and to develop a hazard mitigation plan. In order for a mitigation project to receive HMGP funding, it must be included in an applicant's adopted hazard mitigation plan.

Type of Financial Assistance

The HMGP provides assistance in the form of grants administered through TDEM.

Funding Priorities

HMGP emphasizes long-term efforts to reduce risk and the potential impact of future disasters. HMGP assists communities in rebuilding in a better, stronger, and safer way in order to become mor e resilient overall. The grant program can fund a wide variety of mitigation projects:

- Planning and Development
  - Developing and adopting or updating hazard mitigation plans.
  - Acquisition of hazard prone homes and businesses to restore open space in floodplains.
  - Post-disaster code enforcement.
- Flood Protection
  - Protecting homes and businesses with permanent barriers to prevent floodwater from entering, using levees, floodwalls, and flood-proofing.
  - Elevating structures above known flood levels to prevent and reduce losses, i.e.,elevation.
  - Reconstructing a damaged dwelling on an elevated foundation to prevent and reduce future flood losses.
  - Drainage improvement projects to reduce flooding, i.e., flood risk reduction projects.
- Retrofitting
  - Structural retrofits to make a building more resistant to floods, earthquakes, wind, wildfire and other natural hazards.
  - Retrofits to utilities and other infrastructure to enhance resistance to natural hazards, i.e., utility retrofits.

- Construction
    - Construction of safe rooms for both communities and individual residences in areas prone to hurricane and tornado activity; and slope stabilization projects to prevent and reduce losses to structures.

Cost Share Requirements

The federal cost share through the HMGP is typically limited to 75%, with the remaining 25% covered by state/local sources.

It should be noted that on March 15, 2022 "H.R. 2471, Consolidated Appropriations Act, 2022" was signed into law, which granted a minimum 90% federal cost share for any emergency or major disaster declaration made or having an incident period between, Jan. 1, 2020 and Dec. 31, 2021. However, there is no indication at this time that this higher federal cost share will be extended to future disasters.

Funding Frequency

The HMGP is funded following a presidentially-declared disaster on a sliding scale based on the percentage of funds spent on public and individual assistance in a given state for the applicable disaster. Funding is provided through allocations from the federal Disaster Relief Fund (DRF) which is financed by Congressional appropriations to the Department of Homeland Security.

Benefit Cost Analysis (BCA)

HMGP requires that applicants demonstrate a BCR > 1.0, as calculated using FEMA's BCA Toolkit.

9.A.4.f. FEMA Public Assistance (PA)

When an area has received a Presidential declaration of an emergency or major disaster, then its state, tribal, territorial and local governments may be eligible to apply for Public Assistance (PA). Public Assistance is primarily provided to restore the function and capacity of facilities to their pre-disaster condition. However, this program also provides mitigation funds through Section 406 of the Stafford Act to improve damaged facilities to reduce the risk of similar damage in the future.

Type of Financial Assistance

The PA Program provides assistance in the form of grants administered through TDEM. Mitigation funds are provided as part of the grant to restore damaged facilities.

Funding Priorities

The PA Program provides Section 406 mitigation funds for eligible damaged facilities if the proposed mitigation measures reduce risk of similar damages in the future, are cost-effective, are technically feasible, and are in compliance with all applicable laws and regulations.

Cost Share Requirements

The federal cost share through the PA is typically limited to 75%, with the remaining 25% covered by state/local sources. Depending on the severity of the disaster, Congress may authorize a 90/10 federal/non-federal cost share for the PA program, including mitigation funds.

Funding Frequency

The PA Program is funded following a presidentially-declared disaster through allocations from the DRF.

Benefit Cost Analysis (BCA)

The PA program requires that applicants demonstrate that a project is cost effective. FEMA considers a mitigation measure cost effective if any one of the following three criteria are met:

- The cost for the mitigation measure does not exceed 15% of the damaged facility's repair cost to which mitigation measures apply.
- The mitigation measure must specifically be listed in Appendix J: Cost-Effective Hazard Mitigation Measures of the Public Assitance Program and Policy Guide, AND the cost of the mitigation measure does not exceed 100% of the damaged facility's repair cost to which the mitigation measure applies.
- The mitigation measure provides a BCR > 1.0, as calculated using FEMA's BCA Toolkit.

9.A.4.g. FEMA Building Resilient Infrastructure and Communities (BRIC)

The BRIC program supports states, local communities, tribes, and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. The BRIC program shifts the federal focus from reactive disaster spending to proactive investment in community resilience. This way, communities are better prepared and remain resilient when a disaster, such as a hurricane, flood or wildfire occurs. Like its predecessor, the Pre-Disaster Mitigation program, BRIC provides funds annually for hazard mitigation planning and projects to reduce risk before a disaster.

It is important to note that Applicants must have a FEMA-approved State or Tribal Hazard Mitigation Plan by the application deadline and at the time of obligation of grant funds in order to qualify for BRIC grants.

Type of Financial Assistance

The BRIC program provides assistance in the form of grants administered through the TDEM. The majority of allotted funding is awarded through a nationwide competition, but approximately $1 million is allocated to each state annually for Planning and Capability and Capacity Building activities.

Funding Priorities

The BRIC program aims to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. BRIC projects must:

- Mitigate natural hazard risk to critical physical structures, facilities, and systems that provide support to a community, its population, and its economy.
- Incorporate nature-based solutions.
- Meet either of the two latest published editions of relevant consensus-based codes, specifications and standards, as noted below).
- Be cost effective.
- Align with the applicable hazard mitigation plan.
- Meet all environmental and historic preservation (EHP) requirements.

As mentioned above, the BRIC program emphasizes adoption of current building codes and encourages this emphasis through scoring prioritization under national funding competition. In order to receive maximum scoring, states must adopt state-wide the 2015, or more current, International Building Code and International Residential Code. Unfortunately, since Texas has not adopted these statewide building codes, projects in Texas will face a tremendous disadvantage when scored against states that have adopted these codes.

Cost Share Requirements

The federal cost share through the BRIC is typically limited to 75%, with the remaining 25% covered by state/local sources. However, small and impoverished communities are eligible for 90 percent federal cost share. A small and impoverished community is defined as having these characteristics:

- Population – A community of 3,000 or fewer individuals.
- Location – A community that is identified as a rural community that is not a remote area within the corporate boundaries of a larger city.
- Economy – Be economically disadvantaged, with residents having an average per capita annual income not exceeding 80% of the national per capita income.

However, FEMA awards 10 points to applications if the local sponsor is prepared to provide a higher non-federal cost share, 12% for small and impoverished communities and 30% for other entities. These 10 points may be necessary for successful funding through the nationwide competition.

Funding Frequency

The BRIC program is funded annually by a 6% set-aside from post-disaster grant expenditures under FEMA's HMGP, PA, and Individual Assistance programs. The BRIC program was also recently funded for an additional $200 million per year for Fiscal Years 2022-2026, at $1 billion total, above the 6% set-aside.

Benefit Cost Analysis (BCA)

BRIC requires that applicants demonstrate a BCR > 1.0, as calculated using FEMA's BCA Toolkit.

9.A.4.h. FEMA Flood Mitigation Assistance (FMA)

The Flood Mitigation Assistance program is a competitive grant program that provides funding to states, local communities, and federally recognized tribes and territories. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the NFIP. FEMA chooses recipients based on the state's prioritization ranking of the project and the eligibility and cost-effectiveness of the project. In order for a mitigation project to receive HMGP funding, it must be included in an applicant's adopted hazard mitigation plan.

Type of Financial Assistance

The FMA program provides assistance in the form of grants administered through the TWDB.

Funding Priorities

FMA prioritizes planning and flood hazard mitigation projects that will reduce flood risk to buildings insured under the NFIP. Special emphasis is applied to projects that reduce flood risk to Repetitive Loss and Severe Repetitive Loss properties. Projects must:

- Be cost effective.
- Be located in a participating NFIP Community, in good standing.
- Align with the applicable hazard mitigation plan.
- Meet all environmental and historic preservation (EHP) requirements.

Cost Share Requirements

Generally, the cost share for this program is 75% federal / 25% non-federal. The federal cost share may be increased for individual property flood mitigation projects, but community flood mitigation projects are limited to 75% federal cost share.

Funding Frequency

The FMA program is funded annually by Congressional appropriations and managed by FEMA. The FMA program was recently funded for $700 million per year for Fiscal Years 2022-2026, for $3.5 billion total.

