Region 2 Lower Red-Sulphur-Cypress Flood Planning Group

Ark-Tex Council of Governments

Texas Water Development Board

Region 2 Lower Red-Sulphur-Cypress Regional Flood Plan

Contracting Entity:
Ark-Tex Council of Governments

December 2022

LOWER RED-SULPHUR-CYPRESS
REGIONAL FLOOD PLANNING GROUP
REGION 2

HALFF

Region 2 Lower Red-Sulphur-Cypress Regional Flood Plan

December 2022

Prepared for:
Texas Water Development Board

Prepared by:
Region 2 Regional Flood Planning Group

With assistance from:
Halff Associates, Inc. (TBPELS Firm #312)

with support from:
Freese and Nichols, Inc. (TBPELS Firm #2144), H2O Partners, Inc., and MTG Engineers, Inc. (TBPELS Firm #354)

STATE OF TEXAS
JOSHUA W. McCLURE
101177
LICENSED
PROFESSIONAL ENGINEER

1/3/2023

Joshua McClure, PE, PhD, PMP, CFM
Project Manager, Halff Associates, Inc.

STATE OF TEXAS
HÉCTOR DAVID RIVERA RAMIREZ
108842
LICENSED
PROFESSIONAL ENGINEER

01/03/2023

David Rivera, PE, PhD, CFM
Deputy Project Manager, Freese and Nichols, Inc.

STATE OF TEXAS
PARKER C. MOORE
137516
LICENSED
PROFESSIONAL ENGINEER

1/3/2023

Parker Moore, PE, CFM
Halff Associates, Inc.

Acronyms and Abbreviations

1D	One-Dimensional Model
2D	Two-Dimensional Model
ACE	Annual Chance Exceedance
ATCOG	Ark-Tex Council of Governments
ATSDR	Agency for Toxic Substances and Disease Registry
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
BLE	Base Level Engineering
BRIC	Building Resilient Infrastructure and Communities
CAP	Continuing Authorities Program
CDBG	Community Development Block Grant
CDBG-MIT	Community Development Block Grant - Mitigation
CDBG-DR	Community Development Block Grant – Disaster Recovery
CDC	Centers for Disease Control and Prevention
COG	Council of Governments
CRS	Community Rating System
CTP	Cooperating Partners Program
CWMS	Corps Water Management System
CWSRF	Clean Water State Revolving Fund
DD	Drainage District
DFUND	Texas Water Development Fund
DHS	Department of Homeland Security
DPS	Department of Public Safety
DR	Disaster Declaration

EAP	Emergency Action Plan
EAS	Emergency Alert System
EM	Emergency Declaration
EPA	Environmental Protection Agency
EWP	Emergency Watershed Protection
FEMA	Federal Emergency Management Agency
FIF	Flood Infrastructure Fund
FIS	Flood Insurance Study
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
FME	Flood Management Evaluations
FMP	Flood Mitigation Projects
FMS	Flood Management Strategies
FRMP	Flood Risk Management Program
FWSD	Fresh Water Supply Districts
GIS	Geographic Information Systems
GLO	General Land Office
H&H	Hydrology and Hydraulics
HIFLD	Homeland Infrastructure Foundation-Level Data
HMAP	Hazard Mitigation Action Plan
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HUC	Hydraulic Unit Code
HUD	Housing and Urban Development
ICLUS	Integrated Climate and Land Use Scenarios
IDF	Intensity-Duration-Frequency
LID	Levee Improvement District

LIDAR	Light Detection and Ranging
LOS	Level of Service
MHI	Median Household Income
MUD	Municipal Utility District
MWD	Municipal Water District
NAICS	North American Industry Classification System
NFIP	National Flood Insurance Program
NCEI	National Center for Environmental Information
NNBS	Natural and Nature-Based
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
PA	Public Assistance
PAYANN	Total Sum of Annual payroll
PDA	Preliminary Damage Assessments
PDM	Pre-Disaster Mitigation
RFC	River Forecast Center
RFPG	Regional Flood Planning Group
SB3	Senate Bill 3
SCS	Soil Conservation Service
SFHA	Special Flood Hazard Areas
SGCN	Species of Greatest Conservation Need
STORM	Safeguarding Tomorrow through Ongoing Risk Mitigation
SUD	Special Utility District
SVI	Social Vulnerability Index

SWCD	Soil and Water Conservation Districts
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
TDEM	Texas Department of Emergency Management
TFMA	Texas Floodplain Management Association
TNRIS	Texas Natural Resources Information System
TPWD	Texas Parks and Wildlife Department
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WCID	Water Control Improvement District
WMS	Water Management Strategies
WRDA	Water Resources Development Act
WSEL	Water Surface Elevation
WUG	Water User Group
WWP	Watershed Work Plan

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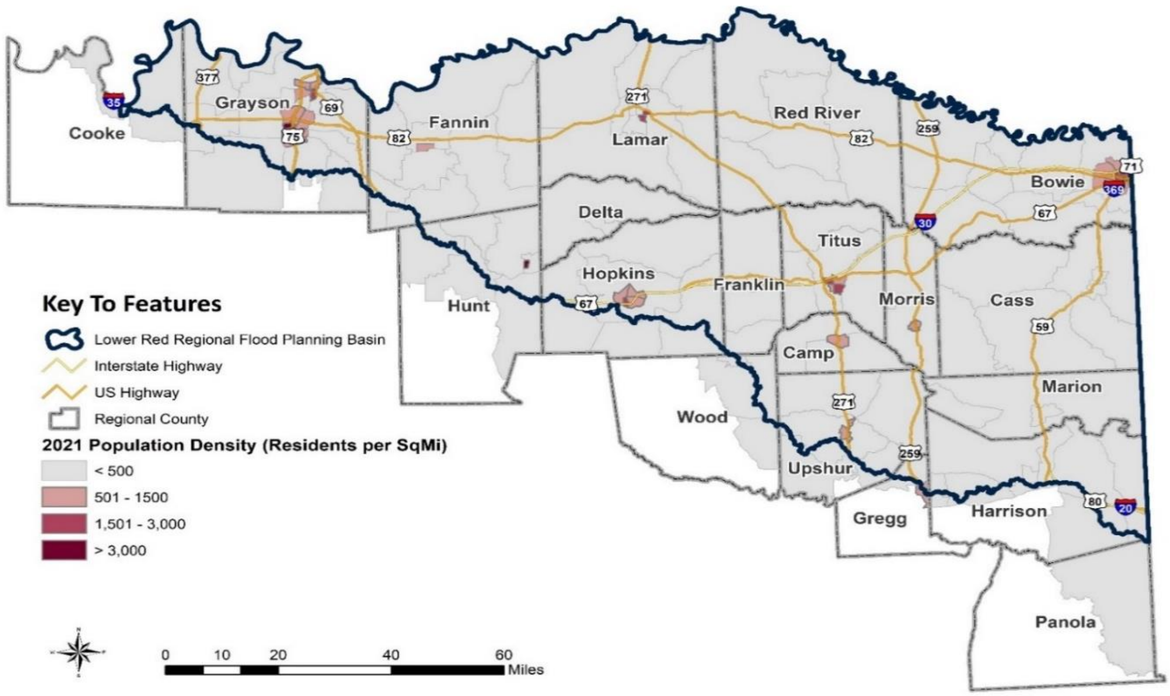
Executive Summary

In 2019, the 86th Texas Legislature passed Senate Bill 8, which authorized and established the regional and state flood planning processes. The legislature assigned the responsibility of the regional and state flood planning process to the Texas Water Development Board (TWDB). This report presents the Final Region 2 Lower Red-Sulphur-Cypress Regional Flood Plan, representing the first-ever region-wide flood plan. Region 2 is one of 15 Regional Flood Planning Groups across the State of Texas tasked with developing a Regional Flood Plan.

Region 2 encompasses all or part of 19 counties and spans an area of 9,161 square miles. The area stretches from Gainesville in Cooke County into the northwest to Waskom (east of Marshall) to the southeast and up to Texarkana at the northeast corner. The region borders Oklahoma to the north and Arkansas and Louisiana to the east. Only the lower portion of the Red River is included, with Region 1 covering the upper Red River. The entirety of the Sulphur River and Cypress Creek basins within Texas are included in the region. Both of these streams are tributaries of the Red River in Louisiana. *Figure ES.1* represents the boundaries of Region 2.

According to the TWDB's population projections, Region 2 is one of the state's least populated flood planning areas. According to the 2019 five-year American Community Survey estimates, 531,100 residents, or less than 2% of Texas residents, currently reside in Region 2. Encompassing 9,161 square miles, the region is largely rural, with 57% of the people living in rural areas and only 44% living in cities and towns. Of those living in urban areas, most live in the major cities that fall within Grayson, Lamar, and Bowie County. With roughly 43,000 residents, Sherman is the largest city within Region 2. There are significant population centers in Texarkana, Denison, and Paris as well. These cities are located along Highway 82, which runs east-west through the region. To the west, the communities of Denison and Sherman are located on the southern border with Oklahoma and the Red River. The other population centers are generally located along I-30. A few larger cities, such as Longview and Marshall, touch the southern boundary of the Region along the I-20 corridor, but those cities are mainly situated within the Sabine River Basin (Region 4).

Figure ES.1 Region 2 Lower-Red-Sulphur-Cypress Flood Planning Area



Agriculture has always been a major economic and cultural factor in the region. Today, there are nearly 200,000 more cattle in the region than people. But this pales compared to the over 28 million poultry being raised in the area, primarily as broilers. There is one broiler chicken for each person in Texas. In addition, there is roughly one layer hen for every two people in the region. Much of the eastern portion of the region is actively or passively managed timber land that contributes significantly to the region's economy, including local manufacturing at sawmills and wood product manufacturing. Combined with the warehousing and distribution of products from and through the region, flooding could significantly impact the Texas economy.

The Region 2 Flood Planning Group (RFPG) is comprised of 25 volunteers who oversaw and directed the development of this plan. The RFPG held a public meeting on July 21, 2022, to approve the submittal of the Draft Region 2 Lower Red-Sulphur-Cypress Regional Flood Plan to the TWDB by August 1, 2022 deadline. Before this meeting, the preliminary draft flood plan was made available to the public on the RFPG's website. After the meeting, the Technical Consultant Team addressed the comments received and made any necessary revisions before submitting the Draft Regional Flood Plan to the TWDB and the public. The draft plan was posted on the RFPG's website and paper copies of the plan were available at three locations within the region:

- Sherman City Clerk's Office at 220 West Mulberry Street, Sherman, Texas 75090
- Mount Pleasant Public Library at 601 North Madison, Mount Pleasant, Texas 75455
- Texarkana Public Library at 600 West 3rd Street, Texarkana, Texas 75501

The draft plan was available from August 1, 2022 to October 1, 2022. A public hearing was held on September 1, 2022, in Mount Pleasant, Texas, to present and receive feedback on the draft plan. The public had at least 30 days before and 30 days following the public hearing to provide written comments in addition to providing written and/or oral comments at the public hearing. The RFPG responded to the comments received and revised the draft plan as appropriate. On December 15, 2022, in Mount Pleasant, Texas, the final plan was approved by the RFPG for submission to the TWDB by the January 10, 2023 deadline.

Chapters within the Plan

The TWDB developed the scope of work and technical guidelines that adhere to the legislation for each RFPG to develop its Regional Flood Plan. The plan includes 10 required chapters plus the TWDB-required tables and maps. The TWDB-required tables and maps are included in various appendices of this plan.

- **Chapter 1 (Task 1) Planning Area Description**
  Chapter 1 provides an overview of the region, including location, economics, agricultural information, social vulnerability, flood-prone areas, historical floods and associated damages, jurisdictions with flood-related authorities or responsibilities, existing infrastructure, and ongoing flood mitigation projects.
- **Chapter 2 (Tasks 2A and 2B) Flood Risk Analyses**
  This plan focuses on the 1% and the 0.2% annual chance events (ACE) for existing and future conditions. Future conditions are based on 30 years from 2022.
  - **Task 2A Existing Condition Flood Risk Analyses**
    This task estimates existing condition flood risk based on information provided by local entities and the public, as well as regional, state, and federal data sources. The best available existing condition flood risk data is stitched together to create a floodplain quilt. Data gaps are identified, as is the region’s vulnerability.
  - **Task 2B Future Condition Flood Risk Analyses**
    Task 2B assess potential future flood risk considering two scenarios: a “no action” scenario in which development and population growth continue according to current trends and development incorporating floodplain regulations. Future flood risk condition considers multiple potential impacts on flood risk, such as land use, population growth, sea level change, land subsidence, and sedimentation. The RFPG developed an approach to estimate a range of potential future flood risk conditions using a hierarchy of available data sources that the TWDB approved.
- **Chapter 3 (Tasks 3A and 3B) Floodplain Management Practices and Flood Protection Goals**
  Survey questions related to floodplain management practices within the region were included in the data collection effort in Summer 2021, which the RFPG considered in its recommendations in the goals presented in Chapter 3.

- **Task 3A Evaluation and Recommendations on Floodplain Management Practices**
  The RFPG recommends eight region-wide floodplain management standards to be included in this plan. Entities are encouraged to adopt and implement these standards; however, this is not a requirement for their Flood Management Evaluations (FMEs), Flood Mitigation Projects (FMPs), and/or Flood Management Strategies (FMSs) to be included in this plan.
- **Task 3B Flood Mitigation and Floodplain Management Goals**
  The RFPG established eight overarching goals in six categories. Each goal includes at least one specific goal statement with short-term (goal year 2033) and long-term (goal year 2053) measurements. Every recommended FME, FMP, and FMS must meet at least one of these goals.

- **Chapter 4 (Tasks 4A and 4B) Assessment and Identification of Flood Mitigation Needs**
  The RFPG adopted a process to analyze flood mitigation needs and develop potentially feasible actions (FMEs, FMPs, and FMSs) to address these needs.
  - **Task 4A Flood Mitigation Needs Analysis**
    The scoring criteria to identify the areas of greatest known flood risk and knowledge gaps considers flood-prone areas that threaten life and property, current floodplain regulations, lack of inundation maps, lack of hydrologic and hydraulic (H&H) models, emergency need, existing models, previously identified projects, historical floods, previously implemented projects, and additional factors identified by the RFPG. The analysis results conclude significant knowledge gaps, as the vast majority of the region is inadequately mapped (98%). The areas of greatest known flood risk are primarily associated with the main cities in the region and adjacent areas.
  - **Task 4B Classification of Potential FMEs and Potentially Feasible FMSs and FMPs**
    Task 4B identifies potentially feasible actions (FMEs, FMPs, and FMSs) that might reduce or mitigate flood risk within the region. Potential actions include those identified by the RFPG in previous tasks and those provided by local entities. Planning level costs and estimated benefits are also developed for each potential action.
- **Chapter 5 (Task 5) Recommendation of Flood Management Evaluations, Flood Management Strategies, and Associated Flood Mitigation Projects**
  The RFPG established a Technical Subcommittee to review the potentially feasible actions and develop lists of FMEs, FMPs, and FMSs for the full RFPG to consider including in this plan. The RFPG applied a screening process to determine the actions for inclusion in this plan. Sixty-six FMEs, three FMPs, and 79 FMSs were considered for inclusion in the plans. Of these, 42 FMEs, three FMPs, and 38 FMSs are recommended in this Regional Flood Plan. The reduction of those numbers was mostly due to combining potential individual FMEs and FMSs within a city or region. The limited number of FMPs is due to the difficulty in providing the appropriate information and verifying that the project would have no negative impact. As a result, many potential FMPs were converted to FMEs to prove the project viability in meeting the TWDB requirements.

- **Chapter 6 (Tasks 6A and 6B) Impact and Contribution of the Regional Flood Plan**
  The RFPG considers the potential impacts of the recommended FMEs, FMPs, and FMSs on upstream and downstream neighbors and adjacent regions, as well as potential impacts on the 2022 State Water Plan. Each of the recommended FMPs and FMSs has demonstrated no negative impacts on its neighboring area to be included as a recommended action.
  - **Task 6A Impacts of Regional Flood Plan**
    The recommended actions are assessed to determine anticipated flood risk reduction and socioeconomic and recreational impacts, as well as environmental, agricultural, water quality, erosion, navigation, and other impacts.
  - **Task 6B Contributions to and Impacts on Water Supply Development and the State Water Plan**
    The recommended FMPs and FMSs are assessed to determine the potential contribution to or impact on the State Water Plan. The assessment concludes that these recommended actions will not have any anticipated significant impacts on water supply, availability, or projects in the State Water Plan.
- **Chapter 7 (Task 7) Flood Response Information and Activities**
  Chapter 7 summarizes flood response preparations in the region. This chapter discusses the four phases of emergency management at the local, regional, state, and federal levels. Survey responses regarding emergency management are summarized. The TWDB requirements strictly prohibit the RFPG from analyzing or performing other activities related to planning for disaster response or recovery activities.
- **Chapter 8 (Task 8) Legislative, Administrative, and Regulatory Recommendations**
  The RFPG recommends eight legislative ideas to implement the recommended flood mitigation actions. Nine regulatory or administrative Regional Flood Planning process ideas are recommended to provide clarification or updates to statewide concerns. The RFPG recommends 18 flood planning ideas to improve future cycles of Regional Flood Planning.
- **Chapter 9 (Task 9) Flood Infrastructure Financing Analysis**
  Chapter 9 summarizes potential local, state, and federal funding opportunities that local sponsors could pursue while implementing the recommended FMEs, FMPs and FMSs. The survey results soliciting sponsor feedback on recommended actions and potential funding sources are presented.
- **Chapter 10 (Task 10) Public Participation and Plan Adoption**
  The Regional Flood Planning process is designed to be a public process. The RFPG adheres to the Texas Open Meetings Act and Freedom of Information Act, including notification requirements. The RFPG incorporates a robust public outreach plan to encourage and solicit local entities and public input. The development of this plan and its adoption is also included in Chapter 10.
- **Related Appendices**
  Appendices include the TWDB-required tables and maps, as well as supplemental details supporting information presented throughout the Regional Flood Plan.

Task 4C referred to the Technical Memorandum and Technical Memorandum Addendum that were approved by the RFPG and submitted to the TWDB in January and March 2022, respectively, to indicate significant progress in developing this plan. These two memos were significant milestones in the plan development and included outdated information. To reduce confusion, these two memos were not included in the Regional Flood Plan, although much of the content has been incorporated.

The TWDB will merge the required tables submitted by the RFPGs to develop the 2023 State Flood Plan and corresponding database. The TWDB also required specific Geographical Information System (GIS) schema to be submitted electronically as part of this plan. These files were provided directly to the TWDB.

Key Findings and Recommendations

Existing and Future Flood Risks

The Regional Flood Plan considered the 1% and 0.2% ACE. Both of these storm events were considered in the existing conditions and future conditions flood risk analyses. The future conditions scenario is assumed for 30 years from 2022.

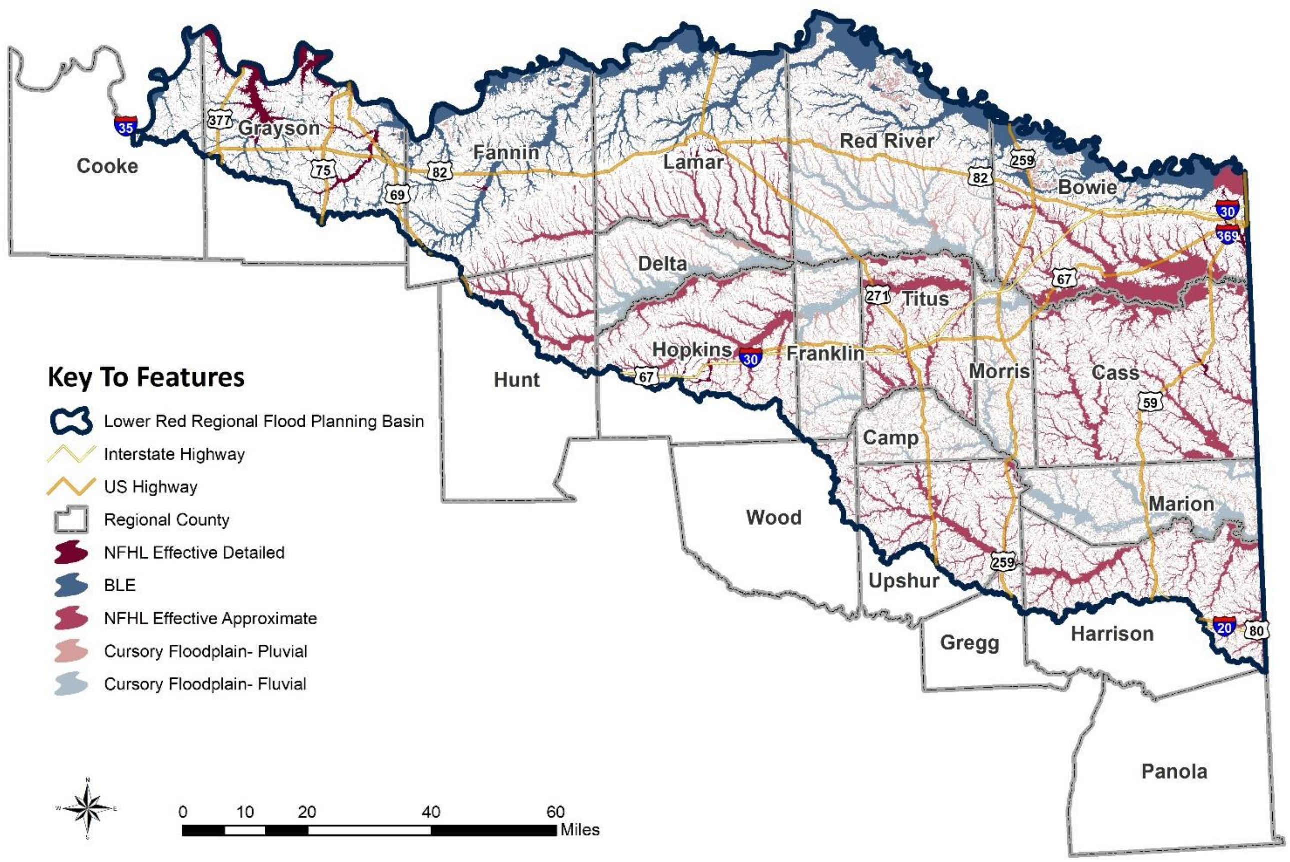
The RFPG was tasked with determining the best available data within the region. In some areas of Region 2, the RFPG could obtain local flood studies with models and maps; in others, localized studies were unavailable. The TWDB provided multiple GIS layers for Region 2 to use as a starting point in developing the floodplain quilt. The best available data for existing and future flood risks were used according to the hierarchy presented in *Table ES.1*. Pluvial Cursory Floodplain Data was provided by the TWDB. Pluvial flooding includes flooding in shallower, smaller concentrations than typical riverine floodplains shown on Flood Insurance Rate Maps (FIRM). This expanded flood hazard limit better represents flood risks in Region 2. The resulting stitching of floodplain layers produced *Figure ES.2*, which shows the flood risks for the 1% and 0.2% floodplains. This information was applied across Region 2 to identify flood data gaps.

Most communities have older, approximate mapping in Region 2, with five counties not having any floodplain mapping. This updated floodplain quilt represents a significant improvement in understanding flood risks in Region 2; however, it is composed of approximate data and should not be used outside the purposes of flood planning.

Table ES.1 Existing and Future Conditions Flood Hazard Approach

	Best Available	→	→	→	Most Approximate
	Local Floodplain (if determined current)	**NFHL AE**	**BLE**	**NFHL A**	**FAFDS, or No FEMA**
Existing	**1% ACE:** Local Study, if provided **0.2% ACE:** Local Study, if provided	**1% ACE:** Zone AE + Pluvial Cursory Floodplain Data* **0.2% ACE:** Zone AE + Pluvial Cursory Floodplain Data*	**1% ACE:** BLE + Pluvial Cursory Floodplain Data **0.2% ACE:** BLE + Pluvial Cursory Floodplain Data	**1% ACE:** Zone A + Pluvial Cursory Floodplain Data **0.2% ACE:** Zone A + Pluvial Cursory Floodplain Data	**1% ACE:** Combined Pluvial & Fluvial (Replaced FAFDS with Cursory Floodplain Data) **0.2% ACE:** Combined Pluvial & Fluvial (Replaced FAFDS with Cursory Floodplain Data)
Future	**1% ACE:** Local Study, if provided **0.2% ACE:** Local Study, if provided	**1% ACE:** Existing 500-Year **0.2% ACE:** 22-Foot Buffer of Existing 500-Year	**1% ACE:** Existing 500-Year **0.2% ACE:** 22-Foot Buffer of Existing 500' Year	**1% ACE:** Existing 500-Year **0.2% ACE:** 22-Foot Buffer of Existing 500-Year	**1% ACE:** Cursory Floodplain Data Existing 500-Year **0.2% ACE:** 22-Foot Buffer of Existing 500-Year

Figure ES.2 Region 2 Existing Conditions Floodplain Quilt



The existing flood control infrastructure was assessed, including dams and levees. Dams and levees protect against flooding but still have associated risks. It is critical to note that not all dams are permitted or constructed for flood control purposes. Six United States Army Corps of Engineers (USACE) flood control dams are located in Region 2. The Natural Resources Conservation Service has constructed 100 flood-control reservoirs intended to primarily serve agricultural areas. The remaining 377 dams are not known to have a flood control mission, but they provide some measure of flood control within Region 2. Approximately 19 levees are located within Region 2 to provide flood protection, although only eight are accredited by the Federal Emergency Management Agency (FEMA). Maintaining these critical infrastructures is crucial to protecting life and property within Region 2.

Severe flooding can impact people, property, critical facilities, infrastructure, agricultural production, and other items in Region 2. The exposure analysis revealed that around 21,000 people within Region 2 would be displaced during a 1% annual chance flood event, with just over 8,000 homes impacted. The loss of transportation infrastructure was estimated, along with water and wastewater treatment facilities. The impacts of flooding on socially vulnerable populations and a community's ability to recover were also assessed in Chapter 2.

As for future condition flood risk, the RFPG considered a variety of factors that could exacerbate flood risk, including:

- future land use/land cover
- population growth
- sea level change
- land subsidence
- changes in the floodplain
- major geomorphic changes
- sedimentation

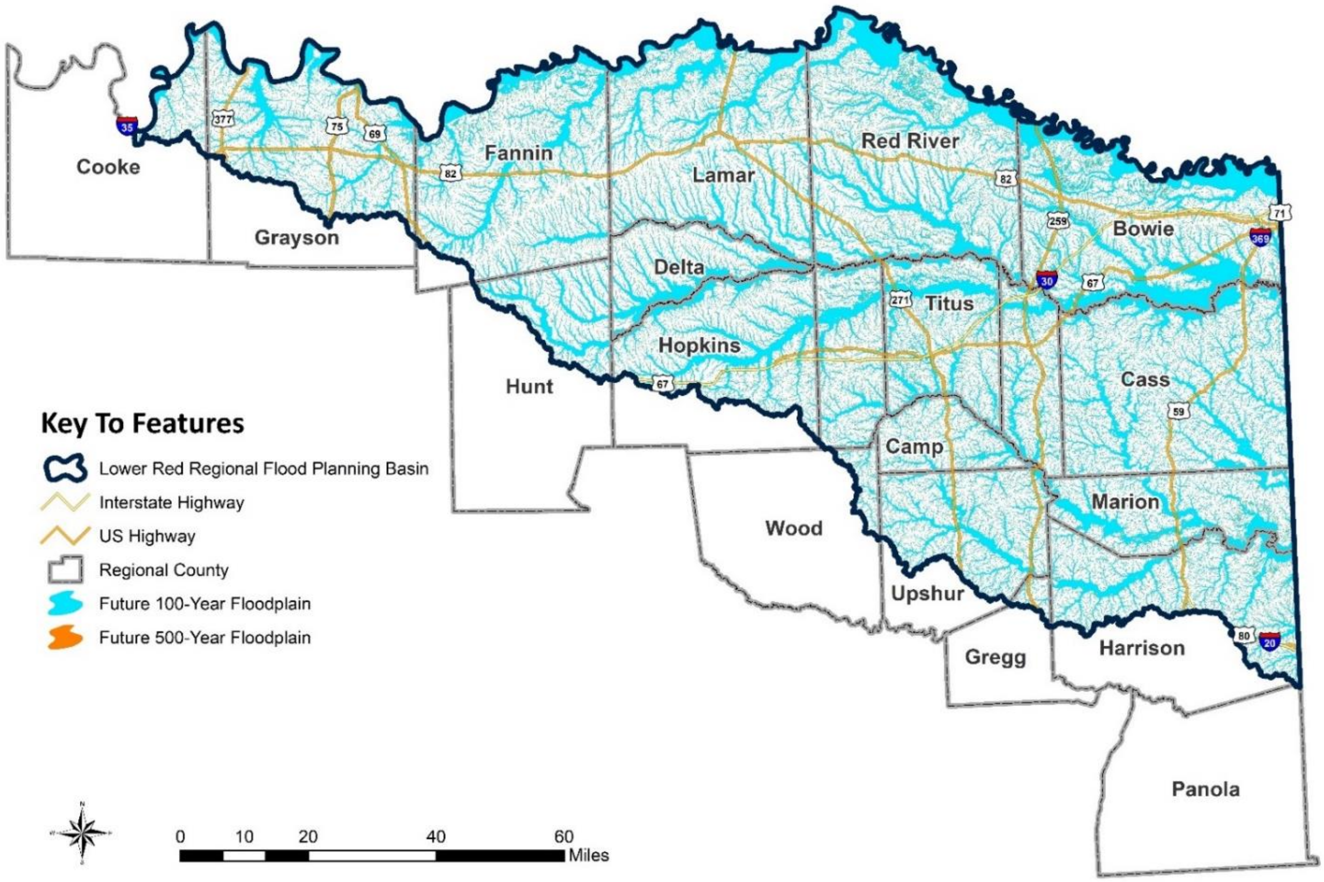
Some entities include future conditions in their mapping and modeling. However, the assumptions and methods vary from one entity to another. The few future flood studies that were available in Region 2 were incorporated into the future floodplain quilt. Where future studies were unavailable, it was necessary to develop a method of estimating future flood risks that met the TWDB requirements. A sensitivity analysis was performed based on future studies in the North Texas and North Louisiana areas. Based on this analysis, the future 1% annual chance floodplain could be conservatively estimated using the existing 0.2% annual chance floodplain. Unfortunately, no such proxy was available for the future 0.2% annual chance floodplain. Using the same sensitivity analysis of available future conditions studies, it was determined that the mean difference between existing and future conditions was a 22-foot offset in the floodplain width. This was applied to the existing 0.2% annual chance floodplain to approximate the future 0.2% floodplain. Due to the coarse estimating required in this process, the RFPG would have preferred not to provide future conditions floodplain data, especially for the 0.2% annual floodplain. *Figure ES.3* shows the future flood risk area for Region 2. The resulting future conditions 1% and 0.2% flood risk areas shown in the future floodplain quilt resulted in generally larger mapped areas than the existing conditions floodplain quilt.

The potential future flood exposure and vulnerability analysis consisted of two scenarios:

1. Estimated the structure count of buildings, critical facilities, infrastructure systems, population, and agriculture potentially exposed to flooding by overlaying the future conditions floodplain quilt developed for Region 2.
2. Estimated additional exposure and vulnerability by identifying areas of existing and known flood hazard and future flood hazard areas where development might occur within the next 30 years if the current land development practices in Region 2 continue.

If measures are not taken to mitigate future flooding, the future floodplain will impact 57% more structures and 72% more people than existing conditions while only adding 12% more land area. The more significant effects are seen in the more developed cities, but some impacts will occur over the entire region.

Figure ES.3 Region 2 Future Conditions Floodplain Quilt



Identification and Selection of Recommended Floodplain Management and Flood Mitigation Actions

To address the identified flood risks, the RFPG's Technical Consultant Team developed potential actions to reduce flood risk. Those actions included FMEs, FMPs, and FMSs. FMEs consist of watershed studies or additional evaluations needed to determine the viability of a project. FMPs are structural or non-structural projects to mitigate flood risk. The FMS category is intended to capture other types of solutions, such as ordinances, flood early warning systems, and buyouts.

The RFPG established a Technical Subcommittee to review the lists of potentially feasible floodplain management or flood mitigation actions and recommend to the RFPG those actions that should be considered for inclusion in this Regional Flood Plan. The subcommittee met multiple times over several months and reviewed each potential action.

The screening process removed any potential FMEs, FMPs, and/or FMSs that did not support an RFPG goal. If a potential sponsor indicated that a potential action had already been completed or was no longer a priority, the potential action was removed from further consideration. The RFPG considered potential FMEs that were most likely to result in FMPs. FME and FMS evaluations required a "No Negative Impact" determination for the action to be considered for inclusion in this plan. Cost estimates were prepared for each potential action, as appropriate. Benefit-cost ratios were also developed for potential FMPs and FMSs. In situations where the TWDB-required information was needed for a potential project to remain in the plan, the potential FMP was moved to the list of FMEs.

The Technical Subcommittee recommended the lists of FMEs, FMPs, and FMSs to the RFPG to be ultimately adopted for inclusion in this plan:

- 47 FMEs
- 3 FMPs
- 38 FMSs

Table ES.2 summarizes the types and counts of potential and recommended FMEs. *Table ES.3* includes information on each of the recommended FMPs. *Table ES.4* summarizes the types and counts of potential and recommended FMSs.

Table ES.2 Summary of Recommended FMEs

FME Types	FME Descriptions	Number of FMEs Identified	Number of FMEs Recommended	Total Cost of Recommended FMEs
Preparedness	Gauges, Barriers, Debris/Vegetation Removal, and Channelization	10	10	$3,275,000
Project Planning	Previously Identified Drainage Projects and Flood Studies	23	13	$7,375,000

FME Types	FME Descriptions	Number of FMEs Identified	Number of FMEs Recommended	Total Cost of Recommended FMEs
Watershed Planning	FIS Studies, Watershed Studies	26	19	$26,550,000
Other	Property Acquisition and Buyout Programs	7	5	$1,250,000
	Total	**66**	**47**	**$38,450,000**

Table ES.3 Summary of Recommended FMPs

FMP ID	FMP Name	FMP Type	FMP Description	Cost
023000001	Ferguson Park Improvements	Infrastructure (channels, ditches, ponds, pipes, etc.)	Improvements to existing culverts and channelization	$11,983,000
023000002	Wagner Creek	Regional Channel Improvements	Channel/Overbank Clearing	$978,000
023000003	Stream WC-2	Infrastructure (channels, ditches, ponds, pipes, etc.)	Independence Circle & Lexington Place Bridge Improvements	$540,000
			Total	**$13,501,000**

Table ES.4 Summary of Recommended FMSs

FMS Types	FMS Descriptions	Number of FMSs Identified	Number of FMSs Recommended	Total Cost of Recommended FMSs
Education and Outreach	Turn Around, Don't Drown Campaigns; Flood Safety Education	5	3	$250,000
Flood Measurement and Warning	Flood Gauges, Early Alert Systems, Flood Warning Systems	4	3	$750,000
Property Acquisition and Structural Elevation	Infrastructure flood-proofing, Land acquisition to protect open space.	2	1	$100,000

FMS Types	FMS Descriptions	Number of FMSs Identified	Number of FMSs Recommended	Total Cost of Recommended FMSs
Regulatory and Guidance	NFIP Participation, Stormwater Management Criteria Development, Floodplain Management Staff Acquisition, and Training	57	31	$3,400,000
Preventive Maintenance Programs	Storm Drainage Clearing, Annual Maintenance Programs	11	0	N/A
	Total	**79**	**38**	**$4,500,000**

Ultimately, the RFPG agreed with the subcommittee's recommendations and approved the recommended actions at its April 2022 RFPG meetings.

Cost of the Recommended Plan

Following the selection of recommended actions to mitigate flood risk, the RFPG's Technical Consultant Team initiated an email survey to potential sponsors regarding the recommended actions for the entity. A one-page summary was developed for each recommended action and sent to the potential sponsor. The RFPG inquired whether the sponsor agreed with the information presented and confirmed the potential sponsor's continued interest in the action. For those actions that were of interest to the sponsors, the RFPG inquired how the entity might fund the action, such as with grants, loans, stormwater utility fees, general budget, or something else. If a potential sponsor did not respond, the RFPG assumed the entity was interested and would need a grant for 100% of the action's cost. Overall, the estimated cost to implement the recommended FMEs, FMPs, and FMSs in this plan is $56.5 million. Once all the FMEs are conducted and FMPs are developed, this number is expected to increase by more than a magnitude.

Public Participation and Outreach

In its inaugural Regional Flood Planning effort, the RFPG developed a website and an extensive public outreach plan. The website provides information on the planning effort, such as meeting notices, meeting materials, and draft chapters. Multiple data collection or surveys have been accessible through the website. In addition, Constant Contact was used to notify interested parties of upcoming meetings, surveys, and other RFPG-related activities.

Most of the RFPG meetings have been held in a hybrid fashion allowing the planning group members and the public to participate remotely. The physical meeting location has moved around Region 2 to encourage local, in-person participation.

The Draft Regional Flood Plan was presented at the September 1, 2022 RFPG meeting in Mount Pleasant, Texas. This meeting also served as the official public hearing. It provided entities and the public with the opportunity to submit oral and or written comments on the 2022 Draft Regional Flood Plan. Written comments were also accepted 30 days prior and 30 days following the public hearing. These comments were addressed and included as *Appendix 3* in the final Region 2 Lower Red-Sulphur-Cypress Regional Flood Plan submitted to the TWDB in January 2023.

Texas Administrative Code (TAC) Guiding Principles and Required Statements

Following Title 31 TAC §361.20, the draft and final Region 2 Lower Red-Sulphur-Cypress Regional Flood Plans conformed with the guidance principles established in Title 31 TAC §362.3. The RFPG performed a "No Negative Impact" assessment for each potentially feasible FMP and FMS. Those that had or appeared to have a potential negative impact were removed from further consideration and not included as recommended FMPs or FMSs. Chapter 10 includes a table of the 39 regional flood planning principles and where they are addressed in this plan.

The draft and final Region 2 Lower Red-Sulphur-Cypress Regional Flood Plans were developed following the TWDB's scope of work and Technical Guidance documents incorporating all of these principles. The requirements are discussed in Chapters 1 through 10, the appendices, and/or included in the TWDB-required tables or GIS schema.

Statements Regarding Texas Open Meetings Act (TOMA) and Public Information Act Requirements

The Region 2 Lower Red-Sulphur-Cypress Regional Flood Planning Group posted meeting notices and materials per the Texas Open Meetings Act. Meeting notices were posted on the RFPG website at https://texasfloodregion2.org/ and with the Secretary of State. Before the RFPG website development, the meetings were posted on the TWDB's website and with the Secretary of State.

The Region 2 Lower Red-Sulphur-Cypress Regional Flood Planning Group recognizes that it is subject to the Public Information Act and is required to fulfill requests for information that is not protected by another law. As such, the RFPG and the Technical Consultant Team encouraged entities to only provide information to the planning process that the entity deemed was publicly available information. As of December 2022, the RFPG nor the Technical Consultant Team had received a public request for information. The Technical Consultant Team received general comments and questions regarding the Regional Flood Planning process and meetings and responded to each request. *Appendix 3* includes a summary of the questions and comments received as of December 2022.

Chapter 1: Planning Area Description

Introduction: The Regional Flood Plan in Context

Overview of Establishing Legislation

In Texas, the billion-dollar disaster is becoming a regular occurrence. Between 2015 and 2017, flooding alone caused nearly $5 billion in damages to Texas communities. When considered in conjunction with the impact of Hurricane Harvey, the total cost in 2017 approached $200 billion in financial losses (NOAA, 2021) and nearly 100 deaths. As the State grappled with how to better manage flood risk and reduce loss of life and property from future disasters, the Texas Water Development Board (TWDB) led the first-ever flood assessment, which described Texas' flood risks, provided an overview of roles and responsibilities, and included an estimate of potential flood mitigation costs and a summary of entities views on the future of flood planning.

This assessment was prepared because:

- flood risks, impacts, and mitigation costs have never been assessed at a statewide level
- flood risks pose a serious threat to lives and livelihoods
- many of Texas' floodplains are unmapped, or the maps are outdated (Peter M. Lake, 2019)

The TWDB presented its findings to the 86th Texas legislative session in 2019. Later that year, the Legislature adopted changes to Texas Water Code §16.061, which established a regional and state flood planning process led by the TWDB. The legislation provided funding to improve the State's floodplain mapping efforts and develop regional plans to mitigate the impact of future flooding. Regional Flood Plans for each of the State's fifteen major river basins must be delivered to the TWDB by January 10, 2023. An updated version of the Regional Flood Plans will be due every five years thereafter. (TWDB Flood Planning Frequently Asked Questions, 2021)

Overview of the Planning Process

Given Texas's diverse geography, culture, and population, the planning effort is being carried out at a regional level in each of the State's major river basins. The Lower Red-Sulphur-Cypress Basin Regional Flood Planning Area (also known as Region 2) is one of 15 major river basins preparing a flood plan. When complete, the TWDB will compile these regional plans into a single statewide flood plan and present it to the Legislature in 2024. Regional Flood Plans are required to be based on the best available science, data, models, and flood risk mapping, and the funding provided by the State will allow the basin to procure technical assistance to ensure that is the case.

Who's Preparing the Plan?

The TWDB has appointed Regional Flood Planning Groups (RFPG) for each region and has provided them with the funds necessary to prepare their plans. The TWDB will administer the regional planning process through a contract with a planning group sponsor, who is chosen by the RFPG for their significant role within the river basin. The RFPG chose the Ark-Tex Council of Governments (ATCOG) as the group's sponsor, and in that role, they provide support for meetings and communications. Halff Associates, Inc. was selected as the technical consultant to oversee the preparation of each flood plan; as the Sponsor, ATCOG is also managing that contract.

The RFPG's responsibilities include directing the work of Halff Associates, soliciting and considering public input, identifying specific flood risks, and identifying and recommending flood management evaluations, strategies, and flood risks to reduce risk in their region. To ensure a diversity of perspectives is included, members represent a wide variety of stakeholders potentially affected by flooding, including:

- agriculture
- counties
- electric generation utilities
- environmental interests
- flood districts
- industry
- municipalities
- public
- river authorities
- small businesses
- water districts
- water utilities

When complete, the plans will focus both on reducing existing risk to life and property and on floodplain management to avoid increasing flood risk in the future by redirecting population growth away from flood-prone areas.

Data Sources

To ensure that flood plans are based upon consistent and reliable information in every basin, the TWDB compiled geographic information system (GIS) data resources in the TWDB Flood Planning Data Hub. GIS layers are provided for:

- critical infrastructure
- flood infrastructure
- flood risk
- hydrology
- jurisdiction boundaries
- parks
- population
- property
- terrain
- transportation

A dedicated GIS team from Halff Associates organized and analyzed this data for Region 2, identified additional data sources needed to meet the TWDB's objectives, and used the data to prepare the illustrative maps included in this report.

To supplement the data provided by the TWDB, Halff Associates also developed a Data Collection Tool (survey) for individuals with flood-related responsibilities. At least three recipients from each community received this detailed survey to increase response rates. Respondents provided contact information and flood-related responsibilities, verified flood information that had already been collected, responded to questions to support the development of the Regional Flood Plan, and verified and provided geospatial data through data uploads and web maps. An interactive web map allowed survey respondents to draw in both problem areas and proposed projects that were not included in other information about the region.

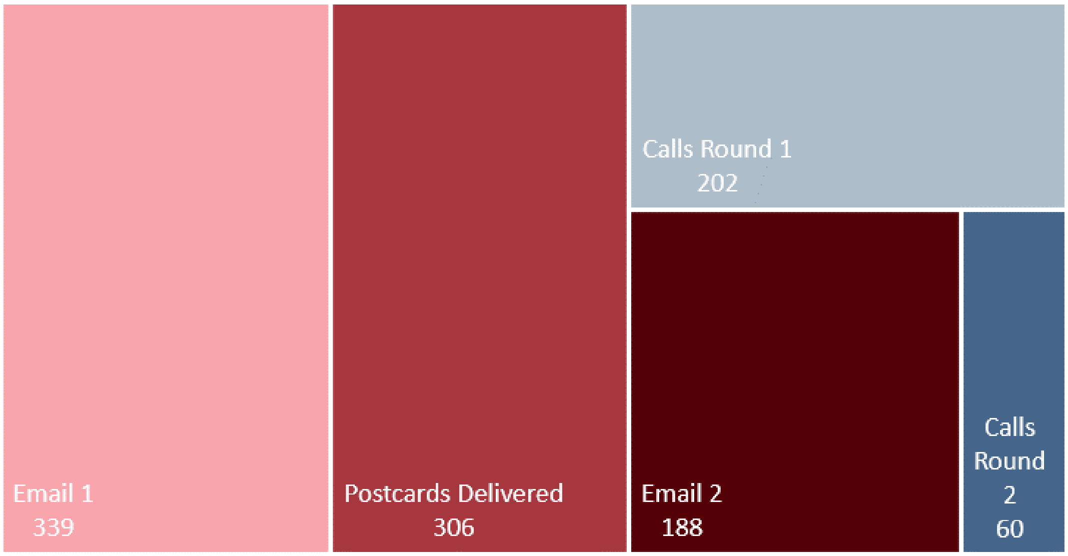
Public Outreach

Approximately 339 people representing the entities in *Figure 1.1* received the survey in July 2021, with 306 e-postcards including flood planning basics and the survey link. *Figure 1.1* illustrates all categories of stakeholders included in the data collection effort. *Figure 1.2* shows the various methods used to contact stakeholders and the number of stakeholders reached by each effort.

Figure 1.1 Outreach Efforts and Contacts Made

To ensure everyone had the opportunity to participate, the team followed up via email a week later. Calls went out to 202 recipients who had not yet responded, and the second round of calls was made to 60 recipients. This effort resulted in a response rate of approximately 23%, with an additional six entities saying they would not participate. This response rate is typical based on discussions with technical consultants in other regions. Survey results are included throughout Chapter 1 and the chapters to follow.

Figure 1.2 Outreach Efforts to Region 2 Entities



Funding Sources

To fund projects identified by these plans, the legislature created a new flood financial assistance fund and charged the TWDB with administering the fund. The Texas Infrastructure Resiliency Fund, as approved by Texas voters in November 2019, is being used to finance the preparation of these plans and will also be used to finance flood-related projects. Communities who identify future projects aimed at flood mitigation could be eligible for financial assistance in the form of grants from the TWDB if the projects are listed in this Regional Flood Plan.

1.1 Characterizing the Lower Red-Sulphur-Cypress Regional Flood Planning Area

1.1.A Social and Economic Character

Located in the Northeastern part of Texas, the Lower Red-Sulphur-Cypress Regional Flood Planning Area (Region 2) shares a border with Oklahoma, Arkansas, and Louisiana; thus, it covers a wide variety of landscapes and communities. Like the changing terrain and demographics, the flood risks faced by communities and landowners vary widely. To better understand the nature of that flood risk, this section discusses the population, type and location of the development, economic activity, and sectors at most significant risk of flood impacts.

Population and Future Growth

Current Conditions

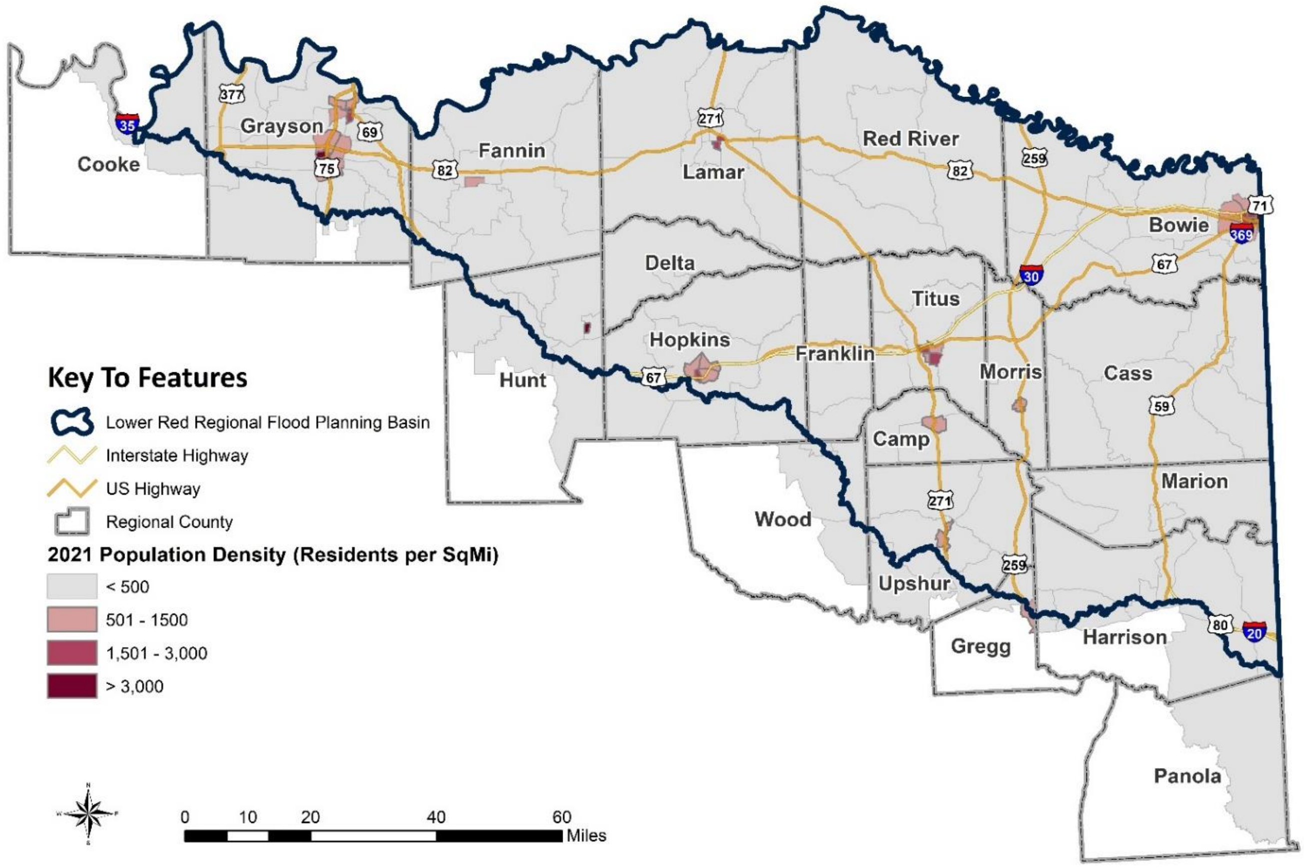
According to the TWDB's population projections, Region 2 is the state's least populated flood planning area. According to the 2019 Five-Year American Community Survey estimates, 531,100 residents, or less than 2% of Texas residents, currently reside in Region 2. Encompassing 9,161 square miles, the region is largely rural, with 57% of the people living in rural areas and only 44% living in cities and towns. Of those living in urban areas, most live in the major cities within Grayson, Lamar, and Bowie counties. With roughly 43,000 residents, Sherman is the largest city within Region 2. There are significant population centers in Texarkana, Denison, and Paris as well. These cities are located along Highway 82, which runs east-west through the region. To the west, the communities of Denison and Sherman are located on the southern border with Oklahoma and the Red River. Other population centers are generally along I-30. A few larger cities, such as Longview and Marshall, touch the southern region boundary along the I-20 corridor, mainly within the Sabine River Basin (Region 4).

Table 1.1 Cities with Population Greater than 15,000 in 2020

Community	County	Population 2020
Texarkana	Bowie	38,007
Mount Pleasant	Titus	17,512
Paris	Lamar	27,230
Longview*	Gregg	88,270
Denison	Grayson	27,340
Sherman	Grayson	43,522
Sulphur Springs	Hopkins	15,849
Marshall*	Harrison	24,761

**Community is within multiple basins.* (Texas Water Development Board, https://www.twdb.texas.gov/flood/planning/regions/2/index.asp)

Figure 1.3 Region 2 Population by Census Tract



(Texas Water Development Board)

Projected Growth within the Region

Based on population projections by Hydraulic Unit Code (HUC)-8 and Water User Group, the growth patterns in Region 2 are projected to continue. A "HUC" is a hydrological unit code used to identify and organize hydrologic areas across the country. The type of hydrologic area is specified by the number following "HUC," with HUC-8 indicating a subbasin (USGS, n.d.) and larger numbers indicating finer (i.e., smaller) basin sizes. By 2050, the overall population is projected to increase by 24% for the entire region. The number of communities with populations over 15,000 is projected to increase slightly from six to seven. *Table 1.2* showcases the seven major cities with population details for each community. Most of the expected growth is in the western portion of the basin near the Dallas-Fort Worth Metroplex and the existing population centers. A significant increase in Fannin County is also expected, likely due to the construction of Bois D'Arc Lake and Lake Ralph Hall, both of which are expected to contribute to the local economies and spur development.

Table 1.2 Cities with Population Greater than 15,000 in 2050

Community	County	Population 2050
Texarkana	Bowie	43,229
Mount Pleasant	Titus	24,689
Paris	Lamar	29,770
Longview*	Gregg	116,979
Bonham	Fannin	30,000
Denison	Grayson	33,805
Sherman	Grayson	50,692
Sulphur Springs	Hopkins	18,213
Marshall*	Harrison	31,148

**Community is within multiple basins.* (Texas Water Development Board Water User Group Population Projections (2020-2070))

There are various cities with a high population growth rate for the next three decades; however, most of the top ten fastest-growing communities noted in *Table 1.3* are located near higher populated suburbs. These include Trenton, Bonham, and Ladonia in Fannin County; Pottsboro, Howe, and Bells in Grayson County; Wolfe City and Commerce in Hunt County; Nash in Bowie County and Cumby in Hopkins County. Cities in Fannin and Grayson counties, including Trenton with a projected growth rate of 471%, are projected to have the greatest growth potential in the region from 2020-2050.

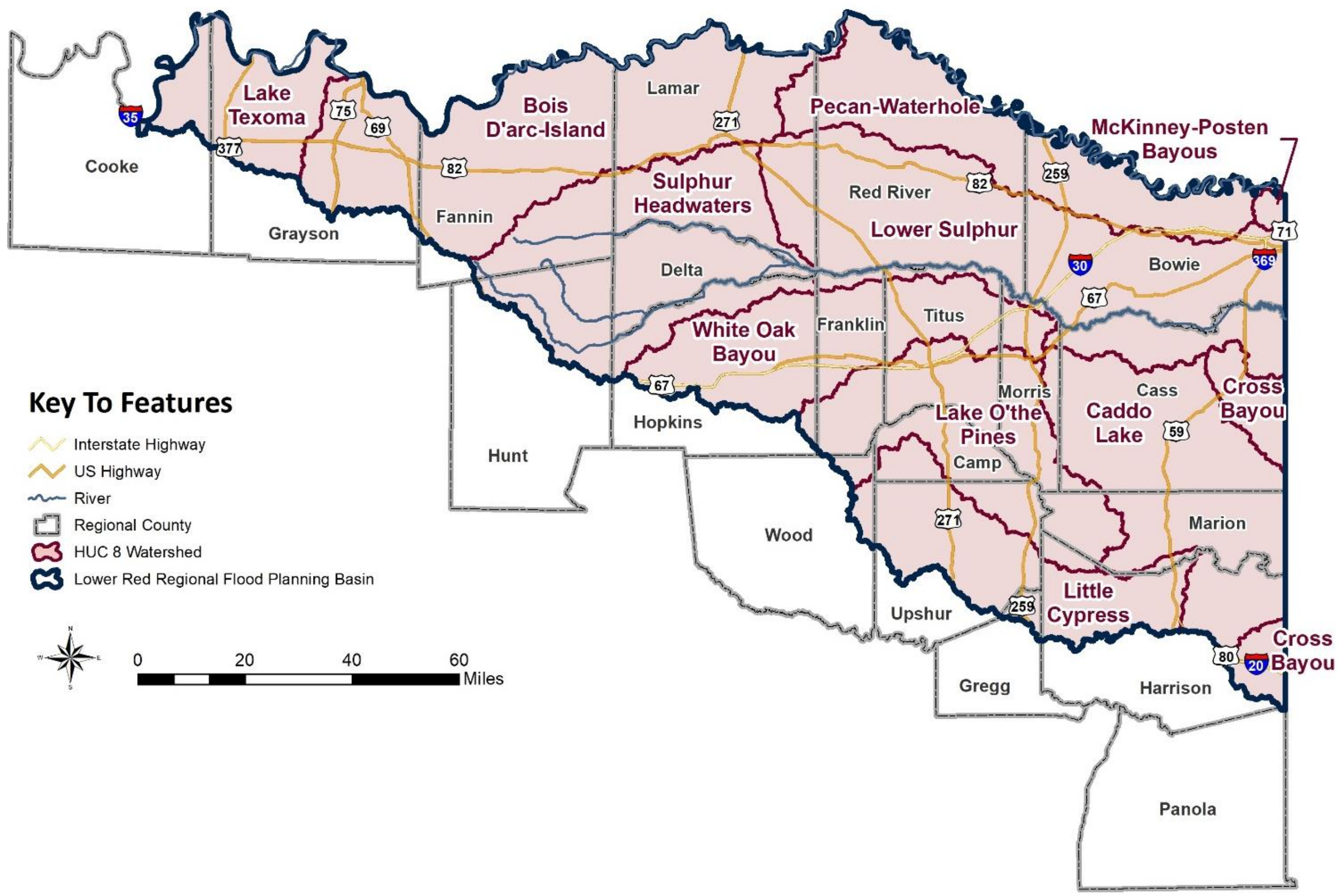
Table 1.3 Projected Population Growth in Communities in Region 2

Community	County	Population 2020	Population 2050	Growth Rate
Trenton	Fannin/Grayson	736	4,203	471%
Bonham	Fannin	12,603	30,000	138%
Pottsboro	Grayson	3,056	6,331	107%
Wolfe City	Hunt	1,810	3,669	103%
Ladonia	Fannin	1,600	2,500	56%
Commerce	Hunt	8,883	13,502	52%
Nash	Bowie	4,070	6,111	50%
Howe	Grayson	2,868	4,275	49%
Bells	Grayson	1,713	2,536	48%
Cumby	Hopkins	1,044	1,496	43%

(Texas Water Development Board Water User Group Population Projections (2020-2070))

Figure 1.4 shows the HUC-8 boundaries for Region 2. As illustrated further in *Figure 1.5,* the prior analysis remains true when looking at population density in the region's HUC-8 areas. In 2050 the highest population density will be shared between Grayson, Fannin, and Lamar, with the second highest in Bowie County.

Figure 1.4 Region 2 Hydrologic Unit Code (HUC-8) Map



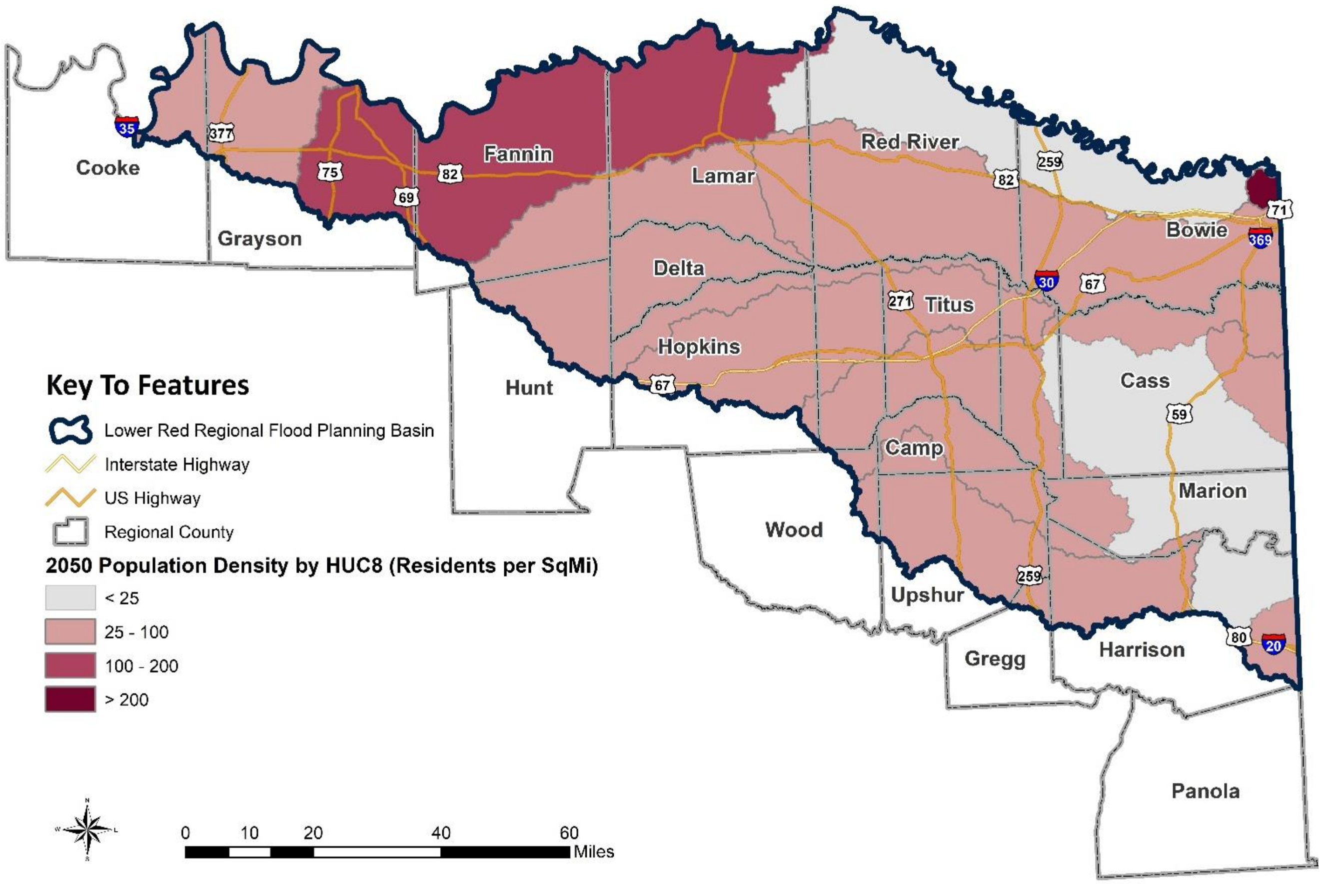
Economic Activity

Commercial Activity

To better understand the economic effects of floods on the region, it is essential to first identify the most prominent industries within the region. When analyzing the largest industry, the values considered included:

- number of establishments
- number of employees
- annual payroll
- total revenue

Figure 1.5 2050 Population Density by HUC-8



(Texas Water Development Board Water User Group Population Projections (2020-2070))

Table 1.4 shows this data from the Economic Census per the North American Industry Classification System (NAICS). While the region has a reasonably diverse economic base, this data shows that manufacturing is the dominant industry at over $22 billion in revenue, with retail and wholesale trade being significant contributors as well. Much of this trade is likely in timber and agricultural products, as discussed below, but is not detailed in this Economic Census data. Some data was notably missing from the Economic Census, particularly Finance and Insurance, Information, and Utilities. Sometimes this data is excluded because disclosure would compromise trade secrets for individual operations. In other case s, the entities simply may not have provided any information. In particular, several known utilities operate coal, natural gas, and solar power plants in the area. In addition, coal mining has been significant in some areas. The power plant flood risks are captured later in the discussion on critical facilities.

Table 1.4 Economic Activity by NAICS Code from the 2017 Census

Category	Number of Firms (FIRM)	Number of Establishments (ESTAB)	Sales, Value of Shipments, or Revenue (RCPTOT)	Number of Employees (EMP)	Total Sum of Annual payroll (PAYANN)
Accommodation and food services	1548	1707	$1,591,556,000	30819	$450,278,000
Administrative and support and waste management and remediation services	647	677	$935,373,000	11284	$331,232,000
Arts, entertainment, and recreation	170	173	$125,631,000	1458	$34,675,000
Educational services	73	73	$25,095,000	519	$8,799,000
Finance and insurance	1031	1338	-	9763	$486,431,000
Health care and social assistance	1885	2159	$5,125,894,000	52520	$1,992,697,000
Information	208	255	-	3079	$135,003,000
Manufacturing	860	878	$22,087,409,000	52975	$2,969,337,000
Other services (except public administration)	1122	1159	$786,561,000	6765	$218,510,000
Professional, scientific, and technical services	1415	1455	$1,440,684,000	10015	$462,922,000
Real estate and rental and leasing	741	810	$706,463,000	3271	$131,633,000
Retail trade	2653	3128	$12,968,225,000	41671	$1,128,641,000

Category	Number of Firms (FIRM)	Number of Establishments (ESTAB)	Sales, Value of Shipments, or Revenue (RCPTOT)	Number of Employees (EMP)	Total Sum of Annual payroll (PAYANN)
Transportation and warehousing	543	581	$1,776,560,000	8287	$404,023,000
Utilities	67	70	-	832	$102,952,000
Wholesale trade	729	765	$6,318,952,000	9090	$502,240,000
Total	**13692**	**15228**	**$53,888,403,000**	**242348**	**$9,359,373,000**

(United States Economic Census Table: EC1700Basic, 2017)

Agricultural and Ranching Activity

Agriculture has always been a major economic driver in the region. Although traditional row crop farming is less apparent in the area today, agriculture is still a significant contributor. *Table 1.5* shows key statistics from the 2017 Agricultural Census. There are nearly 200,000 more cattle in the region than people, including both beef and dairy cattle. This pales compared to the over 28 million poultry raised in the area, primarily as broilers. In this region, there is one broiler chicken for each person in Texas and roughly one layer hen for every two people. These industrial agricultural operations (poultry and dairy) contribute over $715 million to the region’s economy. The other livestock operation, including beef cattle, contribute over $300 million. Crops of various kinds contribute over $180 million to the region’s economy.

Table 1.5 2017 United States Department of Agriculture (USDA) Census of Ag Summary for Region 2

	Region 2 Total	Region 2 Percentage	Texas Total
Number of Farms	18,449	7%	$248,416
Land in Farms (Acres)	$3,592,698	3%	127,036,184
Market Value of Goods ($)	$1,215,378,250	5%	$24,924,041,000
% Crops	15%		
% Livestock, poultry, and products	85%		
Crops	$182,538,000	3%	$6,894,307,000
Grains, oilseeds, dry beans, dry peas	$75,609,900	4%	$2,152,014,000
Cotton and cottonseed	$5,141,500	0%	$2,648,181,000
Vegetables, melons, potatoes, sweet potatoes	$1,809,544	1%	$352,393,000
Fruits, tree nuts, berries	$6,519,500	3%	$213,286,000
Nursery, greenhouse, floriculture, sod	$20,919,050	2%	$838,675,000
Cultivated Christmas trees, short rotation woody crops	$35,000	2%	$1,576,000
Other crops and hay	$50,076,850	7%	$688,183,000
Livestock	$1,032,840,100	6%	$18,029,734,000
Poultry and eggs	$604,909,900	20%	$2,991,846,000
Cattle and calves	$287,303,500	2%	$12,291,224,000
Milk from cows	$110,262,250	5%	$2,159,171,000
Hogs and pigs	$613,900	0%	$163,381,000
Sheep	$1,547,600	1%	$105,562,000
Horse	$8,548,600	7%	$125,292,000
Aquaculture	-	0%	$69,727,000
Other	$2,364,951	2%	$123,986,000
Livestock Inventory			
Broilers	28,093,878	24%	115,297,239
Cattle and Calves	707,703	6%	12,573,876
Goats	19,782	2%	837,889
Hogs and pigs	5,320	1%	1,026,418
Horses and ponies	26,547	8%	330,671
Layers	268,614	1%	21,006,254
Pullets	399,587	7%	5,622,451
Sheep and lambs	10,751	1%	729,438
Turkeys	996	0%	1,317,891

(United States Department of Agriculture, https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Texas/, 2021)

Due to a large percentage of the planning area being outside of urban areas and devoted to farming, forestry, and ranching, it is important to assess the impact of flooding on working lands and developed areas. Not only can floods interrupt the agricultural cycle, but they can also reduce crop size, lower yields, and even kill crops. When floods occur as crops mature in the fields, they may destroy a whole season's work and investment. Floods at harvest time can make it impossible for farmers to harvest mature crops and get them to market. Livestock may drown in flash floods and forestry operations can lose trees to fast-moving waters and erosion, wiping out years of growth in an instant. Even if the animals are safe, damage may occur to barns and other structures, and cleanup of muck and debris can affect their feeding grounds. These potential flood damages will affect the local landowners and the region's economy. (Schnell & Provin, 2021)

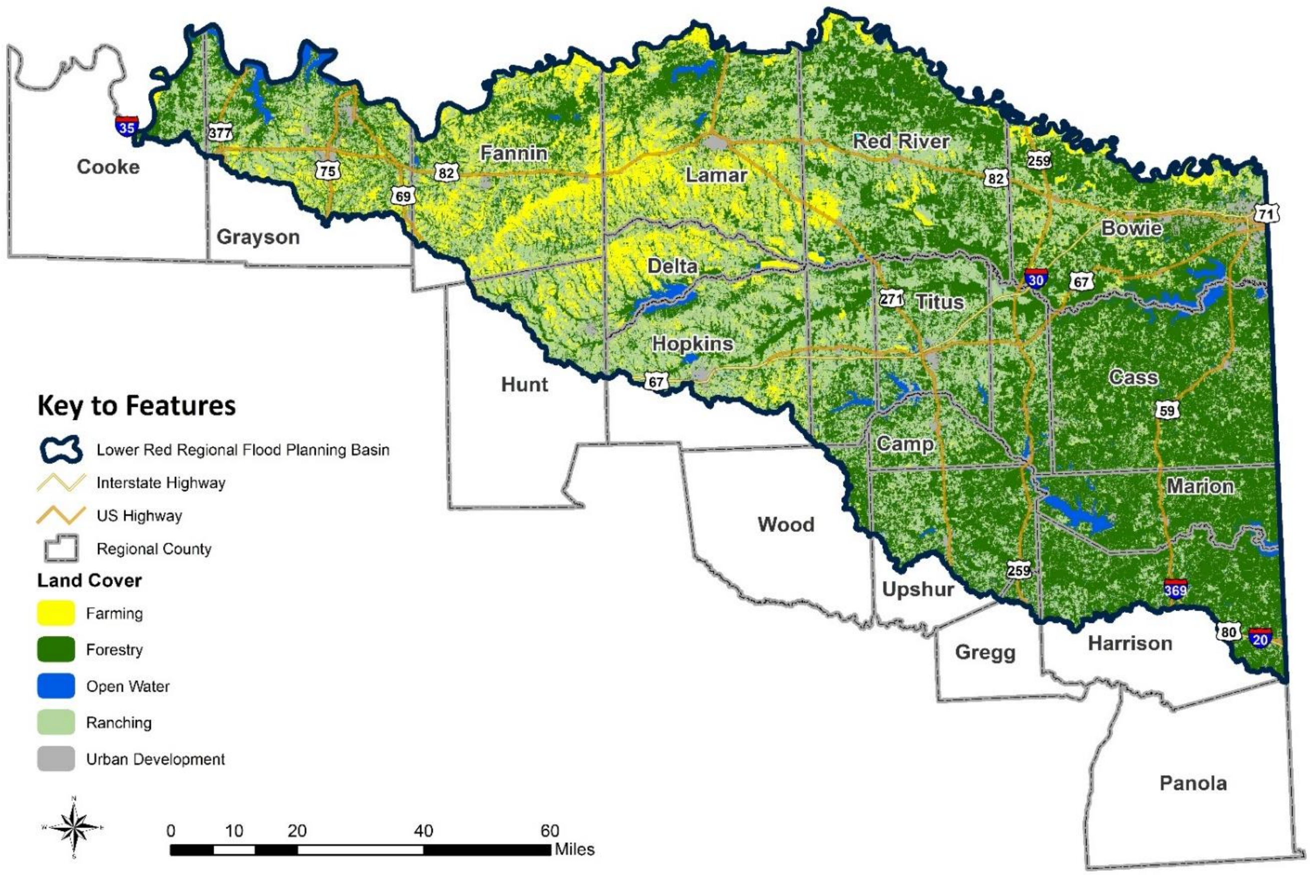
To characterize the economic activity and character of Texas' rural spaces, this report employs the term "working lands," used by the Texas A&M Natural Resources Institute to describe the rural economic activity. Working lands are privately-owned farms or cropland, ranches, and forests and associated uses that make up the majority of economic activity in Texas' rural areas.

The distribution of land use across Region 2 is illustrated in *Figure 1.6,* which uses data from the United States Geological Survey (USGS) to help visualize how land is used across the basin. The area dedicated to each use is identified as follows:

- **farming:** 720,205 acres
- **forestry:** 2,746,128 acres
- **open water:** 178,908 acres
- **ranching:** 1,863,599 acres
- **urban development:** 350,097 acres

Across Texas, the average acreage of farm and ranch operations is decreasing, and a smaller parcel size may reduce the profitability of these enterprises. Combined with flooding losses, this could increase the likelihood of economic failure of a farming, ranching, or forestry operation.

Figure 1.6 Texas Working Lands by Land Cover



(USGS National Land Cover Database, 2016)

Timber

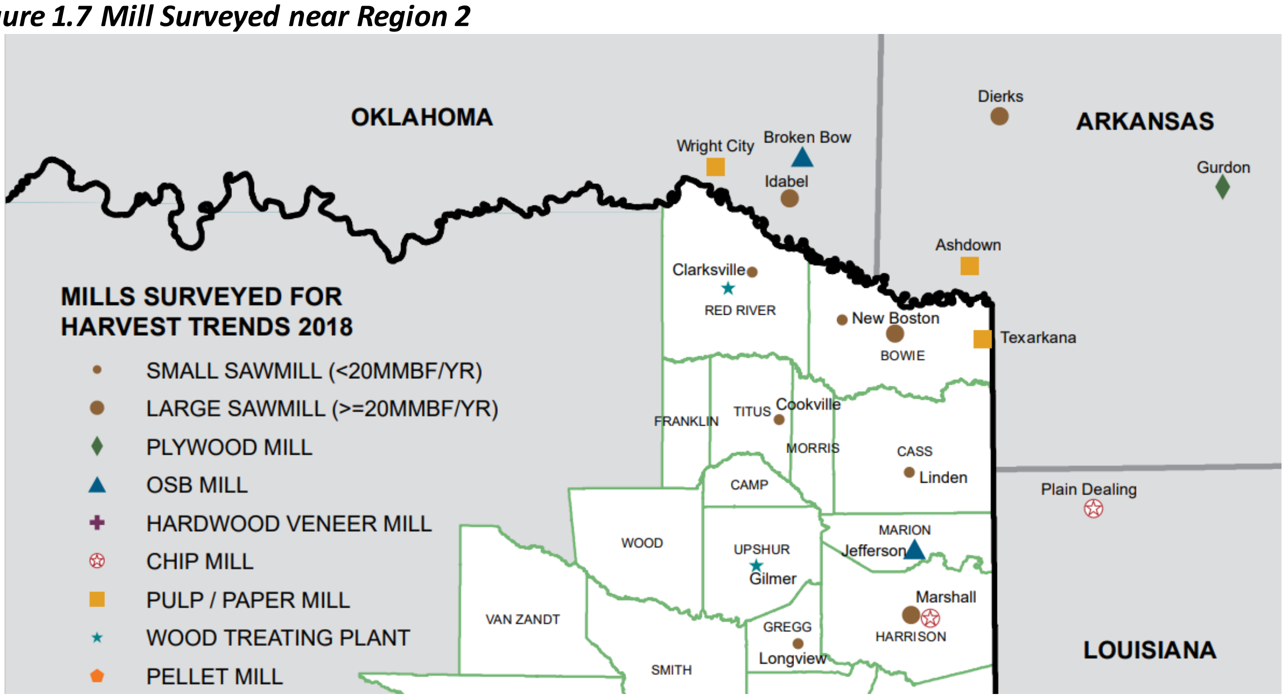
Forestry and timber is a significant driver in the eastern portion of the region. *Table 1.6* shows the 2018 timber harvest data for the region. This report only includes counties from Red River and Franklin east, suggesting that the western half does not have significant timber harvests. This is consistent with the land cover findings discussed in the previous section. Stumpage price is that paid to the landowner for the trees “standing on the stump.” The delivered price includes cutting, skidding, and transporting the logs to the mill. The economic impact of the delivered timber is nearly $100 million, with about 40% occurring in Cass County alone. These numbers do not include the manufacturing and sale of timber products produced in the region, including lumber, treated lumber, paper, and OSB (*Figure 1.7*).

