Task 2: Flood Risk Analysis

Source: City of Austin Lower Shoal Creek Risk Reduction Study – Flood Hazard Analysis of the Shoal Creek Saloon

An important aspect of developing a Regional Flood Plan involves accurately assessing the flood risk. This includes a description of the flood, identifying what is at risk, and estimating the associated impacts. In terms of understanding the environment, the Lower Colorado-Lavaca Regional Flood Plan assessed flood risk for existing and future conditions. In this plan, the existing and future conditions flood risk assessment focused on the following three main components:

1. Flood hazard analyses to determine the location, magnitude, and frequency of flooding
2. Flood exposure analyses to identify who and what might be harmed within the region; and
3. Vulnerability analyses to identify the degree to which communities and critical facilities may be affected by flooding.

Figure 2.1 TWDB Flood Risk Analyses Triangle Framework

Perform existing and future condition **flood hazard analyses** to determine the location and magnitude of both the 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events

Develop existing and future condition **flood exposure analyses** to identify who and what might be harmed by both 1% annual chance (100-year) and 0.2% annual chance (500-year) flood events

Perform existing and future condition vulnerability analyses to identify vulnerability of communities and critical facilities

Flood risk is generally identified through hydrologic and hydraulic (H&H) analysis. In flood risk analysis, hydrology is the study of how rainfall, topography, land cover, and land use affect the amount of water on the region's surface. Hydraulics investigates the movement or flow of that water as it travels across the region by rivers and streams or man-made conveyance structures such as storm drainage systems.

The 1 percent annual chance (100-year) event is the regulatory basis for the National Flood Insurance Program and has a one in a hundred chance of being equaled or exceeded in any given year. It is often referred to as the "100-year flood", the "Special Flood Hazard Area (SFHA)," or the "base flood." This boundary is a convenient tool for assessing vulnerability and risk in communities. The 1 percent annual chance (100-year) event is a mapped high-risk flood area subject to a 1 percent or greater annual chance of flooding in any given year. These areas may also be susceptible to erosion, deposition, and sedimentation.

The base flood or 1 percent annual chance (100-year) event floodplain is the national standard used by the National Flood Insurance Program and other federal agencies to regulate development and require the purchase of flood insurance. On Flood Insurance Rate Maps (or FIRMs), the Federal Emergency Management Agency (FEMA) plots both the 1 percent (100-year) and 0.2 percent (500-year) annual chance events.

Task 2A: Existing Condition Flood Risk Analyses

Existing Condition Flood Hazard Analysis

Sufficiency of Existing Conditions for Planning Purposes

In terms of flood risk analysis, the assessment of the existing conditions represents a current snapshot in time of certain elements that contribute to or protect from flooding. These conditions include the current land cover and use, estimated rainfall data, and constructed drainage-related infrastructure. These variable factors have the potential to change in the future, which will be discussed in Task 2B. The following paragraphs summarize the RFPG's assessment of current condition factors. Refer to *Task 1: Planning Area Description* for a more detailed outline of these existing condition components.

Land Cover and Use

Land cover and land use are the spatial and visual representation of features generally seen on the surface in a given area. Land use is an important factor in determining the propensity for flooding under existing conditions. It affects the hydrological processes such as evaporation, interception of natural flow paths, and infiltration into the soil as water flows across the land. As urban development (characterized by impervious areas) increases in a watershed, the hydrologic response of the runoff across the land changes, and surface runoff often increases. *Figures 1.10* and *1.11* in *Task 1: Planning Area and Description* show the land cover and use across the Lower Colorado-Lavaca Region.

Cultivated agricultural and ranch land can change the watershed's response to rainfall. Additionally, population changes can impact the rate of development and changes in land use. The previous results can be invalidated if the incidence of change since the last flooding analysis is very high. However, if the changes in land use have remained unchanged, the results of previous studies may still be used as valid and up-to-date data.

The Lower Colorado-Lavaca Region includes a distinct divide in the topographic features that occurs due to the presence of the Balcones Escarpment land formation, which separates the Texas Hill Country from the Coastal Plains. The Hill Country portion of the region is characterized by lower infiltration rates and hydraulic conveyance Escarpment is distinguished by higher infiltration rates and hydraulic conveyance through confined natural channels. The portion of the Lower Colorado-Lavaca Region along the Balcones through steep natural channels. The Lower Colorado-Lavaca Region downstream of the Balcones Escarpment may also be referred to as the Coastal Plains of Texas and constitutes the downstream portion of the region. The Coastal Plains are distinguished by flat terrain with higher infiltration rates and hydraulic conveyance through overland areas and natural channels.

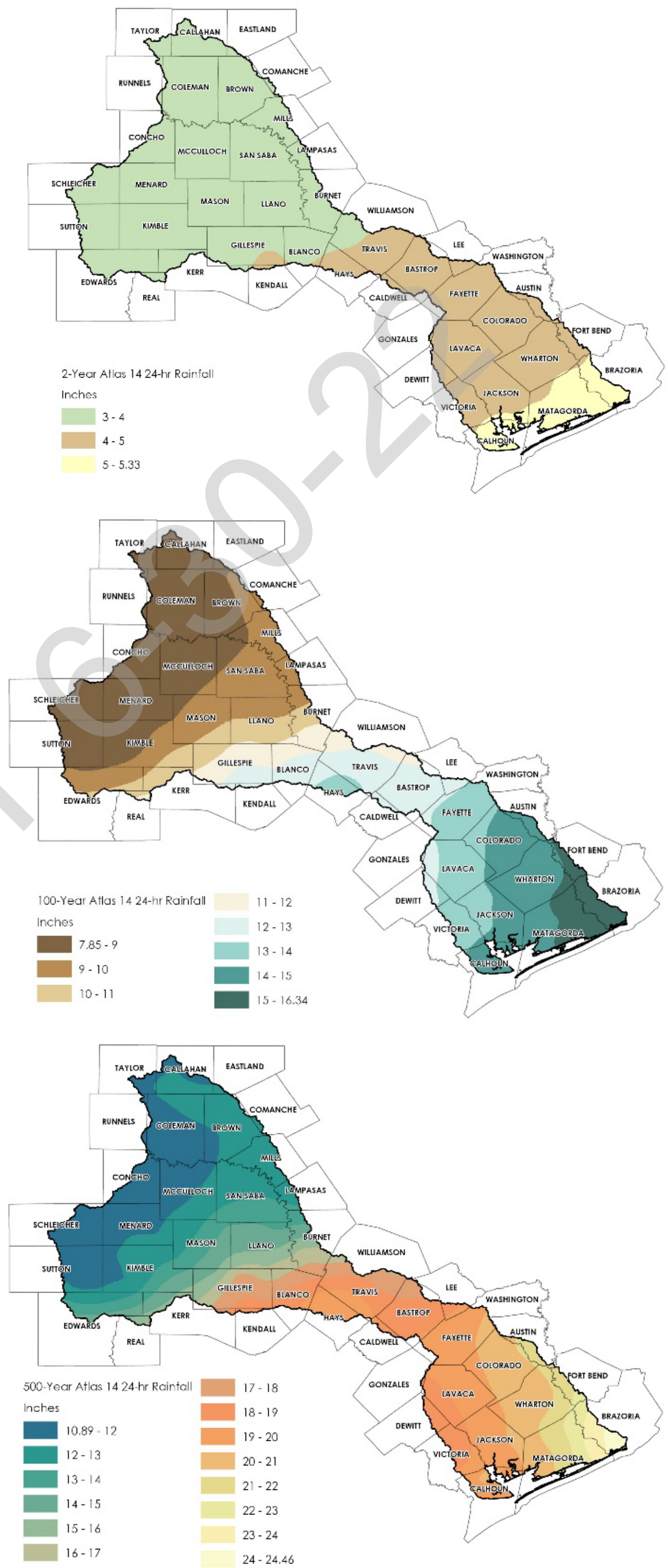
Rainfall Data

When planning for existing conditions flood risk, assessing rainfall depths and frequency of occurrence is crucial. Rainfall data in terms of inches for a 24-hour duration is commonly utilized for flood hazard analysis. In 1973, the National Flood Insurance Program set the standard for flood hazard areas based on the 1 percent annual chance (100-year) event. For the State Flood Plan, all risk assessments are based on this recurrence interval.

In 2018, the National Oceanic and Atmospheric Administration (NOAA) published new precipitation-frequency values for Texas based on historical rainfall data up to 2017. This Atlas 14 publication indicates that the 1 percent annual chance (100-year) event may be greater than what was previously considered in many areas of the Lower Colorado-Lavaca Region, as displayed in *Figure 1.17* in *Task 1: Planning Area and Description*. *Figure 2.2* displays Atlas 14 rainfall depths for the 50 percent (2-year), 1 percent (100-year), and 0.2 percent (500-year) annual chance events.

The City of Austin and other entities in the region are in the process of updating hydrologic and hydraulic models to incorporate NOAA Atlas 14 rainfall data. These updated models, and the resultant map products, are expected to be available for use in the next regional flood planning cycle.

Figure 2.2 Atlas 14 Rainfall Depths for Various Frequency Events



Flood Infrastructure

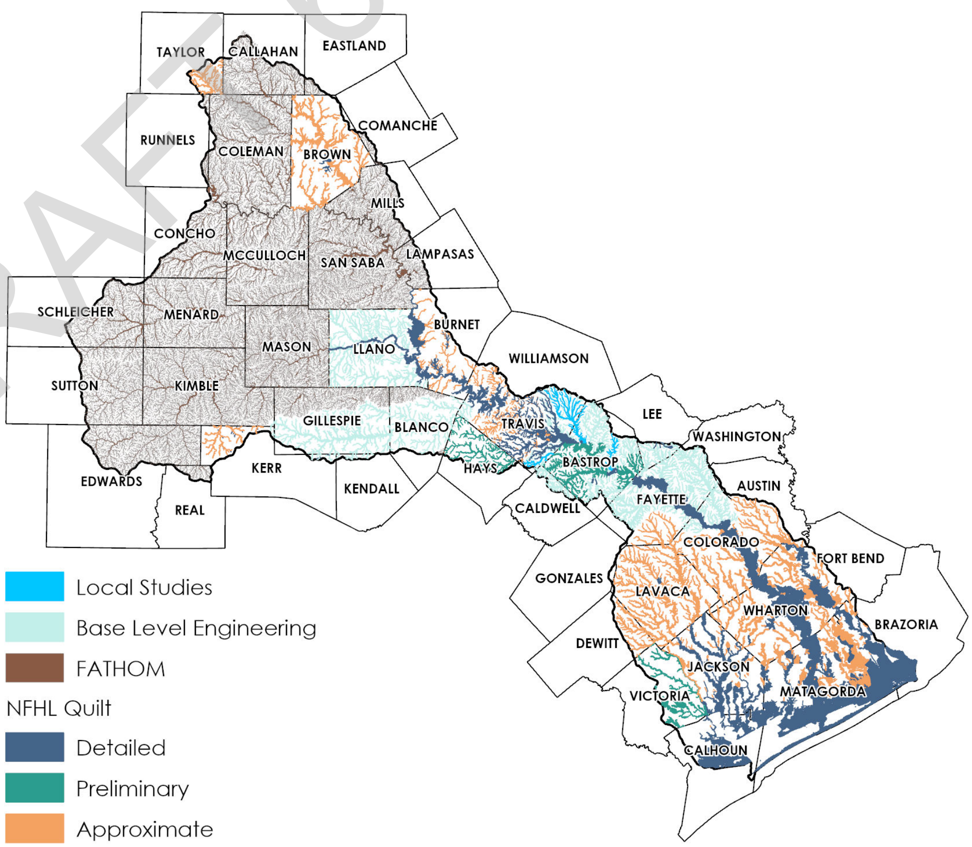
Drainage-related infrastructure is a key element in determining the existing conditions of flood risk. As described in *Task 1: Planning Area and Description*, drainage-related infrastructure includes natural and structural infrastructure such as dams, levees, detention and retention ponds, bridges, culverts, low water crossings, drainage stormwater tunnels, urban storm drain networks, breakwaters, bulkheads, and revetments.

Structural infrastructure is intended to mitigate or reduce flood risk. However, outdated, undersized, or unmaintained drainage infrastructure may increase flood risk. Bridges, culverts, and storm drain systems designed and constructed before major land use changes, rainfall changes, and/or higher floodplain management standards may no longer serve their intended purpose during significant storm events. The result is increased flood risk to both property and life. Structural flood infrastructure must be inspected and maintained regularly to perform as designed in the event of a flood.

Best Available Flood Risk Data

Due to the varying ecoregions and topography, the Lower Colorado-Lavaca Region experiences multiple types of flood risk, as described in *Task 1: Planning Area and Description*. The best available flood risk data within the Lower Colorado-Lavaca Region is primarily riverine with some coastal influence in Calhoun, Jackson, Matagorda, and Fort Bend counties in the south, where they are directly (and frequently) affected by hurricanes from the Gulf of Mexico. Hurricanes typically fade and downgrade to tropical storms or depressions as they move inland away from the coast. Riverine flooding is mostly from general rainfall and thunderstorm floods. Flash floods are common from these rainfall events, which can occur within a few minutes or hours of excessive rainfall, exposing millions of dollars in valuable public and private property to flood risk.

Figure 2.3 Floodplain Quilt



Source: TWDB Floodplain Quilt with regional enhancements

Local floodplains are flood-prone areas located outside of mapped effective FEMA flood zones, designated Special Flood Hazard Areas (SFHA), shown on FIRMs. Some communities have begun taking steps to better define and understand local flooding risks in their community using strategies such as local knowledge, historical events, and approximate or detailed local flood modeling studies, drainage master planning, local neighborhood analysis, and large-scale two-dimensional (2D) hydraulic modeling. All flood risk types were considered in identifying the best available, existing condition flood hazard data for the Lower Colorado-Lavaca Region.

Floodplain Quilt

While developing a comprehensive flood risk model of the region is beyond the scope of this planning effort, the TWDB "floodplain quilt" that is being used in the planning process is "stitched" together from various sources of data to provide comprehensive coverage of all known existing statewide flood hazard information. The floodplain quilt combines numerous data layers from the FEMA, including effective floodplain maps, preliminary maps, and base level elevation (BLE) maps, as well as data from other federal agencies. Information from local and regional flood studies was used to refine the Lower Colorado-Lavaca Region's floodplain quilt "patches" derived from such sources. Finally, the remaining floodplain quilt gaps were filled using the Fathom dataset. Upon review of the various floodplain datasets, it was ultimately recommended that the existing condition floodplain quilt be compiled using the hierarchy outlined below. The resultant floodplain quilt is displayed in *Figure 2.3*.

1. Local Studies
2. National Flood Hazard Layer
    - Pending and Preliminary Data
    - Effective Data for Detailed Study Areas (Zone AE, AO, AH, and VE)
3. Base Level Engineering
4. National Flood Hazard Layer
    - Effective Data for Approximate Study Areas (Zone A and V)
5. Fathom Data

Local Studies

A list of previous studies has been compiled using collected and researched information and is presented in *Table 2.1*. The previous flood studies and associated models included on the list are those that are being used to refine the Lower Colorado-Lavaca Region's floodplain quilt and/or studies that are being used to identify/validate potential evaluations, strategies, and/or projects. In addition to provided studies via the *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap*, the previous studies were collected through online searches and consultant team experience in the Lower Colorado-Lavaca Region. Study reports and communication with sponsors reveal whether hydrologic and hydraulic models are available or presumed available. It was also verified that these local studies reflect current conditions, such as the latest topography and Atlas 14 rainfall data. There are other local studies and the TWDB flood protection planning studies conducted in the Lower Colorado-Lavaca Region. These other local studies were incorporated into the FEMA's National Flood Hazard Layer (NFHL); therefore, they are not listed as local studies in this plan.