Benefit Cost Analysis (BCA)

FMA requires that applicants demonstrate a BCR > 1.0, as calculated using FEMA's BCA Toolkit.

9.A.4.i. FEMA Cooperating Technical Partners (CTP) Program

The CTP program is a relatively new, innovative approach to foster partnerships between FEMA and local entities participating in the NFIP. The CTP seeks to partner with local entities in the development of updated Flood Insurance Rate Maps (FIRMS), Flood Insurance Study reports, and related geospatial data as part of FEMA's MAP program. Funding from this program can help a community with outreach, floodplain management, training, flood mapping, and some planning efforts that support the ongoing mission of the NFIP. In FY 2021, $100 million was appropriated for CTP nationwide.

Type of Financial Assistance

The CTP program may provide assistance in the form of grants through formal partnership agreements.

Funding Priorities

The CTP Program's overall objective is to update the nation's flood hazard maps.

Cost Share Requirements

The CTP program does not require a cost share but FEMA emphasizes that the CTP program is a partnership and there is more direct coordination between the federal and local agencies than with other grant programs.

Funding Frequency

The program is funded annually through the US Department of Homeland Security, via FEMA, and the Federal Insurance and Mitigation Administration (FIMA).

Benefit Cost Analysis (BCA)

The CTP program does not require a BCA.

9.A.4.j. FEMA Rehabilitation of High Hazard Potential Dams (HHPD)

The HHPD awards grants that provide technical, planning, design and construction assistance for rehabilitation of eligible high hazard potential dams. In a state or territory with an enacted dam safety program, the State Administrative Agency, or an equivalent state agency, is eligible for the grant.

In Fiscal Year 2022, FEMA allocated $22 million in grant funding to continue the HHPD program. Of the total funding, $11.64 million will be available for planning and design activities and $10.36 million will be available for construction-ready activities.

Funding is insufficient from the HHPD Grant Program to update the state, local, territorial, or tribal mitigation plan to include all dam risks.

The HHPD Grant Program may provide assistance for technical, planning, design, and construction activities toward repair, removal, or rehabilitation of eligible high hazard potential dams. Hazard classifications are based upon the potential loss of human life or property downstream, not the condition of the dam. Dams are classified as "High hazard potential" if they threaten 3 or more habitable structures and pose a threat of excessive economic loss through damage to public facilities, railroads, utilities, highways, or agricultural/commercial/industrial facilities.

Type of Financial Assistance

The HHPD program provides assistance in the form of grants administered through TCEQ.

Funding Priorities

The following Dams are eligible for HHPD funding are:

- Located in a state or territory with a dam safety program.
- Classified as “high hazard potential” by the state/territory dam safety agency in the state or territory in which the dam is located.
- Has an Emergency Action Plan (EAP)-approved by the state or territory dam safety program; or the dam is in conformance with state or territory law and is pending approval by the relevant state or territory dam safety agency.
- Located in a jurisdiction with a FEMA-approved hazard mitigation plan that includes dam risk.
- Fails to meet minimum state/territory dam safety standards and poses an unacceptable risk to the public.

Cost Share Requirements

The federal cost share for HHPD is 65% federal / 35% non-federal.

Funding Frequency

The HHPD program is funded annually by Congressional appropriations and managed by FEMA. The HHPD program was recently funded for $733 million total for Fiscal Years 2022-2026.

Benefit Cost Analysis (BCA)

HHPD does not require a BCA. However, an applicant must demonstrate in their local mitigation plan that it considered the benefits that would result from the hazard mitigation actions versus the cost of those actions when prioritizing hazard mitigation actions. The requirement is met as long as the economic considerations are summarized in the plan as part of the communities’ analysis.

9.A.4.k. FEMA Safeguarding Tomorrow Through Ongoing Risk Mitigation (STORM) Act

The STORM Act was signed into law on January 1, 2021 to authorize FEMA to provide capitalization grants to states or eligible tribal governments to establish revolving loan funds in order to distribute assistance to local governments for hazard mitigation assistance. This program may finance water, wastewater, infrastructure, disaster recovery, and community/small business development projects. Although this program has not yet been implemented in Texas, The Infrastructure Act signed in 2021 provides $100 million to this program each year for a 5-year period or $500 million total.

9.A.4.l. NRCS Emergency Watershed Protection Program (EWP)

The EWP program allows communities to quickly protect infrastructure and land from additional flooding and soil erosion following a natural disaster. EWP does not require a disaster declaration by federal or state government officials for program assistance to begin. The NRCS State Conservationist can declare a local watershed emergency and initiate EWP program assistance in cooperation with an eligible sponsor. NRCS will not provide funding for activities undertaken by a sponsor prior to the signing of a cooperative agreement between NRCS and the sponsor.

Although the EWP program is typically used to restore facilities to their pre-disaster condition, there may be opportunities to pursue specific flood reduction measures through pilot procedures spearheaded by the Texas NRCS office. Generally, potential mitigation measures under EWP would include restoration of a floodplain to its natural condition. Restoration techniques include the use of structural and non-structural practices to restore the flow and storage of floodwaters, to control erosion, and to improve management of the floodplain.

Type of Financial Assistance

The EWP program provides assistance in the form of grants.

Funding Priorities

The EWP program allows communities to address serious and long-lasting damages to infrastructure and to the land. The program's timelines for assistance ensures NRCS must act quickly to help local communities cope with adverse impacts resulting from natural disasters. All projects must demonstrate that they reduce threats to life and property; be economically, environmentally, and socially sound and must be designed to acceptable engineering standards. The EWP Program also allows NRCS to establish non-traditional partnerships with sponsors to complete projects. NRCS provides financial and technical assistance for the following activities under EWP Program:

- Debris removal from stream channels.
- Reshape and protect eroded banks.
- Correct damaged drainage facilities.
- Establish vegetative cover on critically eroding lands.
- Repair levees and structures.
- Repair certain conservation practices.
- Purchase floodplain easements.

Cost Share Requirements

The federal cost share through the EWP program is typically limited to 75%, with the remaining 25% covered by state/local sources. Depending on the severity of the disaster, NRCS may authorize a 90/10 federal/non-federal cost share, typically matching the cost share implemented by FEMA's PA program for the disaster. Technical assistance is reimbursed at a 100% cost share up to the funding limits established by the grant.

Funding Frequency

The EWP program is funded by special appropriation from Congress, typically following a presidentially declared disaster.

Benefit Cost Analysis (BCA)

The EWP program does not require any benefit cost analysis from local sponsors.

9.A.4.m. NRCS Watershed and Flood Prevention Operations (WFPO)

The WFPO program helps units of federal, state, local, and tribal of governments, as project sponsors, protect and restore watersheds up to 250,000 acres. This program provides for cooperation between the federal government, states, and their political subdivisions to work together to prevent erosion; prevent floodwater and sediment damage; further the conservation, development, use, and disposal of water; and further the conservation and proper use of land in authorized watersheds. The WFPO program offers financial and technical assistance for the following purposes:

- Erosion and sediment control.
- Watershed protection.
- Flood prevention.
- Water quality Improvements.
- Rural, municipal and industrial water supply.
- Water management.
- Fish and wildlife habitat enhancement.
- Hydropower sources.

Type of Financial Assistance

The WFPO program provides assistance in the form of grants.

Funding Priorities

The WFPO program is generally targeted to smaller watersheds and rural communities. Eligible projects are limited to those contained within a watershed covering up to 250,000 acres. Additionally, at least 20% of the project’s total benefits must be directly related to agriculture.

Cost Share Requirements

The federal cost share for flood control and flood prevention is variable but can increase as high as 100%. Engineering and technical assistance is reimbursed at a 100% cost share up to the funding limits established by the grant.

Funding Frequency

The WFPO program is funded annually by appropriation from Congress.

Benefit Cost Analysis (BCA)

The WFPO program does not require a benefit cost analysis from local sponsors. However, sponsors may be required to assist NRCS in quantification of benefits, specifically agricultural benefits in order to document program eligibility.

9.A.4.n. NRCS Watershed Rehabilitation Program

The Watershed Rehabilitation program provides assistance to local sponsors for rehabilitation of existing aging dams. Only dams installed under the Pilot Watershed Program (Public Law-566) or Resource Conservation and Development Programs (Public Law-534) are eligible for assistance. Projects are eligible when downstream development has increased hazards to life and property and when there is a need to rehabilitate the dam to extend the planned life of the structure.