Table 1.6 2018 Value of Harvest Trends for Region 2 Counties

County	Stumpage	Delivered
Bowie	$ 5,273,000	$ 12,282,000
Camp	$ 790,000	$ 1,788,000
Cass	$ 16,355,000	$ 39,417,000
Franklin	$ 133,000	$ 346,000
Gregg	$ 54,300	$ 107,250
Harrison	$ 6,326,100	$ 14,142,700
Marion	$ 3,816,000	$ 10,060,000
Morris	$ 762,000	$ 1,657,000
Red River	$ 4,327,000	$ 11,143,000
Titus	$ 245,000	$ 463,000
Upshur	$ 2,441,250	$ 5,679,000
Wood	$ 103,400	$ 298,850
Total	**$ 40,626,050**	**$ 97,383,800**

(Harvest Trends 2018, Texas A&M Forest Service, 2020)

Figure 1.7 Mill Surveyed near Region 2



(Harvest Trends 2018, Texas A&M Forest Service, 2020)

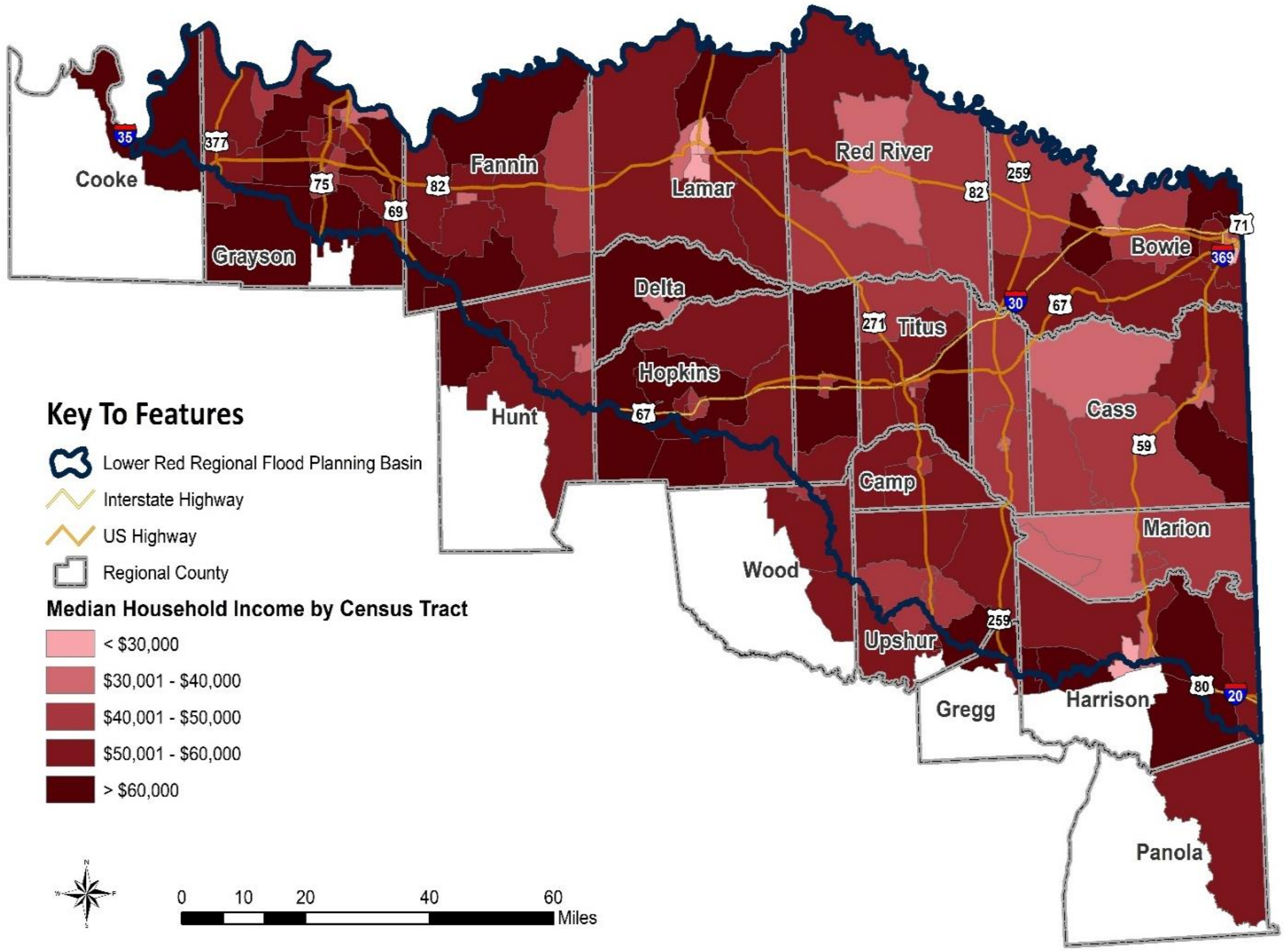
Economic Status of Population

Median Household Incomes can be affected by many factors, including education levels, employment opportunities, and location. It is important to note that within any given area, residents are outliers in both directions of the data. The Median Household Income (MHI) measure divides the data into two equal halves and provides a good comparison of income levels across the basin. According to the 2019 American Community Survey United States Census, Region 2 has a median household income of $52,120, which is below the statewide median income of $61,874 for Texas. As shown in *Figure 1.8*, the majority of areas with the lowest median income are primarily within urban areas for every county. The census tracts with the lowest median household income area (less than $30,000) fall within Bowie, Harrison, and Lamar counties. The census tracts with a median household income higher than the state's value are scattered through every county except Red River, Morris, Camp, Marion, Wood, and Panola. However, the counties with the lowest median household income are Red River with $39,142 and Marion with $37,662.

Income Levels by Area

Table 1.7 and *Figure 1.8* show that the western portion of Region 2 has the highest household income levels. Each county in the west subregion has at least one census tract with a median household income above $60,000 and only seven tracts total below $40,000. These higher incomes are likely due to the proximity to the Dallas-Fort Worth Metroplex. The rest of the region has a diverse mix of incomes, with the average income generally dropping to the eastern end of the region.

Figure 1.8 Yearly Median Household Income by Census Tract



(Harvest Trends 2018, Texas A&M Forest Service, 2020)

Table 1.7 Median Household Income per County

County	Median Household Income	Poverty Rate
Cooke County	$60,202	12.8%
Harrison County	$58,817	17.4%
Hunt County	$54,959	16.1%
Grayson County	$54,815	13.1%
Fannin County	$54,648	12.0%
Gregg County	$53,793	18.0%
Franklin County	$53,783	9.3%
Wood County	$53,394	14.6%
Panola County	$52,982	14.7%
Upshur County	$52,162	16.0%
Hopkins County	$52,078	14.0%
Delta County	$51,038	20.0%
Titus County	$50,196	17.7%
Bowie County	$50,164	16.6%
Camp County	$48,207	18.5%
Lamar County	$45,117	17.4%
Cass County	$44,848	18.5%
Morris County	$41,359	17.8%
Red River County	$39,142	19.7%
Marion County	$37,662	19.2%

(ESRI Business Analyst Census Tract Data, 2021)

Social Vulnerability Analysis

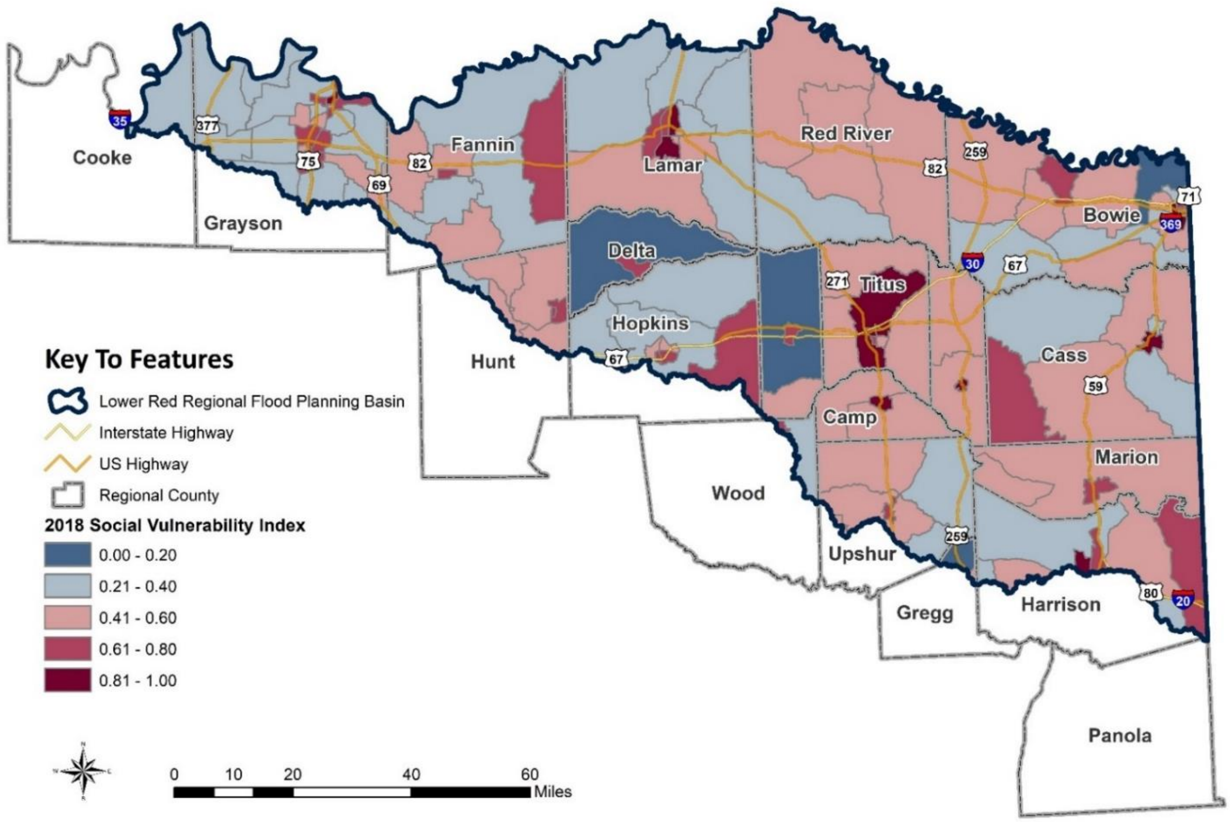
As the state seeks to increase the resiliency of the communities in the region, the geographic location and the vulnerability of people and property are important factors to incorporate. The Social Vulnerability Index (SVI) indicates the relative social vulnerability of every census tract in the United

States and ranks each tract based on percentile values between zero and one, with higher values indicating greater vulnerability. The index considers various factors, including poverty, unemployment, income, education, age, disability, single-parent households, race/minority status, limited English-speaking ability, housing type, crowding, and vehicle ownership. It is important to identify areas with a high social vulnerability within each planning area because these areas have the potential to experience greater difficulty in recovery and to allow focusing of aid following catastrophic events. The Centers for Disease Control and Prevention (CDC) SVI was used for this analysis, as required by the TWDB.

Figure 1.9 shows each county's census tracts with their social vulnerability values. The communities that would have the greatest difficulty recovering from a natural disaster (i.e., SVI of 0.81-1.00) primarily fall within Titus and Lamar counties, with small, isolated areas in Grayson, Camp, Morris, Harrison, Cass, and Bowie counties. As shown in *Figure 1.9*, the SVI value can vary considerably even within each county, where you can have a census tract with the highest and lowest SVI value right next to each other. SVI appears to focus more on the citizen’s ability to recover rather than the community (city or county) itself. This is most evident in Delta County, which has a very low SVI but has such a small population and tax base that it has little institutional ability to plan, mitigate, or recover from flooding.

Overall, having multiple factors considered by the SVI calculations helps indicate the long-term impact of a disaster on a specific population, but it should not be used alone in making planning and financing decisions. RFPG members familiar with some of the tracts identified with particularly low or high SVIs questioned the relationship between the SVI and the difficulty of flood recovery efforts. In Chapters 2 and 3, there are more detailed discussions about the location of high social vulnerability populations, the location of flood infrastructure, and how future flood mitigation projects have the potential to reduce their vulnerability to losses.

Figure 1.9 Social Vulnerability Index by Census Tract



(SVI Index, CDC, 2020)

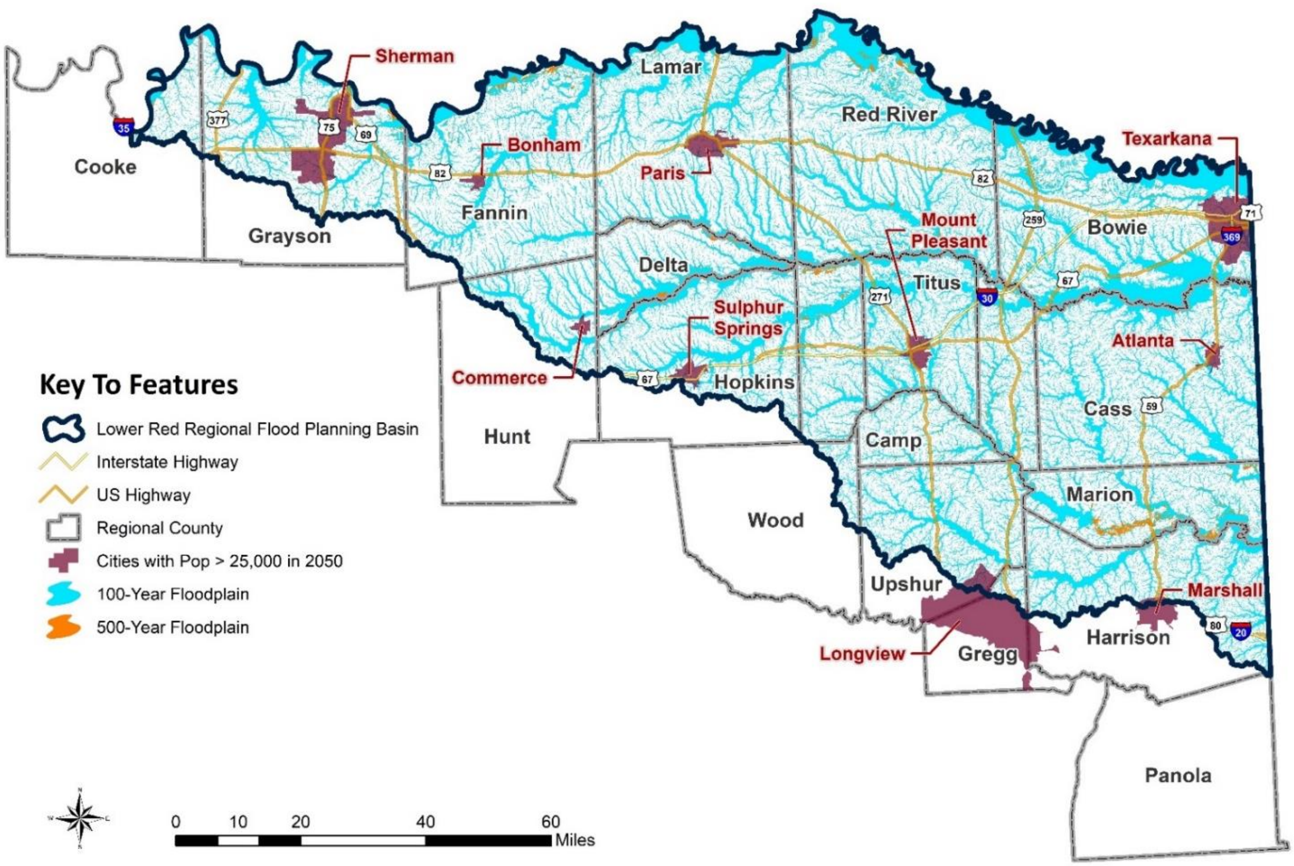
1.1.B Flood-Prone Areas and Flood Risks to Life and Property

Since the State of Texas seeks to better manage flood risk, it is important to establish the area's current exposure to flood hazards and the vulnerability of the communities within Region 2. This section will be a critical step in the process of reducing the vulnerability of Region 2 to future flooding. Today, a patchwork quilt of plans, regulations, and infrastructure provides Texans with limited protection from flooding. This planning primarily takes place at a local level, with an inconsistent set of standards that makes it very difficult to quantify risk across the region. Fortunately, 70% of the communities in Region 2 participate in the National Flood Insurance Program (NFIP), which helps the economic recovery process in the event of a major flood; unfortunately, many communities in the region use outdated maps that may not identify flood risks associated with the changing topography and environment. Due to the absence of a reliable flood map that can be applied across the region, the best available data will be stitched together into a floodplain quilt, as further discussed in Chapter 2. Two flood frequencies were developed as part of the floodplain quilt. First is the 1% annual chance event (1% ACE), which is often referred to as the 100-year floodplain. This is the area that has a 1% chance in any year to be flooded. The second is the 0.2% ACE, commonly referred to as the 500-year floodplain. It has a 0.2% chance of flooding in any year.

Identification of Flood-Prone Areas

To visualize how future residents may be affected by flood risk, a map superimposing the flood plain quilt and the Water User Group population projections for 2050 was created in *Figure 1.10*. The 1% ACE floodplain covers approximately 31% of the region, and 32% is covered by the 0.2% ACE floodplain (including the 1% ACE). This indicates that a significant portion of the region is impacted by the floodplain. It is clear that substantial growth will occur in and near flood-prone areas without changing current patterns. Chapter 2 provides additional detail on flood-prone areas.

Figure 1.10 Floodplain Quilt with WUG 2050 Projection Map

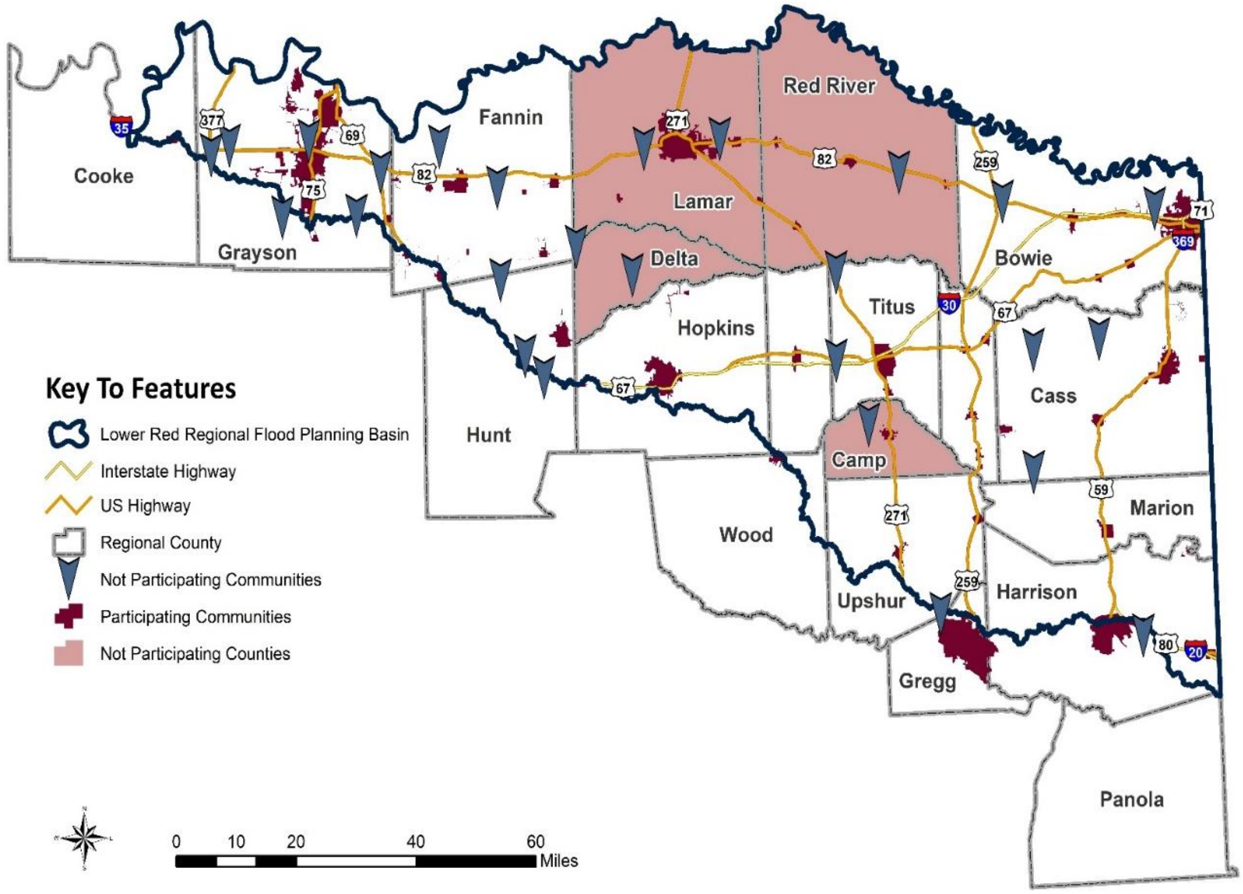


(TWDB Floodplain Quilt Data)

Rates of NFIP participation and Related Flood Planning Activities

Out of 86 communities and 20 counties, 70% of the communities and 80% of the counties within the region participate in the NFIP. As shown in *Figure 1.11*, the non-participating communities are spread throughout the region. With some of these non-participating communities and counties having both a high likelihood of flooding and a high SVI, the residents of these areas will have a difficult time recovering from flood damage. Worse yet, a lack of NFIP participation typically means a lack of floodplain regulations and enforcement. This results in more vulnerable people building in areas more prone to flooding.

Figure 1.11 NFIP Participant Communities and Counties



(TWDB Data Hub)

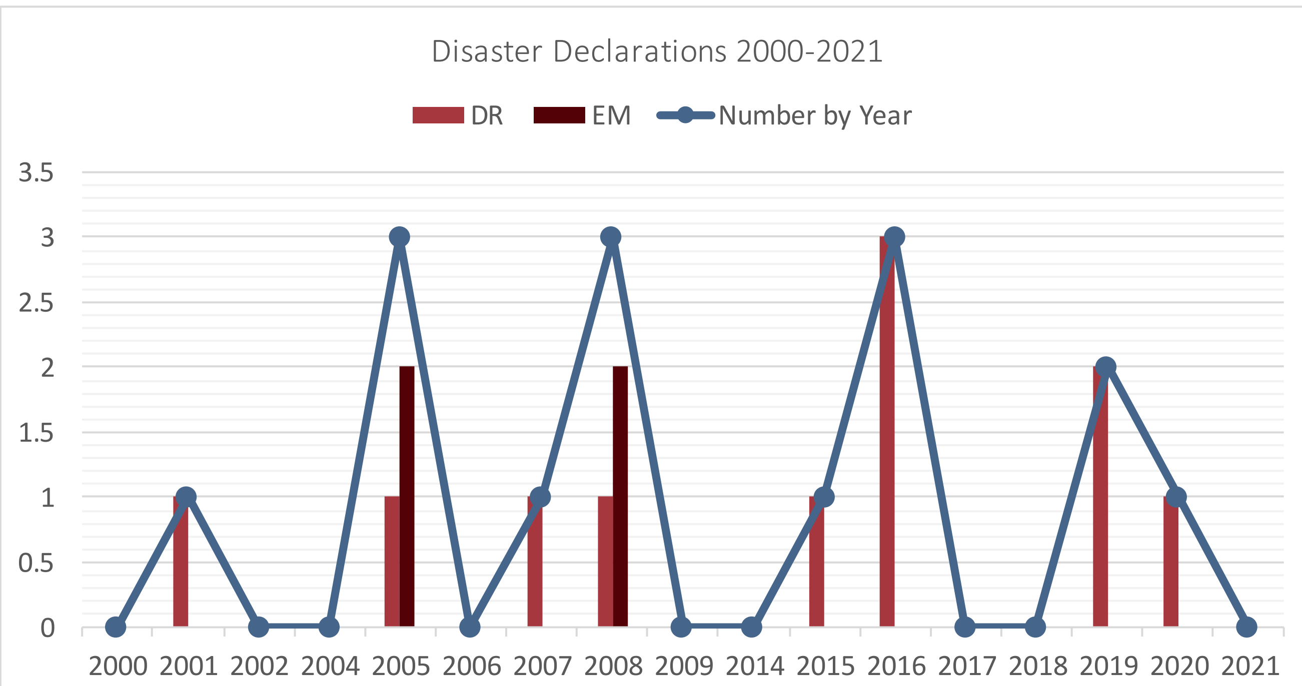
1.1.C Key Historical Flood Events

By understanding past flood events, including frequency, location, the extent of damage caused, and how the community responded, the region can better prepare for future events through better risk prevention, mitigation measures, and recovery procedures. This section summarizes some documented recent flood-related events. The following chapters will present additional events, details, and analyses.

Since 2000, there have been four Emergency Declarations (EMs) and 11 Disaster Declarations (DR) within Region 2. A Presidential Major Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs and designed to help disaster victims, businesses, and public entities. An Emergency Declaration is more limited in scope and without the long-term federal recovery programs of a Major Disaster Declaration. Generally, federal assistance and funding are provided to meet a specific emergency need or help prevent a major disaster. Public Assistance is Federal Emergency Management Agency's (FEMA's) largest grant program providing funds to assist communities responding to and recovering from major disasters or emergencies declared by the President. The program provides funding for emergency assistance to save lives and protect property and assists with financing for permanently restoring community infrastructure affected by a federally declared incident.

Supplementally, Public Assistance can be categorized for emergency work, such as Public Assistance-A for debris removal and Public Assistance-B for emergency protective measures. Individual Assistance programs are made available under emergency declarations. They are limited to supplemental emergency assistance to the affected state, territory, or tribal government to provide immediate and short-term assistance essential to save lives, protect public property, health, and safety, or lessen or avert the threat of a catastrophe. All Individual Assistance programs may be authorized once the President has declared a major disaster. The approval of Individual Assistance under a major disaster declaration may also activate assistance programs provided by other federal agencies based on specific disaster needs.

Figure 1.12 Disaster Declarations 2000-2021



(FEMA Disaster Declarations)

Error! Reference source not found. charts the frequency of these declarations across the region for the l ast 21 years. Some of the most significant events in that period are listed below. To search for more information on Emergency Declarations or Disaster Declarations, FEMA provides a search tool found here: https://www.fema.gov/disaster/declarations

EM-3261-TX, September 2005 (Hurricane Rita)

Hurricane Rita was the most intense tropical cyclone on record in the Gulf of Mexico. It moved westward through the Florida Straits, where it entered an environment of abnormally warm waters. Moving west-northwest, it rapidly intensified, achieving Category Five status on September 21. However, it weakened to a Category Three hurricane before landfall in Johnson's Bayou, Louisiana, between Sabine Pass, Texas, and Holly Beach, Louisiana. The timing of Hurricane Rita following on the heels of Hurricane Katrina compounded the disaster as Texas was still sheltering evacuees across Region 2 when Rita made landfall.

DR-1791-TX, September 2008 (Hurricane Ike)

On September 12, 2008, Governor Rick Perry requested a major disaster declaration due to Hurricane Ike. This event was of a severity and magnitude that the need for supplemental Federal assistance was determined to be necessary. For 34 counties, two of which are in Region 2, this declaration made Individual Assistance funding available to affected individuals and households. This declaration also made the Public Assistance program available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis. A total of 50 counties qualified for Public Assistance, seven of which are within the region.

DR-4223-TX, May 2015

On May 29, 2015, Governor Greg Abbott requested a major disaster declaration due to severe storms, tornadoes, straight-line winds, and flooding, which began on May 4, 2015, and continued through June 22, 2015. The Governor requested a declaration for Individual Assistance for 22 counties, Public Assistance for 110 counties, including 10 Region 2 counties, and Hazard Mitigation for the entire State of Texas. Preliminary Damage Assessments (PDAs) were conducted in the requested counties to estimate damages immediately after the event and determine the need for additional assistance.

Past Casualties and Property Damage

The effects of a major flood event can be seen in many ways, and often, losses are incurred to life and property. The federal government tracks the occurrence of natural disasters in the Storm Events Database at the National Oceanic and Atmosphere Administration (NOAA) National Centers for Environmental Information (NCEI), which relies on reporting from the affected jurisdictions. For that reason, the data may not reflect the entire impact of the storm, but it is the most consistent source available for the whole region. *Table 1.8* shows deaths and damages in Region 2 since 2005; there have been nine losses of life and seven injuries reported as direct results of storm events and flooding. Within the same period, there were multiple reported losses to property. Property damage losses throughout the region amounted to $66,239,500, with the largest losses in the western part.

Table 1.8 Total Casualties and Property Damages

County	Total Events	Deaths Direct	Injuries Direct	Property Damage Value
Bowie County	56	0	0	$1,734,000
Camp County	11	0	0	$30,000
Cass County	23	0	0	$780,000
Cooke County	55	4	4	$32,031,000
Delta County	11	0	0	$50,000
Fannin County	44	0	0	$473,500
Franklin County	17	0	0	$1,500,000 *
Grayson County	63	3	1	$23,704,000
Gregg County	68	0	0	$2,194,000
Harrison County	57	0	0	$441,000
Hopkins County	39	0	2	$589,000
Hunt County	54	0	0	$1,356,000
Lamar County	27	0	0	$212,000
Marion County	4	0	0	$350,000
Morris County	10	0	0	$8,000
Panola County	17	0	0	$0
Red River County	41	0	0	$15,000
Titus County	15	0	0	$130,000
Upshur County	26	1	0	$365,000
Wood County	55	1	0	$277,000
Total	**693**	**9**	**7**	**$66,239,500**

(Flood Events by County via NOAA NCEI, 2005 to 2020)

* Carollo Engineers, 2018

Past Agricultural Losses

Statistics on agricultural flood losses are not readily available from a reliable source. For this report, historical data was obtained from the USDA Risk Management Agency's Cause of Loss Historical Files (https://www.rma.usda.gov/SummaryOfBusiness/CauseOfLoss). This document shows the agricultural insurance policy losses by county from 1989 to 2022. While flooding is one cause of loss, other causes may be claimed related to flooding. For this report, flood, excess moisture/precipitation/rain, or poor drainage were assumed to be caused by flooding. Other causes, such as hail and wind, may also be associated with flooding but were omitted since they do not mention inundation. The Region 2 agricultural insurance claims are shown in *Table 1.9*. These claims do not reflect the true damage caused by flooding because each policy had a deductible that varies widely from 20 - 80% of the crop. This means the actual damages exceed the $173 million claims made. It is apparent that flood damages in the region are significant and appear to be increasing over the last 10 to 12 years. *Table 1.10* shows the total insurance claims by crop. Wheat and corn dominate the claims data making up nearly 75% of all crop claims.

Table 1.9 Region 2 Insurance Claims Listing Flood, Excess Moisture/Precipitation/Rain, or Poor Drainage as a Cause

Year	Insurance Claims
1991	$1,138,798
1992	$1,905,138
1993	$1,611,085
1994	$1,575,877
1995	$4,000,067
1996	$815,558
1997	$2,346,117
1998	$1,668,802
1999	$1,008,190
2000	$1,609,869
2001	$5,416,172
2002	$3,095,515
2003	$2,121,862
2004	$1,611,496
2005	$3,746,585
2006	$41,717
2007	$5,069,825
2008	$2,250,899
2009	$5,466,655
2010	$10,421,760
2011	$108,215

Year	Insurance Claims
2012	$2,316,414
2013	$433,866
2014	$3,723,812
2015	$24,533,245
2016	$16,145,433
2017	$2,831,269
2018	$8,362,110
2019	$23,095,217
2020	$19,601,896
2021	$14,152,634
2022	$344,568
Total	**$172,570,668**

(USDA Cause of Loss Historical Data Files, 1989-2022, https://www.rma.usda.gov/SummaryOfBusiness/CauseOfLoss)

Table 1.10 Region 2 Total Ag Insurance Claims by Crop

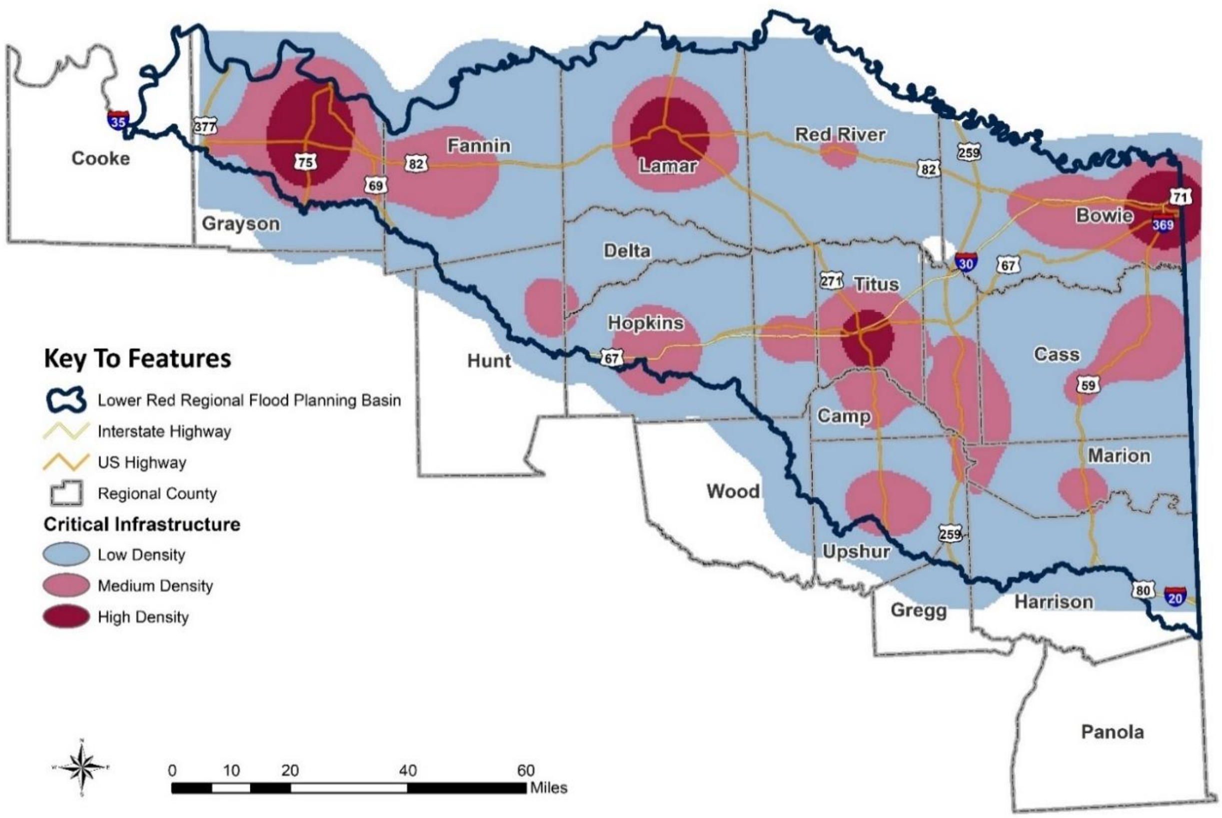
Crop	Total Claims
Corn	$50,292,962
Cotton	$17,127,575
Grain Sorghum	$6,051,793
Oats	$218,344
Peaches	$1,856
Peanuts	$1,853,789
Pecans	$233,437
Rice	$901,224
Soybeans	$10,933,359
Wheat	$77,992,098
All Other Crops	$6,964,230
Region 2 Total	**$172,570,668**

(USDA Cause of Loss Historical Data Files, 1989-2022, https://www.rma.usda.gov/SummaryOfBusiness/CauseOfLoss)

Location of Critical Assets

Critical assets include hospitals, fire stations, police stations, storage of critical records, and similar facilities. These assets or facilities should be given special consideration when formulating regulatory alternatives and floodplain management plans. Due to the regional scale of this study would make it difficult to show the location of individual facilities; *Figure 1.13* illustrates the locations with the highest concentration of facilities of all types. This "heat map" portrays areas with the highest concentration of these facilities in red, indicating where flooding could have the worst impact on critical facilities and the services they offer.

Figure 1.13 Location of Critical Facilities



(TWDB Critical Infrastructure Layer)

Error! Not a valid bookmark self-reference. provides data on the type and number of critical facilities in the region. For a more comprehensive list of these critical assets, refer to Chapters 3 and 4.

Table 1.11 Critical Facilities

Critical Facility	Totals
Assisted Living Facilities, Nursing Homes	100
Emergency Shelter	246
Fire Station	164
Hospital	25
Police Station	90
Power Generating Facility	18
School (K-12, College, Trade)	268
Water/Wastewater Treatment Plants	122

(TWDB Critical Infrastructure Layer)

1.1.D Political subdivisions with Flood-Related Authority

State guidelines for "Flood Protection Planning for Watersheds" 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. Of the political subdivisions referred to above, the majority are municipal or county governments, both of which enjoy broad authority to set a policy to mitigate flood risk.

State law also provides for limited-purpose Water Supply and Utility Districts. Not all of these districts have flood planning authority, but there is some variability in their tasks. The TWDB has indicated that Municipal Utility Districts (MUDs), Municipal Water Districts (MWDs), Fresh Water Supply Districts (FWSDs), or Special Utility Districts (SUDs) may also be endowed with flood planning responsibilities in specific communities, so they are included for consideration. These districts may be located in or adjacent to cities or the county and involved in the reclamation and drainage of its overflowed and other flood-prone lands. (Texas Water Code Chapter 54, 2021).

This section will discuss the range of entities with flood control authority, overlapping and/or joint responsibilities, and areas where there may be no apparent authority. An outreach survey was conducted to collect the quantity and quality of information for each identified political subdivision. Together, the entities outlined in *Table 1.12* constitute the primary flood mitigation stakeholders in Region 2 by the numbers. Each of these entities was invited to participate in the data collection through the Region 2 Data Collection Tool and Interactive web map.

Table 1.12 Political Subdivisions with Flood-Related Authority

	Number of Jurisdictions	NFIP Participants
Cities	86	60
Counties	20	16
Council of Governments	4	N/A
River Authorities	3	N/A
Water Districts	3	N/A
Water Supply & Utility Districts (MUDs, FWSDs, MWDs, SUDs)	17	N/A
Flood Control Entities (WCIDs, LIDs)	10	N/A
Other	5	N/A

(TWDB Data Hub)

As shown in *Table 1.12*, the region has a 72% NFIP participation rate from its eligible entities. For all subdivisions that participate in the NFIP, the Texas Water Code §16.315 requires them to adopt a floodplain management ordinance and designate a floodplain administrator responsible for understanding and interpreting local floodplain management regulations and reviewing them for compliance with NFIP standards.

Some of the rights and responsibilities granted under this authority of the Texas Water Code include:

- applying for grants and financing to support mitigation activities
- guiding the development of future construction away from locations threatened by flood hazards
- setting land use standards to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses
- collecting reasonable fees from citizens to cover the cost of administering floodplain management activities
- using regional or watershed approaches to improve floodplain management
- cooperating with the state to assess the adequacy of local structural and non-structural mitigation activities

Two additional types of districts bear more discussion, as they have a more direct relationship to flood management, as outlined in the Texas Water Code. The differing roles of Water Control and Improvement Districts (WCIDs) and Levee Improvement Districts (LIDs) are described in *Table 1.13*.

Table 1.13 Role of WCIDs and LIDs

	Statutory Authority	Flood Control Responsibilities
Water Control and Improvement Districts (WCIDs)	State Water Code, Title 4, Chapter 51	(1) the improvement of rivers, creeks, and streams to prevent overflows and permit navigation or irrigation; (2) the construction and maintenance of pools, lakes, reservoirs, dams, canals, and waterways for irrigation, drainage, or navigation; (3) the construction and maintenance control, storage, preservation, and distribution of water for flood control, irrigation, and power.
Levee Improvement Districts (LIDs)	State Water Code, Title 4, Chapter 5	(1) to construct and maintain levees and other improvements on, along, and contiguous to rivers, creeks, and streams; (2) to reclaim lands from overflow from these streams; (3) to control and distribute the waters of rivers and streams by straightening and otherwise improving them; (4) to provide for the proper drainage and other improvements of the reclaimed land

Summary of Existing Flood Planning Documents

This section will provide insight into the regulatory and policy environment governing floodplain management in the various jurisdictions of the regional flood planning area. It will summarize the most common types of regulation, structural controls, and planning activities. Approximately 23% of the entities who received an invitation to participate in the flood planning process via the Region 2 Data Collection Survey Tool and Interactive web map provided at least some measure of response at varying levels of detail. *Table 1.14* and *Table 1.15* summarize the entities' responses to questions about their existing regulatory environment and any measures they may have in place to increase resilience. The information in these tables is strictly based on responses to the Data Collection Survey and may not reflect a complete tally of flood preparation plans and policies in the region. For a more comprehensive list of existing floodplain management practices, refer to Chapters 3 and 4.

Table 1.14 Summary of Flood Plan and Regulations Provided via Survey

Type of Regulation	Count
Drainage Criteria Manual/Design Manual	6
Ordinances (Floodplain, Drainage, Stormwater, etc.)	10
Land use regulations	10
Unified Development Code (UDC) and/or Zoning Ordinances with map	4

(Region 2 Data Collection Tool and Interactive Webmap)

Table 1.15 Types of Resilience Measures based on Survey

Resilience Measure	Count
Acquisition of flood-prone properties	4
Flood readiness education and training	7
Flood response planning	4
Higher Standards for floodplain management	6
Land use regulations that limit future flood risk	7
Participation in the NFIP	10

(Region 2 Data Collection Tool and Interactive Webmap)

Floodplain Ordinances and Local and Regional Flood Plans

Besides structural flood control infrastructure, establishing plans and policies can help reduce the flood risk to people and properties. Cities can prevent new investments from being misplaced by introducing policies mandating communities to avoid development in flood-prone areas. Floodplain ordinances dictate how development is to interact with or avoid a community's floodplain. FEMA provides communities with flood hazard information upon which floodplain management regulations can be based. Floodplain ordinances are subject to the NFIP and ensure that communities and entities consider flood hazards when making land use and management decisions. Ordinances may include references to maps with base flood elevations, freeboard requirements, valley storage requirements, as well as criteria for land management and use. In addition, communities can regulate floodplains with higher or more restrictive standards.

Local and Regional Flood Plans may go beyond the regulations in an ordinance, enhancing a region's understanding of its flood risk and establishing how that entity will manage or control floods in the future. They also outline the procedures for more sustainable flood risk management in the communities they serve. (Resilient Coastal Development through Land Use Planning: Tools and Management Techniques in the Gulf of Mexico, Niki L. Pace)

Zoning and Land Use Policies

Zoning ordinances regulate how property owners and developers are allowed to use their property. It is one of the most important tools that communities use to regulate the form and function of current and future development. Within the zoning ordinance, communities may incorporate a variety of tools, which may include, among others:

- floodplain zones
- stream buffers
- setbacks from wetlands and other natural areas
- conservation easements

Subdivision regulations get into a more focused regulation of the design and form of the building blocks of a city. They regulate 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 do not have zoning authority.

Comprehensive Plans and Future Land Use Plans

The comprehensive plan establishes policies and programs of action for the long-term growth and development of a community. The future land use plan provides a guide for future areas of growth and development, as well as areas that are to be conserved in their natural state. This document sets the groundwork that is necessary to undertake quality decision-making.

Comprehensive plans and their associated future land use plans provide legal authority for zoning regulations in the State of Texas and consider capital improvements necessary to support current and future populations and often consider social and environmental concerns the community wishes to address. To produce a comprehensive plan, communities undertake an extensive planning process that encourages discussion about topics such as risk from natural hazards and may include recommendations regarding the location of development with respect to floodplains, the need for future drainage improvements, etc.

Drainage Design Criteria

Drainage design criteria are developed to set minimum standards for planners, architects, and engineers to follow when preparing plans for construction within the jurisdictions in which they apply. These could be prepared by regional entities, such as a council of governments, municipalities, or counties. In all cases, the community must adopt them to be enforceable. Drainage design criteria can cover whether development can occur in a floodplain, the minimum elevation of the structure in or near the floodplain, floodplain permitting requirements, required capacity of stormwater infrastructure, right of way/easement requirements, and hydrology and hydraulics methodology.

A storm drain system is a system of open channels and underground pipes designed to capture and transport concentrated stormwater flows to a point outside the limits of the property being developed. Developers may occasionally oversee creating drainage infrastructure that will be continuous and synergistic with the existing storm drain system and will not prevent adjacent property owners from extracting economic benefits from their properties.

1.2 Assessment of Existing Flood Infrastructure

This section summarizes the existing natural and constructed flood infrastructure that contributes to reducing the flood risk of communities within Region 2. The following assessment of both natural and built flood infrastructure is based on data provided by the TWDB and by the entities who completed Region 2's community survey.

When assessing flood risk management infrastructure, the natural and manmade features that contribute to risk reduction include the following:

Natural Features:

- rivers, tributaries, and functioning floodplains
- wetlands and marshes
- parks, preserves, natural areas
- *playa lakes*
- *sinkholes*
- *alluvial fans*
- *vegetated dunes*

Structural Features:

- levees
- dams that provide flood protection
- local stormwater systems, including tunnels and canals
- detention and retention ponds
- *sea barriers, walls, and revetments*
- *tidal barriers and g*ates

Note: Features shown above in italics have not been identified as major components of the flood control system in Region 2.

Flood infrastructure in the region includes both natural areas and built features that are owned and managed by entities ranging from the National Parks Service to individual landowners. Flood infrastructure may consist of non-structural measures, such as natural area preservation, buyout of repetitive flood loss properties, and flood warning systems, but it also includes all major public infrastructure, such as regional detention. The TWDB provided several data sources to assist with identifying flood management infrastructure in the Flood Data Hub. Several questions in the data collection survey were posed to complement the information provided by existing data sources to create a complete picture of how communities in the region protect themselves from flood risk.

1.2.A Natural Features

When left in their natural state, many soils can efficiently handle rainfall. As drops fall from the sky, they are intercepted by trees, shrubs, or grasses, allowing rain to soak into the soil and slow runoff to the region's waterways. Wetlands and woodlands are most efficient at recycling rainfall. The branches and undergrowth intercept water before reaching the ground, thus minimizing overland flow to tributaries and the river. Pastureland performs this function effectively as well, whereas croplands may shed a greater degree of water to keep from flooding the fields.

Similarly, parklands in urban areas designed for dual functions can achieve nearly the same rate of stormwater capture as lands in undeveloped areas. However, turf in highly trafficked areas is much less efficient at this task (Marsh, 2010). For natural features to be most effective at flood mitigation, they should form part of an interconnected network of open space with natural areas and other green features that protect ecosystem functions and contribute to clean air. This is known as green infrastructure, the practice of replicating natural processes to capture stormwater runoff (Low Impact Development Center).

Natural areas can be managed to be even more efficient at processing stormwater in a variety of settings:

- **Watershed Or Landscape Scale**: Where natural areas are interconnected to provide opportunities for water to slow down, soak in, and overtop the banks of creeks and channels when needed. These solutions often include multiple jurisdictions and natural habitat restoration to achieve maximum effectiveness.
- **Neighborhood Scale**: Solutions built into corridors or neighborhoods that better manage rain where it falls. Communities establish regulatory standards for development that guide neighborhood-scale strategies.
- **Coastal Solutions:** To protect against erosion and mitigate storm surges and tidally influenced flooding, nature-based solutions can be used to stabilize shorelines and restore wetlands. (FEMA, 2021)

As forests and fields give way to urban development, soil permeability decreases. This makes land less efficient at maintaining natural runoff velocities and allowing rainfall to soak into the ground and recharge the groundwater. The region should consider taking a more deliberate approach to managing its natural infrastructure to continue to receive the benefits of open spaces, something which the United States Army Corps of Engineers addresses in its Engineering with Nature initiatives, which align natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative projects. As urban development changes the natural environment and decreases permeability, conducting an inventory of the natural features in the region becomes more important to the flood planning process. The TWDB identified Local, State, and National Parks and Wildlife Management Areas that form part of the region's natural infrastructure, as illustrated in *Figure 1.14*. This section will examine the natural areas of Region 2 and will include different types of natural flood infrastructure, including wetlands, lakes, reservoirs, parks, and preserves.

Wetlands

Wetlands are some of the most effective natural features for recycling water by minimizing the overland flow and reducing the need for other types of flooding infrastructure. The USGS defines wetlands as transitional areas sandwiched between permanently flooded deep water environments and well-drained uplands, where the water table is usually at or near the surface or the land is covered by shallow water. They can include mangroves, marshes, swamps, forested wetlands, and coastal prairies, among other habitats, and their soil or substrate is at least periodically saturated by fresh or salt water. When left undisturbed by development, wetlands can not only mitigate flooding from upstream but also blunt the force of storm surges from the coast in the form of hurricanes and other tropical storms.

As shown in *Table 1.16,* there are over 432,913 acres of wetlands in the region. Over 90% of the total wetland acreage in the basin was identified as freshwater forested/shrub wetlands, and almost 30% of that acreage lies in the Lower Sulphur HUC-8 on the central-northeastern part of the planning area. The absence of wetlands in HUC-8 Blue and Bayou Pierre is due to the extremely low acreage included in Region 2.

Table 1.16 Types of Wetlands by HUC-8

HUC-8	Freshwater Emergent Wetland (acres)	Freshwater Forested/Shrub Wetland (acres)	Total Wetland (acres)	Total Wetland (percent)
Bayou Pierre	-	-	-	-
Blue	-	-	-	-
Bois D Arc-Island	5,519	25,048	30,567	7.1%
Caddo Lake	4,690	63,193	67,883	15.7%
Cross Bayou	156	7,399	7,555	1.7%
Lake O' the Pines	1,916	24,206	26,121	6.0%
Lake Texoma	1,616	4,066	5,681	1.3%
Little Cypress	3,157	31,403	34,560	8.0%
Lower Sulphur	9,750	115,813	125,564	29.0%
McKinney-Posten Bayous	155	443	598	0.1%
Pecan-Waterhole	6,041	54,998	61,039	14.1%
Sulphur Headwater	3,096	25,296	28,392	6.6%
White Oak Bayou	4,558	40,394	44,952	10.4%
Total	**40,653**	**392,260**	**432,913**	**100%**

(USGS National Wetlands Inventory)

Although the Lower Sulphur HUC-8 contains 29% of the total wetland in Region 2, only 12% of the entire Lower Sulphur HUC-8 is covered in wetlands. In comparison, the Pecan-Waterhole HUC-8 represents only 14% of the total wetland in Region 2; however, 12% of its lands are classified as wetlands. HUC-8s on the West and Eastern areas of the basin, including McKinney-Posten Bayous, Lake Texoma, and Cross Bayou, each make up less than 2% of the total wetland acreage of the basin, and less than 5% of their land area is covered in wetlands. Compared to its neighboring Region 4, Region 2 has relatively minimal wetland resources to contribute to natural flood mitigation. Existing wetlands must be stringently protected from future development or damage from agricultural or ranching use.

Rivers, Tributaries, and Functioning Floodplains

The natural flood storage capacity of all streams and rivers and the adjacent floodplains contribute greatly to overall flood control and management. Surface water, floodplains, wetlands, and other features of the landscape function as a single integrated natural system. Disrupting one of these elements can lead to effects throughout the watershed, increasing the risk of flooding adjacent communities and working lands. Maintaining the floodplain in an undeveloped state allows rivers and streams to spread out and store floodwaters to reduce flood peaks and velocities. Even in urban areas, preserving this integrated system of waterways and floodplains serves a valuable function, as even small floods resulting from a five or 10-year storm can cause severe flood damage. Depending on soil type and permeability, a single acre of floodplain land can significantly reduce the risk to properties downstream. Out of the total 5,862,650 acres in Region 2, 1,805,440 acres are in the 100-year floodplain, and an additional 73,600 acres are in the 500-year floodplain. With about 32% in the floodplain, its rivers, tributaries, and functioning floodplain contribute to flood risk reduction as they move into Arkansas and Louisiana. Chapter 2 includes additional information on existing and future condition flood risks.

Parks, Preserves, and Other Natural Areas

Parks and preserves serve as essential components of the ecosystem as they house a wide variety of local flora and fauna, as well as physical features that are necessary for the continued ecological health of the region. Parks include municipal, county, state, and national parks within the region, while preserves include the Texas Parks & Wildlife Department's State Wildlife Management Areas. These areas provide a sanctuary for all these aspects impacted by human activity. Additionally, these are essential components for water retention in the event of flooding and severe rainfall.

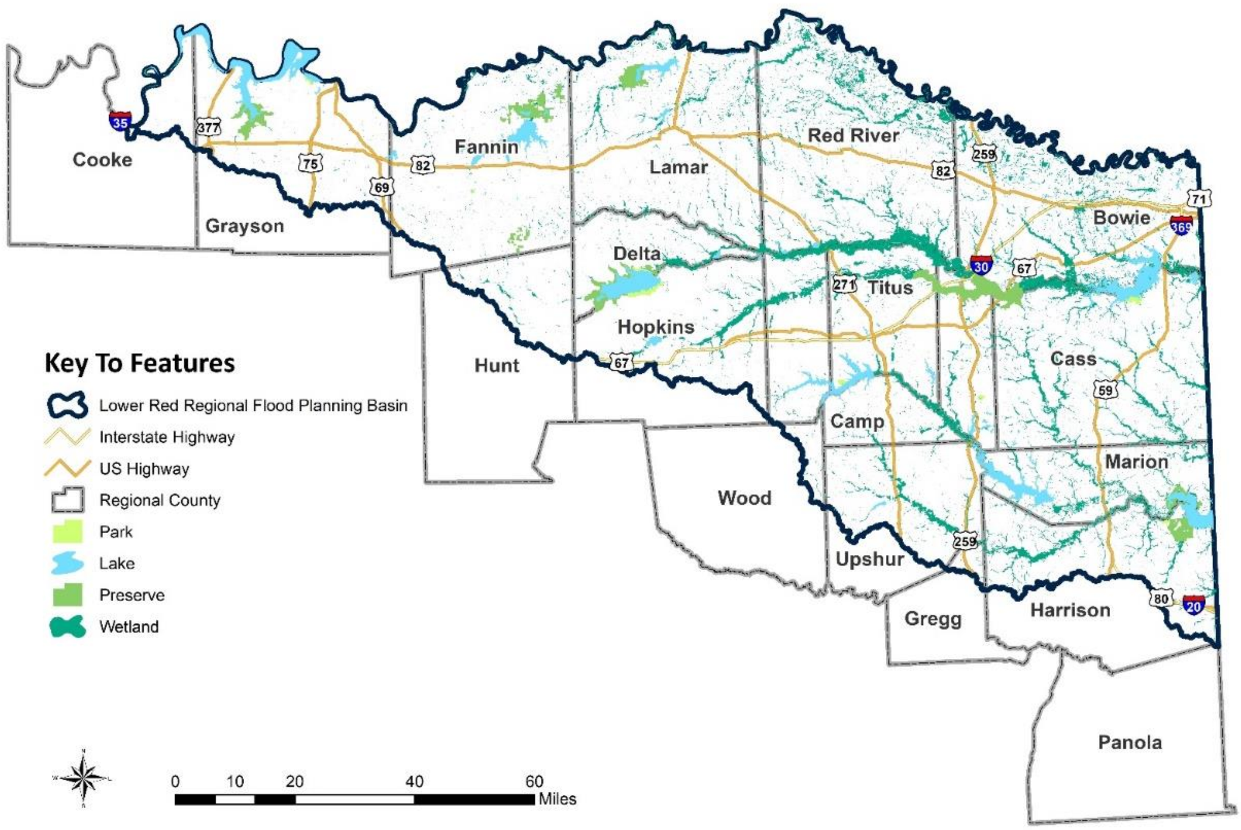
Table 1.17 Parks and Preserves by HUC-8

HUC-8	Parks (acres)	Preserves (acres)	Total Parks and Preserves (acres)	Percent of Total HUC-8 Land Area
Bayou Pierre	-	-	-	-
Blue	-	-	-	-
Bois D Arc-Island	22,357	22,095	44,452	4.9%
Caddo Lake	8,889	8,426	17,315	2.5%
Cross Bayou	-	-	-	-
Lake O' the Pines	1,175	-	1,175	0.2%
Lake Texoma	447	-	447	0.2%
Little Cypress	-	-	-	-
Lower Sulphur	14,149	12,714	26,863	2.6%
McKinney-Posten Bayous	-	-	-	-
Pecan-Waterhole	-	-	-	-
Sulphur Headwater	24,207	20,974	45,181	6.2%
White Oak Bayou	12,812	12,812	25,624	5.0%
Total	**84,035**	**77,021**	**161,056**	

(TWDB Flood Planning Data Hub, Multiple sources (Municipal, County, State Parks, State Wildlife Management Areas, National Park Service Lands, USGS National Wetlands Inventory))

As noted in *Table 1.17*, parks account for 84,035 acres, while preserves make up 77,021 acres within the basin. This acreage includes state and local parks and wetlands identified on the National Wetlands Inventory, as well as United States Army Corps of Engineers (USACE) properties. These types of natural flood infrastructure are usually located in or close to floodplain areas in the basin, with higher concentrations along or adjacent to the major rivers and their watersheds. This pattern is reflected in Region 2, as seen in *Figure 1.14.* Lakes are very important in mitigating the effects of flooding because of their size and ability to store vast amounts of water. Their size allows them to serve as a repository for flood waters and hold, store, and gradually release these waters from floods over time.

Figure 1.14 Natural Flood Infrastructure

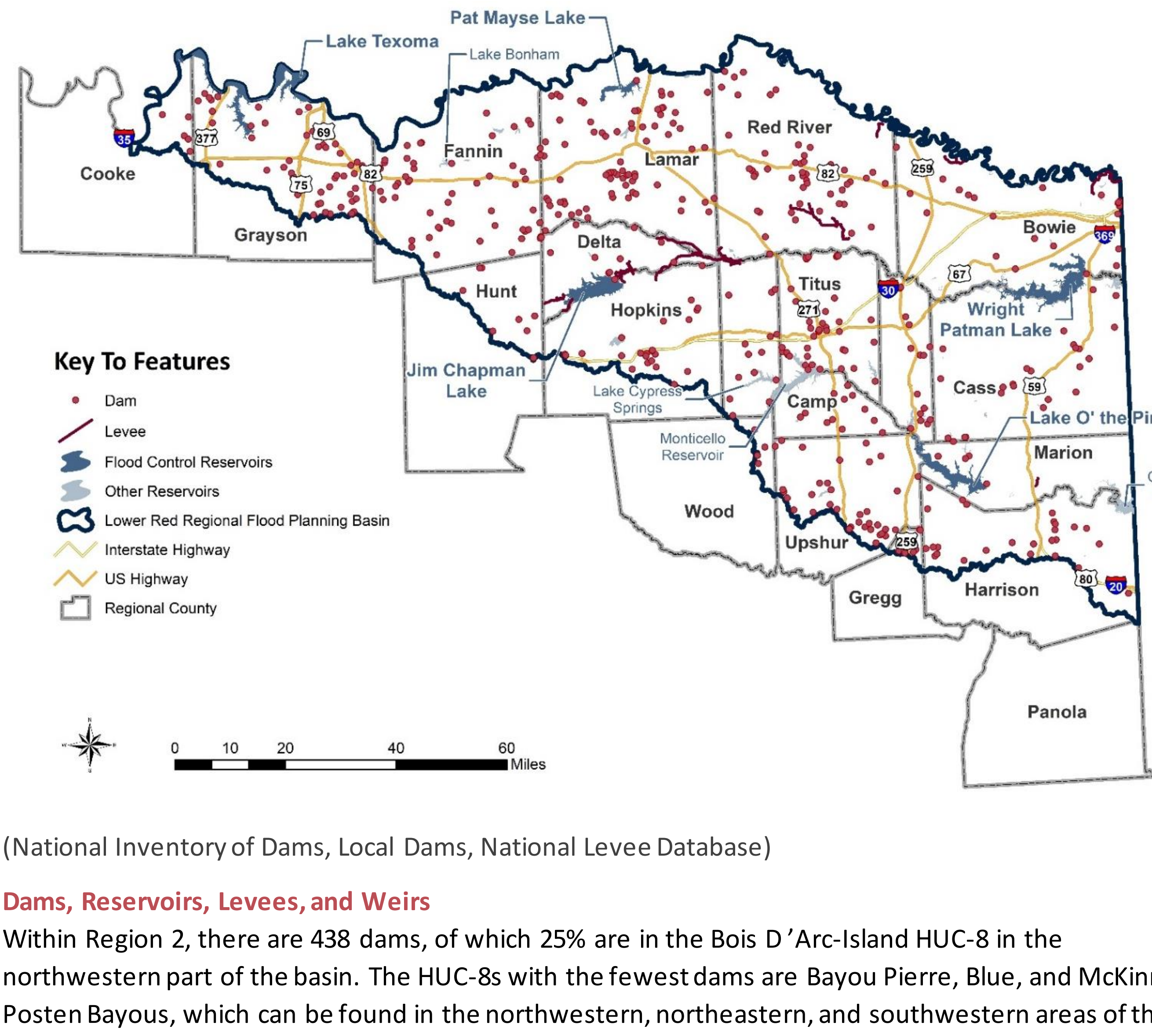


(TWDB Flood Planning Data Hub, Multiple sources (Municipal, County, State Parks, State Wildlife Management Areas, National Park Service Lands, USGS National Wetlands Inventory))

1.2.B Constructed Flood Infrastructure/ Structural Protections

State and federal agencies, Texas communities, and private landowners use a wide variety of structural measures to protect development and agricultural areas from flooding. These may include flood control reservoirs, dams, levees, and local drainage infrastructure such as channels and detention areas. Dams and levees are some of the most frequently used defenses to achieve structural mitigation of future flood risk in this region. They serve an established role of protecting people and property from flood impacts and will therefore be the primary focus of this section. *Figure 1.15* identifies the location of all 438 known dams and 21 levees in Region 2.

Figure 1.15 Constructed Flood Infrastructure/Structural Flood Protection



(National Inventory of Dams, Local Dams, National Levee Database)

Dams, Reservoirs, Levees, and Weirs

Within Region 2, there are 438 dams, of which 25% are in the Bois D'Arc-Island HUC-8 in the northwestern part of the basin. The HUC-8s with the fewest dams are Bayou Pierre, Blue, and McKinney-Posten Bayous, which can be found in the northwestern, northeastern, and southwestern areas of the basin. The reason behind the minimal or lack of constructed flood infrastructure in these HUC-8s is due to their low total acreage in the region. To compare the two scales, the Blue HUC-8 is 38.4 acres, while the Lower Sulphur HUC-8 is 1,044,473.6 acres. Out of the 19 levees found in Region 2, the Sulphur Headwater HUC-8 has almost half of them, with a total of nine levees. *Table 1.18* illustrates the number of constructed flood infrastructure in Region 2.

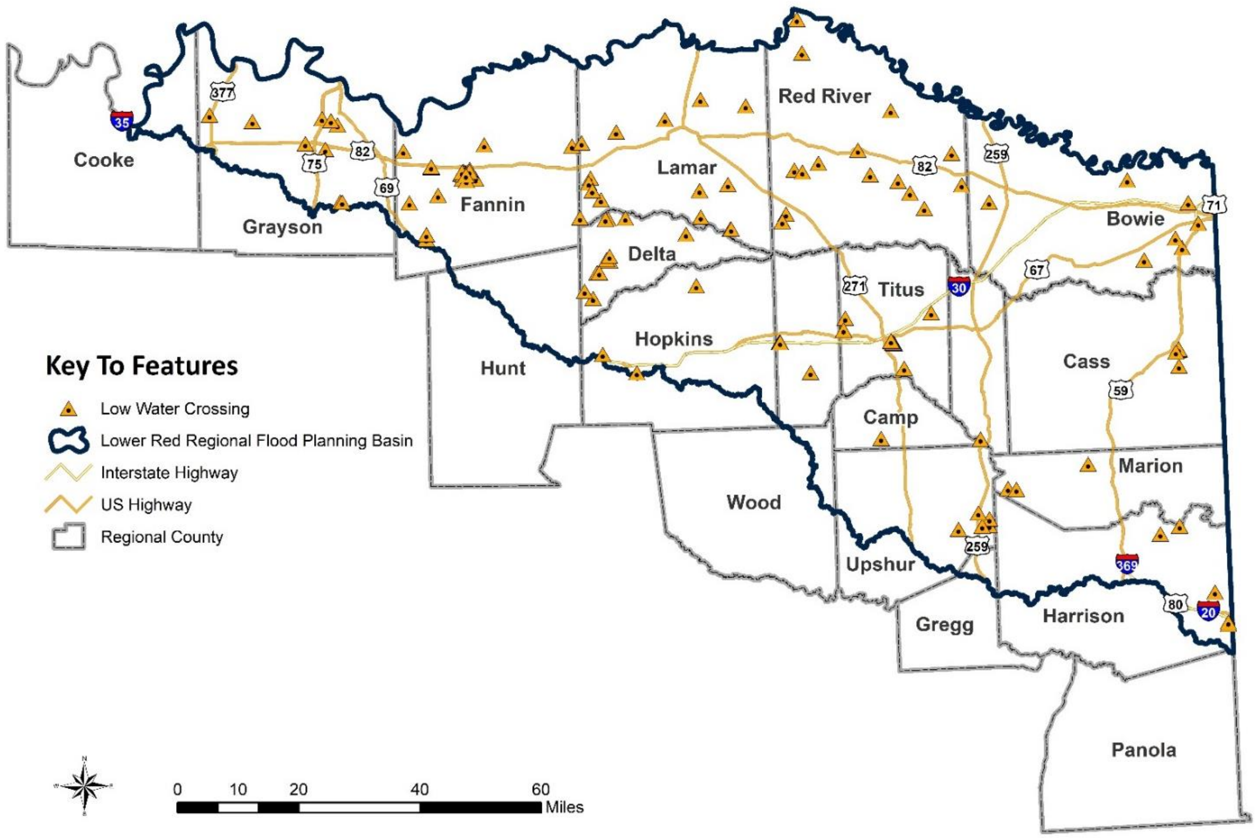
Table 1.18 Dams, Reservoirs, Levees, and Weirs by HUC-8

HUC-8	Dams	Reservoirs	Levees	Total	Lakes (acres)
Bayou Pierre	0	0	0	0	0
Blue	0	0	0	0	0
Bois D'Arc-Island	112	1	0	113	28,612
Caddo Lake	26	0	1	27	14,435
Cross Bayou	10	0	0	10	119
Lake O' the Pines	69	1	0	70	36,514
Lake Texoma	18	1	0	19	33,557
Little Cypress	57	0	0	57	1,309
Lower Sulphur	63	1	6*	70	28,730
McKinney-Posten Bayous	5	0	1*	6	434
Pecan-Waterhole	17	0	4*	21	1,045
Sulphur Headwater	68	1	9*	78	19,402
White Oak Bayou	38	0	0	38	2,400
Total	**483**	**5**	**21***	**509**	**166,556**

** There are 19 levees in total; however, some HUC-8s might include part of another levee*
(National Inventory of Dams, Local Dams, National Levee Database)

Other types of infrastructure that assist in flood protection include low water crossings, which are roadway creek crossings that are subject to relatively frequent inundation. Based on the TWDB-provided data and locations collected through the public input web tool, there are 133 low water crossings in Region 2; as shown in *Figure 1.16*, most are found in the northwestern basin. As shown in *Table 1.19*, Bois D Arc-Island HUC-8 in the northwestern basin has the highest number of low water crossings in Region 2. Lower Sulphur and Sulphur Headwater in the central part of the basin are the other HUC-8s with a large number of low water crossings in the region. Other than the three HUC-8s with a small land area in the Lower Red, Little Cypress in the southern basin has the fewest number of low water crossings.

Figure 1.16 Low Water Crossings



(Texas Natural Resources Information System)

Table 1.19 Low Water Crossings by HUC-8

HUC-8	Low Water Crossings
Bayou Pierre	-
Blue	-
Bois D Arc-Island	45
Caddo Lake	3
Cross Bayou	10
Lake O' the Pines	11
Lake Texoma	2
Little Cypress	1
Lower Sulphur	24
McKinney-Posten Bayous	-
Pecan-Waterhole	6
Sulphur Headwater	21
White Oak Bayou	10
Total	**133**

(Texas Natural Resources Information System)

1.2.C Non-Functional or Deficient Flood Mitigation Features

The State Flood Data Hub provided little relevant information about the state of the region's flood mitigation features, and little direct input was provided by survey respondents that could supplement the information provided. However, throughout Texas, flood infrastructure is rapidly aging and needing repair. In 2019, the Association of State Dam Safety Officials estimated the cost to rehabilitate all non-federal dams in Texas at around $5 billion. The Texas State Soil and Water Conservation Board (TSSWCB) estimates about $2.1 billion is needed to repair or rehabilitate dams included in the Small Watershed Programs (Texas State Soil and Water Conservation Board, 2021).

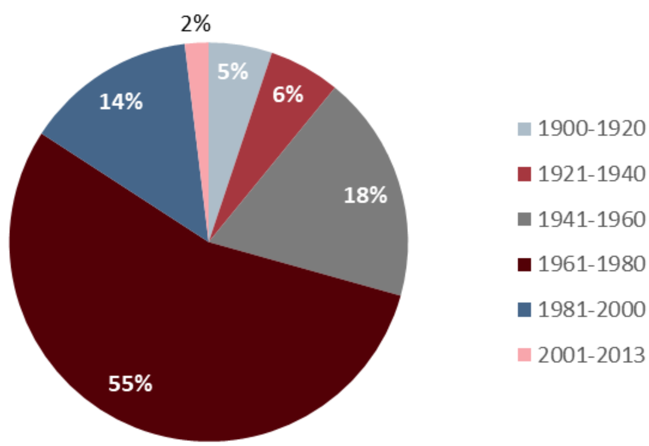
Even though the minority of the dams in the region were built for flood control, the consequences of removal or failure downstream can still be severe, with losses of life, agricultural resources, and property. "Of the about 7,200 non-federal dams in our state, approximately 25% could result in loss of life should they fail. More than 3,200 Texas dams are exempt from dam safety requirements by State legislation. (2021 Texas Infrastructure Report Card, 2021).

Condition-related data for the region's levees is largely unknown since most of the levees in the state are built, inspected and/or maintained by local governing agencies that may not have the resources for routine assessment and performance tracking. The USACE, however, establishes a rigorous maintenance standard for its reservoirs and levees to ensure that they perform to expectations. Recent increases in the frequency and intensity of storms and hurricanes continue to test the capacity of the state's levees. More than 75% of Texas levee systems are without screened risk classification. Without a clearer picture of the state's levee infrastructure and concerted funding to assist private owners, the vast majority of the state's levees that are not managed and maintained by the USACE will remain in the presumed deficient status (2021 Texas Infrastructure Report Card, 2021).

Functionality of Flood Infrastructure

With little available information on flood infrastructure condition, it is difficult to know the functionality of the region's infrastructure. However, it was possible to evaluate the age of constructed flood infrastructure. Over half of the dams in the region were constructed between 1961 and 1980, while another 29% of dams were created between 1900 and 1960. By evaluating the age of dams, it is evident that the region's flood infrastructure is aging. Furthermore, the age of these structures indicates that many could need maintenance, rehabilitation, and even replacement.

Figure 1.17 Dam Year of Construction



(TCEQ Dam Inventory)

1.2.D Condition and Functionality of Infrastructure and Other Flood Mitigation Features (TABLE 1)

Out of the 484 dams in the region, the condition of only 122 dams is known; nonetheless, this starts to create a partial narrative of the flood infrastructure in the region. As illustrated in *Figure 1.18,* dam ownership is divided between federal, local, private, and state entities.

The known number of dams by ownership are:

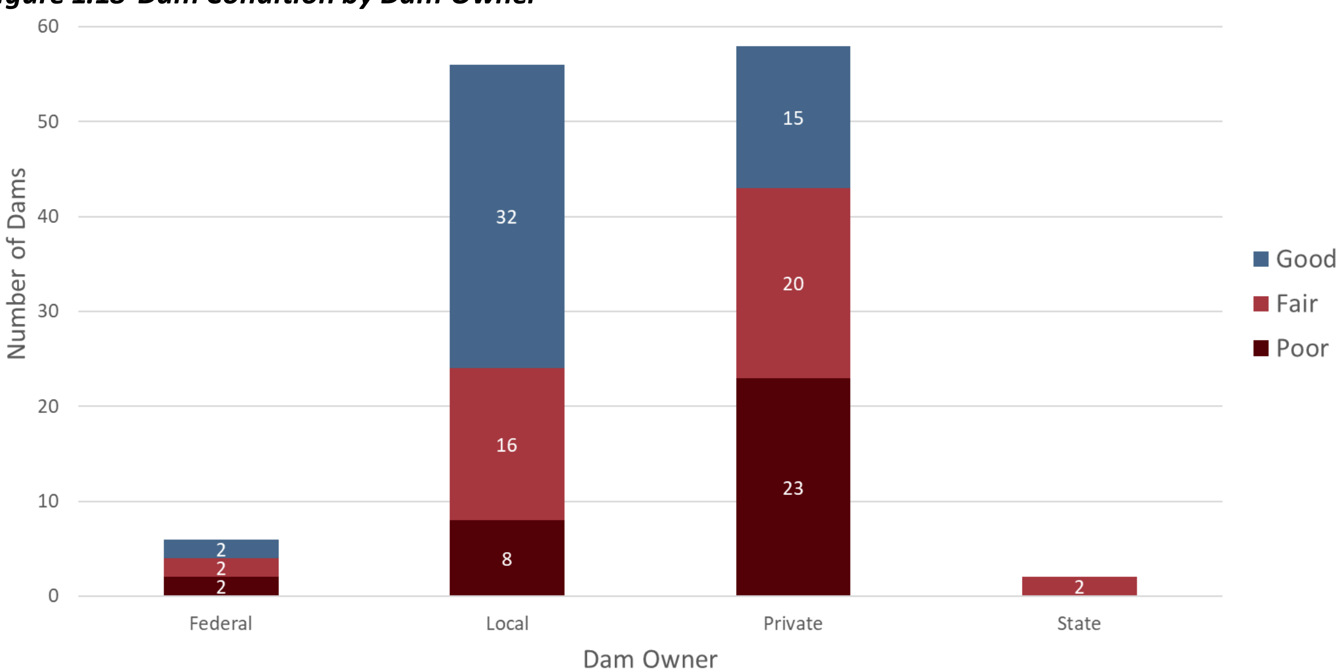
- **federally owned dams**: 6
- **locally owned dams:** 56
- **privately-owned dams:** 58
- **state-owned dams:** 2

Based on the National Dam Safety Review Board, the following are definitions that describe the condition of dams:

- **Good** - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) following the applicable regulatory criteria or tolerable risk guidelines.
- **Fair** - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency, and the risk may be in the range to take further action.
- **Poor** - A dam safety deficiency is recognized for loading conditions that may realistically occur. Remedial action is necessary, and poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.
- **Unsatisfactory** - A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

Based on the condition known for the 122 dams in the region, *Figure 1.18* shows that 73% of the constructed dams are in fair or good condition, and 27% are in poor condition. This condition evaluation is important because it helps prioritize further studies and investigations into those 33 dams in poor condition. Private dam owners have the worst record of dam maintenance with 40% of their dams in poor conditions. The condition of the additional 362 dams is unknown but could represent an additional 145 dams in poor condition (using the 40% in poor condition statistic for privately owned dams).

Figure 1.18 Dam Condition by Dam Owner



(TCEQ Dam Inventory)

1.3 Proposed or Ongoing Flood Mitigation Projects

The data for this section is derived from two sources, including Hazard Mitigation Plans and the region's data collection survey. The region's data collection survey was derived from direct outreach to stakeholders via an online survey and direct calls. In Appendix 2, *Table 2: Summary of Proposed or Ongoing Flood Mitigation Projects* has more detailed results. *Table 1.20* shows the frequency that communities indicated that they undertake a particular project type. Respondents were allowed to select multiple types of roadway and crossing improvements, bridges, culverts, regional dams, reservoirs, detention, retention basins, and local storm drainage systems. No specific projects were provided.

Table 1.20 Typical Types of Projects Undertaken

Type of Projects	Count
Roadway and crossing improvements, bridges, culverts	7
Regional dams, reservoirs, detention, retention basins	6
Local storm drainage systems, tunnels	5
Channel, canal conveyance improvements	3
Property buyouts/acquisitions and/or relocations	2
Floodplain management ordinances	2
Flood awareness outreach and/or education	2
Flood readiness, resilience	2
Property elevations	1
Flood warning system, stream/rain gauges	1

(Region 2 Data Collection Tool and Interactive Webmap)

After compiling the communities' survey responses, the above inventory displays the proposed and ongoing flood mitigation projects being completed by cities, counties, and other entities throughout the basin. The predominant types of projects undertaken include:

- roadway and crossing improvements, bridges, culverts
- regional dams, reservoirs, detention, retention basins
- local storm drainage systems, tunnels

Noticeably absent from these categories are "nature-based" projects. Despite ample land for flood control purposes in much of the region, these solutions have not yet gained ground with local communities. These numbers represent a snapshot of current conditions, however, since they depend on self-reporting and do not include the number of projects within each category.

Structural Projects Under Construction

In the survey, only two respondents recorded that some of their ongoing and proposed infrastructure or flood mitigation projects are at or above a 30% level of design, but no details were provided.

Nonstructural Flood Mitigation Projects Being Implemented

Information provided by survey respondents is not adequate to properly answer the question.

Structural and Non-Structural Flood Mitigation Projects with Dedicated Funding and Year Complete

There are several local and non-local sources of funding that can be put toward flood mitigation projects in communities. This survey section investigated the exact type of funding options communities have under these two sources. Several entities from the survey indicated that the local funding opportunities they had were either their General Funds, Storm Water Utility Fees, Bond Programs, Ad Valorem Tax, or they didn't have a local funding source for flood management activities. As for the non-local sources, the survey respondents included:

- Hazard Mitigation Grant Program (HMGP) [FEMA, TDEM]
- Community Development Block Grant – Mitigation (CDBG-MIT) [HUD, GLO]
- Texas Water Development Fund (DFund) [TWDB]
- U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS)
- Pre-Disaster Mitigation (PDM) [FEMA, TDEM]
- Building Resilient Infrastructure and Communities (BRIC) [FEMA, TDEM]
- Flood Mitigation Assistance (FMA) [FEMA, TWDB]

Chapter 2: Flood Risk Analyses

To assess flood risk in the Lower Red-Sulphur-Cypress Flood Planning Region (Region 2), existing conditions, including flooding history and flood hazard areas, were gathered and analyzed to determine the best estimate of the 1% and 0.2% annual chance event floodplains from available data. Locations of community populations, structures, and identified critical facilities affected by the flood hazard were studied to identify flooding exposure and community vulnerability in these areas.

Future flooding conditions were projected using the best available flooding data and projected regional growth to determine the extent of risk if no action was taken to mitigate the expansion and/or effect of the flood hazard areas. The exposure analysis was rerun with the future flood hazard areas to determine the impact of expansion in the region. The current and future flood risk analyses highlight potential areas of concern and vulnerability within the region.

2A.1 Existing Condition Flood Risk Analyses

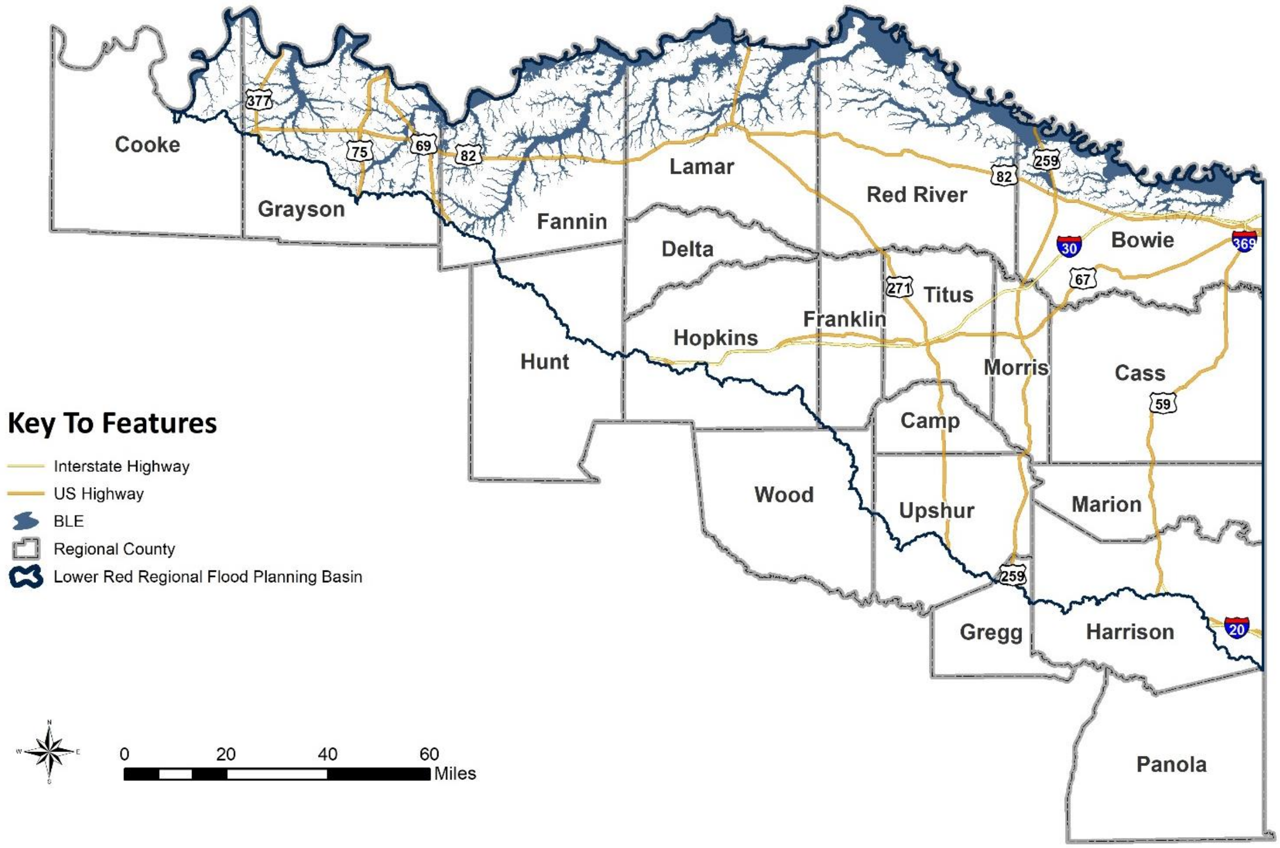
2A.1.A Existing Condition Flood Hazard Analysis

Data for Existing Conditions for Planning Purposes

The existing flood risk for the region was determined by evaluating various existing data sources and collecting public input in the planning process to assess the frequency and magnitude of flooding at locations throughout Region 2. The foundation of the assessment was based on the Federal Emergency Management Agency (FEMA) regulatory effective products. However, five out of nineteen counties within the region do not have available Special Flood Hazard Areas (SFHA) mapped. Out of 14 counties with some SFHA mapped by FEMA, only 10 have detailed studies (Zone AE). Even in these counties, detailed studies are generally limited to the urban centers, with the rest of the county mapped as approximate (Zone A).