Table 2.1 Local Studies Incorporated into Floodplain Quilt

Study Name	County	HUC-8 IDs	Watersheds	Study Completion Year
Bastrop County Flood Protection Planning Study - Alum Creek Watershed (TWDB Contract No. 1800012308)	Bastrop	12090301	Alum	2021
Travis County Maha Creek Atlas 14 Floodplain Study	Travis	12090301	Maha	2021
Bastrop County Flood Protection Planning Study - Wilbarger Creek Watershed (TWDB Contract No. 1800012308)	Travis, Bastrop	12090301	Wilbarger	2021

National Flood Hazard Layer

The FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies represent existing conditions to depict risk for insurance purposes. As such, they represent a snapshot in time and do not consider future conditions or climate change. FEMA's NFHL is a geospatial database that includes digital FEMA floodplain datasets that are currently effective and have become available for the National Flood Insurance Program regulatory use. Related to the NFHL are FEMA's floodplain datasets that are preliminary or pending adoption before becoming effective. These datasets are described below.

Effective Detailed Studies

Detailed studies are developed using detailed hydrologic and hydraulic models and methodologies. Products of a detailed study (Zone AE, AO, AH, and VE) generally include hydrologic models, hydraulic models, survey data, floodplains, floodways, depth grids, profiles, and base flood elevations. Zone AE analysis is a more costly analysis that is generally conducted in urban areas. These studies include both the 1 percent (100-year) and 0.2 percent (500-year) annual chance event floodplains.

Effective Approximate Studies

Approximate studies are developed using approximate methods. Approximate hydrology may utilize regional regression equations to compute flow. Hydraulic simulations do not include survey data, depth grids, profiles, or base flood elevations. Depending on the model, some hydraulic simulations may not include data representing stream crossings. Approximate (Zone A and V) analysis is more appropriate for rural areas or locations with no structures in or near the floodplain. These studies generally only include the 1 percent (100-year) annual chance event floodplain.

Pending and Preliminary Data

Pending flood hazard data is in FEMA's Letter of Final Determination stage, which means the data is considered final and assigned an effective date. The pending timeframe is generally five to six months in advance of the assigned effective date. Preliminary flood hazard data is issued for public review of the proposed floodplain changes, and this data is subject to refinement before finalization. Both the pending and preliminary datasets include both detailed and approximate study data. Because these pending and preliminary studies are more current than the effective studies, they were utilized as the best available data in the floodplain quilt.

Base Level Engineering

The TWDB and FEMA have invested in base level engineering (BLE) across the state with the goal of full coverage by the fiscal year 2022. The BLE studies incorporate automated techniques with traditional model development to produce approximate flood hazard boundaries for the 1 percent (100-year) and 0.2 percent (500-year) annual chance events as well as other events. In the Lower Colorado-Lavaca Region, there are three areas where one-dimensional BLE is available. These areas are within Llano County, the Pedernales watershed, and the Lower Colorado-Cummins watershed. The BLE data is the best available data, above the effective approximate studies and the Fathom data. Existing condition base level engineering studies were determined to be current, reflecting current topography and alignment to current stream gage statistics.

Fathom Data

As displayed in *Task 1: Planning Area and Description Figure 1.15*, a significant portion of the state lacks floodplain maps. For these where data is missing or outdated, the TWDB provided a "cursory floodplain" herein referred to as the Fathom dataset to append the State's initial floodplain quilt. Fathom is developed by a research group at the University of Bristol, England. The intention of the Fathom rapid assessment flood data is to fill the gaps where flood risk data is unavailable. The Fathom "cursory floodplain" dataset includes pluvial (riverine), fluvial (local or urban), and coastal flood risk produced using models developed at 30-meter (approximately 100-feet) resolution for the entire state of Texas. The 30-meter produced Fathom models incorporate TWDB-provided Light Detection and Ranging (Lidar) data in all areas of the state, with model results hydrologically mapped at a 3-meter (approximately 10-feet) resolution. The Fathom dataset has been peer-reviewed and compares reasonably well to the FEMA flood data and BLE. Fathom includes mapping for the 1 percent (100-year) and 0.2 percent (500-year) annual chance events, as well as other storm frequencies.

Fathom's fluvial, pluvial, and coastal flood depth data for the Lower Colorado-Lavaca Region were mosaicked together utilizing the greatest depths where the datasets overlap. The RFPG processed the flood depth data to develop flood polygon boundaries using guidance provided by the TWDB. The Fathom data served as a supplemental dataset for inclusion in the existing flood boundaries where no other data or digitally converted FIRMs from the First American Flood Data Services (FAFDS) were available. Observation of the Fathom dataset in relation to the FAFDS revealed the two datasets were similar, and since the Fathom dataset was better aligned to current topography, it was decided to replace the FAFDS flood risk data with Fathom.

An interesting aspect of the Fathom dataset is the pluvial flood risk information. The pluvial flood risk is also referred to as the local or urban flood risk. This flood risk is generally identified by dropping water onto terrain and letting the topography dictate where water flows. The pluvial flood risk is not intended for regulatory purposes but provides a great resource for flood planning as this dataset displays flood risk beyond the traditional riverine flood risk. This local (urban) flood risk better defines where water will gather and flow once the rain hits the ground.

Possible Flood-Prone Areas and Other Floodplain Data

Due to the varying ecoregions and topography, the Lower Colorado-Lavaca Region experiences various types of flood risk. The flood risk identified throughout the region's planning process is primarily associated with riverine systems. Coastal flood risk identified by the National Flood Hazard Layer is present across Calhoun, Matagorda, and Brazoria counties. Local (sometimes also referred to as urban or pluvial) flood risk data was considered for inclusion in the existing floodplain quilt. This local (urban) flood risk better defines where water will gather and flow once the rain hits the ground. Local (urban) flood risk is incorporated in the areas where the Fathom data was used to fill prior flood risk gaps within the region; however, no other local (urban) flood risk information was provided for incorporation into the region's floodplain quilt. Structural failure flood risk is also present in the region as being associated with the potential failure of flood control structures such as dams and levees, which may cause an uncontrolled release of floodwaters. No structural failure flood risk information was provided for incorporation into the Lower Colorado-Lavaca Region's floodplain quilt.

Other possible flood-prone areas include areas of historical flooding events and areas of reported flood concerns provided by regional entities. Through the summer and fall of 2021, the *Lower Colorado-Lavaca Region Data Collection Survey Tool and Interactive Webmap* provided entities an opportunity to identify flood-prone areas and provide the best available flood risk information for consideration in the amendment of the Lower Colorado-Lavaca Region's floodplain quilt. All information and areas of flood concern were considered in the flood hazard analysis. It was determined that the historical flooding events were well represented by the Lower Colorado-Lavaca Region's floodplain quilt. It was also determined that the survey responses of reported flood concerns were also represented in the Lower Colorado-Lavaca Region's floodplain quilt.

Summary

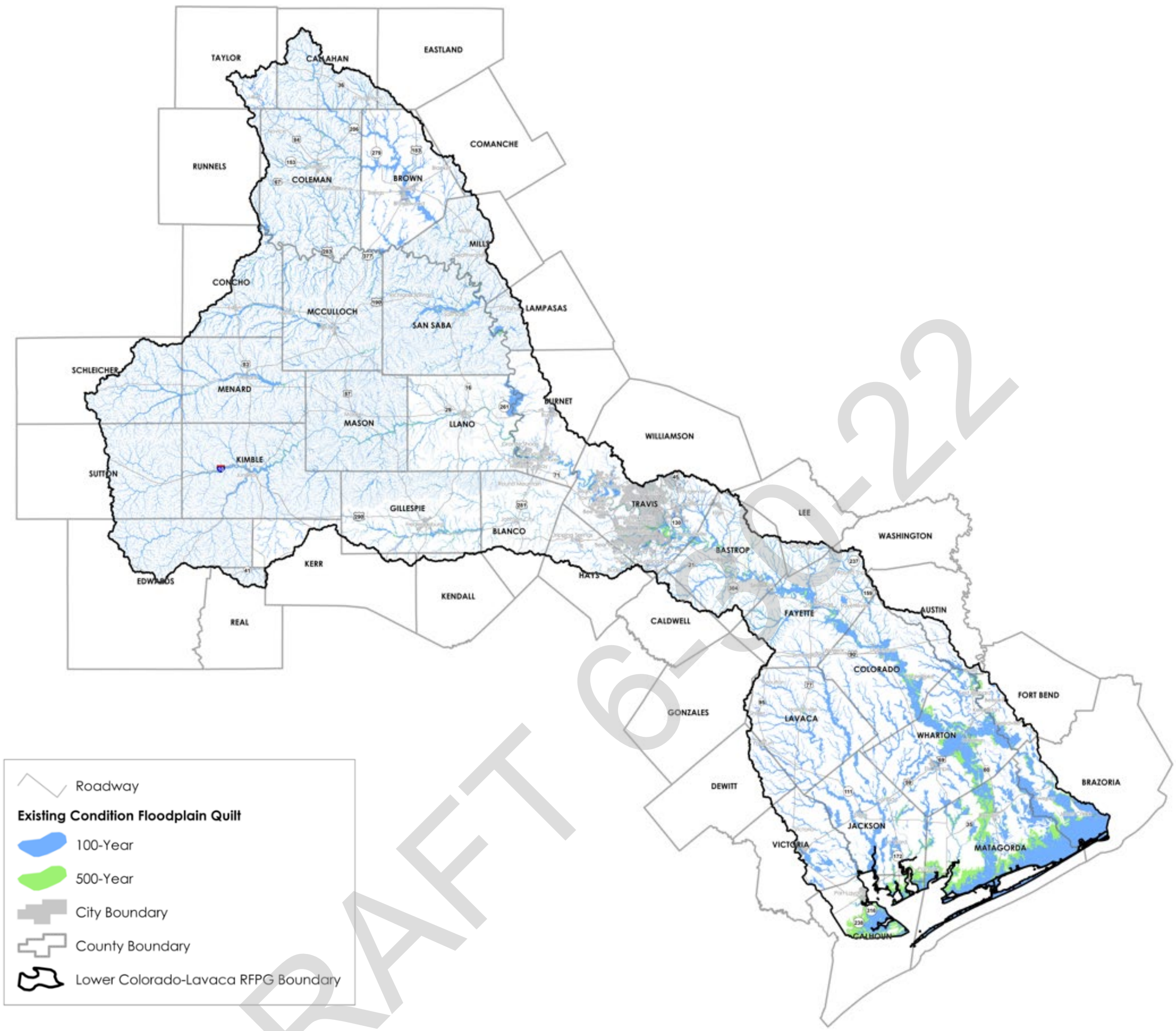
The draft existing condition flood hazard map was discussed during the RFPG meeting on January 31, 2022. A *Flood Risk Webmap* was employed to obtain interest groups and public comments on the draft flood hazard maps.

The *Flood Risk Webmap* provided a tool for users to review and comment on the data presented in the maps and to identify and locate additional potential flood hazard areas. The webmap was launched on February 10, 2022, and was accessible through the end of May. *Figure 2.4* displays a screen capture of the interactive *Lower Colorado-Lavaca Region Flood Risk Webmap*.

Figure 2.4 Draft Flood Hazard Interactive Webmap

The compiled existing condition floodplain quilt data for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.5* shows a map of the comprehensive existing flood hazard data compiled for the Lower Colorado-Lavaca Region. A larger, more detailed version of this figure is included as *TWDB-required Map 4.*

Figure 2.5 Existing Condition Flood Hazard Map



Hydrology & Hydraulic (H&H) Model Availability

H&H modeling is necessary to determine how water moves across the Lower Colorado-Lavaca Region. It is vital to develop effective flood planning strategies. Various entities within the Lower Colorado-Lavaca Region have previously developed hydrology and hydraulic models to further understand how water impacts their communities.

Since the 1970s, H&H analyses have used computer software applications to identify areas at risk of flooding and mitigation measures to reduce flood risk. Within the Lower Colorado-Lavaca Region, there are hundreds of H&H models, each calibrated for a specific study extent and purpose. The best available data from the various modeling efforts were ultimately incorporated into the Lower Colorado-Lavaca Region's floodplain quilt. *Table 2.2* lists previous studies in the region that were compiled using collected and researched information. The previous flood studies and associated models included on the list are those that are being used to refine the Lower Colorado-Lavaca Region's floodplain quilt and/or studies that are being used to identify/validate potential evaluations, strategies, and/or projects. In addition to provided studies via the *Lower Colorado-Lavaca Region*

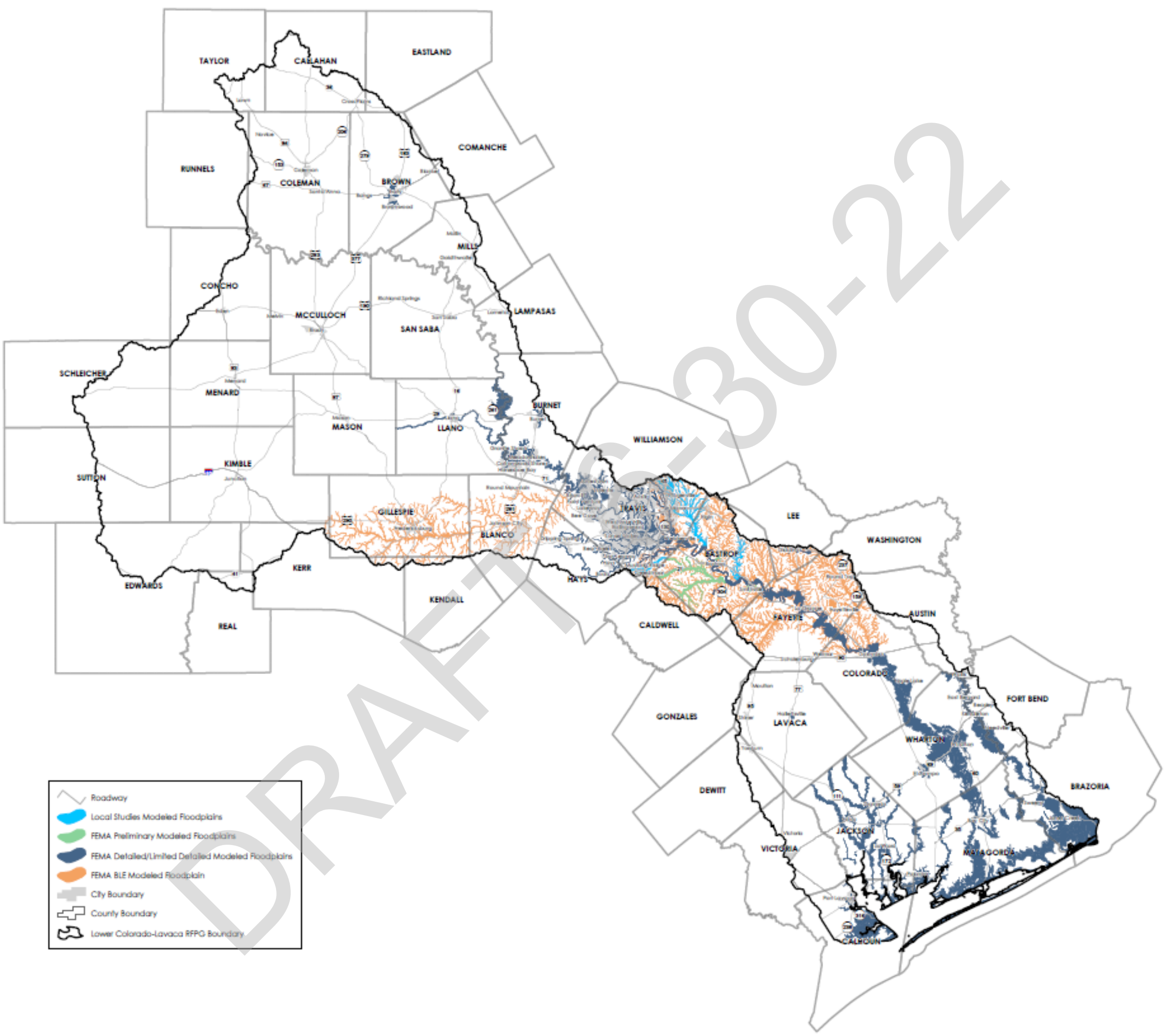
Data Collection Survey Tool and Interactive Webmap, the previous studies were collected through online searches and the technical consultant team's experience in the Lower Colorado-Lavaca Region.