Type of Financial Assistance

This program provides assistance in the form of grants.

Funding Priorities

Priority of funding is given to dam structures that pose the highest risk to life and property.

Cost Share Requirements

The federal cost share is 65% of the total rehabilitation cost, not to exceed 100% of the construction cost. Local sponsors are responsible for the non-federal share, but State match funding is available through TSSWCB, as described in Section 9.A.2.f.

Funding Frequency

This program is funded by Congressional appropriation, generally through the Farm Bill.

Benefit Cost Analysis (BCA)

This program does not require a benefit cost analysis from local sponsors. However, sponsors may be required to assist NRCS in quantification of benefits during evaluation of the application.

9.A.4.o. NRCS Wetland Reserve Easements

The Wetland Reserve Easements is part of NRCS's Agricultural Conservation Easement program and provides funding to private landowners to permanently protect lands with historical wetlands. The program also allows NRCS to enhance or restore drained or degraded wetlands. While this NRCS program does not directly target flood prevention, this program does protect and restore wetlands, leading to reduced runoff and reducing potential for development in flood prone areas.

Type of Financial Assitance

This program provides assistance in the form of grants.

Funding Priorities

Priority is given to lands which contain historical wetlands that have been degraded, and may be restored.

Cost Share Requirements

The federal cost share is 100% of the easement purchase cost and restoration cost.

Funding Frequency

This program is funded by Congressional appropriation, generally through the Farm Bill.

Benefit Cost analysis (BCA)

This program does not require a benefit cost analysis.

9.A.4.p. USACE Continuing Authorities Program (CAP)

CAP authorizes the USACE to plan, design and construct small scale projects under existing programmatic authority from Congress. Local governments and agencies seeking assistance may request USACE to investigate potential water resource issues that may fit one of the following authorities covered by the CAP:

- Section 14, Emergency Streambank Protection.
- Section 103, Hurricane and Storm Damage Reduction.
- Section 107, Small Navigation Improvements.
- Section 111, Shoreline Damage Attributable to a Federal Navigation Project.
- Section 204, Beneficial Use of Dredged Material.
- Section 205, Flood Damage Reduction.
- Section 206, Aquatic Ecosystem Restoration.
- Section 1135, Project Modifications.

Type of Financial Assistance

The CAP program provides assistance through cost sharing and partnership agreements.

Funding Priorities

The CAP priorities are governed by each of the 9 authorities overseen by the USACE.

Cost Share Requirements

The federal cost share for the feasibility phase is 100% up to $100,000. Any remaining feasibility phase costs are shared 50/50 with the non-Federal sponsor. The final design, preparation of contract plans and specifications, permitting, real estate acquisition, project contracting and construction, and any other activities required to construct or implement the approved project are completed with costs shared as specified in the authorizing legislation for each section, but generally have non-federal cost shares ranging from 25-50%. Certain territories of the United States, Puerto Rico and the U.S. Virgin Islands, as well as tribal organizations, are eligible for a reduction of the CAP Program non-federal cost-sharing requirement.

Funding Frequency

The CAP is funded by Congressional appropriations, generally through the Energy and Water Development appropriations acts.

Benefit Cost Analysis (BCA)

The CAP program does not require any benefit cost analysis from local sponsors at the time of application. However, sponsors may be required to assist USACE in in the development of a BCA as the projects are developed.

9.A.4.q. EPA Clean Water State Revolving Fund (CWSRF)

This program is listed here to illustrate the ultimate source of funding is federal, but, as outlined in Section 9.A.2, loans from this program are administered at the state level by TWDB. Please refer to Section 9.A.2.b above for additional information.

9.A.4.r. Economic Development Administration (EDA)

Through special Congressional appropriations, the Economic Development Administration (EDA) receives funding for various initiatives and programs designed to stimulate economic growth. Some of these programs may overlap with flood mitigation efforts, where the mitigation measures can also provide a demonstrable benefit to job growth or other economic stimulus. Each appropriation and program may come with unique requirements requiring Notices of Funding Opportunities be reviewed as they are published. The data presented below are provided based on experience with previous funding allocations to provide a general framework for making funding decisions.

Type of Financial Assistance

EDA's programs generally provide assistance in the form of grants, which are typically administered in close coordination with local economic agencies and regional councils of government.

Funding Priorities

Although each program may emphasize somewhat different priorities, the listed tenets are common threads across all of the EDA initiatives. EDA prioritizes:

- Equity.
- Recovery and resilience.
- Workforce development.
- Manufacturing.
- Technology-based economic development.
- Environmentally sustainable development.
- Exports and foreign direct investment.

In order to pursue a flood mitigation project under EDA, it will be necessary to tie the project to at least one of these economic priorities.

Cost Share Requirements

The federal cost share under EDA programs varies but generally ranges from 50%-80% with the local project sponsor contributing the remaining cost.

Funding Frequency

The EDA's programs are funded annually by Congressional appropriations to the US Department of Commerce. Some programs are funded following federally declared disasters.

Benefit Cost Analysis (BCA)

EDA's programs do not typically include any specific BCA requirements, but successful projects must demonstrate economic benefits in order to receive funding.

9.A.4.s. Community Project Funding (CPF)

CPF is a new initiative by the U.S. House of Representatives that will allow Members of Congress to request direct funding for fiscal year 2022, and thereafter, for projects that benefit the communities they represent. CPF is separate from federal grants and funding apportioned by formula to states or awarded by federal agencies.

CPF will be available only to nonprofit organizations and to state, local, tribal, political subdivision, and territorial governments. In addition, only projects with evidence of strong support from the community will be considered. Evidence of community support and community need is required as part of the submission. This evidence can take the form of a letter from local stakeholders, inclusion on a state or local planning document, letters to the editor in local papers, and more printed documentation. Funding under CPF may be awarded under a variety of federal programs.

In 2022, Texas received multiple CPF awards through the FEMA Pre-Disaster Mitigation program (PDM). The following data are based upon the PDM program, but it is important to note that requirements may change, depending on the federal program used for each CPF award.

Type of Financial Assistance

The CPF program through PDM will be provided in the form of grants administered through TDEM. Future CPF program funds may be awarded/administered under different rules.

Funding Priorities

The CPF program is based upon political advocacy at the federal level to obtain funding for specific projects. Under PDM, projects must demonstrate a reduction in the impacts of future disasters.

Cost Share Requirements

The CPF program federal cost share under PDM is limited to 75% or the project funding authorized by Congress, whichever is less. Any remaining project costs are the responsibility of the local applicant. If CPF funds are routed through other federal programs, the cost share may vary.

Funding Frequency

The CPF program is dependent on Congressional appropriations for specific project awards.

Benefit Cost Analysis (BCA)

PDM requires that applicants demonstrate a BCR > 1.0, as calculated using FEMA's BCA Toolkit. If CPF funds are routed through other federal programs, a BCA may not be required.

9.A.4.t. Water Resources Development Act

Under the Water Resources Development Act (WRDA), Congress provides direct appropriation of funding for a broad range of activities under USACE authority for flood control, navigation, and ecosystem restoration. This bill is traditionally passed every two years by Congress.

Type of Financial Assitance

WRDA is not a funding program, but can provide funding for projects through direct Congressional appropriations to USACE. The Coastal Texas Study Storm Surge Protection System project, administered by USACE, is a prime example of a project that can be funded by WRDA and is part of the San Jacinto RFP.

Funding Priorities

WRDA 2022 authorizes the study and construction of locally-driven projects that were developed in cooperation and consultation with the USACE. These projects are key to preserving our nation's economy, to protecting our communities, and to maintaining our quality of life.

Cost Share Requirements

Cost shares are established in each WRDA bill that is passed by Congress. The Coastal Texas Study Storm Surge Protection System project has a 65%/35% federal/non-federal cost share, as an example of typical cost share apportionment.

Funding Frequency

This bill is traditionally passed every two years by Congress.

Benefit Cost analysis (BCA)

Any BCAs required by WRDA would have to comply with USACE procedures for establishing federal interest.

Chapter 9.B. Survey Results

A FIF survey was sent to 99 sponsors with FMEs, FMSs, and FMPs identified in the San Jacinto RFP. An example of the survey distributed is provided in **Appendix 9-1**. In the survey, each potential sponsor was provided the list of proposed mitigation solutions identified under their authority, including project costs, and was asked to provide the level and type of local funding available for the proposed mitigation solutions and the amount of federal and state assistance needed to complete each project. The goal of the survey was to gauge the level and type of local funding available within the San Jacinto region, and to then propose the role the state should have in future funding of these solutions.