New FEMA-provided Base Level Engineering (BLE) data was published in Fall 2021 for most of the Lower Red River Basin within the region, including the Lake Texoma, Bois D'Arc, and Pecan Waterhole Hydraulic Unit Code (HUC)-8's. These are not regulatory products but are often intended to supplement the regulatory products, estimate the base flood elevations (BFE), and provide communities with approximate modeling on which to build their own modeling and regulations. BLE for the Red River tributaries was derived from one-dimensional (1D) modeling using regression analysis. For the main stem of the Red River, the United States Army Corps of Engineers (USACE)'s frequency analysis was utilized to account for the regulation due to Lake Texoma. Light Detection and Ranging (lidar) ground elevation data is also used to produce this BLE information. This new BLE data provides mapping extents, including the potential for 1% and 0.2% annual chance exceedance flood events to primarily unmapped areas, and is extremely valuable in assessing the flood risk to these areas.

Figure 2.1 New Base Level Engineering Released for Region 2



A cursory statewide dataset from an external contractor, Cursory Floodplain Data, was acquired by the Texas Water Development Board (TWDB) to assist in determining the locations of flood risk. The modeling process defined the extent of different frequencies of flooding events (floodplains) based on Texas-provided lidar data, historical National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rain frequency, stream gauges, and other land cover data on a 30-meter grid, and then mapped onto a three-meter resolution topographic dataset. The approach is also referred to as “rain-on-mesh” or “rain-on-grid,” but different types of modeling collection methods comprise the data.

Reports of flooding gathered from the public input process were incorporated when determining flood risk locations. Over 400 stakeholders, comprised mostly of governmental agencies in the region, were surveyed and open public input was solicited using interactive maps requesting local knowledge of flooding and flood risks. Twenty-Four known flooding locations were gathered through the input tool during this process, while more detailed information came from subsequent meetings and phone calls with regional stakeholders.

Fifteen years of NOAA flooding-related data with narrative flooding descriptions, often reported by law enforcement and emergency management officials through the National Weather Service (NWS), was used to understand the locations and extent of previous floods to determine existing flooding conditions. The data reported deaths, injuries, lost property, and crop value. Based on stakeholder input, the impacted property values did not seem to report and/or reflect the actual value of property damaged in some events.

Precipitation

In 1973 the National Flood Insurance Program (NFIP) set the standard for flood hazard areas based on the 1% annual chance exceedance (ACE), commonly referred to as the 100-year flood. Much of the floodplain mapping at that time was developed using the Weather Bureau's (U.S. Department of Commerce) Technical Paper 40 (TP-40) Rainfall Frequency Atlas f the United States (1961). TP-40 provided isopluvial (contours of equal rainfall) maps of the continental United States for various frequencies and durations from one-year, 30-minute rainfalls to 100-year, 24-hour. There were no 0.2% ACE (500-year) rainfalls included. *Figure 2.2* shows the 100-year (1% ACE), 24-hour duration rainfall isopluvials for the continental United States. *Figure 2.3* shows the same rainfall isopluvials with a focus on Texas. As summarized in *Table 2.1*, the 1% ACE (100-year) 24-hour rainfall totals range from 9.3 inches at the region's northwest corner to 10.5 inches at the southwest corner of the region. TP-40 was the basis of most flood studies in Region 2.

Table 2.1 TP-40 Precipitation Frequency Estimates

Region 2 Watershed	1-year 24-hour rainfall (inches)	100-year 24-hour rainfall (inches)	500-year 24-hour rainfall (inches)
Northwest Portion	3.1	9.3	NA
Northeast Portion	3.65	9.8	NA
Southeast Portion	3.7	10.5	NA

(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

Figure 2.2 TP-40 Rainfall Isopluvials for the Continental U.S. for the 100-year (1% ACE), 24-hour rainfall event

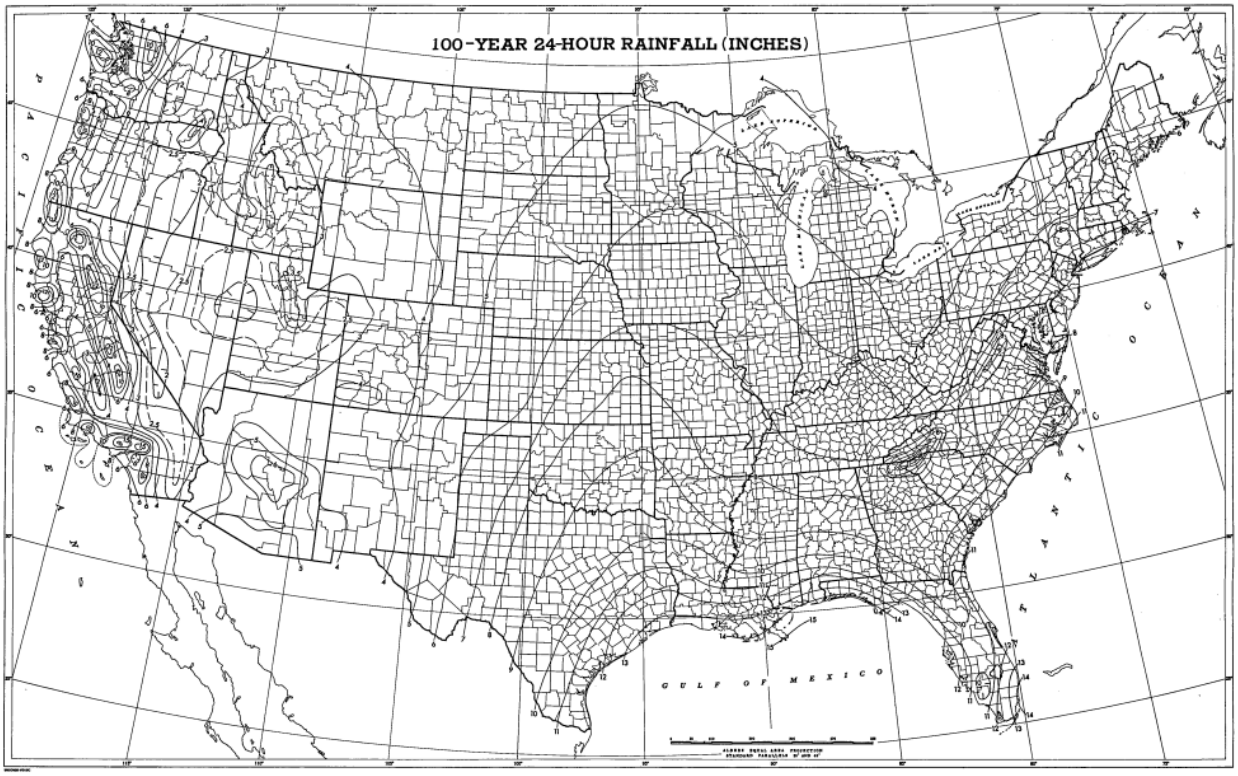
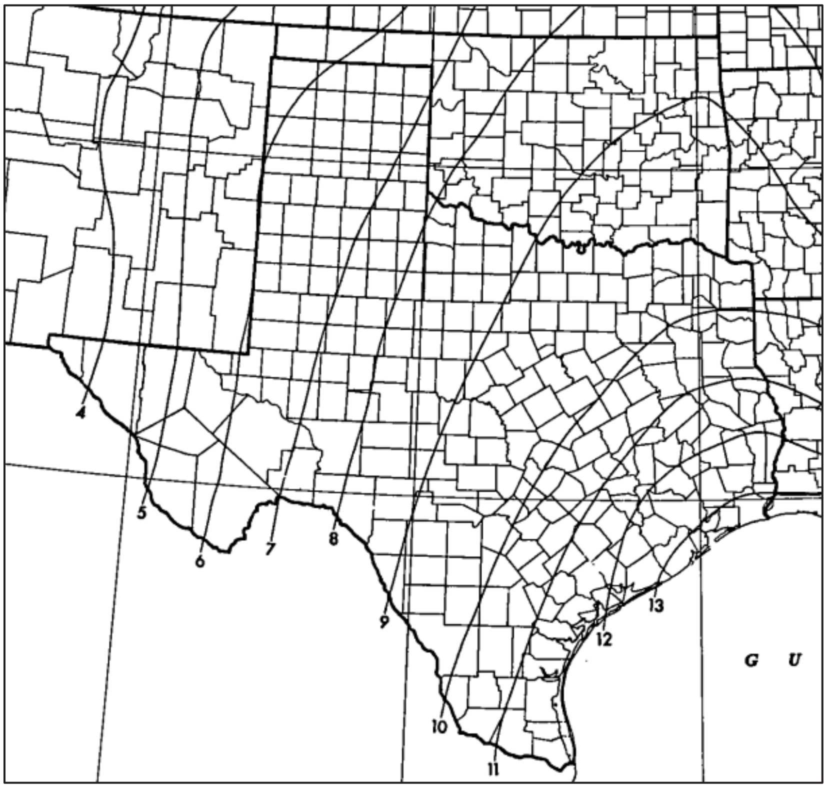


Figure 2.3 TP-40 Isopluvials across Texas for the 100-year (1% ACE), 24-hour rainfall event



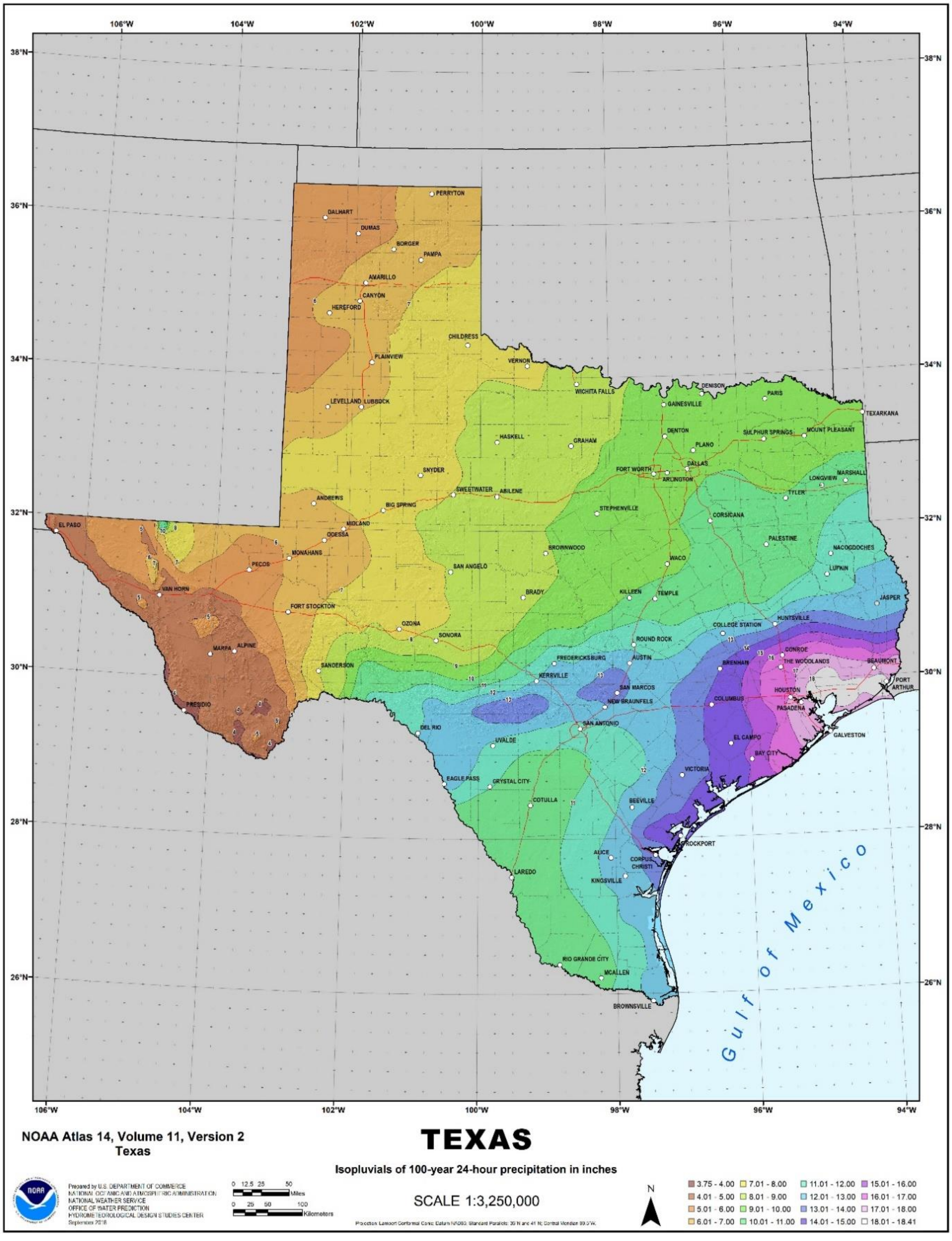
In 2018, NOAA developed hypothetical Texas rainfall based on historical rainfall data in its NOAA Atlas 14, Volume 11 study. Rainfall data was broken down in duration and recurrence interval, as shown in *Table 2.2* and *Figure 2.4*. *Figure 2.4* shows the general isopluvial patterns and rainfall totals are similar to those seen in TP-40. Other than in specific local situations, Atlas 14 is not expected to have major impacts on the floodplain boundaries in the region. Over time, Atlas 14 will be used to create new floodplain mapping in Region 2. It is advised that local jurisdictions adopt Atlas 14 as the basis of design since it provides a more up-to-date and complete picture of rainfall frequencies; however, most of the floodplain mapping used in this flood plan is likely based on TP-40.

Table 2.2 Precipitation Frequency Estimates

Region 2 Watershed	One-year 24-hour rainfall (inches)	100-year 24-hour rainfall (inches)	500-year 24-hour rainfall (inches)
Northwest Portion	3.27	9.62	12.8
Northeast Portion	3.61	9.26	11.9
Southeast Portion	3.44	10.6	14.7

(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

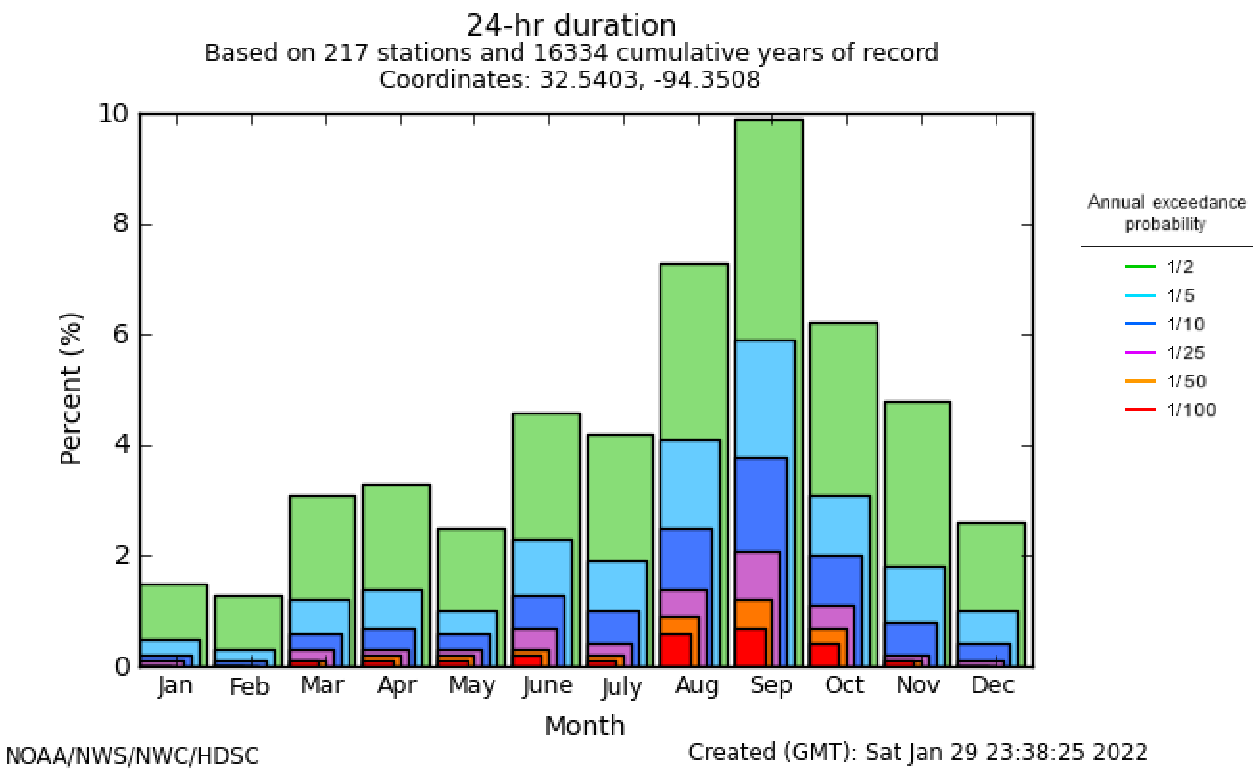
Figure 2.4 NOAA 100-year (1% ACE), 24-hour Rainfall Isopluvials – Rainfall Intensity Map



(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

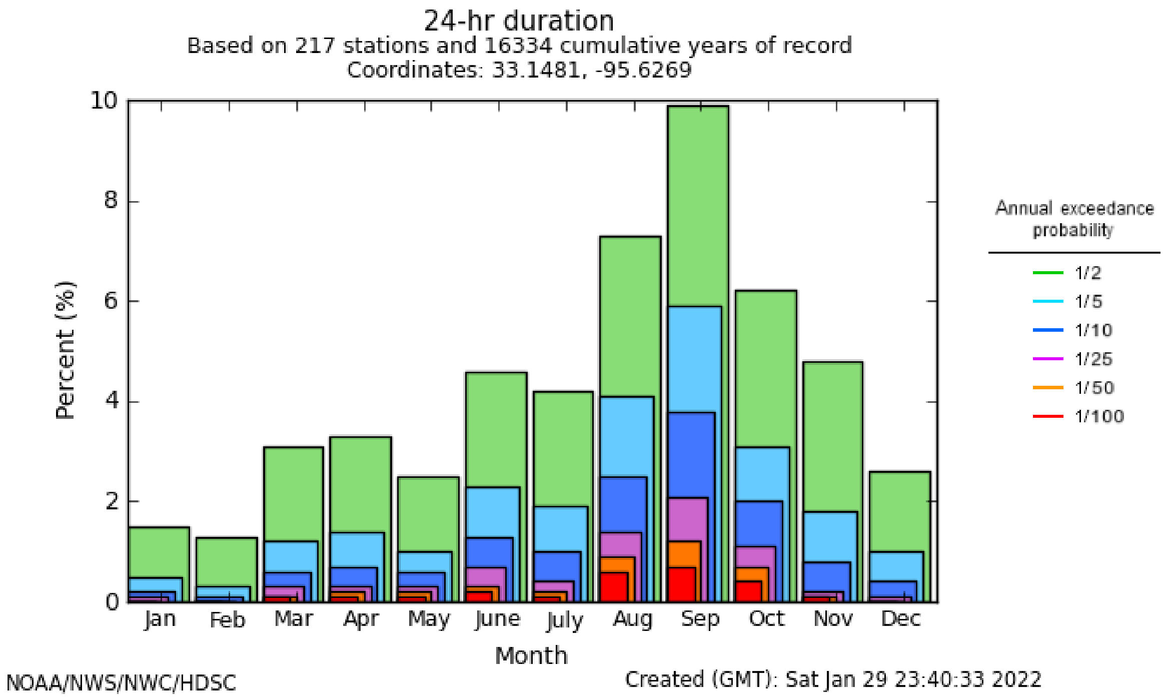
The following NOAA seasonality graphs illustrate when extreme rainfall events typically occur during the year in various portions of the region. These show the percentage of precipitation totals for a 24-hour duration that exceeded the precipitation frequency estimates and selected annual exceedance probabilities in each month for each region. The precipitation frequency estimates were derived from the annual maximum series at each station in the region. Results are provided for 24-hour durations and annual exceedance probabilities of one-half (50% ACE), one-fifth (20% ACE), one-tenth (10% ACE), and one-twenty-fifth (4% ACE), one-fiftieth (2% ACE), and one-hundredth (1% ACE). These graphs show that extreme rainfall is most likely to occur in the late summer and early fall for most of the region and is least likely to happen in the winter. In the western portion of the region, there is an increased risk of heavy rainfall in the spring. These trends suggest that flood risks to agriculture are high since flooding is most likely to occur during most crops' growing and harvesting seasons.

Figure 2.5 Seasonality Graph from Marshall NOAA Station (near the southeast corner of the region)



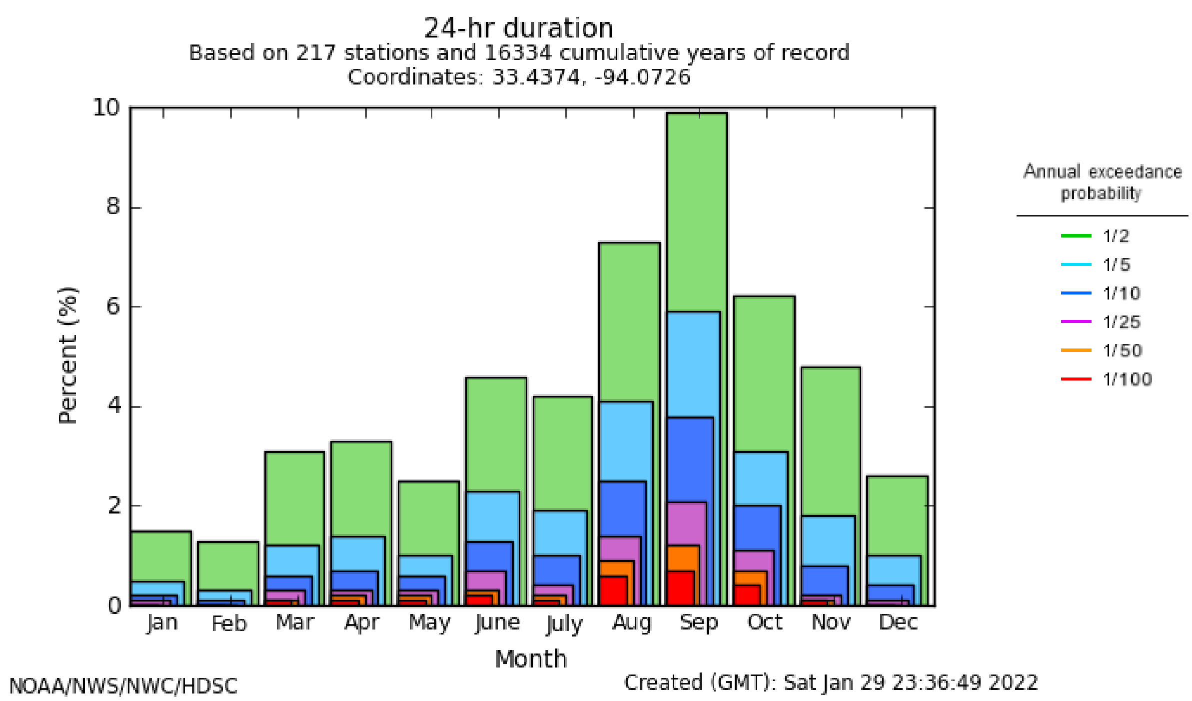
(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

Figure 2.6 Seasonality Graph from Sulphur Springs NOAA Station (near the center of the region)



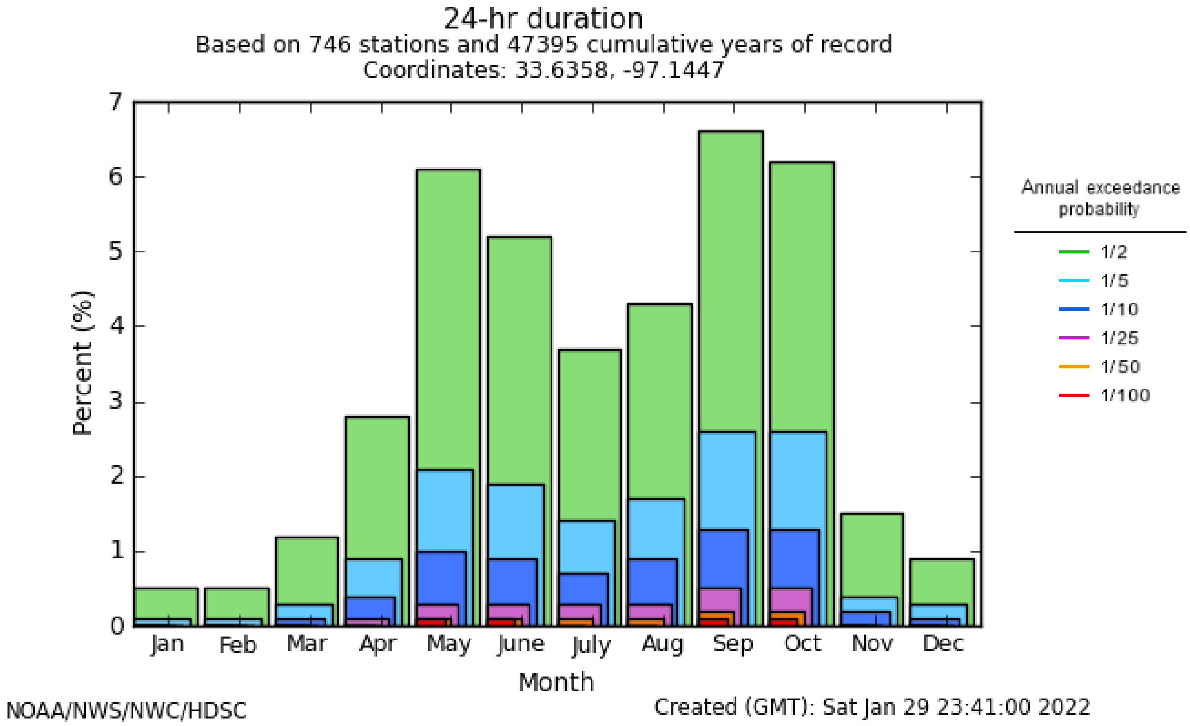
(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

Figure 2.7 Seasonality Graph from Texarkana NOAA Station (northeast corner of the region)



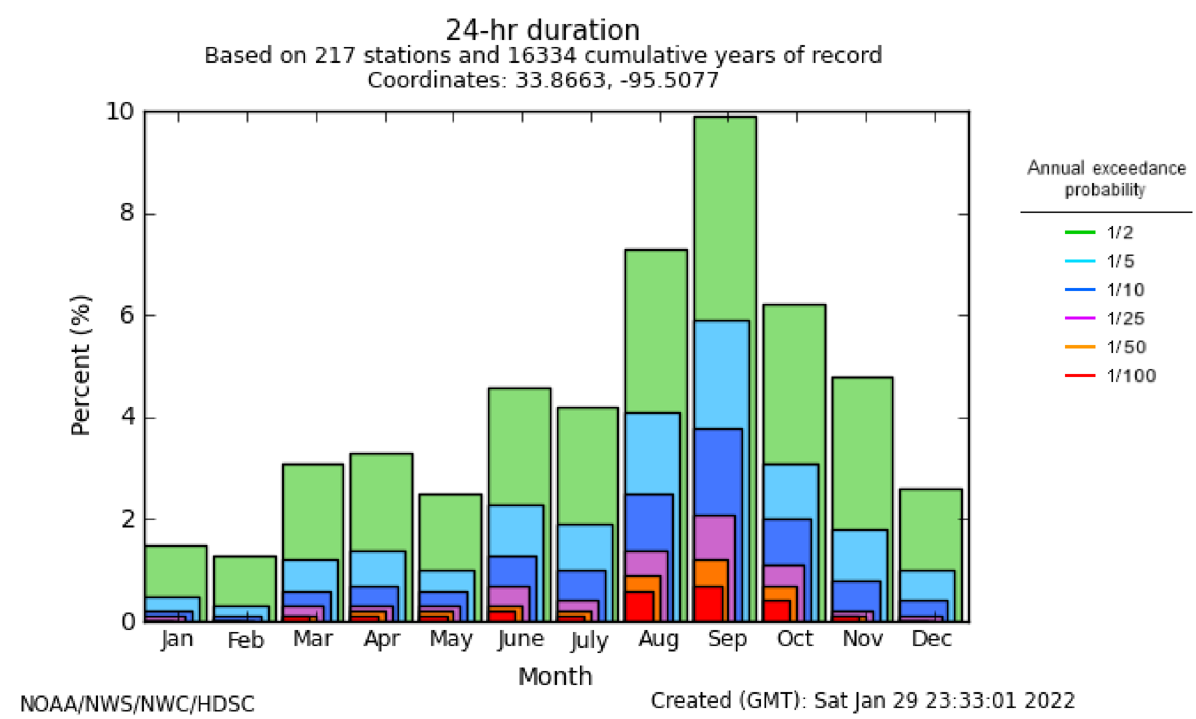
(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

Figure 2.8 Seasonality Graph from Gainesville NOAA Station (northwestern corner of the region)



(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

Figure 2.9 Seasonality Graph from Arthur City NOAA Station (northern center of the region)

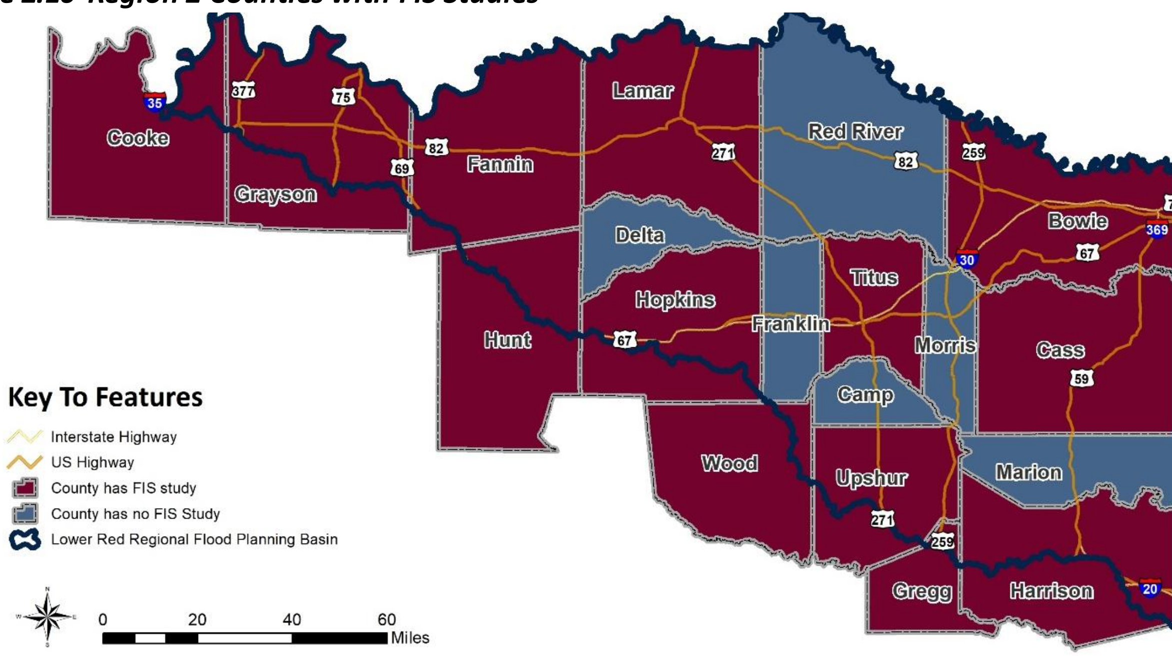


(NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/index.html)

Existing Hydrologic and Hydraulic Model Availability

Known hydraulic and hydrologic models exist for areas of the cities of Paris, Texarkana, and Sherman from local drainage studies. These models were all conducted or updated within the last 10 years. USACE conducted Corps Water Management System (CWMS) watershed modeling for Region 2 for forecasting and dam safety studies. Flood Insurance Study (FIS) studies are presumed to exist for 13 out of the 19 primary counties in the region, but this data has not been requested from FEMA. Out of the 13 counties with FIS studies, nine counties had studies performed within the last 10 years.

Figure 2.10 Region 2 Counties with FIS Studies



Best Available Data

A seamless flood hazard geographical information system (GIS) layer referred to as the "floodplain quilt" was assembled using the best available data for each area in the region. The data sources were prioritized by their accuracy for each area, including the collection method and the spatial representation, establishing a data hierarchy. The intent was not to create a regulatory product but one for planning purposes to identify existing conditions, areas of exposure risk and vulnerability. *Table 2.3* summarizes the hierarchy of the floodplain quilt data sources used for existing conditions.

Existing detailed studies with FEMA effective Zone AE (FEMA detailed 1% ACE floodplains) areas were prioritized as the highest quality data source of established flood risk. Flood risk has been established in these locations based on detailed studies. The largest area of AE exists in Grayson County; otherwise, only the larger cities in the region have detailed Zone AE floodplains. The recently published BLE data was usually considered second-most accurate in the floodplain quilt, having been recently modeled from high-quality lidar data. BLE data was used both where there was no previous mapping and in place of less-reliable FEMA Zone A zones. In Grayson County, in an AE area just downstream of Lake Texoma, BLE was used instead of the AE because the last updated date for that mapping was in 1991, being studied initially in 1978.

BLE products were released for areas within the Red River basin. The drainage areas that fall outside the Red River basins are mostly comprised of FEMA Zone A flood risk mapping or are unmapped. Detailed hydraulic analyses have not been performed to determine Zone A floodplains, so they are often referred to as approximate. No FIS studies exist for Camp, Delta, Franklin, Marion, Morris, and Red River counties; therefore, no regulatory floodplains are mapped for most of the counties. Morris County has some flood insurance rate maps, but they were not available digitally in the TWDB-provided floodplain quilt. The Cursory Floodplain Data was used in these counties in its entirety to represent the limits of the 1% ACE and 0.2% ACE flood events.

Table 2.3 Lower Red-Sulphur-Cypress Floodplain Quilt Data Source Hierarchy Matrix

	Source	1%	0.2%
Best Available Data	Local Floodplain (if determined current)	Local Study, if provided (no additional detailed studies were provided)	Local Study, if provided
↓	National Flood Hazard Layer (NFHL) AE	Zone AE + Pluvial Cursory Floodplain Data	Zone AE + Pluvial Cursory Floodplain Data
↓	Base Level Engineering	BLE + Pluvial Cursory Floodplain Data	BLE + Pluvial Cursory Floodplain Data
↓	NFHL A	Zone A + Pluvial Cursory Floodplain Data	Pluvial Cursory Floodplain Data (no 0.2% ACE Zone in most Zone A areas)
Most Approximate	First American Flood Data Services (FAFDS) or No FEMA	Combined Pluvial & Fluvial Cursory Floodplain Data (Replaced FAFDS with Cursory Floodplain Data)	Combined Pluvial & Fluvial Cursory Floodplain Data (Replaced FAFDS with Cursory Floodplain Data)

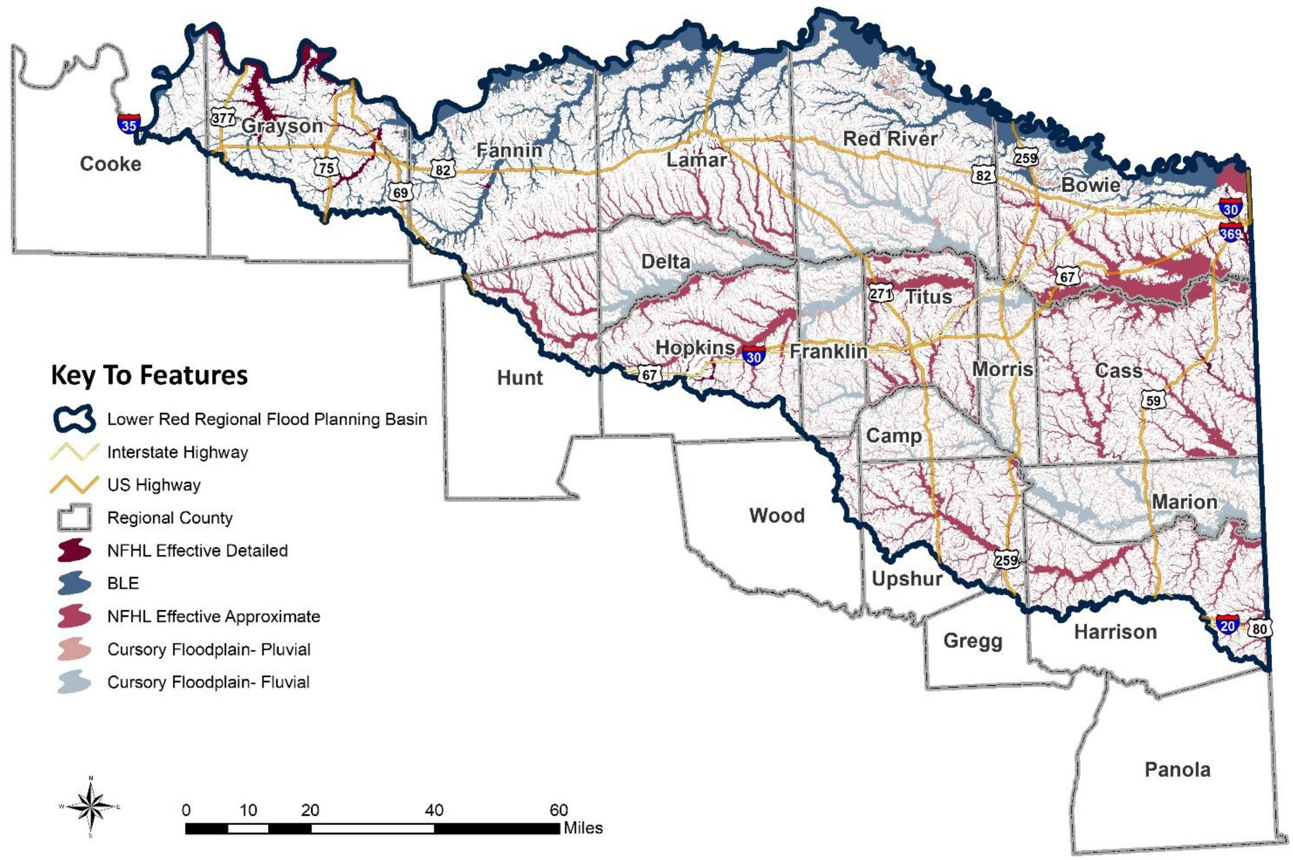
Traditional floodplains are mapped based on fluvial flooding, which is when the water level in a stream or lake rises and overflows onto the surrounding banks and neighboring land. Pluvial flooding typically occurs in more upland areas due to inadequate drainage for intense rainfalls. For Region 2, pluvial and fluvial products from the TWDB-provided Cursory Floodplain Data were incorporated into the floodplain quilt to represent flood risk areas that were missing or had limited data. Pluvial boundary data was created from a complex, proprietary hydraulic model using intensity-duration-frequency (IDF) curves from historical rainfall data mapped to a 30-meter grid. Intended to represent river flooding conditions, the fluvial boundary data was created from a similar modeling process, but stream discharge at inflow points, water levels, and downstream boundaries were incorporated for each river reach. Both data sets were mapped to a three-meter resolution with the TWDB-provided lidar data. The data is intended to be used to understand areas of flood risk where there is no data or limited data.

Pluvial and fluvial datasets were used to represent riverine and upland flooding in counties with no existing mapping (Camp, Delta, Franklin, Marion, Morris, and Red River). New BLE data in the northern part of Red River County was utilized instead of the fluvial Cursory Floodplain Data. All other areas were supplemented with pluvial Cursory Floodplain Data to better capture the region's flood risks. Between 2015-2019, more than 40% of all NFIP paid losses occurred in areas outside of mapped high-risk areas (FEMA Answers to Questions About the National Flood Insurance, 2020), so a fuller understanding of flood risks will help the region better plan and prepare.

1% and 0.2% Annual Chance Exceedance Floodplains

Through this process, the most current and accurate data was pieced together for the region, tying different data sources together without overlap to create the current GIS flood hazard layer of the 1% and 0.2% ACE existing conditions floodplain quilt, as shown in *Figure 2.11*. The 1% ACE fluvial and pluvial flood risk polygons may not be continuous where they are interrupted by the 0.2% ACE BLE or Zone AE floodplain. This is because these 0.2% ACE floodplains are considered higher quality and outrank the pluvial 1% ACE.

Figure 2.11 Region 2 Floodplain Quilt



With the addition of the non-regulatory data sources, total flood hazard areas by flood frequency and county can be summarized, as seen in *Figure 2.12.* The percentage of the area in a county within the 1% or 0.2% ACE floodplain quilt is noted in *Table 2.4*.

Figure 2.12 Square Miles of Flood Hazard in Each County in the Region

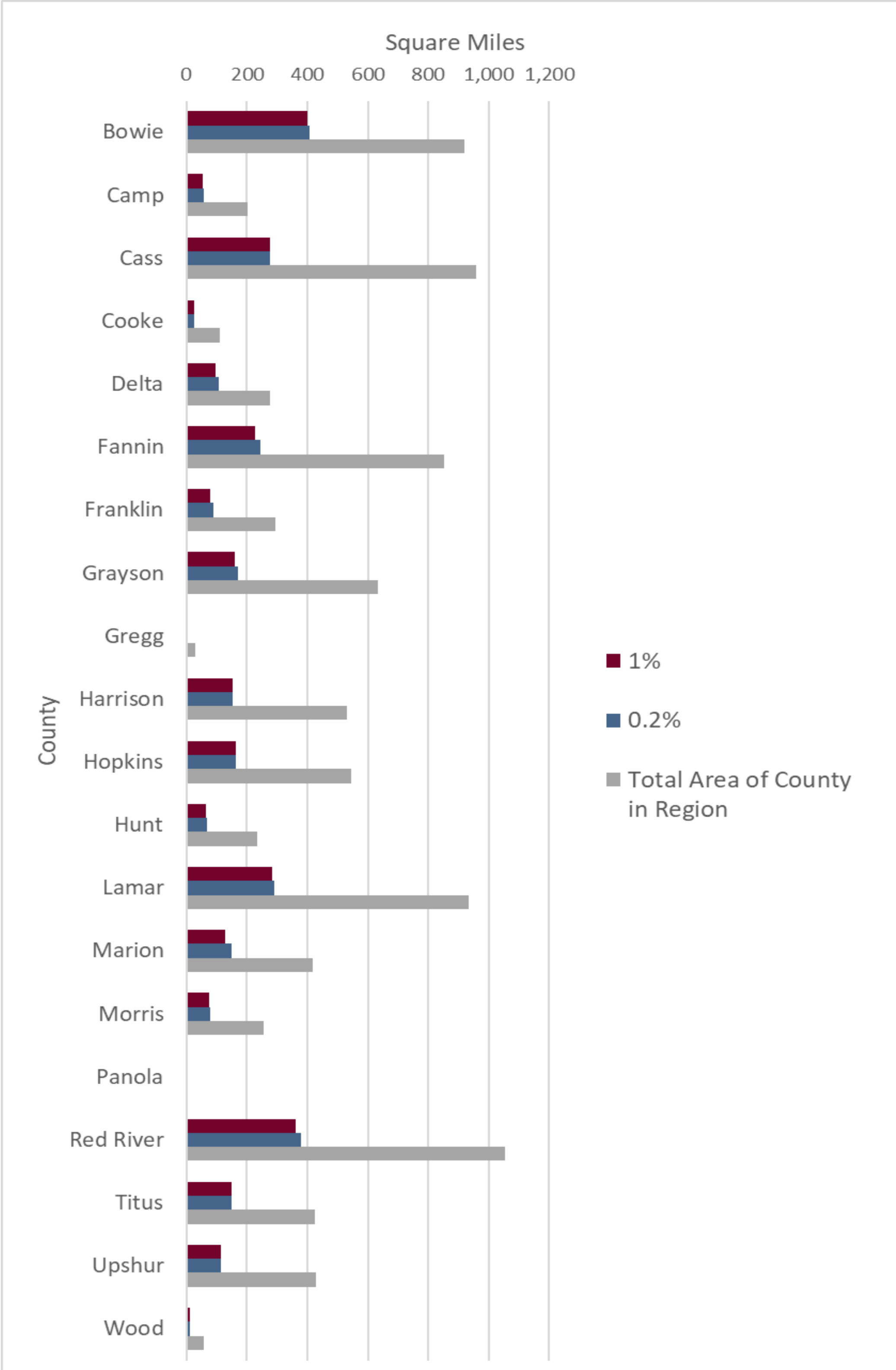


Table 2.4 Percentage of County in the Flood Hazard Area

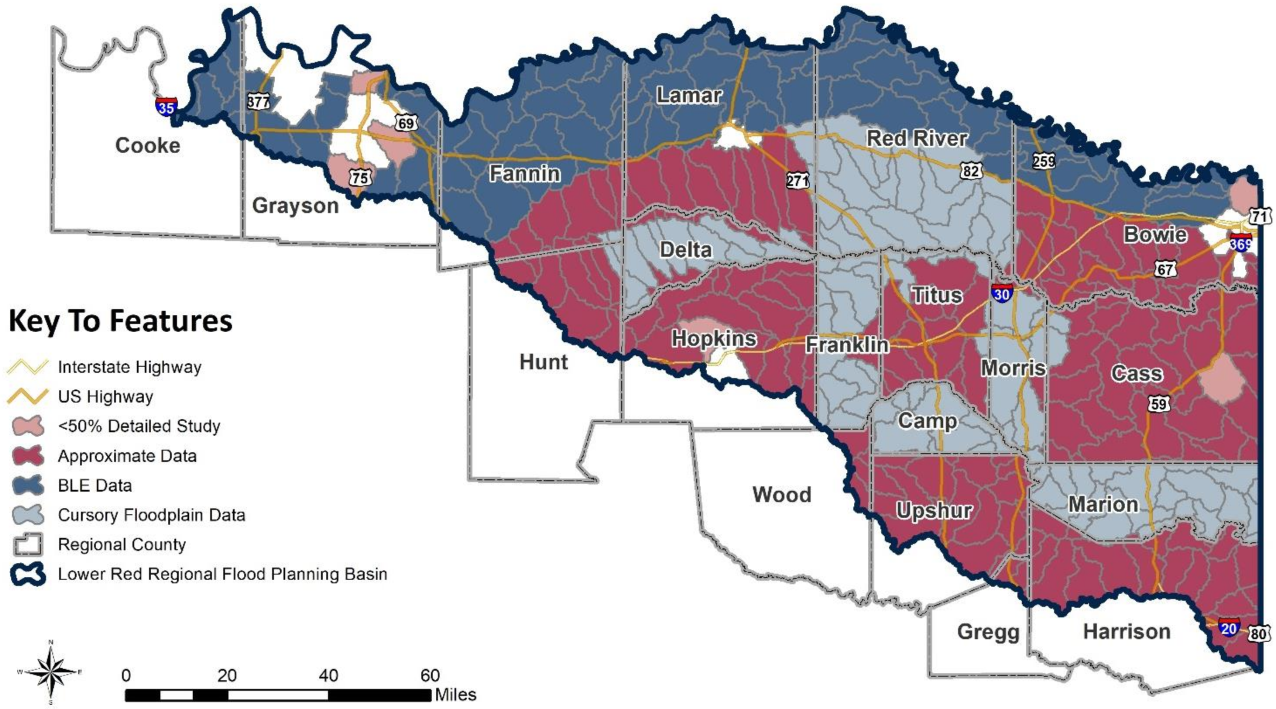
County	Percentage of County in the Region in the 1% And 0.2% Flood Hazard Area
Bowie	44.2%
Camp	27.6%
Cass	28.9%
Cooke*	24.5%
Delta	39.0%
Fannin*	28.5%
Franklin*	29.8%
Grayson*	26.7%
Gregg*	20.8%
Harrison*	28.7%
Hopkins*	30.1%
Hunt*	28.3%
Lamar	31.3%
Marion	35.5%
Morris	30.0%
Panola*	9.2%
Red River	35.9%
Titus	35.4%
Upshur*	26.7%
Wood*	20.2%

**Entire County is not within Region 2's Boundary*

Data Gaps

Data gaps are areas lacking current modeling and/or mapping, including missing and/or outdated data. Data gaps were identified by identifying the best available data sources for flood hazard studies. Local knowledge of flooding was also collected through the process of community input. Gaps were captured at the HUC-12 level to understand the need for detailed studies in the region.

Figure 2.13 Gaps in the Current Detailed Flooding Data



2A.2 Existing Condition Flood Exposure Analysis

2A.2.A Existing Development and FEMA Floodplains

A region-wide GIS analysis was conducted to understand who and what might be affected by both the 1% and 0.2% ACE flood events indicated in the extent of the floodplain quilt. Structures, populations, critical facilities, infrastructure, and agricultural areas were evaluated at a high level to understand the regional impact of flooding. Most of these datasets were provided by the TWDB and confirmed and sometimes supplemented through the public input process of the Regional Flood Planning Group (RFPG).

Each dataset was intersected with the floodplain quilt to create exposure-related output files to glean summaries of flooding impact for all areas within the region. The related exposure output GIS files are part of the results of the flood planning process. The exposure results by county are summarized in Table 3.

Existing regulatory FEMA floodplains exist for many counties in the region. *Table 2.5* shows identified areas of increased flood risk for each county in the floodplain quilt compared to the limited areas of FEMA regulatory mapping, as well as possible structures at risk. It is essential to understand flood risks beyond the FEMA floodplains because over 20% of NFIP claims occur outside of the high-risk (1% ACE) flood zones (https://www.fema.gov/press-release/20210318/fact-sheet-flood-plain-management-insurance-and-rebuilding). In larger events, such as Hurricane Harvey, more than 50% was outside a designated flood zone (https://www.tdi.texas.gov/tips/flood-insurance-cost.html). For this planning cycle, structures are identified from high-level mapping efforts and have not been verified to be a fully walled or finished-out building.

Table 2.5 Square Miles in FEMA Regulatory Floodplain vs. Determined Flood Hazard Area

County	Square Miles in FEMA Regulatory Floodplain (1% and 0.2% ACE)	Square Miles in Determined Floodplain Quilt (1% and 0.2% ACE)	Structures in FEMA Regulatory Floodplain (1% and 0.2% ACE)	Structures in Determined Floodplain Quilt Area (1% and 0.2% ACE)
Bowie	324	407	1,839	3,055
Camp	0	56	0	276
Cass	175	276	290	583
Cooke*	10	27	6	38
Delta	1	108	1	127
Fannin*	153	243	749	1,256
Franklin*	0	88	0	555
Grayson*	109	169	1,689	2,924
Gregg*	3	6	14	58
Harrison*	84	153	663	917
Hopkins*	108	164	340	710
Hunt*	45	66	202	432
Lamar	184	292	1,259	1,904
Marion	0	149	1	390
Morris	0	77	1	265
Panola*	0	0	0	0
Red River	0	379	0	441
Titus	103	151	266	634
Upshur*	70	114	189	432
Wood*	5	11	7	26

**Entire County is not within Region 2's Boundary*

2A.2.B Potential Flood Mitigation Projects

Through this planning cycle's extensive public input process, no flood mitigation projects with dedicated construction funding and scheduled completion were identified. There are water supply projects (Bois d'Arc Lake and Lake Ralph Hall) under construction, but these projects do not have a flood control function.

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

The exposure analysis considers populations and properties potentially impacted by levees that do not meet FEMA accreditation. Through the regional infrastructure inventory process, 19 levee systems were identified in the region. However, 11 levees are considered *Non-Accredited* by FEMA's classification standards. This classification occurs when an area goes through a remapping process and the levee is no longer certified as meeting the minimum federal requirements for reducing the flood hazard. *Table 2.6* shows the number of people and structures potentially impacted by non-accredited levees.

The Texas Commission on Environmental Quality (TCEQ) provided a list of dams in their inventory and, for those that had been inspected, the dam condition. Due to security concerns, TCEQ does not release the hazard classification based on the amount of damage and loss of life expected in the event of a breach, emergency action plans, or potential inundation areas that dam breaches would cause. To get a sense of the potential risks of a dam breach in the region, we included a summary of the number of dams that have been inspected and listed in poor condition, as provided by TCEQ, shown in Dams in poor condition are not necessarily at risk of imminent failure but are at a higher risk than those in good or fair condition. Dams in fair or good condition can still breach, especially if they are overtopped by a flood larger than their capacity. Unfortunately, TCEQ does not provide information to assess the dam's capacity to handle design flows.

Table 2.6 Populations and Structures Potentially Impacted by Non-Accredited Levees per County in Region 2

County	Population at Risk	Structures at Risk
Bowie	174	151
Delta	0	1
Hopkins	25	6
Marion	35	14

(USACE, National Levee Database, and the TWDB-provided structures, including nighttime population from Oak Ridge National Laboratory 2019 Landscan population estimates)

Table 2.7 Number of Dams Inspected Known to be in Poor Condition per County in Region 2

County	Dams Known to be in Poor Condition
Bowie	4
Cass	2
Franklin	1
Grayson	5
Harrison	1
Hopkins	1
Hunt	3
Lamar	2
Morris	4
Red River	2
Titus	5
Upshur	3

(TCEQ, Dam Inventory, 2021 and National Inventory of Dams)

2A.2.D Potential Flood Exposure

Residential Properties and Associated Population

Building footprints were provided by the TWDB in November 2021 through the Flood Planning Data Hub. They are comprised of building footprint locations developed by Texas Natural Resources Information System (TNRIS) utilizing information from Microsoft Buildings and Stratmap lidar, each containing:

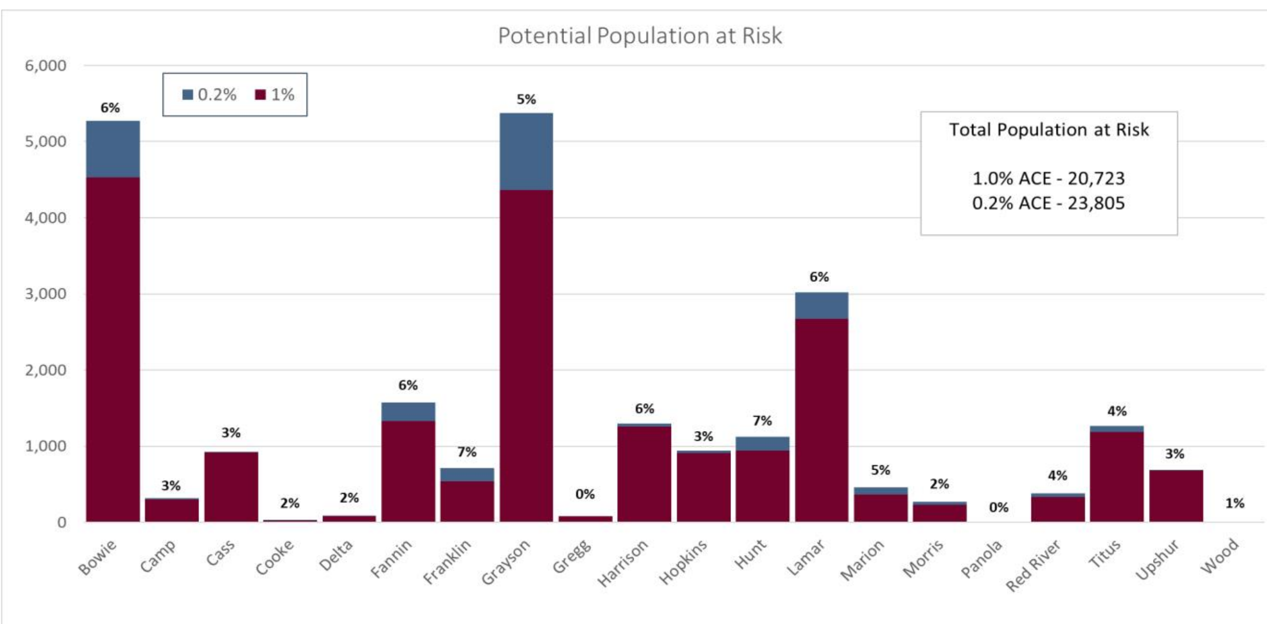
- land use type derived from TNRIS parcel data land use categories
- Social Vulnerability Index (SVI) value from the Centers for Disease Control and Prevention (CDC) gathered from the U.S. Census tract
- day and night population from 2019 Landscan population estimates from Oak Ridge National Laboratory
- estimate of floors in a structure when heights were available from lidar

For this first regional analysis, the term structure and building are interchangeable. The numbers and classification of their use are derived from this generalized but detailed mapping process at the state level. These numbers could be higher than actual insured structures, but it was noted in some areas these footprints did not capture recently constructed finished buildings.

Night and daytime population estimates were distributed to the buildings based on their identified square footage of the building footprint from high level mapping efforts. Nighttime populations were used for the analysis since they represent the distribution of people and homes in a community. Approximately 15% of impacted structures identified as residential did not have populations associated with them; however, upon review, it was hard to determine at this scale which structures were habitable homes, so the numbers were not adjusted during this planning cycle. The distribution of the population potentially living in the identified flood hazard areas is shown in *Figure 2.15*. All counties with any area in the region are included in the exposure analysis graphs, but the amount of impact only refers to the county's area within the flood planning region. Approximately 23,800 people live within the 0.2% ACE floodplain.

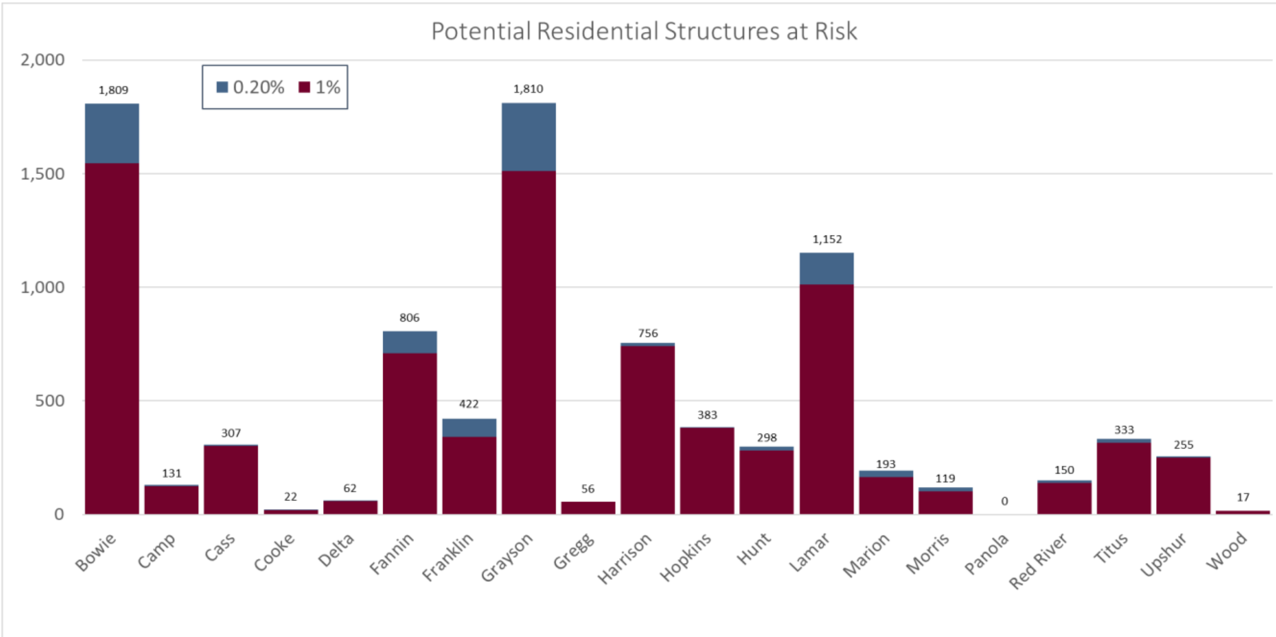
The population potentially at risk from the identified 1% and 0.2% ACE flood hazard is proportionate to the most populated counties with the highest number of people and residential structures in Grayson, Bowie, and Lamar, in that order (*Figure 2.14*). It is important to note that Grayson County is only partially in the region. Hence, the potentially impacted population of 5,376 represents the portions of the county that are within the region. Bowie has slightly more people and residential structures at risk in the 1% ACE floodplain, with an estimated population of 4,529 in the 1% flood hazard area. Red River has the largest land area in the region and the second-largest amount of identified flood hazard area, but one of the smaller amounts of residential structures with a nighttime population impacted in the 1% and 0.2% ACE floodplain of 380 people.

Figure 2.14 Potential Nighttime Population at Risk in Flood Hazard Area



The percentage indicates the total nighttime county population within Region 2

Figure 2.15 Potential Residential Structures at Risk in Flood Hazard Area



Non-Residential Properties

The type (use) of the structure was assumed to be the same as the land use, as provided by TNRIS. *Figure 2.16* shows a summary of the structure type for the region. *Figure 2.17* shows a breakdown of the non-residential structures by county. The most populated counties also have the most non-residential properties at risk. However, the number of non-residential properties is highest in Bowie County, with an estimated 1,246 non-residential structures in the 1% and 0.2% ACE flood hazard areas. The highest number of commercial buildings potentially at risk, 577, is in the portion of Grayson County within Region 2. Agricultural buildings are the second highest type of structure at risk after residential buildings with an estimated 2,142 buildings in the flood risk area. Lamar County has 395 agricultural buildings in the risk area, while Grayson County has 386.

Figure 2.17 shows the regional composition of the types of structures, with categories developed by TNRIS within the flood hazard area.

Figure 2.16 Types of Structures Within the Flood Hazard Area

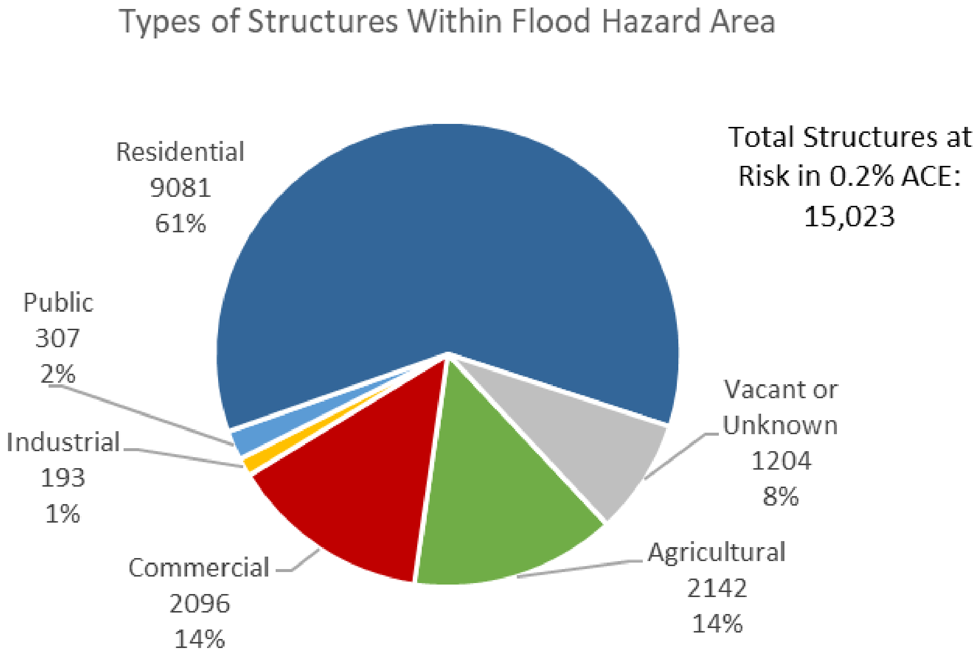
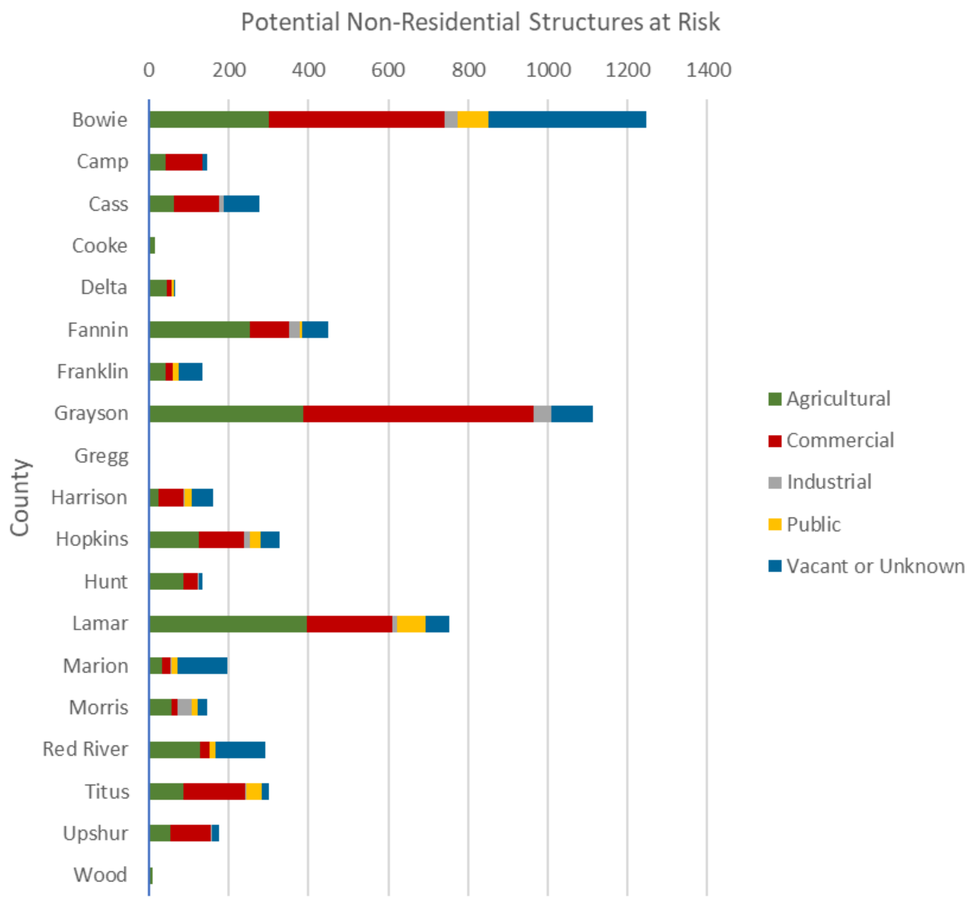


Figure 2.17 Number and Type of Non-Residential Structures in the Flood Hazard Area

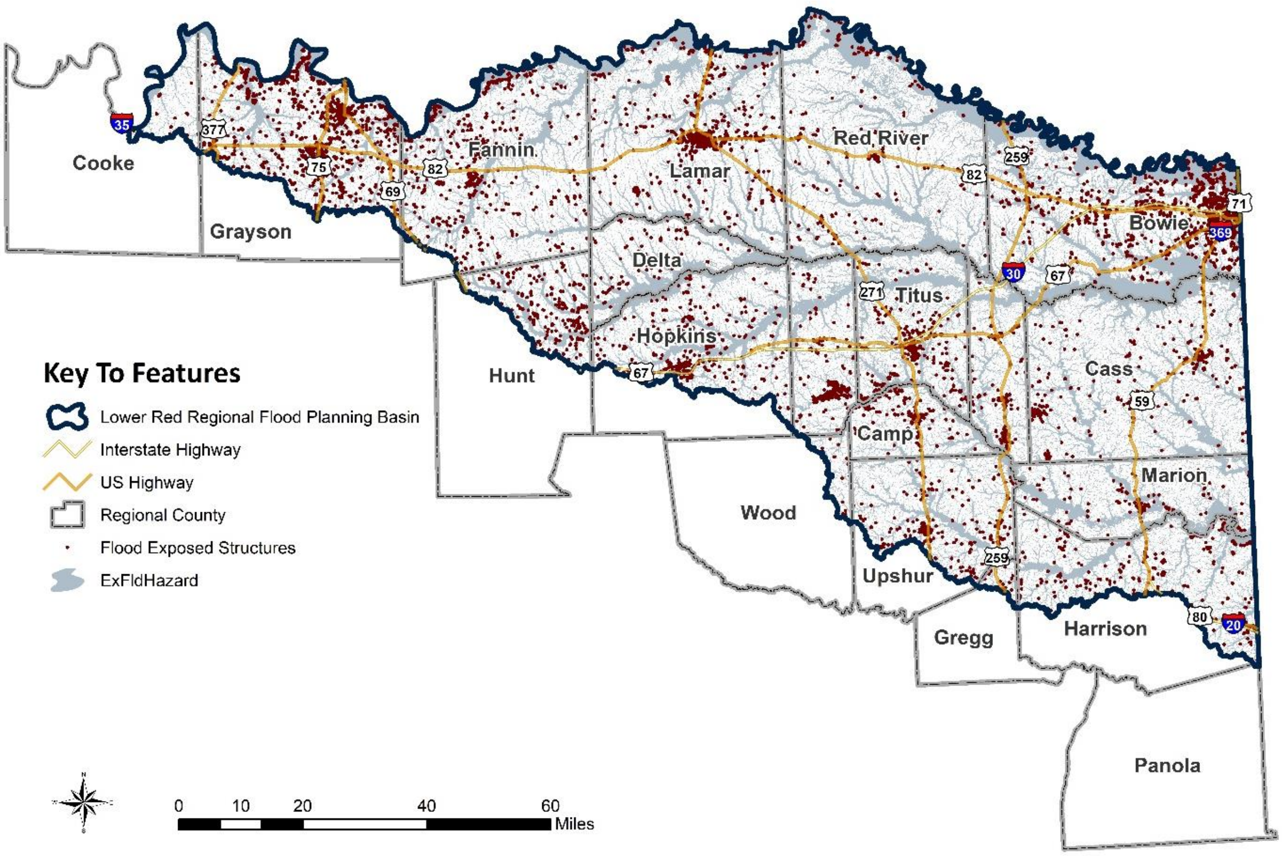


Structures - Loss of Function

Residential structures are the predominant structure at risk, with approximately 8,000 homes in the determined 1% ACE flood risk area, as shown in *Figure 2.18*. Grayson County has the highest number of residential homes in the combined 1% and 0.2% ACE areas. Sherman and Denison are two of the three most populated cities in the region. However, Bowie County has nearly the same number of impacted structures but with about half of the population of the portion of Grayson County in the region. Bowie County has slightly more residential structures in the 1% ACE than Grayson County.

Residential displacement from a disaster can have ripple effects on a community depending on the extent of the disaster impacting everything from employment to basic human needs. The 2017 Atlantic hurricane season was the seventh most active season since recording in 1851, displacing three million people in 16 countries (https://www.internal-displacement.org/sites/default/files/publications/documents/2018-GRID-spotlight-atlantic-hurricane-season_0.pdf). By 2020, 20% of a sample survey of 1,065 respondents of people displaced by Hurricane Harvey were still in temporary housing and over 23% reported a related job loss in the family from the hurricane (https://uh.edu/hobby/harvey/).

Figure 2.18 Structures in the Flood Hazard Area



Utility Infrastructure

The exposure analysis looked at many facets of the effects of flooding at a regional level, including public infrastructure. Readily available datasets were included and data was collected during the public input process. This included airports, roads, power plants, gas and power lines, wastewater outfalls, water/wastewater treatment plants, and publicly entered lift stations. GIS files for airports, power plants, and major gas and electric transmission lines were obtained from the TWDB Flood Planning Data Hub or the federal Homeland Infrastructure Foundation-Level Data (HIFLD) repository. Wastewater outfalls and water treatment plant locations were acquired from TCEQ.

Potentially impacted large gas and electric transmission lines are located throughout the region, with over 515 linear miles of gas lines and over 720 miles of electric lines within the determined flood hazard area. These transmission lines were not deemed critical for analysis as it is difficult to determine how significantly a flooding event would affect them. While assessment of the lines themselves is beyond the scope of this effort, powerline safety in and near water bodies is an important issue in Region 2. In 2017, three Boy Scouts were killed when their sailboat hit a power line on Lake O' the Pines. This led to the Texas Legislature passing the Willam Thomas Heath Power Line Safety Act to ensure adequate clearance is provided below power lines for the type of navigation that is likely on a particular water body. Implementation of this law is ongoing as transmission companies upgrade their lines as needed. This effort will help prevent damage to electrical lines from flooding as well.

Both Cedar Mills Airport in Grayson County and Greater Morris County Airport in Morris County fall within the determined flood hazard areas. Treatment plants in the cities of Diana, Paris, Commerce, and Bonham and over 90 TCEQ-permitted wastewater outfalls are within the flood hazard area. The public input process reported eight lift stations as critical infrastructure within the flood hazard area. While they were only reported for the City of Paris, they are likely found within the flood hazard throughout the region. Water outfalls, treatment plants, and lift stations are designed to exist in lower elevations but are all considered critical to health and human safety. Any sustained inundation in these areas could potentially impact the operations of water and wastewater treatment. Inundation at an outfall location could cause potential upstream operational issues, resulting in additional flooding and/or water and wildlife contamination.

Major Industrial and Power Generation Facilities

Four of the region's 18 power plants on file with the HIFLD fall within the determined 1% ACE hazard area. Three of the four use fossil fuel, and one is a hydroelectric facility. The hydroelectric power plant is in Grayson County, outside the City of Denison, while the other three are in Titus, Red River, and Fannin counties. The turbines in the Denison plant have recently been replaced and will increase the electrical generation capacity of the plant from about 42 megawatts to over 50 megawatts (https://www.kxii.com/2021/01/20/historic-work-underway-at-denison-dam-powerhouse/).

Power and Utility Infrastructure - Loss of Function

Wastewater treatment facilities have a high level of risk in the event of a flood. These low-lying facilities and lift stations are vulnerable because of their lower elevations and proximity to streams and floodplains. Dysfunction of wastewater systems can result in system failures and surface water contamination from sanitary sewer overflows, potentially killing wildlife and affecting ecosystems. Smaller components of wastewater systems, such as wastewater transmission mains and manhole locations, were not submitted for analysis.

Four power plants in the 1% ACE flood risk area can potentially impact electric services in the region. More analysis would need to be conducted to understand the resiliency of the plants and the energy network.

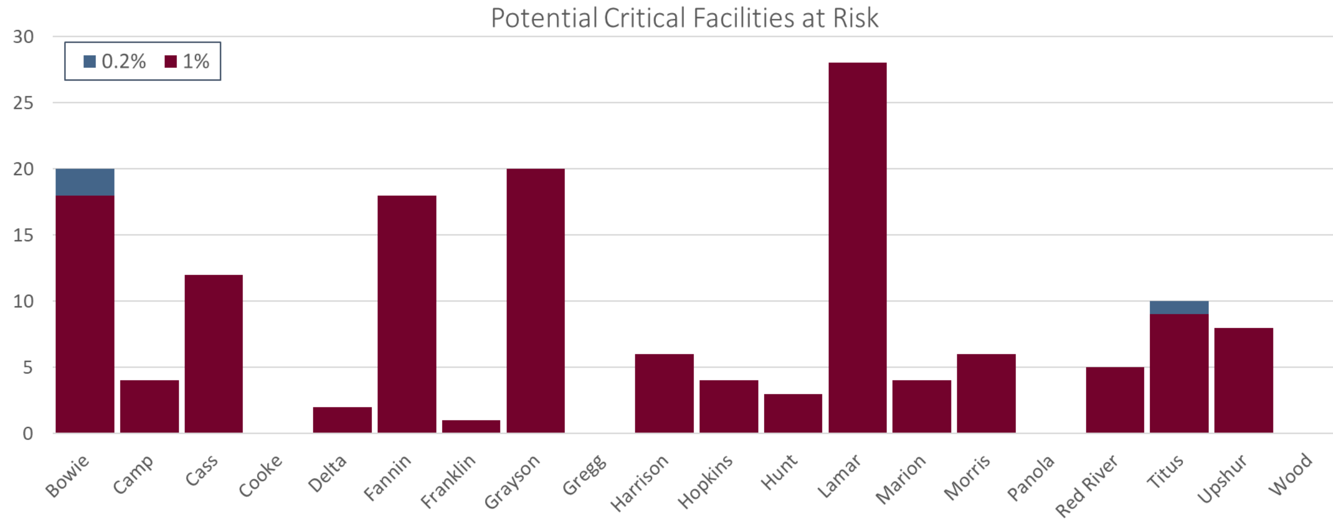
Critical Facilities

The State of Texas defines a critical facility as including all public and private assets, systems, and functions vital to the security, governance, public health and safety, economy, or morale of the state of the nation (https://statutes.capitol.texas.gov/Docs/GV/htm/GV.421.htm). Schools, hospitals, police stations, fire stations, emergency shelters, nursing homes, assisted living centers, power generation facilities, superfund sites, and water and wastewater plants were deemed critical facilities in this plan. These GIS data sets were gathered from either the TWDB Flood Planning Data Hub, which was from HIFLD, TCEQ, or Texas Education Agency.

The critical facility locations were overlaid with the existing flood hazard areas to determine the magnitude of community exposure in a significant flood. Similar to population and structure impacts, the top three highest impacted counties are Grayson, Bowie, and Lamar; however, Lamar County had the highest number of critical facilities potentially affected by the flood hazard. The City of Paris submitted many critical facility locations through the public input process, such as their lift stations. Throughout the region, 151 critical facilities were at risk of potential flooding from the determined flood hazard. There are nine schools, five police stations, six fire stations, two hospitals, six nursing homes, and seven shelters, which could be churches, schools, or other community centers. The rest are comprised of infrastructure-type critical facilities, including the permitted wastewater outfalls.