Table 2.2 Available H&H Models in the Lower Colorado-Lavaca Region

Study Name	County	HUC-8 IDs	Watersheds	Study Completion Year	How Study used in Plan
Bastrop County Flood Protection Planning Study - Alum Creek Watershed (TWDB Contract No. 1800012308)	Bastrop	12090301	Alum	2021	Floodplain Quilt, FMEs
Bastrop County Physical Map Revision	Bastrop	12090301	Cedar, Walnut, Piney, Gills, Willow-Gazley	2021	Floodplain Quilt
Bastrop County Flood Protection Planning Study - Willow-Gazley Creeks (TWDB Contract No. 1800012308)	Bastrop	12090301	Willow and Gazley	2018	FMEs
Bastrop County Flood Protection Planning Study - Piney Creek Watershed (TWDB Contract No. 1800012308)	Bastrop	12090301	Piney	2018	FMEs
City of Bastrop Gills Branch Flood Mitigation Improvements	Bastrop	12090301	Gills	2021	FMP
Bastrop County Flood Protection Planning Study - Walnut Creek Watershed (TWDB Contract No. 1800012308)	Bastrop	12090301	Walnut	2018	FMEs
City of Fredericksburg Drainage Master Plan	Gillespie	12090206	Pedernales	2016	FMEs
City of Brady Drainage Master Plan	McCulloch	12090110	Brady Creek	2015	FMEs
City of Bee Cave Capital Improvements Project Great Divide	Travis	12090205	Little Barton Creek	2021	FMP
Travis County Maha Creek Atlas 14 Floodplain Study	Travis	12090301	Maha	2021	Floodplain Quilt
Travis County Flood Mitigation Study	Travis	12090301, 12090205	Onion and Dry Creek East	2017	FMEs
Bastrop County Flood Protection Planning Study - Wilbarger Creek Watershed (TWDB Contract No. 1800012308)	Travis, Bastrop	12090301	Wilbarger	2021	Floodplain Quilt, FMEs
1D Base Level Engineering: Pedernales Watershed	Gillespie, Blanco, Hays, Travis	12090206	Pedernales	2021	Floodplain Quilt
1D Base Level Engineering: Lower Colorado-Cummins Watershed	Travis, Bastrop, Caldwell, Lee, Fayette, Colorado	12090301	Lower Colorado-Cummins	2018	Floodplain Quilt
1D Base Level Engineering: Llano County	Llano	12090204, 12090201	Watersheds in Llano County	2017	Floodplain Quilt
FEMA Detailed and Limited Detailed Modeled Floodplains	Multiple	Multiple	Multiple	Varies	Floodplain Quilt

These local studies, BLE studies, and FEMA detailed and limited detailed studies are locations where H&H models are available. It should be noted that for use in developing evaluations, strategies, or projects, these models will likely require some level of enhancement. A graphical representation of these locations is provided in *Figure 2.6*. The geodatabase feature classes titled 'ModelCoverage' provides a spatial representation of available models in the Lower Colorado-Lavaca Region.

Figure 2.6 Locations where Hydrologic and Hydraulic Models are Available



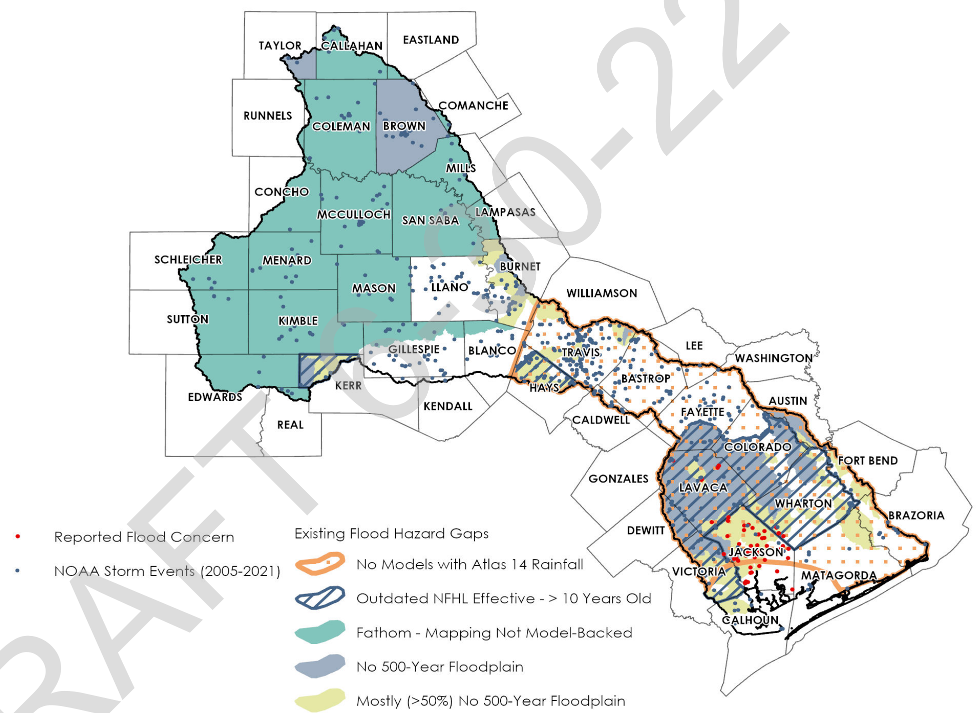
Data Gaps

Once the best available comprehensive existing flood data was complied, data gaps were assessed to identify any remaining areas where flood inundation boundary mapping was missing, lacked modeling and/or mapping, or used outdated modeling and/or mapping. Other contributing engineering factors used to identify data gaps included modeling technology, significant topographic change, significant land use and/or impervious area change, change in flood control structures, channel configuration (including erosion and sedimentation) changes, and rainfall pattern changes altering peaks discharges.

Following the compilation of the floodplain quilt, a flood hazard gap analysis was performed to identify known or "apparent" flood-prone areas that lack models and maps or have existing models and maps that are outdated or otherwise not considered reliable. The existing condition gap analysis identifies the following:

- Absence of hydrologic and hydraulic models where the Fathom mapping is utilized
- Outdated National Flood Hazard Layer data greater than 10 years old
- Absence of 0.2 percent annual chance (500-year) flood risk data
- More than 50 percent absence of 0.2 percent annual chance (500-year) flood risk data
- Absence of modeling and mapping utilizing NOAA Atlas 14 rainfall data

Figure 2.7 Existing Condition Flood Hazard Gaps



The compiled existing condition gap analysis for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.7* shows a map of the locations of identified existing condition flood data gaps. A larger, more detailed version of this figure is included as *TWDB-required Map 5*.

While areas were identified within the floodplain quilt as data gaps with outdated information, the complied existing floodplain quilt still comprised the best available floodplain datasets for the Lower Colorado-Lavaca Region and was used for the flood risk analysis in the Lower Colorado-Lavaca Regional Flood Plan. It is the goal of this plan to further evaluate these data gaps for inclusion as Flood Management Evaluations (FMEs) discussed in *Task 4A*.

Existing Condition Flood Exposure Analysis

In Texas, flooding frequency and intensity have been increasing in recent years, sometimes necessitating state and federal relief, which has risen to record levels. Flooding can become a significant hazard when it inundates the built environment and causes direct damage to buildings, critical facilities, crops, and occasionally injuries or loss of life.

The existing condition flood risk exposure analysis leveraged the compiled existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt in the Lower Colorado-Lavaca Region to determine existing flooding exposure to identify who and what might be at risk of flooding. This floodplain quilt is comprised of the best available flood hazard data. The *Lower Colorado-Lavaca Region Data Collection Survey Tool and*

Interactive Webmap discussed in *Task 1: Planning Area and Description* included multiple opportunities for entities to submit conceptual, planning, or ongoing projects or studies related to flooding. No entities in the Lower Colorado-Lavaca Region submitted revised floodplains that would result from flood mitigation projects with dedicated construction funding and a completion date before the completion of this plan.

Potential Flood Exposure

Exposure is the estimated quantification of what is at risk of flooding. Multiple assets can be exposed to flooding, including buildings, businesses, infrastructure systems, and even people. Exposure also refers to the economic value of assets subjected to flood hazards. For the Lower Colorado-Lavaca Region, the flood exposure analysis considered floodplain areas, buildings including residential and non-residential properties, populations, critical facilities, and public infrastructure, including industrial and power generating facilities, roadways, and agricultural areas within the Lower Colorado-Lavaca Region.

The table below displays the region-wide exposure results for the existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events. The following sections further describe the exposure analysis results for each exposure category.

Table 2.3 Summary of Existing Condition Exposure in the Lower Colorado-Lavaca Region

Exposure Category	1% (100-year) Floodplain	0.2% (500-year) Floodplain	Difference
Floodplain Area (square miles)	4,526	5,252	*726*
Buildings	67,826	102,312	34,486
Residential Structures	*45,800*	*71,251*	*25,451*
Non-Residential Structures	*22,026*	*31,061*	*9,035*
Population (All Buildings)	149,831	244,671	94,840
Critical Facilities	118	205	87
Industrial and Power Generating Facilities	*13*	*18*	*5*
Roadway Low Water Crossings	1,109	1,132	23
Roadway Segments (miles)	2,374	3,285	911
Area of Agriculture (square miles)	3,545	4,155	610

Existing Development

Buildings (Structures)

In December 2021, the TWDB provided a building dataset that was built on available Light Detection and Ranging (Lidar) information (2010 to 2021), Microsoft Artificial Intelligence Version 2 data, and 2021 Open Street Map (OSM) buildings. As displayed in *Figure 2.9,* the intersection of the floodplain quilt with the building footprints revealed that the greatest numbers of buildings are exposed in Travis, Brazoria, Matagorda, and Wharton counties.

At risk buildings are quantified by overlaying the existing condition floodplains over the building footprints in the region. Elevation certificates for every structure within the Lower Colorado-Lavaca Region are not available and are impractical for the Lower Colorado-Lavaca Region's size. The TWDB provided the building footprints as of 2018. This approach assumes that the building footprint is essentially constructed at grade and does not consider elevated foundations. Therefore, the approach may assume more structures are at risk of flooding than would be at risk if the elevation was considered. *Figure 2.8* shows a heat map of structures within the 1 percent annual chance (100-year) event, and *Figure 2.9* shows the results of building existing condition exposure analysis per county within the Lower Colorado-Lavaca Region.

Figure 2.8 Heat map of Buildings within the Existing 100-Year Floodplain

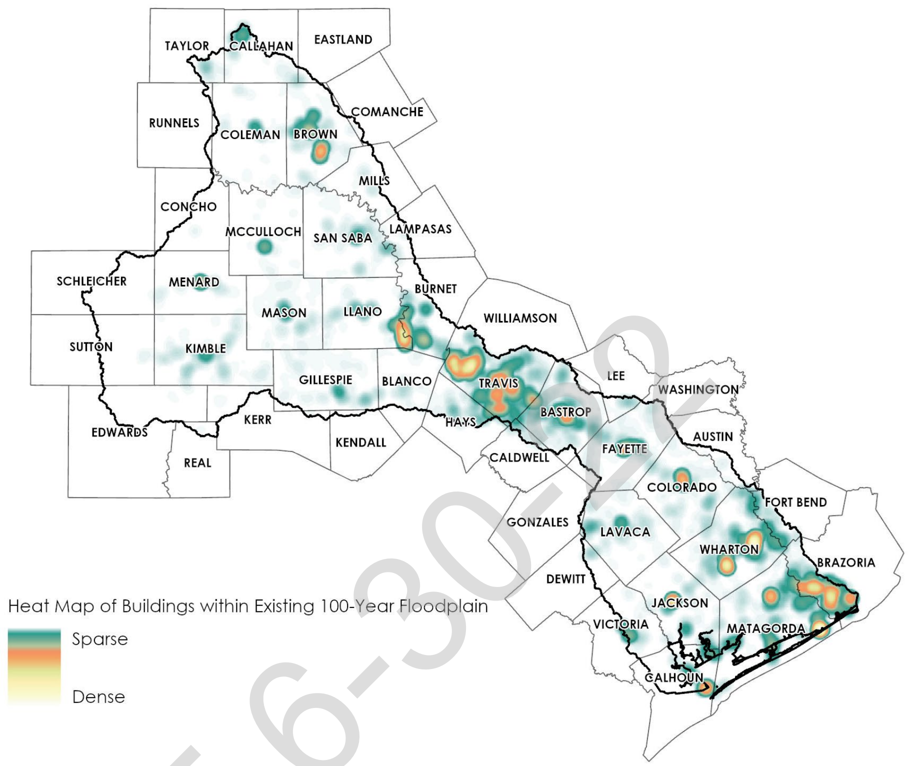
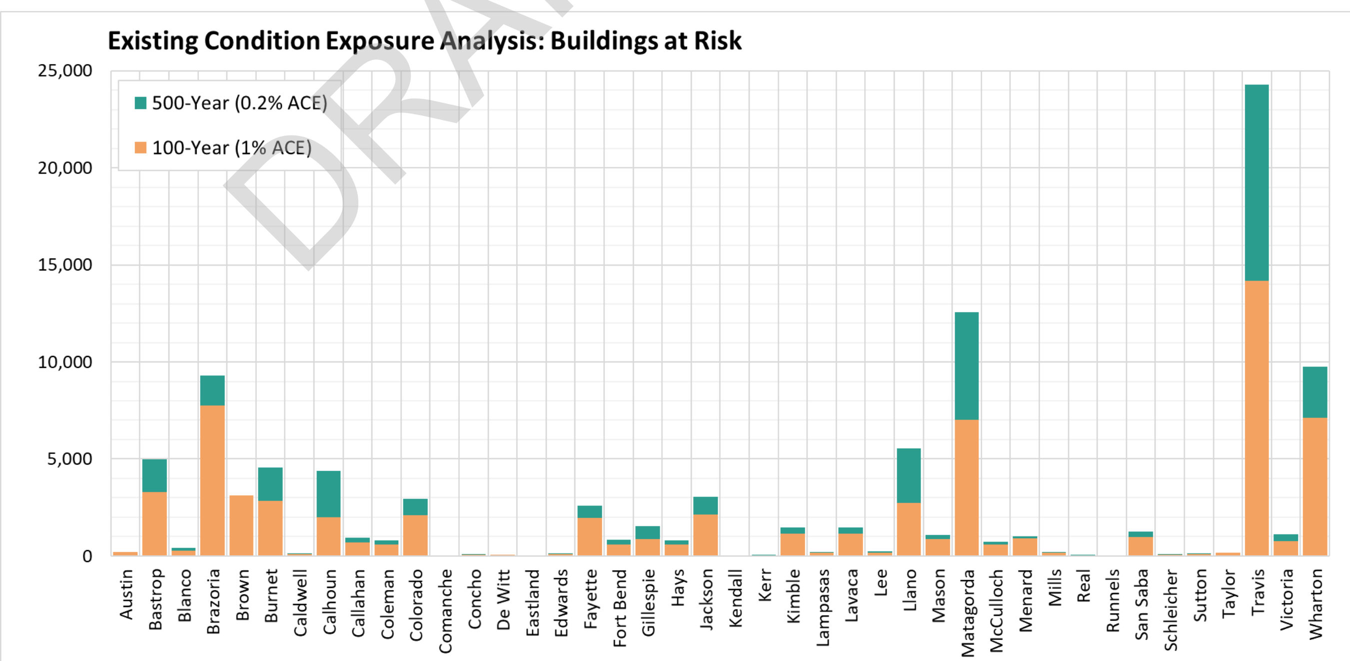