Of the 99 surveys distributed, 17 sponsors responded (17.2%). Although this is only a fraction of the total potential respondents, it does provide the RFPG with useful data in estimating the local funding landscape in the San Jacinto region. For FMEs, FMSs, and FMPs where survey responses were not received, the RFPG estimated 100% of the total project costs are required from state and federal sources. Additional surveying time in future planning phases should result in additional responses and can help to further refine the data.

The table provided in **Appendix 9-2** presents the results of the survey.

Chapter 9.C. Funding Required

Based upon the survey results received to date, an estimated $25.3 billion in state and federal funding is needed to implement the FMEs, FMSs, and FMPs identified in this RFP. This figure is only based upon the mitigation solutions identified and is insufficient to complete all of the mitigation measures needed to solve all of the San Jacinto region's flooding concerns. Even so, it does provide a valuable tool to evaluate the tremendous funding gap that must be filled in order to protect the citizens of the San Jacinto region.

Chapter 9.D. Role of State Funding

As outlined above, sponsors for the proposed FMSs, FMPs, and FMEs face significant local funding shortfalls that inhibit their ability to complete the proposed mitigation initiatives that their communities require to reduce flood risk. Although several federal and state assistance programs have been identified in this chapter, many sponsors face continued challenges in navigating the complex web of individual program requirements, timelines, and priorities. Unfortunately, many of the federal programs are only triggered following federally declared disasters, which limit their reliability for long-term regional flood mitigation funding.

However, one of the most impactful developments that has helped move flood mitigation forward in this region in the last five years is the establishment of the FIF through TWDB. The FIF provides a critical support lifeline to help local agencies throughout the state advance their flood mitigation planning and implementation initiatives. However, the FIF is not continuously funded and relies on additional appropriations from the Texas Legislature to continue. The RFPG understands the significance of the programs like FIF and how they effectively enable state funding to leverage both federal and local funds toward a meaningful result. Passing legislation to permanently fund and annually operate the FIF would provide the San Jacinto region, and other regions across the state, with a reliable source of funding assistance to advance flood mitigation projects, including the FMEs, FMSs, and FMPs identified in this RFP.

Additionally, in one of the most effective, annually-funded federal programs, BRIC, Texas is severely impaired in competitive project scoring because the state has not adopted the 2015, or more current, versions of the International Building Code and International Residential Code. The federal government has recently announced that mandatory building codes will be a point of emphasis for funding programs in the future.Therefore, not only will BRIC continue to prioritize state-wide codes, but other programs will likely follow suit. If Texas does not adopt updated building and residential codes on a statewide basis, the state will face reduced federal participation in future funding for flood mitigation initiatives, which will increase the burden on state and local funding sources.

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CHAPTER 10. PUBLIC PARTICIPATION AND PLAN ADOPTION

As directed by the TDWB , the objective of Task 10 – Public Participation and Plan Adoption, is to address public participation, public meetings, eligible administrative and technical support activities, and other requirements and activities eligible for reimbursement. Objectives also include activities necessary to complete and submit a draft and final RFP and obtain TWDB approval of the RFP.

To satisfy this objective, the San Jacinto RFPG has conducted five public meetings, including two virtual public meetings in 2021 and three open house meetings in May 2022, two in-person open houses and one virtual open house. These efforts are in addition to 19 RFPG Committee meetings, 16 Executive Committee meetings, seven Technical Committee meetings and four Public Engagement Committee meetings. Additionally, the RFPG has made 13 presentations to local organizations and stakeholders as well as shared information with the public and water professionals at the March 2022, Texas Floodplain Management Association (TFMA) Conference in Houston.

As required by 31 TAC §361, in particular §361.21, the San Jacinto RFPG conducts all business in meetings posted and held in accordance with the Texas Open Meetings Act, Texas Government Code Chapter 551, with a copy of all materials presented or discussed available for public inspection prior to and following public meetings via the San Jacinto RFPG website. Additional notice requirements referenced in 31 TAC §361.21 were followed, when applicable. The plan was developed in accordance with 31 TAC §361.50 and §361.50-.61 the flood planning *Guidance Principles 31 TAC §361.20 (31 TAC §362.3)* and includes an explanation of how the plan satisfies each of the guidance principles including that the plan will not negatively affect a neighboring area. **Table 10-1** details where each of the guidance principles are satisfied in the RFP.

TABLE 10-1: TWDB REGIONAL FLOOD PLANNING GUIDANCE PRINCIPLES

	Guidance Principle ("The regional and state flood plans…")	RFP Section(s)
1	shall be a guide to state, regional, and local flood risk management policy.	Chapter 3
2	shall be based on the best available science, data, models, and flood risk mapping.	Chapter 2
3	shall focus on identifying both current and future flood risks, including hazard, exposure, vulnerability, and residual risks; selecting achievable flood mitigation goals, as determined by each RFPG for their region; and incorporating strategies and projects to reduce the identified risks accordingly.	Chapter 2, Chapter 3, Chapter 4, Chapter 5
4	shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2% ACE flood (the 500-year recurrence interval flood) and, in these efforts, shall not be limited to consideration of historic flood events.	Chapter 2
5	shall, when possible and at a minimum, evaluate flood risk to life and property associated with 1.0% ACE flood (the 100-year recurrence interval flood) and address, through recommended strategies and projects, the flood mitigation goals of the RFPG (per item 2. above) to address flood events associated with a 1.0% ACE flood; and, in these efforts, shall not be limited to consideration of historic flood events.	Chapter 2

	Guidance Principle ("The regional and state flood plans…")	RFP Section(s)
6	shall consider the extent to which current floodplain management, land use regulations, and economic development practices increase future flood risks to life and property and consider recommending adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk.	Chapter 2, Chapter 3
7	shall consider future development within the planning region and its potential to impact the benefits of flood management strategies, and associated projects, recommended in the plan.	Chapter 1, Chapter 2, Chapter 6
8	shall consider various types of flood risks that pose a threat to life and property, including, but not limited to, riverine flooding, urban flooding, engineered structure failures, slow rise flooding, ponding, flash flooding, and coastal flooding, including relative sea level change and storm surge.	Chapter 2
9	shall focus primarily on flood management strategies and projects with a contributing drainage area greater than or equal to 1.0 (one) square mile, except in instances of flooding of critical facilities or transportation routes or for other reasons, including levels of risk or project size, determined by the RFPG.	Chapter 4, Chapter 5
10	shall consider the potential upstream and downstream effects, including environmental, of potential flood management strategies, and associated projects, on neighboring areas. In recommending strategies, RFPGs shall ensure that no neighboring area is negatively affected by the RFP.	Chapter 4, Chapter 5
11	shall include an assessment of existing, major flood mitigation infrastructure and will recommend both new strategies and projects that will further reduce risk, beyond what existing flood strategies and projects were designed to provide, and make recommendations regarding required expenditures to address deferred maintenance on or repairs to existing flood mitigation infrastructure.	Chapter 1, Chapter 4, Chapter 5
12	shall include the estimate of costs and benefits at a level of detail sufficient for RFPGs and sponsors of flood mitigation projects to understand project benefits and, when applicable, compare the relative benefits and costs, including environmental and social benefits and costs, among feasible options.	Chapter 4, Chapter 5
13	shall provide for the orderly preparation for and response to flood conditions to protect against the loss of life and property and reduce injuries and other flood-related human suffering.	Chapter 7
14	shall provide for an achievable reduction in flood risk at a reasonable cost to protect against the loss of life and property from flooding.	Chapter 4, Chapter 5, Chapter 6
15	shall be supported by state agencies, including the TWDB, GLO, TCEQ, TSSWCB, Texas Parks and Wildlife Department, and the TDA, working cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources.	Chapter 10