The initial dataset of over 1,000 critical facilities for the region was reviewed at a high level, prioritized, and reviewed for accuracy. Still, all locations could not realistically be verified for this planning cycle. The initial datasets are often created for statewide or national analysis and are not necessarily located in the precise location of the structure.

Figure 2.19 Number of Critical Facilities in the Flood Hazard Area



Health and Human Services - Loss of Function

Critical facilities provide essential services during and after a disaster. The Wadley Hospital in Texarkana is in a pluvial mapped 1% ACE floodplain. Bowie, Camp, Grayson, and Hopkins counties nursing homes fall under 1% ACE. Seven designated emergency shelters, including churches, schools, and community centers, fall within the flood hazard area. The City of Paris has a fire and a police station in the 1% ACE area. Harrison County has two volunteer fire department buildings in 1% ACE, in Nesbitt and Uncertain. Critical care facilities in flood hazard areas put patients and caretakers at risk during times of emergency and worst-case flooding scenarios become inoperative.

Roadway Stream Crossings

Roads were analyzed at a high level to understand potential impacts from 1% or 0.2% annual chance flood event. To get an understanding of the number of potential exposures for this planning cycle, road locations from the Texas Department of Transportation (TxDOT) were intersected with the best and latest stream data, which was a combination of named tributaries from the National Hydrography Dataset and recently aligned BLE streams (being performed in the region under a separate TWDB contract) to get a count and location of potential crossings. Elevations were not considered in this analysis.

Figure 2.20 captures the potential impacts flooding could have on roads based on the number of locations of intersections of streams. The fourth-largest county in the region, Bowie, had the highest number of potential stream crossings, at 373 with both the Sulphur and Red River converging within County limits. Fannin County had the second-highest number of road stream crossings, totaling 300.

Locations of low water crossings, which are roadway creek crossings frequently inundated, were also incorporated into the exposure analysis. These locations were provided from the TWDB Flood Planning Data Hub, collected by TNRIS. Both datasets have been kept and identified separately due to some low water crossings not being located at an actual stream and road intersection. *Table 2.8* identifies the locations of low water crossings by county.

Roadway Segments

The determined flood hazard area GIS layers were overlaid with the TxDOT roads, including all TxDOT and other known public roads, to determine the miles of roads potentially impacted by a flooding event (*Figure 2.22* and *Figure 2.23*). Similar to roadway stream crossings, Bowie County has the most linear miles, 336 in the identified 1% and 0.2% ACE. Lamar County has nearly 240 miles within the 1% and 0.2% ACE areas between the Red River and the Sulphur River.

Figure 2.20 Number of Road and Stream Crossings in Flood Hazard Area

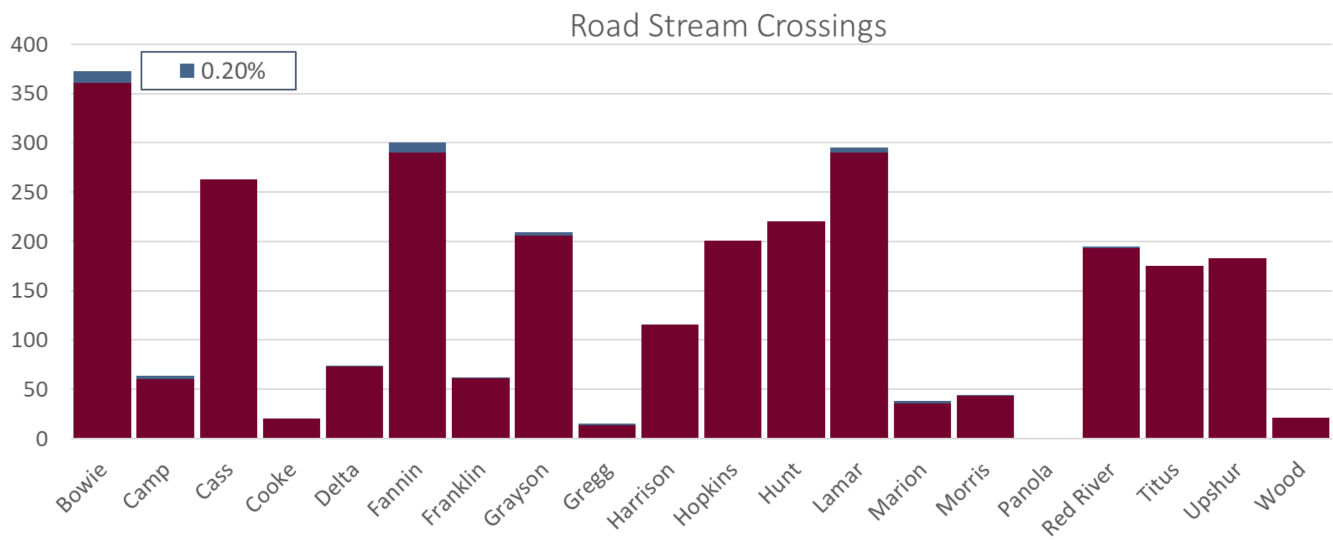


Figure 2.21 Road and Stream Crossings in the Flood Hazard Area

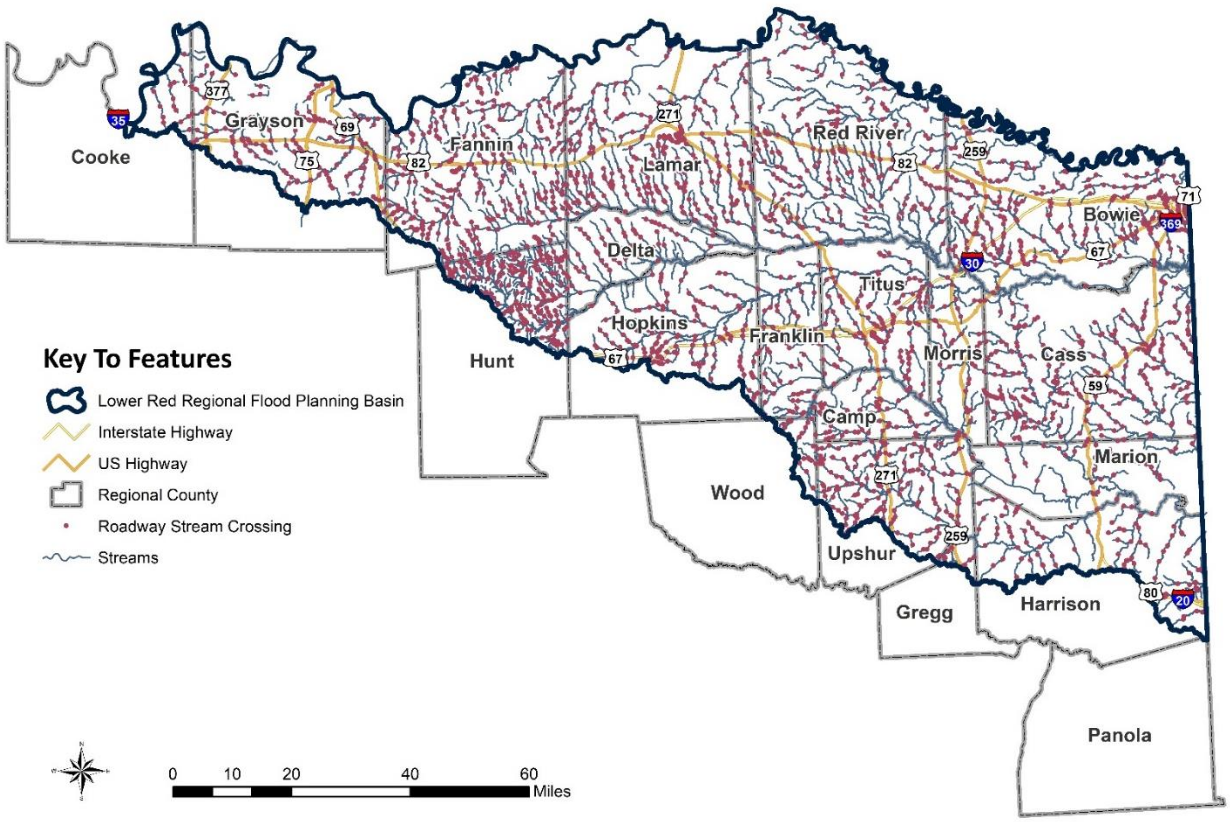


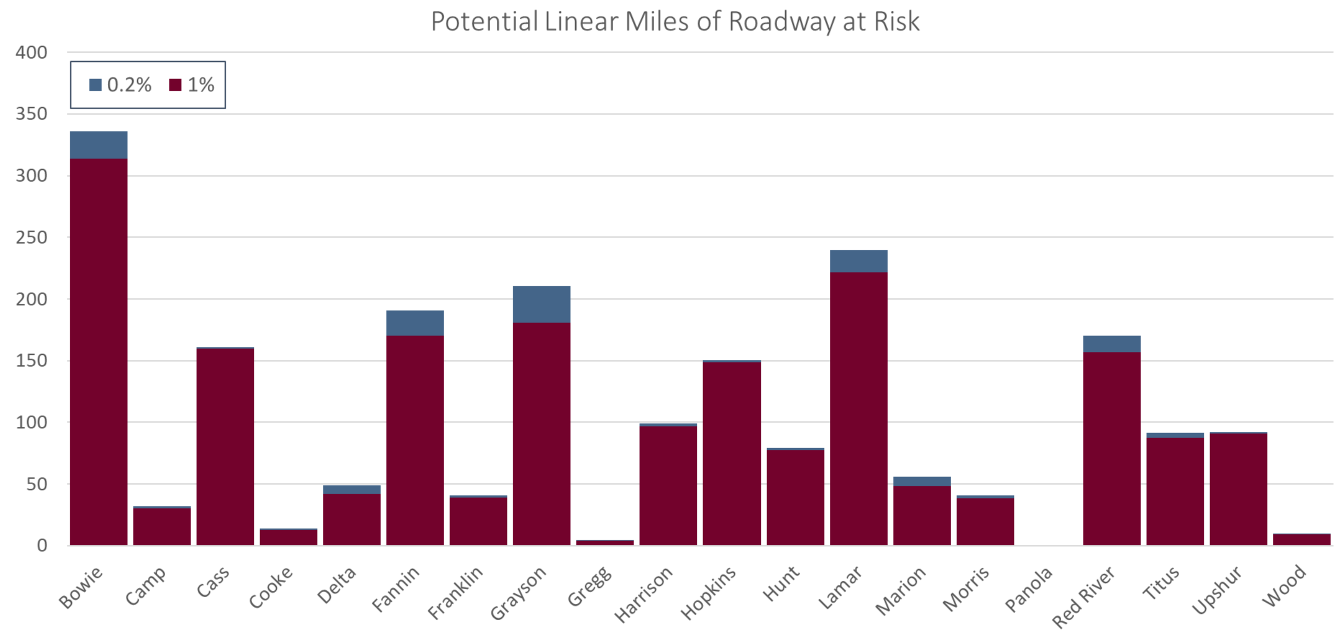
Table 2.8 Low Water Crossings by County

County	Number of Low Water Crossings
Bowie	7
Camp	1
Cass	7
Delta	8
Fannin	26
Franklin	5
Grayson	8
Harrison	5
Hopkins	3
Lamar	15
Marion	1

County	Number of Low Water Crossings
Morris	2
Red River	16
Titus	9
Upshur	3

(TNRIS, Region 2 Flood Planning Public Input)

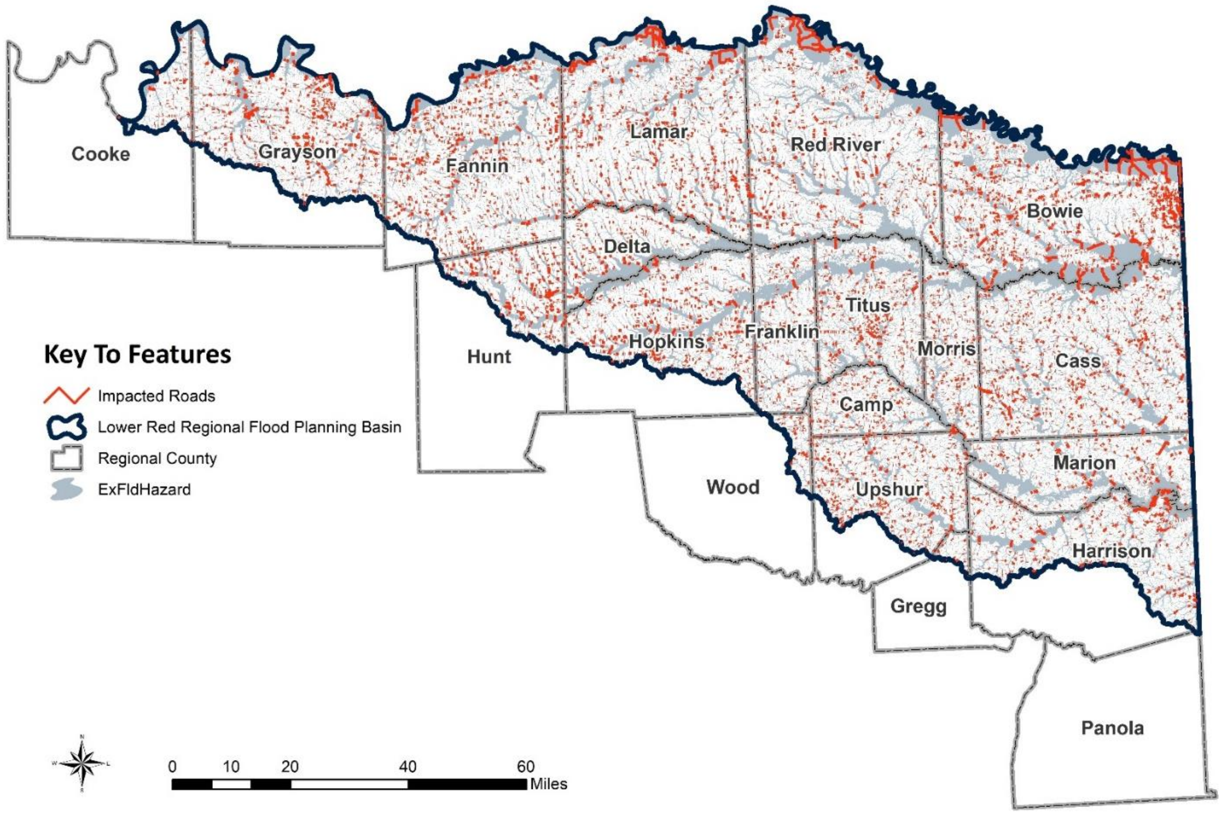
Figure 2.22 Miles of Roadway in the Flood Hazard Area



Transportation - Loss of Function

Flooding is a considerable threat to the road network of the region. The vast system of tributaries and floodplains of the Sulphur, Cypress, and Red Rivers intersect with 2,868 roads in the determined 0.2% flood hazard area. County roads account for 36% of these intersections, which means access for providing emergency services or fleeing from hazard areas could be compromised. Out of all flood hazards, traveling on flooding roads provides the most imminent danger to human life. Texas has the highest number of flooding-related fatalities in the country, with 222 reported from 2010-2020 (https://www.weather.gov/images/arx/floodeaths/2020_total.png). In Texas and the country, flash flooding is the leading cause of weather-related deaths, and 76% are vehicle-related deaths (https://www.floodsafety.com/national/life/statistics.htm). Between lack of access during emergencies and the risk of being washed away during a flood, these potentially flooded roadways represent a significant risk in the region.

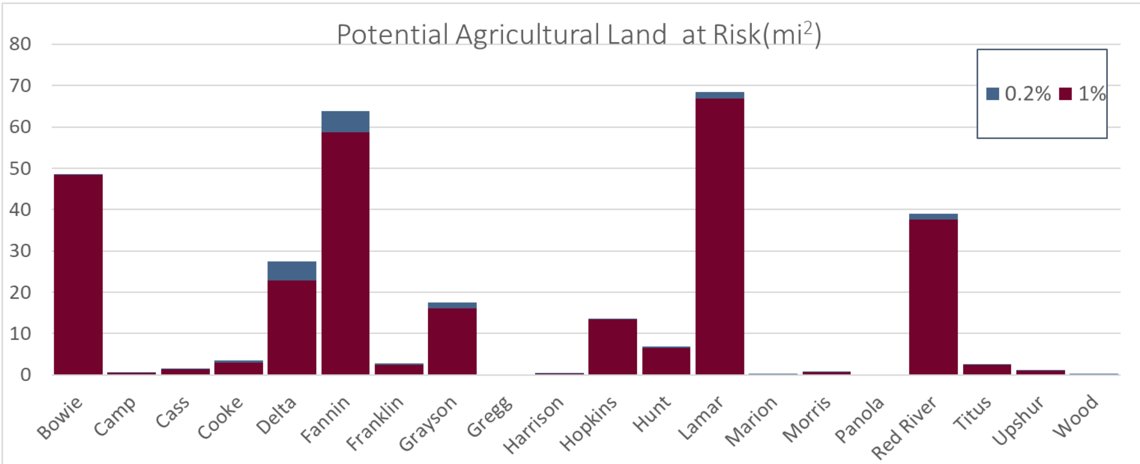
Figure 2.23 Road Segments in the Flood Hazard Area



Agricultural Area

As a primary economic driver for the region, the effects of agricultural flooding were evaluated for Region 2. The United States Department of Agriculture (USDA) CropScape data layer was intersected with the floodplain quilt to show the land cover and crops potentially impacted by a 1% and a 0.2% ACE flood. Just over 305 square miles of farmland in the region falls within the determined flood hazard area, which accounts for 10% of the total land in the flood hazard area. The distribution of the farmland can be seen in *Figure 2.24.*

Figure 2.24 Square Miles of Agricultural Land in Flood Hazard Area

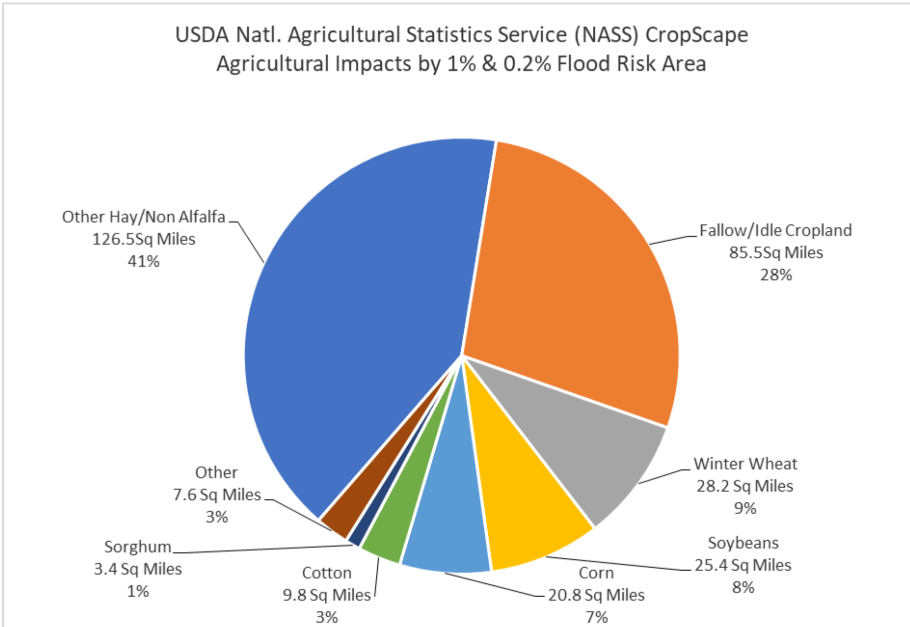


The breakdown of the type of crops in the flood hazard area can be seen in *Figure 2.25*. At a regional planning level, it is difficult to determine what type of rain event would affect which crops because of differences in harvesting schedules and crop suitability. The value of the top six producing crops for the area at risk exceeds $47 million.

Table 2.9 illustrates the value of the top six crops assuming average published commodity prices and yields from 2021 USDA reports.

Depending on the severity and length of a flooding event, the suitability of the farmland can be compromised; as such, we estimated the value of cropland within the region potentially exposed to flooding. The 2021 USDA value of cropland is $2,150 per acre. The value of the 196,670 acres in the determined 1% and 0.2% ACE floodplain is over $422 million.

Figure 2.25 Composition of Cropland in the Flood Hazard Area



(USDA NASS CropScape Cropland Data Layer)

Table 2.9 Valuation of the Top Six Crops in the Flood Hazard Area

Crop	Acreage	November 2021 Value Per Unit	2021 Yield Average per Acre	Estimated Value
Other Hay/ Non-Alfalfa	80,943	$147/ton	1.85	$22 Million
Winter Wheat	18,073	$7.78/bushel	30	$4.2 Million
Soybeans	16,252	$12.20/bushel	38	$7.5 Million
Corn	13,339	$5.27/bushel	128	$9 Million
Cotton	6,267	$.86/lb	695	$3.7 Million
Sorghum	2,198	$5.60/cwt	61	$750,800

(USDA, https://downloads.usda.library.cornell.edu/usda-esmis/files/c821gj76b/02871x558/bz60dx529/agpr1221.pdf, https://www.nass.usda.gov/Statistics_by_State/Texas/Publications/Current_News_Release/2022_Rls/spr-ann-crop-prod-2022.pdf)

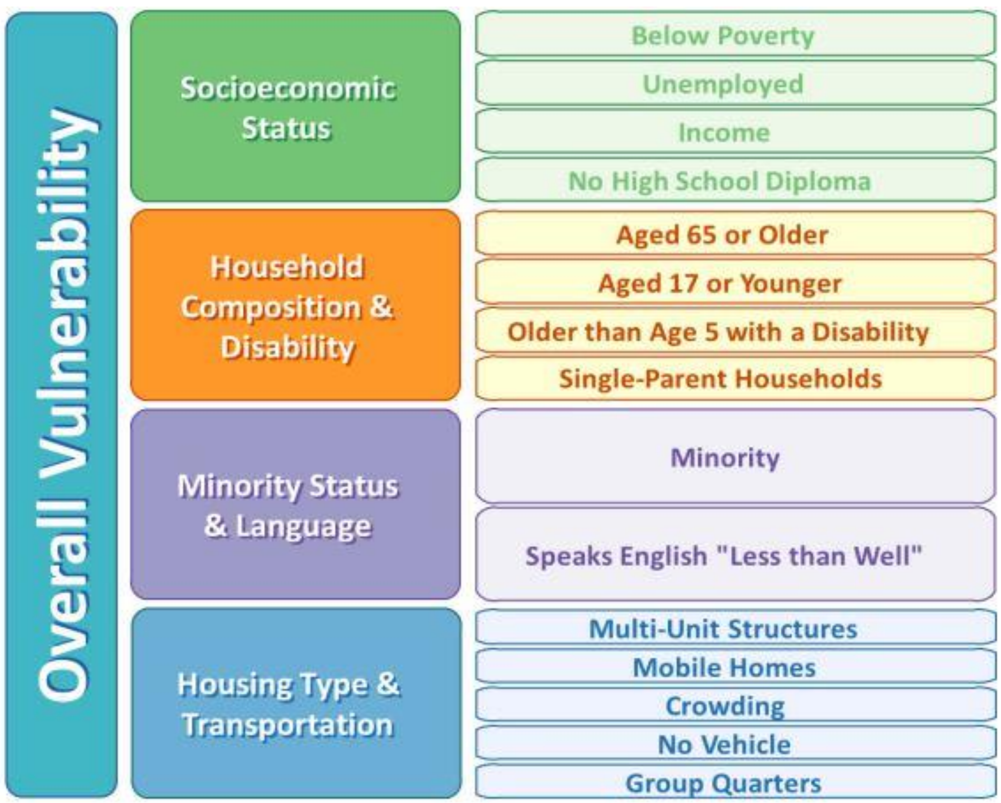
2A.3 Existing Condition Vulnerability Analysis

2A.3.A Resiliency of Communities

The resiliency of a community refers to its ability to use its assets and resources to recover from a crisis or disaster. This refers to individual and governmental financial assets and the strength of political cooperation and planning to prepare and plan for emergencies such as flooding, allowing smoother and more coordinated recovery efforts. Understanding existing vulnerabilities in the region helps the community understand where flood mitigation solutions and funding are most needed.

A standard measure of community vulnerability is the SVI, provided by the CDC. The SVI ranks census tracts on 15 social factors listed in *Figure 2.26* on their ability to recover from a disaster. All features that fell within the floodplain quilt in the exposure analysis, including structures, roads, agricultural land, power lines, electric lines and identified critical facilities, were assigned the SVI value of the census tract that they fell within and averaged at the county level to get an understanding of the county's mean SVI of exposed features.

Figure 2.26 Factors of the 2018 SVI



(CDC, https://svi.cdc.gov/Documents/Data/2018_SVI_Data/SVI2018Documentation.pdf)

The mean SVI by county is shown in *Figure 2.28.* When averaged at the county level, no county was considered to have an SVI above .75, defined by the TWDB as a high SVI, meaning the area will have a much more difficult time recovering from a disaster. Although the county averages for all flood exposures stay below .75, *Figure 2.29* shows the most developed communities within the region with high SVI areas. *Table 2.10* highlights all cities within the region with flood exposure points with SVI values over 0.75.

2A.3.B Vulnerabilities of Critical Facilities

Critical facilities are the key asset to community resiliency and recovery. The region's critical facilities are generally more vulnerable than other flood-exposed parts of the community. *Figure 2.29* compares the county mean SVI of all flood exposures (including structures, roads, critical facilities, agricultural land, and pipelines) with the mean SVI of only the critical facilities in the county. Most of the counties' critical facilities are in areas with higher SVIs, indicating some impedance to access and ability to recover. Franklin County only has one critical facility in the flood hazard, located in an area with a higher SVI.

Figure 2.27 SVI of All Flood Exposures by County

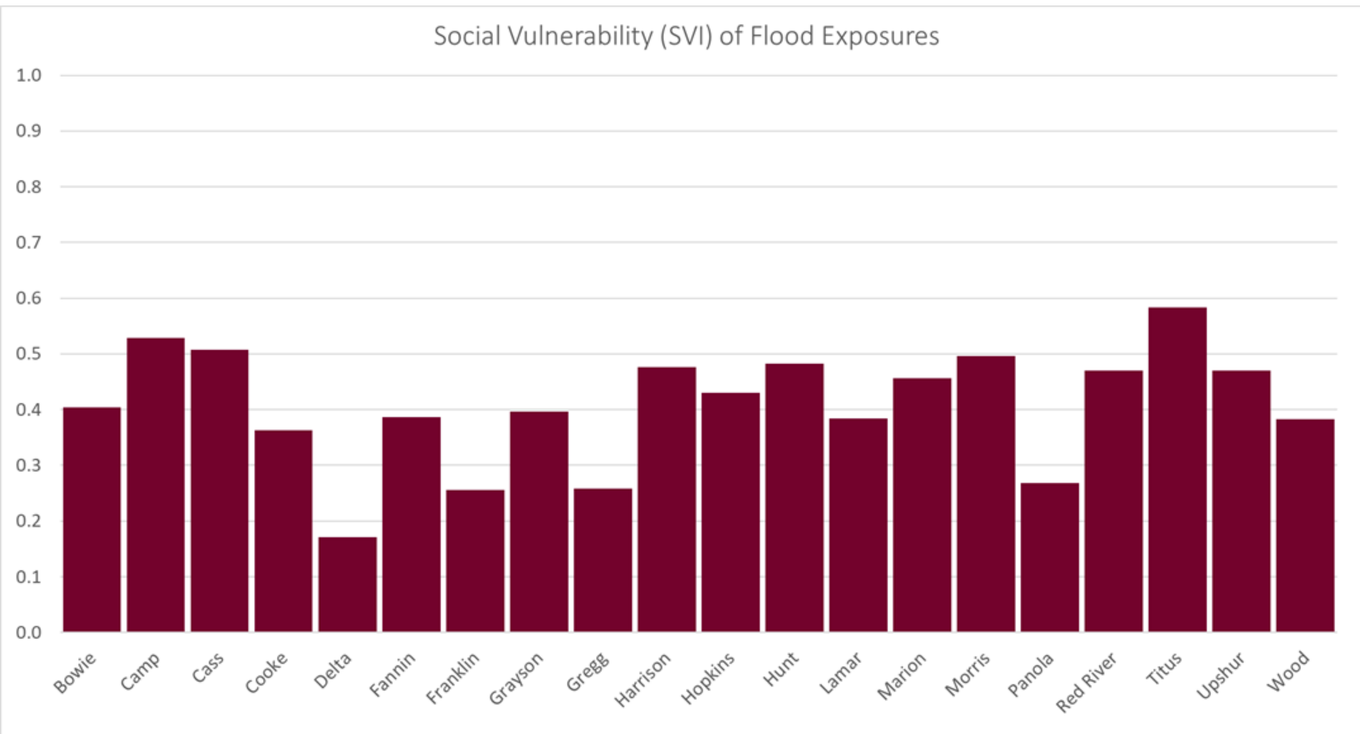


Figure 2.28 SVI of All Flood Exposures

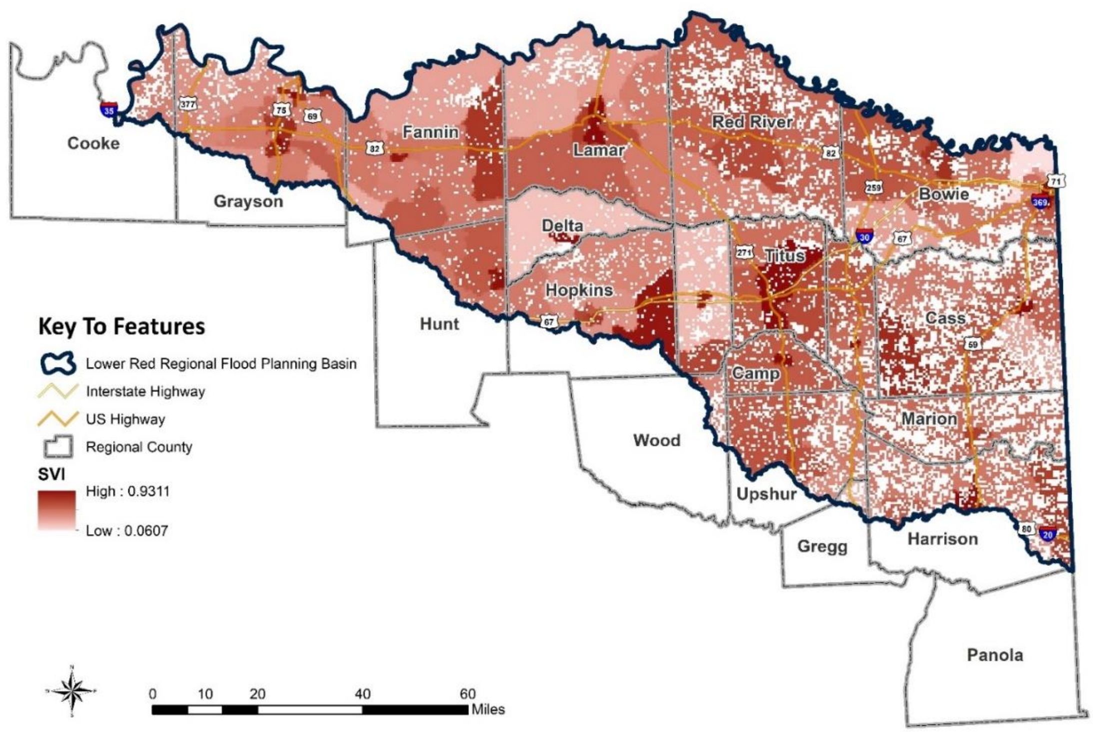
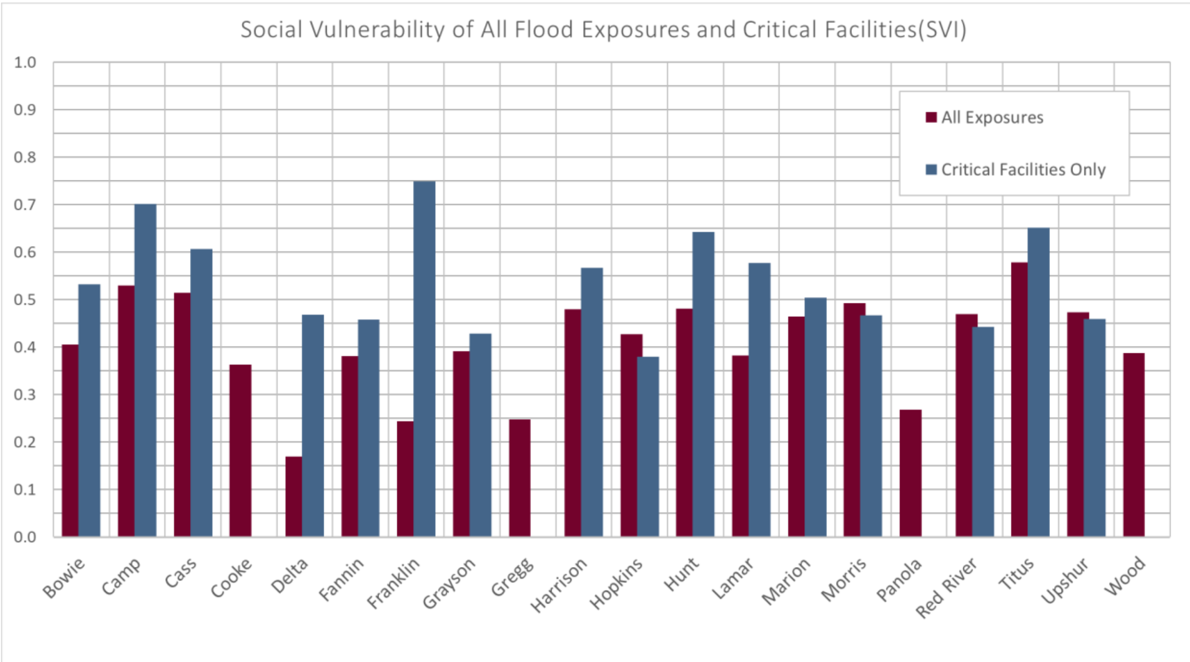


Table 2.10 Cities with Flood Exposures with SVI over .75

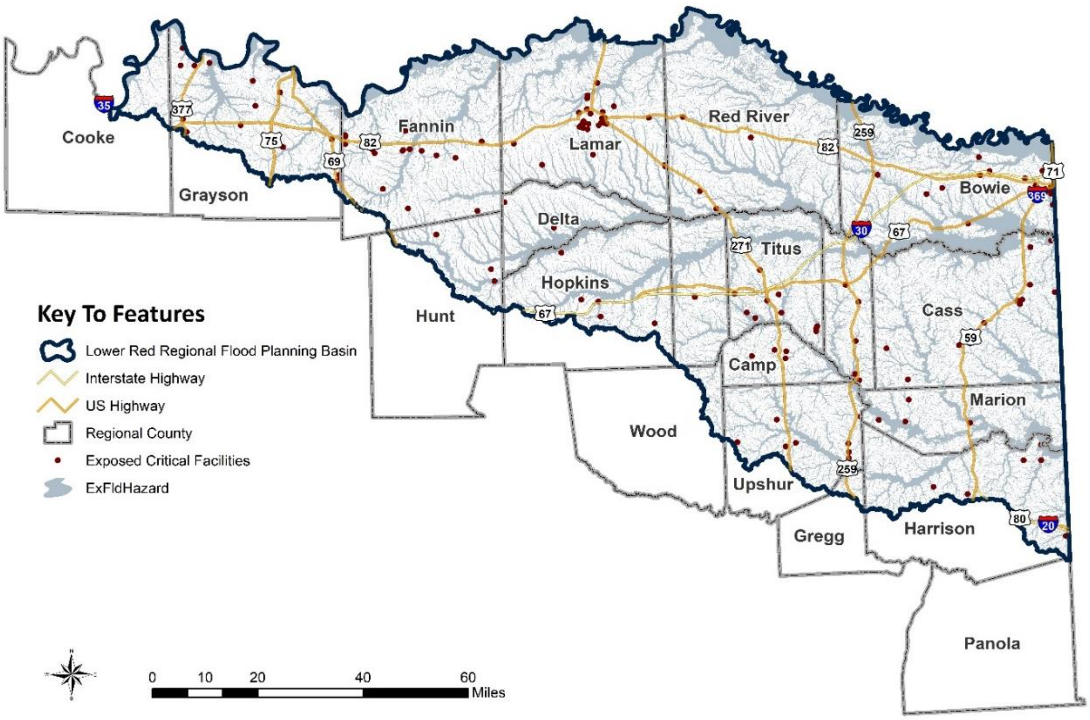
City	Number of Flood Exposure Points with SVI Over .75
Atlanta	516
Bonham	399
Commerce	337
Como	7
Cooper	19
Daingerfield	116
Denison	145
Marshall	126
Mount Pleasant	932
Paris	1,595
Pittsburg	139
Sherman	424
Texarkana	1,929

Figure 2.29 SVI of All Flood Exposures Compared to Critical Facilities



**All exposures include structures, agricultural land, roads, pipelines, and critical facilities within the flood hazard area*

Figure 2.30 Exposed Critical Facility Locations



2A.4 Summary of Existing Conditions Flood Exposure Analysis and Vulnerability

Community impacts from flooding within Region 2 became better understood after the exposure and vulnerability analysis. Perhaps the most significant regional impact is the number of roads within the flood hazard because of the threat to human life and emergency services. Concentrations of structures and populations are impacted in most developed cities within the region and those with larger concentrations of higher SVI exposures are more vulnerable to the impacts of a flood. The cities of Texarkana, Paris, Mount Pleasant, and Atlanta all had over 500 flood exposure points with SVI values of over 0.75, indicating highly vulnerable communities.

2B.1 Future Condition Flood Risk Analyses

The future conditions flood risk assessment estimates the flood risk in 30 years based on a "no action" scenario considering changes in population, development and impervious area, sedimentation in flood control structures, as well as any changes to sea level or possible rainfall patterns due to climate change. The assessment of future hazard areas is being used only to recognize the general magnitude of flood risk in a regional flood planning context and will not be used for developing maps for any regulatory process.

2B.1.A Future Condition Flood Hazard Analysis

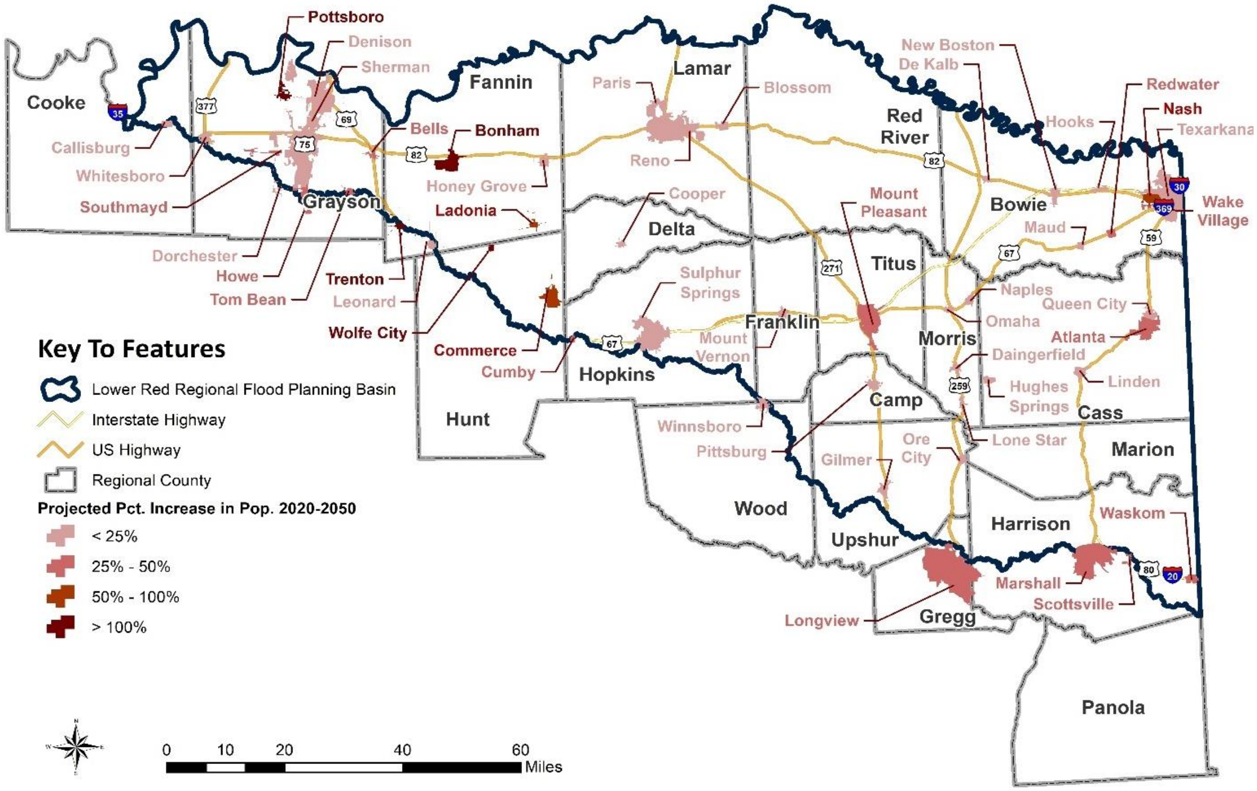
Future Conditions Based on "No Action" Scenario

Population Change, Land Use, and Development Trends

According to the World Bank, 2.2 billion people, or around 29% of the world population, live in areas that experience various inundation levels during a 1% ACE (100-year) flood event (Rentschler and Salhab, 2020). FEMA estimates that 13 million people live within a 100-year flood zone, while recent research argues that the actual number is about 41 million (Wing et al., 2018). On the one hand, future flood conditions will significantly affect the people exposed to flood risks, leading to higher flood vulnerability in areas with rapid population growth in the United States (Swain et al. 2020). On the other hand, population dynamics, which shows how and why populations change in structure and size over time, also have essential interrelationships with the changes in land cover, land use, and water demands for all uses (National Research Council, 1994). Rapid population growth results in expanding urban and industrial lands and depleting wetlands, floodplains, and water bodies, potentially impacting flood dynamics (Rahman et al., 2021). Identifying the future growth, composition, and distribution of a population is crucial for flood planning and related works by governments and policymakers.

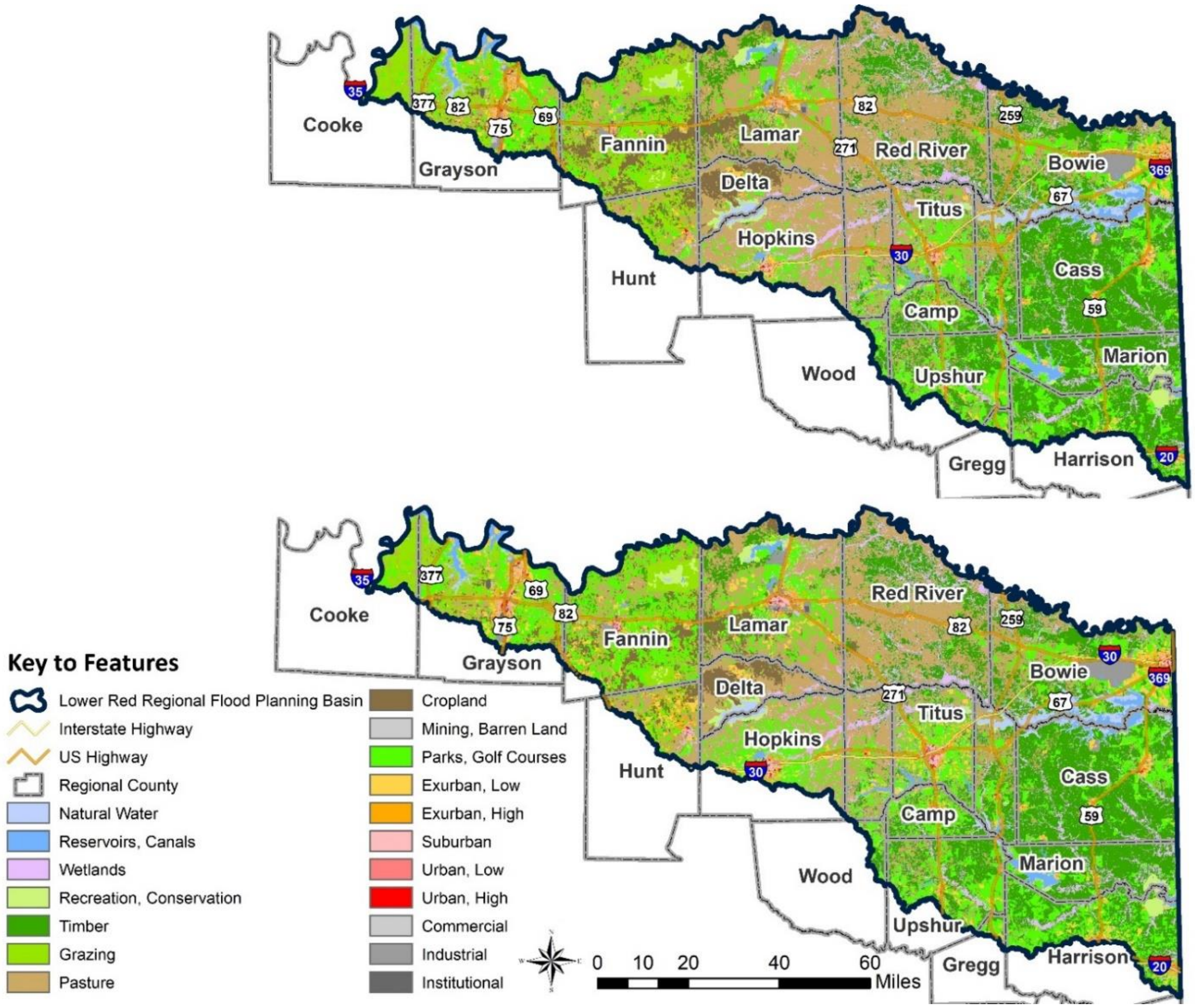
The population in Texas is expected to increase by 42% between 2020 and 2050, from 29.7 million to 42.3 million people (TWDB, 2021a). The projection was made based on a standard demographic methodology known as a cohort-component model, which uses different cohorts (combinations of age, gender, and racial-ethnic groups) and components of cohort change (birth, survival, and migration rates) to estimate the future population in a county level. The Texas State Data Center provides the TWDB with each county's 30-year population projections. The population in Region 2 is expected to increase by 24% between 2020 and 2050, from 531,000 to 660,000. *Figure 2.31* shows the predicted change in population across the region, with the most significant increases near the Dallas-Fort Worth Metroplex and along the I-30 and I-20 corridors, but with increases in most communities. Not only will the population growth demand a significantly higher water supply, but it also will change regional land cover and land use conditions that could alter the floodplain and increase flood risks in these areas.

Figure 2.31 TWDB Estimated population increases from 2020-2050



It is generally expected for land use to change from rural uses (forest, farms, etc.) to more developed uses (residential, commercial, etc.) as the population increases. Minimal future land use data was provided for the region, so other widely available datasets were considered for evaluating future land use changes. The United States Environmental Protection Agency (EPA) has developed the Integrated Climate and Land Use Scenarios (ICLUS) to estimate future conditions for climate modeling purposes. ICLUS is based on the EPA demographic and spatial allocation models to produce land use changes according to different scenarios. The dataset includes land use classifications of the conterminous United States at a spatial resolution of 90 meters. This data was used to estimate development trends between 2020 and 2050. Most of the region's land uses are not projected to change substantially, except in Hunt County, where rapid development occurs and some expansion of the urban footprint along US-75. Most other changes are relatively undetectable at the scale of these exhibits. As discussed in the following section, the expected population increase and other development impacts will be considered in this future conditions flood risk analysis.

Figure 2.32 ICLUS Land Use Projections 2020 and 2050



Sea Level Change

The global mean sea level has risen by about 0.2 meters (8 inches) at 1.7 millimeters per year. Since reliable record-keeping began in 1880 (Church and White, 2006), research shows that rising sea levels can affect coastal regions in many ways, including shoreline erosion, loss of land, tidal flooding, and saltwater intrusion into groundwater (Anthoff et al., 2006; Nicholls and Tol, 2006; Nicholls and Cazenave, 2010; Church and White, 2011). The contributions to sea level rise come primarily from two factors related to global warming — increases in water mass from melting ice and glaciers and thermal expansion of seawater (Church et al., 2007; Nicholls and Cazenave, 2010; Church and White, 2011). The rapid changes observed in polar regions suggest that the ice sheets melt faster than previously anticipated due to global warming (IPCC, 2021), and many studies show that the sea level is projected to rise another 0.3-1.8 meters (1-4 feet) by 2100 as global warming continues (Rahmstorf, 2007; Vermeer and Rahmstorf, 2009; Grinsted, 2010; Nicholls and Cazenave, 2010; Walsh et al., 2014). The Upper Red-Sulphur-Cypress Basins do not drain directly into the ocean or other coastal bays and are at least 160 feet above mean sea level; therefore, this century's anticipated sea level will not impact the region's floodplains.

Subsidence

Land subsidence, as a sudden sinking or a gradual settling of the Earth's surface on account of the subsurface movement of earth materials, is regarded as a worldwide problem leading to numerous adverse impacts on infrastructure and the environment (Galloway et al., 1999). The natural and human-induced causes of land subsidence include tectonic motion, aquifer-system compaction associated with groundwater, soil, and gas withdrawals, underground mining, etc. (Galloway et al., 1999; Xue et al., 2005; Braun and Ramage, 2020; Herrera-García et al., 2021). During the past century, land subsidence caused by groundwater depletion took place at around 200 locations in 34 countries (Herrera-García et al., 2021).

In the United States, more than 17,000 square miles in 45 states have been directly affected by land subsidence and as much as 30 feet (9 meters) of subsidence was measured in California's Central Valley (Galloway et al., 1999). It is of particular concern, especially in flat coastal areas such as the Houston-Galveston Region, since land subsidence in conjunction with the sea level rise would exacerbate the severity of flooding in the neighboring watersheds (Coplin and Galloway, 1999). In a report produced by the United States Geological Survey (Galloway et al., 1999), land subsidence is not mentioned as a significant concern in Region 2. The TWDB contracted a report titled: "Final Report: Identification of the Vulnerability of the Major and Minor Aquifers of Texas to Subsidence with Regard to Groundwater Pumping" (TWDB Contract Number 1648302062, 2017) that found that subsidence potential in Region 2 is low to medium, depending on groundwater use. Since subsidence has not been reported in the region and the potential is not high, it is recommended that subsidence be monitored in future plan iterations but that no subsidence considerations are addressed in this iteration of the Regional Flood Plan.

Future Rainfall Variability and Climate Change

The other factor the TWDB suggested the planning group consider when estimating future flood risk is future rainfall patterns. To aid the regional planning groups, the Office of the Texas State Climatologist provided the TWDB with guidance on incorporating projected future rainfall in their April 16, 2021, report titled "Climate Change Recommendations for Regional Flood Planning." The report states that one-day 1% ACE (100-year) rainfall amounts 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 amounts and future increases in global temperature. The percent increase in future precipitation was developed for urban and rural watershed conditions. Due to the uncertainty of predicting weather patterns for extreme rainfall events, the climatologist provided a minimum and maximum range for estimating future rainfall increases. The climatologist found even more uncertainty when analyzing rural and large river catchments due to expected future decreases in soil moisture. This led them to provide a percent decrease as a minimum range. The climatologist recommendations for future percent rainfall increase are provided in *Table 2.11*. The following sections will evaluate the maximum potential impact of this range.

Table 2.11 Range of Potential Future Rainfall Changes in 2050-2060 Relative to the NOAA Atlas 14

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

Sedimentation and Major Geomorphic Changes

Anticipated Impacts of Sedimentation on Flood Control Structures

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 the most important single form of human adaptation to the flood hazard. In Region 2, the most prominent flood control structures at a regional scale are levees, dams, and their associated reservoirs. In general, reservoirs are the flood control facilities that are most susceptible to the impacts of sediment deposition over time within this watershed. While sedimentation in reservoirs is a directly measurable impact and is typically accounted for in the design, the plan needs to recognize the reduction in conveyances due to sedimentation in channels and floodplain fringes.

Historically, reservoirs have been designed with relatively large storage capacities to offset sediment deposition and achieve the desired reservoir life. In general, reservoir design includes a sedimentation pool, commonly known as “dead storage,” which is a portion of its storage capacity that is essentially set aside for sediment deposition during the structure's design life. It could be argued that the operation of the reservoir for authorized purposes, such as municipal water supply, flood control, hydropower generation, and recreation, is not significantly impacted if sediment accumulation does not exceed the dead storage capacity. However, large flood events will carry relatively large loads of sediment that can be deposited in portions of the reservoir outside the designated dead storage areas. Thus, provisions need to be considered for sediment management to achieve sustainable long-term facility use.

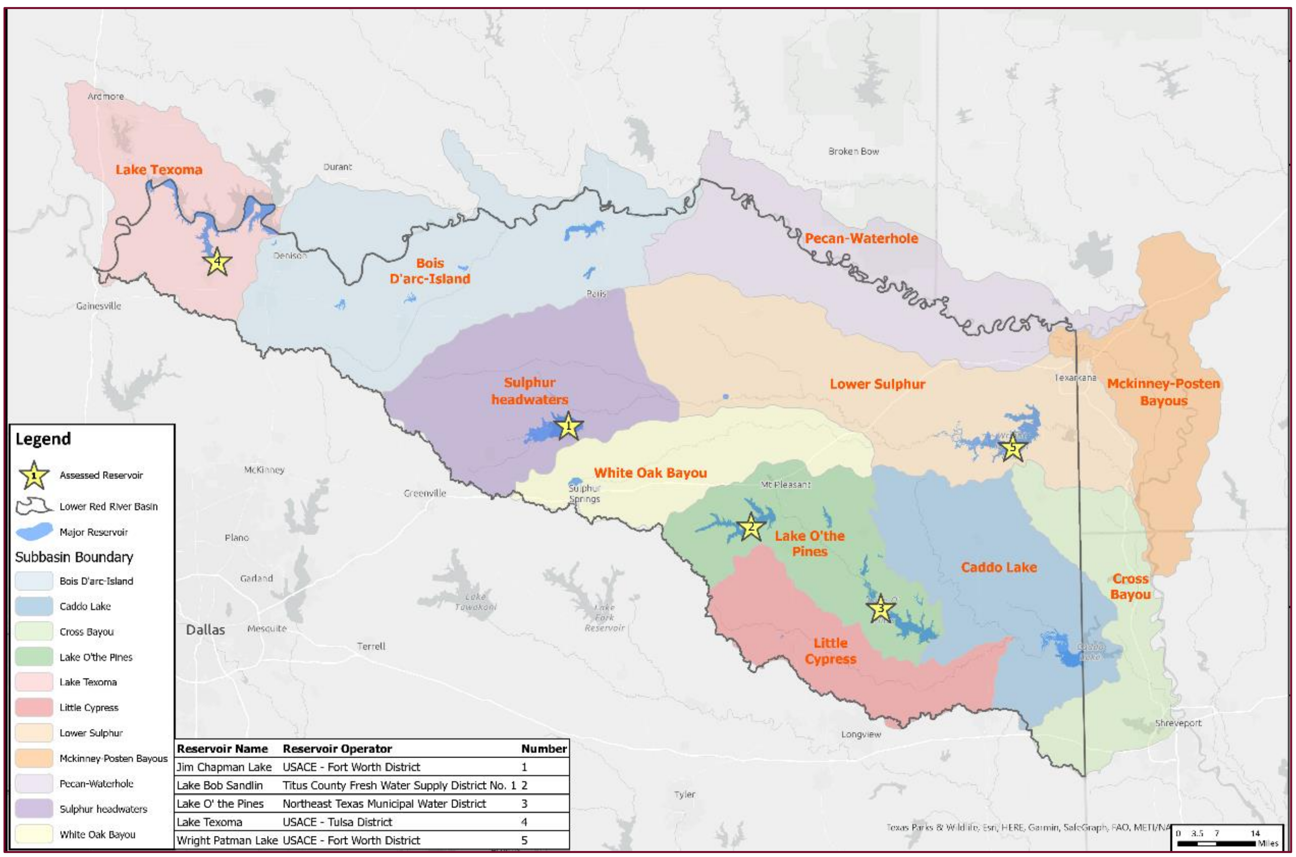
Within the framework of the Lower Red-Sulphur-Cypress Region Flood Plan, the loss of flood storage is considered the primary impact of sedimentation to increase future flood risk. Reservoir flood operations can be severely impacted when 50% of the sedimentation volume has been filled with sediment. Operational issues may arise even when smaller percentages of flood storage areas are lost. This section intends to provide a high level assessment of the expected loss of flood storage capacity due to sedimentation in the region’s flood control facilities and determine if these losses would significantly increase flooding risks. Data for this assessment was obtained from the Natural Resources Conservation Service (NRCS) historical documents and the TWDB volumetric and sedimentation surveys. The assessment was subdivided into two main groups: major reservoirs and NRCS floodwater retarding structures.

It is recognized, however, that sediment transport in a river system is a complex phenomenon with substantial geographic and temporal variability. The assessment and information provided in this section are based on a series of simplifying assumptions and are only intended to serve as a general indicator of the potential impacts of sedimentation in future flood risk at a regional scale within a 30-year planning horizon.

Major Reservoirs Assessment

The TWDB recognizes 21 major lakes and reservoirs within Region 2. A body of water that contains at least 5,000 acre-feet of storage capacity at its normal operating level is considered a major reservoir, according to the TWDB. Some of the operators of these reservoirs include the USACE and Municipal Water Districts. These facilities may serve multiple purposes, including municipal water supply, irrigation, flood control, and/or recreation. Not all reservoirs are designed with flood control capacity. Five of these reservoirs were selected for this high level assessment as a representative sample for the watershed (see *Figure 2.33*).

Figure 2.33 Major Reservoirs within Region 2

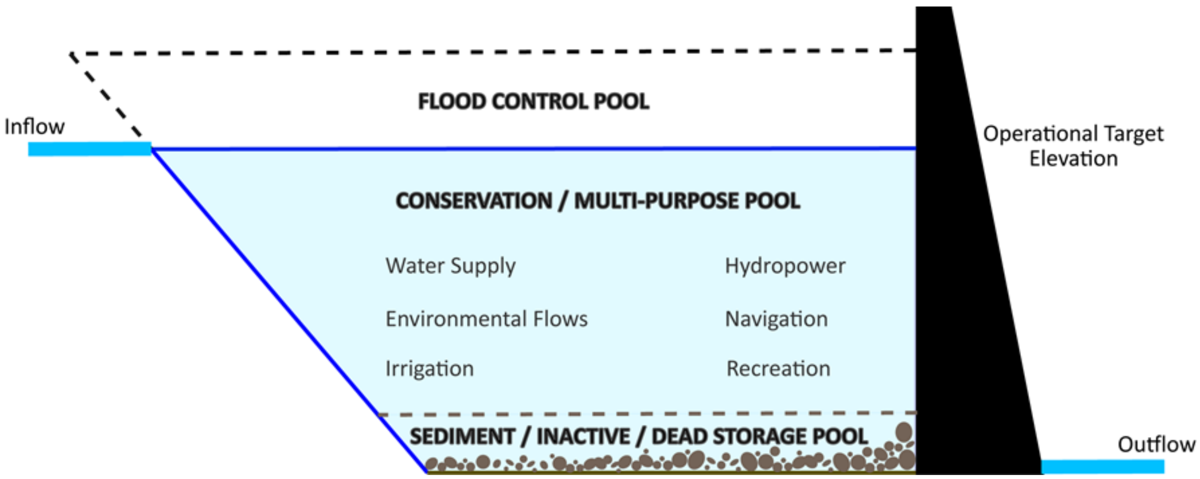


Reservoir Name	Reservoir Operator	Number
Jim Chapman Lake	USACE - Fort Worth District	1
Lake Bob Sandlin	Titus County Fresh Water Supply District No. 1	2
Lake O' the Pines	Northeast Texas Municipal Water District	3
Lake Texoma	USACE - Tulsa District	4
Wright Patman Lake	USACE - Fort Worth District	5

Design and Operation of Multipurpose Reservoirs

The design and operation of reservoirs include allocating volumes of reservoir storage (typically referred to as "pools") for each purpose. There are three broad categories of pools *(Figure 2.34*): flood control, conservation (also referred to as multi-purpose), and sediment (also referred to as inactive or dead storage). In *Figure 2.34*, these water storage areas are depicted. Each reservoir is designed with specific capacity limits for each pool. The top of the conservation pool is typically varied based on seasonal patterns. Reservoir operators attempt to maintain this pool at the highest possible level. On top of the conservation pool is the zone reserved for flood control, which is also influenced by seasonal variations. Major reservoirs that provide flood control benefits are designed to capture upstream runoff, store it, and then release it at a controlled rate to minimize the flooding downstream.

Figure 2.34 Typical Multipurpose Reservoir Design



(https://nicholasinstitute.duke.edu/reservoir-reallocation/)

Sediment Deposition

The amount of sediment accumulation in a reservoir depends on the sediment yield to the reservoir and the trap efficiency. Trap efficiency is the amount (percentage) of the sediment delivered to a reservoir that remains in it. How the accumulated sediment is distributed within the reservoir pools depends on the inflowing sediment's character, the reservoir's operation, detention time, and other factors. The incoming sediment deposited underwater is called "submerged sediment." The sediment deposited above the conservation pool elevation is "aerated sediment" (Soil Conservation Service National Engineering Handbook, Section 3, 1983).

The distinction between submerged and aerated sediment is essential in determining the capacity that each will displace within a reservoir. The high level assessment presented in the following sections assumes that 90% of the incoming sediment will be submerged and 10% aerated. This assumption is based on guidelines established in the Soil Conservation Service National Engineering Handbook, Section 3 - Chapter 8 (1983) and a study performed by Strand and Pemberton (1987) for 11 reservoirs in the US Great Plains Region. In this study, the reported percent of aerated sediment deposited in the flood control pool for Lake Texoma was approximately 10%, and this same value was adopted for all other reservoirs included in this assessment. Due to the complexity of determining the trap efficiency for each reservoir, a conservative assumption of 100% trap efficiency was adopted for this assessment. A 100% trap efficiency indicates that all sediment delivered to a given reservoir remains in it, and no sedimentation management practices are being implemented.

Flood Control Capacity Loss Assessment

The TWDB, in conjunction with the USACE - Fort Worth District and USACE – Tulsa District, developed Volumetric and Sedimentation Surveys for several major reservoirs within the region (https://www.twdb.texas.gov/surfacewater/surveys/completed/files/). The five water bodies chosen for this study (See *Figure 2.33*) span across all of Region 2 as a representative sample of the major reservoirs in the watershed for this high-level assessment.

In the sedimentation surveys, a range of values is typically provided for the annual sedimentation rates of each reservoir. The reported high and low annual sedimentation rate estimates are reflected in *Table 2.12*. These sedimentation rates are generally determined based on comparing storage capacity from volumetric surveys over time. In addition to the TWDB Volumetric and Sedimentation Surveys, the TWDB's Water Data for Texas website and the USACE – Fort Worth District website were used to collect pertinent reservoir data. The flood control storage volume was not provided as part of the TWDB surveys; however, those volumes were collected from multiple sources, including data sheets from the USACE – Fort Worth and Tulsa Districts websites.

This assessment aims to estimate the potential loss of flood control storage capacity for the selected reservoirs over a 30-year planning horizon. Sediment accumulation was calculated from the year of the latest volumetric survey for each reservoir until 2053. The percentage of reservoir capacity lost from the conservation and flood pools by 2053 was determined using both the high and low annual sedimentation rates. This calculation assumes that the annual sedimentation rate will be constant over time. As stated in the previous section, 90% of the annual sediment load will deposit in the conservation pool and 10% in the flood control pool. A conservative 100% trap efficiency assumption was adopted for this assessment. It was also assumed that the conservation storage included any additional volume designated as dead pool storage. The analysis results are summarized in *Table 2.12* and *Figure 2.35*. Detailed calculations are provided in *Table 2.13*. Analysis results suggest that sedimentation will have a minor impact on the flood control function of the major reservoirs in Region 2, as nearly all reservoirs resulted in over 97% of their flood control storage capacity still available by the end of the 30-year planning horizon.

Table 2.12 Estimate of Flood Control Storage Capacity Remaining by 2053 – Representative Reservoirs

Reservoir Name	Reservoir Operator	Drainage Area (square miles)	Total Conservation Storage (acre-feet)	Total Flood Control Storage (acre-feet)	Annual Sedimentation Rate (acre-feet/year)	Remaining Flood Control Capacity (%) by 2053
Lake Texoma	USACE – Tulsa District	37,719	1,401,466	3,531,606	**Low** 3,774 **High** 16,440	**Low** 99.6% **High** 98.1%
Jim Chapman Lake	USACE – Fort Worth District	479	260,332	137,043	**Low** 711 **High** 711	**Low** 97.9% **High** 97.9%
Lake Bob Sandlin	Titus County Fresh Water Supply District No. 1	239	199,975	81,207	**Low** 191 **High** 191	**Low** 99.2% **High** 99.2%
Wright Patman Lake	USACE - Fort Worth District	3,400	231,496	1,516,292	**Low** 730 **High** 1,362	**Low** 99.8% **High** 99.6%
Lake O' the Pines	Northeast Texas Municipal Water District	880	239,122	602,978	**Low** 636 **High** 636	**Low** 99.6% **High** 99.6%

Figure 2.35 Estimate of Flood Control Storage Capacity Remaining by 2053 – Representative Reservoirs

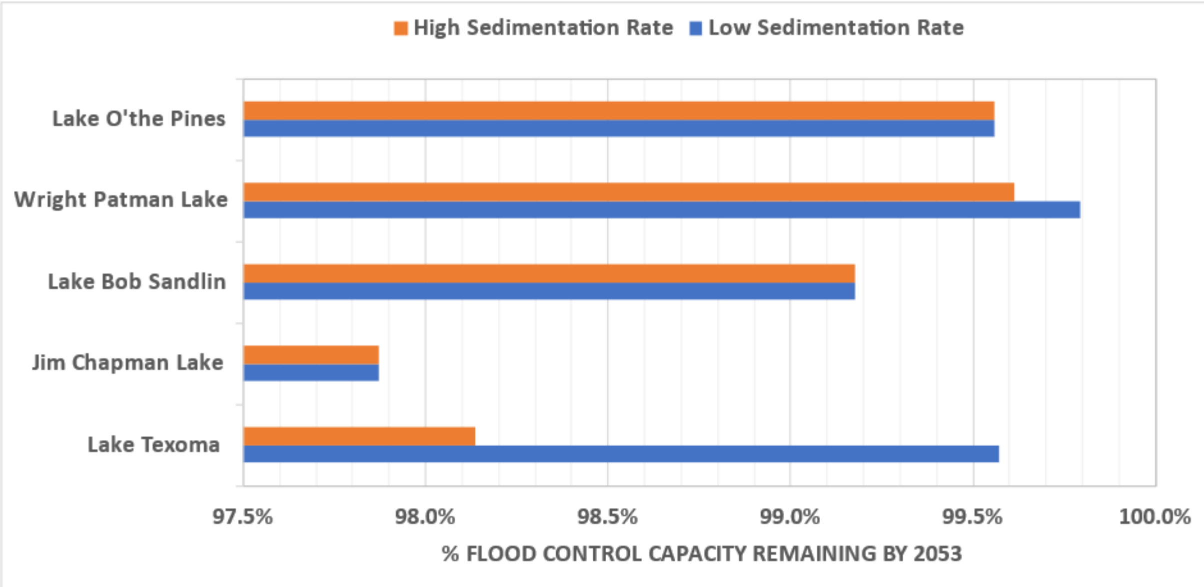


Table 2.13 Estimated loss of Conservation Pool and Flood Control Pool Capacity due to Sedimentation – Detailed Calculations

Reservoir Name	Reservoir Operator	Drainage Area (sq.mi)	Survey Year	Years to 2053	Total Conservation Storage (ac-ft)	Total Flood Control Storage (ac-ft)	Annual Sedimentation Rate (ac-ft/yr)		% Capacity lost from Conservation Pool by 2053		% Capacity lost from Flood Control Pool by 2053		Remaining Flood Control Capacity (%) by 2053	
							Low	High	Low	High	Low	High	Low	High
Lake Texoma	USACE - Tulsa District	37,719	2013	40	1,401,466	3,531,606	3774	16440	9.7%	42.2%	0.4%	1.9%	99.6%	98.1%
Jim Chapman Lake	USACE - Fort Worth District	479	2012	41	260,332	137,043	711	711	10.1%	10.1%	2.1%	2.1%	97.9%	97.9%
Lake Bob Sandlin	Titus County Fresh Water Supply District No. 1	239	2018	35	199,975	81,207	191	191	3.0%	3.0%	0.8%	0.8%	99.2%	99.2%
Wright Patman Lake	USACE - Fort Worth District	3,400	2010	43	231,496	1,516,292	730	1362	12.2%	22.8%	0.2%	0.4%	99.8%	99.6%
Lake O'the Pines	Northeast Texas Municipal Water District	880	2011	42	239,122	602,978	636	636	10.1%	10.1%	0.4%	0.4%	99.6%	99.6%

NRCS Floodwater Retarding Structures

The NRCS, formerly known as the Soil Conservation Service (SCS), has a long history of designing and building dams and reservoirs to serve rural/agricultural areas. Based on a combination of data from the USACE's National Dam Inventory and the Texas State Soil and Water Conservation Board's (TSSWCB) Local Dams Inventory, there are 164 NRCS dams within Region 2 (*Figure 2.37*), most of which were designed and built during the early 1950s and 1960s. These dams are one of the elements that comprise what is known as a Watershed Work Plan (WWP). The typical goals of a WWP are to improve agricultural practices, apply land treatment practices that will reduce upland erosion, and implement structural measures to reduce flood damage and provide for sediment control.

The WWPs refer to their dams and reservoirs as "Floodwater Retarding Structures." Their intent is to reduce flood-related damages to both private property and agricultural crops. Reducing floodplain scour and capturing excess sediment is also a typical goal for these facilities. A section of a typical floodwater retarding structure is shown in *Figure 2.36*. It is important to note that the design of these structures includes a sediment pool and a sediment reserve. Thus, sedimentation may have an adverse impact on the structure's flood control performance only when the sediment pool capacity has been depleted, and sediment starts to accumulate in the detention pool. However, as stated earlier, large flood events will carry relatively large loads of sediment that can be deposited in portions of the reservoir outside the designated sediment pool, which results in some loss of detention storage before filling the entire sediment pool.

Figure 2.36 Section of a Typical NRCS Floodwater Retarding Structure (Auds Creek Watershed Work Plan, SCS, 1975)

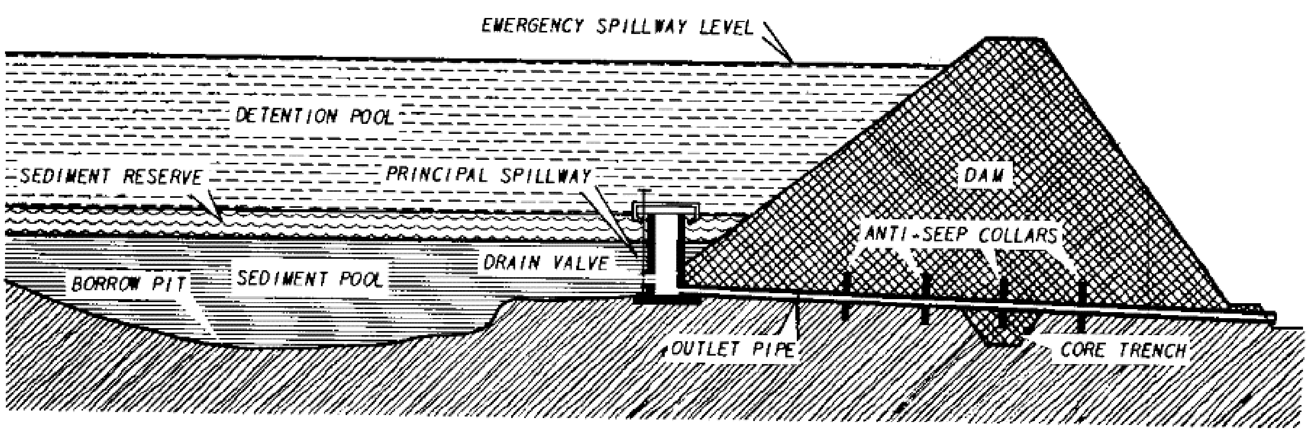
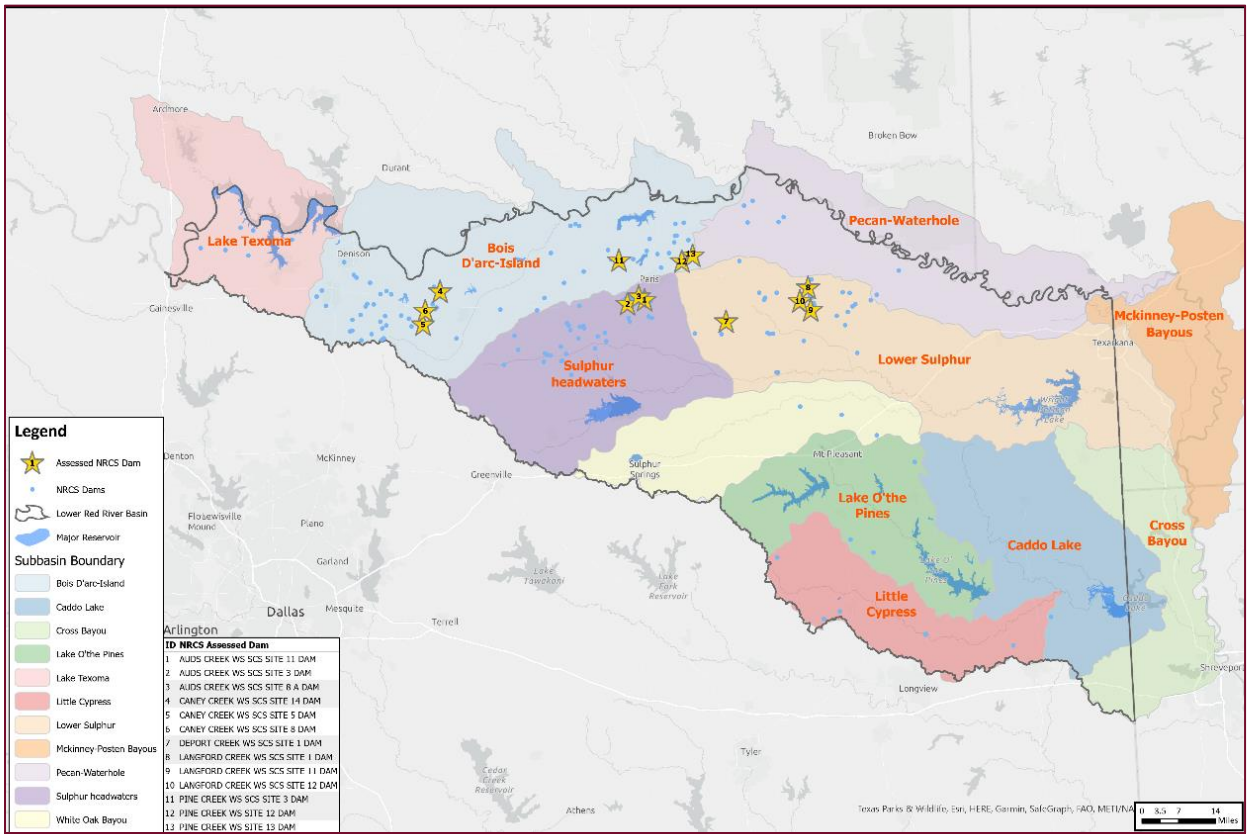


Figure 2.37 NRCS Floodwater Retarding Structures within Region 2



Flood Storage Loss Assessment

A high level assessment of the loss of flood storage capacity due to sedimentation in the region's NRCS facilities was conducted as part of this Regional Flood Plan. A total of nine WWPs were reviewed in this effort. The watershed areas included in these WWPs (PL 566 Watersheds) are scattered throughout Region 2. WWPs can be downloaded from the following NRCS website: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/tx/programs/planning/wpfp/?cid=stelprdb1186445.

The WWPs include relevant data about each of the floodwater retarding structures, including sedimentation pool storage, detention storage, drainage area, and the year the facility was built. Most WWPs include a "Sedimentation Investigation" section that provides an average annual rate per area of sediment deposition into the floodwater retarding structures. This data was used to perform approximate calculations of the time it would take to fill the sedimentation pool and the time it would take to fill a given percentage of the detention or flood control storage. For this high level assessment, it is assumed that the structure's performance in terms of reducing flooding risk starts to be significantly affected once 20% of the flood control pool is lost due to sedimentation.

Given the large number of NRCS floodwater retarding structures in the region and other limitations, the assessment was limited to 13 representative structures. The selected structures are primarily located on the three sub-basins with the greatest concentration of NRCS dams: Bois D'Arc Island, Sulphur Headwaters, and Lower Sulphur (*Figure 2.37*).

Based on the sedimentation rates reported in the above-mentioned references, an average rate was calculated for each structure. To calculate the time it would take to fill 100% of the sediment pool and 20% of the flood control pool, it was assumed that 90% of the annual sediment deposition would occur within the sediment pool and 10% within the flood pool. Once the sediment pool was filled, the entire sediment accumulation would occur within the flood pool. A conservative 100% trap efficiency assumption was adopted for this assessment. These calculations are presented graphically in *Figure 2.38* and summarized in *Table 2.14*. Further details on the data and calculations are shown in *Table 2.15*.

Figure 2.38 shows a series of bar graphs representing each site. The first point on the bar represents the year the structure was built. The segment between the first and second points represents the time to fill the sedimentation pool. At that point, the facility would no longer perform its sediment control purpose as designed. The segment between the second and third points represents the additional time to fill 20% of the flood control pool. This point represents a conservative assumption of when flood control benefits could be significantly reduced due to loss of storage capacity. The red dashed line marks the year 2053, which is the long-term planning horizon for this first Regional Flood Plan. Based on these calculations, flood control operations would not be significantly affected for any of the selected sites within the next 30 years. All sites would still have the residual capacity in their sedimentation pool to continue accumulating sediment beyond 2053. For the flood retarding structures in the Pine Creek Watershed, the bars extend beyond the limits of the time axis, indicating extensive time frames to reach the set storage losses. Furthermore, our professional experience with NRCS ponds suggests that sedimentation rates reported in these early documents can be quite conservative and are typically much lower due to significant improvements in agricultural practices and the implementation of erosion control policies, among other factors.

The results of this high level assessment suggest that at a regional scale, sedimentation will not pose a significant limitation to achieving flood control benefits from these structures within the 30-year planning horizon. However, it is recognized that 13 structures is a relatively small sample size and that further analysis is certainly required to comprehensively assess the impacts of sedimentation on these structures, especially at the local scale.