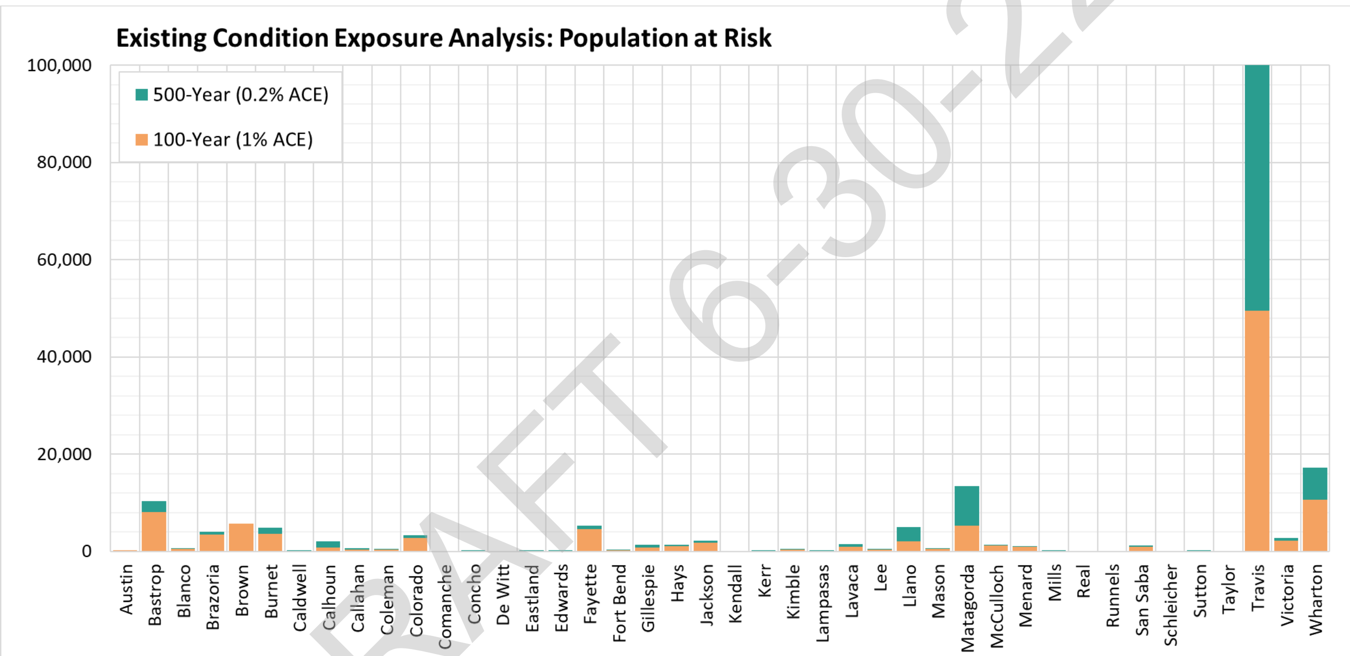
Figure 2.9 Existing Condition Exposure Analysis Results for Buildings in the Floodplain



Population

The TWDB building dataset includes population estimates per building for both day and night using the 2019 LandScan USA dataset from Oak Ridge National Laboratory (ORNL). Buildings with zero populations identified were evaluated were updated where additional information was available. It was assumed that residential structures in the Lower Colorado-Lavaca Region include an average population of 2.6 persons, as outlined in the TWDB Technical Guidance. The source of this estimation is the 2015-2019 American Community Survey five-year estimates. The chart below displays population estimations of existing condition exposure per county within the Lower Colorado-Lavaca Region. While the buildings at risk in *Figure 2.8* display high building exposure in Travis, Brazoria, Matagorda, and Wharton counties, the population counts at risk of flooding in *Figure 2.10,* indicating that the at risk buildings in Brazoria and Matagorda counties have low population counts. Travis County contains 47 percent of the estimated population at risk.

Figure 2.10 Existing Condition Exposure Analysis Results for Populations in the Floodplain



Residential Properties

As provided by the TWDB, the building dataset indicated residential structures. Residential property data utilized in the Regional Flood Plan included single-family homes, townhomes, mobile homes, and multi-family residences like apartments and condominiums. Over 71,000 residential building footprints are within the existing 1 percent (100-year) and 0.2 percent (500-year) annual chance events in the Lower Colorado-Lavaca Region. An associated residential population of over 95,000 is estimated to be at risk of flooding.

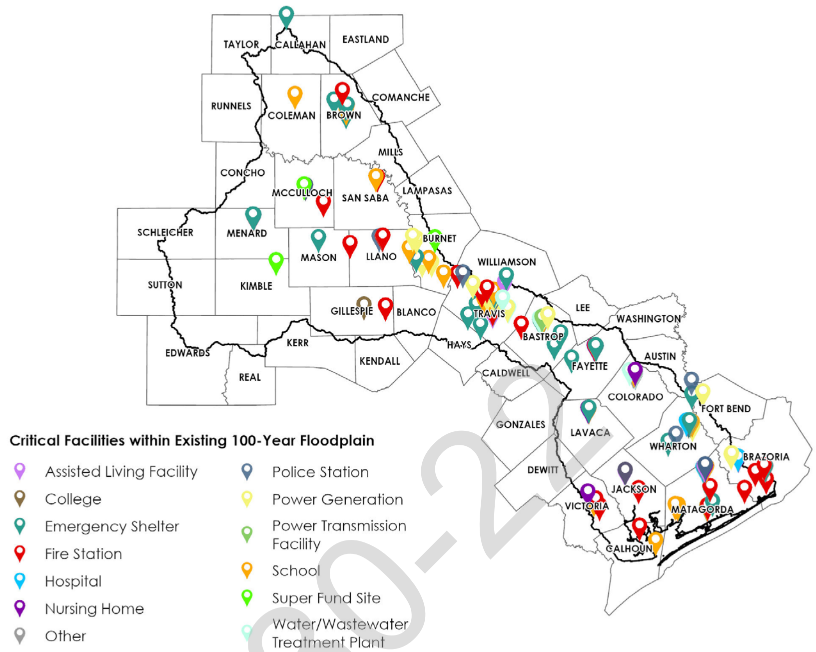
Non-Residential Properties

The building dataset also included agricultural, commercial, industrial, and other public buildings. Over 31,000 non-residential building footprints were documented in the floodplain for the existing 1 percent (100-year) and 0.2 percent (500-year) annual chance events in the Lower Colorado-Lavaca Region. This indicates that an estimated 30 percent of at risk buildings are non-residential structures.

Critical Facilities and Public Infrastructure

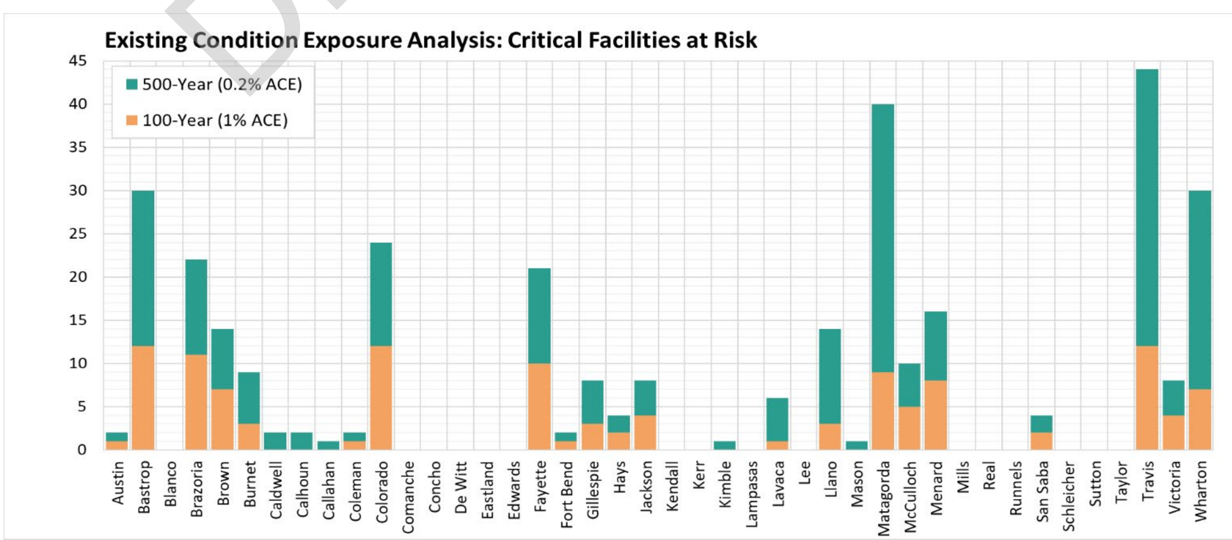
A critical facility provides services and functions essential to a community, especially during and after a disaster. As defined by the TWDB Technical Guidelines, critical infrastructure includes all public or private assets, systems, and functions vital to the security, governance, public health, and safety, economy, or morale of the state or the nation. Critical facilities include hospitals, nursing homes, assisted living facilities, schools (K-12 and private), colleges, fire stations, police stations, emergency shelters, super fund sites, water and wastewater treatment plants, and power generating and transmitting facilities. Critical facilities data was compiled using data from the TWDB, Texas Commission on Environmental Quality, Homeland Infrastructure Foundation Level Data, as well as data from Lower Colorado-Lavaca Region entities.

Figure 2.11 Critical Facilities within the Existing 100-Year Floodplain



Over 1,700 critical facilities were documented in the Lower Colorado-Lavaca Region. An estimated 7 percent of these critical facilities appear to be exposed to flooding within the existing 1 percent annual chance (100-year) event. Critical facilities within the 1 percent annual chance event floodplain in the Lower Colorado-Lavaca Region are shown in *Figure 2.11* and on the *TWDB-Required Map 7-B*. *Figure 2.12* shows the results of critical facility existing condition exposure analysis per county within the Lower Colorado-Lavaca Region. The majority of at risk critical facilities are within Bastrop, Matagorda, Travis, and Wharton counties, accounting for 51 percent of the total at risk within the Lower Colorado-Lavaca Region.

Figure 2.12 Existing Condition Critical Facilities in the Floodplain



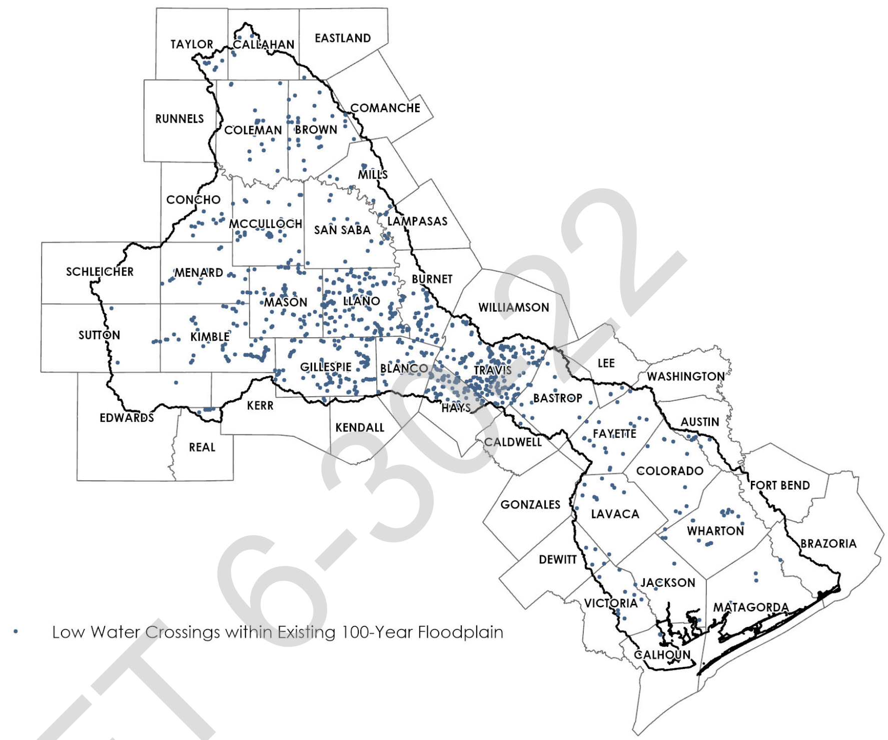
Major Industrial and Power Generation Facilities

Lifeline utility systems data such as power generation and transmission facilities were included as critical facilities for this exposure analysis. There are 18 power generation facilities at risk of flooding in the Lower Colorado-Lavaca Region, and the majority of these facilities are energy plants.

Transportation

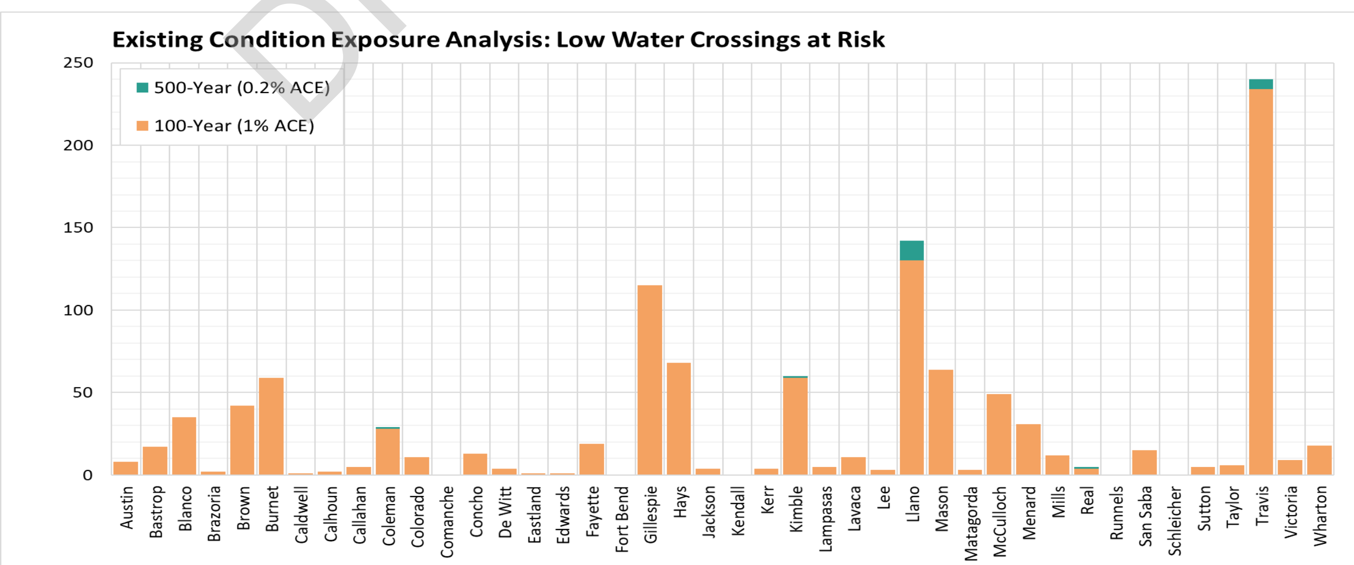
Transportation line data (roadways and railroads) from the Texas Department of Transportation (TxDOT) was used to estimate road and railway segments at risk of flooding. There are over 29,000 transportation miles in the Lower Colorado-Lavaca Region, with an estimated 12 percent of these segments at risk of flooding. The highest mileage exposures are observed in Matagorda, Travis, and Wharton counties, all with over 400 miles of at risk road and railway segments.