Guidance Principle ("The regional and state flood plans…")	RFP Section(s)
16 shall include recommended strategies and projects that minimize residual flood risk and provide effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits.	Chapter 4, Chapter 5, Chapter 6
17 shall include strategies and projects that provide for a balance of structural and nonstructural flood mitigation measures, including projects that use nature-based features, which lead to long-term mitigation of flood risk.	Chapter 4, Chapter 5, Chapter 6
18 shall contribute to water supply development where possible.	Chapter 6
19 shall also follow all regional and state water planning guidance principles (31 TAC §358.3) in instances where recommended flood projects also include a water supply component.	Chapter 6
20 shall be based on decision-making that is open to, understandable for, and accountable to the public with full dissemination of planning results except for those matters made confidential by law.	Chapter 10
21 shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation.	Chapter 10
22 shall include flood management strategies and projects recommended by the RFPGs that are based upon identification, analysis, and comparison of all flood management strategies the RFPGs determine to be potentially feasible to meet flood mitigation and floodplain management goals.	Chapter 4, Chapter 5
23 shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals.	Chapter 3
24 shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services.	Chapter 1, Chapter 3
25 shall be consistent with the NFIP and shall not undermine participation in NFIP or the incentives or benefits associated with NFIP.	Chapter 3
26 shall emphasize the fundamental importance of floodplain management policies that reduce flood risk.	Chapter 3
27 shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains.	Chapter 3, Chapter 4, Chapter 5
28 shall not cause long-term impairment to the designated water quality as shown in the state water quality management plan as a result of a recommended flood management strategy or project.	Chapter 6
29 shall be based on identifying common needs, issues, and challenges; achieving efficiencies; fostering cooperative planning with local, state, and federal partners; and resolving conflicts in a fair, equitable, and efficient manner.	Chapter 10

	Guidance Principle (“The regional and state flood plans…”)	RFP Section(s)
30	shall include recommended strategies and projects that are described in sufficient detail to allow a state agency making a financial or regulatory decision to determine if a proposed action before the state agency is consistent with an approved RFP.	Chapter 4, Chapter 5
31	shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction.	Chapter 1
32	shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property.	Chapter 8
33	shall be based on coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals.	Chapter 10
34	shall be in accordance with all existing water rights laws, including but not limited to, Texas statutes and rules, federal statutes and rules, interstate compacts, and international treaties.	Chapter 6
35	shall consider protection of vulnerable populations.	Chapter 4
36	shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation, as appropriate.	Chapter 6
37	shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards.	Chapter 6
38	shall consider how long-term maintenance and operation of flood strategies will be conducted and funded	Chapter 9
39	shall consider multi-use opportunities such as green space, parks, water quality, or recreation, portions of which could be funded, constructed, and or maintained by additional, third-party project participants.	Chapter 4, Chapter 5

Chapter 10.A. Communications and Media Engagement Plan

10.A.1. Overview

The strategies outlined in the Communications and Media Engagement Plan were developed to ensure that members of the public and San Jacinto RFPG stakeholders are proactively included in the development of the San Jacinto RFPG’s RFP, as well as to ensure the San Jacinto RFPG is in compliance with TWDB’s First Planning Cycle Documents (May 2020 - April 2021), the Texas Open Meetings Act and Public Information Act, and best practices for public involvement, engagement, collaboration, and coordination.

The RFP aims to provide consistent information to key audiences so that they feel heard and informed, thus building trust in the San Jacinto RFPG and its long-term goals. Furthermore, the RFP is intended to formalize the interfaces between all parties involved in the San Jacinto RFPG, including counties within the San Jacinto region, San Jacinto RFPG voting and non-voting members, the San Jacinto RFPG's technical consultant team, the TWDB, members of the public, and other San Jacinto RFPG stakeholders. This will be accomplished by informing and engaging the various key audience groups ,e.g., elected officials, governmental entities, special interest groups, businesses, communities, and the public, throughout the development of the RFP.The communications approach for the San Jacinto RFPG aims to provide meaningful opportunities for the public and stakeholders to interact and engage with the San Jacinto RFPG. The Plan will accomplish the following goals:

- Identify communication strategies, methods, and tools to facilitate stakeholder participation and meet the evolving needs of stakeholders throughout the San Jacinto region.
- Communicate information consistently and efficiently to reach and engage as many audiences as possible throughout the San Jacinto region.
- Drive overall awareness of the San Jacinto RFPG and its efforts to develop an RFP to reduce existing flood risks to life and property and avoid increasing flood risk in the future.
- Provide opportunities for interested stakeholders to provide input and participate in the development of the RFP.
- Track and report regularly on public engagement activities and public input to allow for adjustments that reach and accommodate stakeholders.

10.A.2. Public Comment Management System

Public comments are received through several channels, including the San Jacinto RFPG website, www.sanjacintofloodplanning.org, the San Jacinto RFPG email address (SanJacFldPG@eng.hctx.net), public engagement events and forums, in-person/virtual briefings and meetings, and written or emailed comments to the various entities involved in the San Jacinto RFPG. All comments, inquiries, and requests for information received through these channels are tracked through the Public Comment Management System.

The following information is collected and tracked in the Public Comment Management System:

- Name of individual.
- Physical address.
- Mailing address.
- Phone number(s).
- Email address.
- Subject matter/topic.
- Specific comment, question, or request to include the date received.
- Comment resolution status updates through coordination with the technical consultant team.
- Date of comment resolution.

10.A.3. Comment/Response Procedure

The following public comment tracking, documentation, and response procedures are followed:

- The Public Comment Management System database associated with the San Jacinto RFPG website's "Contact Us" page is continuously monitored.
- Upon a comment or inquiry from a stakeholder, an automated "thank you" message will be sent to the stakeholder within one business day of receipt.
- Project consultants partner with the San Jacinto RFPG to formulate an appropriate response to the inquiry.
    - The comment or inquiry is evaluated to confirm if it could be resolved with a standard FAQ or redirection to pages of the San Jacinto RFPG website.
    - If the comment/inquiry cannot be answered by a standard FAQ or website redirection, a draft proposed response and the comment/inquiry are forwarded to the San Jacinto RFPG for input and review by project consultants.
    - Once a response is approved, the project consultant responds to comments. Responses will be provided to the stakeholder within one business day upon finalization with San Jacinto RFPG.

10.A.4. Media Engagement Protocol

The San Jacinto RFPG endeavors to provide progress updates and information to stakeholders seeking information; however, having different sources providing information to media representatives increases the risk of unintentionally disseminating inaccurate or incomplete information. Avoiding inaccuracies in communication requires strict adherence to the following protocol, which restricts media communications to the designated spokespersons for the San Jacinto RFPG.

Therefore, as part of a formal media communications process, the San Jacinto RFPG has designated the Chair of the San Jacinto RFPG as the Public Information Officer (PIO) for the San Jacinto RFPG. The San Jacinto RFPG Chair, as the official spokesperson for the San Jacinto RFPG, is the only person who will respond to media inquiries. If the San Jacinto RFPG Chair is unavailable, the San Jacinto RFPG Vice-Chair will serve as deputy spokesperson for the San Jacinto RFPG.

Should any representative of the San Jacinto RFPG be contacted by a member of the media or receive a media inquiry, the following response is required:

1. Inform the media that the San Jacinto RFPG Chair is the PIO for the San Jacinto RFPG and is the official spokesperson. The San Jacinto RFPG Chair is the only person who can comment. If a representative of the San Jacinto RFPG receives a call from or is approached by a reporter, the San Jacinto RFPG representative must politely decline to answer any questions and let them know that the message will be delivered to the San Jacinto RFPG Chair immediately.

2. Anyone receiving a media inquiry must take down the reporter's name, affiliation, phone number, and a summary of the reporter's inquiry to convey to the spokesperson. This will enable the San Jacinto RFPG to keep a record of who calls so that information can be provided to the spokesperson for a response.
3. After steps 1 and 2 are complete, the person receiving the inquiry must contact the San Jacinto RFPG Chair or Vice Chair, not both, immediately using the contact information set forth in the Plan. If the San Jacinto RFPG Chair and Vice Chair are unavailable, the person will contact the San Jacinto RFPG's sponsor. The Project Sponsor can continue to coordinate with the Chair or Vice Chair for the media response. The spokesperson needs to receive the reporter's name, affiliation, phone number, and a summary of the inquiry that the reporter is requesting so that the spokesperson can respond to the reporter promptly. The complete Communications and Media Engagement Plan is located in **Appendix 10-1**.

Chapter 10.B. Communications Tools and Tactics

10.B.1. Overview

This section describes the communication tools and tactics implemented to support the San Jacinto RFPG. All public engagement events are in alignment with local government pandemic guidance and follow appropriate safety precautions.

10.B.2. Key Messaging

As necessary, key messaging for the San Jacinto RFPG will promote the public engagement goals and be refined. The messaging is used to develop communications collateral to enable engagement of the San Jacinto RFPG's key audiences.