Figure 2.38 Estimate of Time to Lose Sediment Pool and Flood Control Pool Capacity due to Sedimentation – Representative NRCS Structures

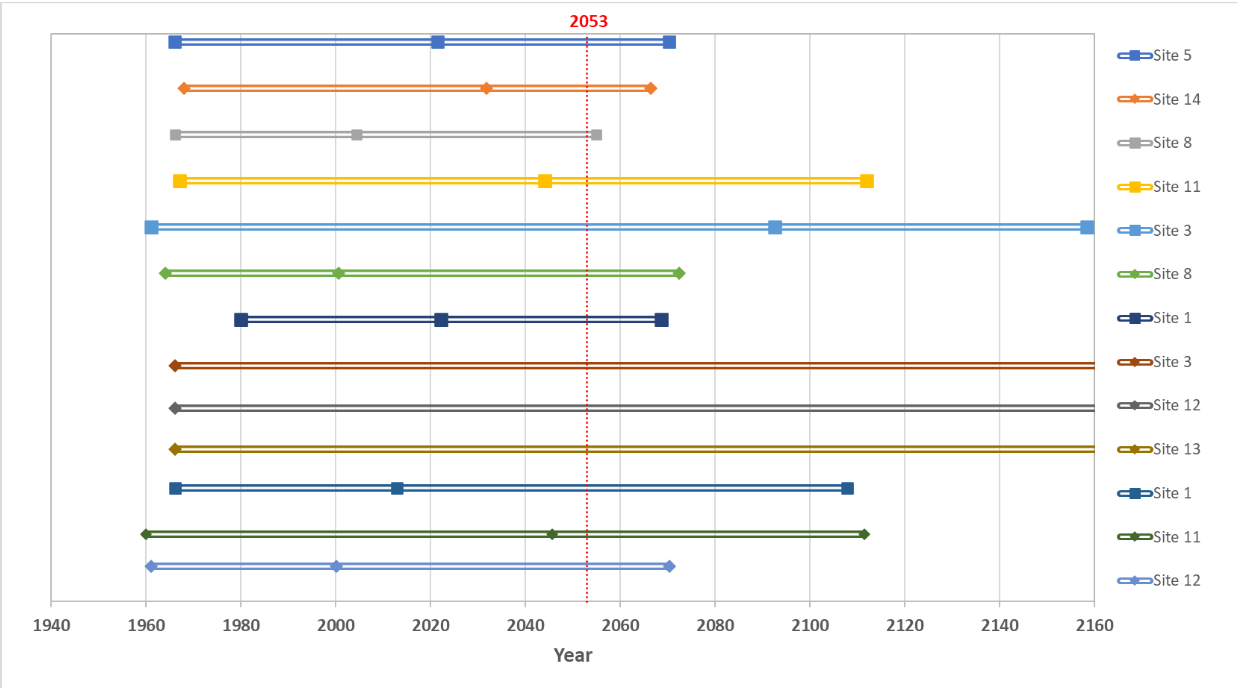


Table 2.14 Estimate of Time to Lose Sediment Pool and Flood Control Pool Capacity due to Sedimentation – Representative NRCS Structures

Lower Red-Sulphur-Cypress sub-basin	Creek	NRCS Dam ID	Sedimentation Rate Estimate (acre-feet/square miles/year)	Year Built	Estimated Year Sediment Pool is Filled	Estimated Year Flood Pool is Filled 20%
Caney Creek Watershed	Hutchins Creek	Site 5	1.39	1966	2021	2070
Caney Creek Watershed	Willhoit Branch	Site 14	1.39	1968	2032	2066
Caney Creek Watershed	Caney Creek	Site 8	1.39	1966	2004	2055
Auds Creek Watershed	Cottonwood Branch	Site 11	0.84	1967	2044	2112
Auds Creek Watershed	Cottonwood Branch	Site 3	0.84	1961	2092	2158
Auds Creek Watershed	Cottonwood Branch	Site 8	0.84	1964	2001	2072
Deport Creek Watershed	Mustang Creek	Site 1	1.49	1980	2022	2069
Pine Creek Watershed	Little Pine Creek	Site 3	0.04	1966	3707	5663
Pine Creek Watershed	Sevenmile Creek	Site 12	0.04	1966	3139	5084
Pine Creek Watershed	Nine Mile Creek	Site 13	0.04	1966	3317	5286
Langford Creek Watershed	Langford Creek	Site 1	0.76	1966	2013	2108
Langford Creek Watershed	Lynch Creek	Site 11	0.76	1960	2046	2112
Langford Creek Watershed	Boggy Creek	Site 12	0.76	1961	2000	2070

Table 2.15 Estimated Loss of Sediment Pool and Flood Control Pool Capacity due to Sedimentation – Detailed Calculations

Lower Red-Sulphur-Cypress sub-basin	Creek	NRCS Dam ID	Year Built	Drainage Area (sqmi)	Sediment Pool Storage (ac-ft)	Flood Pool Storage (ac-ft)	Total Capacity (ac-ft)	Sed. Rate Estimate (ac-ft/sqmi/yr)	Sed. Rate Estimate (ac-ft/yr)	Estimated Years to fill Sediment Pool	Estimated Year when Sediment Pool is Filled	Additional Years to fill 20% of Flood Pool	Estimated Year when 20% of Flood Pool is lost
Caney Creek Watershed	Hutchins Creek	Site 5	1966	2.8	197	1,075	1,272	*1.39*	*3.9*	*55*	*2021*	*49*	*2070*
Caney Creek Watershed	Wilhoit Branch	Site 14	1968	1.9	154	551	705	*1.39*	*2.7*	*64*	*2032*	*35*	*2066*
Caney Creek Watershed	Caney Creek	Site 8	1966	1.0	47	371	418	*1.39*	*1.4*	*38*	*2004*	*51*	*2055*
Auds Creek Watershed	Cottonwood Branch	Site 11	1967	2.3	135	737	872	*0.84*	*1.9*	*77*	*2044*	*68*	*2112*
Auds Creek Watershed	Cottonwood Branch	Site 8	1964	2.5	70	801	871	*0.84*	*2.1*	*37*	*2001*	*72*	*2072*
Auds Creek Watershed	Cottonwood Branch	Site 3	1961	1.7	169	564	733	*0.84*	*1.4*	*131*	*2092*	*66*	*2158*
Deport Creek Watershed	Mustang Creek	Site 1	1980	5.7	322	*2,156*	2,478	*1.49*	*8.5*	*42*	*2022*	*47*	*2069*
Pine Creek Watershed	Little Pine Creek	Site 3	1966	7.5	428	2,908	3,336	*0.04*	*0.3*	*1741*	*3707*	*1956*	*5663*
Pine Creek Watershed	Sevenmile Creek	Site 12	1966	6.7	256	2,501	2,757	*0.04*	*0.2*	*1173*	*3139*	*1945*	*5084*
Pine Creek Watershed	Nine Mile Creek	Site 13	1966	3.4	149	1,289	1,438	*0.04*	*0.1*	*1351*	*3317*	*1969*	*5286*
Langford Creek Watershed	Langford Creek	Site 1	1966	3.0	95	1,120	1,215	*0.76*	*2.2*	*47*	*2013*	*95*	*2108*
Langford Creek Watershed	Lynch Creek	Site 11	1960	2.2	126	608	734	*0.76*	*1.6*	*86*	*2046*	*66*	*2112*
Langford Creek Watershed	Boggy Creek	Site 12	1961	7.2	192	2,028	2,220	*0.76*	*5.5*	*39*	*2000*	*70*	*2070*

Anticipated Impacts of Major Geomorphic Changes in Flood Risk

Geomorphic changes in fluvial systems have a clear relationship with flood hazard protection. Fluvial systems are a series of complex feedback loops where many interrelated variables influence both flood hazards and changes in a river condition. In short, the geometry of river systems changes when the influencing variables, such as hydrology (caused by climate change, land use changes, stormwater infrastructure, etc.) and sediment dynamics, such as erosion, sediment deposition, and sediment transport changes. This ultimately relates to flood hazards because of increases or decreases in flood conveyance inherent to changes in river geometry.

Regardless, most flood hazard assessments assume the capacity of river channels to convey flood flows is stationary, with the thought that changes in flood frequency are primarily driven by hydrology. However, several studies have shown that while hydrology has a greater influence on flood hazards and flood variability, identifying potential geomorphic changes is essential because flood hazards and flood variability are not driven by hydrology alone.

Predicting Geomorphic Changes

Effectively predicting geomorphic channel changes quantitatively requires intense data collection and modeling. These requirements are further magnified at larger scales because the factors that control the geomorphology of a system are variable throughout a watershed. At the regional scale, there is significant heterogeneity within a river system. As such geomorphic channel changes and sediment dynamics are difficult to quantify at the regional scale because of the lack of available data, number of interrelated influential variables, and differences in the local conditions within a watershed.

Including predicted geomorphic changes in the flood assessment is often not appropriate or feasible at the regional scale due to the uncertainty of predictions becoming exceedingly high with the introduction of additional variables/complexity, which can lead to erroneous flood predictions. However, this does not mean that the general effects of geomorphic channel changes on flood risks should not be considered.

Effects of Geomorphic Changes on Flood Risks

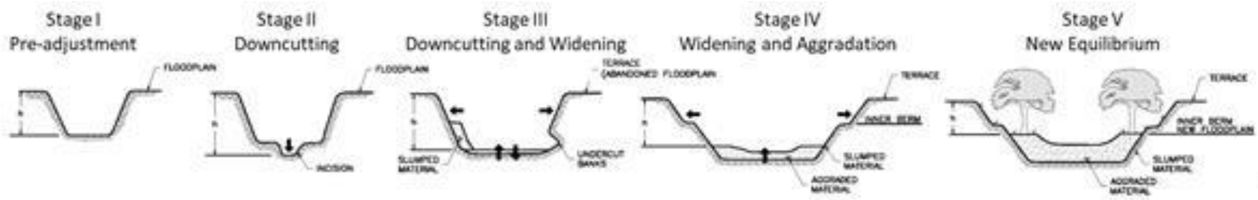
While major geomorphic changes can occur at the regional scale, their effect on flood risks are most apparent at the local level. This is because of the variability of geomorphic conditions within a river. Local changes in the channel geometry and sediment dynamics of the system can have profound effects on flood inundation extents at smaller scales. This section provides high-level descriptions of how geomorphic changes can affect flood risks.

Hydrology and Channel Changes

River geometry changes to accommodate the amount of flow it receives, and both increases and decreases in the flow regime can initiate these changes. Common causes of hydrologic changes include urbanization/land use changes, implementation of stormwater infrastructure (such as detention/retention ponds), climate change, and reservoir release schedules.

Increased flow often occurs when a watershed urbanizes or has land use changes. Flow in streams becomes flashier because surface runoff reaches streams more quickly and in greater magnitude due to increased smooth, impermeable surfaces that prevent water infiltration into the ground. While this gets floodwaters downstream faster, stream geometries will enlarge via erosion to accommodate the additional flow. This is manifested first by channel downcutting until the stream slope can accommodate the discharge without scouring the channel bed; second by channel widening caused by overly steep stream banks following downcutting. *Figure 2.39* shows the processes involved in the channel evolution model.

Figure 2.39 Diagram of Channel Downcutting and Channel Widening (adapted from Schumm et al., 1984)



Channel enlargement is a gradual process that migrates from downstream to upstream between local base levels or hardpoints. Local base levels are features that prevent the channel from downcutting; examples may include tributary confluences, bedrock outcrops, concrete-lined channels, and culvert crossings. Geometric changes to the channel (i.e., channel enlargement) typically affect flood levels within these bounded local base levels.

Locally, channel enlargement may increase the flow capacity and reduce flood risks, affecting river size/drainage area scales. Flood capacity is less impacted by erosion in larger streams than in smaller streams because the amount of material removed relative to the channel size is less in larger streams. In smaller streams, it is common for erosion to create enough capacity to completely remove overbank flows during flood events. Likewise, significant erosion in larger streams may only have a marginal effect on flood inundation levels.

This does not mean that erosion is solely beneficial to flood risks; there are adverse impacts of erosion brought about by increased hydrology, including:

- direct erosion impacts to homes, infrastructure (e.g., stormwater outfalls, waterlines, sewer lines, roads, bridges, culverts, etc.), and private property adjacent to the stream
- channel geometry used in flood assessment analyses is becoming outdated
- excess sediment yields are sourced from channel erosion and subsequent downstream effects

Lastly, decreased flow in the stream can occur due to detention/retention ponds, lakes/reservoirs, or climate change. This can cause channels to aggrade because flows no longer have enough stream power to carry the sediment in the system. As a result, channel capacity will decrease as sediment aggrades in the channel, and flood levels can rise for a given storm event. In addition to aggradation, erosion can also occur on stream banks caused by deposition patterns/sediment bars directing flow into stream banks.

Changes to Sediment Dynamics and Culvert Sedimentation

Sediment transport is a fundamental function of stream systems. However, changes in sediment dynamics can affect flood risk and are often interrelated with hydrologic changes, the presence of man-made structures, or local disturbances to channel geomorphology.

Upstream channel change/erosion can account for as much as 90% of sediment yield volumes. When sediment yields increase, the resulting excess sediment typically has one of three fates:

1. Sediment can be redeposited downstream within the channel or floodplain. This reduces flood capacity in locations where the stream no longer has the sediment transport capacity to move the sediment through the system. This can happen in places where the channel has become overly wide due to historic channel downcutting and widening.
2. Sediment can be transported and stored within reservoirs or retention/detention ponds and can reduce flood storage if not adequately addressed by maintenance (as discussed in previous sections). This becomes a maintenance responsibility for the owner of the reservoir.
3. Sediment is effectively transported out of the watershed over time.

Sedimentation within culverts or stormwater infrastructure is also a common source of increased local flood risk. Culvert designs are typically based on maximum expected flood events. However, culvert designs have traditionally not considered lower-level flood events or sediment transport, as many such culverts are oversized for more frequent storm events. Flows entering culverts spread out laterally, increasing the channel width and decreasing the channel depth. This reduces the stream power through the culvert. The result is a loss in sediment transport capacity and deposition within the culvert. As deposition continues, culverts lose capacity causing increased flood risks as water stacks up behind filled-in culverts and road crossings. This phenomenon is often not accounted for in flood risk analysis.

There are two primary solutions to local sedimentation at culverts and road crossings. First is ongoing monitoring and maintenance by the owner of the culvert to ensure that sedimentation is reducing culvert capacities, which could lead to local increases in flood risks. The second is to consider sediment transport and stream geomorphology during culvert design.

One example of culverts that account for sediment transport are tiered culverts or staged culverts. These have shown to be considerably more effective at reducing sedimentation while still maintaining flood capacity than the traditional practice of oversizing culverts. A tiered culvert set-up has a primary culvert that accommodates more frequent flow events and maintains the stream channels width-depth ratio and sediment transport capacity. Adjacent culverts are placed at higher flow elevations and become activated during larger flood events. This allows flood capacity to be maintained while reducing sedimentation within culverts. An example of a staged culvert is shown in *Figure 2.40*.

Figure 2.40 Staged or Tiered Culvert Design used in North Texas with Multiple Culvert Sizes and Flow Elevations

Other Considerations

In summary, it is often not feasible to evaluate region-scale geomorphic changes and their potential effects on flood hazards because of the significant uncertainties introduced into flood hazard assessment without accounting for the intensive data requirements, extensive analysis of interrelated variables, and system heterogeneity. Major geomorphic changes and their effects on flood hazards are most prominently experienced at the local level and can be accounted for at this scale.

The above sections provide high-level examples of the connection between geomorphic changes and flood hazards at specific locations due to local sediment dynamics or bank erosion. Due to these effects occurring at a particular location or piece of infrastructure, mitigating these flood hazards are primarily a maintenance issue; therefore, it is often the responsibility of the owner of the easement, culvert, retention/detention pond, reservoir, etc.

However, one method used by numerous cities and regulatory bodies to account for uncertainty in geomorphic changes at a high level includes erosion hazard setbacks (also known as erosion clear zone, stream buffer area, etc.). This consists of a buffer area around the stream system that is not allowed to be disturbed without prior investigation. Multiple methods of creating this setback distance have been developed in design criteria manuals, and local flood plans to account for the uncertainty in future geomorphic changes without intense data requirements. Maintaining a buffer around streams provides numerous benefits, including:

- allowing for geomorphic channel adjustments to occur within an allotted lateral extent without significantly affecting flood inundation extents
- reducing hydrologic changes in the stream by slowing overland flow via riparian vegetation
- improving water quality via riparian vegetation filtering surface runoff

- reduction of bank erosion and subsequent excess sediment due to streambanks increased resistance to bank erosion from the roots of established riparian vegetation (i.e., bank vegetation reduces streambank erosion)
- prevention of erosion impacts to homes, infrastructure, and property adjacent to the stream

In larger drainage area streams with more thorough flood inundation mapping, these setbacks may not be as effective at reducing flood risk due to their relatively small buffer distances from streams compared to mapped floodplains. However, smaller watersheds with limited flood analysis can effectively provide an extra layer of protection with relatively low effort.

Future Conditions Hydrologic & Hydraulic Model Availability

Only two areas had models representing future conditions in the region. A summary of these studies is as follows:

1. **Texarkana** – A fully-developed (future) conditions model was prepared for the City of Texarkana that used the 2010 zoning map to represent future conditions. This would represent a fully developed condition within the City limits and would therefore be a conservative estimate of the 30-year future conditions required by the TWDB.
2. **Sherman** - Future conditions modeling for the 100-year floodplain has been conducted as part of a drainage study.

Due to the models being somewhat outdated and limited to the 100-year floodplain, neither was used to develop the floodplain quilt.

Hydrologic & Hydraulic Models Without Future Conditions

Limited existing conditions modeling was available in the region and only covered some municipal areas and portions of Grayson County. Of this, only the models previously discussed included future conditions. Many of these models are over 30 years old and need to be updated to existing conditions before updating them to future conditions. Due to the limited timeframe and budget of the initial regional flood planning effort, these models could not be updated to include future conditions. Such modeling has been identified as data gaps and is considered for potential Flood Management Evaluation (FME).

Future Conditions Estimation

Since reliable future conditions modeling and mapping were unavailable in the region, another method was needed to approximate future conditions. The TWDB allows for the following four methods to determine future flooding conditions:

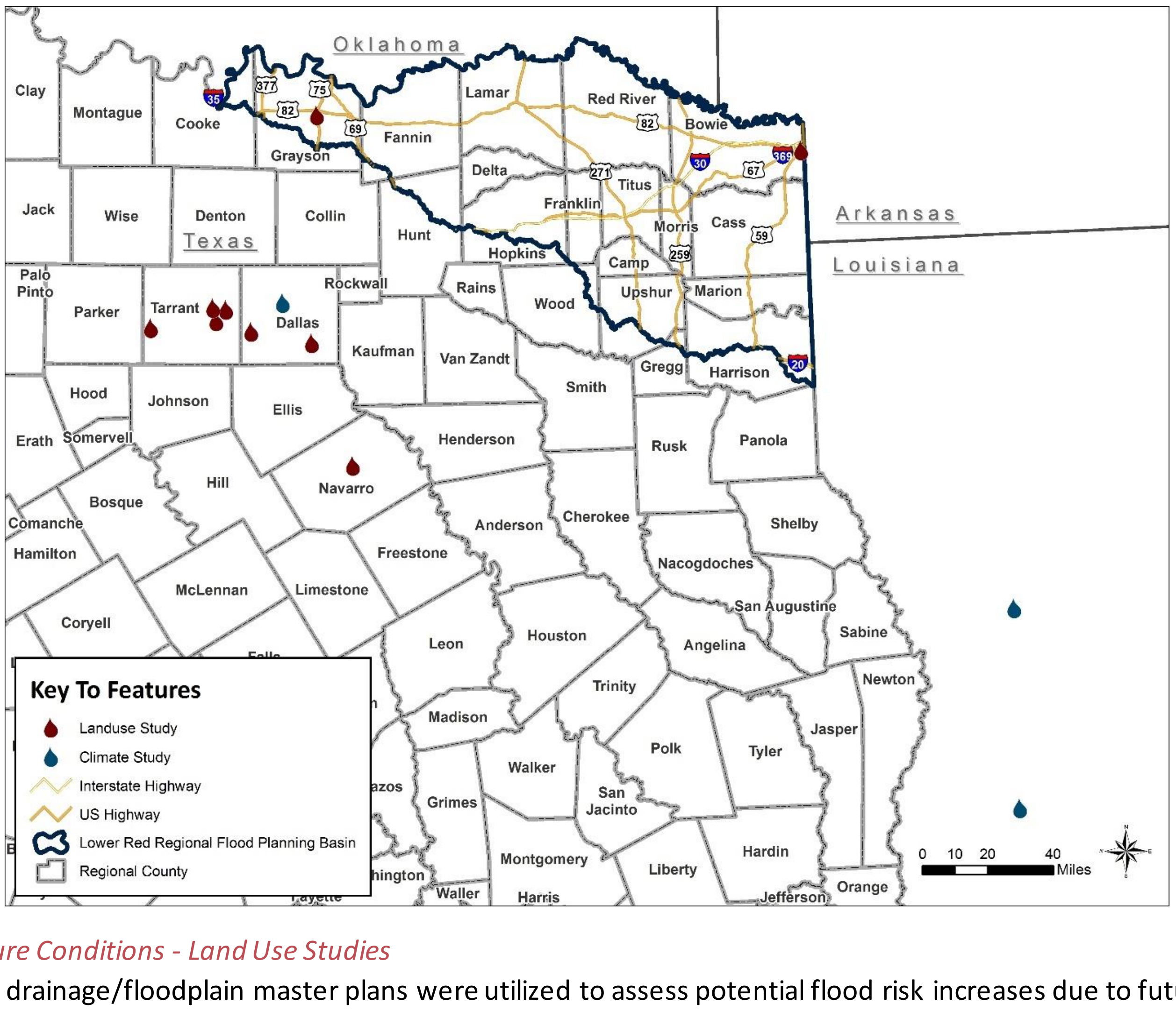
1. Increase water surface elevation based on projected percent population increase (as a proxy for the development of land areas)
2. Utilize the existing condition 0.2% ACE floodplain as a proxy for the future 1% ACE
3. Combination of methods one and two or an RFPG-proposed method
4. Request from the TWDB for a Desktop Analysis

An analysis was conducted to evaluate existing future conditions studies to help decide which method was best for the region.

Future Conditions Flood Risk Case Studies

Preexisting available hydrologic and hydraulic models containing future flood risk data were analyzed to better understand how future conditions affect flood risk within Region 2. Results from these studies estimated how future land use and climate change impact floodplain elevations and widths compared to existing conditions. Comparable studies were chosen based on availability, location, and similar hydrologic/hydraulic parameters. *Figure 2.41* provides a location for the existing studies collected for this assessment.

Figure 2.41 Future Conditions Case Study Locations



Future Conditions - Land Use Studies

Five drainage/floodplain master plans were utilized to assess potential flood risk increases due to future fully developed land use conditions. The future conditions analysis for these studies did not consider potential increases to rainfall data and is therefore based on land use changes only. A comparison was made between the existing and future conditions of 100-year flood elevations. In addition to the future

100-year comparison, a flood elevation comparison was made between the existing 100-year and 500-year storm events to analyze the viability of utilizing Method 2 for future flood hazard data for this planning cycle. The results of the comparisons are provided in *Table 2.16.*

Table 2.16 Case Study Future Conditions Land Use Water Surface Elevations (WSEL) Comparison

Location	Flooding Source	Average WSEL Change Existing vs. Future 100-year (feet)	Average WSEL Change Existing 100-year vs. 500-year (feet)
Parker County	Marys Creek	0.1	0.8
Grand Prairie	Fish, Kirby, Rush, Prairie Creek	0.2	1.4
Sherman	Post Oak, East Fork Post Oak, Sand Creek	0.7	1
Texarkana	Wagner, Swampoodle, Corral Creek	0.6	1.8
Corsicana	Post Oak, South Fork Post Oak, Mesquite Creek	0.2	1
	Average	**0.4**	**1.2**

Future Conditions – Projected Future Rainfall

During the data collection phase, no future flood risk based on potential future rainfall predictions were found. Two large-scale rain-on-grid studies were obtained as a substitute: Dallas City-Wide Watershed Masterplan and the FEMA Louisiana Upper Calcasieu Base Level Engineering Analysis. The modeling methodology of these studies allowed rainfall data to be quickly modified following the recommendations from the state climatologists. The 1% ACE storm event rainfall was increased by 15% for both studies, and the flood elevation results were compared to the present-day conditions. The increase of 15% was chosen because it fell into the high range of rainfall increases and matched the historical period of record increase. The existing 1% and 0.2% ACE flood elevations were also compared for the Method 2 consideration. The results of the comparisons are provided in *Table 2.17*.

Potential Future 100-Year Flood Hazard Methodology

The potential future conditions 1% ACE flood hazard approach methodologies were discussed during the September 2, 2021, Region 2 RFPG meeting. Due to the existing 0.2% ACE floodplain coverage developed in the floodplain quilt, Method 2 was chosen. The planning group had reservations about using the existing 0.2% ACE as a potential future 1% ACE flood risk proxy due to the case studies showing the floodplain may be too conservative of an approach; however, the TWDB required a future 1% ACE to be developed.

Table 2.17 Case Study Future Rainfall Increase WSEL Comparison

Location	Average WSEL Change Existing vs. Future 1% ACE (feet)	Average WSEL Change Existing 1% ACE vs. 0.2% ACE (feet)
Dallas	0.2	Unavailable*
Upper Calcasieu	0.4	1.7
Average	0.3	N/A

From the future conditions land use case study results, the average change in potential future 1% ACE WSEL compared to existing conditions was only 0.4 feet, while the comparison between the existing 1% ACE and existing 0.2% ACE water surface elevations yielded an average 1.2 feet change. By Increasing the average change in WSEL between existing and potential future conditions from *Table 2.16* by the average taken from *Table 2.17* to account for future rainfall projections, the results generally yielded a comparison less than that of the differences between the existing 1% ACE and existing 0.2% ACE water surface elevation.

In Region 2, this concern is mitigated because the 0.2% ACE floodplain mapping was developed primarily from Fluvial and Pluvial Cursory Floodplain Data, which was often narrower than the existing 1% ACE Zone A floodplains. Because of this, most of the region with Zone A mapping shows a 0.2% ACE floodplain that matches the 1% ACE floodplain; therefore, overestimation in these areas is unlikely. There will be some overestimation in the more developed areas and those with no mapping previously available (where 1% and 0.2% ACE Cursory Floodplain Data were relied upon), but this is unavoidable using these approximate methods.

Potential Future 500-Year Flood Hazard Methodology

The potential future conditions 0.2% ACE flood hazard approach methodology was discussed during the February 3, 2022, Region 2 RFPG meeting. Under Method 2 in the TWDB Technical Guidelines, an excerpt regarding the determination of the future 0.2% ACE flood hazard states: "RFPGs will have to utilize an alternate approach to develop a proxy for the 0.2% annual chance future condition floodplain, such as adding freeboard (vertical) or buffer (horizontal) estimates. The decision on what specific approach or values to use, which may vary within the region (e.g., for urban vs. rural areas) for these estimates will be up to the RFPGs, but technical justification should be provided to explain how the estimates were developed. This method cannot be applied to flood risk areas that do not already have a delineated existing condition 0.2% annual chance floodplain (i.e., flood-prone areas)." Based on this statement, reasonable buffer limits were researched based on the difference in existing top widths between the 1% ACE and 0.2% ACE floodplain quilt in and near Region 2. It is reasonable to assume that the difference between top widths for the existing conditions will be similar for potential future conditions. Previously collected BLE data was analyzed to establish a reasonable buffer zone representing a potential future 0.2% ACE flood risk. The average difference in top width between 1% ACE and 0.2% ACE floodplain was determined for the Pecan Waterhole HUC-8 using the flood hazard layer and mapped cross-sections, as shown in *Figure 2.42*. This HUC is part of the Red River's drainage area crossing Lamar, Red River, and Bowie counties. Over 11,400 cross-sections were analyzed and the average buffer between 1% ACE and 0.2% ACE floodplain was found to be 22 feet (in the TWDB specified NAD 83 2011 Texas Centric Lambert projection). To approximate the future floodplain, a 22-foot buffer has been applied to the existing 0.2% ACE floodplain showing a typical future conditions floodplain offset.

Best Available Data

The method used for determining the best available data is similar to that described in the existing condition section above and detailed in *Table 2.3*, but with changes due to the future conditions analysis discussed above. *Table 2.18* shows the best available hierarchy used for Region 2.

Figure 2.42 Cross-Sections Comparing distances between 1% and 0.2% ACE New BLE in Pecan Waterhole HUC-8

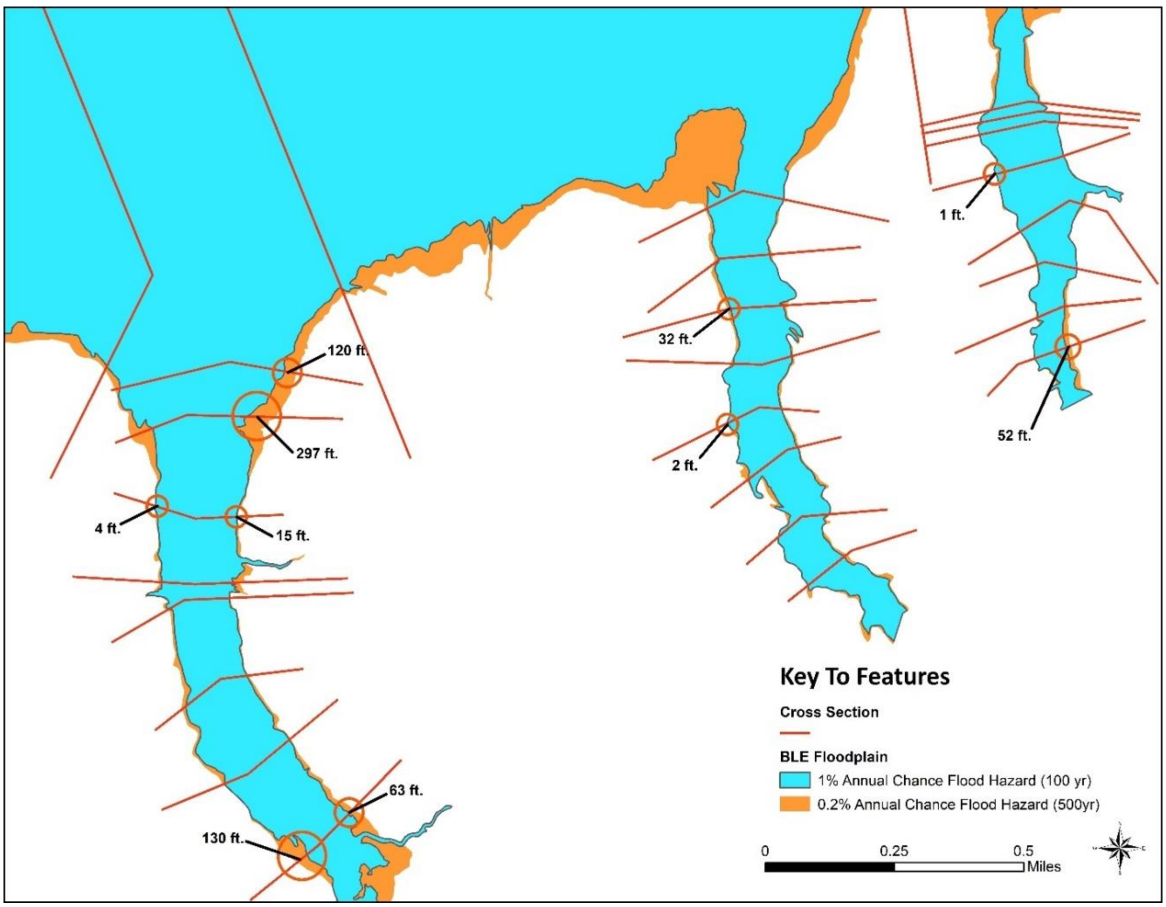


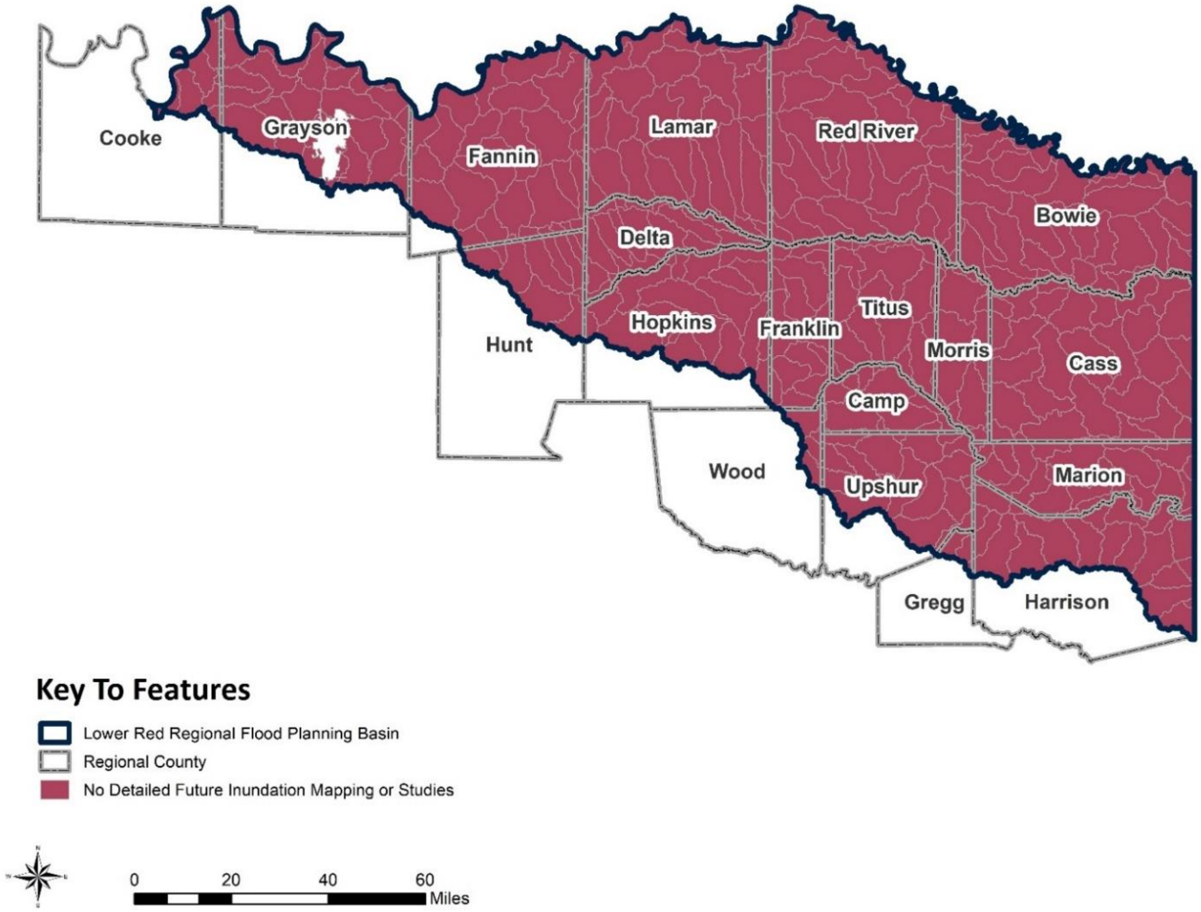
Table 2.18 Region 2 Floodplain Quilt Data Source Hierarchy Matrix

	Source	1%	0.2%
Best Available Data	Local Floodplain (if determined current)	**Existing:** Local Study, if provided **Future:** Local Study, if provided	**Existing:** Local Study, if provided **Future:** Local Study, if provided
↓	NFHL AE	**Existing:** Zone AE + Pluvial Cursory Floodplain Data **Future:** Existing 500-Year	**Existing:** Zone AE + Pluvial Cursory Floodplain Data **Future:** 22-Foot Buffer of Existing 500- Year
↓	BLE	**Existing:** BLE + Pluvial Cursory Floodplain Data **Future:** Existing 500-Year	**Existing:** BLE + Pluvial Cursory Floodplain Data **Future:** 22-Foot Buffer of Existing 500- Year
↓	NFHL A	**Existing:** Zone A + Pluvial Cursory Floodplain Data **Future:** Existing 500-Year	**Existing:** Zone A + Pluvial Cursory Floodplain Data **Future:** 22-Foot Buffer of Existing 500- Year
Most Approximate	FAFDS, or No FEMA	**Existing:** Combined Pluvial & Fluvial (Replaced FAFDS with Cursory Floodplain Data) **Future:** Existing 500-Year Cursory Floodplain Data	**Existing:** Combined Pluvial & Fluvial (Replaced FAFDS with Cursory Floodplain Data) **Future:** 22-Foot Buffer of Existing 500- Year

Data Gaps

The same data gaps exist for future conditions mapping as existing conditions mapping since existing conditions were used to assess the future extents. The City of Sherman analyzed and created 100-year future conditions in their modeling and drainage studies, so it has been excluded from the data gaps shown in *Figure 2.43*.

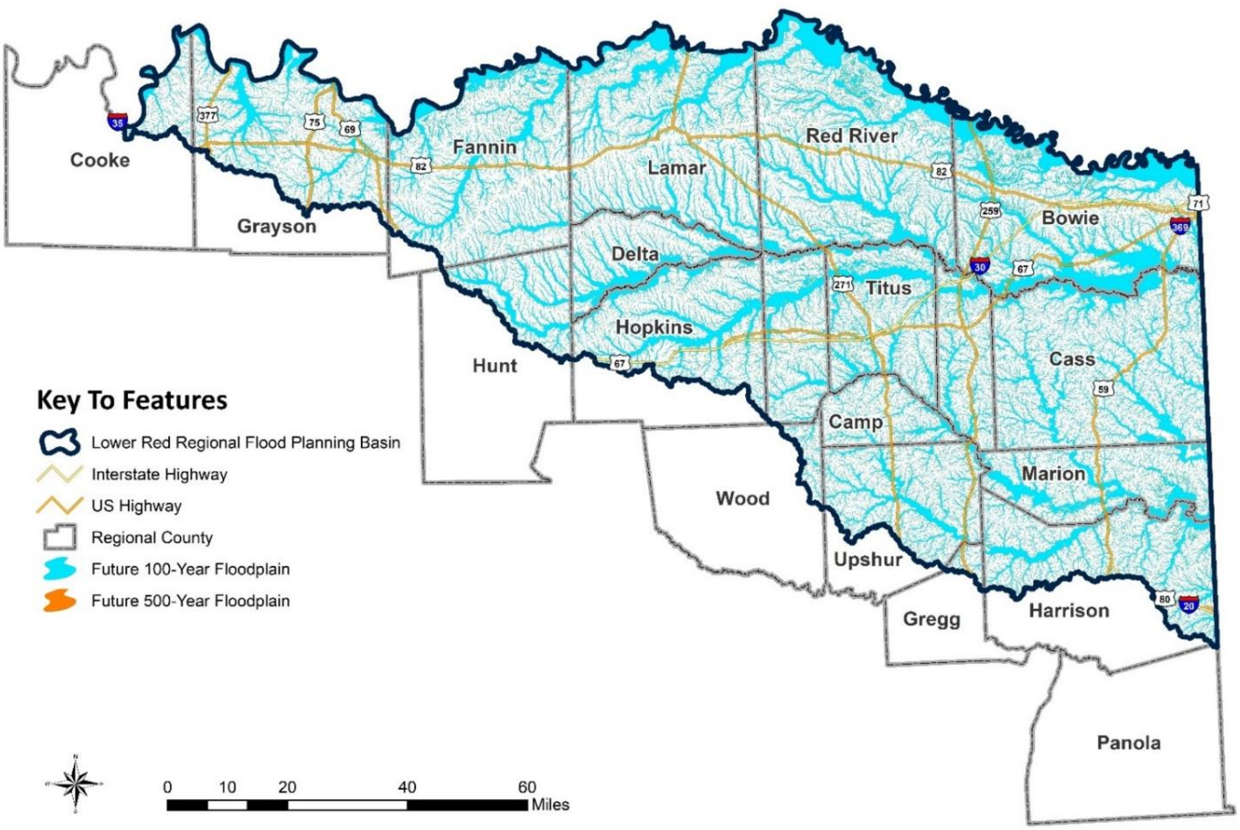
Figure 2.43 Future Conditions Data Gaps



1% and 0.2% Annual Chance Exceedance Future Floodplains

Future floodplain data developed for Region 2 includes only the 1% and 0.2% ACE events to describe the flood hazards and perform the exposure and vulnerability analyses. The future floodplains developed as described in *Figure 2.44.*

Figure 2.44 Map of Future 1% and 0.2% ACE Flood Hazard Areas



2B.2.A Future Condition Flood Exposure Analysis

Existing Development within the Existing Conditions Floodplains

The 30-year future conditions floodplain quilt was intersected with all of the same GIS exposure layers as in 2A to understand the effects of an increase in the flood hazard area, assuming no changes in policy, population growth, and related development, climate change, and natural sedimentation. The future condition exposure results by county are summarized in Table 5.

Existing and Future Developments within the Future Conditions Floodplains

As shown in *Figure 2.45* and *Figure 2.46*, the future floodplain would impact 57% more structures and 72% more people than existing conditions while only adding 12% more land area. The more significant effects are seen in the more developed cities, highlighting the amount of development that does happen just outside existing floodplains, as seen in *Figure 2.44*. The graphs below show a considerable difference from the existing conditions graphs, where most impacted structures are in the 1% ACE flood hazard area.

Figure 2.45 Potential Total Structures at Risk in Future Flood Hazard Area

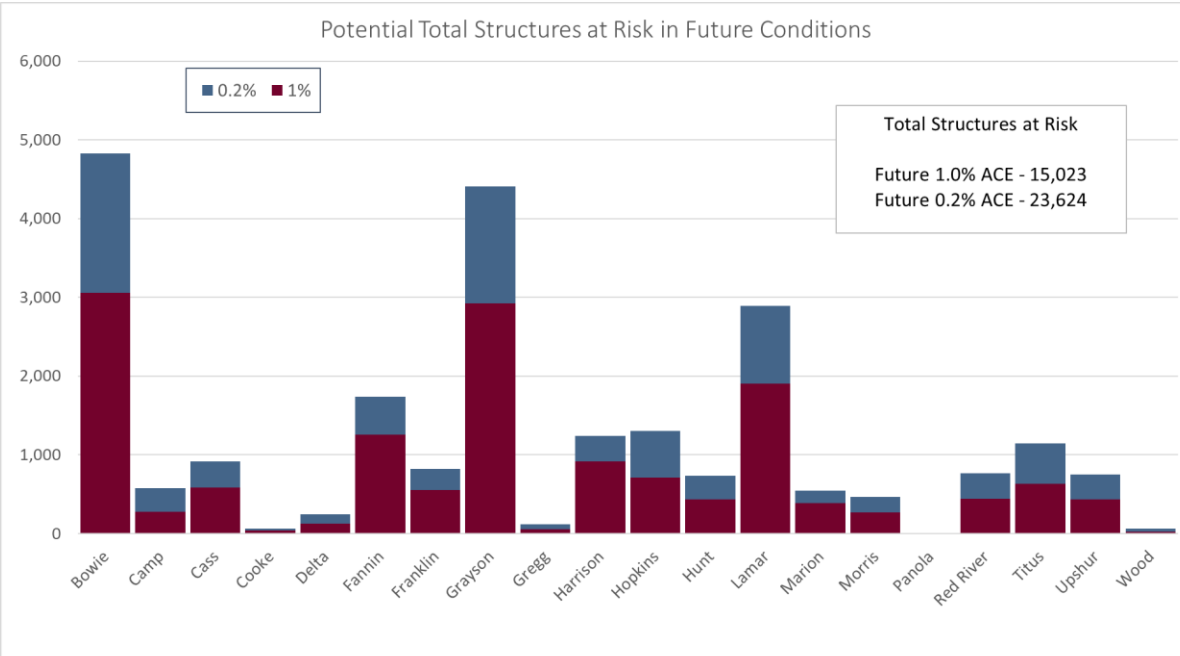


Figure 2.46 Potential Residential Structures at Risk in Future Flood Hazard Area

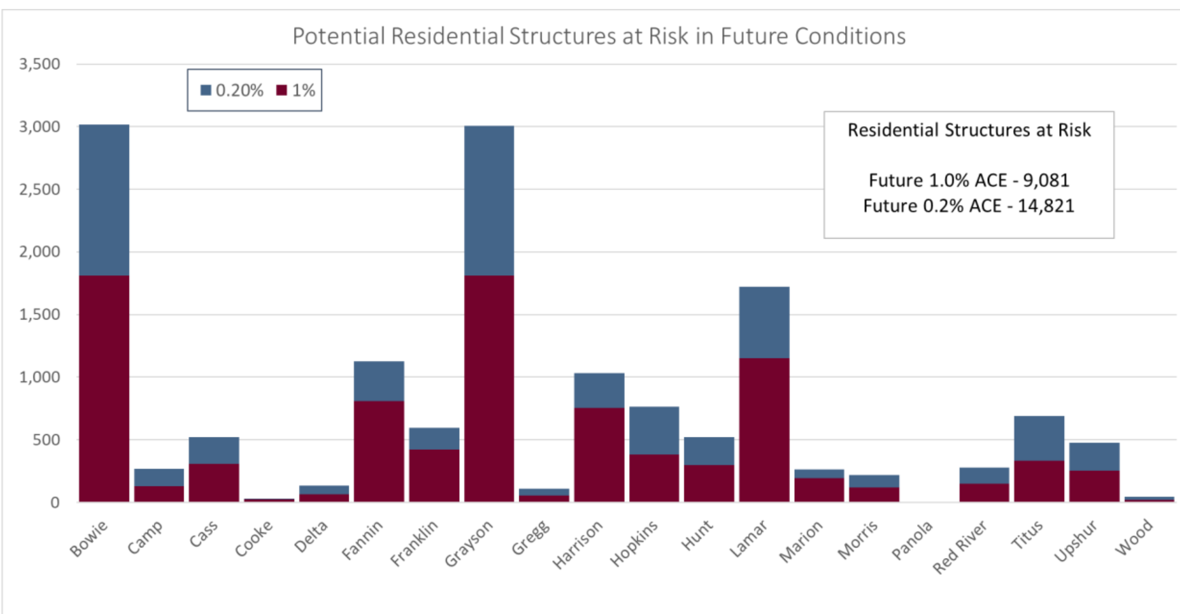


Figure 2.47 Structures Impacted in the Future 0.2% ACE

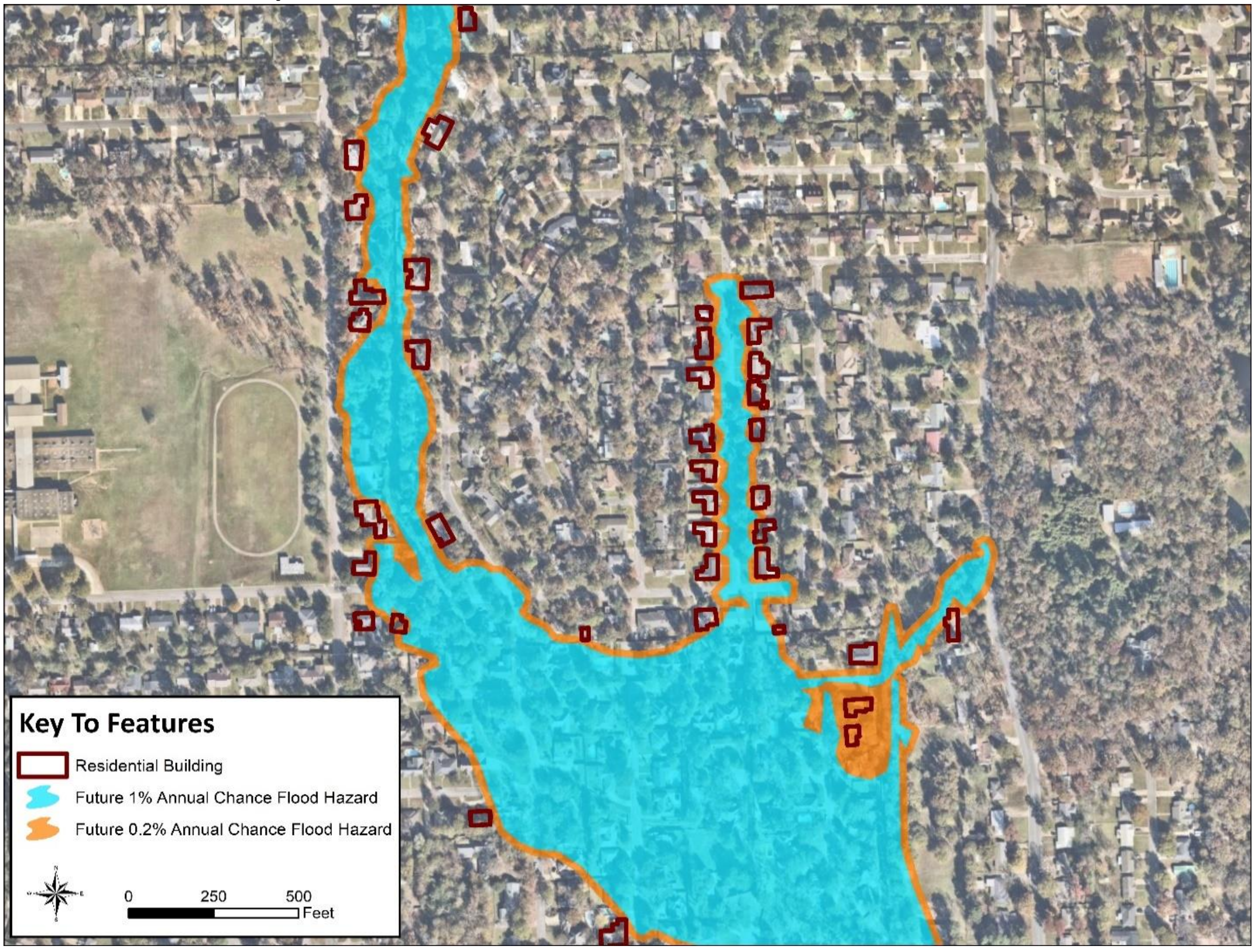


Figure 2.47 illustrates that even a small floodplain expansion in future conditions can significantly impact more structures. This is generally to the success in the past of preventing construction in the existing floodplain and highlights the need to consider future conditions in land planning or regulations. *Table 2.19* also highlights the disproportionate impact on structures compared to roadway crossings and low water crossings, which are often designed with some amount of freeboard above existing floodplains. Roadway segments show a 46% increase in floodplain impacts, mainly because many neighborhoods and roads near the floodplain are built just above the existing floodplain conditions. Agricultural lands would be minimally impacted since they are directly related to the increase in area. Most rural areas will see fewer increases in the floodplain than urban areas with greater development.

Table 2.19 Percent of Increase in Flood Exposures between Existing and Future Conditions

Exposure	Percentage Increase from Existing 0.2% to Future 0.2%
Residential Buildings	63%
Roadway Stream Crossings	15%
Low Water Crossings*	9%
Length of Roadway Segments	46%
Agricultural Land	9%

**Low Water Crossings are counted separately from Roadway Stream Crossings*

2B.2.B Potential Flood Mitigation Projects

Multiple projects are in various stages of a project lifecycle throughout Region 2. As weather and development patterns change, such projects must address the changing risks of future disasters. Communities that invest in forward-looking projects will see fewer impacts and are more likely to recover quickly after severe events. Projects completed considering future conditions will eliminate structures from being in the floodplain and reduce losses to life and property over time.

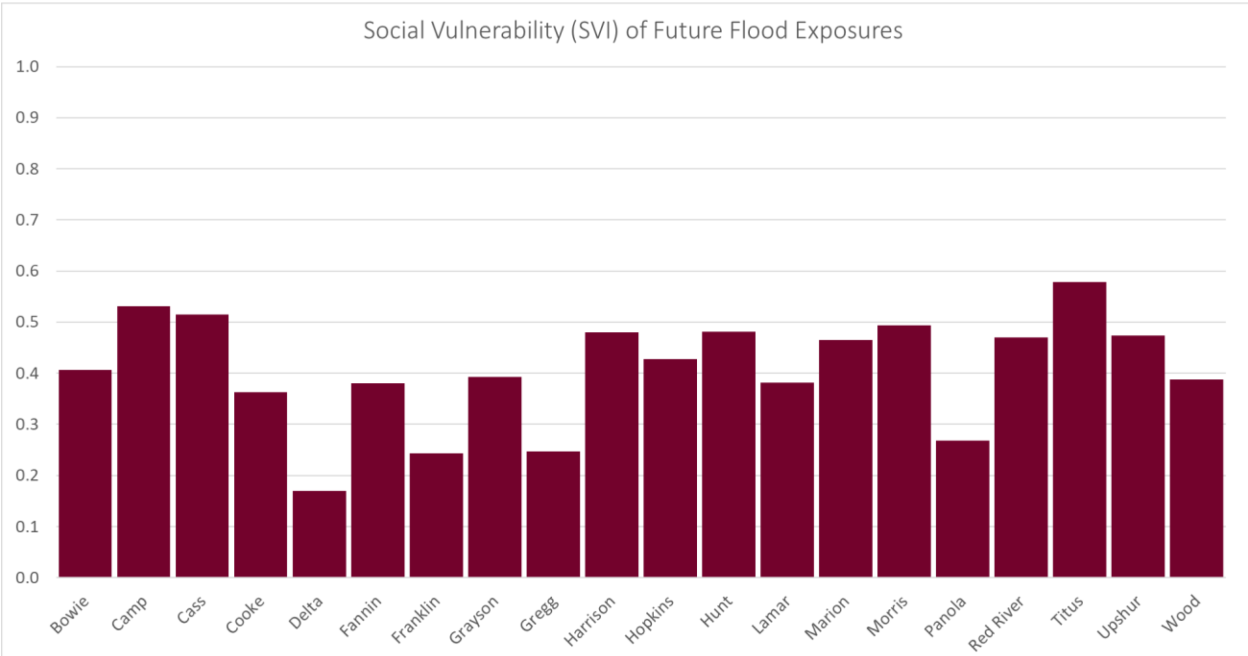
When asked what flood management strategies or flood mitigation projects are currently in progress, we received many responses, but no upcoming projects were provided.

2B.3 Future Condition Vulnerability Analysis

2B.3.A Resiliency of Communities

Similar to existing vulnerability, there are not highly vulnerable counties when averaging at the county level, but there are still vulnerable areas with higher SVIs in more developed census tracts, indicating the inability of many parts of cities within the region to recover and respond to a flooding disaster adequately.

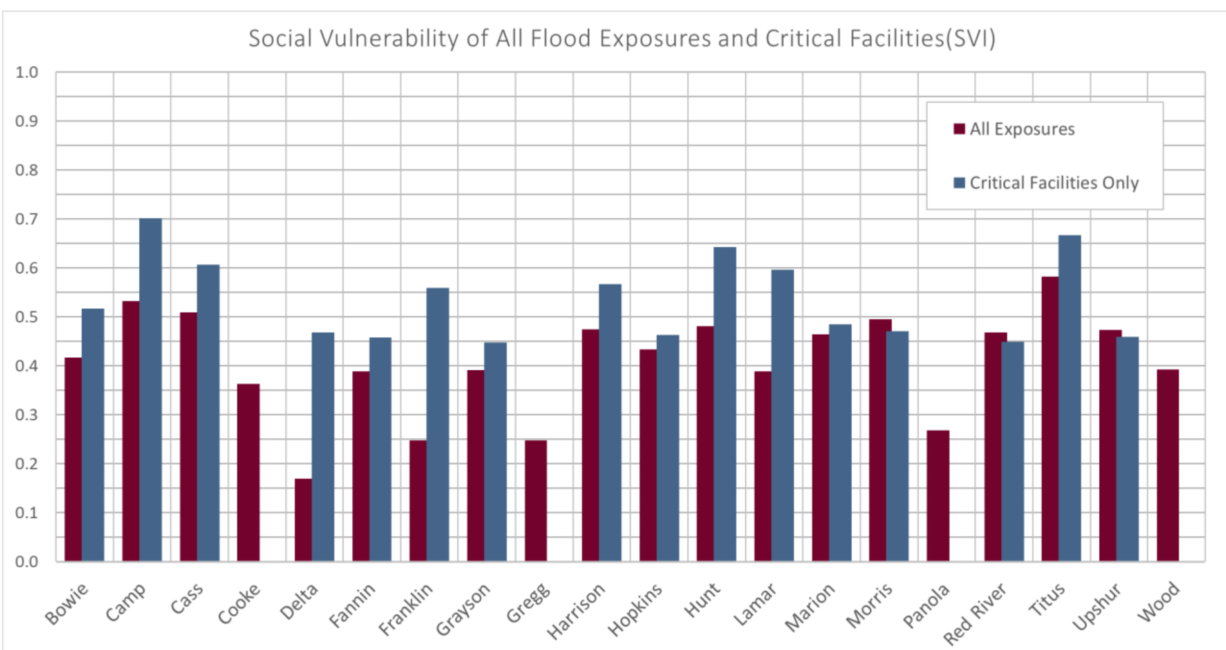
Figure 2.48 SVI of All Future Flood Exposures by County



2B.3.B Vulnerabilities of Critical Facilities

Figure 2.49 contrasts the average SVI for all future flood exposure with the SVI for critical facilities by county. It is worth noting that while critical facility SVI is usually higher because they are located in more developed areas, fewer critical facilities comprise this SVI calculation than total exposures.

Figure 2.49 SVI of All Future Flood Exposures and Critical Facilities by County



2B.4 Summary of Future Conditions Flood Exposure Analysis and Vulnerability

The future floodplain anticipates that there will be 57% more structures and 72% more people in the floodplain than in existing conditions while only adding 12% more land area. This shows the importance of floodplain regulations and planning for future conditions.

The future flood risk, exposure, and vulnerability assessment for Region 2 are summarized in the TWDB-required Table 5, located in Appendix 2. The TWDB Table 5 provides 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 and associated TWDB-required Figures 1 through 10 are provided in Appendix 5 as digital data. *Table 2.2*, in Appendix 2, outlines the geodatabase deliverables in the Technical Memorandum, spatial files, and tables.

Chapter 3: Floodplain Management Practices and Flood Protection Goals

The Lower Red-Sulphur-Cypress Regional Flood Planning Group (RFPG) is tasked with evaluating and recommending floodplain management practices (Task 3A) and flood mitigation 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 endeavor.

3A.1 Evaluation and Recommendations on Floodplain Management Practices (361.35)

The initial effort under Task 3A was to collect and perform a qualitative assessment of current floodplain management regulations within the region (i.e., floodplain ordinances, court orders, drainage design standards, and other related policies). Floodplain management regulations readily available on the regulatory entity's websites 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. Based on the data collected in this effort, a total of 18 out of 20 counties (90%) and 63 out of 85 cities/towns (74%) within the region have some form of floodplain management regulation (see TWDB-required *Table 6* and Figure *3.1/Map 13*). The remaining regulatory entities were classified as "unknown" as data was not provided through the survey or could not be found online.

3A.1.A Extent to which Current Floodplain Management and Land Use Practices Impact Flood Risks

This section examines the region's regulations, policies, and trends. From a flood risk perspective, these management practices improve the protection of life and property. Floodplain management and land use practices may vary widely from one entity to another. The Federal Emergency Management Agency (FEMA) manages the National Flood Insurance Program (NFIP), which provides the minimum standards for development in and around the floodplain.

In 1968, Congress established the NFIP through the National Flood Insurance Act of 1968 to provide federally subsidized flood insurance protection. The program has been updated multiple times to strengthen the program, provide fiscal soundness and inform the public of flood risk through insurance rate maps. Title 44 of the Code of Federal Regulations (44 CFR) includes the rules and regulations of the program. 44 CFR Part 60 establishes the minimum criteria that FEMA requires for NFIP participation, including identifying special flood hazard areas within the community.

Cities and counties work with FEMA to establish 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). 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 flood risk, which determines the flood insurance rate for individual properties.

Cities and counties have the authority to establish their own policies, standards, and practices to manage land use in and around flood-risk areas. Participating communities 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 that choose to establish higher standards to better protect life and property.

Cities and counties that participate in the NFIP program provide residents and businesses the opportunity to purchase flood insurance to reduce the socioeconomic impacts of floods and make the community eligible for disaster assistance following a flood event.

Existing Population and Property

Multiple resources were considered to determine the extent to which floodplain management and land use practices impact flood risk to existing population and property. Cities and counties can approve floodplain ordinances or court orders, respectively. Therefore, the NFIP participants are limited to these entities, and the results included in this report's section are limited to cities and counties.

Communities participating in the NFIP must have a floodplain ordinance or court order that meets or exceeds the NFIP minimum standards. As of October 2021, 16 counties (80%) and 59 cities (70%) in the Lower Red-Sulphur-Cypress Region (Region 2) participate in the NFIP and have floodplain ordinances that meet or exceed the NFIP minimum standards.

44 CFR Part 60 establishes minimum standards that a city or county must meet to be eligible to participate in the NFIP. The minimum standards require buildings to be constructed at or above the BFE, provide floodproofing options for non-residential buildings, and mandate provisions specific to the elevation and anchoring of manufactured houses. The minimum standards are based on maps that represent "current" conditions, which may, in reality, be based on outdated topography, rainfall, and runoff data. Therefore, the minimum standards may offer limited protection from flood damage.

According to the TWDB Exhibit C *Guidance Document*, the term "higher" standard is defined as freeboard, detention requirements, or fill restrictions. FEMA defines freeboard as additional height above the BFE that serves as a safety factor when determining the elevation of the lowest floor. The BFE is the surface water elevation resulting from a flood with a 1% chance of occurring in any given year (1% ACE). The BFE is typically based on FEMA FIRMs (maps) and associated Flood Insurance Studies (models). However, the BFE can be based on localized data developed by the community that may not be incorporated into a FEMA mapping product.

Floodplain ordinances were readily available for 19 of the 59 cities participating in the NFIP. These ordinances were reviewed, and it was found that 17 of them included a freeboard requirement. Seven cities require both residential and non-residential structures to have the lowest floor elevated to at least the BFE. Two cities require a one-foot freeboard, and eight require a two-foot freeboard. In the case of counties, only seven of those with floodplain management regulations include a freeboard requirement. *Figure 3.1* and *Figure 3.2* summarize freeboard requirements for cities and counties, respectively.

Figure 3.1 Number of Cities with Freeboard Requirements

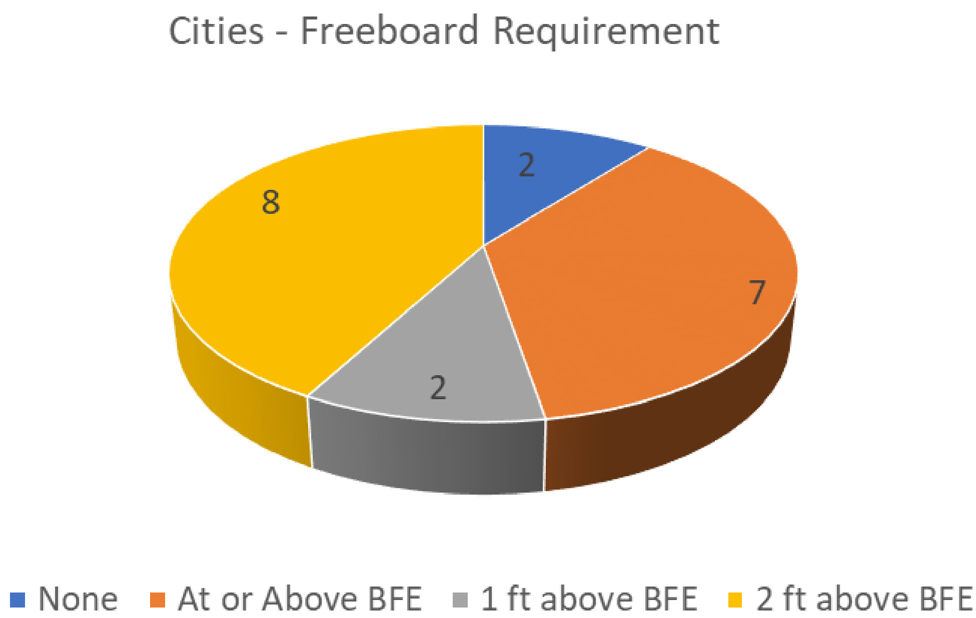
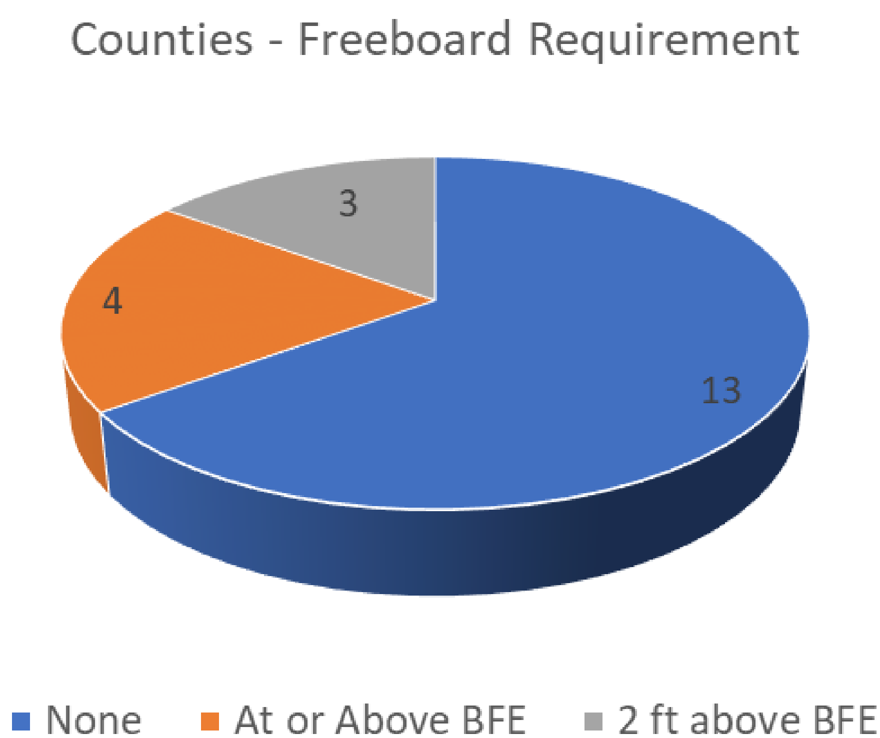


Figure 3.2 Number of Counties with Freeboard Requirements



Other floodplain management practices that were observed in some of the reviewed floodplain regulations include:

- requiring new developments to perform detailed studies to establish BFE data when not available
- stormwater detention requirements
- limitations to criteria variance within designated floodways

Typically, the threshold for requiring BFE data to be developed was for subdivisions proposing 50 lots or greater or with an area greater than five acres. A total of 16 cities (19%) and six counties (30%) include this requirement in their floodplain regulations. With respect to detention facilities, only seven cities (8%) and two counties (10%) include a stormwater detention requirement in their floodplain regulations. Regarding criteria variances, it was found that 14 cities (17%) and six counties (30%) include some form of limitation when there are impacts in the designated floodway. The most common language found is that variances shall not be issued within any designated floodway if any increase in flood levels during the base flood discharge would result.

Although the region has a relatively high NFIP participation, the RFPG considers that there is still a significant gap concerning key floodplain management practices and that communities could enhance their efforts to prevent the creation of additional flooding risks in the future.

Future Population and Property

Region 2 is projected to experience a population increase of about 24% from 2020 to 2050. Some of the existing floodplain ordinances and court orders with higher standards may continue to protect future populations and property as long as they are enforced. However, the gap in key floodplain management practices across the region poses an increasing flood risk level as the population continues to increase. Local floodplain regulations with higher standards need to be adopted and enforced to better protect future populations and property. **The RFPG encourages those 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**.

Future floodplains are uncertain. However, it is anticipated that future floodplains will look different from existing floodplains in some areas within the region. The hydrologic and hydraulic (H&H) models used to generate floodplain maps are regularly being updated with new topography, survey, precipitation, runoff, and other data as development occurs in and around floodplains. The future BFE will likely increase, expanding floodplain areas, due to several conditions presented in *Section 3B.1*. Cities and counties typically develop future land use plans considering areas of anticipated population growth and development within their communities. However, the existing and future floodplains are not necessarily a component of the future land use plan. Incorporating the existing and future floodplains will provide cities and counties with additional direction as to where population and development should be directed to protect people and property. Some of the region's cities and counties have already incorporated requirements where H&H analyses should be based on fully developed land use conditions. Entities that currently use future flood conditions as part of their design criteria provide a factor of safety that reduces future flood hazard exposure for new and existing developments.

Freeboard is another factor of safety that can be implemented to reduce future flood hazard exposure. The freeboard provides additional height above the BFE, as discussed in the "Existing Population and Property" section. While the BFE is likely to change in the future, the freeboard is intended to allow the structure to remain above the anticipated future water surface elevation but possibly with less height above the water surface.

Detention and retention ponds are often required to mitigate the impacts of impervious surfaces and more efficient drainage infrastructure on a developed property's runoff. As discussed in the "Existing Population and Property" section, a handful of entities within the region currently incorporate stormwater detention requirements in their design criteria. The standard engineering design requirement is to manage runoff so that it discharges from the developed property at the existing rate that leaves the property in its natural state. Incorporating this requirement mitigates increased runoff in the future, which in turn can reduce future flood hazard exposure.

Areas without maps and models or outdated maps and models are at greater risk in terms of future population and property development within the floodplain. Entities need comprehensive and updated maps to direct development away from flood-prone areas. Future floodplain maps and models are anticipated to be updated with higher resolution data, best available data, and advanced modeling techniques in the years to come. Reducing floodplain mapping gaps within the region and increasing mapping accuracy should reduce flood risk uncertainty and translate into life and property savings in the future.

3A.2 Consideration of Recommendation or Adoption of Minimum Floodplain Management and Land Use Practices

The Lower Red-Sulphur-Cypress RFPG must consider the possibility of recommending or adopting consistent minimum floodplain management standards and land use practices for the entire region. Recommended practices encourage entities with flood control responsibilities to establish minimum floodplain management standards over the next several years, whereas adopting minimum standards requires entities to have adopted the minimum standards before their Flood Management Strategies (FMSs), Flood Management Evaluations (FMEs), and Flood Mitigation Projects (FMPs) could be considered for potential inclusion in the Regional Flood Plan.

The RFPG considered all the information gathered and analyzed as part of Task 3A.1 to deliberate on recommending or adopting minimum floodplain management standards. This topic was first introduced during the July 8, 2021 RFPG meeting. During this public meeting, an interactive web-based polling session was conducted to start gathering feedback from the RFPG and members of the community with regard to the following topics:

- main flooding concerns
- issues that were considered the main impediments to effective floodplain management
- recommending or adopting minimum standards for all entities within the region
- types of minimum standards to be considered
- most important outcomes of the Regional Flood Planning effort

The qualitative assessment of current floodplain management regulations described previously and the results of this initial survey served as a guide to compiling a preliminary set of minimum standards, which were presented and debated during the September 2, 2021 RFPG meeting. One of the primary outcomes of this meeting was that **the RFPG only intends to recommend, not adopt, minimum standards for the region**.

The preliminary minimum standards were then updated based on the discussion and feedback from the September 2, 2021 meeting. These updated standards were summarized in a memorandum submitted to the RFPG on September 22, 2021 to provide a final opportunity for reviewing and providing comments before taking an official vote on the next RFPG meeting. In response to this review, some additional updates were incorporated into the standards language. The final recommended minimum standards were presented for the RFPG's consideration and final approval at the October 7, 2021 RFPG meeting. Some final adjustments were requested to the recommended standards during this meeting before voting, but the RFPG voted in favor of the recommended minimum standards as amended during the meeting.

In general, the final RFPG recommended minimum standards can be grouped into six general categories:

- freeboard
- roadways
- culverts/bridges
- storm drainage systems
- detention
- mapping coverage

Table 3.1 presents the final recommended minimum standards approved by the RFPG for consideration by local entities within the region. These recommended minimum standards were compiled in parallel with the flood mitigation and floodplain management goals developed as part of Task 3B.1. Therefore, the recommended minimum standards also reflect the vision and objectives captured in the region's goals.

The recommended freeboard for residential, commercial, and critical facilities (i.e., hospitals, fire stations, and police stations) exceeds the minimum NFIP requirements. The RFPG recognizes this is a higher standard for most cities and counties within the region but considers it an essential recommendation as freeboard is one of the most effective means for reducing flood risk to a structure in the floodplain.

When considering roadways, culverts/bridges, and storm drainage systems, the RFPG determined that recommending minimum standards based on the Texas Department of Transportation (TxDOT) hydraulic design manual would provide a consistent and well-known set of standards. The design frequencies (or level of service) established by these standards vary as a function of roadway classification, which was considered a desirable component of the recommended standards. In addition, the RFPG considered that TxDOT standards would not pose an excessive burden on small communities which currently do not have any floodplain management standards in place.

The recommended multi-stage detention standard is intended to provide a basic design requirement in which multiple storm frequencies are considered in the design of the detention facility and its outlet structures. The objective is that the detention facility should be effective across a range of storm events and provide proper peak discharge attenuation for the low frequency/large magnitude events and the more frequent, smaller-magnitude storms.

Finally, the RFPG recognizes the importance of increasing and improving floodplain mapping coverage across the region to reduce flood risk uncertainty and improve the tools for regulating development within the floodplain. As development continues within the region, it is important to leverage the best available data and modeling tools to establish BFEs, update approximate floodplain boundaries (FEMA Zone A), and create new floodplain maps where they are nonexistent. Furthermore, the RFPG also recommends using modeling tools to demonstrate that a proposed development will have no adverse impacts on downstream properties.

Table 3.1 Recommended Minimum Floodplain Management Standards for New Construction or Redevelopment

Infrastructure	Recommended Standard*
Residential Properties	Finished floor elevation (FFE) 1-foot above BFE (BFE = Base Flood Elevation, 1% ACE)
Commercial Properties	Finished floor elevation (FFE) 1-foot above BFE (BFE = Base Flood Elevation, 1% ACE)
Critical Facilities	FFE above 0.2% ACE or 2 feet above 1% ACE whichever is lowest
Roadways	TxDOT Hydraulic Design Manual (Sep/2019) Chapter 10 (http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf)
Culverts **Bridges**	TxDOT Hydraulic Design Manual (Sep/2019) Chapter 4, Section 6 - Table 4.2: Recommended Design Standards for Various Drainage Facilities. (http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf)

Infrastructure	Recommended Standard*
Private Storm Drainage Systems (New Site Development)	TxDOT Hydraulic Design Manual (Sep/2019) Chapter 10 (http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf)
Detention Facilities	Multi-stage Detention - detain to existing conditions peak discharge for 50%, 4% and 1% ACE
Mapping Coverage	Developers building in Zone A or unmapped areas must provide an engineering analysis to establish BFE and determine no adverse impacts downstream.

** Standards do not apply to existing structures and are not intended to be applied based on floodplain maps presented in Chapter 2*

3B.1 Flood Mitigation and Floodplain Management Goals (361.36)

One of the critical components of the inaugural State Flood Plan process was the development of 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 spent significant time and resources exploring values and discussing what they felt were the best goals for Region 2.

The overarching goal of all Regional Flood Plans must be "to protect against the loss of life and property" as set forth in the *Guidance Principles* (31 TAC §362.3). This is further defined to:

- identify and reduce the risk and impact to life and property that already exists
- avoid increasing or creating new flood risk by addressing future development within the areas known to have existing or future flood risk

The RFPG must identify specific and achievable goals that, when implemented, will demonstrate progress toward the overarching goal set by the state. Per the 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) and 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

The RFPG utilized the existing and future condition flood risk analyses from Chapter 2 and the assessment of current floodplain management and land use practices from Chapter 3A.1 as guides for developing and defining the goals for the region. After careful consideration of these factors, the RFPG adopted the flood mitigation and floodplain management goals listed in *Table 3.2*. These specific goals were reviewed and approved by the RFPG on October 7, 2021, during the RFPG public meeting. The adopted goals apply to the entire Region 2; no sub-regional goals were identified. The information requirements listed above are presented for each goal in the TWDB-required *Table 11 in Appendix 2*.

The selected specific goals will guide the development of the FMSs, FMEs, and FMPs for Region 2. They build upon the 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. The process for defining, refining, and selecting these goals is described in the following sub-sections.

Table 3.2 Adopted Flood Mitigation and Floodplain Management Goals

Short Term (10 years)	Long Term (30 years)
For each planning cycle, hold three public outreach and education activities (in multiple locations within the region) to improve awareness of flood hazards and the benefits of flood planning.	For each planning cycle, **hold three public outreach and education activities** (in multiple locations within the region) to improve awareness of flood hazards and the benefits of flood planning.
Support the development of a community-coordinated warning and emergency response program (including flood gauges) that can detect the flood threat and provide timely warning of impending flood danger Identify potential areas where flood warning systems would be beneficial.	Support the development of a community-coordinated warning and emergency response program (including flood gauges) that can detect the flood threat and provide timely warning of impending flood danger Implement a minimum of **1 flood warning system.**
Increase the coverage of flood hazard data by completing studies to reduce areas identified as having current gaps in flood mapping by 25%.	Increase the coverage of flood hazard data by completing studies to reduce areas identified as having current gaps in flood mapping **by 90%.**
Reduce the percentage of communities that do not have floodplain standards that meet or exceed the NFIP minimum standards by 25%.	Reduce the percentage of communities that do not have floodplain standards that meet or exceed the NFIP minimum standards **by 90%.**
Support the development of minimum stormwater infrastructure design standards applicable across Region 2 by creating an integrated stormwater management manual to serve as a guide/foundation for local governments.	Support the development of minimum stormwater infrastructure design standards applicable across Region 2 by **helping local governments** adopt and implement the stormwater management manual.
Reduce the number of NFIP repetitive-loss properties by 10%, including purchase or floodproofing of vulnerable properties.	Reduce the number of NFIP repetitive-loss properties **by 50%,** including purchase or floodproofing of vulnerable properties.
Identify at least one non-structural flood mitigation project in the region.	Identify at least **three** non-structural flood mitigation projects in the region.
Improve the level of service for 10% of vulnerable roadway segments and low water crossings located within the existing and future 1% annual chance floodplain.	Improve the level of service for **50%** of vulnerable roadway segments and low water crossings located within the existing and future 1% annual chance floodplain.
Repair, rehabilitate, or replace 10% of the aging stormwater infrastructure at high risk of failure and where failure would increase flood risks.	Repair, rehabilitate, or replace **50%** of aging stormwater infrastructure at high risk of failure and where failure would increase flood risks.