Figure 2.13 Low Water Crossings within the Existing 100-Year Floodplain



Low water crossing data provided by the TWDB and confirmed by the Lower Colorado-Lavaca Region entities were also used to identify exposed roadway crossings. There are over 1,300 low water crossings in the region, with an estimated 84 percent of these crossings at risk of flooding. *Figure 2.14* displays the low water crossing exposure totals per county within the Lower Colorado-Lavaca Region. Travis County contains the highest number of at risk crossings accounting for 23 percent of the total.

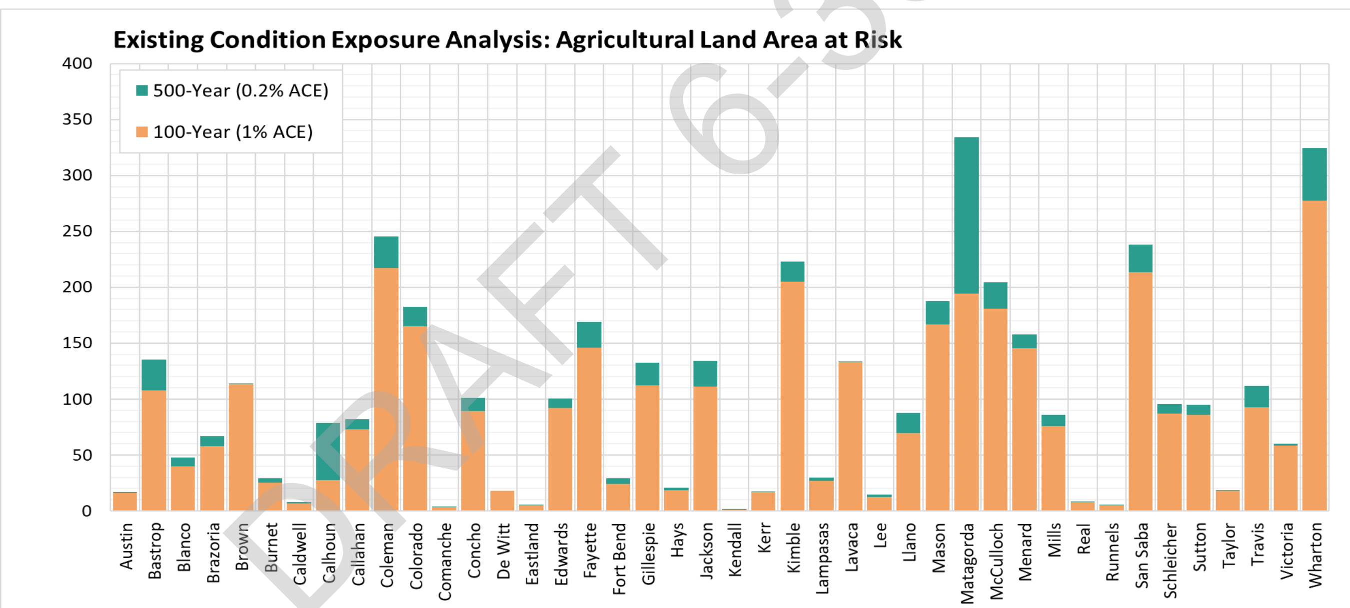
Figure 2.14 Existing Condition Exposure Analysis Results for Low Water Crossings in the Floodplain



Agriculture

While water is a vital commodity for agriculture and ranching, flooding can destroy crops, dwindle herd numbers, or cause contamination of livestock and farming exports. Agricultural land use data in the Lower Colorado-Lavaca Region was obtained from the 2020 Texas Cropland Data layer developed by the United States Department of Agriculture National Agricultural Statistics Service. In the Lower Colorado-Lavaca Region, the vast majority of land use is grazing land transitioning to farming and ranching moving south. There are approximately 3,500 square miles of agricultural land at risk during the 1 percent annual chance (100-year) event and approximately 4,200 square miles at risk during the 0.2 percent annual chance (500-year) event. These values are calculated from all land use types except urban development, wetlands, and open water. *Figure 2.15* shows the results of agricultural land existing condition exposure analysis per county within the Lower Colorado-Lavaca Region. Each county has agricultural land at risk of flooding within the Lower Colorado-Lavaca Region, with the risk being more evenly distributed than other exposure categories. As described in *Task 1: Planning Area and Description*, NOAA's Storm Event Database shows crop losses in the Lower Colorado-Lavaca Region to total $40 million in the past 10 years. The database shows counties in the southeast and west have experienced more total crop disasters than the rest of the Lower Colorado-Lavaca Region.

Figure 2.15 Existing Condition Exposure Analysis Results for Agricultural Land Area (square miles) in the Floodplain



Existing Dams and Levees

Existing dams, floodwalls, and levees within the Lower Colorado-Lavaca Region are described in *Task 1: Planning Area and Description. Figure 1.21* in *Task 1: Planning Area and Description* shows the locations of dams, floodwalls, and levees in the Lower Colorado-Lavaca Region. The National Inventory of Dams is a database maintained by the United States Army Corps of Engineers that includes the location and age of dams, among other attributes. In addition to the National Inventory of Dams, dam information within the Lower Colorado-Lavaca Region was gathered from additional sources, including the Texas Commission on Environmental Quality and Texas State Soil & Water Conservation Board. The combined sources show 700 dams within the Lower Colorado-Lavaca Region. As outlined in *Task 1: Planning Area and Description,* over 50 percent of the dams in the Lower Colorado-Lavaca Region are reaching their life span, typically considered 50 years old. The average age of dams within most Lower Colorado-Lavaca Region counties exceeds 50 years. *Table 2.4* shows the quantification of dams in the Lower Colorado-Lavaca Region counties. Although entities provided little information about the flood risk associated with dam infrastructure, the age of these structures alone indicates that many may be due for modernization, upgrades, maintenance, rehabilitation, or even retirement. Potential flood hazard exposure associated with dams could not be evaluated without entities providing dam breach information.

Table 2.4 Quantification of Dams by County

County	Dams within County Limits	Avg Age of Dams (years)	County	Dams within County Limits	Avg Age of Dams (years)
Austin	4	67	Jackson	6	44
Bastrop	33	57	Kimble	4	79
Blanco	3	48	Lampasas	1	113
Brazoria	8	65	Lavaca	2	59
Brown	70	57	Lee	16	62
Burnet	20	55	Llano	10	62
Calhoun	4	61	Mason	1	83
Callahan	34	56	Matagorda	10	56
Coleman	113	59	McCulloch	40	65
Colorado	18	52	Menard	4	60
Comanche	4	55	Mills	35	55
Concho	40	59	Runnels	1	57
De Witt	5	61	San Saba	39	58
Eastland	1	-	Sutton	1	59
Fayette	49	53	Taylor	11	67
Fort Bend	2	52	Travis	77	43
Gillespie	11	54	Victoria	2	57
Hays	9	46	Wharton	12	52

According to the United States Army Corps of Engineers (USACE) National Levee Database, there are 24 floodwalls and levees in the Lower Colorado-Lavaca Region, with one managed by the USACE – Fort Worth District. There are 110 miles of levees in the Lower Colorado-Lavaca Region; approximately 45 miles (41 percent) are identified as being accredited by the USACE. *Table 2.5* shows floodwall and levee mileage within each county. Flood risk associated with non-accredited levees is generally displayed on FEMA floodplain maps. Potential flood hazard exposure associated with floodwalls and levees beyond FEMA's floodplains could not be evaluated without entities providing additional flood risk information.

Table 2.5 Levee Length by County

County	Levee Miles
Brazoria	8
Calhoun	14
Colorado	9
Matagorda	49
Travis	3
Victoria	2
Wharton	25
Region Total	110

Expected Loss of Function

Severe flooding results in a loss of function of community infrastructure and economy, impacting the socioeconomic systems supported by them. These impacts include disruptions to life, business, and public services. Some public services are essential to a community during and after a flood event. Flood inundation depth and duration are typically considered the best flood characteristics in predicting expected functionality losses.

Inundated Structures

Inundated buildings (structures) are often not functional during the flood event and through the recovery process. Structural inundation may result in physical damage, displacement costs, occupants' inability to work, as well as mental health and welfare impacts to occupants. These impacts are dependent on the severity of damage to the structure, interrupted access, and lingering health hazards. While all building types may experience these impacts, the loss of function of business in commercial and industrial services may also be extensive.

Critical Facilities

Critical facilities provide essential services for communities and are integral to maintaining stability after a flood event. During and after hazard events, the availability and functionality of first responders, health and human services, water supply and treatment, and operable utilities are vital. These facilities can become inoperable or impaired in the incidence of flooding, severely impacting their communities.

Health and Human Services

Floods can have an extensive impact on the health of the public, directly and indirectly. Most flood-related deaths are from drowning, but physical trauma, heart attacks, electrocution, and carbon monoxide poisoning also account for flood-related mortalities. Furthermore, flooding can damage and restrict access and utilities to schools, hospitals, nursing homes, and assisted living facilities infrastructure, leading to loss of education and health care services.

Water Supply and Water Treatment

Water supply and wastewater treatment facilities generally operate 24 hours a day, seven days a week, 365 days of the year. Floods can contaminate water supply sources such as wells, springs, and lakes/ponds through polluted runoff laden with sediment, bacteria, animal waste, pesticides, and industrial waste and chemicals. Floods can also physically damage or render inoperable water treatment plants to further incapacitate a community's water supply.

Due to their usual proximity to active water bodies such as rivers and streams, multiple wastewater treatment plants are located in low-lying areas within the region. These low-lying areas are generally within or near floodplains. Flooded wastewater treatment plants can cause physical damage, chemical spills, and raw sewage spills, among other issues. These facilities generally receive chemical deliveries, material deliveries, and other critical equipment deliveries regularly. Without those deliveries, operations may cease within a couple of days. Additionally, shift changes enable safe operation. Without access to the facility, personnel is unable to relieve the shift on duty, causing unsafe conditions for on-duty staff.

Utilities and Energy Generation

Energy generating and distributing facilities generally operate 24 hours a day, seven days a week, 365 days of the year. Flooded energy generation and distribution facilities can cause physical damage and loss of operation. These facilities regularly receive chemical, hydrogen, and other critical equipment deliveries. Without those deliveries, operations may cease for a couple of days. Additionally, shift changes enable safe operation. Without access to the facility, personnel is unable to relieve the shift on duty, causing unsafe conditions for on-duty staff.

Transportation

Transportation systems are vital to the Lower Colorado-Lavaca Region's economy. This plan evaluates transportation as exposed roadway crossings or roadway segments that are impacted by flood events, such as poorly-drained stretches of road or low water crossings. Roadway segments impacted by flooding result in the loss of transportation routes needed by the first responders and the public alike.

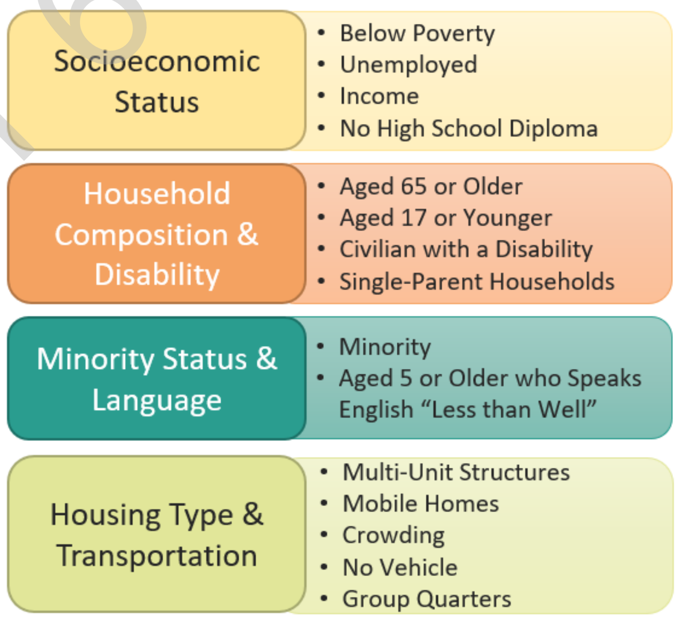
Agriculture

The impact of flooding on agriculture, ranching, and range/pasture can be severe and have serious local and regional economic consequences. Floods can delay the planting season as they immerse the fields and make them impassable for heavy equipment. This can lead to decreased crop size, lower yields, and reduced profits. When floods occur as crops grow in the fields, they can destroy an entire 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 could drown in floodwaters if they do not have access to a higher elevation where they can escape. Even if the livestock is safe, the damage could occur to barns and other buildings, and cleanup of muck and debris can affect their feeding grounds. Forestry or orchard operations can lose trees to fast-moving waters and erosion, instantaneously wiping out years of growth.

Existing Conditions Vulnerability Analysis

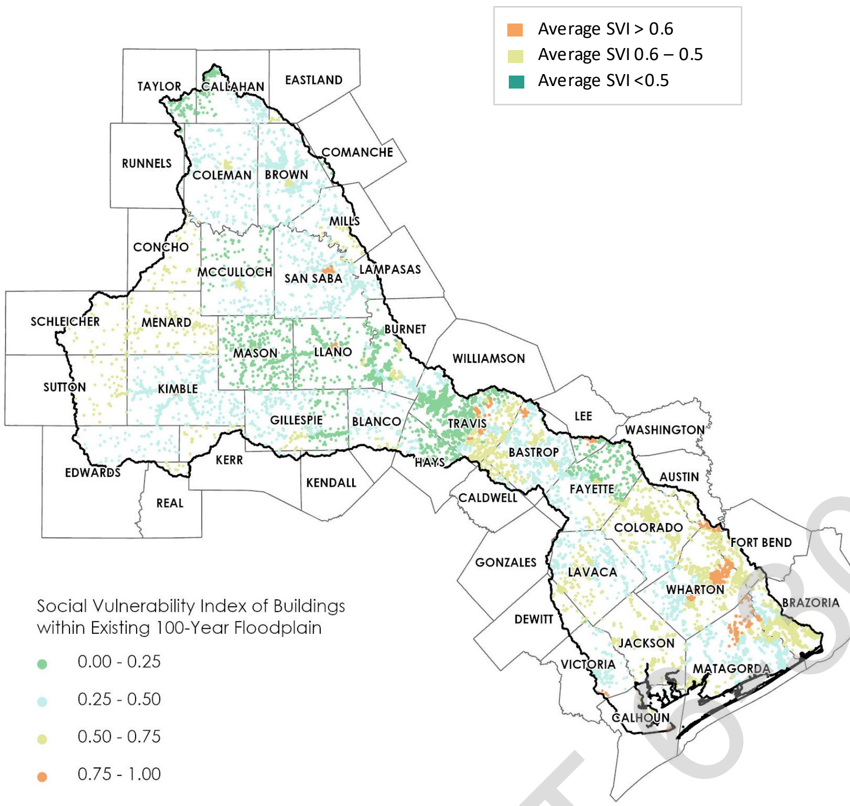
The vulnerability analysis uses the data from the existing condition flood exposure analysis to determine the vulnerability of exposed structures and population to flooding. Vulnerability is an assessment of the potential negative impact of flood hazards on communities as well as a description of the impacts. The 2018 Social Vulnerability Index (SVI) data developed by the United States Centers for Disease Control and Prevention (CDC) is used to assess social vulnerabilities within the Lower Colorado-Lavaca Region.