Primary and secondary key messaging is maintained and updated, as needed, to support communication with various key audiences. Primary messages convey broader, less detailed information, and secondary messages include more detailed information supporting the primary message. Key messaging will be consistent across all communications.

10.B.3. Education Communications Tool

The development and distribution of accessible, bilingual, English and Spanish, communications tools is critical to achieving the goals of this Plan and the San Jacinto RFPG. In coordination with the technical consultant team and the San Jacinto RFPG Sponsor (Harris County), the following educational materials are available to support the various needs that may arise throughout the life of the San Jacinto RFPG and the RFP development:

- Print and digital collateral, e.g., fact sheets, FAQs, self-mailing comment forms, email notices, informational exhibits, and others.
- PowerPoint Presentations.

- Digital tools, e.g., educational graphics for presentations, social media, website, and other platforms.
- Electronic surveys.
- Other items to be identified as necessary.

10.B.3.a. Monthly E-blasts

Monthly e-blasts are distributed to the San Jacinto RFPG stakeholder database to ensure timely and consistent communication about the RFP process are shared with regional stakeholders. An example of the monthly e-blasts can be found in **Appendix 10-2**. The San Jacinto RFPG Distribution List is located in **Appendix 10-3**.

10.B.3.b. Website

The TWDB maintains a webpage dedicated to the San Jacinto region, www.twdb.texas.gov/flood/planning/regions/6, which includes demographic and geographic information about the region as well as resources about the San Jacinto RFPG process and contact information for the Project Sponsor, Planning Group Chair and the TWDB contact for Region 6.

Additionally, a website dedicated to the San Jacinto RFPG, www.sanjacintofloodplanning.com,was established in summer 2021 and serves as an easily accessible forum for obtaining and sharing public information specific to the San Jacinto region. The technical consultant team hosts and manages a design-forward, interactive, mobile-friendly, and accessible web platform.

10.B.3.c. Social Media

The San Jacinto RFPG established social media platforms, onFacebook and Twitter, in fall 2021 to:

- Drive awareness through accessible and free information channels.
- Announce upcoming San Jacinto RFPG meetings and provide access information.
- Promote the transparency and authenticity of the San Jacinto RFPG.

A targeted social media and content strategy was developed and is updated throughout the San Jacinto RFPG planning cycle. During this time, these social media accounts are monitored, managed, and maintained.

Content is developed and customized for each platform to inform and engage key audiences. Examples of content include:

- General safety, preparedness, and flood risk awareness messaging.
- Educational information and graphics.
- Information about/documentation of public engagement efforts.
- Opportunities for the public to participate and engage with San Jacinto RFPG representatives.

Chapter 10.C. San Jacinto RFPG Meetings

10.C.1. Overview

All RFPG meetings and committee meetings abide by TWDB noticing guidelines and are in compliance with the Texas Open Meetings Act and Public Information Act. Notices include the date, time, and location of the meeting as well as a summary of the proposed action to be taken. A statement of how and when comments will be received from the members and public is included on all public noticing materials. This information includes the name, telephone number, email, and address of an RFPG contact to whom questions or requests for additional information may be submitted.. All meeting information, including meeting notices, agendas, supporting materials, meeting recordings and minutes can be found on the San Jacinto RFPG website (sanjacintofloodplanning.org).

10.C.2. Regular San Jacinto RFPG Meetings

The purpose of RFPG meetings is to consider and take action on matters brought before the RFPG in step with the timeline and scope of work provided by TWDB.

A total of 28 RFPG meetings have occurred since the inception of the San Jacinto RFPG in 2020. A list of all RFPG meetings to date is included in **Table 10-2**.

TABLE 10-2: SCHEDULE OF SAN JACINTO RFPG MEETINGS

Date	Time
Oct. 28, 2020	9:00 a.m.
Dec. 10, 2020	9:00 a.m.
Jan. 14, 2021	9:00 a.m.
Feb. 11, 2021	9:00 a.m.
March 11, 2021	9:00 a.m.
April 8, 2021	9:00 a.m.
May 13, 2021	9:00 a.m.
June 4, 2021	1:00 p.m.
June 10, 2021	9:00 a.m.
July 8, 2021	9:00 a.m.
Sept. 9, 2021	9:00 a.m.
Oct. 14, 2021	9:00 a.m.
Nov. 18, 2021	9:00 a.m.
Dec. 9, 2021	9:00 a.m.
Jan. 13, 2022	9:00 a.m.
March 3, 2022	9:00 a.m.
April 14, 2022	9:00 a.m.
May 12, 2022	9:00 a.m.
June 9, 2022	9:00 a.m.
July 14, 2022	9:00 a.m.
Aug. 11, 2022	9:00 a.m.

Date	Time
Sept. 8, 2022	9:00 a.m.
Oct. 13, 2022	9:00 a.m.
Nov. 10, 2022	9:00 a.m.
Dec. 8, 2022	9:00 a.m.
Feb. 9, 2023	9:00 a.m.
April 13, 2023	9:00 a.m.
June 8, 2023	9:00 a.m.

10.C.3. Committee Meetings

In addition to the larger San Jacinto RFPG meetings, certain members of the San Jacinto RFPG meet in subcommittee which includes the Executive Committee, Technical Committee, and the Public Engagement Committee. A list of all committee meetings to date by committee is included in **Table 10-3**, **Table 10-4**, and **Table 10-5**, respectively.

10.C.3.a. Executive Committee Meetings

The purpose of the Executive Committee is to take action on items pertaining to the general management of the San Jacinto RFPG.

TABLE 10-3: SCHEDULE OF EXECUTIVE COMMITTEE MEETINGS

Date	Time
Jan. 8, 2021	1:00 p.m.
Feb. 2, 2021	1:00 p.m.
April 6, 2021	9:00 a.m.
May 7, 2021	12:00 p.m.
June 4, 2021	1:00 p.m.
June 23, 2021	9:00 a.m.
June 25, 2021	1:00 p.m.
Aug. 27, 2021	10:00 a.m.
Aug. 31, 2021	1:00 p.m.
Oct. 4, 2021	11:00 a.m.
Nov. 4, 2021	9:00 a.m.
Feb. 4, 2022	9:00 a.m.
Feb. 9, 2022	10:00 a.m.
Feb. 21, 2022	1:00 p.m.
April 25, 2022	9:30 a.m.
June 1, 2022	3:30 p.m.
Oct. 10, 2022	1:00 p.m.

10.C.3.b. Technical Committee Meetings

The purpose of the Technical Committee is to take action on items pertaining to the development of the RFP. Technical Committee meetings held are outlined in **Table 10-4.** The meeting minutes and materials for the Technical Committee meetings are located in Appendix 10-4.

TABLE 10-4: SCHEDULE OF TECHNICAL COMMITTEE MEETINGS

Date	Time
June 3, 2021	9:00 a.m.
June 28, 2021	1:00 p.m.
Aug. 23, 2021	12:00 p.m.
Sept. 29, 2021	1:00 p.m.
Oct. 27, 2021	12:00 p.m.
Feb. 3, 2022	2:00 p.m.
March 31, 2022	10:00 a.m.
Sept. 2, 2022	9:00 a.m.

10.C.3.c. Public Engagement Committee Meetings*

The purpose of the Public Engagement Committee is to take action on items pertaining to best practices for public involvement, engagement, collaboration, and coordination for the San Jacinto RFPG. The meeting minutes and materials for the Public Engagement Committee Meetings are located in **Appendix 10-5**.

TABLE 10-5: SCHEDULE OF PUBLIC ENGAGEMENT COMMITTEE MEETINGS

Date	Time
Feb. 22, 2022	2:30 p.m.
March 10, 2022	11:30 a.m.
May 5, 2022	10:00 a.m.
July 5, 2022	1:30 p.m.
Aug. 5, 2022	1:30 p.m.
Oct. 5, 2022	1:30 p.m.

**The Public Engagement Committee was created at the request of the San Jacinto RFPG members*

Chapter 10.D. Public Meetings and Engagement

10.D.1. May 2021 Virtual Pre-Planning Public Meeting

On May 18, 2021, the San Jacinto RFPG held a virtual public meeting to gather community concerns to aid with the development of the RFP. The meeting was held on Zoom simultaneously in English and Spanish using the Zoom live interpretation feature. This meeting served as the pre-planning meeting and was intended to provide background on formation of RFPGs and the Regional Flood Planning process and to gather suggestions and recommendations regarding issues, provisions, projects, and strategies that should be considered in development of RFP.