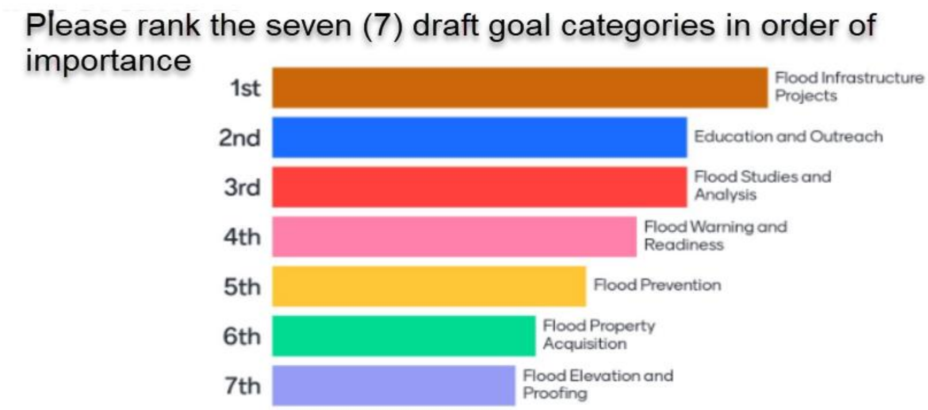
3B.1.A Flood Mitigation and Floodplain Management Goal Selection Process

The RFPG initiated the process for developing flood mitigation and floodplain management goals during the July 8, 2021 RFPG public meeting. This topic was introduced during this meeting, including legislative and TWDB Guidance for developing goals. Based on the initial feedback collected from the RFPG and community members, the RFPG carried out a process in which 26 preliminary goals were defined and grouped into seven categories. The preliminary list of goals was intended to provide a wide variety of possible goals. The goal categories and general objective of the preliminary goals developed under each category are described below:

1. **Education and Outreach** - Increase the amount of flood education and outreach opportunities to improve awareness of flood hazards and future participation throughout Region 2.
2. **Flood Warning and Readiness** - Improve the dissemination of information regarding early flood recognition and danger, emergency response procedures, and post-flood recovery actions.
3. **Flood Studies and Analyses** - Increase the number and extent of regional flood planning studies (FMEs) and analyses to better prepare communities for implementing flood mitigation projects.
4. **Flood Prevention** - Increase the number and extent of protective regulatory measures and programs to limit future risk and reduce flood damage in Region 2.
5. **Flood Property Acquisition** - Reduce the amount of existing and future vulnerable properties within Region 2.
6. **Flood Elevation and Proofing** - Reduce future vulnerability to existing structures through improved elevation and other flood-proofing programs and initiatives.
7. **Flood Infrastructure Projects** - Reduce flood risk and mitigate flood hazards to life and property through implementing flood infrastructure projects.

The preliminary goals were presented and considered during the August 5, 2021 RFPG public meeting. After presenting each category and associated goals, a live web survey was conducted to help determine if there was general agreement with the categories. Both the RFPG and members of the community were allowed to participate. The web-based survey also asked the participants to rank the goal categories in order of importance (see *Figure 3.3*). After reviewing and discussing survey results, the RFPG decided to eliminate the “Flood Property Acquisition” and “Flood Elevation and Proofing” categories. In addition, it was decided that the top-ranked category, “Flood Infrastructure Projects,” could be split into “Structural and Non-Structural flood Infrastructure” projects.

Figure 3.3 Goal Category Ranking Results



A follow-up web-based survey was then provided to the RFPG members requesting their feedback on the specific preliminary goals under each category. The survey was designed to gauge the RFPG's level of support for each specific goal, not to compare them or rank them against each other. The survey intended to provide a quantitative assessment of the level of support for each preliminary goal that would aid in selecting final goals. At this point, the goals did not include the specific target by which each would be measured, only the goal description. For each preliminary goal, the participants expressed their level of support by choosing one of the following options: Strongly Agree – Agree – Neutral – Disagree – Strongly Disagree.

The results of the web-based survey were analyzed and the preliminary goals with the highest level of support were selected from each category. This list was presented and considered during the September 2, 2021 RFPG public meeting. Short-term and long-term targets were recommended as a starting point to create measurable goals. Based on the feedback received during this meeting, the preliminary goals and targets were refined (*Table 3.3*) and presented for a vote and formal adoption during the October 7, 2021 RFPG public meeting. The RFPG requested some final modifications and the goals were adopted unanimously (as amended).

Table 3.3 Refined Preliminary Goals (as presented on October 7, 2021 RFPG public meeting)

Goal Category	Goal	Short Term Goal (2022)	Long Term Goal (2052)
Education and Outreach	For each planning cycle, hold public outreach and education activities (in multiple locations) to improve awareness of flood hazards and the benefits of flood planning.	3	3
Flood Warning and Readiness	Support the development of a community-coordinated warning and emergency response program, including flood gauges that can detect the flood threat and provide timely warnings for impending flood danger.	Identify potential areas where flood warning systems would be beneficial	Implement a minimum of one flood warning system

Goal Category	Goal	Short Term Goal (2022)	Long Term Goal (2052)
Flood Studies and Analysis	Increase the coverage of flood hazard data by completing studies to reduce areas identified as having current gaps in flood mapping by X percent.	25%	90%
Flood Protection	Reduce the percentage of communities without floodplain standards that meet or exceed the NFIP minimum standards by X.	Create an integrated stormwater management manual to serve as a guide/foundation for local governments	Help local governments to adopt and implement the stormwater management manual.
Flood Protection	Support the development of minimum stormwater infrastructure design standards across the region.	Create an integrated stormwater management manual to serve as a guide/foundation for local governments	Help local governments to adopt and implement the stormwater management manual.
Non-Structural Flood Infrastructure	Reduce the number of NFIP repetitive-loss properties by X percent, including purchasing or floodproofing vulnerable properties.	10%	50%
Structural Flood Infrastructure	Improve the level of service of vulnerable roadway segments and low water crossings located within the existing and future 1% annual chance storm events by X percent.	25%	90%
Structural Flood Infrastructure	Repair, rehabilitate, or replace X percent of the aging stormwater infrastructure at high risk of failure and where failure would increase flood risk.	25%	90%

3B.1.B Benefits and Residual Risk after Goals are Met

The adopted goals were developed to set the stage for specific actions that can be quantified and measured in future Regional and State Flood Planning cycles. Future data collection efforts or implementation of evaluations, strategies, and/or projects may be used to establish baseline data for future measurements to determine progress toward achieving the goals. Implementation efforts will also demonstrate progress towards the overall purpose and intent of the Regional Flood Planning process and will provide various benefits to individuals, communities, and the region. Achieving the adopted goals will certainly reduce the region's current and future levels of flood risk.

However, it is recognized that it is impossible to protect against all potential flood risks. In selecting the flood risk reduction goals, the RFPG is inherently determining the accepted residual risk for the region. In general, residual risks for flood risk reduction goals could be characterized as follows:

1. While a new development may be constructed outside the 1% annual chance floodplain, flood events of greater magnitude will inundate areas beyond those preserved as a floodplain.
2. Flood events may exceed the level of service for which infrastructure is designed.
3. Communities depend on future funding and program priorities to maintain, repair, and replace flood protection assets. Routine maintenance of infrastructure is required to maintain its design capacity, and maintenance is sometimes overlooked due to budget, staff, and time constraints.
4. Policies, regulations, and standards reduce adverse impacts associated with development activity but do not eliminate them.
5. The lack of local enforcement of floodplain regulations also creates risk.
6. In our representative government, policy changes that adversely impact budgets, prior plans, assets, and standards are always possible.
7. Practical (time and money) limits of understanding and precision associated with studies, models, and plans.
8. Human behavior is unpredictable; people may ignore flood warning systems or cross over flooded roadways for various reasons.

The residual risk for each of the specific goals adopted in Region 2 is presented in TWDB-required *Table 11 in Appendix 2*.

CHAPTER 4: Assessment and Identification of Flood Mitigation Needs

4A.1 Flood Mitigation Needs Analysis

This chapter describes the process adopted by the Regional Flood Planning Group (RFPG) to conduct the Flood Mitigation Needs Analysis resulting in identifying the areas with the greatest gaps in flood risk knowledge and the areas of greatest known flood risk and mitigation needs. The Task 4A process is a big-picture assessment that helps guide the subsequent Task 4B effort of identifying Flood Management Evaluations (FMEs), Flood Mitigation Projects (FMPs), and Flood Management Strategy (FMSs). *Table 4.1* summarizes the Texas Water Development Board (TWDB) guidance and factors considered in the Flood Mitigation Needs Analysis.

Table 4.1 TWDB Guidance and Factors to Consider

Guidance	Factors to Consider
Most prone to flooding that threatens life and property	• buildings within the 100-year floodplain • low water crossings • agricultural and ranching areas in the 100-year floodplain • critical facilities in the 100-year floodplain
Locations, extent, and performance of current floodplain management and land use policies and infrastructure	• communities not participating in National Flood Insurance Program (NFIP) • disadvantaged/underserved communities • city/county design manuals • land use policies • floodplain ordinance(s)
Inadequate inundation mapping	• no mapping • presence of Fathom/Base Level Engineering (BLE)/Federal Emergency Management Agency (FEMA) Zone A flood risk data • detailed FEMA models older than 10 years
Lack of Hydrologic and Hydraulic (H&H) models	• communities with zero or limited models
Emergency need	• damaged or failing infrastructure • other emergency conditions
Existing modeling analyses and flood risk mitigation plans	• exclude flood mitigation plans already in implementation • leverage existing models, analyses, and flood risk mitigation plans

Guidance	Factors to Consider
Previously identified and evaluated flood mitigation projects	• exclude flood mitigation projects already in implementation • leverage existing flood mitigation projects
Historic flooding events	• flood insurance claim information • areas with a history of flooding, according to survey responses • other significant local events
Previously implemented flood mitigation projects	• exclude areas where flood mitigation projects have already been implemented unless significant residual risk remains
Additional other factors deemed relevant by RFPG	• alignment with RFPG goals • alignment with TWDB guidance principles • Social Vulnerability Index (SVI)

4A.1.A Process and Scoring Criteria

The main objectives of the Flood Mitigation Needs Analysis are to identify the areas of greatest **known flood risk** and areas where the greatest **flood risk knowledge gaps** exist. This analysis was based on a geospatial process that combines information from multiple datasets representing several of the factors listed in *Table 4.1* and provides a basis for achieving the analysis objectives. The geospatial process was developed in geographic information system (GIS) based on the data collected in Tasks 1 through 3. Various data sources were used in this assessment, including GIS data collected directly from entities during outreach efforts. During the data collection phase, stakeholders participated in an online survey where they could respond geographically on a map. The stakeholder responses, as of September 28, 2021, were directly applied to this assessment.

The geospatial assessment was prepared at a HUC-12 watershed level, which provides a level of resolution that was considered suitable for performing the assessment at a regional scale. A Hydrologic Unit Code (HUC) is a unique code assigned to watersheds in the United States. As the watersheds get smaller, the number of units used to identify them gets longer. The smallest unit of division that is completely delineated for the United States is the HUC-12 level (https://water.usgs.gov/GIS/huc.html). The Lower Red-Sulphur-Cypress River basin has 262 HUC-12 watersheds, with an average size of 35 square miles.

A total of 12 data categories were used in the geospatial assessment. The statistical distribution determined a scoring range for each data category. A uniform scoring scale of zero to five was adopted and each HUC-12 was assigned an appropriate score for each category. The scoring ranges vary for each category based on the HUC-12s with the smallest and largest quantity. The scores for each HUC-12 under each category were then added to obtain a total score used to quantify the level of known flood risk. The HUC-12s with the highest scores indicate areas of greatest known flood risk. The Inadequate

Inundation Mapping category (see *Section 4A.1.C*) was selected to determine where the greatest flood risk knowledge gaps exist.

The following sections briefly describe the data categories included and how each HUC-12 watershed was scored. Note that the objective of the Task 4A process is to determine the factors that are present within a given HUC-12 and to what degree, not necessarily to determine the relative importance of each factor in determining flood risk. Therefore, no weight has been applied to emphasize one factor over another at this time.

Areas Most Prone to Flooding that Threatens Life and Property

Buildings in the 100-year Floodplain

The buildings within the 100-year floodplain were identified as part of the flood exposure analysis (See *Chapter 2*). Point values were assigned for this category based on the total number of buildings in the 100-year floodplain within each HUC-12. The points breakdown for this metric is shown in *Table 4.2.*

Low Water Crossings

Low water crossings were identified as part of the flood exposure analysis (See *Chapter 2*). This category is scored based on the number of low water crossings occurring within a HUC-12. The points breakdown for this metric is shown in *Table 4.2*.

Agricultural Areas at Risk of Flooding

Agricultural areas have been defined for this task as land used for either farming or ranching. Impacted agricultural areas intersect the 100-year floodplain as determined in the flood exposure analysis (See *Chapter 2*). This layer will emphasize rural HUC-12s where agricultural impacts due to flooding are most prominent. The total impacted agricultural area in each HUC-12 was the criteria considered to assign points. The points breakdown for this metric is shown in *Table 4.2.*

Existing Critical Facilities

Critical facilities within the 100-year floodplain were identified as part of the flood exposure analysis (See *Chapter 2*). Critical facilities for this assessment include hospitals, schools, fire stations, shelters, power plants, public works facilities, superfund sites, and water/wastewater treatment plants. Overall, 80 critical facilities were identified within the 100-year floodplain. This category is scored based on the total number of critical facilities within each HUC-12. The points breakdown for this metric is shown in *Table 4.2*.

Locations where the Road Floods

Road flooding locations within the 100-year floodplain were identified as part of the flood exposure analysis (See *Chapter 2*). Although this factor primarily addresses water over roadways, it also represents potential urban flooding scenarios. Each road flooding location was represented as a line feature. This category is scored based on the total mileage of roads within each HUC-12. The points breakdown for this metric is shown in *Table 4.2.*

Table 4.2 Scoring Ranges: Areas Most Prone to Flooding that Threatens Life and Property

Score (points)	0	1	2	3	4	5
Number of Buildings	0	1-2	3-9	10-44	45-112	113+
Number of Low Water Crossings	0	1	2	3	4	5+
Total Agricultural Area (sq. mi.)	0	0.01-0.024	0.025-0.09	0.1-0.75	0.74-3.57	3.58+
Number of Critical Facilities	0	1	2	3	4	5+
Total mileage of Roads	0	0.01-2.3	2.4-4.8	4.9-8.6	8.7-13.3	13.4+

Current Floodplain Management and Land Use Policies and Infrastructure

Communities Not Participating in the NFIP

Participation in the NFIP was considered as a proxy for having adequate floodplain management regulations in a given community. The NFIP participation status for each community is presented in Chapter 3 (*Section 3A.1.A*). Non-participating communities are not eligible for flood insurance under the NFIP. Furthermore, if a presidentially declared disaster occurs due to flooding, no federal financial assistance can be provided to non-participating communities for repairing or reconstructing insurable buildings in Special Flood Hazard Areas (SFHA). Therefore, this analysis considered non-NFIP communities more vulnerable to flooding risks. If most of the HUC-12 (>= 50%) intersected a non-NFIP community, it was assigned five points. Otherwise, no points were allocated (*Table 4.3*).

Table 4.3 Task 4A Scoring Range: Current Floodplain Management and Land Use Policies and Infrastructure

Score (points)	0	1	2	3	4	5
Community	**NFIP Participant**	**NFIP Participant**			**Non-NFIP Participant**	**Non-NFIP Participant**

Areas Without Adequate Inundation Maps

Inadequate Inundation Mapping

This analysis was completed based on the Fld_Map_Gaps layer. Within that layer, the "Reason for Gap" field was used to assign points to each HUC-12 layer. Based on the definitions of the source data from the TWDB (Floodplain Quilt Pri | Hub: GIS Resources, Flooding Planning, Texas), it was assumed that the sources that represented adequate inundation mapping data are:

- National Flood Hazard Layer (NFHL) Preliminary Data (zones AE, AH, OH, and VE)
- NFHL Effective Data (zones AE, AH, OH, and VE)

The following data sources were considered inadequate inundation mapping data in this assessment as they only provide approximate inundation boundaries:

- Base Level Engineering (BLE)
- NFHL Zone A
- Fathom

The points breakdown for this metric is shown in *Table 4.4,* which considers the floodplain quilt data prioritization ranking established by the TWDB.

Table 4.4 Task 4A Scoring Range: Areas Without Adequate Inundation Maps

Flood Mapping Gap Status	Score (points)
Only Fathom data available/no data is available	5
Only approximate data is available (NFHL Zone A)	4
Base Level Engineering (BLE) data	3
Detailed study covers less than half of the watershed*	2
Detailed study covers most of the watershed and is less than 10 years old*	1

**Detailed study refers to NFHL Preliminary Data or Effective Data*

Areas Without Hydrologic and Hydraulic Models

The existing H&H models identified for the Lower Red-Sulphur-Cypress River Basin are described in *Chapter 2* (Existing Hydrologic and Hydraulic Model Availability). A separate scoring criteria was not developed for this category since the risk associated with lack of technical data is already being considered by the "Inadequate Inundation Mapping" category. Any areas with detailed mapping are presumed to have hydrologic and hydraulic modeling.

Areas with Emergency Needs

An emergency need has been defined as infrastructure in immediate need of repair or construction, particularly following a natural disaster or other destructive event. No emergency need has been identified for Region 2, therefore, this category was not included in this assessment for the first draft of the Regional Flood Plan.

Existing Modeling Analyses and Flood Risk Mitigation Plans

Hazard Mitigation Action Plans were identified for all 17 counties within the Lower Red-Sulphur-Cypress River Basin. Therefore, this category was not included in the assessment since it does not provide any differentiation regarding flood risk within the basin.

Flood Mitigation Projects Previously Identified

Per the public survey responses, no projects were identified as in progress and had dedicated funding. Therefore, this category was not included in this assessment.

Historic Flooding Events

Reported Flood Concerns

This category was generated by the community responses to the survey in Task 2. The category is represented by inputs to the "Flood History" and "Mitigation Needs" fields. A total of 27 locations were identified by survey participants. The points are assigned to HUC-12s and scored based on the count of flood concern locations within each HUC-12 boundary. The points breakdown for this metric is shown in *Table 4.5*.

FEMA Claims

This data set compiles all the FEMA flood claims within the Lower Red-Sulphur-Cypress basin as of February 8, 2021. FEMA claims were grouped by census tracts using the census track ID (which is also in the FEMA Claims dataset). The FEMA claims count was assigned to each HUC-12 based on an area-weighted average. The percent of a census tract that intersects a HUC-12 was multiplied by the total number of FEMA claims for the census tract. This procedure is followed for all census tracts intersecting a HUC-12 boundary, and those weighted FEMA claim values are added together to produce the total number of claims for each HUC-12. Most of the claims recorded in this data set occurred in the region's main urban centers, primarily the cities of Sherman, Denison, Bonham, Paris, Sulphur Springs, Texarkana, and Atlanta. The points breakdown for this metric is shown in *Table 4.5*.

Historic Storm Events

The occurrence of historic storms events was evaluated using the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information Storm Events Database. This database compiles historic storms events from 1950 to 2021. This dataset is an official NOAA publication that documents:

a) occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce
b) rare, unusual weather phenomena that generate media attention
c) significant meteorological events, such as record maximum or minimum temperatures or precipitation that occur in connection with another event

Storm events are included in this database following the procedures established in the National Weather Service Directive number 10-1605 – Storm Data Preparation. Storm events are subdivided into 48 categories, including flood-related events and other natural hazards. Three primary categories were selected for this assessment: Floods, Flash Floods, and Heavy Rain. A total of 693 storm events were reported for the Lower Red-Sulphur-Cypress River Basin between 1996 and 2020, consisting of 95 floods, 591 flash floods, and seven heavy rain events. Each event includes the source of data and a narrative describing the event's details.

The number of historical storm events occurring within each HUC-12 was tabulated, and scores were assigned according to the points breakdown (shown in *Table 4.5*).

Damages from Historic Storms

In addition to the frequency of historical storm events, the severity of these events was also considered in the assessment. Event severity was represented by reported damages, injuries, and deaths associated with each event as recorded in the Historic Storm Events database. A score of zero to five points was first assigned based on reported property damages (see scoring scale in *Table 4.5*). One additional point was added if injuries were reported and two additional points if deaths were reported.

Table 4.5 Task 4A Scoring Ranges: Historic Flood Events

Score (points)	0	1	2	3	4	5
Number of Flood Concerns	0	1	2	3	4	5+
Number of FEMA Claims	0	1	2	3-6	7-10	10+
Number of Historic Storms Events	0	1-2	3-4	5-6	7-8	9+
Property Damages ($)*	0	1-10,000	10,001-30,000	30,001-100,000	100,001-500,000	500,000+

** One additional point was added if injuries were reported, and two additional points if deaths were reported*

Previously Implemented Flood Mitigation Projects

Per the public survey responses, no flood mitigation projects were identified as previously implemented. Therefore, this category was not included in this assessment.

Other Factors

Social Vulnerability Index (SVI)

SVI refers to the potential negative impact on communities caused by external stresses on human health. Such stresses include natural or human-caused disasters or disease outbreaks. SVI values for the State of Texas were downloaded from the Agency for Toxic Substances and Disease Registry (ATSDR) website (https://www.atsdr.cdc.gov/placeandhealth/svi/index.html). The most recent SVI values published on the website (2018) were used in this assessment. SVI values are assigned per census tract, which needed to be converted to SVI per HUC-12.

SVI values were assigned to each HUC-12 based on an area-weighted average. The percent of a census tract that intersects a HUC-12 was multiplied by the SVI for the census tract. This procedure is followed for all census tracts intersecting a HUC-12 boundary, and those weighted SVI values are added together to produce one SVI value for each HUC-12. The SVI ratings varied between zero to one and were scored according to *Table 4.6*. The higher the SVI, the higher the vulnerability of a community; the lower the SVI, the higher the resilience. Overall, the HUC-12s within the Titus, Camp, Morris, and Cass counties resulted in the highest SVI values.

Table 4.6 Task 4A Scoring Ranges: SVI ratings

Score (points)	1	2	3	4	5
SVI rating	0.01-0.25	0.26-0.36	0.37-0.48	0.49-0.56	0.57+

4A.2 Analysis and Results

The process and scoring methodology described above were implemented across the Lower Red-Sulphur-Cypress River Basin. As previously discussed, this assessment was performed to address the two goals of the Flood Mitigation Needs Analysis. The first goal is to identify the areas where the greatest **flood risk knowledge gaps** exist *(Map 14* in *Appendix 1*). The Inadequate Inundation Mapping category was selected as the basis for identifying these areas. Based on the data utilized in this assessment, the vast majority of the Lower Red-Sulphur-Cypress River Basin is considered inadequately mapped (~98%). The areas colored in red and orange in *Map 14* in *Appendix 1* represent those with the lowest level of accuracy, and these are concentrated in the central and eastern portions of the basin (~70% of the watershed). These areas only have approximate inundation mapping data (Zone A or Fathom data) or have no available data.

Only the dark green areas in *Map 14* in *Appendix 1,* near the cities of Sherman and Texarkana, are considered adequately mapped as they have recent detailed studies that define the floodplains. These areas represent approximately 2% of the total watershed area for Region 2. Although the City of Paris has areas with adequate local mapping, these detailed maps only cover small portions of the surrounding HUC-12s, and the area-weighted score still reflects a knowledge gap for these HUC-12s. Note that some of the HUC-12s that were considered as having inadequate mapping may contain studies that have been completed but are not yet regulatory products. The TWDB is currently developing BLE for all of the Cypress Creek and Sulphur River basins within Texas. Unfortunately, this mapping will not be available until the draft Regional Flood Plan has been prepared, but it will be available for future cycles.

The second goal is to determine the areas of greatest **known flood risk** and flood mitigation needs. The score from each of the 12 categories was added to obtain a total score for each HUC-12 in the region. All categories have an equal representation in the total score. This analysis also included the Inadequate Inundation Mapping category because uncertainty itself is a risk. The combination of different factors helped determine if a given HUC-12 has a higher level of known flood risk relative to the others. Based on the distribution of the final scores in this assessment, the top 10% were colored red to highlight the areas with the greatest known flood risks in *Map 14* in *Appendix 1*. It is important to note that the fact that a HUC-12 resulted in a low score does not necessarily mean that there is no flood risk in this area, only that this risk is relatively low compared to the others.

It can be observed from *Map 15* in *Appendix 1* that areas with a relatively high population, such as the cities of Sherman, Bonham, Paris, Sulphur Springs, Texarkana, and Atlanta, were identified as those with the greatest known flood risks (red HUC-12s). The areas with the second-highest level of known flood risk (orange HUC-12s) are mainly located in the surrounding areas of these population centers, but several are scattered throughout the region. The eastern portion of the region (east of Mount Pleasant) generally resulted in the lowest level of known flood risk, except for the cities of Texarkana, Atlanta, and DeKalb.

The maps resulting from the Flood Mitigation Needs Analysis served as a guide to the RFPG's subsequent efforts to identify potential FMEs and potentially feasible FMPs and FMSs (Task 4B.1). The red and orange HUC-12s in *Map 14* in *Appendix 1* highlight the areas in the Lower Red-Sulphur-Cypress River Basin where potentially feasible flood risk studies (FMEs) should be considered. The red and orange HUC-12s in *Map 15* in *Appendix 1* emphasize watersheds where the RFPG should strive to identify FMSs and FMPs to reduce the known flood risks within those areas.

4B.1 Identification and Evaluation of Potential Flood Management Evaluations, Potentially Feasible Flood Management Strategies, and Flood Mitigation Projects

4B.1.A Process to Identify Flood Management Evaluations, Flood Management Strategies, and Flood Mitigation Projects

The goal of Section 4B.1 is to define and evaluate a wide range of potential actions to identify and mitigate flood risk across the basin. These actions have been broadly categorized into three distinct types, as defined below:

- **Flood Management Evaluation (FME)**: a proposed flood study of a specific, flood-prone area that is needed 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 costs 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.

Identification of potential FMEs and potentially feasible FMPs and FMSs begins with the execution of the Flood Mitigation Needs Analysis to identify the areas with the greatest gaps in flood risk knowledge and the areas of greatest known flood risk. This process and its outputs have been described previously in *Section 4A.1*. Based on the results of this analysis, several sources of data were used to develop a list of potential flood risk reduction actions that may address the basin's needs. The data includes information compiled under previous tasks, such as:

- existing flood infrastructure, flood mitigation projects currently in progress, and known flood mitigation needs (*Chapter 1*)
- existing and future flood risk exposure and vulnerability (*Tasks 2A and 2B*)
- floodplain management and flood protection goals and strategies developed by the RFPG for the region (*Task 3A and 3B*)
- stakeholder input

These actions were identified and evaluated through initial screening and data gathering under Section 4B.1. As part of Chapter 5, FMEs, FMSs, and FMPs were further evaluated to compile the technical data for the RFPG to decide whether or not to recommend these actions or a subset of these actions.

This first Regional Flood Planning cycle relies primarily on compiling readily available information to determine appropriate flood mitigation actions to recommend for inclusion in the plan rather than performing technical analysis to identify new actions. The list of potential FMEs and potentially feasible FMSs and FMPs for the Regional Flood Plan were compiled based on contributions from the RFPG and other regional entities from sources, including previous flood studies, drainage master plans, flood protection studies, and capital improvement studies.

The specific list of previous flood studies and models relevant to flood plan development for Region 2 are provided in *Table 4.7*, *Table 4.8*, and *Table 4.9*.

Table 4.7 Flood Insurance Studies (FIS)

Study Name	Effective Date(s)
Bowie County FIS	12/21/2017
Cass County FIS	4/3/2012
Cooke County FIS	1/16/2008
Fannin County FIS	2/18/2011; 9/29/2010
Grayson County FIS	6/7/2017; 2/18/2011; 9/29/2010
Gregg County FIS	9/3/2014; 10/19/2010; 9/29/2010; 8/16/1996
Harrison County FIS	9/3/2014; 10/19/2010
Hopkins County FIS	3/17/2011; 9/3/2010
Hunt County FIS	6/7/2017; 1/6/2012; 9/26/2008
Lamar County FIS	8/16/2011
Titus County FIS	9/29/2010
Upshur County FIS	9/3/2014; 10/19/2010
Wood County FIS	4/17/2012; 3/17/2011; 9/3/2010

Table 4.8 Municipal Planning Studies

Entity Name	Study Name	Study Date
City of Cooper	Storm Drainage Study	9/1/2017
City of Paris	Big Sandy Creek Tributary 4 and 6	3/24/2017
City of Paris	Comprehensive Plan	2/26/2014
City of Paris	Drainage Master Plan	1/1/1993
City of Paris	Johnson Woods Drainage Improvements	10/27/2016
City of Sherman	Master Drainage Study	02/2019
City of Texarkana	City-Wide Flood Protection Planning Study	1/31/2012

Table 4.9 Regional and Federal Studies

Entity Name	Study Name	Study Date
Sulphur River Basin Authority (SRBA)	Sulphur River Basin Instream Flow Study	10/31/2016
United States Army Corps of Engineers (USACE)	Cypress River Studies	
USACE	Lower Red Studies	
USACE	Sulphur River Studies	

4B.2 Classification of Potential FMEs and Potentially Feasible FMSs and FMPs

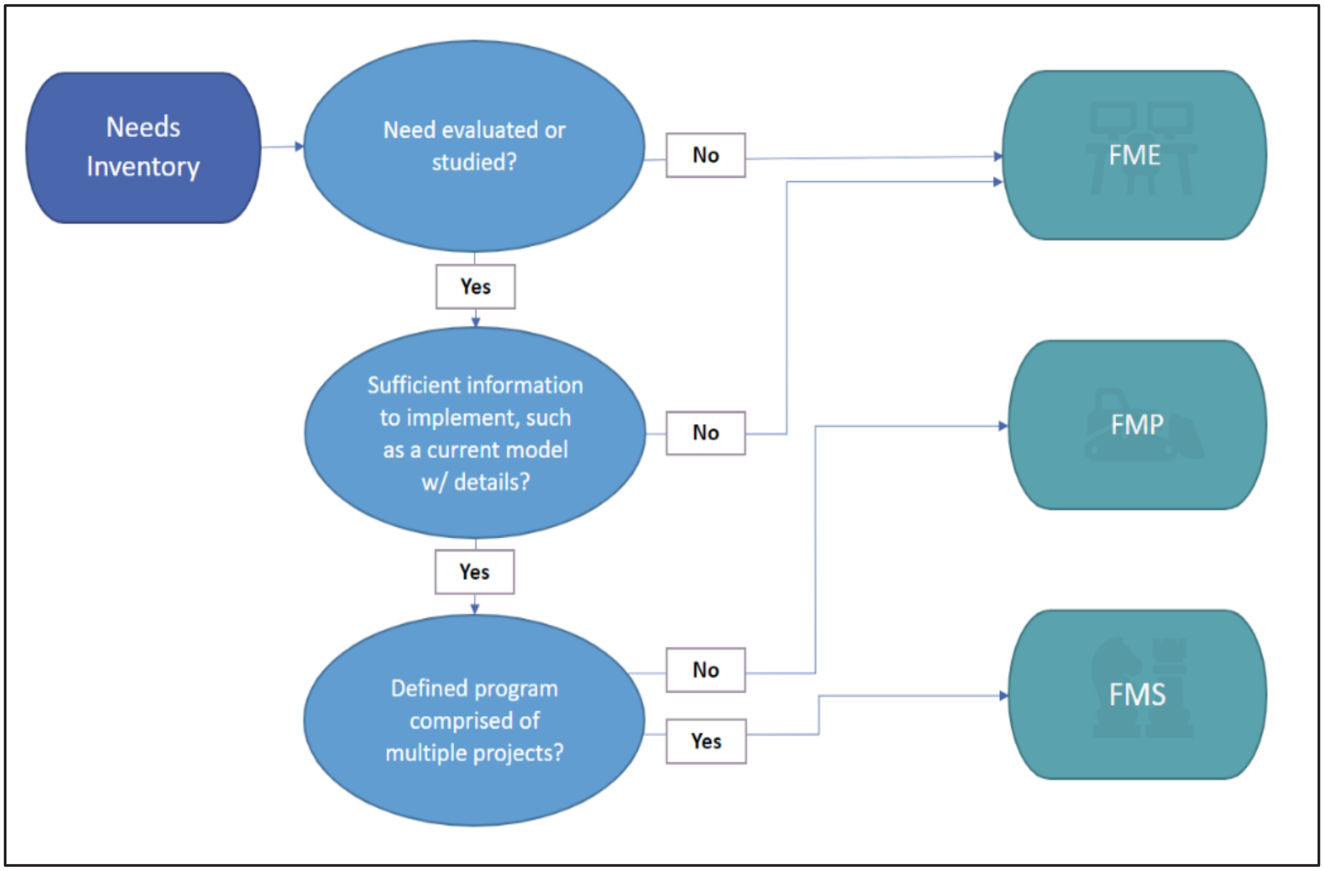
The *Technical Guidance* included a summary of different general action types, listed below in *Table 4.10*. Once potential flood risk reduction actions were preliminarily identified using this list, a high-level screening process was used to confirm that potential actions had been sorted into their appropriate categorization. The screening process is shown in *Figure 4.1*.

Table 4.10 General Flood Risk Reduction Action Types

Flood Risk Reduction Action Category	Action Types
FME	Watershed Planning H&H Modeling Flood Mapping Updates Regional Watershed Studies Engineering Project Planning Feasibility Assessments Preliminary Engineering (alternative analysis and up to 30% design) Studies on Flood Preparedness

Flood Risk Reduction Action Category	Action Types
FMP	Structural Low Water Crossings or Bridge Improvements Infrastructure (channels, ditches, ponds, stormwater pipes, etc.) Regional Detention Regional Channel Improvements Storm Drain Improvements Reservoirs Dam Improvements, Maintenance, and Repair Flood Walls/Levees Coastal Protections **Nature-Based Projects –** living levees, increasing storage, increasing channel roughness, increasing losses, de-synchronizing peak flows, dune management, river restoration, riparian restoration, run-off pathway management, wetland restoration, low impact development, green infrastructure **Comprehensive Regional Project –** includes a combination of projects intended to work together.
FMP	Non-Structural Property or Easement Acquisition Elevation of Individual Structures Flood Readiness and Resilience Flood Early Warning Systems, including stream gauges and monitoring stations Floodproofing Regulatory Requirements for Reduction of Flood Risk
FMS	None specified; RFPGs were instructed to include at a minimum any proposed action that the group wanted to consider for inclusion in the plan that did not qualify as either an FME or FMP.

Figure 4.1 Potential Flood Risk Reduction Action Screening Process



Generally, an action is considered an FME if it requires a study to quantify flood risk in an area, define potential FMPs and FMSs to address the risk or assess downstream impacts. Potential actions that could be considered FMPs and FMSs were screened to determine if they have been developed in enough detail and include sufficient data to meet the technical requirements for these action types. Actions that were initially considered for FMSs and FMPs that did not meet these requirements were adapted and repurposed as FMEs. The specific requirements for each action type are described in subsequent sections.

FMSs were also identified for other strategies the RFPG wishes to pursue. One example of a potential FMS is identifying repetitive loss properties and establishing a community-wide program of voluntary acquisitions to be implemented over several years. Another example would be a program to enhance public education and awareness about flooding throughout the region, which does not include a construction cost.

4B.3 Evaluation of Potential Flood Management Evaluations

Several actions were identified as potential FMEs to address gaps in available flood risk data associated with the first planning cycle. The following sources of data were used to identify FMEs across the basin:

- Hazard Mitigation Action Plans (HMAP)
- Flood Infrastructure Fund (FIF) applications not chosen for funding
- drainage master plans
- regionwide flood studies
- direct input from the RFPG

The evaluation of FMEs relied on the compilation of planning level data to gauge alignment with regional strategies and flood planning guidance, the potential flood risk in the area, and the funding need and availability. This data included:

- type of study and location
- availability of existing modeling and mapping data
- regional flood mitigation and floodplain management goals addressed by the FME, and whether the FME meets an emergency need
- flood risk information, including flood risk type, number and location of structures, population, roadways, and agricultural areas at risk
- sponsor entity and other entities with oversight
- cost information, including study cost and potential funding sources

4B.3.A FME Types

The definition of an FME allows various study types to help assess flood risk and potentially define future FMPs and FMSs. A general list of study types was previously summarized in *Table 4.10*. The following section describes these project types in more detail and summarizes the different potential FMEs identified in Region 2.

Watershed Planning

FMEs classified as Watershed Planning typically involve efforts associated with H&H modeling to help define flood risk or identify flood-prone areas at a regional and/or watershed scale. Watershed planning aims to distribute resources equitably throughout the watershed to implement plans, programs, and projects that maintain watershed function and prevent adverse flood effects. A wide variety of project types fit under the umbrella of watershed planning, and the subcategories defined in Region 2 include:

- H&H modeling
- flood risk mapping updates
- regional watershed studies

Engineering Project Planning

FMEs classified as Engineering Project Planning include studies to evaluate potential structural mitigation projects. These evaluations include feasibility assessments, preliminary alternatives analysis, and preliminary engineering design. The scope of the flood planning process defines a 30% design level as the cut-off between the study phase associated with an FME and the design and implementation phase associated with an FMP. The following Engineering Project Planning subcategories were identified in Region 2:

- channel improvements
- road/bridge improvements
- storm drain improvements
- levee systems

Flood Preparedness Studies

FMEs classified as Flood Preparedness Studies include proactive evaluations of a community's readiness to respond to a flood event. The identified FMEs under this category consider non-structural mitigation actions such as early warning systems, public awareness of flooding, and channel maintenance efforts to avoid reductions in flow capacity along rivers and creeks.

FME Classification Summary

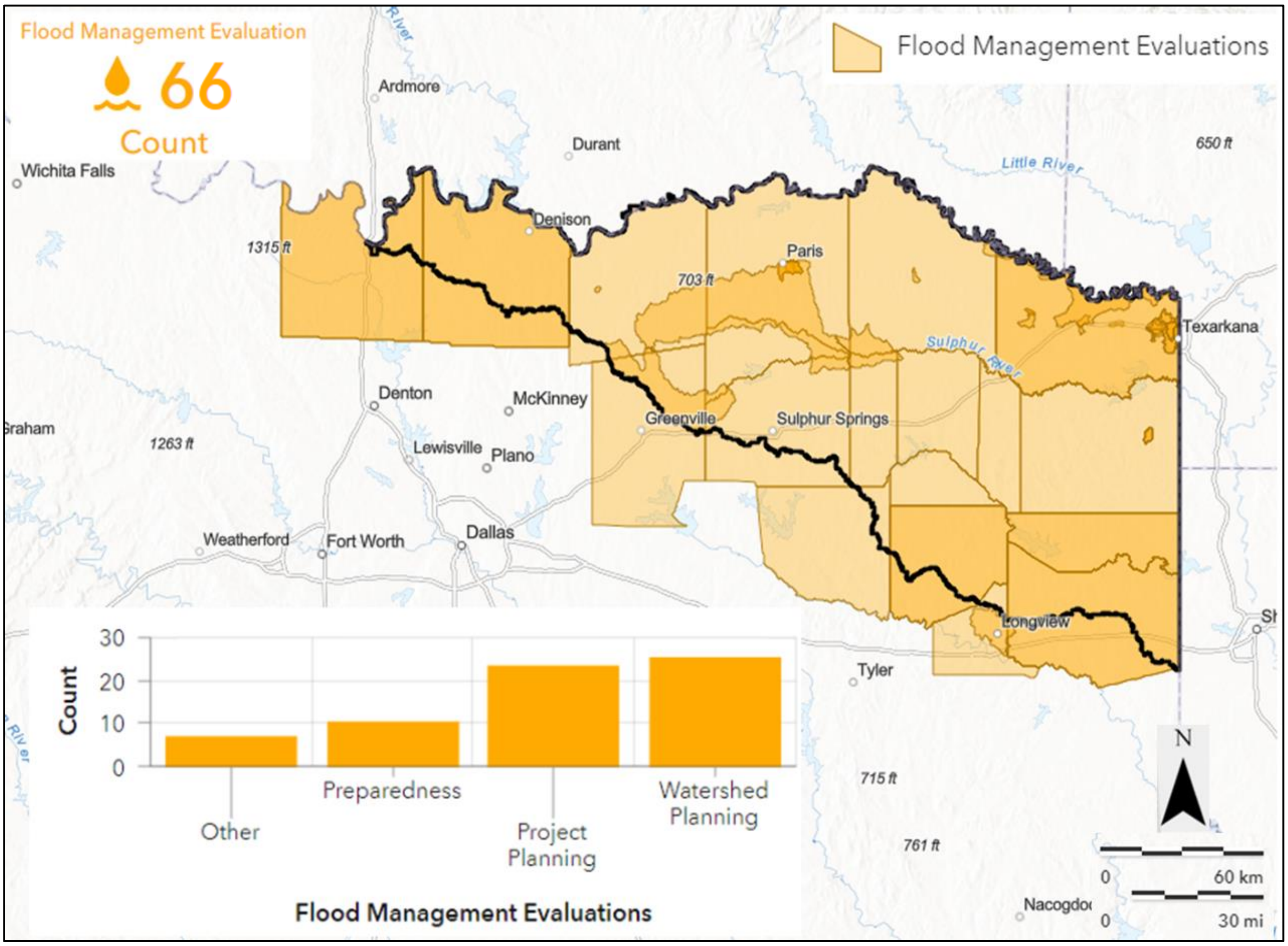
An overall summary of the identified FMEs is provided in *Table 4.11*. All potential FMEs identified are listed with supporting technical information in the TWDB-Required *Table 12 (Appendix 2)*. In total, 66 potential FMEs were identified and evaluated. The geographical distribution of the identified FMEs is shown in *Figure 4.2*. Color gradations in *Figure 4.2* reflect the number of FMEs that overlap for the same area; the darker the color, the greater the number of FMEs.

Table 4.11 FME Types and General Description

FME Type	General Description	FMEs Identified
Watershed Planning H&H Modeling, Regional Watershed Studies	Supports the development and analysis of H&H models to define flood risk or identify flood-prone areas or large-scale studies that are likely to benefit multiple jurisdictions.	7
Watershed Planning Flood Risk Mapping Updates	Promotes the development and/or refinement of detailed flood risk maps to address data gaps and inadequate mapping. Create FEMA mapping in previously unmapped areas and update existing FEMA maps as needed.	19
Engineering Project Planning	Evaluation of a proposed project to determine whether implementation would be feasible or initial engineering assessment, including conceptual design, alternative analysis, and up to 30% engineering design.	23
Studies on Flood Preparedness	Encourages preemptive evaluations and strategies to better prepare an area in the event of a flood.	10

FME Type	General Description	FMEs Identified
Other	Other projects are not classified above. All FMEs classified as "Other" are associated with studies to support property acquisition programs (including high-risk and repetitive loss properties and acquiring and preserving open space adjacent to floodplain areas).	7

Figure 4.2 Geographical Distribution of Potential FMEs



4B.3.B Planning Level Cost Estimates

Following the *Technical Guidelines*, a planning level cost estimate was developed for each FME. The process of producing these cost estimates for each FME project type is outlined in the following sections. Cost estimates presented in this section are for planning purposes only and are not supported by detailed scopes of work or manhour estimates. It is anticipated that scopes of work and cost estimates will be refined before any future funding application through the TWDB or other sources.

Watershed Planning – H&H Modeling and Regional Watershed Studies

The objective of H&H modeling FMEs is to evaluate and define flood risk, identify flood-prone areas, and evaluate alternatives for mitigating such risks at a local level. Regional watershed studies are large-scale H&H studies that are likely to benefit multiple jurisdictions.

Planning level cost estimates were developed for these types of FMEs, assuming a typical scope of work that includes management, data collection, topographic survey, hydrologic analysis, hydraulic analysis, alternatives evaluation, and final deliverables. A range of unit costs was developed to generate estimates based on the square mileage of the study areas and the total length of stream miles for which hydraulic modeling would be performed. Experience from previous studies was used to scale the study effort and estimate the level of detail associated with the required H&H analyses. It was estimated that 20% of the total project area could be analyzed with a low level of detail, 70% with medium detail, and 10% requiring highly detailed H&H models. Unit costs were applied to reflect these different levels of detail, which reflect differences in the physical characteristics of the basins and their levels of urban development.

Each cost estimate includes standard budget items based on the total project cost. These include a markup of 2% to account for quality assurance and quality control and 15% for project management, survey data capture, and technical reporting. Finally, a 30% contingency was applied to account for uncertainties associated with planning-level estimates.

Watershed Planning – Flood Risk Mapping Updates

Flood risk mapping data helps communities quantify and manage their flood risk and also provides communities a pathway to access flood insurance administered through the NFIP. Flood Risk Mapping FMEs were identified for all counties within Region 2. The FMEs included projects to develop regulatory maps where none exist and to update existing maps to account for revised rainfall data, recent development or topographic changes, and advances in floodplain modeling and mapping methodologies.

A spreadsheet was generated to produce planning level cost estimates for Flood Insurance Studies (FIS) utilizing relevant line items from the FEMA guidance document *Estimating the Value of Partner Contributions to Flood Mapping Projects* ("Blue Book") version 4.1. Costs pertaining to management, discovery data capture, hydrologic data capture, hydraulic data capture, floodplain mapping data capture, and final deliverables were included as part of the overall cost. The number of Flood Insurance Rate Map (FIRM) panels that were contained within each project boundary was also accounted for in the cost estimates.

The FME study area was defined as the portion of the county boundary within the Lower Red-Sulphur-Cypress River basin. A range of unit costs was developed to generate estimates based on the square mileage of the study areas and the total length of stream miles for which hydraulic modeling would be performed. It was assumed that the stream miles included are those classified as FEMA Zone A or unmapped within a given study area.

Experience with previous mapping projects was used to estimate the level of detail associated with the H&H analyses required. The level of detail needed to perform a regulatory study reflects differences in the physical characteristics of the basins and their levels of urban development. In terms of hydrologic analysis, it was estimated that 80% of the total project area could be analyzed using low-detail methods, while 20% would require more detailed rainfall-runoff analyses. For the hydraulic analysis, it was estimated that 70% of the included streams could be properly modeled with a low-detail hydraulic model, 20% with a medium-detail model, and the remaining 10% would require highly detailed models. Unit costs were applied to reflect these different levels of detail.

Each cost estimate includes standard budget items based on the total project cost. These include a markup of 2% to account for quality assurance and quality control and 15% for project management, survey data capture, and technical reporting. Finally, a 30% contingency was applied to account for uncertainties associated with planning-level estimates.

Engineering Project Planning

Engineering project planning considers two important components: (1) the evaluation of a proposed project to determine whether implementation would be feasible, and (2) an initial engineering assessment including conceptual design, alternative analysis, and up to 30% engineering design. Each evaluation area is project-specific and varies significantly due to the wide range of improvements in channels, low water crossings, roads and bridges, storm drain systems, and levee systems. Hazard Mitigation Action Plans (HMAP) were used, when available, for the respective entity in determining planning level cost estimates. It was assumed that each evaluation would be 5% of the total construction cost reported in the HMAP or a minimum of $250,000. In instances where no HMAP was available, additional research was conducted to gather supplemental information from FME sponsors or similar studies to develop a scope of work and planning level cost estimate.

Studies on Flood Preparedness

Studies on flood preparedness encourage preemptive evaluations and strategies to better prepare an area in the event of a flood. The identified FMEs in this category include various studies to evaluate alternatives for log and debris removal from stream channels, the feasibility of installing flood warning systems and low water crossing barriers, and channel stability studies. Due to the open-ended nature of the scope of work for these FMEs, it was not possible to scale the cost estimates for these studies. Therefore, placeholder costs were assigned to these FMEs based on professional engineering experience with similar projects.

Other

All FMEs classified as "Other" are associated with studies to develop and support property acquisition programs. The scope and scale of property acquisition programs can vary widely, and there is great uncertainty regarding the number of properties/parcels that could be acquired and their fluctuating market values. Therefore, rather than scaling each FME individually, a standard project cost of $250,000 was assigned to each FME.

It is assumed that this placeholder budget would provide sufficient funds to perform an initial assessment to identify potential areas for acquisition, prioritize areas/properties, perform market research, and define a scope of work for specific acquisition projects. This scope of work could include H&H studies, deed studies, property appraisals, inquiries about voluntary participation, identifying potential funding sources, and identifying supplementary work such as stream restoration and other flood risk reduction projects. This placeholder budget is not intended for acquiring properties, and further funding will be required in the future to implement the acquisition programs developed under these FMEs.

4B.3.C Process to Determine Flood Risk Indicators

Flood risk indicators were quantified to define the existing flood hazard, flood risk, and flood vulnerability within each FME project area. GIS operations were performed to combine and summarize this information by clipping the flood risk information generated for the basin as part of Task 2A to the individual project boundaries associated with each FME. The resulting flood risk indicator information was used to populate the associated fields in the FME feature class. These values are summarized in TWDB-required *Table 12 (Appendix 2).*

4B.3.D Comparison and Assessment of FMEs

Due to the lack of available detailed studies in the regions, FMEs are the most numerous flood mitigation actions in the Regional Flood Plan. The inclusion of FMPs and some FMSs in this plan was hampered by the lack of detailed H&H modeling needed to assess them to meet the TWDB's technical requirements. Over 97% of the region has no detailed Zone AE flood studies, and six counties had no FIRM maps. Other than the cities of Texarkana, Paris, and Sherman, the rest of the maps or models are over two decades old and likely do not reflect current conditions, much less future conditions.

Twenty new Flood Insurance Studies (FISs) and associated floodplain maps and models are recommended to ensure that appropriate regulation of the floodplains can occur, flood damages can be mitigated, and a solid basis for future assessment of riverine flooding issues and solutions is available. The portion of Upshur County within the region has the largest population without detailed studies, indicating the largest potential number of people at risk. Titus County has the highest SVI, indicating that they would have the most difficulty recovering from a flood and, therefore, are the most in need of up-to-date detailed floodplain information.

Over 20 potential FMPs, or collections of FMPs, were submitted by communities within the region, but they did not have adequate modeling to meet the TWDB requirements. These potential FMPs have been included as FMEs to support the preparation of the needed studies and verify that the projects would meet the TWDB requirements.

Every recommended FME will leverage any existing or ongoing studies and expand the H&H modeling analysis as necessary to achieve the FME goals. For example, some FMEs may be able to use data and analysis results from ongoing FIF Category 1 studies such as the Sabine River Authority Flood Protection Planning for Watersheds - Upper Sabine River Basin (FIF ID 40058) and the Hunt County Countywide Drainage Study (FIF ID 40027).

A total of 10 Preparedness FMEs were requested, including stream gauge and warning systems, debris and vegetation removal, and potential channelization projects. These tended to be relatively vague concepts that needed an FME to determine what exactly needed to be done.

Seven property acquisition and buyout programs were requested. These were general requests without specific locations indicated; therefore, they were included as FMEs to allow for analysis of which properties must be required, the priority, and potential funding options.

4B.3.E Determination of Emergency Need

For this evaluation, an action was considered to meet an emergency need if it addresses an issue related to infrastructure in immediate need of repair or construction, particularly following a natural disaster or other destructive event. While flooding can occur at any time of year with any magnitude and often without warning, studies and evaluations on flooding generally do not meet these criteria because of the time, it takes to complete a study and develop actionable alternatives. As a result, no FME was classified as demonstrating an emergency need.

4B.4 Evaluation of Potentially Feasible FMPs and FMSs

Potentially feasible FMPs were identified based on responses to surveys, reviews of previous studies, FIF applications not selected for funding, and direct coordination with entities. FMSs and FMPs are required to be developed in sufficient detail to be included in the Regional Flood Plan and recommended for state funding. In most cases, this includes having recent H&H modeling data to assess the project's impacts and an associated project cost to develop the benefit-cost ratio. The development and use of the technical information to evaluate potentially feasible actions are described in the following subsections.

4B.4.A Potentially Feasible FMPs

Due to the limited number of flood studies that have taken place in Region 2, the RFPG was only able to identify three potentially feasible FMPs, all within the City of Texarkana (Ferguson Park, Wagner Creek, and Stream WC-2). These potential FMPs are primarily focused on stormwater infrastructure and open channel improvements. None has been classified as meeting an emergency need. A summary listing of FMP types is provided in *Table 4.12*.

Further details are provided for the recommended FMPs in *Chapter 5*. The geographical distribution of each identified FMP is shown in *Figure 4.3,* with technical information for each FMP summarized in TWDB-Required *Table 13 (Appendix 2).* Color gradations in *Figure 4.3* reflect the overlap of FMPs for the same area.

Additional potentially feasible FMPs may be identified through continued outreach with regional entities under Task 11, and the execution of identified FMEs, either as FMEs are approved by the RFPG to be performed under Task 12 or as individual stakeholders acquire other funding sources.

Figure 4.3 Geographical Distribution of Identified FMPs

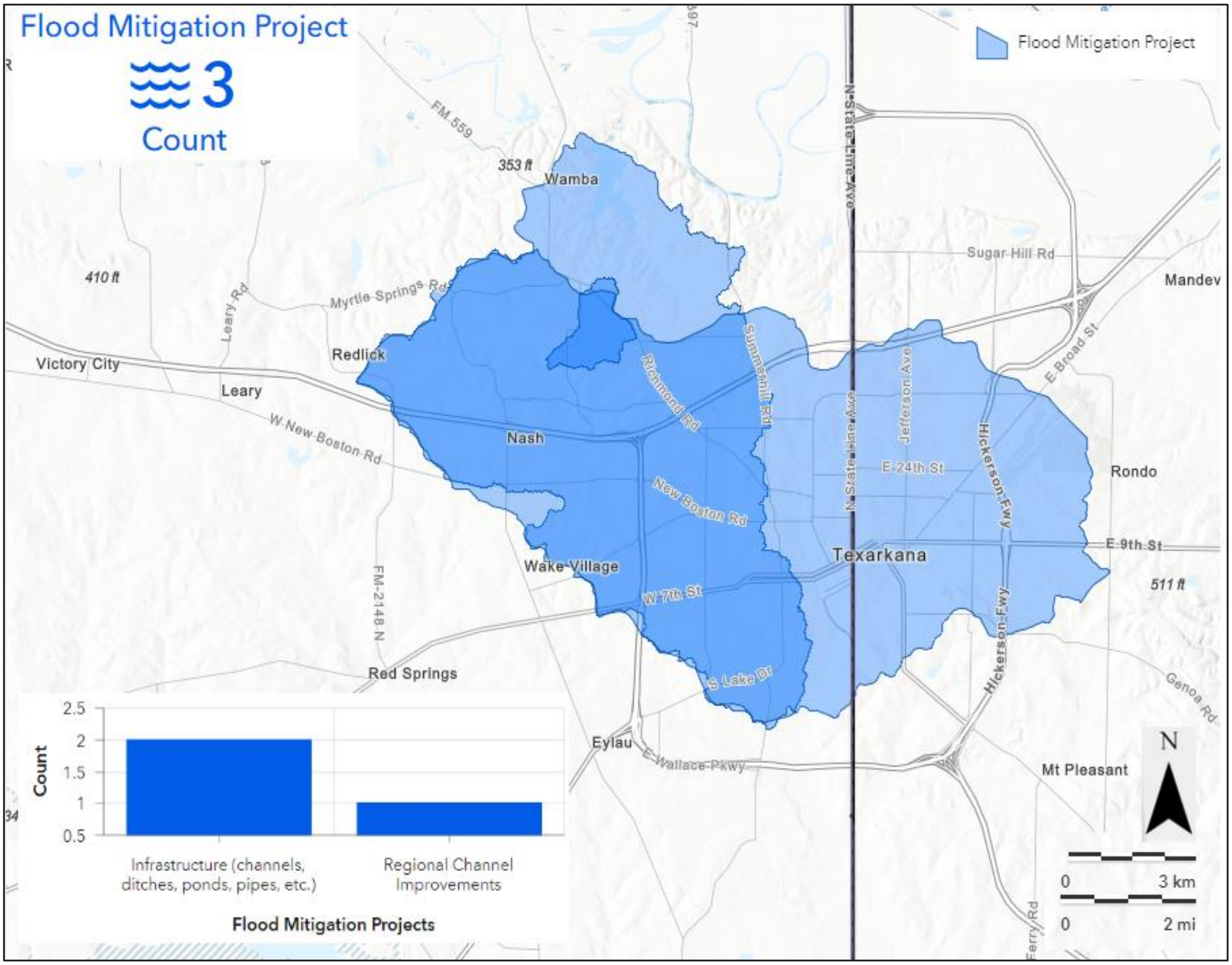


Table 4.12 FMP Types and General Description

FMP Type	General Description	Number of FMPs Identified
Flood Mitigation Project – Structural: Infrastructure (channels, ditches, ponds, pipes, etc.)	Improvements to existing culverts and bridges.	2
Flood Mitigation Project – Structural: Regional Channel Improvements	Open channel and overbank clearing of debris.	1

4B.4.B Potentially Feasible Flood Management Strategies

The RFPG identified 79 potentially feasible FMSs for Region 2. The geographic distribution of each FMS is shown in *Figure 4.4* with technical information for each FMS summarized in the TWDB-required *Table 14 (Appendix 2).* Color gradations in *Figure 4.4* reflect the number of FMSs that overlap for the same area; the darker the color, the greater the number of FMSs.

A variety of FMS types were identified. Some strategies encourage and support communities and municipalities to actively participate in the NFIP. Other FMSs recommend establishing and implementing public awareness and educational programs to better inform communities of the risks associated with flood waters. Additional FMSs promote preventive maintenance programs to optimize the efficiency of existing stormwater management infrastructure, recommend the development of a stormwater management manual to encourage best management practices, or promote the establishment of community-wide flood warning systems. None have been classified as meeting an emergency need. A summary listing of FMS types is provided in *Table 4.13*.

Figure 4.4 Geographical Distribution of Identified FMSs

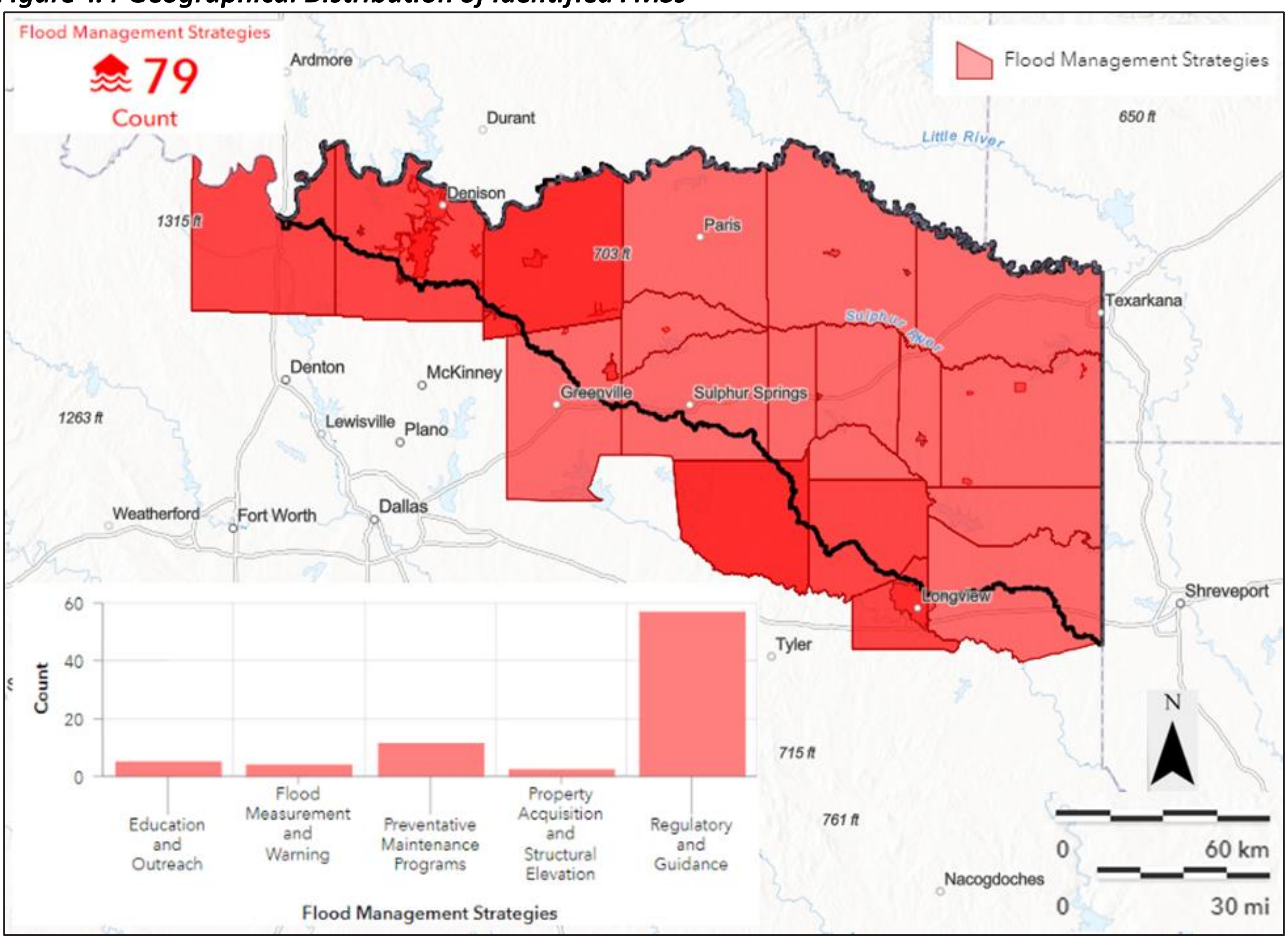


Table 4.13 Summary Listing of FMS types

FMS Type	General Description	Number of FMSs Identified
Education and Outreach	Develop a coordinated education, outreach, and training program to inform and educate the public about the dangers of flooding and how to prevent damage to property.	5
Flood Measurement and Warning Systems	Install gauges, sensors, and precipitation measuring sites to monitor streams and waterways for potential flooding and support emergency response.	4
Property Acquisition and/or Structural Elevation	Acquire, relocate, and/or elevate flood-prone structures or acquire floodplain and protect environmentally sensitive areas by converting floodplain encroachments into open space land.	2
Regulatory and Guidance	Create and implement an integrated stormwater management manual containing minimum standards for infrastructure design. Application to join NFIP or adoption of equivalent standards.	57
Preventive Maintenance Programs	Adopt and implement a program for clearing debris from bridges, drains, ditches, channels, and culverts.	11

4B.4.C Comparison and Assessment of FMPs

As discussed in the FME section, nearly 30 potential FMPs were originally requested by communities in the region; however, only three appeared to have the TWDB-required analysis to support them as FMPs. All three are within the City of Texarkana. These range in cost from $540,000 to $11.9 million. Stream WC-2 had the highest Benefit-Cost Ratio (BCR) of 1.15. Wagner Creek had a BCR of less than one but would still reduce flooding risks for 305 people.

4B.4.D Comparison and Assessment of FMSs

A total of 79 potential FMSs were generated or requested by communities. Regulatory and Guidance was the largest category, with 57 potential FMSs. These included adding communities to the NFIP, developing and adopting stormwater management criteria, and floodplain management staff acquisition and training. Developing minimum NFIP or higher floodplain regulatory standards for new development near a floodplain preserves the natural capacity of the flooding source and limits upstream and downstream negative impacts. Minimum FEMA NFIP floodplain regulations can be found in Chapter 44 of the Code of Federal Regulations (44 CRF). The Texas Floodplain Management Association (TFMA) has developed a Guide for Higher Standards for Floodplain Management (2018), which can serve as an example of higher floodplain development standards for the referenced FMSs. At a total of $3.4 million, these FMSs can have the greatest impact as they help prevent future flooding through a better understanding of flood risks, preventing development in the floodplain, and improving drainage design and development standards. Of these communities, Titus County has the highest SVI, indicating the greatest difficulty in recovering from a flood. Fannin County had the largest number of exposures indicating the greatest risk of flooding and the largest potential need for improvement in floodplain management.

Five sponsors requested flood awareness and safety education support. These FMSs range from implementing the National Weather Service's "Turn Around, Don't Drown" campaign to general education regarding NFIP. Of the sponsors requesting education and outreach support, Bowie County demonstrated the highest flood risk to habitable structures and road crossings.

Four sponsors expressed interest in flood measuring, monitoring, and warning systems. These systems include local warning notifications, monitoring/measuring gages, highwater detection systems, sirens, warning lights, signage, and automated gates.

Two projects requested were related to floodproofing lift stations in the City of Sadler. Lift stations should generally be considered critical infrastructure and important to the continued operation of sanitary sewer systems.

Eleven preventative maintenance programs were proposed, mainly in the form of channel or pipe maintenance. While important, these ongoing maintenance programs are not considered appropriate for this Regional Flood Plan and will not be recommended.

4B.4.E Effects on Neighboring Areas of FMS or FMP

Each potentially feasible FMP and FMS must demonstrate that there would be no negative flood impacts on a neighboring area due to its implementation. No negative impact means a project will not increase flood risk to surrounding properties. The analysis must be based on the best available data and be sufficiently robust to demonstrate that the post-project flood hazard is not greater than the existing flood hazard.

Some communities in the Lower Red-Sulphur-Cypress River Basin have established no adverse flood impact policies for the proposed development, but communities have different thresholds for defining what level of impact is considered adverse and require the analysis to be performed for different flood event scenarios. The *Technical Guidelines* and *Rules* governing the State Flood Plan require the impacts analysis to be performed for the 1% ACE event. Additionally, the *Technical Guidelines* require the following criteria to be met, as applicable, to establish no negative flood impact:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.
2. Stormwater does not increase the inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. The maximum increase of 1D (assumes flow is parallel to stream centerline) Water Surface Elevation must round to 0.0 feet (< 0.05 feet) measured along the hydraulic cross-section.
4. The maximum increase of 2D (allows flow in any direction) Water Surface Elevations must round to 0.3 feet (< 0.35 feet) measured at each computational cell.
5. The maximum increase in hydrologic peak discharge must be < 0.5% measured at computational nodes (sub-basins, 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 identified design-level mitigation measures may be included in the Regional Flood Plan and could be finalized later to conform to the "No Negative Impact" requirements before funding or execution of a project.

A preliminary comparison of pre-and post-project conditions for the 1% ACE event (100-year flood) was performed for each potentially feasible FMP to determine if the FMP conforms to the no negative impacts requirements. This preliminary comparison was based on planning-level information found in supporting studies and associated hydrologic and hydraulic model results when available. This planning level review was performed for the entire zone of influence of the FMP. Further details pertaining to the no negative impact determination for each potentially feasible FMP are provided in *Chapter 5*.

4B.4.F Estimated Benefits of FMS or FMP

To be recommended, each FMP or FMS must align with a regional floodplain management goal established under Chapter 3 and demonstrate a flood risk reduction benefit. To quantify the flood risk reduction benefit of each FMP or FMS, the anticipated impact after project implementation was evaluated with the following criteria:

- reduction in habitable, equivalent living units flood risk
- reduction in residential population flood risk
- reduction in critical facilities flood risk
- reduction in road closure occurrences
- reduction in acres of active farmland and ranchland flood risk
- estimated reduction in fatalities, when available
- estimated reduction in injuries, when available
- reduction in expected annual damages from residential, commercial, and public property
- other benefits as deemed relevant by the RFPG include environmental benefits and other public benefits

These estimated benefits were produced from geospatial data by analyzing the existing 1 and 0.2% ACE floodplain boundaries with the proposed post-project floodplain boundaries. These proposed flood risk conditions were compared to the existing flood risk indicators for a given area to quantify the reduction of flood risk achieved by implementing an FMP or FMS. The analysis results are shown for each FMP or FMS in the TWDB-required *Tables 13* and *14*, respectively (*Appendix 2*).

4B.4.G Potential Impacts and Benefits from the FMS or FMP to other resources

Potential impacts and benefits from FMS or FMP are explored for Region 2 from the standpoint of environment, agriculture, recreation, navigation, water quality, erosion and sedimentation. Factors unique to the region were reviewed, and an assessment of how they might interact with a potential FMS or FMP is discussed below.

Environmental

Senate Bill 3 (SB3) was designed to establish environmental flow standards for all major river basins and bay systems in Texas through a scientific, entity-driven, and consensus-based process. The key questions addressed by the SB3 process as defined by the TWDB are:

1. What is the quantity of water required by the state's rivers/estuaries to sustain a sound ecological environment?
2. How can this water be protected?
3. What is the appropriate balance between water needed to sustain a sound ecological environment and water needed for human or other uses?

FMS or FMP in the region should consider potential impacts related to the ecological flows established under the directive of SB3. None of the proposed FMSs or FMPs involved detention or retention; therefore, there would be minimal or no impact on base or environmental flows.

Several studies and projects, especially those assessing the Sulphur River log jams and geomorphologic assessment, would have direct or indirect environmental benefits by minimizing erosion and restoring natural stream function.

Agricultural

According to the Texas A&M AgriLife Extension Service economists, Hurricane Harvey caused more than $200 million in crop and livestock losses in Texas. Flood waters can destroy standing crops, create water-logged conditions that delay planting or harvesting, wash away productive topsoil, and damage farm equipment and infrastructure. FMS or FMP potentially reduces extremely high flows in rivers and streams, thereby preventing flood waters from inundating areas outside the floodway, including agricultural areas. Structural FMS or FMP, like small flood control ponds, also have the potential to assist in agricultural production by serving the dual purpose of flood mitigation and water supply. Non-structural FMS or FMP have similar impacts on flood peak flow reduction and flooding, including agricultural conservation practices such as conservation tillage, residue management, cover crops, and furrow dikes. These practices reduce downstream flooding by reducing surface runoff and increasing infiltration on agricultural lands and sediment and nutrient losses, thereby improving downstream water quality.

Most mitigation FMPs and FMEs are focused on urban areas and will have only incidental benefits to agriculture. The Regulatory and Guidance FMSs and Watershed Planning FMEs have the potential to benefit agricultural operations by improving their understanding of flood risks, making insurance available for structures, and preventing the construction of regulated structures within the floodplain.

Recreational Resources

There are 16 major lakes and reservoirs in Region 2. Ten reservoirs have a flood control function. Recreational opportunities associated with these lakes and reservoirs have the potential to be impacted when they are being operated to mitigate flood risk. Flood control reservoirs hold water in their flood pools during peak runoff periods until the impounded water can be safely released downstream. During these periods, the recreation use potential of adjacent parks and playgrounds may be vastly reduced. No new flood control reservoirs, or other reservoirs of any kind, are being proposed in the Regional Flood Plan. None of the proposed actions should impact the current reservoir operations.

Navigation

None of the major rivers within Region 2 are currently used for commercial navigation; however, the Red River is navigable from its confluence with the Mississippi River up to Shreveport-Bossier City, Louisiana. The Red River Valley Association advocated to extend the Lower Red navigability from Shreveport-Bossier City to Denison Dam at Lake Texoma. This would involve four states, two USACE Divisions (Southwest and Mississippi Valley Divisions), and potentially four USACE Districts (Tulsa, Little Rock, Vicksburg, and possibly Fort Worth). The Tulsa District of USACE performed a study in 1989 that determined that navigation of this reach is possible. Two additional studies will begin in 2022. The first is a Section 203 Feasibility Study for the reach between Shreveport-Bossier City, Louisiana and Index, Arkansas. The second is an economic evaluation of making the river navigable from Index, Arkansas to Denison Dam. USACE Tulsa District will conduct this study. One FME has been included to support this effort should additional funding be needed to evaluate floodplain impacts. No other considered actions should have an impact on actual or planned navigation.

Water Quality, Erosion, and Sedimentation

Water quality, erosion, and sedimentation are complex and interrelated issues. Water quality usually relates to nutrient and bacterial loading but also includes turbidity, which relates to sediment load. Most water quality issues are influenced by upland portions of the watershed, while sedimentation and erosion are more impacted by channel dynamics. These issues have been of significant concern to the region because of the straightening of the Sulphur River during the 1930s for flood control purposes. The project effectively reduced flooding by focusing flows in the channel, resulting in significant scour, which has deepened and widened the channel significantly. This has caused the loss of land as the channel has widened, an excess of trees and other debris in the channel, and excess sediment in reservoirs. Three FMEs have been proposed to evaluate log jams along the river and study options for restoring the natural channel and its functions. These evaluations will consider the impacts on water quality, erosion, and sedimentation. Most of the other actions considered in this plan will improve understanding of the floodplains and allow for a better understanding of any future project's impacts. None of the proposed actions are expected to adversely impact water quality, erosion, or sedimentation, but these will need to be considered as future FMPs are developed.

4B.4.H Estimated Capital Cost of FMPs and FMSs

Cost estimates for each FMP were acquired from the engineering report used to generate the FMP. Cost estimates were adjusted as needed to account for inflation and other changes in the price of labor and commodities since the original reports' publication date. The cost estimates listed in the TWDB-Required *Table 13* and *Table 14* are expressed in 2020 dollars (*Appendix 2*).

Cost estimates for each FMS were acquired from the HMAPs used to generate the FMS. Cost assumptions from *Table 4.14* were used if the HMAPs did not have associated costs or if the reported costs were lower than the cost assumptions. The cost assumptions are expressed in 2020 dollars and were developed based on engineering experience and other similar projects.

Table 4.14 FMS Cost Assumptions

FMS Type	Cost Estimate Range	Scope and Assumptions
Public Awareness and Educational Programs	$100,000	Region-Wide Public Education on Flooding: Assume $100,000 based on similar educational programs.
Flood Warning Systems	$250,000	Early Alert System/Gauge Notification: Assume $250,000 based on similar projects that have received the TWDB flood protection grants.
Property Acquisition and/or Flood Proofing Programs	$100,000	Lift Station Flood-Proofing: Assume $100,000 based on similar projects.
Regulatory and Guidance	$75,000 to $500,000	Floodplain Manager Position: Assume $75,000 for a first-year salary based on a floodplain manager's top 25% annual salary. NFIP Participation: Assume $100,000 to cover engineering consultant fees. Region-Wide Stormwater Management Manual: Assume $500,000 to cover engineering consultant fees and support communities in their implementation process.
Preventive Maintenance Programs	$100,000 to $1,000,000	Storm Drain Debris Maintenance Program: Assume $100,000 based on similar projects.

FMS Type	Cost Estimate Range	Scope and Assumptions
NFIP/CRS	$100,000	Join NFIP: Assume $100,000 to cover engineering consultant fees and adopt standards. Participate in Community Rating System (CRS): Assume $100,000 to cover engineering consultant fees and implement projects to increase rating.

4B.4.I Benefit-Cost Analysis 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 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 equal to or greater than one is not required for inclusion in the Regional Flood Plan. The RFPG can decide to recommend a project with a lower BCR with appropriate justification.

When a BCR had been previously calculated in an engineering report or study that was used to create an FMP, the previously calculated BCR value was utilized for the FMP analysis. The BCR for the Ferguson Park Improvements project (FMP 023000001) was adopted from the Ferguson Conceptual Alternatives Study of 2016. BCR calculations from the City-wide Flood Protection Planning Study for the City of Texarkana were adopted for the Wagner Creek channel improvements (FMP 023000002) and the Stream WC-2 project (FMP 023000003). The BCR value for each FMP is listed in TWDB-Required *Table 13 (Appendix 2).*

4B.4.J Residual, Post-Project, and Future Risks of FMPs

The implementation of recommended FMPs is expected to reduce current and future levels of flood risk in the region. However, it is not possible to protect against all potential flood risks, and there is potential for future increases in flood risk due to lack of maintenance or even a catastrophic failure. In general, residual and future risks for FMPs could be characterized as follows:

1. Flood events may exceed the level of service for which infrastructure is designed.
2. Potential failure or overtopping of dams and levees.
3. Communities depend on future funding and program priorities to maintain, repair, and replace flood protection assets. Routine maintenance of infrastructure is required to maintain its design capacity.
4. Maintenance is sometimes overlooked due to budget, staff, and time constraints.
5. In our representative government, policy changes that adversely impact budgets, prior plans, assets, and standards are always possible.

6. Human behavior is unpredictable; people may choose to ignore flood warning systems or cross over flooded roadways for a variety of reasons.

The engineering studies that provide the supporting data for the potential Region 2 FMPs were reviewed to identify the residual, post-project, and future risks associated with each FMP. This review revealed a significant residual risk for the Ferguson Park Improvements project (FMP 023000001), as its design level of service is only the five-year storm. Any storm event that exceeds a five-year recurrence interval (20% annual chance storm) will exceed the design capacity of these improvements. Additionally, regular infrastructure maintenance is required to maintain its design capacity as any debris or structural deterioration can hinder its performance.

The City-wide Flood Protection Planning Study for the City of Texarkana states that the proposed channel and overbank clearing to Wagner Creek (FMP 023000002) would increase the hydraulic conductivity and flow capacity resulting in a decrease in water surface elevations throughout the reach. These channel improvements would increase the level of service of the downstream portion of the channel from a 10-year storm event (10% ACE) to a 25-year storm event (4% ACE). However, this will require mowing at least three times a year to maintain the capacity of the stream. Improper or infrequent maintenance would decrease the channel's capacity due to a reduction in velocities, thereby increasing flood risks along the creek. Additionally, the level of service would not increase for the upstream portion of Wagner Creek following these improvements.

For the Stream WC-2 project (FMP 023000003), residual risks include any storm event greater than a 1% ACE for Lexington Place or greater than a 2% ACE event for Independence Circle. Additionally, routine infrastructure maintenance is required to maintain its design capacity, and failure to adequately maintain the infrastructure could increase the flooding risk throughout the project area.

4B.4.K Implementation Issues of FMPs

Implementation issues that could be identified include conflicts pertaining to rights-of-way, permitting, acquisitions, and utility or transportation relocations, among other issues that might be encountered before an FMP can be fully implemented.

The Ferguson Conceptual Alternatives Study of Texarkana from 2016 states that the infrastructure improvements within the Ferguson Park Improvements project (FMP 023000001) would face various implementation issues, including conflicts with existing sanitary sewer and water lines. Additional easement acquisitions would be required, and sections of the roadway would need to be removed and replaced to accommodate the proposed improvements.

Based on the City-wide Flood Protection Planning Study for the City of Texarkana, there are no significant implementation issues identified that impact the Wagner Creek channel improvements (FMP 023000002) or the Stream WC-2 project (FMP 023000003).

4B.5 Potential Funding Sources

A wide variety of funding opportunities could be utilized to fund the identified actions. Traditionally, stormwater and flood mitigation project funding sources have either been locally-sourced user fees or general taxes or externally by state and federal grants.

While low-interest loan programs provide additional funding, few local entities chose this path due to the lack of a dedicated funding source to cover debt service. Therefore, many communities adopted a "pay-as-you-go" method of funding stormwater projects or in the event of a disaster, applying for state and federal disaster recovery grants.

Today, communities have a broader range of funding sources and programs, including the above, plus recently created mitigation grant and loan programs such as the Building Resilient Infrastructure and Communities (BRIC) and the TWDB Flood Infrastructure Fund (FIF). The potential funding sources for the identified FME, FMP, and FMS are listed in *Tables 12, 13,* and *14*, respectively (*Appendix 2*). Further details on funding opportunities and the anticipated funding sources for the recommended actions are included in *Chapter 9*.