Figure 2.16 CDC Themes considered in the Social Vulnerability Index



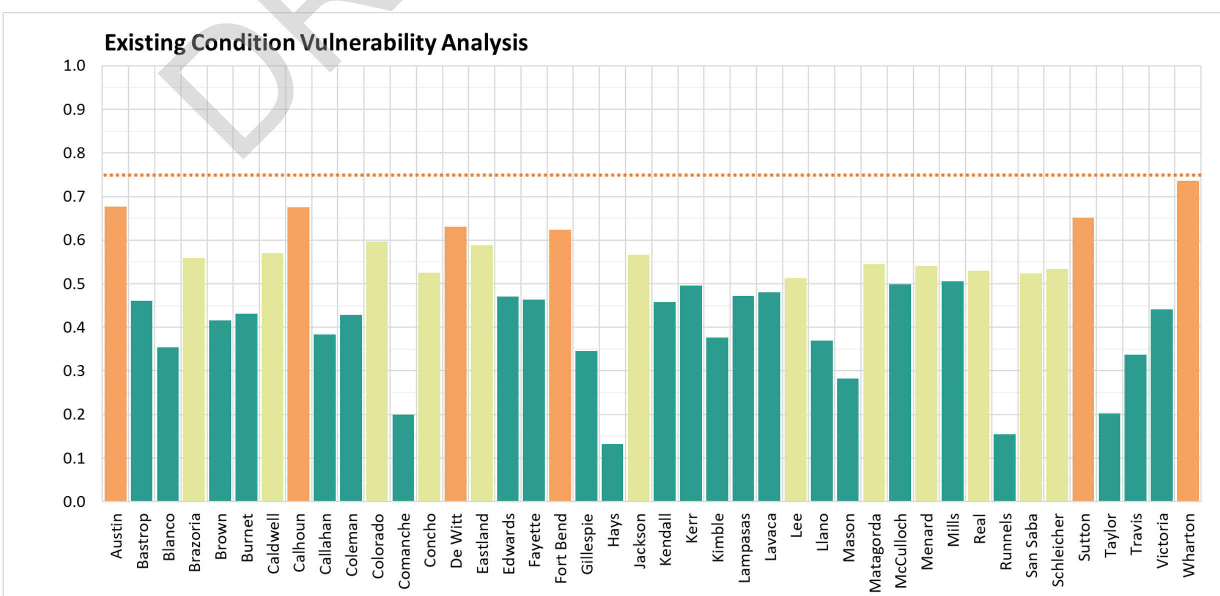
The CDC calculates the SVI at the census tract level within a specified county using 15 sociable factors, including poverty, housing, ethnicity, and vehicle access, and groups them into four related themes: Socioeconomic Status, Household Composition, Race/Ethnicity/Language, and Housing/Transportation. Each tract receives a separate ranking for each of the four themes, as well as an overall ranking. *Figure 2.16* shows the CDC themes used in the SVI calculation.

Figure 2.17 Social Vulnerability Index of Buildings within the Existing 100-Year Floodplain



Social vulnerability is the measure of the capacity to weather, resist, or recover from the impacts of a hazard in the long and short term. An SVI rating represents the relative level of a community's vulnerability compared to similar communities. SVI values between 0.75 and 1 denote populations with high vulnerability. *Figure 2.17* and *Figure 2.18* show the SVI results of structures within the existing condition 1 percent annual chance (100-year) floodplain. This figure shows the largest clusters of buildings with the highest vulnerabilities are within Wharton and Matagorda counties. Austin, Calhoun, De Witt, Fort Bend, Sutton, and Wharton counties all have a mean SVI of over 0.6. All but Sutton are located in the lower third of the Lower Colorado-Lavaca Region.

Figure 2.18 Existing Condition Vulnerability Analysis Results for Exposed Buildings and Critical Facilities in the Floodplain



Vulnerability of Critical Facilities

The 2018 CDC SVI data was overlaid with the at risk critical facility dataset for the Lower Colorado-Lavaca Region to attribute their associated SVI values. The SVI values for the critical facilities are summarized by county averages, as shown in *Table 2.6*.

Table 2.6 SVI Averages of At Risk Critical Facilities by County

County*	Number of Critical Facilities at Risk	Critical Facility SVI Average	County*	Number of Critical Facilities at Risk	Critical Facility SVI Average	County*	Number of Critical Facilities at Risk	Critical Facility SVI Average
Austin	1	0.77	Fayette	10	0.68	Matagorda	9	0.5
Bastrop	12	0.4	Fort Bend	1	0.58	McCulloch	5	0.6
Brazoria	11	0.56	Gillespie	3	0.36	Menard	8	0.54
Brown	7	0.49	Hays	2	0.06	San Saba	2	0.81
Burnet	3	0.63	Jackson	4	0.59	Travis	12	0.27
Coleman	1	0.56	Lavaca	1	0.7	Victoria	4	0.47
Colorado	12	0.63	Llano	3	0.41	Wharton	7	0.86

*Not all counties are listed in the table, as not all counties in the region have at risk critical facilities within their limits.

Not all counties are listed in the table as not all counties in the Lower Colorado-Lavaca Region have critical facilities within the existing condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain.

Austin, San Saba, and Wharton counties all have an average SVI for at risk critical facilities of over 0.75, indicating high vulnerability. Although Colorado and Fayette counties' averages are slightly lower at 0.63 and 0.68, both have large counts with over 10 facilities at risk.

Resiliency of Communities

Community resilience is a measure of the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. FEMA has created a Resilience Analysis and Planning Tool (RAPT) that calculates the resiliency of a community (in this case, by county) compared to other similar communities. RAPT takes into consideration a multitude of factors by county, including, but not limited to:

- Population over age 65
- Population with a disability
- Population without a high school diploma
- Unemployed population
- Population lacking health insurance
- Households with limited English proficiency
- Single-parent households
- Households without a vehicle
- Public schools per 5,000 residents
- Hospitals per 10,000 residents

The community resilience score is inversely proportional to a community's risk. A higher community resilience score results in a lower risk index score. A score of zero is average resilience for similar communities. A positive number between zero and one indicates better resilience than similar communities, and a negative number between negative one and zero indicates less resilience than similar communities. *Table 2.7* shows the resiliency score for the counties in the Lower Colorado-Lavaca Region as calculated by RAPT.

Table 2.7 Resiliency Score By County

County	Resiliency Score	County	Resiliency Score	County	Resiliency Score	County	Resiliency Score
Austin	-0.05	Comanche	-0.08	Kendall	0.07	Mills	-0.27
Bastrop	-0.29	Concho	-0.72	Kerr	-0.34	Real	-0.37
Blanco	-0.25	De Witt	-0.14	Kimble	-0.14	Runnels	0.07
Brazoria	0.3	Eastland	-0.2	Lampasas	-0.25	San Saba	-0.17
Brown	-0.02	Edwards	-0.4	Lavaca	0.27	Schleicher	-0.07
Burnet	-0.29	Fayette	-0.21	Lee	-0.1	Sutton	0.14
Caldwell	-0.44	Fort Bend	0.37	Llano	-0.72	Taylor	0.07
Calhoun	-0.32	Gillespie	-0.11	Mason	-0.56	Travis	0.07
Callahan	-0.1	Gonzales	-0.34	Matagorda	-0.17	Victoria	0
Coleman	-0.1	Hays	-0.02	McCulloch	-0.22	Wharton	-0.25
Colorado	-0.06	Jackson	-0.05	Menard	-0.82		

Certain documentation can help promote a community's flood resiliency, such as Hazard Mitigation Plans (HMPs) or Floodplain Ordinances. Creating these and similar publications indicates an awareness of guidelines and best practices where flood resiliency is concerned.

Hazard Mitigation Plans are not an indicator of the likelihood of a given hazard but are a great planning tool to better understand hazards and potential mitigation measures. HMPs are not a requirement, but entities without HMPs can be considered less resilient than those with HMPs, sheerly from a preparedness standpoint. Currently, 33 (77 percent) of the counties in the Lower Colorado-Lavaca Region either have an HMP on file with the Texas Department of Emergency Management (TDEM) or are actively in the development or adoption phases of the process. Ten counties (23 percent) do not have an HMP on file with TDEM, or the HMP on file has expired.

Table 2.8 Status of Hazard Mitigation Plans within the Lower Colorado-Lavaca Region

County	HMP Approved by FEMA	HMP Approved - Expires within Next Year	HMP in Review, Revision, or Adoption	HMP in Development or Update	HMP Expired - Seeking or Pending Funding	HMP Expired - Not Developing
Austin	X					
Bastrop				X		
Blanco				X		
Brazoria	X					
Brown	X					
Burnet				X		
Caldwell	X					
Calhoun		X				
Callahan	X					
Coleman	X					
Colorado					X	
Comanche	X					
Concho						X

County	HMP Approved by FEMA	HMP Approved - Expires within Next Year	HMP in Review, Revision, or Adoption	HMP in Development or Update	HMP Expired - Seeking or Pending Funding	HMP Expired - Not Developing
De Witt	X					
Eastland	X					
Edwards					X	
Fayette					X	
Fort Bend		X				
Gillespie	X					
Gonzales		X				
Hays		X				
Jackson			X			
Kendall	X					
Kerr	X					
Kimble					X	
Lampasas				X		
Lavaca	X					
Lee		X				
Llano				X		
Mason		X				
Matagorda		X				
McCulloch						X
Menard						X
Mills		X				
Real					X	
Runnels	X					
San Saba		X				
Schleicher						X
Sutton						X
Taylor	X					
Travis		X				
Victoria		X				
Wharton	X					

Like Hazard Mitigation Plans, floodplain ordinances are not an indicator of flood events; however, they are an indicator of resiliency in a community. Much of the state is experiencing unprecedented population growth and development along with a likely increase in rainfall caused by climate variability. Floodplain ordinances help guide the community to develop safely and with minimal impacts on the day-to-day life of their constituents in the case (however unlikely) of a flood event. Only 21 counties (58 percent) in the Lower Colorado-Lavaca Region have Floodplain Ordinances on file with the National Flood Insurance Program or the Texas Water Development Board. Fifteen counties (42 percent) do not have floodplain ordinances on file. This does not consider any individual cities, towns, or other smaller jurisdictions within a county that may have adopted more stringent floodplain ordinances than the counties where they reside.

Summary of Existing Conditions Flood Exposure Analysis and Vulnerability

The existing flood risk, exposure, and vulnerability for the Lower Colorado-Lavaca Region are summarized in *TWDB-Required Table 3*. The *TWDB Table 3* provides the results of the existing flood exposure and vulnerability analysis by county as outlined in the Technical Guidelines for Regional Flood Planning.

Table 2.9 outlines the files in the TWDB-required geodatabase included with this chapter. These deliverables comply with Exhibit D: Data Submittal Guidelines for Regional Flood Planning.

Table 2.9 Geodatabase Layers Indicative of Existing Condition Flood Risk in the Lower Colorado-Lavaca Region

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Existing Flood Hazard	Perform existing condition flood hazard analyses to determine the locations and magnitude of both 1% and 0.2% annual chance flood events	ExFldHazard	Polygon
Flood Mapping Gaps	Gaps in the existing condition inundation boundary mapping	Fld_Map_Gaps	Polygon
Existing Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polygons) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	ExFldExpPol	Polygon
	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polylines) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	ExFldExpLn	Line
	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as points) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	ExFldExpPt	Point
	High-level, region-wide information was identified in the flood hazard analysis, indicating all features (represented as points) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	ExFldExpAll	Point
	High-level, region-wide information was identified in the flood hazard analysis, indicating all active well features (represented as points) that may be at risk for the existing condition 1% and 0.2% annual chance flood events.	Ex_RRC_ ActiveWells	Point

Task 2B: Future Condition Flood Risk Analyses

Future Condition Flood Hazard Analysis

Estimation of Future Conditions for Planning Purposes

In terms of flood risk analysis, the future conditions assessment is a characterization of conditions for the planning area based on a "no-action" scenario of approximately 30 years of continued development and population growth under current development trends and patterns, existing flood regulations and policies, as well as anticipated climate and land changes. The following paragraphs summarize the RFPG's assessment of future condition factors.

Development and Population Growth

As described in *Task 1: Planning Area and Description*, the current growth patterns are generally projected to continue over the next 30 years, with greater concentrations of the population being aggregated in urbanized areas and possible continuation of declining population in more rural areas. The analysis for this section was undertaken using the Water User Groups and HUC-8 watershed population projections provided to each region by the TWDB from the State Water Plan. From 2020 to 2050, the population is projected to increase from 1.9 million people to almost 2.9 million people. This is an increase of 33 percent from 2020 to 2050. *Figures 1.3, 1.5, 1.6,* and *1.7* in *Task 1: Planning Area and Description* show the population distributions across the Lower Colorado-Lavaca Region.

Population increases typically lead to more development. New growth generally develops over open lands and natural areas by increasing impervious surfaces while simultaneously reducing the land's natural ability to absorb flood water. In these areas, increased flood management and mitigation efforts are needed to prevent future populations from being placed in areas of increased flood risk.

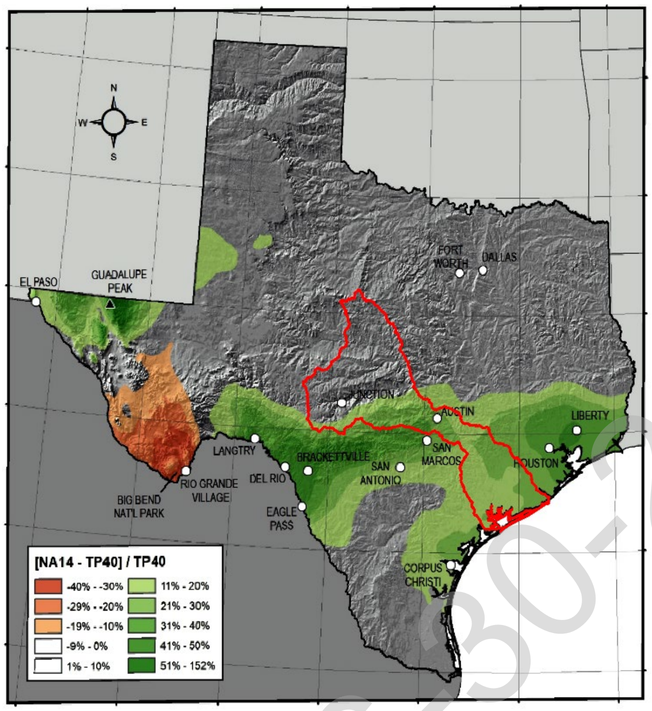
Climate Changes

Climate change refers to long-term shifts in temperatures and weather patterns. These changes may be due to changes in natural patterns or activities directly or indirectly linked to human activities. In addition to the observed changes, the period of record for gathering and analyzing weather data allows for a better understanding of future risks due to severe weather. An example is the long-term observation and analysis of rainfall data that was updated in 2018, 50 years after its initial release.

Potential Future Rainfall

Changing rainfall patterns in the basin significantly contributes to increased flood risk. Two major rainfall atlases have been completed in the Lower Colorado-Lavaca Region, which ultimately covers the entire country. Technical Paper Number 40 (TP-40) was released in 1962, and NOAA Atlas 14, an update to TP-40, was released in 2018. As a result of the new analysis, the rainfall associated with a 1 percent annual chance flood event and used to create floodplain models and maps increased 10-30 percent in the lower third of the basin and 10-40 percent in the central portion of the region. *Figure 2.9* shows the statewide historical change in rainfall. The Texas State Climatologist report, "Climate Change Recommendations for Regional Flood Planning," states that *climate change may lead to substantial increases in flood vulnerability over and above increases due to greater population*. Increased rainfall in a community without increased mitigation will result in more expansive flood hazard areas. Anticipated further increases in rainfall throughout the region were reflected in the increased future conditions flood hazard area.