10.D.1.a. Public Noticing

A public notice and a flyer were disseminated to relevant organizations and the public. The public notice and flyer were shared with elected officials in the San Jacinto region and the San Jacinto RFPG distribution list.

10.D.1.b. Public Meeting Overview

Due to the ongoing COVID-19 pandemic in 2021, the San Jacinto RFPG hosted the public meeting virtually via Zoom. The meeting was presented in English and Spanish using Zoom's live interpretation function. The meeting began with a presentation to provide context on San Jacinto RFPG's purpose and the need for public participation to complete the RFP. Following the presentation, attendees were given the opportunity to provide comments regarding the information reviewed and to identify flood risk areas in their communities. Each speaker was given three minutes to make comments.

10.D.1.c. Summary of Public Comments Received

Seven comments were received during the public commenter period of the meeting. A copy of the May 2021 Pre-Planning Meeting Minutes, which contains a copy of the notification materials, public meeting materials, and comments received, is available in **Appendix 10-6**.

10.D.2. August 2021 Existing Flood Risk Public Meeting

On Aug. 31, 2021, the San Jacinto RFPG held a virtual public meeting to provide an overview and update on the San Jacinto RFPG's efforts and to identify existing flood risk in the region. The meeting was held on Zoom simultaneously in English and Spanish using the Zoom live interpretation feature. This meeting was intended to satisfy the TWDB requirement for a public meeting to identify flood risk in the region.

10.D.2.a. Public Noticing

A public notice and a flyer were disseminated to relevant organizations and the public. The public notice and flyer were shared with elected officials in the San Jacinto region and the San Jacinto RFPG distribution list.

10.D.2.b. Public Meeting Overview

The meeting began with a presentation to update the San Jacinto RFPG's efforts and next steps. Following the presentation, attendees were given the opportunity to provide comments regarding the information reviewed and to identify flood risk areas in their community. Each speaker was given three minutes to make comments.

10.D.2.c. Summary of Public Comments Received

A total of four comments were received during the public commenter period of the meeting. A copy of the August 2021 Existing Flood Risk Meeting minutes, which contains a copy of the noticing materials, public meeting materials, and comments received, is available in **Appendix 10-7**.

10.D.3. May 2022 Public Open Houses (Virtual and In-Person)

In May 2022, the San Jacinto RFPG group held three open houses on May 24, 26 and 31. In order to provide equal opportunity for public input, the meetings were hosted in-person and virtually. The meetings were held in different locations within the San Jacinto region to allow for a diverse geographic spread. The May 2022 open houses were held to solicit public input and collect further information to be used to develop the draft RFP for the San Jacinto region. This meeting was intended to satisfy the TWDB requirement for a public meeting to receive feedback and recommendations from the public related to issues, provisions, and types of FMSs, FMPs, and FMEs in this planning cycle.

TABLE 10-6: MAY 2022 PUBLIC OPEN HOUSES DATES AND LOCATIONS

Date	Time
May 24, 2022	Rob Fleming Recreation Center 6464 Creekside Forest Dr The Woodlands, TX 77389
May 26, 2022 (virtual)	Zoom
May 31, 2022	Clear Lake Shores Clubhouse 931 Cedar Rd Clear Lake Shores, TX 77565

10.D.3.a. Public Noticing

The public was notified of the meeting through the following methods: Facebook, Twitter, San Jacinto RFPG website, three e-blasts, press release and leveraging the community networks of the San Jacinto RFPG members.

10.D.3.b. Public Meeting Overview

The in-person open houses consisted of three project specific stations: Flood Risk, Flood Management Practices and Goals, and Project, Studies, and Strategies. Additionally, a comment station was set up to solicit additional public input. The stations were self-paced, and the public was able to learn more about the San Jacinto RFPG process and projects from the Social Pinpoint open house website, informational handouts and open dialogues with project team members at each station.

The virtual open house format was modeled after the in-person meetings to provide equal opportunity to members of the public who participated online. The virtual open house offered three breakout rooms in different rotations, which mirrored the three stations offered at the in-person open houses. Each rotation was approximately 30 minutes. During the breakout sessions, participants were able to navigate between any of three project specific stations at their own pace. Participants were given a brief orientation on how to use Zoom to support the public in navigating breakout rooms. Additionally, project team members were available to help troubleshoot any technical issues.

10.D.3.c. Summary of Public Comments Received

Participants were able to comment online through the project website or in-person using comment cards for written comments. A total of twenty (20) online and written comments were received.

A copy of the May 2022 Open Houses Meeting minutes, which contains a copy of the noticing materials, public meeting materials and comments received, is available in **Appendix 10-8**.

Chapter 10.E. Public Engagements

10.E.1. Overview

To support ongoing awareness of the San Jacinto RFPG and the RPF process, the Technical Consultant and the San Jacinto RFPG members have sought out opportunities to engage with the public throughout the San Jacinto region. This includes creating a presence at local conferences and giving project presentations across the region. Additionally, the Technical Consultant team sought feedback and opportunities for engagement with entities and stakeholders involved with flood planning across the region. This included target emails, collecting comments via the website, phone calls and individual meetings with entities to maximize coordination and the collection of information process.

10.E.2. Interregional RFPG Coordination

Interregional RFPG Coordination included the use of liaisons and non-voting RFPG members as a means of facilitating and communicating between Region 6 and other regions and entities. RFPG Liaisons from the Trinity, Neches, and Lower Brazos regions, as well as the Region H Water Planning Group, provided updates to ongoings in other regions. RFPG non-voting members were also utilized to incorporate considerations from other stakeholder agencies, such as the Houston-Galveston Area Council. Additionally, a Memorandum of Understanding (MOU) between the GLO and the TWDB, regarding the GLO Combined River Basin Flood Study efforts, allowed for greater data collection and coordination between the two planning efforts and agencies.

10.E.3. Stakeholder and Member of the Public Surveys

To bolster target engagement efforts, a survey, accessible through the San Jacinto RFPG website, was developed to collect input and feedback from both members of the public and regional stakeholders to facilitate development of the RFP. There were three major components of the survey including a questionnaire, data submittal portal and an interactive webmap.

As part of the first component, two questionnaires were developed, one for members of the public and one for stakeholders, so that questions could be tailored to both groups. The questionnaire for members of the public was shorter and included less technical language. The questionnaire for regional stakeholders included technical questions aimed at better understanding the existing needs and flood management practices of entities in the region. Examples of the questionnaire can be found in **Appendix 10-9**.

The second component of the survey, the data submittal portal, was developed to provide individuals an opportunity to submit relevant data to the San Jacinto RFPG as well as request additional assistance to facilitate large data submittals. The results of the questionnaire and data submittal portal were:

- 14 regional stakeholder responses.
- 48 members of the public responses, including 1 Spanish language member of the public response.
- Four data submittal responses.

The third component of the survey, the interactive webmap, was developed to provide individuals an opportunity to view existing flood hazard in their area and identify on the map flood prone areas and existing flood control projects. **Figure 10-1** provides an image of the webmap. The webmap and associated instructions were also made available in Spanish.