Chapter 5: Recommendation of Flood Management Evaluations, Flood Management Strategies, and Associated Flood Mitigation Projects

The objective of Task 5 is for the Regional Flood Planning Group (RFPG) to use the information developed under Task 4 to recommend flood mitigation actions - Flood Management Evaluation (FMEs), Flood Management Strategy (FMSs), and Flood Mitigation Project (FMPs) - for inclusion in the Regional Flood Plan. While Chapter 4B discusses the technical evaluations of the potential FMEs and potentially feasible FMSs and FMPs identified by the RFPG, Chapter 5 focuses on how the RFPG used this data to decide whether to recommend a given flood mitigation action. Generally, this chapter summarizes and documents the following:

- the process undertaken by the RFPG to make final recommendations on the given flood mitigation action types
- potential FMEs and potentially feasible FMSs and FMPs identified and evaluated under Task 4B and whether the RFPG recommends these actions

While there is an abundant need across Region 2, as well as the state, for better, recent, and more widely available data on flood risk, it is evident that not every conceivable flood mitigation action can be recommended in the Regional Flood Plan or included in the State Flood Plan. The RFPG evaluated the identified potential flood mitigation actions and, based on the significant needs in the region, recommended those that met the Texas Water Development Board (TWDB) requirements while understanding that not all recommendations may be performed in the same planning cycle as they are identified. Finally, all recommendations considered alignment with the RFPG-adopted flood mitigation and floodplain management goals.

5.1 RFPG Evaluation and Recommendation Process

The RFPG considered recommendations on flood mitigation actions through a multi-step process. The RFPG created a Technical Subcommittee tasked with establishing a selection methodology, implementing the evaluation and selection process, and reporting their findings and recommendations to the RFPG for formal approval. The general methodology included screening all potential flood mitigation actions considering the TWDB requirements for inclusion in the Regional Flood Plan and any other additional considerations established by the Technical Subcommittee. The reasons for not recommending a particular flood mitigation action were clearly documented as part of the evaluation and recommendation process.

The screening process for evaluating and recommending flood mitigation actions is summarized in *Figure 5.1* for FMEs and *Figure 5.2* for FMPs and FMSs. This process was primarily developed following the TWDB rules and requirements for inclusion in the plan. However, the TWDB left some evaluation criteria at the discretion of the RFPG, and additional guidance was necessary before implementing the screening process. The main discretionary evaluation criteria are the Level of Service (LOS) to be provided by an FMP and the Benefit/Cost Ratio (BCR) for the project. The TWDB recommends that, at a minimum, FMPs mitigate flood events associated with the 1% annual chance (ACE) flood (100-year LOS). However, if a 100-year LOS is not feasible, the RFGP can document the reasons for its infeasibility and still recommend an FMP with a lower LOS. Similarly, the TWDB recommends that proposed actions have a BCR greater than one, but the RFPG may recommend FMPs with a BCR lower than one with proper justification.

During the first Technical Subcommittee meeting held on March 18, 2022, the Technical Consultants provided a series of sample evaluations to demonstrate how the screening process would be implemented and requested feedback on the discretionary evaluation criteria. The Technical Subcommittee vetted the process and provided the following additional guidance to determine whether a flood mitigation action may be recommended:

- contact Non-National Flood Insurance Program (NFIP) communities and obtain their consent before recommending FMEs related to creating or updating Federal Emergency Management Agency (FEMA) flood maps
- no need to confirm Sponsor support for all other flood mitigation actions

The RFPGs will:

- not recommend a flood mitigation action if less than 50% of the project area is within Region 2. The Technical Consultants should coordinate with adjacent regions to ensure that these actions are captured in the appropriate Regional Flood Plan.
- accept flood mitigation actions with a LOS that is lower than the 100-year flood event. The Technical Consultants shall determine the LOS for each FMP, and the RFPG will make the final determination for its recommendation.
- accept an FMP with a BCR lower than one. The Technical Consultants shall determine the BCR for each FMP, and the RFPG will make the final determination for its recommendation.

The Technical Consultants subsequently applied the screening process based on the technical data developed under Task 4B and the Technical Subcommittee guidance. An initial recommendation for each flood mitigation action was presented to the Technical Subcommittee on March 28, 2022. All flood mitigation actions were discussed during this meeting and the Technical Subcommittee indicated if they agreed/disagreed with the initial recommendations. This working session allowed multiple adjustments to the flood mitigation action lists, including additions of new FMEs and FMSs, merging multiple FMEs or FMSs into one action, and enhancing project descriptions. Although the no negative impacts analysis, LOS, and BCR for FMPs were still pending at the time of this meeting, the Technical Subcommittee recommended them contingent upon confirmation of no negative impacts and a reasonable LOS and

BCR. A final list of recommendations was subsequently prepared to capture all the input gathered during the meeting.

Finally, on April 7, 2022, the RFPG voted to recommend FMEs, FMPs, and FMSs, as advised by the Technical Subcommittee. All meetings were held in accordance with the requirements of the RFPG bylaws, the Texas Open Meetings Act, the general requirements of the Texas Water Code, and the TWDB's flood planning process requirements. Additional details regarding the flood mitigation actions evaluation process and final recommendations are provided in subsequent sections.

Figure 5.1 FME Screening Process

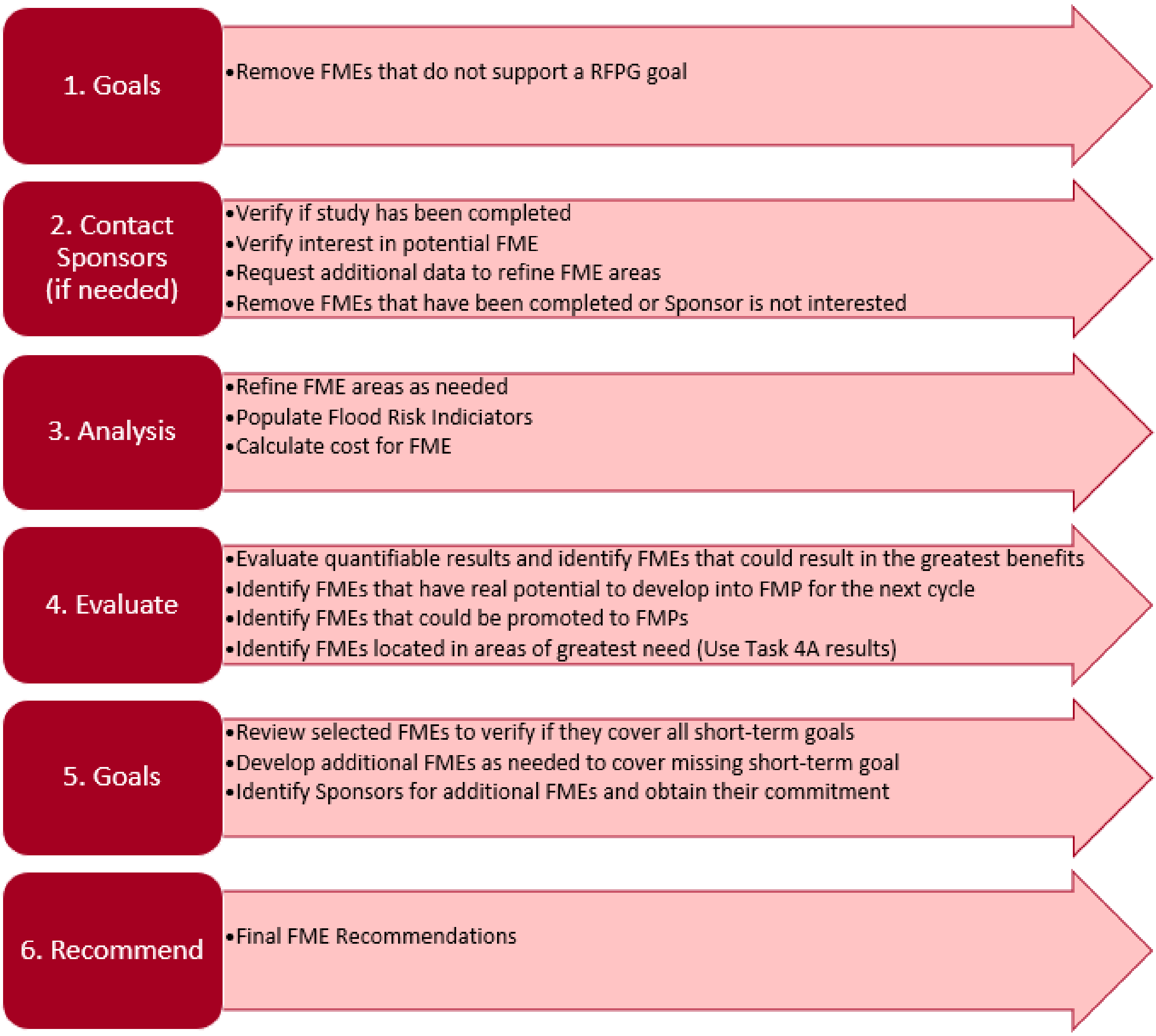
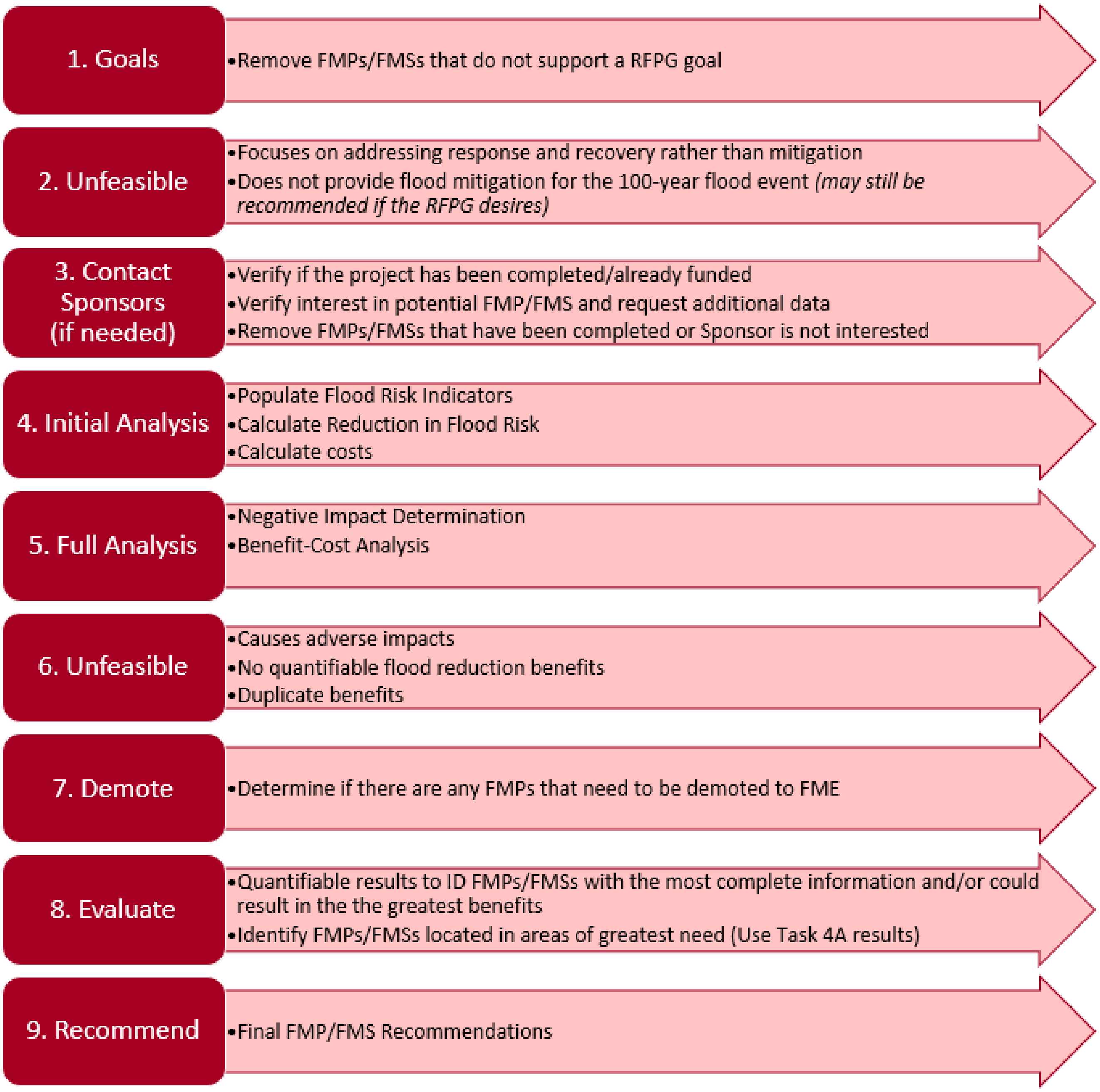


Figure 5.2 FMP and FMS Screening Process



5.2 Sponsor Support

An initial effort to contact potential sponsors was conducted to obtain their feedback regarding the flood mitigation actions that the RFPG was considering for inclusion in the Regional Flood Plan. Due to schedule limitations, only a small fraction of potential sponsors were initially contacted. However, flood mitigation actions must be included in the Regional Flood Plan to be eligible for future state funding through the Flood Infrastructure Fund (FIF). Given this constraint, the RFPG decided that an affirmative willingness to sponsor a given action would not be a prerequisite for inclusion in the plan. As a result, all potential actions were considered for inclusion unless an entity had declined to be listed as a sponsor and no other appropriate potential sponsor was identified. This approach was adopted because it:

- provides a conservative estimate of the flood mitigation need in the region
- does not oblige an entity to sponsorship; it simply allows an entity to be eligible for funding if interest in and capacity to sponsor a project become evident within this planning cycle

It is important to note that all sponsors associated with recommended actions were subsequently sent a survey to communicate that they are identified as a sponsor and to request information for potential funding sources for the actions listed in the plan. This effort is detailed in Chapter 9.

5.3 Flood Management Evaluations

5.3.A Summary of Approach in Recommending FMEs

The RFPG evaluated the identified potential FMEs and based on the significant needs in the region, recommended all FMEs that met the TWDB requirements, with the understanding that not all FMEs may be performed in the same planning cycle as they are identified. Recommended FMEs were also required to demonstrate alignment with at least one regional floodplain management and flood mitigation goal developed in Chapter 3. Finally, each recommended FME should identify and investigate at least one solution to mitigate the 1% ACE flood. It is the intent that all FMEs with a hydrology and hydraulic (H&H) modeling component will evaluate multiple storm events, including the 1% ACE flood. The exact solutions identified through performing these FMEs cannot be defined at this time. However, it is anticipated that an impact analysis will be performed for all alternatives, and project benefits will be tabulated for the 1% ACE flood to help inform any recommended alternatives and define potentially feasible FMPs. Based on the TWDB requirements, the RFPG identified and recommended two main types of FMEs.

The first subset of recommended FMEs would increase flood risk modeling and mapping coverage across the region as they are implemented. These types of FMEs have two major implications for the identification of potentially feasible FMSs and FMPs. Firstly, a current and comprehensive understanding of flood risk across the basin is necessary to identify high-risk areas for evaluating and developing flood risk reduction alternatives. Secondly, FMPs, and in some cases, FMSs, require a demonstrated potential reduction in flood risk to be recommended in the Regional Flood Plan. For this metric to be assessed, H&H modeling must be available to compare existing and post-project floodplain boundaries to determine the flood risk reduction potential of a given project.

The second subset of recommended FMEs was the project planning type. These FMEs are generally studies or preliminary designs to address a specific, known flood need. However, these flood mitigation actions currently lack some or all the detailed technical data necessary for evaluation and recommendation as an FMP. An example would be an existing study that identifies potential drainage construction projects but does not provide a full impact analysis. Completing these components as part of an FME will result in a potentially feasible FMP for consideration during future flood planning efforts.

There were a variety of different reasons why FMEs were not recommended. Generally, the RFPG took the approach that if less than 50% of the project area was contained within Region 2, it was not appropriate for inclusion in the flood plan for this region. Additionally, some FMEs were not recommended if they were redundant with another recommended FME. In some cases, multiple FMEs were combined into a single FME for recommendation due to the proximity of the study areas. Finally, sponsor input was considered when available and FMEs were not recommended if a sponsor indicated that the study had already been performed or they had no interest in pursuing the study.

5.3.B Description and Summary of Recommended FMEs

A total of 66 potential FMEs were identified and evaluated by the RFPG. Of these projects, 47 were recommended, representing a total of $38,450,000 in flood management evaluation needs across the region. The number and types of projects recommended by the RFPG are summarized in *Table 5.1.* The complete list of FMEs and supporting technical data is included in TWDB-required *Table 15* in *Appendix 2.* A map of recommended FMEs is presented in *Appendix 1.* A one-page report summary for each recommended FME is included in *Appendix 4.* Overall, the recommended FMEs represent over 18,500 square miles of contributing drainage area and provide extensive coverage of Region 2.

Table 5.1 Summary of Recommended FMEs

FME Types	FME Descriptions	Number of FMEs Identified	Number of FMEs Recommended	Total Cost of Recommended FMEs
Preparedness	Gauges, Barriers, Debris/Vegetation Removal, and Channelization	10	10	$3,275,000
Project Planning	Previously Identified Drainage Projects and Flood Studies	23	13*	$7,375,000
Watershed Planning	FIS Studies, Watershed Studies	26	19*	$26,550,000
Other	Property Acquisition and Buyout Programs	7	5	$1,250,000
	Total	66	47	$38,450,000

** In some cases, multiple FMEs were combined into a single FME for recommendation due to the proximity of the study areas.*

5.4 Flood Mitigation Projects

5.4.A Summary of 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 developed by the TWDB. In summary, the RFPG must be able to demonstrate that each recommended FMP meets the following TWDB requirements:

- supports at least one regional floodplain management and flood mitigation goal
- primary purpose is mitigation (response and recovery projects are not eligible for inclusion in the Regional Flood Plan)
- FMP is a discrete project (not an entire capital program or drainage master plan)
- implementation of the FMP results in:
    - quantifiable flood risk reduction benefits
    - no negative impacts to adjacent or downstream properties (a No Negative Impact certification is required)
    - no negative impacts on an entity's water supply
    - 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% ACE flood (100-year LOS). However, if a 100-year LOS is not feasible, the RFGP can document the reasons for its infeasibility and still recommend an FMP with a lower LOS.

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 one, but the RFPG may recommend FMPs with a BCR lower than one with proper justification.

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

5.4.B FMP Evaluation

Initial Evaluation

The scope of work for 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. The goal(s) associated with each FMP are included in TWDB-required *Table 16* in *Appendix 2.* Based on a revision of the supporting studies and H&H models, it was determined that the primary purpose for each FMP is mitigation (rather than a response or recovery project), they are discrete projects, and they do not have any anticipated impacts on water supply or water availability allocations as established in the most recently adopted State Water Plan.

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 a project will not increase the flood risk of surrounding properties. Using the best available data, the increase in flood risk is measured by the 1% annual chance event water surface elevation and peak discharge. According to the TWDB *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 prove that proposed project conditions are equal to or less than the existing conditions.

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

- stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement
- stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond the design capacity
- maximum increase of one-dimensional (1D) water surface elevation must round to 0.0 feet (<0.05 feet) measured along the hydraulic cross-section
- maximum increase of two-dimensional (2D) water surface elevations must round to 0.3 feet (<0.35 feet) measured at each computation cell
- maximum increase in hydrologic peak discharge must be <0.5% measured at computation nodes (sub-basins, 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 identified design-level mitigation measures may be included in the Regional Flood Plan. They could be finalized at a later stage to conform to the "No Negative Impact" requirements before funding or execution of a project.

Furthermore, the RFPG has the flexibility to consider and accept additional "negative impact" for requirements 1 through 5 based on the 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 the TWDB review.

A preliminary comparison of pre-and post-project conditions for the 1% ACE event (100-year flood) was performed for each potentially feasible FMP to determine if the FMP conforms to the no negative impacts requirements. This preliminary comparison was based on planning-level information found in supporting studies and associated H&H model results when available. Based on this planning level review, it was determined that all potentially feasible FMPs would require mitigation measures to offset potential impacts downstream and conform to the no negative impact requirements (see *Table 5.2*). It is anticipated that mitigation measures will be incorporated into the design phases of the FMPs. However, the local sponsor will ultimately be responsible for proving the final project design has no negative flood impact before initiating construction.

Below is a general description of the scope of work and a summary of the expected impacts of the proposed improvements for each potentially feasible FMP.

Ferguson Park Improvements (FMP 023000001)

The Ferguson Park Improvements project was generated from the Ferguson Conceptual Alternatives Study of 2016. The proposed project aims to mitigate flooding along Swampoodle Creek East Tributary in Texarkana. An InfoWorks ICM v6.5 model was created for this study and was utilized alongside an HEC-HMS model produced as part of the City of Texarkana Flood Protection Planning Study. The proposed projects include up to seven property buyouts, the development of a 50' wide grass-lined channel between Texas Boulevard and Olive Street, the development of three 7'x4' RCB channels between Olive Street and Walnut Street, and a proposed 6' tall berm upstream of 36th Street. Project components are depicted in *Figure 5.3*.

Following the Ferguson Park Improvements, an estimated 2.12 miles of roadway and 57 structures would be removed from the 100-year floodplain, 35 of which are residential. This correlates to an estimated 330 individuals removed from the 100-year flood risk.

Wagner Creek (FMP 023000002)

The Wagner Creek FMP, analyzed within the City-wide Flood Protection Planning Study for the City of Texarkana, targets flooding in the lower reach of Wagner Creek that impacts numerous residential and commercial properties. An HEC-RAS and HEC-HMS model was created to analyze the impact that the proposed improvements would have based on ultimate land use conditions. The proposed project consists of an approximate 400’-450' wide clearing corridor along Wagner Creek to increase the conveyance capacity of flood waters. The proposed clearing would involve the removal of all trees and brush within the proposed corridor, followed by maintaining the cleared area by mowing three times a year. Project components for this FMP are depicted in *Figure 5.4.*

The estimated flood risk reduction benefits following the implementation of this FMP include the removal of an estimated 2.1 miles of roadway and 44 structures from the 1% ACE floodplain, 26 of which are residential structures. This correlates to an estimated 305 individuals removed from the 1% ACE flood risk.

Stream WC-2 (FMP 023000003)

The Stream WC-2 FMP, described within the City-wide Flood Protection Planning Study for the City of Texarkana, aims to alleviate the flooding experienced along Stream WC-2 from Independence Circle to Concord Place. An HEC-RAS and HEC-HMS model was created to analyze the impact that the proposed improvements would have based on ultimate land use conditions. The proposed project includes the replacement of two '6'x4’ box culverts at Independence Circle with a 60' wide bridge opening and replacing two '6'x4' box culverts at Lexington Place with a 40' wide bridge opening. Project components for this FMP are depicted in *Figure 5.5*.

Following the implementation of this FMP, an estimated 0.01 miles of roadway and six residential structures would be removed from the 100-year floodplain. This correlates to an estimated 19 individuals removed from the 100-year flood risk.

Table 5.2 No Negative Impact Determination for Potentially Feasible Flood Mitigation Projects

FMP ID	FMP Name	FMP Meets All No Negative Impacts Requirements from Exhibit C Section 3.6.A	FMP Meets No Negative Impacts Requirements based on Engineering Judgment	Source for Determining No Negative Impacts
023000001	Ferguson Park Improvements	No	Yes (with proper mitigation)	City of Texarkana Flood Protection Planning Study
023000002	Wagner Creek	No	Yes (with proper mitigation)	City of Texarkana Flood Protection Planning Study
023000003	Stream WC-2	No	Yes (with proper mitigation)	City of Texarkana Flood Protection Planning Study

Figure 5.3 Ferguson Park Improvements - Project Components (FMP 023000001)

Figure 5.4 Wagner Creek – Project Components (FMP 023000002)

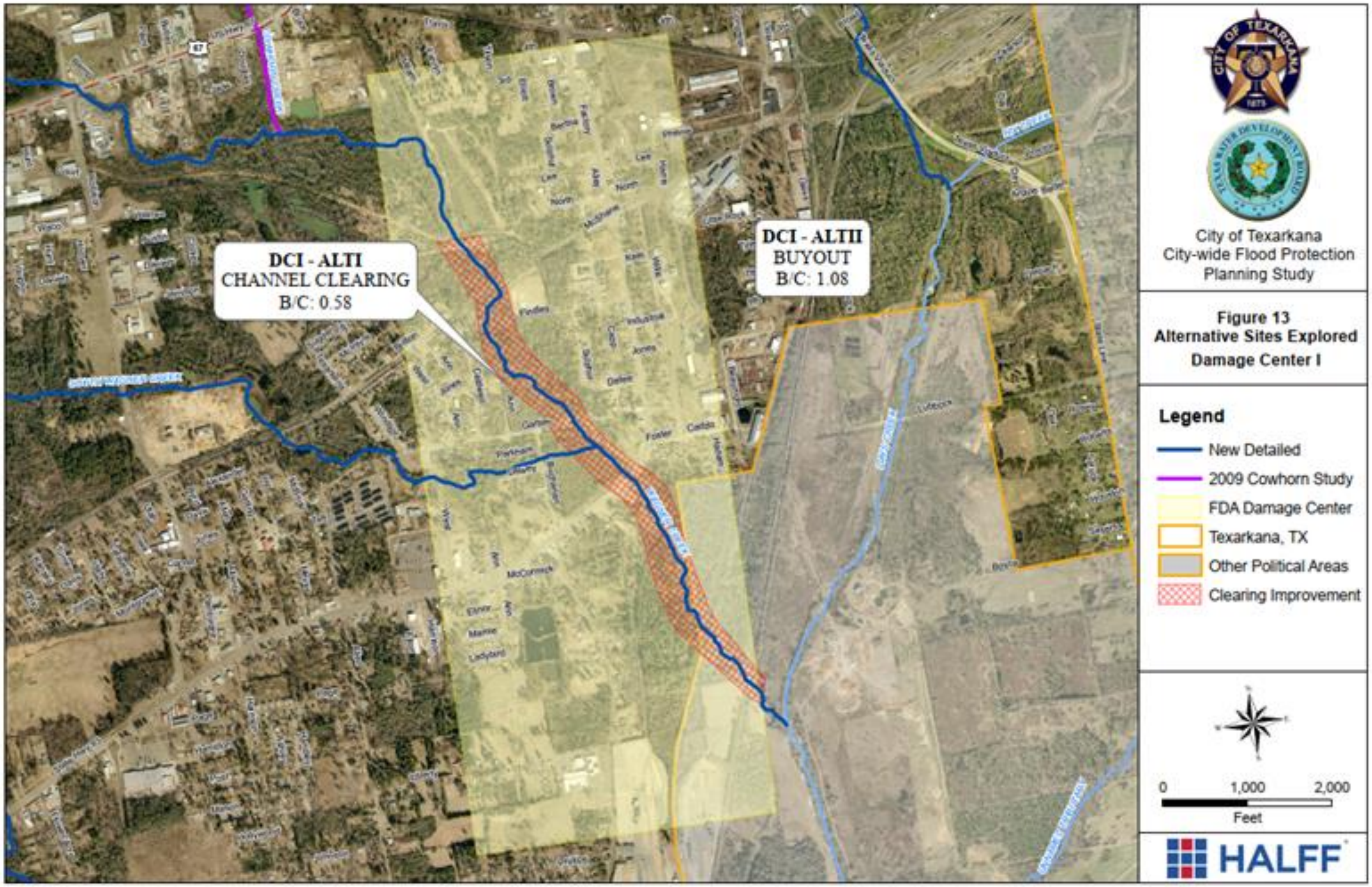
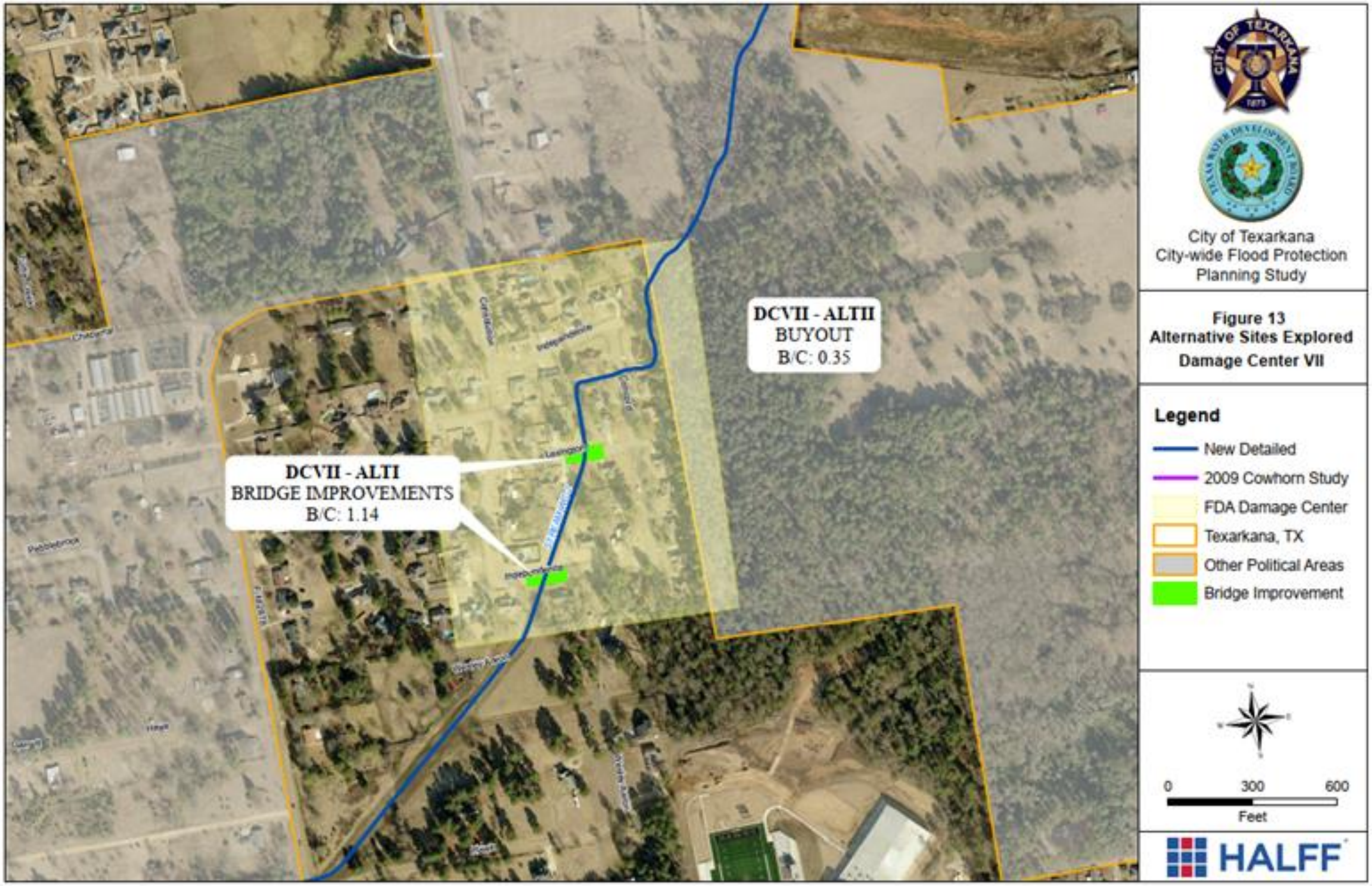


Figure 5.5 Stream WC-2 – Project Components (FMP 023000003)



Level of Service (LOS) Evaluation and BCR

All the recommended FMPs provide some level of flood reduction benefits. However, in most cases, their expected LOS is less than the 100-year flood event. The Ferguson Park Improvements project (FMP 023000001) only has a five-year design LOS (20% ACE). The channel improvements proposed under the Wagner Creek project (FMP 023000002) would increase the LOS of the downstream portion of the channel from a 10-year storm event (10% ACE) to a 25-year storm event (4% ACE). The Stream WC-2 project (FMP 023000003) does provide a 100-year LOS (1% ACE) for Lexington Place and 50-year LOS (2% ACE) for Independence Circle.

Based on the Ferguson Conceptual Alternatives Study of 2016, the Ferguson Park Improvements project has a BCR of 0.1. BCR calculations from the City-wide Flood Protection Planning Study for the City of Texarkana were adopted for the Wagner Creek channel improvements and the Stream WC-2 project. The BCR value generated for Wagner Creek is 0.58, while Stream WC-2 resulted in a BCR of 1.15 (see Table 16 in *Appendix 2*).

The RFPG considered these results and determined that recommending these FMPs would still be consistent with the overarching goal of the Regional Flood Plan, which is "*to protect against the loss of life and property*," even if that protection can only be provided against smaller magnitude storm events.

5.4.C Description and Summary of Recommended FMPs

Due to the high level of detail required for consideration as an FMP, only three projects were determined to have enough details available for evaluation and potential recommendation as FMPs. These projects are all located in the City of Texarkana in Bowie County. All FMPs were recommended by the RFPG, representing a combined total construction cost of $13,501,000. A summary of the recommended FMPs for inclusion in the Regional Flood Plan is presented in *Table 5.3*. Supporting technical data for each FMP, including their flood risk reduction benefits, is included in Table 16 in *Appendix 2*. A map of project areas for the recommended FMPs is provided in *Appendix 1*. A one-page report summary for each recommended FMP is included in *Appendix 4*. Additionally, *Appendix 2* provides a detailed breakdown of the estimated planning-level costs for each FMP following the TWDB *Technical Guidelines*. The required *Project Details Spreadsheet,* which will be used for evaluation and project ranking by the state, is included in the geodatabase in *Appendix 5*.

Table 5.3 Summary of Recommended FMPs

FMP ID	FMP Name	FMP Type	FMP Description	Cost
023000001	Ferguson Park Improvements	Infrastructure (channels, ditches, ponds, pipes, etc.)	Improvements to existing culverts and channelization	$11,983,000
023000002	Wagner Creek	Regional Channel Improvements	Channel/Overbank Clearing	$978,000

FMP ID	FMP Name	FMP Type	FMP Description	Cost
023000003	Stream WC-2	Infrastructure (channels, ditches, ponds, pipes, etc.)	Independence Circle & Lexington Place Bridge Improvements	$540,000
			Total	**$13,501,000**

5.5 Flood Management Strategies

5.5.A Summary of Approach in Recommending FMSs

The approach for recommending FMSs adheres to similar requirements as the FMP process. However, due to the flexibility and varying nature of the RFPG's potential utilization of FMSs, some of these requirements may not apply to certain FMSs. In general, the RFPG must be able to demonstrate that each recommended FMS meets the following TWDB requirements as applicable:

- supports at least one regional floodplain management and flood mitigation goal
- primary purpose is mitigation (response and recovery projects are not eligible for inclusion in the Regional Flood Plan)
- implementation of the FMS results in:
    a) quantifiable flood risk reduction benefits
    b) no negative impacts to adjacent or downstream properties (a No Negative Impact certification is required)
    c) no negative impacts on 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, FMSs should mitigate flood events associated with the 1% ACE flood (100-year LOS). However, if a 100-year LOS is not feasible, the RFGP can document the reasons for its infeasibility and still recommend an FMS with a lower LOS.

Although each potentially feasible FMS must demonstrate that there would be no negative flood impacts on a neighboring area due to its implementation, there were no structural FMSs identified for this region, and therefore no adverse impacts from flooding or to the water supply are anticipated.

In addition to the above requirements, if less than 50% of the defined implementation area was contained within Region 2, the FMS was not recommended (similar to FMEs). Additionally, some FMSs were not recommended if they were redundant with another recommended FMS. In some cases, multiple FMSs were combined into a single FMS for a recommendation. This included the development of a region-wide stormwater management manual with a single set of best practices that could be adopted by various regional entities rather than developing individual sets of stormwater criteria for each entity.

5.5.B Description and Summary of Recommended FMSs

A variety of FMS types were identified for Region 2. Generally, these FMSs recommend broad regional strategies and initiatives. Some strategies encourage and support communities and municipalities to actively participate in the NFIP. Other FMSs recommend establishing and implementing public awareness and educational programs to better inform communities of the risks associated with flood waters. Additional FMSs promote preventive maintenance programs to optimize the efficiency of existing stormwater management infrastructure, recommend the development of a stormwater management manual to encourage best management practices, or promote the establishment of community-wide flood warning systems. These FMSs support several regional floodplain management and flood mitigation goals established in Chapter 3.

A total of 79 potential FMSs were identified and evaluated by the RFPG. Of these projects, 38 were recommended, representing a total cost of $4,500,000. A summary of recommended FMSs is shown in *Table 5.4*. The complete list of FMSs and supporting technical data, including their flood risk reduction benefits as applicable, is included in TWDB-required Table 17 in *Appendix 2*. A map of recommended FMSs is presented in *Appendix 1.*

Table 5.4 Summary of Recommended FMSs

FMS Types	FMS Descriptions	Number of FMSs Identified	Number of FMSs Recommended	Total Cost of Recommended FMSs
Education and Outreach	Turn Around, Don't Drown Campaigns; Flood Safety Education	5	3	$250,000
Flood Measurement and Warning	Flood Gauges, Early Alert Systems, Flood Warning Systems	4	3	$750,000
Property Acquisition and Structural Elevation	Infrastructure flood-proofing, Land acquisition to protect open space.	2	1	$100,000
Regulatory and Guidance	NFIP Participation, Stormwater Management Criteria Development, Floodplain Management Acquisition, and Training	57	31	$3,400,000
Preventive Maintenance Programs	Storm Drainage Clearing, Annual Maintenance Programs	11	0	N/A
	Total	**79**	**38**	**$4,500,000**

Chapter 6 – Impact and Contribution of the Regional Flood Plan

6A.1 Impacts of the Regional Flood Plan

The goal of Task 6A is to summarize the overall impacts of the Regional Flood Plan. This includes potential impacts on areas at risk of flooding, structures and populations in the floodplain, number of low water crossings impacted, impacts on future flood risk, impact on water supply (details provided in Chapter 6B), and overall impact on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation. This chapter describes the processes undertaken by the Regional Flood Planning Group (RFPG) to achieve these tasks and summarizes the outcomes of this effort.

The impacts will generally be determined based on two before-and-after (Regional Flood Plan implementation) comparisons of the same types of information provided under both the Task 2 Existing Flood Risk and Future Flood Risk Analyses. These two comparisons may, for example, also indicate a percentage change in flood risk faced by various elements, including critical infrastructure. These two comparisons (one comparison each for a 1% annual chance event (ACE) and another for a 0.2% ACE) should illustrate both how much the region's existing flood risk will be reduced through the implementation of the plan as well as how much additional future flood risk (that might otherwise arise if no changes were made to floodplain policies, etc.) will be avoided through implementation of the Regional Flood Plan, including recommended changes/improvements to the region's floodplain management policies.

This effort included a:

- region-wide summary of the relative reduction in flood risk that implementation of the Regional Flood Plan would achieve within the region, including with regard to life, injuries, and property
- statement that the Flood Mitigation Projects (FMPs) in the plan, when implemented, will not negatively affect neighboring areas located within or outside of Region 2
- general description of the types of potential positive and negative socioeconomic or recreational impacts of the recommended FMSs and FMPs within Region 2
- general description of the overall impacts of the recommended FMPs and FMSs in the Regional Flood Plan on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation

6A.1.A FMP Impacts

Due to limited data available and the no-adverse impact constraints imposed on FMPs, only three FMPs were identified and recommended, as discussed in Chapters 4 and 5. These projects are all conveyance improvement projects that have the potential to increase flows downstream by expanding channels, culverts, and/or bridges. To ensure that there will be no negative impacts on neighboring areas, conveyance mitigation measures, such as detention or valley storage mitigation, have been included in the projects and will have to be analyzed and designed once the projects are funded. The comparative assessment to determine "no negative flood impact" on upstream or downstream areas or neighboring regions was performed based on currently available regional planning level data. The local sponsor will ultimately be responsible for proving the final project design has no negative flood impact before initiating construction. **As proposed, the recommended FMPs, when implemented, would not negatively affect neighboring areas located within or outside of the Flood Planning Region.**

As detailed in *Appendix 2* and summarized in *Table 6.1,* the three FMPs would reduce the number of structures in the 1% ACE floodplain by 107, including 67 residential structures. This would help protect approximately 654 people from living within the 1% ACE floodplain. An estimated 419 road closure occurrences can be avoided over 4.25 miles of roadway currently impacted by the 1% ACE floodplain. Being primarily in the urban area of Texarkana, these projects are not expected to benefit any agricultural lands. Additional benefits will include a reduction in park land flooding, benefiting recreational users. Impacts on the environment, water quality, and erosion are expected to be minimal since the existing channels have been previously manipulated and armored; they are likely to be replaced with similar ones. The streams impacted by the FMPs are not currently navigable, which will not change when the projects are implemented.

Table 6.1 Summary of impacts of FMPs on flooding in Region 2

Flood Exposure	Existing Conditions 1% ACE	Existing Conditions 0.2% ACE	After FMP Implementation 1% ACE	After FMP Implementation 0.2% ACE*	Exposure Reduction from FMPs 1% ACE	Exposure Reduction from FMPs 0.2% ACE*
Exposed Structures	13,438	15,023	13,331	N/A	107	N/A
Exposed Population	20,723	23,805	20,069	N/A	654	N/A
Exposed Low Water Crossing	266	270	266	N/A	-	N/A

** 0.2% ACE impacts were not provided by the FMP sponsor*

6A.1.B FMS Impacts

A total of 38 FMSs have been recommended by the RFPG, in five broad categories listed below (*Figure 6.1*), along with their general impacts.

Figure 6.1 FMS Impacts

Regulatory and Guidance

Description: Strategies that improve regulation of development to decrease current and future flood risks.

Example FMSs

NFIP Participation, Stormwater Management Criteria Development, Floodplain Management Staff Acquisition, and Training

Typical Positive Impacts

- Reduce the number of structures and roadways built in the floodplain
- Minimize expansion of future floodplains.
- Protect riparian areas from development, which protects the environment, water quality, erosion, and sedimentation.
- Provides more regulatory certainty and consistency across the region

Potential Negative Impacts

- Increases regulatory burden on citizens
- Increases staff workloads for communities

Property Acquisition and Structural Elevation

Description: Acquire or raise properties to protect against flooding

Example FMSs

Infrastructure flood-proofing, Land acquisition to protect open space or buy-outs of flood-prone structures

Typical Positive Impacts

- Reduce the number of structures in the floodplain and increased the protection of citizens
- Minimize expansion of future floodplains.
- Protect riparian areas from development, which protects the environment, water quality, erosion, and sedimentation.
- Allow those in the floodplain to "escape" without losing their investment

Potential Negative Impacts

- Increases regulatory burden on citizens
- Increases staff workloads for communities
- Can cause "blight" in certain neighborhoods, if not handled appropriately
- Can be politically objectionable in some circumstances

Education and Outreach

Description: Education and outreach to citizens and other stakeholders to increase awareness of flooding issues, risks, and regulations.

Example FMSs

Turn Around, Don't Drown Campaigns; Flood Safety Education

Typical Positive Impacts

- Reduce violations of floodplain regulations which can decrease flood risks
- Increase awareness of flood hazard areas
- Increase awareness of imminent flood events which can help with early evacuations and mitigation measures to prevent damages and save lives
- Minimize risky behavior during floods which can reduce deaths, especially while driving

Potential Negative Impacts

- Increases staff workloads for communities

Flood Measurement and Warning

Description: Installation and operation of rainfall and flow measurement devices and predictive systems to predict flooding and potentially provide barricades and warnings.

Example FMSs

Flood Gauges, Early Alert Systems, Flood Warning Systems

Typical Positive Impacts

- Allow people at risk of flooding to prepare, mitigate damages, and evacuate
- Prevent cars from driving on flooded roads, which can save lives
- Allow community staff to close roads and evacuate flooded areas before the flood begins

Potential Negative Impacts

- Increases staff workloads for communities
- Potential for false alarms or failed warnings if the system is not properly maintained and calibrated

If all of these FMSs are implemented and enforced, then Region 2 will prevent a significant increase in flood exposures, as shown in *Table 6.2.* Without these FMSs in place, the region could see the 1% ACE floodplain area increase by 115 square miles and the 0.2% ACE floodplain increase by 363 square miles. This would expose an additional 1,585 structures and 3,082 people to the 1% ACE floodplain and 8,601 structures and 17,130 people to the 0.2% ACE floodplain.

These FMSs will reduce the impact of development on downstream flows and help protect the floodplain from over-development, which will help protect the environment and reduce erosion, channel incision, and sedimentation. While the streams in the area are not generally considered navigable, these FMSs will preserve the opportunity for developing navigation in the region. This will also serve to protect agricultural lands and recreational areas from flooding and experiencing degradation along their riparian corridors.

While the number of injuries and deaths prevented by these FMSs could not be quantified, they are expected to be significant. These will be prevented by educating people about the risks of flooding, providing warnings of current and potential flooding, and reducing the frequency and severity of flooding of roads and structures.

There are two primary downsides to these FMSs. First is the additional burden it places on the communities that will have to adopt and enforce the measures. Secondly, adding mapped floodplain and regulations will impose restrictions on building within the floodplain that will affect the development and value of the property. While this helps protect citizens from putting themselves and others at risk, it does have some political risks for those seeking to adopt them. Considering the abundance of land in the Region, there is ample room for development while preventing people from building in high-risk floodplain locations.

Table 6.2 Flood exposures with and without the Regional Flood Plan FMSs

Flood Exposure	Existing Conditions (EC) 1% ACE	EC 0.2% ACE	Future Conditions (FC) (no RFP) 1% ACE	FC (no RFP) 0.2% ACE	FC with RFP Implemented 1% ACE	Future Conditions with RFP Implemented 0.2% ACE	Protected through RFP FMSs 1% ACE	Protected through RFP FMSs 0.2% ACE
Exposed Structures	13,438	15,023	15,023	23,624	13,438	15,023	1,585	8,601
Exposed Population	20,723	23,805	23,805	40,935	20,723	23,805	3,082	17,130
Exposed Area (Square Miles)	2,821	2,936	2,936	3,299	2,821	2,936	115	363

Flood Exposure	Existing Conditions (EC) 1% ACE	EC 0.2% ACE	Future Conditions (FC) (no RFP) 1% ACE	FC (no RFP) 0.2% ACE	FC with RFP Implemented 1% ACE	Future Conditions with RFP Implemented 0.2% ACE	Protected through RFP FMSs 1% ACE	Protected through RFP FMSs 0.2% ACE
Exposed LWC	266	270	266	284	266	270	-	14

6A.1.C FME Impacts

A total of 42 FMEs were recommended by the RFPG in four broad categories. These categories, examples, and their positive and negative impacts are described in *Figure 6.2.*

Figure 6.2 FME Impacts

Preparedness

Description: Evaluations pertaining to preparing for and mitigating damages from flood events.

Example FMEs

Evaluations to determine the need for, feasibility of, and coneptual design of gages, barriers, debris/vegetation removal, and channelization

Typical Positive Impacts

- Gages will help alert people to impending flooding, allowing them to protect their property and evacuate flood-prone areas
- Debris removal restores conveyance and reduces flooding

Potential Negative Impacts

- Debris removal can lead to erosion and increase downstream flows. These impacts will have to be evaluated as part of the FME
- Increases staff workloads for communities

Project Planning

Description: Conducting up to 30% design for specific projects and flood mitigation measures that were previously identified by sponsors.

Example FMEs

Storm sewer upgrades, flood protection projects, and channel modifications

Typical Positive Impacts

- Projects can reduce flooding and exposure to flooding
- Reduce impact of flooding on existing facilities
- Reduce roadway overtopping

Potential Negative Impacts

- All conveyance improvement projects have the potential to increase flooding downstream. Mitigation measures will need to be considered during the FME.

Watershed Planning

Description: Conduct watershed studies to establish accurate floodplain modeling and mapping and evaluate potential flood mitigation measures.

Example FMEs

Flood Insurance Studies, watershed master plans, and project prioritization studies

Typical Positive Impacts

- Accurate flood maps allow for risk avoidance, better regulations, and better planning
- Understanding the need for flood reduction in a watershed allows for better allocation of resources
- Provide design details needed for converting an FME into an FMP that can be funded and implemented.
- Projects that come from these FMEs can reduce flooding and exposure to flooding

Potential Negative Impacts

- All conveyance improvement projects have the potential to increase flooding downstream. Mitigation measures will need to be considered during the FME.
- More projects than funding are usually identified.

Other

Description: Miscellaneous studies that do not fall in the other categories above.

Example FMEs

Property acquisition and buy-out programs

Typical Positive Impacts

- Projects can reduce flooding and exposure to flooding through the acquisition of flood-prone properties.
- Allow people to offload their flood risks without losing the investment in their property
- Potentially provide public space and recreation areas

Potential Negative Impacts

- Property acquisition can face political resistance to those not wanting to leave an area.
- If not handled well, the vacant properties can “blight” a neighborhood.

Most of Region 2 has outdated or approximate floodplain mapping. This approximate mapping usually does not include modeling, making evaluating potential floodplain development and mitigation challenging. The proposed FMEs would provide up-to-date mapping to all counties within the region and would cover 12,654 square miles, which would be approximately 2,821 square miles of 1% ACE floodplain and 2,936 square miles of 0.2% ACE floodplain. This improved mapping and models will allow citizens, developers, planners, and community officials to consider their flood risks and avoid risky construction. The model availability will help communities evaluate potential flood mitigation projects to reduce flood risks and impacts in the area. These models, along with flood gages and warning systems, will also help save lives by warning people of flooding in advance and allow for more rapid and accurate road closures.

The watershed studies and project-specific FMEs will provide the information needed to ensure that cost-effective flood mitigation measures are implemented in the region that do not adversely impact other areas. These projects will reduce flood risks, save lives, and protect valuable infrastructure.

The detailed modeling and mapping will also help protect recreation resources and agriculture by evaluating future development impacts. The degradation of the Sulphur River due to past flood control projects shows the impacts of short-sighted planning. These FMEs, especially those pertaining to evaluating the Sulphur River channelization, will allow the Region to evaluate the impacts on the environment, erosion, and sedimentation so that these issues can be avoided in the future.

Until the FMEs are completed, their specific benefits cannot be quantified; however, we know that approximately 13,438 structures are currently in the 1% ACE floodplain, and 15,023 are in the 0.2% ACE floodplain. These structures house approximately 20,723 and 23,805 people, respectively. Tens of thousands more are exposed to risk as they travel across the flooded roadway and the 270 Low Water Crossings. These FMEs will help reduce the risks to these people and help prevent an additional 3,082 people from becoming exposed to the 1% ACE floodplain (17,130 in the 0.2% ACE floodplain) due to the expansion of the floodplain and uncontrolled development. By providing more accurate information on the flood risks, the communities will be empowered to control development within the floodplain.

Approximately 31 of the FMEs will specifically evaluate flood mitigation measures. *Table 6.3* shows the exposures within these study areas. While any mitigation measure will not fully resolve flood exposures, these numbers reflect the maximum potential impact of flood mitigation studies in the region.

Table 6.3 Total Flood Mitigation FME Existing 1% ACE Exposures

Type	Amount
Structures	5,831
Population	32,443
Ag Land (Acres)	942
Critical Facilities	73
Road Length (miles)	151

6A.1.D Summary of the Impacts of the Regional Flood Plan

If fully implemented, the Regional Flood Plan will have profound and lasting impacts on flooding in Region 2. With only three initial FMPs, 107 structures and 654 people can be protected from 1% ACE flood risks. This number can be expanded upwards of 5,800 structures and 32,400 people as FMPs are developed from FMEs in the future. In addition to these tangible reductions in flood risks, the Regional Flood Plan FMSs and associated FMEs will significantly reduce the expansion of flood risks in the future by providing communities with the data and resources needed to control floodplain development and prevent the expansion of the floodplain. This can prevent an additional 1,585 structures from being constructed in the 1% ACE (8,601 in the 0.2% ACE), which will help protect 3,082 people from the 1% ACE (17,130 from the 0.2% ACE). This will also preserve 115 square miles of land from becoming 1% ACE floodplain and 363 square miles from becoming 0.2% ACE floodplain.

While not readily quantifiable, these measures will protect the health and safety of the region, as well as its economic well-being. This is done by reducing the flooding frequency and severity, providing advanced warning of flood risks, reducing driving on flooded roads, and giving community officials the tools they need to prevent construction in flood-prone areas and alleviate known flooding issues.

Development in general, especially in the floodplain, leads to increases in flood flows that can cause downcutting and stream erosion, leading to environmental issues and sedimentation downstream. This can also happen due to poorly conceived flood reduction measures, such as those implemented on the Sulphur River in the 1930s. The FMEs and FMSs in this Regional Flood Plan will help restore past damages and prevent future damage, which will help preserve useable land in the region, protect agricultural and recreation lands, reduce erosion, and prevent downstream sedimentation.

Most flood mitigation measures have the potential to adversely impact neighboring areas, especially when conveyance is increased. These impacts will be mitigated during design and construction to ensure no adverse impacts occur. Many FMSs will require more active floodplain management by communities in the region. This will burden community officials who must enforce regulations and will meet some resistance from citizens who perceive the risks of development in or adjacent to the floodplain to be outweighed by the immediate economic benefits of the development. These issues can be overcome and lead to stronger communities and this Regional Flood Plan, fully funded and implemented, would provide the tools needed to make this happen.

This Region 2 Regional Flood Plan fosters the preservation of life and property, and considered the development of water supply sources, where applicable. None of the FMSs, FMEs, or FMPs specifically address water supply issues and are not expected to impact the water supply, as discussed in the following section.

6B.1 Contributions to and Impacts on Water Supply Development and the State Water Plan

The goal of Task 6B is to evaluate the potential impacts of the Regional Flood Plan on water supply development and the State Water Plan. This chapter describes the processes undertaken by the 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 Regional Flood Plan would have on water supply development, including a list of specific FMSs and FMPs that would measurably impact water supply
- description of any anticipated impacts that the Regional Flood Plan FMSs and FMPs may have on water supply, water availability, or projects in the State Water Plan

6B.1.A 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:

- involves directly increasing water supply volume available during the drought of record, which requires both availability increase and directly connecting supply to specific water user group(s)
- directly benefits water availability
- indirectly benefits water availability
- 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, 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. This can help manage downstream water treatment costs and benefit ratepayers.

Additionally, RFPGs must also list recommended FMSs or FMPs that, if implemented, would negatively impact and/or measurably reduce:

- water availability volumes that are the basis for the most recently adopted State Water Plan
- 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 currently designated for water supply purposes to be used for flood storage instead. There are no recommended actions related to reservoirs for Region 2. Additionally, land use changes over time could potentially reduce groundwater availability due to less naturally occurring aquifer recharge and an FMS that preserves open space or limits additional impervious cover could help maintain aquifer recharge.

As noted in *Table 13* and *Table 14 (Appendix 2),* it was determined that there were no recommended FMSs or FMPs that would measurably contribute or have a negative impact and/or measurably reduce water supply.

One FMS that could potentially be applicable to water supply involves the creation of a region-wide stormwater management manual (FMS 022000083). The stormwater management manual could promote low-impact development, green infrastructure, stormwater detention, and/or include a water supply aspect of beneficial reuse for irrigation purposes. Ultimately, it was determined that this strategy would not have a measurable impact on the water supply.

Additionally, three recommended FMPs involve culvert and/or channel improvements. It was determined that these projects would not measurably contribute to the water supply.

Some of the actions proposed here could have tangential impacts. In particular, the FMEs to evaluate the restoration of the portions of the Sulphur River that were straightened in the 1930s could lead to FMPs to restore the channel. This would reduce the incising and widening of the channel, which would reduce sediment loads into the downstream lakes. This would extend their conservation pool lifespans before dredging becomes necessary. This benefit to the water supply cannot be quantified at this time, but funding the FMEs would help demonstrate the benefits for future plans.

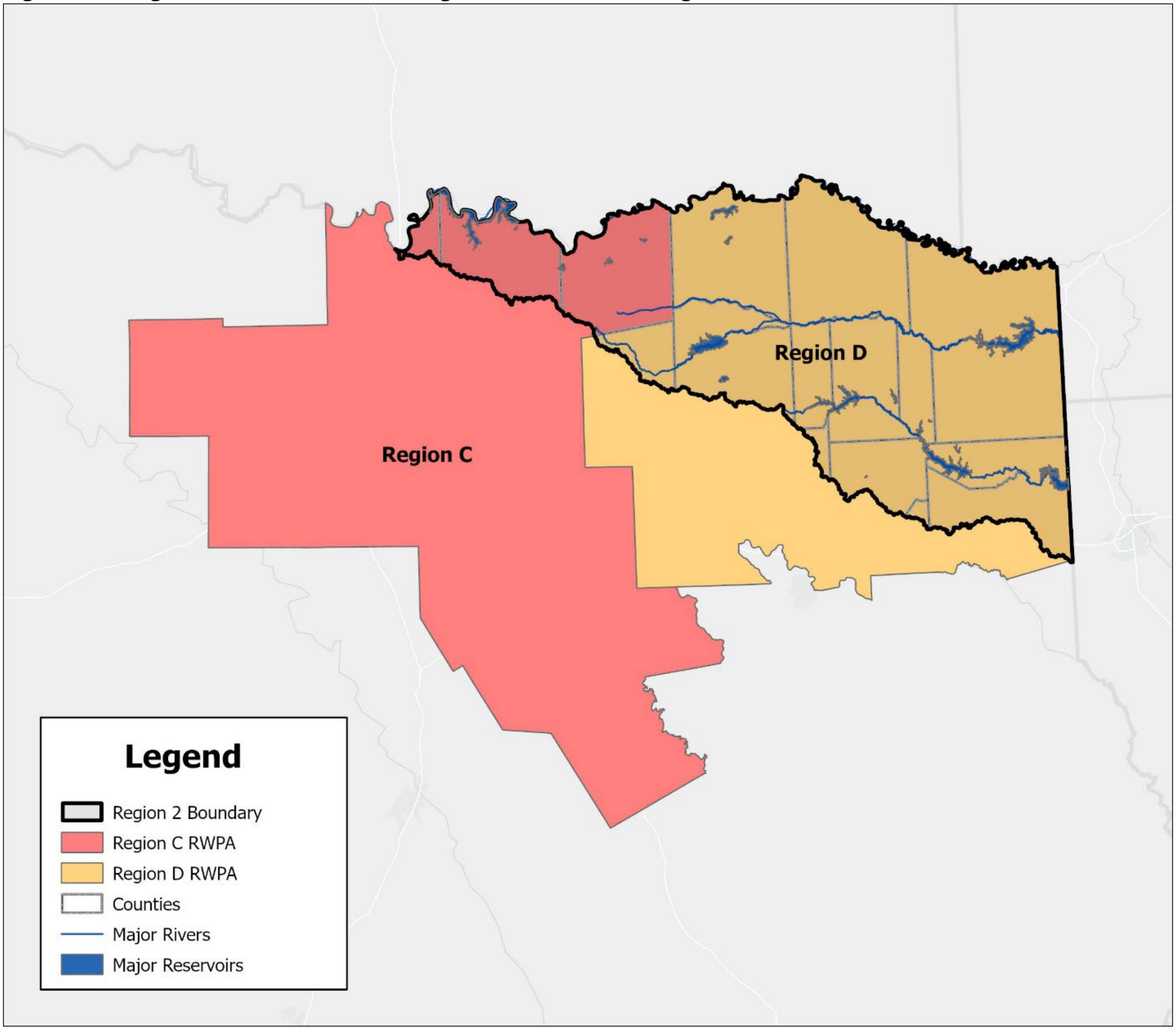
6B.2.A Anticipated Impacts to the State Water Plan

In response to the 1950s drought, the TWDB was established in 1957 to prepare a comprehensive long-term plan for developing, conserving, and managing the state's water resources. The current State Water Plan, 2022 State Water Plan – Water for Texas, was produced by the TWDB and based on approved Regional Water Plans 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 and appointed members representing 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 2 primarily covers Region D (North East Texas Region) and Region C Regional Water Planning Area, as shown in *Figure 6.3*.

Figure 6.3 Region 2 with Associated Regional Water Planning Areas



Most of Region 2 is located within Region D. Region D encompasses approximately 11,500 square miles and includes all or portions of 19 counties located in the northeast corner of Texas. This RWPG includes representatives from 11 key public interest groups and at least one representative from each county. There are two major aquifers and four minor aquifers in the region. A majority of the region relies on surface water supplies as groundwater is limited in quality and quantity. According to the 2021 Region D Plan, there are 34 existing reservoirs in the region. Major existing reservoirs in Region D by river basin are listed in *Table 6.4*. No recommended FMSs or FMPs impact the proposed operation of these existing reservoirs. USACE lakes such as Pat Mayse, Wright Patman, and Lake O' the Pines are primarily used for flood control but are also important water supply reservoirs.

The 2021 North East Texas Region Plan recommends 111 water management strategies (WMSs) to meet water shortages in the following categories: advanced water conservation, water reuse, groundwater, and surface water.

Table 6.4 Major Existing Reservoirs in the North East Texas Region (Region D) Associated with Region 2

River Basin	Lake/Reservoir	County
Red River Basin	Pat Mayse Lake	Lamar
Sulphur River Basin	Cooper	Delta
Sulphur River Basin	Lake Sulphur Springs	Hopkins
Sulphur River Basin	Lake Wright Patman	Bowie/Cass
Cypress Creek Basin	Lake Bob Sandlin	Wood/Titus/Franklin
Cypress Creek Basin	Caddo Lake	Marion/Harrison
Cypress Creek Basin	Cypress Springs	Franklin
Cypress Creek Basin	Ellison Creek	Morris
Cypress Creek Basin	Lake Gilmer	Upshur
Cypress Creek Basin	Johnson Creek Reservoir	Marion
Cypress Creek Basin	Lake O' the Pines	Marion/Upshur
Cypress Creek Basin	Monticello Lake	Titus
Cypress Creek Basin	Welsh Reservoir	Titus
Sabine River Basin	Brandy Branch Reservoir	Harrison
Sabine River Basin	Lake Cherokee	Gregg
Sabine River Basin	Lake Fork	Wood/Rains
Sabine River Basin	Lake Hawkins	Wood
Sabine River Basin	Lake Tawakoni	Rains/Van Zandt/Hunt

A small portion in the northwest part of Region 2 is located within Region C, including portions of Cooke, Grayson, and Fannin counties. Region C covers all or portions of 16 counties located in north-central Texas. This RWPG includes representatives from 12 key public interest groups. There is one major (Trinity aquifer) and one minor aquifer (Woodbine aquifer) in the portion of Region 2 that overlaps Region C. Groundwater provides most of the total water use in Cooke County and over 33% in Fannin and Grayson counties. According to the 2021 Region C Plan, 22 major reservoirs with conservation storage of over 5,000 acre-feet are in the region. Major existing reservoirs in Region C that are also within Region 2 are listed in *Table 6.5.* No recommended FMSs or FMPs impact the proposed operation of these existing reservoirs. Lake Texoma has a major operational goal of flood control.

Two new major reservoirs are being constructed in the region for water supply purposes. Neither has a flood control objective, although limited downstream flood risk benefits are likely. Bois d'Arc Lake is currently being impounded in Fannin County. Lake Ralph Hall is also being constructed in Fannin County at the upper end of the Sulphur River. Lake Ralph Hall is being constructed on a straightened portion of the river, which helps prevent further degradation of that reach. Significant stream and wetland restoration is being performed for a short distance downstream of the dam as well, which will also help with downstream sedimentation issues.

Table 6.5 Major Existing Reservoirs in Region C Associated with Region 2

River Basin	Lake/Reservoir	County
Red River Basin	Coffee Mill Lake	Fannin
Red River Basin	Lake Bonham	Fannin
Red River Basin	Lake Texoma	Grayson
Red River Basin	Randell Lake	Grayson
Red River Basin	Valley Lake	Fannin/Grayson

It was determined that there were no anticipated impacts that recommended FMSs and FMPs may have on water supply, water availability, or projects in the State Water Plan based on the no measurable impact as previously evaluated.

Chapter 7: Flood Response Information and Activities

The following chapter summarizes the flood response preparations for the Lower Red-Sulphur-Cypress Region (Region 2), using demographic, historical, projected, and statistical data from the previous chapters and implementing data from the survey responses. The Texas Water Development Board (TWDB) specifically stated that the Regional Flood Planning Group (RFPG) "shall not perform analyses or other activities related to planning for disaster response or recovery activities." This chapter summarizes information obtained and provides general recommendations regarding flood response activities.

Types of Flooding in Region 2

There are three major categories of floods: riverine, coastal, and shallow flooding. With coastal flooding not being relevant in Region 2, the two most common would be riverine and shallow flooding. Region 2 is prone to each type depending on the part of the region. Riverine flooding, which is the most common, occurs when excess rainfall moves downstream causing an overtopping of the channel banks with water collecting onto nearby land (i.e., floodplain). It can be classified as flash flooding when floodwater rises rapidly caused by heavy rainfall over a relatively short period. Flood water can be very powerful, making it extremely dangerous.

Shallow floods happen when flooding is independent of an overflowing body of water, or river channel, due to extreme rainfall. There are three types of shallow flooding: sheet flow, ponding, and urban drainage. Urban flooding is perhaps the most common. Urban flooding is caused by excess runoff water in developed areas, where the drainage systems are inadequate to convey the flow away. Urban flooding can be a type of pluvial flooding caused by rainfall.

When such flood events occur, it is imperative that plans are already in place to combat the effects of flooding.

Nature and Types of Flood Response Preparations

There are four phases to emergency management (see *Figure 7.1*):

1. **Flood Mitigation:** The implementation of both structural and non-structural solutions, to reduce flood risk to protect against the loss of life and property.
2. **Flood Preparedness:** Actions, aside from mitigation, that are taken before flood events to prepare for flood response activities.
3. **Flood Response:** Actions taken during and in the immediate aftermath of a flood event.
4. **Flood Recovery:** Actions taken after a flood event involving repairs or other actions necessary to return to pre-event conditions.

Figure 7.1 Flood Responses

For example, during the **preparedness** phase, disaster preparedness plans are in place, drills and exercises are performed, an essential supply list is created, and potential vulnerabilities are assessed. During the **response** phase, disaster plans are implemented, search and rescue may occur, and low water crossing signs may be erected. In the **recovery** phase, evaluation of flood damage, rebuilding of damaged structures, and removing debris occur. The most critical step of the four phases of emergency management is **mitigation**.

Hazard mitigation is defined as any sustained action taken to reduce or eliminate the lasting risk to life and property from hazard events. It is an ongoing process that occurs before, during, and after disasters and seeks to break the cycle of damage and restoration in hazardous areas.

Flood mitigation is the primary focus of the Regional Flood Planning process and plan development efforts by RFPGs include identifying and recommending Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs). The planning process may include flood preparedness FMEs, FMSs, and FMPs.

Examples of mitigation actions include planning and zoning, floodplain protection, property acquisition and relocation, or public outreach projects. Examples of preparedness actions include installing disaster warning systems, purchasing radio communications equipment, or conducting emergency response training.

Actions and Preparations

Mitigation actions from Hazard Mitigation Action Plans (HMAPs) include:

- buyout, acquisition, and elevation projects
- drainage control and maintenance
- education and awareness for citizens

- equipment procurement for response
- erosion control measures
- flood insurance education
- flood study/assessment
- infrastructure improvement
- installation/procurement of generators
- natural planning improvements
- outreach and community engagement
- technology improvements
- urban planning and maintenance

The survey, as indicated in *Figure 7.2*, found that several of the types of actions listed were in place or being implemented in the next five years, including utilizing social media to disseminate information, utilizing crews to set up barricades or close gates at low water crossings, as well as creating a public-facing website to communicate with the community.

Figure 7.2: Survey results indicating the Flood Response Measures Your Jurisdiction CURRENTLY uses or PLANS to Implement for Emergency Response

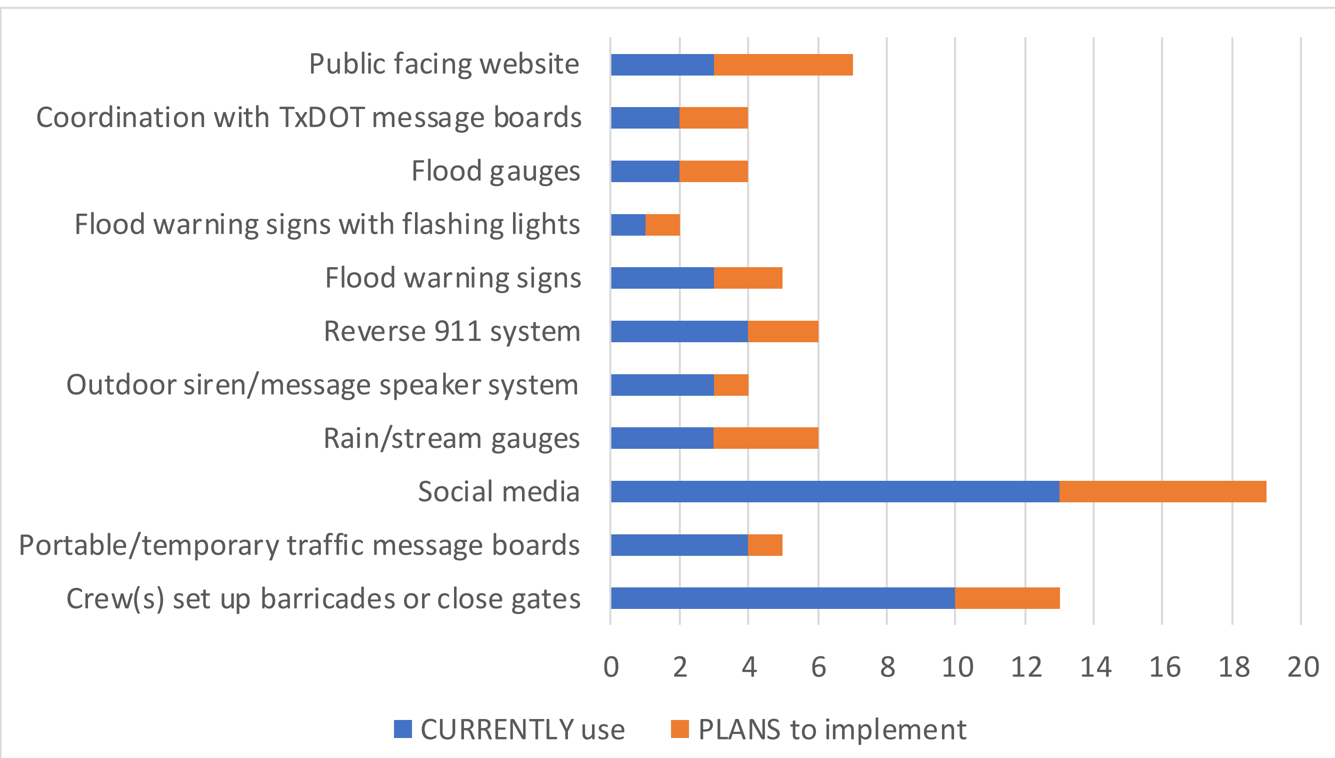
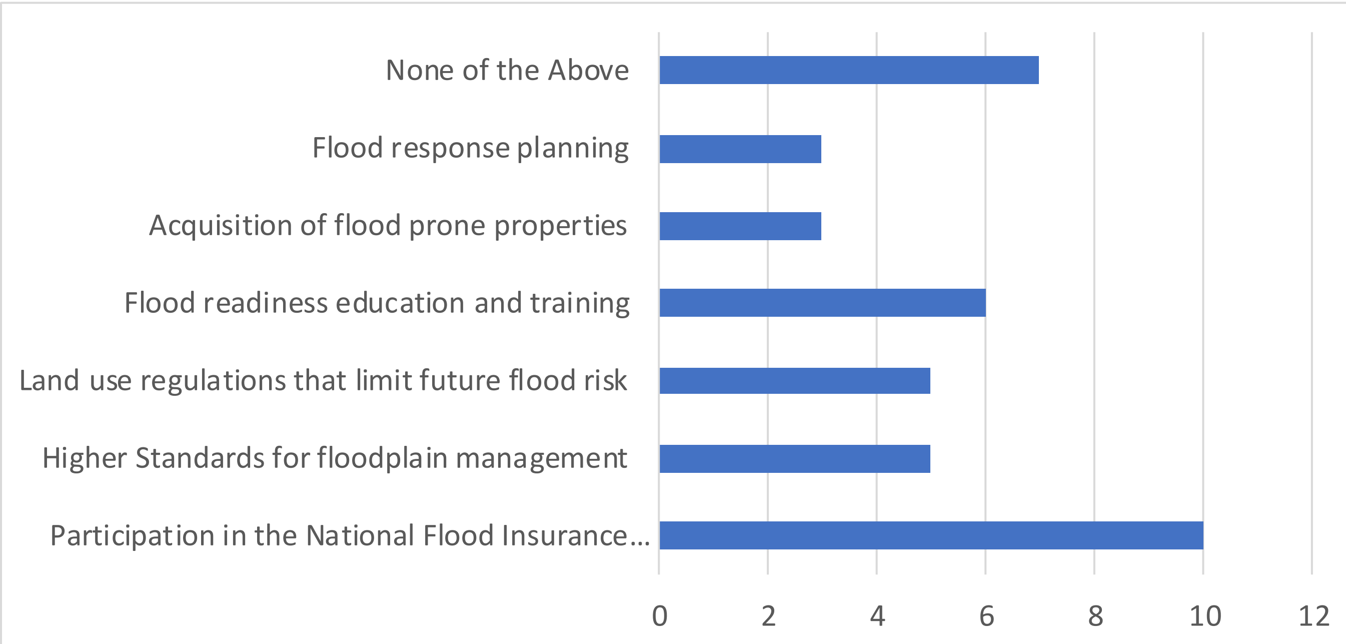


Figure 7.3 shows additional measures undertaken by jurisdictions to promote participation in the National Flood Insurance Program (NFIP), focusing on higher standards for floodplain management and land use regulations that limit future flood risk.

Figure 7.3: Measures Being Taken to Promote Resilience within Flood-Prone Areas



Most mitigation and preparatory actions are done in conjunction with the relevant entities who put these actions into practice.

Relevant Entities in Region 2

The purpose of flood risk management is to help prevent or reduce flood risk by using either structural or non-structural means or a combination of the two. Responsibility for flood risk management is shared between federal, state, and local government agencies; private-sector entities; and the general public. In *Chapter 1*, the various stakeholders that were contacted to provide data via the survey were listed and included: agriculture agents and organizations; cities; counties; Councils of Government (COGs); districts, such as a Municipal Utility District (MUD), Special Utility District (SUD), etc.; and state and federal agencies. Listed below are the various contributing entities and partners.

Ag Extension Agents are employed by land-grant universities and serve the citizens of that particular state by serving as an expert or educating others on agriculture. Ag extension agents can provide valuable information on preparation and recovery from flood events specific to agricultural entities. Region 2 has a significant farming and agricultural footprint, making working closely with Ag Extension Agents crucial to prevent losses.

Cities or Municipalities generally take responsibility for parks and recreation services, police and fire departments, housing services, emergency medical services, municipal courts, transportation services (including public transportation), and public works (streets, sewers, signage, etc.). There are 86 municipalities within Region 2.

The major responsibilities of the 20 Region 2 **County** governments include providing public safety and justice, holding elections at every level of government, maintaining Texans' most important records, building and maintaining roads, bridges, and in some cases, county airports, providing emergency management services, providing health and safety services, collecting property taxes for the county and sometimes for other taxing entities, issuing vehicle registration and transfers, and registering voters.

In the aftermath of a flood event, cities and counties coordinate to provide recovery services for residents including, but not limited to, debris clean up, vital resources distribution, medical care, short-term shelter, buyout programs for flooded properties, and local infrastructure improvements to mitigate future risk in long-term implementation. Cities and counties can provide increased resiliency through the successful implementation of mitigation projects to reduce the impact of floods.

The four regional **Councils of Governments (COGs)** are voluntary associations representing member local governments, mainly cities and counties, that seek to provide cooperative planning, coordination, and technical assistance on issues of mutual concern that cross jurisdictional lines. COGs can serve as a resource for flood data, flood planning, and flood management.

The mission of the **TWDB** is to lead the state's efforts to ensure a secure water future for Texas and its citizens. The TWDB provides water planning, data collection and dissemination, financial assistance, and technical assistance services to the citizens of Texas.

The **Federal Emergency Management Agency** (**FEMA**) is an agency of the United States Department of Homeland Security (DHS), initially created under President Jimmy Carter. 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 and funding for rebuilding efforts and relief funds for infrastructure by directing individuals to access low-interest loans in conjunction with the Small Business Administration. In addition, FEMA provides funds for training response personnel throughout the United States and its territories as part of the agency's preparedness effort.

A **Flood Control District** is a special-purpose district created by the Texas Legislature and governed by county commissioners' courts. It is a government agency established to reduce the effects of flooding. There are ten flood control districts in the region, but no evidence was found that these were active.

Dams and Levees are owned and operated by individuals, private and public organizations, and the government. The responsibility for maintaining a safe dam rests with the owner. A dam failure resulting in an uncontrolled reservoir release can have a devastating effect on persons and property downstream. The owners must be part of the flood planning process to ensure collaborative and cohesive flood planning.

The **National Weather Service's (NWS)** mission is to provide weather, water, and climate data, forecasts, warnings, and impact-based decision support services to protect life and property and enhance the national economy.

NWS provides flash flood indicators through watches, warnings, and emergency notices, such as:

- **Flash Flood WATCH** is issued when conditions look favorable for flash flooding and usually encompasses several counties. This is the time to start thinking about your action plan and where you would go if water began to rise.
- **Flash Flood WARNING** is issued when dangerous flash flooding happens or is anticipated soon. A warning is usually a smaller, more specific area. This can be issued due to excessive heavy rain or a dam/levee failure. This is when you must act quickly, as flash floods are an imminent threat to you and your family, and you may only have seconds to move to higher ground.
- **Flash Flood EMERGENCY** is issued for the exceedingly rare situations when extremely heavy rain is leading to a severe threat to human life and catastrophic damage from a flash flood that is happening or anticipated soon. Emergency officials will typically report life-threatening water rises resulting in water rescues/evacuations.

The **National Oceanic and Atmospheric Administration (NOAA)** is an American scientific and regulatory agency within the United States Department of Commerce that forecasts weather, monitors oceanic and atmospheric conditions, charts the seas, conducts deep-sea exploration, and manages fishing and protection of marine mammals and endangered species in the United States, exclusive economic zone. 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 vital in the planning and mitigation process.

River Authorities or Districts in Texas are public agencies established by the state legislature and given authority to develop and manage the state's water. Region 2 has two river authorities for each of the major basins (Red River Authority and Sulphur River Basin Authority) that have the power to conserve, store, control, preserve, utilize, and distribute the waters of a designated geographic region for the benefit of the public.

Daily river forecasts are issued by the 13 **River Forecast Centers (RFCs)** using hydrologic models based on rainfall, soil characteristics, precipitation forecasts, and several other variables. Some RFCs, especially those in mountainous regions, also provide seasonal snowpack and peak flow forecasts. These forecasts are used by a wide range of users, including those in agriculture, hydroelectric dam operation, and water supply resources. The forecasts can provide essential information on river levels and conditions.