Figure 2.19 Rainfall Increase between Atlas 14 and TP-40



Potential Future Sea Level

Relative sea level change refers to the change in sea level compared to land elevation at a particular location. Sea level change is understood to be affected by global and local phenomena, including changes in:

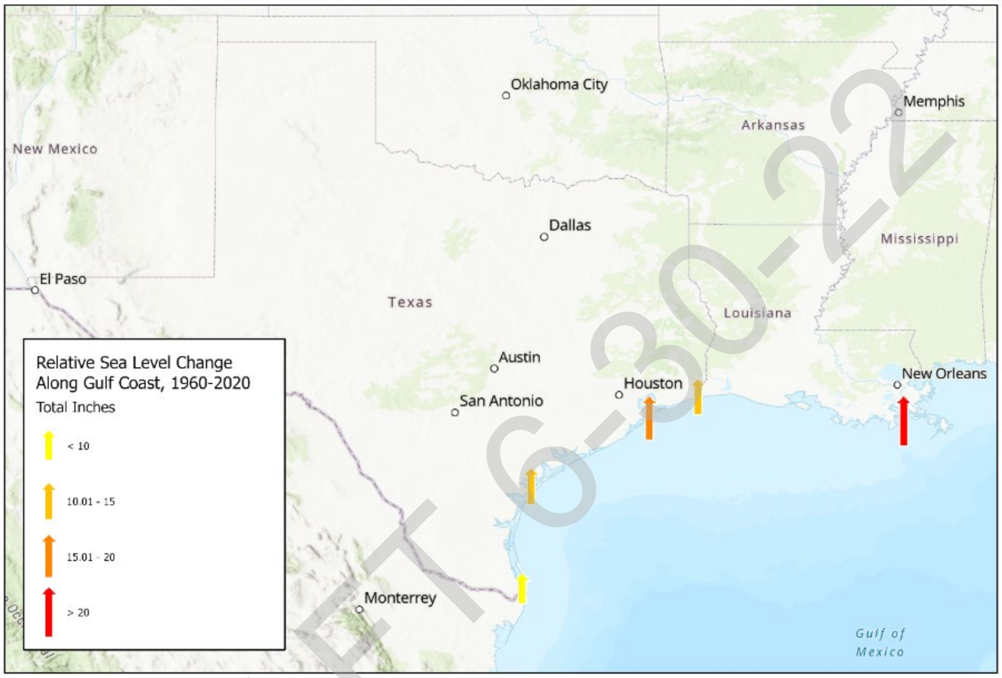
- Ocean mass associated with long-term forcing of the ice ages ultimately caused by small variations in the orbit of the earth around the sun
- Density from total salinity
- Heat content of the world's ocean
- Estuarine and shelf hydrodynamics
- Regional oceanographic circulation patterns (often caused by changes in regional atmospheric patterns)
- Hydrologic cycles (river flow)
- Local and/or regional vertical land motion (subsidence or uplift)

Relative sea level change can increase flood hazards in low-lying coastal communities. The Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (USACE) developed a methodology for tracking relative sea level change by quantifying the average number of coastal flood events per year and estimating anticipated future relative sea level change. *Figure 2.20* shows the average number of coastal flood events per year for various Gulf Coast communities. The EPA found that each station experienced a significant increase in the quantity of annual coastal flooding compared to previous decades. From 1960 to the present, the National Oceanic and Atmospheric Administration (NOAA) tide gauges along the Texas and Louisiana coasts recorded a relative sea level increase of 10 to 20 inches, as shown in *Figure 2.21*. During this timeframe, the Rockport Gage has experienced XX total inches of measured sea level rise.

The USACE has developed a methodology to estimate future relative sea level change by calculating "low," "intermediate," and "high" scenarios. The "low" scenario projects a continuation of the currently observed linear sea level trend. The "intermediate" scenario uses the National Research Council (NRC) I model with low assumed values for global and local phenomena. The "high" scenario uses the NRC III model with assumed values for global and local phenomena, as well as low assumptions for glacier melt.

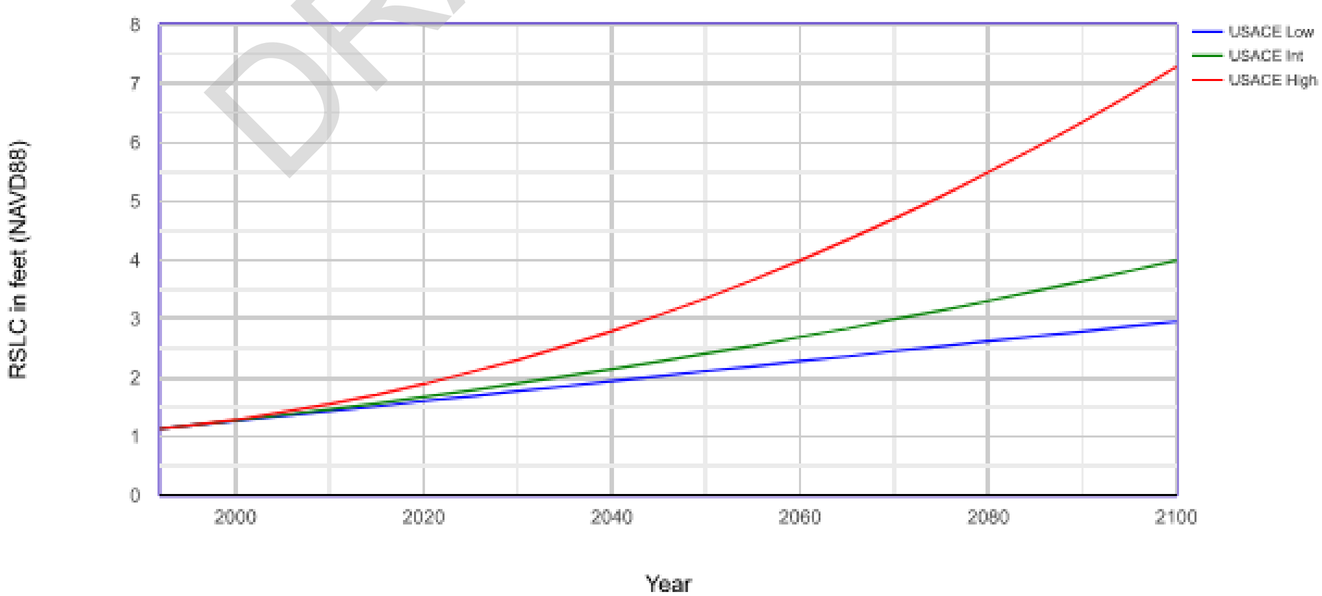
Figure 2.20 shows the relative sea level change experience along the Gulf Coast from 1960-2020. *Figure 2.21* shows the USACE projected relative sea level change at Rockport, Texas. The projected "low" relative sea level change over the next 30 years is approximately 1.1 feet. The "intermediate" sea level rise projected over the next 30 years is approximately 1.5 feet, and the "high" scenario is approximately 2.5 feet by 2050.

Figure 2.20 Relative Sea Level Change Along Gulf Coast



Adapted from EPA's Climate Change Indicators in the United States: www.epa.gov/climate-indicators

Figure 2.21 Relative Sea Level Change Projection for Rockport (Gauge: 8774770)



Land Changes

Sedimentation, erosion, and geomorphic changes throughout the basin can influence flood risk, particularly along the affected river reaches but are not anticipated to significantly impact future floodplains. Geomorphic changes, for instance, are not likely to have significant regional impacts. However, erosion or shifts in the river plan form or profile can affect the existing infrastructure by threatening the structural stability of bridges or pump stations and reducing the conveyance in stream segments and culverts.

Potential Geomorphic Changes

Sediment transport on a river system is a complex phenomenon with substantial geographic and temporal variability, and predicting geomorphic changes requires detailed data collection and modeling. Predicting stream plan form, profile, and shape changes are even more difficult at a regional scale due to variations in rainfall, geology, and topography. Therefore predicting how geomorphic changes could impact future flood risk is not feasible at the regional scale. However, the general or potential effects can be considered. Two common impacts are channel degradation, which can result in downcutting and widening of creeks and rivers that threaten surrounding infrastructure and damage riparian corridors, or channel aggregation, which is often the result of man-made structures (i.e., culverts) that reduce local conveyance capacity and increase local flood risk. These challenges can be addressed through routine maintenance programs and project designs considering pre-and post-project channel dynamics.

Another method many cities use to account for uncertainty is implementing erosion hazard setbacks. These include a stream buffer to prohibit development and disturbance, and the methods used to establish the zones vary from community to community.

Potential Sedimentation

Sediment transport on a river system is a complex phenomenon with substantial geographic and temporal variability. The Lower Colorado-Lavaca Basin has a number of reservoirs and dams that protect people and property from floods; many have other uses, such as recreational and water supply. Historically, reservoirs have been designed with storage capacities to offset sediment deposition and achieve the desired reservoir life, commonly known as “dead storage,” which is a portion of its storage capacity that is essentially set aside for sediment deposition during the design life of the structure. Thus, sedimentation within the reservoirs will primarily impact the conservation pool, which is more likely to impact future water supply rather than flood control. The TWDB Surface Water Resources Division conducts surveys on major reservoirs (>5,000 ac-ft storage) about every 10 to 12 years to, among other things, estimate sedimentation levels and rates to support the State Water Planning efforts.

Completed Flood Mitigation Projects

Approximately 20 sponsors indicated they had ongoing or proposed flood mitigation projects far enough in design or implementation to be considered complete for the 2023 Regional Flood Plan. The information about these projects is limited; however, the projects appear to be focused on local flood mitigation and are not anticipated to have a statistically significant impact on the future regional flood risk exposure or vulnerability. If additional information or review changes that initial assessment, the flood risk assessment will be updated accordingly.

Best Available Future Condition Flood Risk Data

Consistent with the existing condition analysis, all flood risk types were considered in identifying the best available future condition flood hazard data for the Lower Colorado-Lavaca Region. It should be noted that the potential future condition flood hazard maps, as is the case with existing conditions maps, are for planning purposes only and are not to be used for floodplain regulation. Rather, these flood hazards represent the potential future flood risk in 30 years if no mitigation actions are implemented.

Future Condition Hydrology & Hydraulic (H&H) Model Availability

As noted under the existing condition model availability, H&H models are not available across the Lower Colorado-Lavaca Region. The City of Austin and other regional entities are updating hydrologic and hydraulic models to incorporate NOAA Atlas 14 rainfall data. Many of these studies will also include future condition hazard analysis. These updated models, and the resultant map products, are expected to be available for use in the next regional flood planning cycle. There are currently no future condition hydrology and hydraulic models available within the Lower Colorado-Lavaca Region that account for a "no-action" scenario of approximately 30 years of continued development, population growth, and anticipated climate and land changes.

Future Condition Floodplain Quilt

As outlined in the guidance documents, the TWDB suggested four options for estimating potential future condition flood risk. These four options include increasing water surface elevation or floodplain extent, utilizing a proxy floodplain, combining methods, or requesting TWDB desktop analysis. Given the lack of sufficient future condition models, a combination of a proxy floodplain and an increase in floodplain extent would be utilized to estimate the potential future condition flood hazard boundaries.

For the Lower Colorado-Lavaca Region, the potential future condition flood risk was estimated using the following methods:

- Utilize the existing condition 0.2 percent annual chance (500-year) floodplain as a proxy for the potential future condition 1 percent annual chance (100-year) floodplain.
- Estimate the potential future condition 0.2 percent annual chance (500-year) floodplain using a horizontal buffer based on the measured difference (delta) between the existing condition 1 percent annual chance (100-year) and the existing 0.2 percent annual chance (500-year) floodplain.

Table 2.10 outlines the specific sources and methods utilized to generate the future condition floodplain quilt. The process used to compute the horizontal buffers (deltas) is explained below.

Table 2.10 Summary of Flood Hazard Analysis by Source

	Best Available		→						Most Approximate	
	Local Studies		NFHL Detailed Studies (Zone AE, AO, AH, and VE)		Base Level Engineering		NFHL Approximate Studies (Zone A)		Fathom	
	1%	0.2%	1%	0.2%	1%	0.2%	1%	0.2%	1%	0.2%
Existing	Local Study 1%	Local Study 0.2%	NFHL 1%	NFHL 0.2%	BLE 1%	BLE 0.2%	NFHL 1%	*Areas without 0.2% are gaps*	Fathom 1%	Fathom 0.2%
Future	Local Study Existing 0.2%	Delta Mapping applied to Local Study Existing 0.2%	NFHL Existing 0.2%	Delta Mapping applied to NFHL Existing 0.2%	BLE Existing 0.2%	Delta Mapping applied to BLE Existing 0.2%	Delta Mapping applied to NFHL Existing 1%	*Areas without 0.2% are gaps*	Fathom Existing 0.2%	Delta Mapping applied to Fathom Existing 0.2%

Based on a sampling of 155 delta locations across the Lower Colorado-Lavaca Region, it was decided a uniform horizontal buffer would not be appropriate. Rather horizontal buffers were generated in six regions, as shown in *Figure 2.22* and outlined in *Table 2.11*. Following the application of the delta buffers, small islands less than or equal to 2 acres were filled to avoid small gaps in the future condition floodplain boundary.