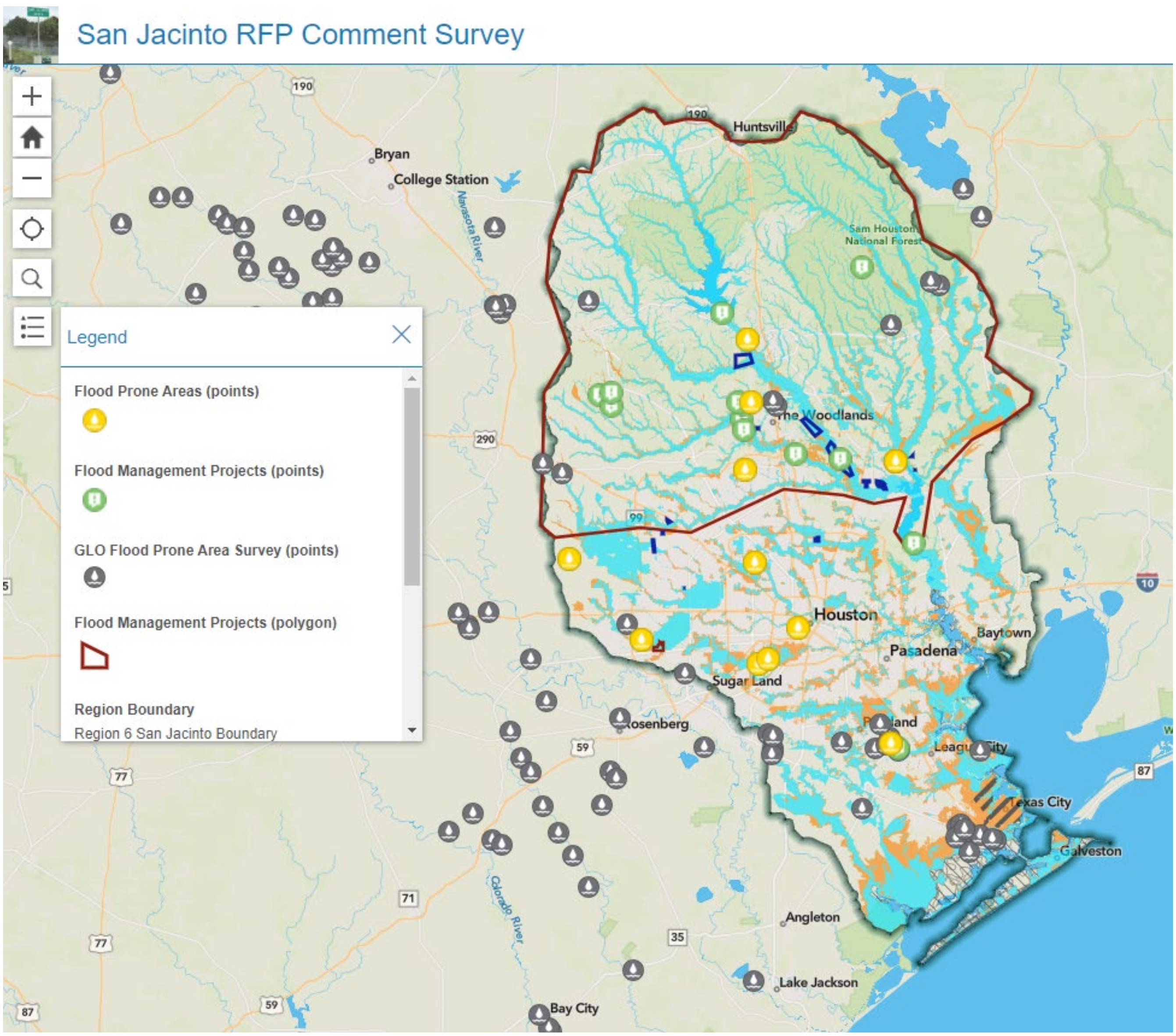

FIGURE 10-1: INTERACTIVE WEBMAP SURVEY

10.E.4. Texas Floodplain Management Association Conference Participation

In March 2022, the San Jacinto RFPG sponsored a booth at the 2022 TFMA Conference held in Houston. The booth was used to inform the public about the purpose of the San Jacinto RFPG and solicit further feedback on the flooding survey developed to inform the RFP. The materials available at the booth were handouts with more information on the San Jacinto RFPG and links to the organization website and survey. TFMA Conference Materials are located in **Appendix 10-10**.

10.E.5. San Jacinto RFPG Presentations

The Technical Consultant and the San Jacinto RFPG members have presented 13 times throughout the lifecycle of the draft RFP process. A list of presentations by organization and date is included in **Table 10-7**. A public engagement sample presentation is located in **Appendix 10-11**.

TABLE 10-7: RFPG PUBLIC ENGAGEMENT PRESENTATIONS

Organizations	Date
Houston-Galveston Area Council	Dec. 14, 2021
Houston-Galveston Area Council	Jan. 19, 2022
Dickinson Bayou Watershed Partnership	Feb. 1, 2022
The Woodlands Township Board Meeting	Feb. 23, 2022
Gulf Coast Protection District	March 9, 2022
Houston-Galveston Area Council - Regional Flood Management Committee	April 20, 2022
North Houston Association	May 5, 2022
Houston Stronger	May 6, 2022
Galveston County Consolidated Drainage District	May 24, 2022
The Woodlands GREEN	May 26, 2022
West Houston Chamber of Commerce Monthly meeting	May 26, 2022
Association of Water Board Directors	June 24, 2022
Houston Real Estate Lawyers Council	July 12, 2022

Chapter 10.F. Public Review and Comment on the Draft Plan

10.F.1. Overview

As required by the planning process, the San Jacinto RFPG prepared and made available a draft RFP for review by the public and the TWDB. Comments were received on this document and considered for possible revision prior to the completion and submittal of the final, adopted RFP.

10.F.2. Notice and Distribution of the Draft Plan

As required by the planning process, the San Jacinto RFPG prepared and made available a draft RFP for review by the public. The San Jacinto RFPG identified 3 locations to host hard copies of the draft RFP for public review. The locations were selected to allow for a geographic spread across the region and to promote access to the draft plan. The 3 locations selected are listed in **Appendix 10-12** and were made available from August 17, 2022 until the close of the review period on October 29, 2022. An electronic copy of the draft RFP was also made available on the San Jacinto RFPG website.

As required by 31 TAC 361, notice of the public meetings to receive input on the draft RFP was distributed by several means including:

- Notice of public meetings, instruction for how to provide comments, and locations of hard copies of the draft RFP for public review were distributed through email to individuals on the San Jacinto stakeholder database on September 1, 20, 26, and 29 of 2022 as well as October 27, 2022.
- Notice of public meetings, instruction for how to provide comments, and locations of hard copies of the draft RFP for public review were posted on the San Jacinto RFPG website on August 22, 2022 and the Texas Secretary of State's website.
- Notice of public meetings was distributed to adjacent RFPGs through email.
- Notice of public meetings was shared on social media on August 17 and 31 of 2022, as well as on September 9, 21, 27, and 29 of 2022.

The San Jacinto RFPG advertised two public open-house style meetings in 2022 to receive comment on the draft RFP scheduled for September 27 and 29 of 2022. Both an in-person meeting and a virtual meeting were held to accommodate as many individuals as possible. The in-person meeting location, the White Oak Conference Center, was identified by the Public Engagement Committee due to its central location, proximity to public transportation routes, and location in an area of the San Jacinto region that had previously had low rates of engagement with the flood planning process.

A summary of the draft RFP, included in noticing, can be found in **Appendix 10-12**.

10.F.3. September 2022 Open Houses (Virtual and In-Person)

An in-person public open house meeting was held at the White Oak Conference Center on September 27, 2022 at 5:30PM. Subsequently, a virtual public open house meeting was held on September 29, 2022 at 5:30PM. A brief video documenting a summary of the draft RFP was presented at both meetings followed by break outs to discuss the plan in more detail. The public was encouraged to provide verbal comment, written comment, or comments electronically via the website or to the San Jacinto RFPG technical consultant email. Materials from the September 2022 public open house meeting can be viewed on the San Jacinto RFPG website (Sanjacintofloodplanning.org).

10.F.4. Summary of Comments and Responses

The public comment period for the San Jacinto draft RFP extended through October 29, 2022. The San Jacinto RFPG received comments from 64 individuals or organizations. A breakdown of the sources of comments is provided in **Table 10-8**.

TABLE 10-8: SOURCES OF PUBLIC COMMENTS

Source of Comment	Fraction of Submittals Attributed to this Source
Members of the Public	48%
Municipalities	25%
Drainage Districts or River Authorities	8%
Authoritative Organizations	7%
State and Regulatory Agencies	5%
Counties	4%
RFPG Members	3%

The most significant and common comments were:

- Requests by sponsors to revise details of currently recommended FMEs, FMSs, and FMPs.
- Additional flood financing survey submittals by sponsors of currently recommended FMEs, FMSs, and FMPs.
- Requests for inclusion of additional FMEs, FMSs, and FMPs.
- Submittal of additional data to elevate FMEs to FMPs.
- Voicing of both support and opposition to actions recommended within the plan.
- Voicing of support for the inclusion of nature-based solutions.

Once comments were received, they were summarized for consideration by the San Jacinto RFPG. At meetings on November 10, 2022 and December 8, 2022 the San Jacinto RFPG reviewed comments and initial responses. Responses to comments and revisions to the draft RFP, in response to those comments, were approved at the meeting on December 8, 2022. Responses were prepared in writing. Comments received and the approved responses can be viewed in **Appendix 10-13** along with responses to comments issued by the TWDB.