The **Texas Division of Emergency Management (TDEM)**, a division of the Texas Department of Public Safety (DPS), coordinates state and local responses to natural disasters and other emergencies in Texas. TDEM is intended to ensure the state and its local governments respond to and recover from emergencies and disasters. TDEM also implements plans and programs to help prevent or lessen the impact of emergencies and disasters.

There are six TDEM regions within Texas. In those regions, Assistant Chiefs and District Coordinators 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 carrying out emergency planning, training, and exercises. They also develop emergency teams and facilities and teach various emergency management training 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. Region 2 is entirely in TDEM Region 1.

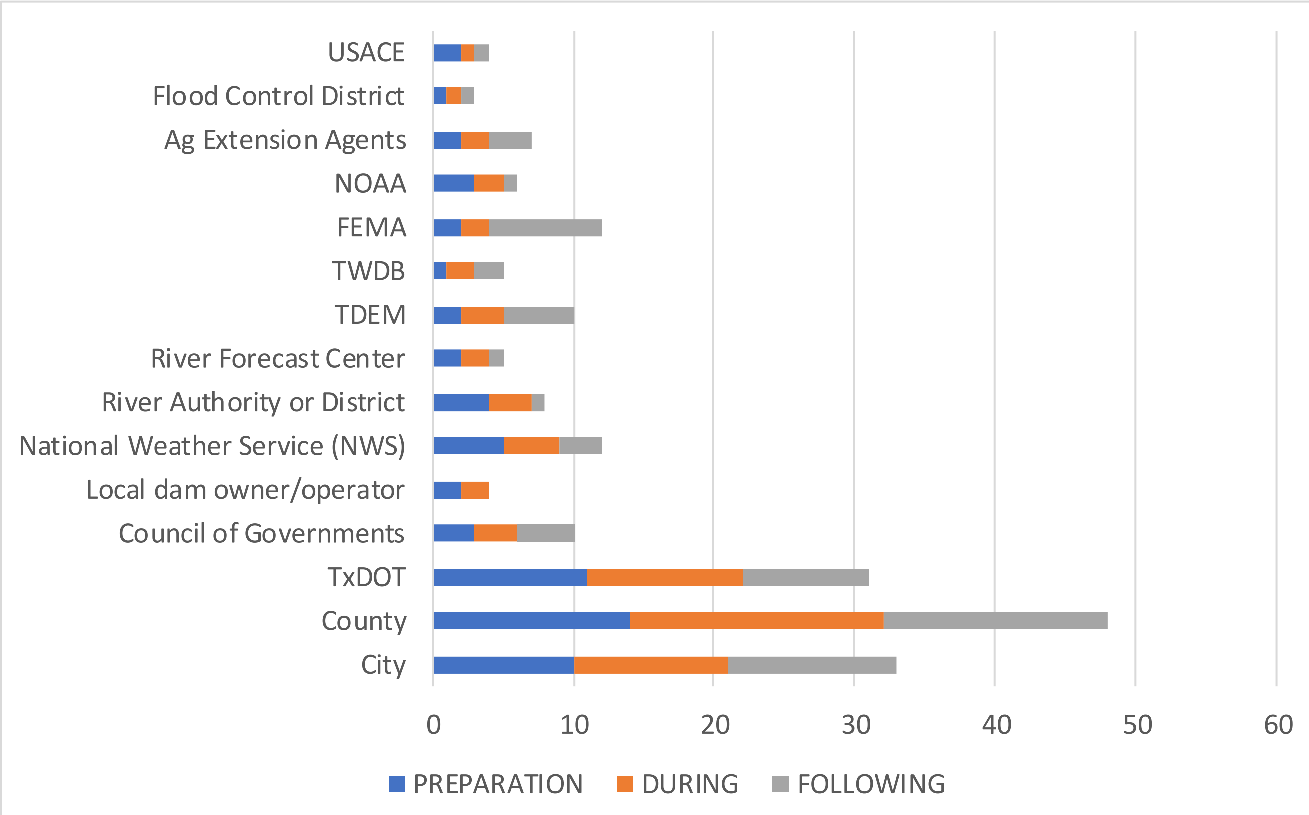
Though the public face of the agency is generally associated with the construction and maintenance of the state's immense state highway system, the **Texas Department of Transportation** (**TxDOT**) is also responsible for overseeing aviation, rail, and public transportation systems (https://en.wikipedia.org/wiki/Texas_Department_of_Transportation - cite_note-3). TxDOT can provide real-time road closure and low water crossing information during and after a flood event. An interactive site can be found here: https://drivetexas.org.

The **United States Corps of Engineers (USACE)** is essential to the nation's military. The agency is responsible for a wide range of efforts in the United States, including addressing safety issues related to waterways, dams, and canals, environmental protection, emergency relief, hydroelectric power, and much more. USACE is composed of several divisions, with Region 2 located in the Southwestern Division with the Lower Red Basin in the Tulsa District and the Sulphur and Cypress Basins in the Fort Worth District.

The USACE Flood Risk Management Program (FRMP) focuses on the policies, programs, and expertise of USACE to help reduce overall flood risk. This includes the appropriate use and resiliency of structures such as levees and floodwalls, as well as promoting alternatives when other approaches (e.g., land acquisition, floodproofing, etc.) reduce the risk of loss of life, reduce long-term economic damages to the public and private sector, and improve the natural environment.

In the planning process, it is important to consider flood planning in preparation, during, and following a flood event to access the entities that provide the respondents with the most assistance and support. *Figure 7.4* shows the entities most commonly coordinated with during flood events. The top five key entities in which coordination was indicated were counties, cities, TxDOT, FEMA, and the NWS, with all other entities accounting for much smaller responses.

Figure 7.4 Flood Response Coordination Entities



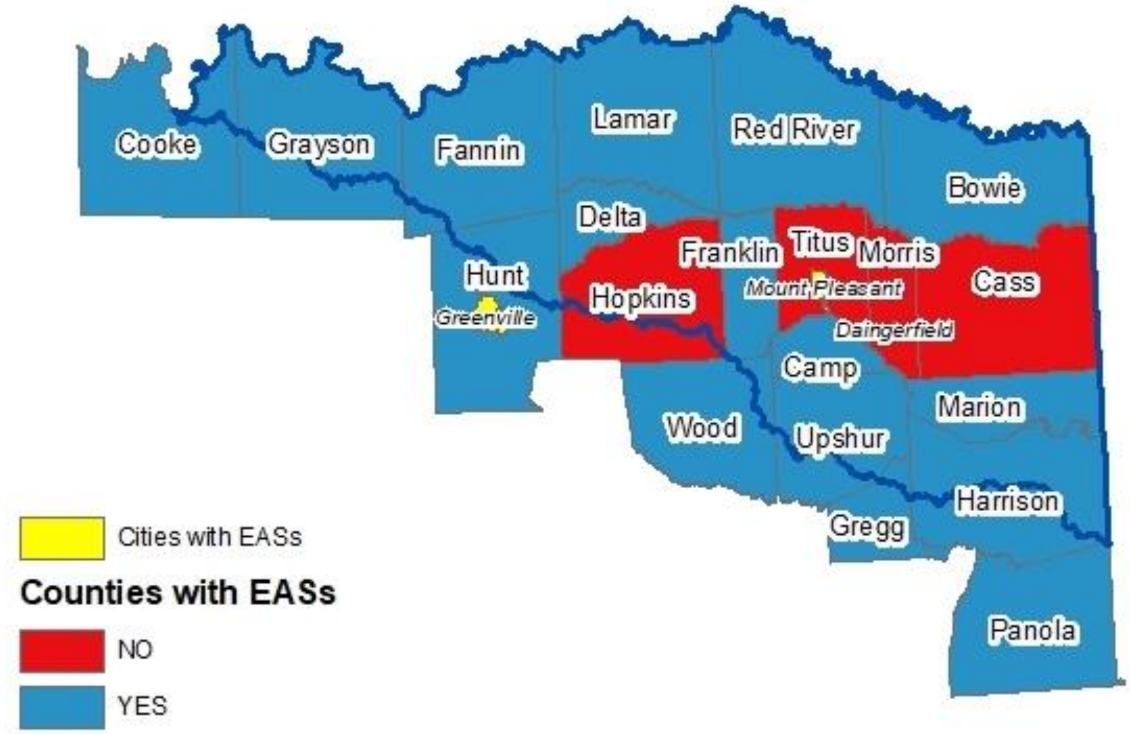
Emergency Information

There are various means by which data can be collected and disseminated in a flood event. Two types of gauges used are rain gauges and stream gauges. A rain gauge is a meteorological instrument to measure the precipitating rain in a given amount of time per unit area. It collects water falling on it and records the change over time in the rainfall depth. Stream gauging is a technique used to measure a stream's discharge or the volume of water moving through a channel per unit of time. The height of water in the stream channel, known as a stage or gauge height, can be used to determine the discharge in a stream.

In addition to the NWS, local news stations or radio stations are vital components in relaying real-time information to local residents about inclement weather and flooding. They can also alert residents to low water crossing closings, dam or levee breaches, and other potential dangers. In addition, they can issue flood watches, warnings, and emergency notifications.

An Emergency Alert System (EAS) is software that provides alert messages during an emergency. Messages can interrupt radio and television to broadcast emergency alert information. Messages cover a large geographic footprint, including about half of Region 2. Emergency message audio/text may be repeated twice, but EAS activation interrupts programming only once, then regular programming continues. *Figure 7.5* shows the areas covered by Emergency Alert Systems.

Figure 7.5 Geographic Distribution of Emergency Alert Systems



A reverse 911 system allows an agency to pull up a map on a computer, define an area, and send a recorded phone message to each business or residence in that area. It can provide data to residents on flood dangers in their area.

School emergency alert systems are tools that allow schools to communicate quickly with staff, students, first responders, and others to take appropriate action in the event of an emergency. Various versions are used in schools throughout the region, from daycares to K-12 grades and universities.

Plans to be Considered

State and Regional Plans

The State Hazard Mitigation Plan effectively reduces losses by reducing the impact of disasters upon people and property. However, mitigation efforts cannot completely eliminate the impacts of disastrous events; the plan endeavors 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 an event, economic impact, deaths, and injuries.

The plan:

- assesses hazard risk
- reviews current state and local hazard mitigation and climate adaption capabilities
- develops strategies and identifies state agency (and other entities) potential actions to address needs

The Regional Emergency Preparedness Program is one of the largest and most effective programs of its kind nationwide. Bringing together urban, suburban, and rural jurisdictions, the program facilitates information sharing, collaboration, and cooperation between jurisdictions in a politically neutral and supportive environment. The Regional Preparedness Program accomplishes this through networking, standardization of policy and procedures, and coordination efforts with stakeholders.

Local Plans

In Region 2's data collection effort and survey tool in 2021, the region requested local emergency management and emergency response plans that were publicly available (see *Table 7.1*). Some emergency plans are protected by law and are not available for public consumption. In addition to the plans provided by local entities, the region also obtained emergency management plans, hazard mitigation plans, and other regional and local flood planning studies from the county and local jurisdictions.

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 should include measures that provide for personnel safety and, if possible, property and facilities.

Region 2 has several regional plans and regulations that provide the framework that dictates a community's capabilities in implementing mitigation and preparedness actions. Other plans to consider include HMAPs, Emergency Action Plans (EAPs), and watershed master plans. An EAP provides the basis for the coordinated planning and management of emergencies and disaster events. Watershed master plans promote collaboration between all community sectors to create a resilient flood hazard community.

Hazard mitigation planning reduces loss of life and property by minimizing the impact of disasters. It begins with state, tribal, and local governments identifying common natural disaster risks and vulnerabilities in their area. After identifying these risks, they develop long-term strategies for protecting people and property from similar events. Mitigation plans are key to breaking the cycle of disaster damage and reconstruction. While 18 counties and one city have an HMAP, 15 out of 18 county plans are currently approved by FEMA, as they are to be updated on a five-year cycle. Several counties are in the process of having their plans updated or are in review. An up-to-date HMAP is key in assessing risk and developing mitigation actions.

In the private sector, an EAP is required by the Occupational Safety and Health Administration (OSHA) standards. An EAP aims to facilitate and organize employer and employee actions during workplace emergencies. EAPs are essential in emergency management for critical facilities and dams. EAPs for dams are essential in identifying potential emergency conditions and specifying preplanned actions to minimize property damage and loss of life.

A watershed master plan helps in the understanding of and addressing existing flooding, erosion, and water quality problems, and it can help prepare for future challenges. Watershed master plans inform recommendations, help educate the public, and influence decision-makers regarding land use changes, investment in capital projects and modifications to development regulations within the basin.

Table 7.1 Status of County HMAPs

Jurisdiction	Year of HMAP	HMAP Status
Bowie County	2017	In progress
Cass County	2022	
Cooke County	2018	
Delta County	2021	
Fannin County	2015	In review
Grayson County	2012	
Gregg County	2018	In progress
Harrison County	2019	
Hopkins County	2022	
Hunt County	2021	
Lamar County	2017	
Marion County	2018	
Morris County	2017	
Panola County	2019	
Red River County	2020	
Titus County	2013	
Upshur County	2011	In progress
Wood County	2018	
City of Texarkana	2012	In progress with Bowie County

Region 2’s ability to prepare, respond, recover, and mitigate disaster events is determined by several factors. With a clear understanding of the plans that determine a community's capabilities, a recognition of the entities with whom coordination is key, and knowledge of the actions sustained to promote resiliency, and the region can be better equipped to implement sound measures for flood mitigation and preparedness.

Aligning common regional goals and objectives can facilitate the efficiency of plans and actions taken. More robust floodplain practices at local and regional levels create an ideal flood mitigation scenario and promote good floodplain management practices.

Chapter 8: Legislative, Administrative, and Regulatory Recommendations

Part of the Regional Flood Planning effort includes proposing changes to existing statutes to make floodplain management and flood mitigation planning and implementation throughout the State of Texas more efficient or logical. Recommendations can include alterations to the legislature associated with flood planning throughout Texas and regulatory or administrative features associated with flood-related activities. Recommendations may be proposed to further the flood planning process, such as desired support or data from the Texas Water Development Board (TWDB) or other state entities. Lastly, recommendations regarding new funding or revenue-raising opportunities for stormwater and floodplain management are included.

8.1 Legislative Recommendations

Being a part of the state flood planning effort has allowed the Regional Flood Planning Groups (RFPGs), Sponsors, and Technical Consultants a more hands-on experience with a wide variety of entities. The RFPGs see trends and occurrences throughout a large portion of the state. Some of these practices are positive and should be encouraged, while others may be detrimental to the floodplain and stormwater management of the entity, region, and/or state as a whole.

Throughout the flood planning process, the RFPGs, Technical Consultants, surveyed entities, and members of the public have provided input on the functionality and usefulness of the existing legislation as it relates to floodplain and stormwater management. As they have the occasion to see the effects of Texas' legislature or lack thereof, the Region 2 RFPG proposes the following legislative recommendations for consideration concerning floodplain and stormwater management, as listed in *Table 8.1*.

Table 8.1 Legislative Recommendations for Region 2

ID	Specific Recommendation Statements	Reason for Recommendation
8.1.1	Increase state funding to counties to maintain drainage and stormwater infrastructure in unincorporated areas.	Counties have floodplain and drainage-related responsibilities in Texas without a current way to fund projects.
8.1.2	Develop state strategies to aid in acquiring federal funds.	Entities in Texas do not qualify for some federal funding programs due to minimal or no state participation, such as FEMA's Building Resilient Infrastructure and Communities (BRIC) Grant.

ID	Specific Recommendation Statements	Reason for Recommendation
8.1.3	Develop and allocate state funding to assist private dam owners with the costs associated with repairing, maintaining, and upgrading dam structures, as well as decommissioning studies, where applicable.	Developments now surround many privately-owned dams that were initially constructed in rural areas. Therefore, the potential impact of flood damages resulting from dam failure has increased significantly, and the maintenance cost is often far too high for a private entity to take on.
8.1.4	Provide funding and/or technical assistance to develop regulatory floodplain maps.	Several entities with outdated maps or no mapping are not able to fund the projects necessary to update or create those maps.
8.1.5	Provide additional grant funding to the RFPGs to enable them to continue to function during the interim timeframe between planning cycles.	In the interim of the planning cycles, not only could RFPGs continue adding FMEs, FMPs, and/or FMSs to the Regional Flood Plan, but they could also implement RFPG-sponsored flood management activities, outreach, and stay informed on regional flood-related occurrences
8.1.6	Establish a levee safety program similar to the dam safety program.	Levees are often constructed to protect a specific commodity; however, they do not have a safety program like dams, despite being designed for routine flood protection.
8.1.7	Extend Local Government Code, Title 13, Subtitle A, Chapter 552 to allow counties the opportunity to establish and collect drainage utilities/fees in unincorporated areas.	Counties have floodplain and drainage-related responsibilities in Texas. Currently, counties cannot establish and collect stormwater utility fees, thus limiting their ability to fund stormwater or drainage projects, despite having the responsibility.
8.1.8	Provide alternative sources of funding. Expand eligibility for and use of funding for stormwater and flood mitigation solutions (Local, State, Federal, Public/Private Partnerships, etc.)	Flood mitigation studies/projects do not generate revenue, making them more challenging to fund locally.

8.2 Regulatory or Administrative Recommendations

Some of the suggestions that the RFPGs proposed are not directly controlled by the Texas Legislature. Instead, some recommendations are of a regulatory or administrative nature concerning existing procedures, state entities, or state/regional regulations. Alterations to these procedures could also be proposed to the TWDB for consideration.

These recommendations are suggested changes to implementing existing standards and procedures by state-controlled entities. They are listed in *Table 8.2*.

Table 8.2 Regulatory and Administrative Recommendations for Region 2

ID	Specific Recommendation Statements	Reason for Recommendation
8.2.1	Review and revise as necessary all state infrastructure entities (i.e., TxDOT) standards and practices for legislative and regulatory compliance with stormwater best practices.	State entities should be cognizant of the drainage and stormwater standards in the areas where they are active and follow them as feasible.
8.2.2	Develop resources for and educate city and county officials regarding the respective entities' ability/authorization to establish and enforce higher development standards.	City and county officials are often unaware of their authority to establish and enforce stormwater regulations. (Texas Local Government Code Title 7, Subtitle B.; Texas Water Code Chapter 16, Section 16.315) The flooding and drainage component of city and county officials' training is often inadequate for their level of responsibility.
8.2.3	Provide measures to encourage and allow jurisdictions to work together towards regional flood mitigation solutions.	Flooding does not recognize jurisdictional boundaries. Allowing and encouraging entities to work together towards common flood mitigation goals would benefit all involved.
8.2.4	Develop a publicly available statewide database and tracking system to document flood damage data required in the regional flood plan, including flood deaths and injuries, flood insurance claims, agricultural flood damage, etc.	High-flood-risk areas should be tracked and reported to address the public's health, safety, and welfare. Doing so would increase awareness of the area, so the public could be aware of the risks, and elected officials and decision-makers could institute solutions to reduce the risk in those areas.

ID	Specific Recommendation Statements	Reason for Recommendation
8.2.5	Update and provide details on statewide datasets, including low water crossings, critical facilities, structures, etc.	The source and methods for determining low water crossings, structures, and other data were unclear, making it difficult to determine the accuracy of the data and what, if any, changes should be made by the RFPG.
8.2.6	Revise the scoring criteria for funding associated with stormwater and flood-related projects that benefit agricultural activities.	The traditional benefit-cost analysis tools prevent agricultural projects from competing with municipal benefit-cost ratios.
8.2.7	Provide financial or technical assistance to smaller/rural jurisdictions.	Smaller communities lack resources to plan around flooding, implement and enforce floodplain regulations, and construct mitigation projects. Actions such as maintaining a department or program specifically for smaller/rural entities, incentivizing consultants to pursue work for smaller or rural entities, or adjusting benefit-cost analysis to rank small/rural entities equally are all ideas towards addressing this challenge.
8.2.8	Simplify all funding application processes.	Current funding applications require significant time and resources to prepare a project for consideration and complete the application itself, especially for jurisdictions with limited resources. Thus, jurisdictions that need the funding the most typically do not apply for current opportunities, despite the need.
8.2.9	Address the concern of "takings" regarding floodplain development regulations, comprehensive plans, land use regulations, and zoning ordinances.	Jurisdictions should be allowed to regulate development responsibly, reducing future flood risk exposure without fearing legal action by property owners. Conversely, the regulations should allow property owners maximum use of their property without causing adverse floodplain impacts on others. The community floodplain and property owner's rights should be balanced and clear.

8.3 Flood Planning Recommendations

Having been involved in the first-ever State Flood Planning effort, Region 2 offers the recommendations in *Table 8.3* to improve the regional flood planning process for future planning cycles.

Table 8.3 State Flood Planning Recommendations for Region 2

ID	Specific Recommendation Statements	Reason for Recommendation
8.3.1	Update the scope of work, guidance documents, rules, checklists, etc., based on the adjustments made to these documents during the first planning cycle.	During the first cycle of the State Flood Plan, multiple amendments and additions to the TWDB documents and the TWDB's interpretation of its documents occurred. Moving forward, the TWDB documents provided at the onset of each new planning cycle should reflect what is ultimately required of the RFPGs.
8.3.2	Develop a fact sheet and/or other publicity measures to encourage entities to participate in the Regional Flood Planning effort.	Many entities were unaware of the Regional and State Flood Plan efforts despite the RFPG outreach efforts. Some entities still request information regarding the flood planning process and do not understand the benefits of participating. Other entities did not want to participate due to a perceived lack of benefits.
8.3.3	Host "lessons learned" discussions with RFPG Members, Sponsors, and Technical Consultants following the submittal of the Regional Flood Plan.	Opening dialogue among these participants to discuss proposed improvements to the regional planning process will streamline and improve future Regional Flood Planning cycles.
8.3.4	Develop an amendment process similar to the Regional Water Planning Process to efficiently amend their approved Regional Flood Plans to incorporate additional recommended FMEs, FMPs, and FMSs. Develop language allowing the RFPG to advance the recommended FMEs to FMPs based on the results provided after an FME.	Amending the Regional Flood Plan, as seen with the Technical Memorandum Addendum, can be an extensive process. Amendments to move FMEs to FMPs and incorporate new flood management solutions should have a quicker turn-around time to include them in the Regional Flood Plan efficiently. A simplification of the Regional Water Planning Process amendment process is recommended.

ID	Specific Recommendation Statements	Reason for Recommendation
8.3.5	Implement an invoice review and advancement request process that provides for timely reimbursements.	Several regions experienced extensive delays in their billing cycles which can delay planning efforts.
8.3.6	Include the reimbursement of audio and visual (A/V) equipment expenses required to support hybrid and/or virtual meetings for the RFPG grants.	Many RFPGs have had to rent or purchase A/V equipment to uphold the Texas Open Meetings Act (TOMA) guidelines while supporting hybrid meetings. Given the region's area and today's technology, RFPG members prefer to offer hybrid meetings to reduce travel time and increase the opportunity for public participation in the Regional Flood Planning process. Expenses accrued to maintain TOMA standards – set in place by the State – should be eligible for reimbursement.
8.3.7	Reduce the information required to escalate potentially feasible FMEs to FMPs.	Some data currently requested for FMPs are more detailed than traditional planning-level data. The TWDB recommended leaving those cells blank in Table 13, which would likely result in lower scoring for the project and a lower probability of garnering funding; therefore, certain FMPs were submitted as FMEs or FMSs despite having sufficient data to produce a project.
8.3.8	Revise the criteria for the "No Adverse Impact" Certification required for FMPs.	The current criteria give thresholds for increases in flow, water surface elevation, and inundation extents that are extremely constraining. Almost any conveyance improvement project will violate these criteria, even though no meaningful adverse impact occurs downstream. This eliminates most flood mitigation projects from being included without significant additional design and construction costs to acquire land for detention or other flow mitigation measures. The downstream impacts should be more flexible and consider actual downstream impacts rather than arbitrary water surface or flow changes.

ID	Specific Recommendation Statements	Reason for Recommendation
8.3.9	Clarify the phrase "flood-related authorities or entities" with who and what that entails.	The phrase is used in the TWDB planning documents multiple times and is a central part of multiple tasks. TWDB initially provided the RFPG with a list of entities that were thought to have flood-related responsibilities. During outreach efforts, many of those entities informed the RFPG that they did not have flood responsibilities and did not believe they should be part of the flood planning effort. Therefore, the RFPG removed these entities from the plan. Clarification is requested regarding the intent of this phrase.
8.3.10	Streamline the data collection requirements, specifically those identified in Task 1. Focus on collecting the most useful data for the Regional Flood Plan development.	This first round of planning proved that very few entities had the data requested as part of the flood planning process, and even fewer had it readily available in a geographic information system (GIS) format. Of those entities that had GIS data, most were unable to share the information. Furthermore, some of this data was not used or was used minimally to develop potentially feasible and recommended FMEs, FMPs, and FMSs.
8.3.11	Provide applicable data sources and a methodology to determine infrastructure functionality and deficiencies in the next cycle of the flood planning process. Consider the lack of readily available local data when developing the methodology.	Most entities do not have information regarding the functionality and deficiency of their infrastructure. Some fields required by the TWDB-required tables in the Regional Flood Plans are based on data unavailable to entities without extensive fieldwork.
8.3.12	Review and revise the geodatabase submittal attributes and elements.	Normalizing the geodatabase with relationships would allow for cross-referencing data elements and attributes. More domains for attributes need to be developed.
8.3.13	Reconsider the Social Vulnerability Index (SVI) to evaluate community resiliency.	In Region 2, many communities with the lowest SVI (presumably most able to recover from a flood) had the lowest populations and the least number of taxpayers. As a result, the communities cannot plan, regulate, or recover from flooding, as well as larger communities with higher SVIs.

ID	Specific Recommendation Statements	Reason for Recommendation
8.3.14	Use FEMA's SVI when available instead of the Centers for Disease Control and Prevention (CDC) SVI in future planning cycles.	FEMA's SVI is more relevant to flood resiliency and risk than the CDC's SVI. SVI should not be the primary component considered when allocating funding.
8.3.15	Use consistent Hydraulic Unit Code (HUC) reporting requirements throughout the TWDB-required tables.	The RFPG guidance requires HUC-8 in some tables, HUC-10 in other tables, and HUC-12 in other tables. Some tables also require multiple HUCs to be provided. The RFPG recommends that the TWDB require HUC-8 in all TWDB-required tables for consistency and to correspond to FEMA's base-level watershed planning granularity.
8.3.16	Develop a statewide bridge inventory with bridge deck elevations.	The availability of statewide Light Detection and Ranging (lidar) provides the opportunity to more accurately describe the risk at riverine crossings (i.e., overtopping elevation). Creating a statewide database would simplify this data.
8.3.17	Improve flood risk identification and exposure process regarding building footprints and population at risk.	While the building footprints are helpful, without the first-floor elevations of each structure, it is difficult to determine the actual extent of flood risk per structure. If the structure is sufficiently elevated above the Base Flood Elevation (BFE), the footprint still shows the structure in the floodplain, and the corresponding population is considered "at-risk" though the structure meets National Flood Insurance Program (NFIP) standards. This overestimates the population at risk quantification.
8.3.18	Remove the requirement to develop a future floodplain when adequate data is not available to complete it accurately.	Most of Region 2 lacked any modeling, and several counties lacked floodplain maps. Future conditions floodplain development require significant estimation based on very limited or non-existent data, especially for the future 500-year floodplain data. This requirement unnecessarily raises questions about the validity of the planning process.

8.4 Funding Recommendations

Lastly, the RFPG is responsible for providing funding recommendations to the TWDB. These ideas could include new revenue-raising opportunities and "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."

In *Section 1.3* of *Chapter 1*, responders to the data collection survey indicated the use of stormwater utility fees, bond programs, ad valorem taxes, and the general fund to sponsor projects in their regions. Non-local funding sources include the Hazard Mitigation Grant Program through FEMA and the Texas Division of Emergency Management (TDEM), Pre-Disaster Mitigation through FEMA, Cooperating Technical Partner funds through the FEMA, Flood Protection Planning Grants through the TWDB, United States Department of Agriculture Natural Resources Conservation Service, and Flood Mitigation Assistance through FEMA.

No additional funding sources were identified in the region during this planning cycle.

Chapter 9: Flood Infrastructure Financing Analysis

The Texas Water Development Board (TWDB) requires each Regional Flood Planning Group (RFPG) to assess and report on how Sponsors propose to finance recommended Flood Management Evaluations (FMEs), Flood Management Strategies (FMSs), and Flood Mitigation Projects (FMPs). A primary aim of this survey effort is to understand the funding needs of local Sponsors and propose what role the state should have in financing the recommended FMEs, FMSs, and FMPs. Section 9.1 presents an overview of common funding sources for flood mitigation planning, projects, and other flood management efforts. The methodology and results of the financing survey are presented in Section 9.2.

9.1 Sources of Funding for Flood Management Activities

Communities across the state utilize a variety of funding sources for their flood management efforts, including local, state, and federal sources. This section discusses some of the most common avenues of generating local funding and discusses various state and federal financial assistance programs available to communities. *Table 9.1* summarizes the local, state, and federal sources discussed in this chapter and characterizes each by the following three key parameters: first, which state and federal agencies are involved, if applicable; second, whether they offer grants, loans, or both; and third, whether they are classified as regularly occurring opportunities or are only available after a disaster.

9.1.A Local Funding

This section primarily focuses on the funding mechanisms available to municipalities and counties, as a large majority of the FME, FMS, and FMP Sponsors are these types of entities. Special Purpose Districts are briefly discussed as there may be opportunities to create more of these types of districts in the region. Funding avenues for other types of local and regional entities, such as river authorities, are not discussed in detail herein.

A community's general fund (for cities or counties) revenue stems from sales, property, and other taxes and is typically the primary fund used by a government entity to support most departments and services such as police, fire, parks, trash collection, and local government administration. Due to the high demands on this fund for many local needs, there is often not a significant amount available for funding flood projects out of the general fund.

Dedicated fees such as stormwater or drainage fees are an increasingly popular tool for local flood-related funding. Municipalities can establish a stormwater utility (sometimes called a drainage utility), which is a legal mechanism used to generate revenue to finance a city's cost to provide and manage stormwater services. To provide these services, municipalities assess fees to users of the stormwater utility system. Impact fees, which are collected from development to cover a portion of the expense to expand stormwater systems necessitated by the new development, can also be used as a source of local funding for flood-related efforts.

Another source for local funding to support flood management efforts includes special districts. A special district is a political subdivision established to provide a single public service (such as water supply, drainage, or sanitation) within a specific geographic area. Examples of these special districts include Water Control and Improvement Districts (WCID), Municipal Utility Districts (MUD), Drainage Districts (DD), and Flood Control Districts (FCD). Each of the different types of districts are governed by different state laws, which specify the authorities and process for creating a district. Districts can be created by various entities, from the Texas Legislature or the Texas Commission on Environmental Quality to county commissioners' courts or city councils. Depending on the type of district, it may have the ability to raise revenue through taxes, fees, or issuing bonds to fund flood and drainage-related improvements within its area.

Table 9.1 Common Sources of Flood Funding in Texas

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
Federal	FEMA	TDEM	Hazard Mitigation Grant Program (HMGP)	G		D
Federal	FEMA	TWDB	Flood Mitigation Assistance (FMA)	G		
Federal	FEMA	TDEM	Building Resilient Infrastructure and Communities (BRIC)	G		
Federal	FEMA	TCEQ	Rehabilitation of High Hazard Potential Dam Grant Program	G		
Federal	FEMA	*TBD*	Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM)		L	
Federal	FEMA	TDEM	Public Assistance (PA)	G		D
Federal	HUD	GLO	Community Development Block Grant – Mitigation (CDBG-MIT)	G		D
Federal	HUD	GLO	Community Development Block Grant Disaster Recovery Funds (CDBG-DR)	G		D
Federal	HUD	TDA	Community Development Block Grant (TxCDBG) Program for Rural Texas	G		

Source	Federal Agency	State Agency	Program Name	Grant (G)	Loan (L)	Post-Disaster (D)
Federal	USACE		Partnerships with USACE, funded through Continuing Authorities Program (CAP), Water Resources Development Acts (WRDA), or other legislative vehicles*			
Federal	EPA	TWDB	Clean Water State Revolving Fund (CWSRF)	G**	L	
State		TSSWCB	Structural Dam Repair Grant Program	G		
State		TWDB	Flood Infrastructure Fund (FIF)	G	L	
State		TWDB	Texas Water Development Fund (Dfund)		L	
State		TSSWCB	Operation and Maintenance (O&M) Grant Program	G		
State		TSSWCB	Flood Control Dam Infrastructure Projects - Supplemental Funding	G		
Local			General Fund			
Local			Bonds			
Local			Stormwater or Drainage Utility Fee			
Local			Special-Purpose District Taxes and Fees			

**Opportunities to partner with USACE are not considered grant or loan opportunities but shared participation projects where USACE performs planning work and shares in the construction cost.*
***The CWSRF program offers principal forgiveness, similar to grant funding.*

Lastly, municipalities and counties have the option to issue debt through general obligation bonds, revenue bonds, or certificates of obligation, which are typically paid back using any of the previously mentioned local revenue-raising mechanisms.

Overall, local governments have various options for raising revenue to support local flood-related efforts; however, each avenue presents its own unique challenges and considerations. It is important to note that municipalities have more authority to establish various revenue-raising options compared to counties. Of the communities with access to local funding, the amount available is generally much lower than the total need, leading local communities to seek out state and federal financial assistance programs.

9.1.B State Funding

Today, communities have a broader range of state and federal funding sources and programs available due to new grant and loan programs that didn't exist even five years ago. Two primary state agencies are currently involved in providing state funding for flood projects: the TWDB and the Texas State Soil and Water Conservation Board (TSSWCB). It is important to note that state and federal financial assistance programs discussed herein are not directly available to homeowners and the general public. Local governments apply on behalf of their communities to receive and implement funding for flood projects in their jurisdiction.

The TWDB's Flood Infrastructure Fund (FIF) is a new funding program passed by the Texas Legislature and approved by Texas voters through a constitutional amendment in 2019. The program provides financial assistance in the form of low or no-interest loans and grants (cost match varies) to eligible political subdivisions for flood control, flood mitigation, and drainage projects. FIF rules allow for a wide range of flood projects, including structural and non-structural projects, planning studies, and preparedness efforts such as flood early warning systems. After the first State Flood Plan is adopted, only projects included in the most recently adopted state plan will be eligible for funding from the FIF. FMEs, FMSs, and FMPs recommended in this Regional Flood Plan will be included in the overall State Flood Plan and thus be eligible for this funding source. The Flood Protection Planning Grant referenced in *Table 9.1* has been replaced by the Flood Infrastructure Fund Category 1 planning grants.

The TWDB also manages the Texas Water Development Fund (Dfund) program, a state-funded streamlined loan program that provides financing for several types of infrastructure projects to eligible political subdivisions. This program enables the TWDB to fund projects with multiple eligible components (water supply, wastewater, or flood control) in one loan at low market rates. Financial assistance for flood control may include structural and non-structural projects, planning efforts, and flood warning systems.

The Texas State Soil & Water Conservation Board (TSSWCB) has three state-funded programs specifically for flood control dams: the Operation and Maintenance (O&M) Grant Program, the Flood Control Dam Infrastructure Projects - Supplemental Funding program, and the Structural Repair Grant Program. The O&M Grant Program is a grant program for local soil and water conservation districts (SWCD) and certain co-sponsors of flood control dams. This program reimburses SWCDs 90% of the cost of an eligible operation and maintenance activity as defined by the program rules; the remaining 10% must be paid with non-state funding. The Flood Control Dam Infrastructure Projects - Supplemental Funding program was newly created and funded in 2019 by the Texas Legislature. Grants are provided to local sponsors of flood control dams, including SWCDs, to fund the repair and rehabilitation of the flood control structures to ensure dams meet safety criteria to adequately protect lives downstream. The Structural Repair Grant Program provides state grant funds to provide 95% of the cost of allowable repair activities on dams constructed by the United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS), including match funding for federal projects through the Dam Rehabilitation Program and the Emergency Watershed Protection (EWP) Program of the Texas NRCS.

9.1.C Federal Funding

Federal funding currently accounts for a large share of total available funding for flood projects throughout the state, with federal funding programs having greater access and availability to large funding amounts from the federal government appropriated by Congress. Commonly utilized funding programs administered by seven different federal agencies are discussed in this section. The funding for these programs originates from the federal government, but for many programs, a state agency partner plays a key role in the management of the program. Each funding program has unique eligible applicants, project types, requirements, and application and award timelines. More information regarding each program and these details can be found at the links below.

Federal Emergency Management Agency (FEMA)

Common FEMA-administered federal flood-related funding programs include Flood Mitigation Assistance (FMA), Building Resilient Infrastructure and Communities (BRIC), Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM), Rehabilitation of High Hazard Potential Dam (HHPD) Grant Program, Hazard Mitigation Grant Program (HMGP), the Public Assistance (PA) program, and the Cooperating Technical Partners (CTP) Program.

Flood Mitigation Assistance is a nationally competitive grant program that provides funding to states, local communities, federally recognized tribes, and territories. FMA is administered in Texas by the Texas Water Development Board (TWDB). Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program (NFIP). Funding is typically a 75% federal grant with a 25% local match. Projects mitigating Repetitive Loss and Severe Repetitive Loss properties may be funded through a 90% federal grant and 100% federal grant, respectively. FEMA's FMA program now includes a disaster initiative called Swift Current. The program was released as a pilot initiative in 2022 and explored ways to make flood mitigation assistance more readily available during disaster recovery. Similar to traditional FMA, the program mitigates repetitive losses and substantially damaged buildings insured under the NFIP.

The Building Resilient Infrastructure and Communities (BRIC) is a new nationally competitive grant program implemented in 2020. The program supports states, local communities, tribes, and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC is administered in Texas by the Texas Division of Emergency Management (TDEM). Funding is typically a 75% federal grant with a 25% local match. Small, impoverished communities and U.S. Island territories may be funded through a 90% federal grant and a 100% federal grant, respectively.

Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) is a new revolving loan program enacted through federal legislation in 2021 to provide needed and sustainable funding for hazard mitigation projects. The program is designed to provide capitalization grants to states to establish revolving loan funds for projects to reduce risks from disaster, natural hazards, and other related environmental harm. At the time of the publication of this plan, the program does not yet appear to be operational and has not yet been implemented in Texas.

FEMA's Rehabilitation of High Hazard Potential Dam (HHPD) Grant Program, administered in Texas by the Texas Commission on Environmental Quality (TCEQ), provides technical, planning, design, and construction assistance in the form of grants for the rehabilitation of eligible high-hazard potential dams. The cost-share requirement is typically no less than 35% state or local share.

Under the Hazard Mitigation Grant Program (HMGP), FEMA provides funding to state, local, tribal, and territorial governments to rebuild from a recent disaster in a way that reduces, or mitigates, future disaster losses in their communities. The program is administered in Texas by TDEM. Funding is typically a 75% federal grant with a 25% local match. While the program is associated with Presidential Disaster Declarations, the HMGP is not a disaster relief program for individual disaster victims or a recovery program that funds repairs to public property damaged during a disaster. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster.

FEMA's FEMA Public Assistance (PA) program provides supplemental grants to state, tribal, territorial, and local governments and certain types of private non-profits following a declared disaster so communities can quickly respond to and recover from major disasters or emergencies through actions such as debris removal, life-saving emergency protective measures, and restoring public infrastructure. Funding cost-share levels are determined for each disaster and are typically not less than 75% federal grant (25% local match) and typically not more than 90% federal grant (10% local match). In Texas, FEMA PA is administered by TDEM. In some situations, FEMA may fund mitigation measures as part of the repair of damaged infrastructure. Generally, mitigation measures are eligible if they directly reduce future hazard impacts on damaged infrastructure and are cost-effective. Funding is limited to eligible damaged facilities located within PA-declared counties.

The Cooperating Technical Partners (CTP) program is an effort launched by FEMA in 1999 to increase local involvement in developing and updating Flood Insurance Rate Maps (FIRMs), Flood Insurance Study reports, and associated geospatial data in support of FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) Program. To participate in the program, interested NFIP-participating communities, state or regional agencies, universities, territories, tribes, or non-profits must complete training and execute a partnership agreement. Working with the FEMA regions, a program participant can develop business plans and apply for grants to perform eligible activities.

Housing and Urban Development (HUD)

HUD administers the following three federal funding programs: Community Development Block Grant – Disaster Recovery (CDBG-DR), Community Development Block Grant – Mitigation (CDBG-MIT), and Community Development Block Grant (TxCDBG) for Rural Texas.

Following a major disaster, Congress may appropriate funds to the Department of Housing and Urban Development (HUD) under the Community Development Block Grant – Disaster Recovery (CDBG-DR) program when there are significant unmet needs for long-term recovery. Appropriations for CDBG-DR are frequently very large, and the program provides 100% grants in most cases. The CDBG-DR is administered in Texas by the Texas General Land Office (GLO). The special appropriation provides funds to the most impacted and distressed areas for disaster relief, long term-recovery, restoration of infrastructure, housing, and economic revitalization.

The Community Development Block Grant – Mitigation (CDBG-MIT) is administered in Texas by the GLO. Eligible grantees can use CDBG Mitigation (CDBG-MIT) assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks. The primary feature differentiating CDBG-MIT from CDBG-DR is that unlike CDBG-DR, which funds recovery from a recent disaster to restore damaged services, systems, and infrastructure, CDBG-MIT funds are intended to support mitigation efforts to rebuild in a way that will lessen the impact of future disasters.

The Community Development Block Grant (CDBG) program provides annual grants on a formula basis to small, rural cities and counties to develop viable communities by providing decent housing and suitable living environments and expanding economic opportunities principally for persons of low- to moderate-income. Funds can be used for public facilities such as water and wastewater infrastructure, street and drainage improvements, and housing. In Texas, the CDBG program is administered by the Texas Department of Agriculture (TDA).

U.S. Army Corps of Engineers (USACE)

The USACE works with non-Federal partners (States, Tribes, counties, or local governments) throughout the country to investigate water resources and related land problems and opportunities and, if warranted, develop civil works projects that would otherwise be beyond the sole capability of the non-Federal partner(s). Partnerships are typically initiated or requested by the local community to their local USACE District office. Before any project or study can begin, USACE determines whether there is an existing authority under which the project could be considered, such as the US Army Corps of Engineers Continuing Authorities Program (CAP), or whether Congress must establish study or project authority and appropriate specific funding for the activity. New study or project authorizations are typically provided through periodic Water Resource Development Acts (WRDA) or another legislative vehicle. Congress will not provide project authority until a completed study results in a recommendation to Congress of a water resources project, conveyed via a Report of the Chief of Engineers (Chief's Report) or Report of the Director of Civil Works (Director's Report). Opportunities to partner with USACE are not considered grant or loan opportunities but shared participation projects where USACE performs planning work and shares in the construction cost. USACE also has technical assistance opportunities, including Floodplain Management Services and the Planning Assistance to States program, available to local communities.

U.S. Environmental Protection Agency (EPA)

The Clean Water State Revolving Fund (CWSRF) provides financial assistance in the form of loans with subsidized interest rates and opportunities for partial principal forgiveness for planning, acquisition, design, and construction of wastewater, reuse, and stormwater mitigation infrastructure projects. Projects can be structural or non-structural. Low Impact Development (LID) projects are also eligible. The CWSRF is administered in Texas by the TWDB.

U.S. Department of Agriculture (USDA)

The USDA's Natural Resources Conservation Service (NRCS) provides technical and financial assistance to local government agencies through the following programs: Emergency Watershed Protection Program, Watershed Protection, Flood Prevention Program, Watershed Surveys and Planning, and Watershed Rehabilitation. The Emergency Watershed Protection (EWP) program, a federal emergency recovery program, helps local communities recover after a natural disaster by offering technical and financial assistance to relieve imminent threats to life and property caused by floods and other natural disasters that impair a watershed. The Watershed Protection and Flood Prevention Program helps units of federal, state, local, and tribal government protect and restore watersheds; prevent erosion, 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 focus of the Watershed Surveys and Planning program is funding watershed plans, river basin surveys and studies, flood hazard analyses, and flood plain management assistance aimed at identifying solutions that use land treatment and non-structural measures to solve resource problems. Lastly, the Watershed Rehabilitation Program helps project sponsors rehabilitate aging dams that are reaching the end of their design lives. This rehabilitation addresses critical public health and safety concerns. The USDA also offers various Water and Environmental grant and loan funding programs, which can be used for water and waste facilities, including stormwater facilities, in rural communities.

Special Appropriations

When the need is large enough, Congress may appropriate funds for special circumstances such as natural disasters or pandemics. A few examples of recent special appropriations from the federal government that can be used to fund flood-related activities include:

- American Rescue Plan Act (ARPA)
- Infrastructure Investment and Jobs Act (IIJA)/Bipartisan Infrastructure Law (BIL)

In 2021, the American Rescue Plan Act (ARPA) provided a substantial infusion of resources to eligible state, local, territorial, and tribal governments to support their response to and recovery from the COVID-19 pandemic. Coronavirus State and Local Fiscal Recovery Funds (SLFRF), a part of ARPA, delivers $350 billion directly to the state, local, and Tribal governments across the country. Communities have significant flexibility to meet local needs within the eligible use categories, one of which includes improving stormwater facilities and infrastructure as an authorized use. Eligible entities may request their allocation of Coronavirus SLFRP directly from the United States Department of Treasury.

Although not a direct appropriation to local governments like ARPA, the 2021 IIJA, also called the BIL, authorized over $1 trillion for infrastructure spending across the United States and provides for a significant infusion of resources over the next several years into existing federal financial assistance programs, including several of the flood funding programs discussed herein, as well as creating new programs.

9.1.D Barriers to Funding

Barriers to accessing or seeking funding sources for flood management activities include a lack of knowledge of funding sources, lack of expertise to apply for funding, and no local funds available for local match requirements. As opposed to other types of infrastructure, flood projects do not typically generate revenue, and many communities do not have steady revenue streams to fund flood projects, as discussed in Section 9.1.A. Consequently, communities struggle to generate funds for local match requirements or loan repayment. Complex or burdensome application or program requirements and prolonged timelines also act as barriers to accessing state and local financial assistance programs. Of those communities able to overcome these barriers, apply for funding, and generate local resources to match requirements, the high demand for state and federal funding, particularly for grant opportunities, means that need outstrips supply, leaving many local communities without the resources they need to address flood risks.

9.2 Flood Infrastructure Financing Survey

9.2.A Flood Infrastructure Financing Survey Methodology

This task required obtaining relevant information from Sponsors of the recommended FMEs, FMSs, and FMPs that have capital costs. The primary aim of this survey effort was to understand the funding needs of local Sponsors and then propose what role the state should have in financing the recommended FMEs, FMSs, and FMPs.

The RFPG collected information from Sponsors by creating a survey through mail merge and sending it through email. Mail merge allowed the RFPG to automate a batch of emails that were personalized for each Sponsor by linking a main template to a data source. The main template contained the exact text for each survey, while the data source contained all the information to be merged into the survey and the Sponsor's email address. An example of the survey emailed to Sponsors is shown in *Figure 9.1*.

During the mail merge process, a personalized table of recommended FMEs, FMSs, and FMPs was generated for each Sponsor. The table included the identification number, type, name, description, and total estimated cost for each FME, FMS, and FMP listed. Additionally, a link was provided where Sponsors could navigate to their one-page report summaries for more information about their FMEs, FMSs, and FMPs (*Appendix 4*). After receiving the email, Sponsors could reply and fill out the drop-down menu under the financing columns. Sponsors could select a percentage between 0% to 100% (in 5% increments) under the 'Percent Funding to be Financed by Sponsor' and 'Other Funding Needed' columns for each FME, FMS, and/or FMP.

Drop-down menu options for 'Anticipated Source of Sponsor Funding' included:

- taxes
- general revenue
- dedicated revenue inclusion fees
- entity budget/funds
- donations
- bonds/other financing
- other
- TBD

Figure 9.1 Example of the Flood Infrastructure Financing Survey

Hello Sponsor,

We are reaching out to you because there are one or more actions for your community that will be listed in the Lower Red-Sulphur-Cypress regional flood plan, and we need your help to identify how much state or federal funding you may need to implement these projects.

Please reply to this email and fill out the drop-down menu in the table below for each of your entities' Flood Mitigation Actions ***by June 20, 2022.*** Please note the percent funding financed by sponsor and other funding needed must equal 100%. For more information regarding your Flood Mitigation Actions, visit the following link: RFP Region 2 - FMX Summaries by Sponsor.

The Texas Water Development Board (TWDB) designated 15 regional flood planning areas each of which began with a designated regional flood planning group that will develop a regional flood plan for their region by January 2023. TWDB will bring the regional flood plans together to produce the first State Flood Plan by September 1, 2024. Entities must have their project listed in the State Flood Plan to receive state funding for a proposed flood project. As part of the regional flood planning process, RFPGs must indicate how sponsors will propose to finance recommended Flood Mitigation Actions included in the Flood Plan[1]. Flood Mitigation Actions include Flood Management Evaluation (FME), Flood Mitigation Strategy (FMS), and Flood Mitigation Project (FMP)[2].

There is no commitment associated with being a sponsor for an action in the plan, this is just a planning level study.

Flood Mitigation Action ID	Flood Mitigation Action Type[2]	Flood Mitigation Action Name	Flood Mitigation Action Description	Flood Mitigation Action Total Estimated Cost*	Sponsor Funding		Other Funding Needed** (Including state, federal, and/or other funding)
					Anticipated Source of Sponsor Funding	Percent Funding to be Financed by Sponsor**	
21000017	FME	County FIS	Update County maps to Zone AE	$1,225,000	General Revenue	0%	100%
22000014	FMS	County NFIP Involvement	Application to join NFIP or adoption of equivalent standards	$100,000	Choose an item.	Choose an item.	Choose an item.
					Choose an item.	Choose an item.	Choose an item.
					Choose an item.	Choose an item.	Choose an item.

**Costs are based on high level engineering estimates and assumptions.*

***Percent funding financed by sponsor and other funding needed MUST equal 100%*

9.2.B Flood Infrastructure Financing Survey Results

The Flood Infrastructure Funding survey was sent to 42 Sponsors of recommended FMEs, FMSs, and FMPs with capital costs identified. The primary aim of this survey effort was to understand the funding needs of local Sponsors and then propose what role the state should have in financing the recommended FMEs, FMSs, and FMPs. Of the 42 entities surveyed, seven responded. This represents a response rate of approximately 17%. TWDB-required *Table 19,* located in *Appendix 2*, presents the survey results for each FME, FMS, and FMP. The response rate for the survey does not represent a significant percentage of respondents and therefore does not accurately represent the total need for state and federal funding in Region 2. With additional time provided in the second cycle of Regional Flood Planning, it is anticipated that a greater response rate may be obtained through additional outreach efforts such as follow-up emails, phone calls, and meetings.

To assess the remaining need, it was estimated that 100% of total project costs are required from state and federal sources. A high percentage of outside need is supported by the initial entity outreach discussed in *Section 9.1.A,* which confirmed that many communities, particularly smaller and more rural communities, do not have any local funding available for flood management activities. Those communities that reported having local funding indicated relatively little local funding available in relation to overall needs.

Overall, an estimated $49,382,000 in state and federal funding is projected to implement the recommended FMEs, FMSs, and FMPs in this Regional Flood Plan (see *Table 19* in *Appendix 2*). This number does not represent the amount of funding needed to mitigate all risks in the region and solve flooding problems in their totality. This number simply represents the funding needs for the specific, identified studies, strategies, and projects in this cycle of Regional Flood Planning. Future cycles of Regional Flood Planning will continue to identify more projects and studies needed to further flood mitigation efforts in Region 2.

Chapter 10: Public Participation and Plan Adoption

Overview of Chapter

This chapter outlines the outreach efforts of the Lower Red-Sulphur-Cypress Basin Regional Flood Planning Area to provide information to the public and seek participation by the public during the planning process. Soliciting input from the public was a key component in the planning process. All meetings were conducted pursuant to the Texas Open Meeting Act and Texas Government Code Chapter 551.

The Texas Water Development Board (TWDB) presented its findings to the 86th Texas legislative session in 2019. Later that year, the Legislature adopted changes to Texas Water Code §16.061, which established a regional and state flood planning process led by the TWDB. The legislation provided funding to improve the state's floodplain mapping efforts and develop regional plans to mitigate the impact of future flooding. Regional Flood Plans for each of the state's 15 major river basins must be delivered to the TWDB by January 10, 2023. An updated version of the Regional Flood Plans will be due every five years thereafter (TWDB Flood Planning Frequently Asked Questions, 2021). To ensure a diversity of perspectives is included, Regional Flood Planning Group (RFPG) members represent a wide variety of stakeholders potentially affected by flooding, including:

- agriculture
- counties
- electric generation utilities
- environmental interests
- flood districts
- industry
- municipalities
- public
- river authorities
- small businesses
- water districts
- water utilities

Voting members of each RFPG were selected by the TWDB during its board meeting on October 1, 2020. Since then, some voting and non-voting members have been added or replaced as vacancies occurred.

Table 10.1 lists the voting members of the Region 2 Lower Red-Sulphur-Cypress RFPG as of June 2022 and the interests they represent.

Table 10.2 lists the non-voting members of the Region 2 RFPG as of June 2022 and their interests.

Table 10.1 Current Voting Members Lower Red-Sulphur-Cypress Regional Flood Planning Group

Voting Member	Interest
Preston Ingram (William)	Agricultural interests
Andy Endsley	Counties
W. Greg Carter	Electric generating utilities
Laura-Ashley Overdyke	Environmental interests
Casey Johnson	Industries
Dustin Henslee	Municipalities
Kirby Hollingsworth	Public
R Reeves Hayter	River authorities, Chair
Kelly Mitchell	Small business
Joseph W. Weir III	Water districts
Susan Whitfield	Water utilities

Table 10.2 Current Non-Voting Members 2 Lower Red-Sulphur-Cypress Regional Flood Planning Group

Non-Voting Member	Interest
Randy Whiteman	Region 1 Canadian-Upper Red RFPG Liaison
James (Clay) Shipes	Texas Parks and Wildlife Department
Andrea Sanders	Texas Division of Emergency Management
Darrell Dean	Texas Department of Agriculture
Tony Resendez	Texas State Soil and Water Conservation Board
Trey Bahm	General Land Office
Megan Ingram	Texas Water Development Board (TWDB)
Michelle Havelka	Texas Commission on Environmental Quality
Anita Machiavello	Texas Water Development Board (TWDB)
Darlene Prochaska	US Army Corps of Engineers, Fort Worth District
Travis Wilsey	US Army Corps of Engineers, Tulsa District
Richard Brontoli	Red River Valley Association
Jason Dupree	Texas Department of Transportation, Atlanta District
Dan Perry	Texas Department of Transportation, Paris District

Outreach to Entities with Flood-Related Authority or Responsibility

The Region 2 RFPG reached out to various entities and stakeholders throughout the region to communicate about the Regional Flood Planning process and solicit data, input, and engagement. This effort was initiated by establishing a list of entities or individuals to contact with flood planning, mitigation, and floodplain management capabilities in the region. Ultimately, a list of 373 entities or individuals was created to reach out to gauge interest in the Regional Flood Planning process.

Survey Recipients included:

- agriculture
- cities
- counties
- councils of governments
- districts (MUDs, SUDs, etc.)
- federal agencies
- state agencies
- public stakeholders
- river authorities

10.2.A Data Collection Tools and Surveys

The first round of emails was sent to 339 recipients. Electronic postcards were also sent out to 306 recipients. The second round of emails included 188 recipients. Calls were made to entities and individuals to ensure that emails and/or postcards were received and surveys completed. The first round of calls included a list of 202 recipients, while the second round of calls was 60 recipients. *Figure 10.1* shows the methods used for data collection.

Data was provided via the email service used to send out the emails. The data, shown in *Figure 10.2*, indicated the level of engagement of the recipients. Of the 421 recipients, approximately 37% were at least somewhat engaged, while 35% were not engaged. Only four recipients unsubscribed from receiving emails.

Input from the data collection process indicated the location of entities and/or individuals who participated in the survey. *Figure 10.3* indicates the geographical distribution of the recipients.

As shown in *Figure 10.4*, the data collection process also indicated the types of entities that responded to the survey: municipality, county, other, and river authority. Additionally, *Figure 10.5* shows whether the responding entity was from a rural or urban area. Capturing this data allowed the planning team to gain more information on the types of respondents.

Figure 10.1 Methods Used for June – July 2021 Data Collection Outreach

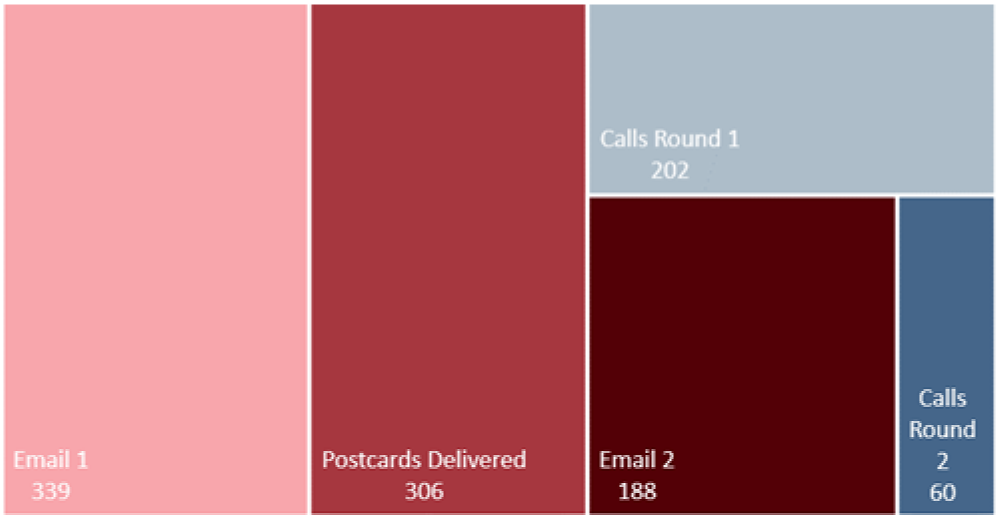


Figure 10.2 Email Marketing Engagement

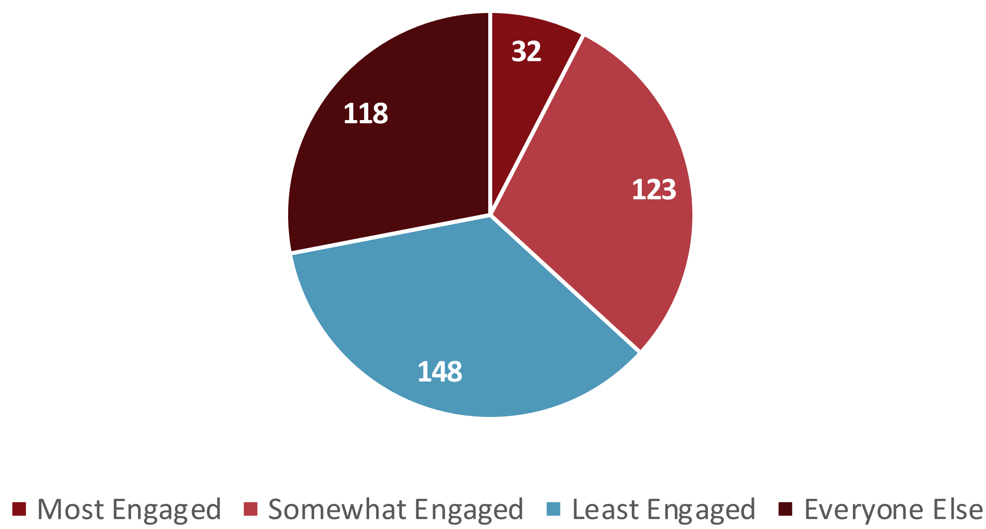


Figure 10.3 Public Input Received from Data Collection Process Locations

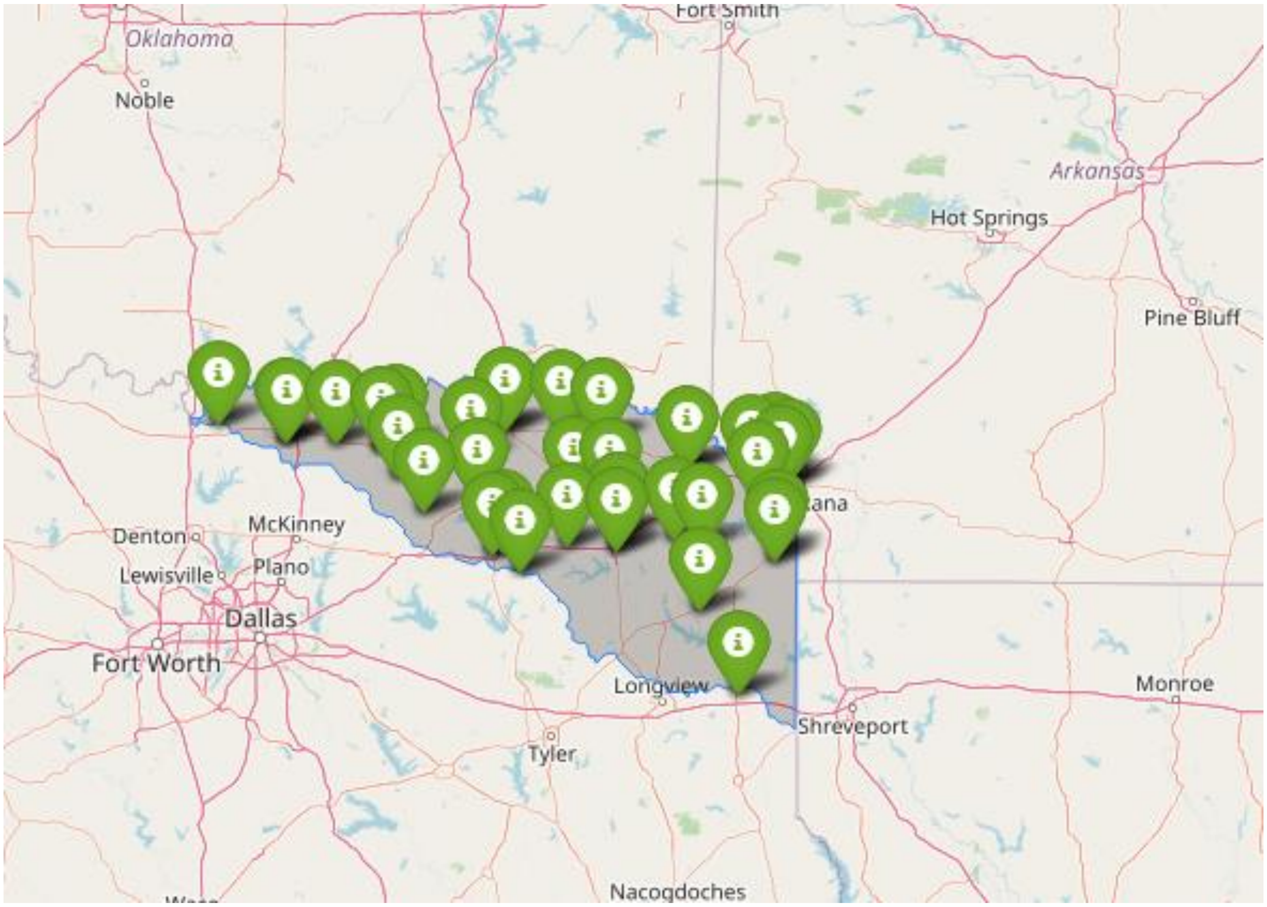


Figure 10.4 Types of Respondents Counts

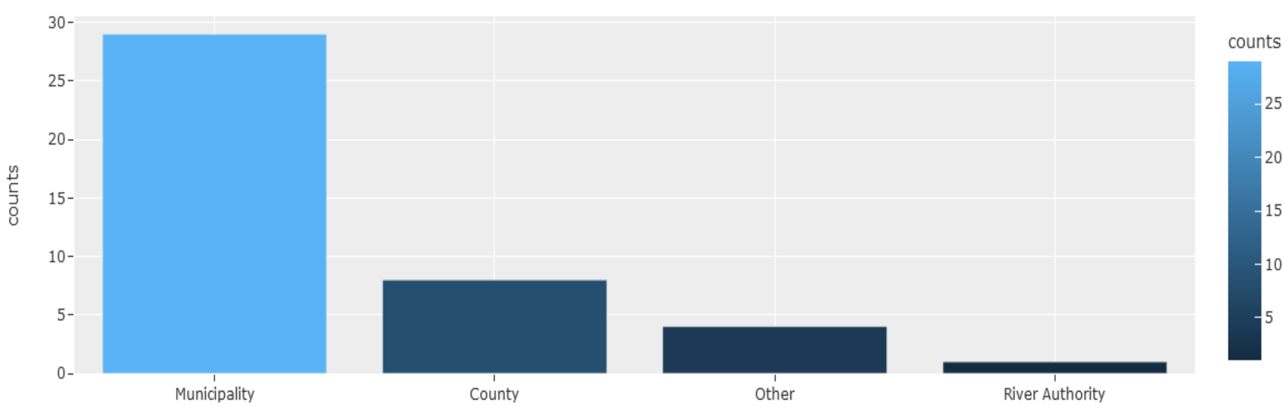
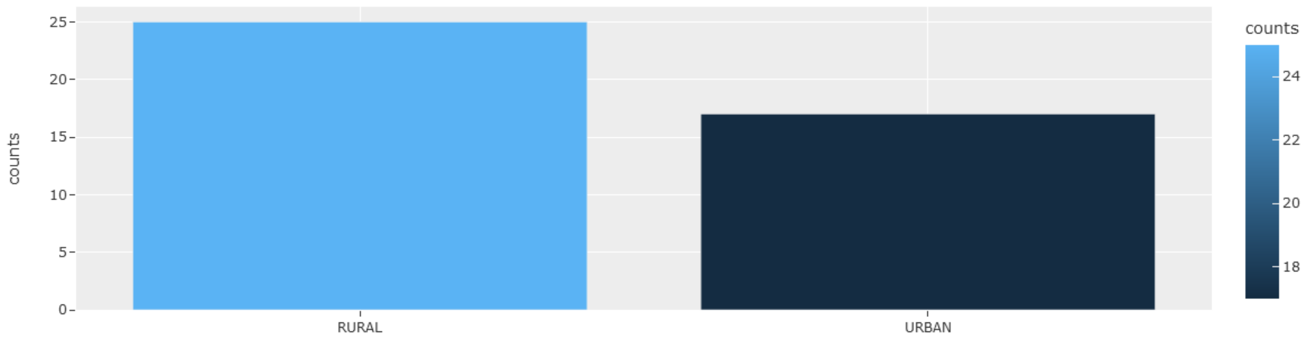


Figure 10.5 Rural and Urban Respondent Counts

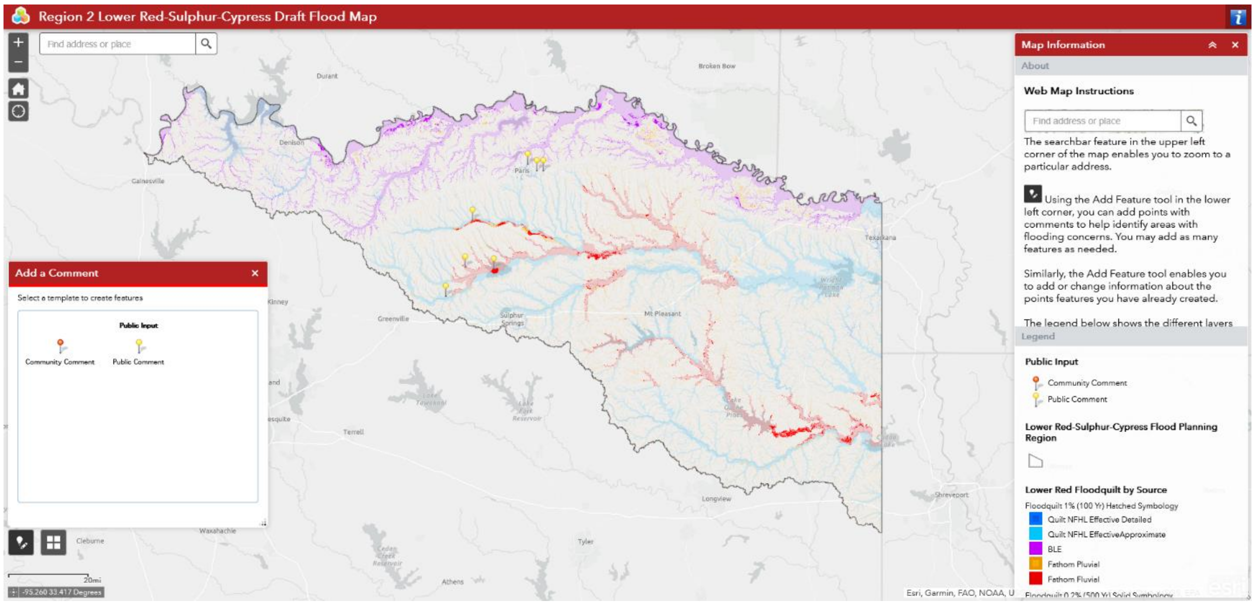


10.2.B Digital Media: Website

Per the Regional Flood Planning guidelines and following public engagement best practices, a website was created to provide key information to the public (https://texasfloodregion2.org/). The website, shown in *Figure 10.6*, allowed users to access information on the flood planning process, membership information, contact information, meeting notices, and notes from past meetings. Community representatives and members of the public were provided the opportunity to upload data to the site for use in the planning process via a webmap. Per the outreach efforts, seven comments from the public were received via the webmap shown in *Figure 10.7*.

Figure 10.6 Lower Red-Sulphur-Cypress Regional Flood Planning Group website

Figure 10.7 Additional Public Input Received on Updated Interactive Webmap, February 2022



10.2.C Public Comments

Efforts to communicate and engage the public, regional stakeholders, entities, and individuals with flood-related authority were made with the intent to provide planning process data and solicit data and regionally-specific input and information. This outreach effort provided key information in the planning process and allowed the public to participate in the process as well. Outreach and engagement was a key component of the process and crucial in creating a plan that is truly reflective of Region 2.

The Draft Regional Flood Plan was made available on August 1, 2022, for public comment, as previously discussed. The plan was available for public comment for 30 days before being presented at a public meeting on September 1, 2022, at Northeast Texas Community College in Mount Pleasant, Texas. This meeting was held to accept public comments. The plan remained available for another 30 days until October 1, 2022, at which time the public comment period officially ended. Members of the public and entities in the region were encouraged to provide comments during this time. All comments were read and evaluated by the RFPG before addressing herein.

The only public comments were received from the Texas Parks and Wildlife Department (TPWD) and the U.S. Army Corps of Engineers (USACE). These comment letters are attached in Appendix 3.

TPWD Comments

TPWD provided two sets of comments, one pertaining to the State Flood Plan process in general and another specific to Region 2. Their comments focused broadly on protecting the floodplain from development and disruption through integrated flood risk management (FRM), utilizing natural and nature-based (NNBS) flood mitigation, and protection of Species of Greatest Conservation Need (SGCN). These SGCN include many aquatic species that migrate and breed, which can be interrupted by culverts, hard-armoring, dams, and other traditional flood mitigation projects. This RFP addresses all of the guiding principles (see below) mentioned by TPWD. In addition, many of the FRM concepts they request are included throughout, with the general purpose of the plan to encourage the protection of the floodplain where feasible to help reduce future flood risks and minimize the need for flood mitigation. Chapter 3 also includes goals to identify potential NNBS opportunities in the region. The comments related to prioritizing projects are directed to TWDB, who are developing these criteria for the State Flood Plan.

The Region 2 specific comments generally pertained to protecting SGCN habitats, utilizing NNBS, including public lands in the region, and designing FMXs, particularly FMPs, to allow for natural riparian function and allow aquatic species migration. Generally, the goals and FMXs included in this RFP follow these recommendations. The three FMPs recommended in this RFP are in urban environments where previous channelization and roadway crossings have disrupted riparian function and SGCN migration. Space constraints will limit the ability of the project sponsor to improve this situation significantly. The sponsor and project designer are encouraged to follow these principles. Incorporation of these design principles should be considered in future Region 2 Flood Plans since they closely align with good stream geomorphic design principles as well.

USACE Comments

USACE provided comments on the Draft RFP in a spreadsheet sent by email from Sonia Sams, Project Coordinator, Water Resources Branch, Fort Worth District. Specific responses are included in the tables in Appendix 3, but an overall summary is provided here. Some of the USACE comments apply to state regulations and policies, which are beyond this Flood Planning Group's reach but are similar to some of the recommendations in Chapter 8. Other comments are directed toward rapidly urbanizing areas that do not generally describe Region 2. USACE also recommends more advanced flood studies. The recommendations in this RFP focus on filling the void of basic flood studies in the region. It is our understanding that USACE will be undertaking some of the studies that they recommend, and these results can be used in future regional flood planning cycles.

10.2.D TWDB Comments

TWDB provided comments on the draft RFP on October 24, 2022. The letter included 48 comments broken into two levels:

> LEVEL 1: Comments and questions that must be satisfactorily addressed to meet specific statute, rule, or contract requirements; and,
>
> LEVEL 2: Comments and suggestions for consideration that may improve the readability and/or overall understanding of the regional flood plan.

The Level 1 comments must be addressed before submission of the Final RFP on January 10, 2023. The Technical Consultant held numerous conversations with TWDB staff to better understand the comments, and our responses reflect those conversations. All Level 1 comments, along with most of the Level 2 comments, have been addressed or resolved per the comment and response table in Appendix 3.

The comments resulted in minor changes to the plan's text and some changes to the figures and tables in the appendices.

10.2.E Comment Resolution and Final RFPG Approval

Public comments were discussed at the October 6, 2022 public RFPG public meeting and responses were approved by the RFPG. TWDB comments were discussed at the November 3, 2022 RFPG public meeting, and draft responses were approved. The Final RFP, including all comment responses, was summarized at the December 15, 2022 RPG meeting and approved by the RFPG for submittal to TWDB before January 10, 2023. This, and all other RFPG meetings, was open to the public, and no additional comments were received.

Texas Administrative Code (TAC) Guiding Principles

Following Title 31 TAC §361.20, the draft and final Region 2 Lower Red-Sulphur-Cypress Regional Flood Plans conform with the guidance principles established in Title 31 TAC §362.3. The RFPG performed a "No Negative Impact" assessment for each potentially feasible FMP and FMS. Those that had or appeared to have a potential negative impact were removed from further consideration and not included as recommended FMPs or FMSs. *Table 10.3* lists the 39 regional flood planning principles and where they are addressed in this plan.

Table 10.3: Title 31 TAC §362.3 Guidance Principles and Regional Flood Planning Group Response Satisfying Said Principles

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
1	Shall be a guide to state, regional, and local flood risk management policy	Incorporated throughout the Regional Flood Planning process
2	Shall be based on the best available science, data, models, and flood risk mapping	Included in ***Chapters 2, 4, 5, 6***, and ***9***
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	Included in ***Chapters 2, 3, 4,*** and ***5***

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
4	Shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2% annual chance flood event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historical flood events	Included in ***Chapter 2***
5	Shall, when possible and at a minimum, evaluate flood risk to life and property associated with a 1% annual chance flood event (the 100-year 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% annual chance flood event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historical flood events	Included in ***Chapters 2, 3,*** and ***5***; ***TWDB-required Tables 15, 16,*** and ***17***
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 the adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk	Included in ***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	Included in ***Chapters 2, 3, 4,*** and ***5***

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
8	Shall consider various types of flooding 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	Included in ***Chapters 2, 4, 5,*** and ***7***
9	Shall focus primarily on flood management strategies and projects with a contributing drainage area greater than or equal to 1.0 (one) square miles 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	Included in ***Chapter 5*** and ***TWDB-required Tables 15, 16,*** and ***17***
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 regional flood plan	Included in ***Chapters 4, 5,*** and ***6***
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 infrastructure	Included in ***Chapters 2*** and ***5*** and ***TWDB-required Tables 1, 16,*** and ***17***

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
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, between feasible options	Included in ***Chapters 4*** and ***5*** and ***TWDB-required Tables 12, 13, 14, 15, 16,*** and ***17***
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	Included in ***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	Included in ***Chapters 5*** and ***9*** and ***TWDB-Required Tables 15, 16, 17,*** and ***19***
15	Shall be supported by state agencies, including the TWDB, General Land Office, Texas Commission on Environmental Quality, Texas State Soil and Water Conservation Board, Texas Parks and Wildlife Department, and the Texas Department of Agriculture, working cooperatively to avoid duplication of effort and to make the best and most efficient use of state and federal resources	Obtained the latest FEMA BLE data for the Lower Red and obtained status reports on TWDB BLE data for the Sulphur and Cypress Basins
16	Shall include recommended strategies and projects that minimize residual flood risk and provide effective and economic management of flood risk to people, properties, and communities, and associated environmental benefits	Included in ***Chapters 5*** and ***6***

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
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 that lead to long-term mitigation of flood risk	Included in ***Chapters 4*** and ***5*** and ***TWDB-required Tables 13, 14, 16,*** and ***17***
18	Shall contribute to water supply development where possible	As discussed in ***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	As discussed in ***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	Included in ***Chapter 10***
21	Shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation	Included in ***Chapter 10***, bylaws are available on the RFPG website
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	Included in ***Chapter 5*** and ***TWDB-required Tables 16*** and ***17***
23	Shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals	Included in ***Chapter 3*** and ***TWDB-required Tables 6*** and ***10***
24	Shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services	Included in ***Chapters 1, 3, 4,*** and ***5***

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
25	Shall be consistent with the National Flood Insurance Program (NFIP) and shall not undermine participation in nor the incentives or benefits associated with the NFIP	Included in ***Chapter 3*** and ***TWDB-required Table 6***
26	Shall emphasize the fundamental importance of floodplain management policies that reduce flood risk	Included in ***Chapter 3*** and ***TWDB-required Table 6***
27	Shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains	Included in ***Chapter 5*** and ***TWDB-required Table 16***
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	Included in ***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	Included in ***Chapters 3, 8,*** and ***10***
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 regional flood plan	Included in ***Chapters 5*** and ***9*** and ***TWDB-required Tables 15, 16, 17,*** and ***19***
31	Shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction	Included in ***Chapter 1*** and ***TWDB-required Table 2***

Principle #	Principle Description	Explanation of How Plan Satisfies Principle
32	Shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property	Included in ***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	Included in ***Chapters 1, 3, 5, 9,*** and ***10*** and ***TWDB-required Tables 16*** and ***17***
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	Included in ***Chapter 6***
35	Shall consider the protection of vulnerable populations	Included in ***Chapters 1*** and ***5*** and ***TWDB-required Tables 3, 13,*** and ***16***
36	Shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation as appropriate	Included in ***Chapter 6***
37	Shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards	As discussed in ***Chapter 6***
38	Shall consider how long-term maintenance and operation of flood strategies will be conducted and funded	As discussed in ***Chapters 4*** and ***6***
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	Included in ***Chapters 5, 6, 8,*** and ***9***