Figure 2.22 Draft Future Condition Buffer Regions

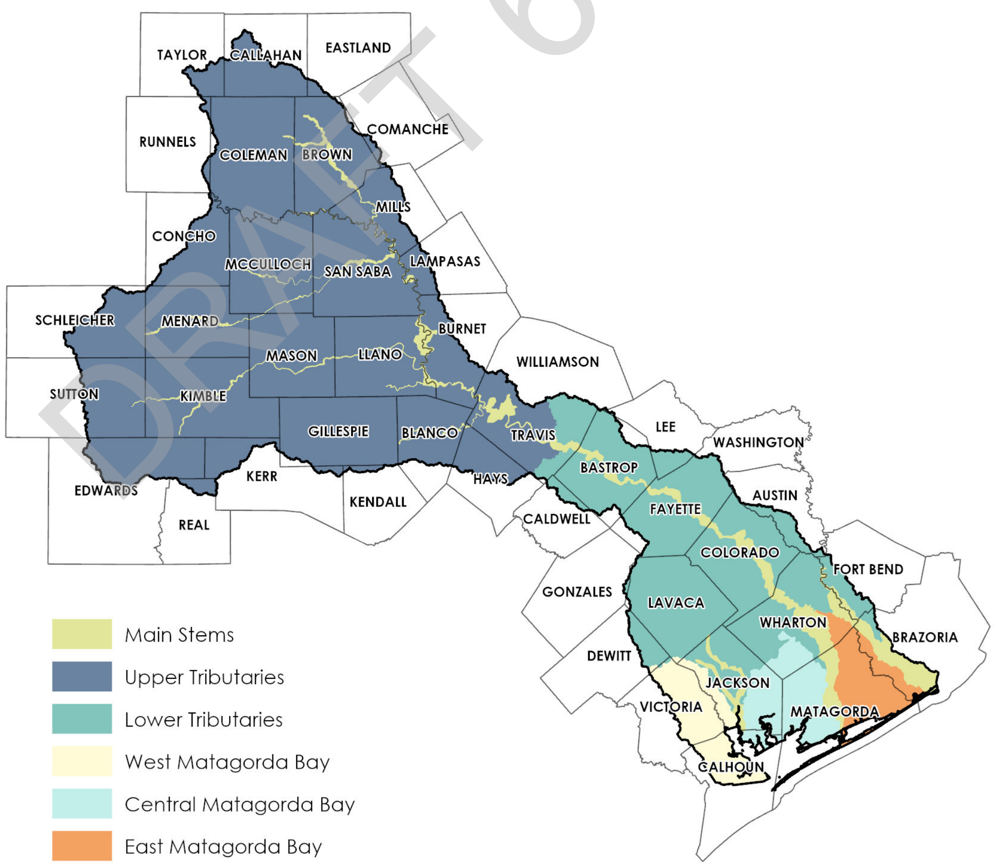


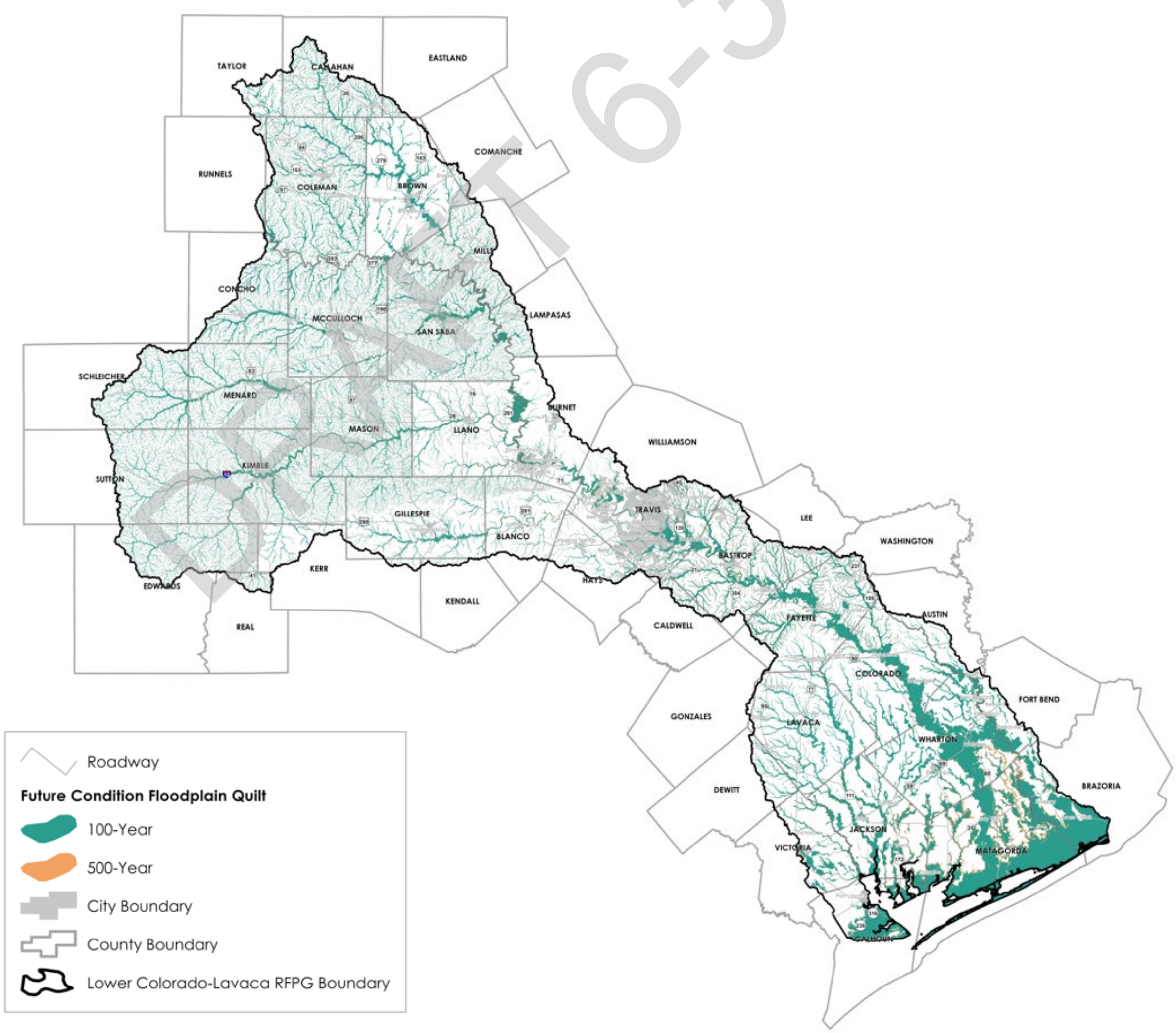
Table 2.11 Draft Future Condition Horizontal Buffers

Buffer Regions	Description	Buffer (feet)
River Main Stems	Main stem of rivers within each HUC	260
Tributaries Upper	Tributaries to the main stems north of Austin	15
Tributaries Lower	Tributaries to the main stems south of Austin	70
West Matagorda Bay	Tributaries west of the Lavaca River	75
Central Matagorda Bay	Tributaries between the Lavaca and Colorado Rivers	315
East Matagorda Bay	Tributaries between the Colorado and San Bernard Rivers	405

It should be noted that the potential future condition flood hazard maps, as is the case with existing conditions maps, are for planning purposes only and are not to be used for floodplain regulation. Rather, these flood hazards represent the potential future flood risk in 30 years if no mitigation actions are implemented.

The compiled future floodplain quilt data for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.23* shows a map of the comprehensive future flood hazard data compiled for the Lower Colorado-Lavaca Region. A larger, more detailed version of this figure is included as *TWDB-required Map 8*.

Figure 2.23 Future Condition Flood Hazard Map

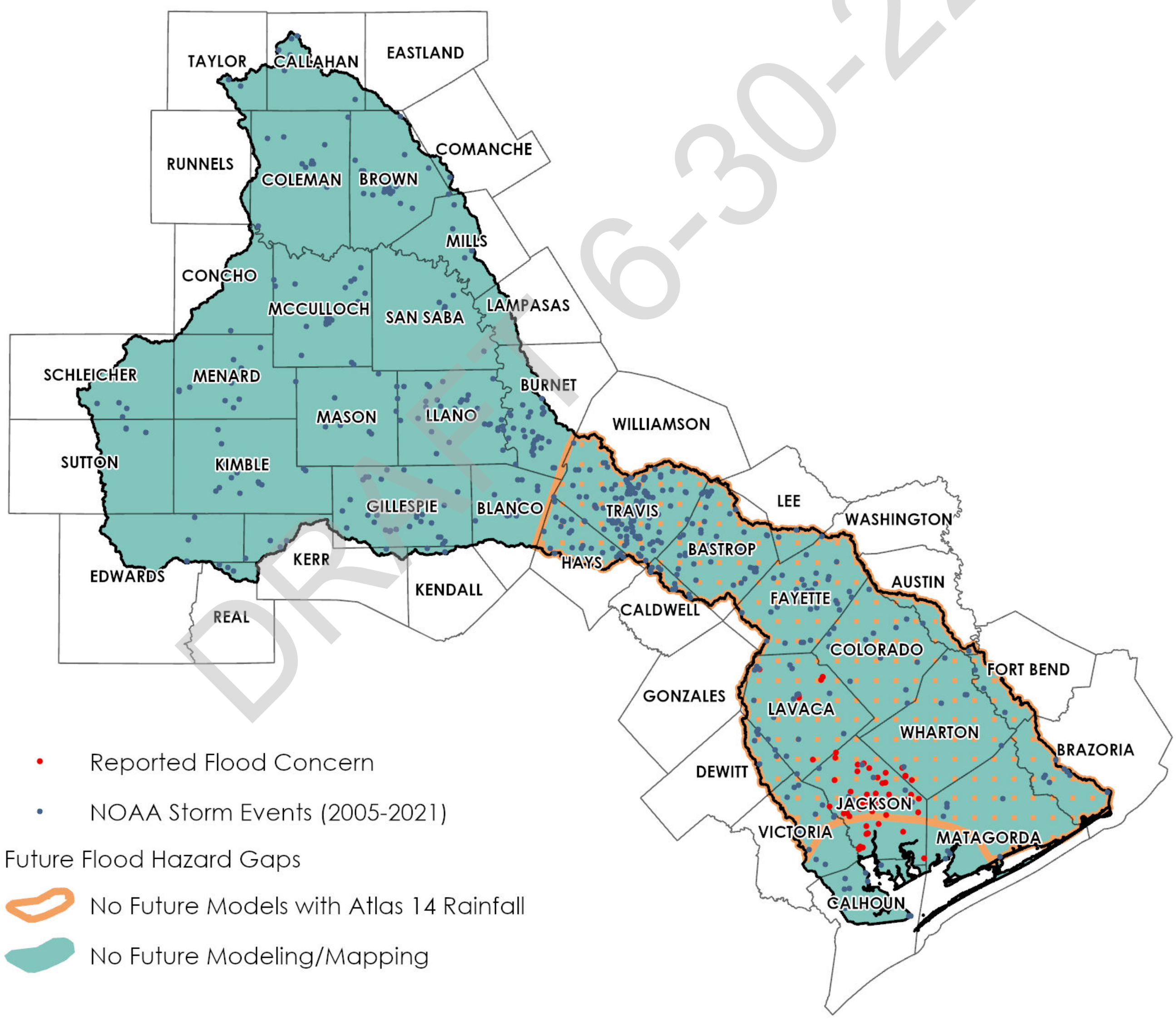


Future Condition Data Gaps

Once the best available comprehensive future condition flood data was complied, data gaps were assessed to identify any remaining areas where flood inundation boundary mapping was missing, lacked modeling and/or mapping, or used outdated modeling and/or mapping. Other contributing engineering factors considered to identify data gaps included anticipated development and population growth and anticipated climate and land changes.

Due to the absence of future condition analysis, the entire region is considered a gap lacking future condition modeling and mapping. The compiled existing condition gap analysis for the Lower Colorado-Lavaca Region is included in the geospatial submittal. *Figure 2.24* shows a map of the locations of identified existing condition flood data gaps. A larger, more detailed version of this figure is included as *TWDB-required Map 9*.

Figure 2.24 Future Condition Flood Hazard Gaps



Future Condition Flood Exposure Analysis

The future condition flood risk exposure analysis leveraged the compiled future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt in the Lower Colorado-Lavaca Region to estimate future flooding exposure to identify who and what might be at risk of flooding.

Potential Flood Exposure

The table below displays the region-wide exposure results for the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events. The following sections further describe the exposure analysis results for each exposure category.

Table 2.12 Summary of Future Condition Exposure in the Lower Colorado-Lavaca Region

Exposure Category	1% (100-year) Floodplain	0.2% (500-year) Floodplain	Difference
Floodplain Area (square miles)	5,385	5,963	578
Buildings	106,637	139,290	32,653
Residential Structures	*74,046*	*98,185*	*24,139*
Non-Residential Structures	*32,591*	*41,105*	*8,514*
Population (All Buildings)	251,626	326,173	74,547
Critical Facilities	207	264	57
Industrial and Power Generating Facilities	*19*	*22*	*3*
Roadway Low Water Crossings	1,120	1,141	21
Roadway Segments (miles)	4,353	5,599	1,246
Area of Agriculture (square miles)	4,270	4,785	515

Existing Development

Buildings (Structures)

A total of over 139,000 structures are located within the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt within the Lower Colorado-Lavaca Region. This reflects an increase of 36 percent in total buildings at risk and a 57 percent increase within the 1 percent annual chance (100-year) event from existing conditions.

Population

Population estimations of future condition exposure is approximately 250,000 and 326,000 people within the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplain quilt within the Lower Colorado-Lavaca Region. This reflects an increase of 36 percent of the total population and a 68 percent increase within the 1 percent annual chance (100-year) event from existing conditions.

Residential Properties

Over 98,000 residential building footprints are within the future 1 percent (100-year) and 0.2 percent (500-year) annual chance events in the Lower Colorado-Lavaca Region. An associated population of over 130,000 is estimated to be at risk of flooding. Residential structures account for 70 percent of both the total future condition at risk structures and those within the 1 percent annual chance (100-year) event.

Non-Residential Properties

The building dataset also included agricultural, commercial, industrial, and other public buildings. Over 41,000 non-residential building footprints were documented in the floodplain for the future 1 percent (100-year), and 0.2 percent (500-year) annual chance events in the Lower Colorado-Lavaca Region, indicating an estimated 30 percent of at risk buildings are non-residential structures.

Critical Facilities and Public Infrastructure

Of the over 1,700 critical facilities documented in the Lower Colorado-Lavaca Region, an estimated 12 percent of these critical facilities appear to be exposed to flooding within the future 1 percent annual chance (100-year) event. There are 264 critical facilities at risk within both the future 1 percent (100-year) and 0.2 percent (500-year) annual chance events accounting for 16 percent of those documented within the Lower Colorado-Lavaca Region.

Major Industrial and Power Generation Facilities

The future flood exposure analysis results indicate 22 power generation facilities at risk of flooding in the Lower Colorado-Lavaca Region. Similar to existing conditions, the majority of these facilities are energy plants.

Transportation

Of the over 29,000 transportation miles in the Lower Colorado-Lavaca Region, an estimated 21 percent of these segments are at risk of flooding in the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events. The highest mileage exposures are observed in Matagorda, Travis, and Wharton counties as was the result of existing condition exposure analysis, each with approximately 600 miles or more of at risk transportation segments. Roadways and railroad data from TxDOT were utilized following tabulating existing condition transportation values.

Of the over 1,300 low water crossings in the Lower Colorado-Lavaca Region, an estimated 84 percent of these crossings are at risk of flooding in the future condition 1 percent (100-year) and 0.2 percent (500-year) annual chance events.

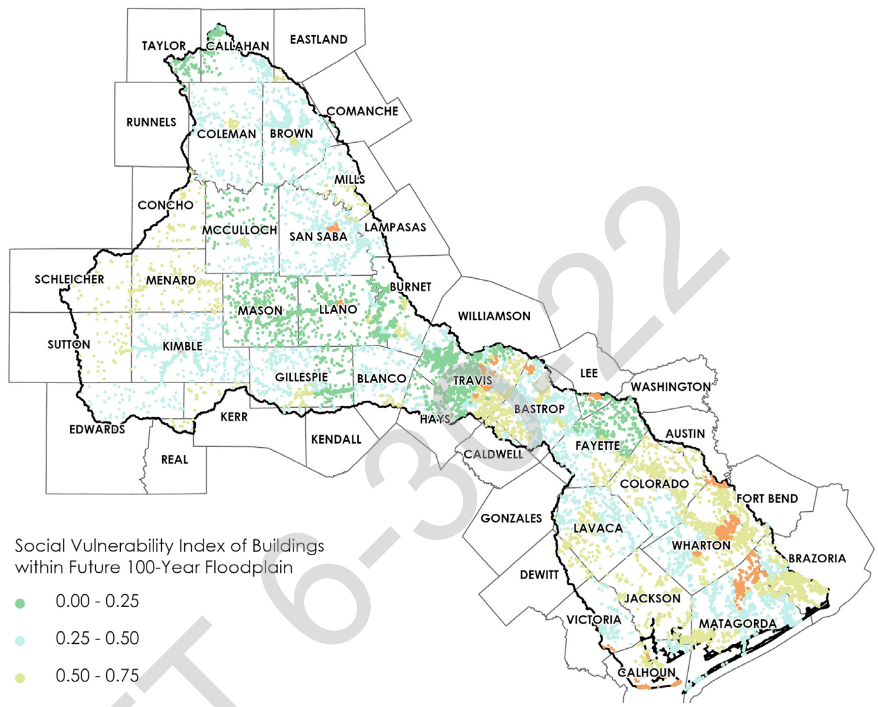
Agriculture

Future condition flood exposure analysis results show over 4,200 square miles of agricultural land at risk during the 1 percent annual chance (100-year) event and over 4,700 square miles at risk during the 0.2 percent annual chance (500-year) event. This is a 20 percent increase for the 100-year event and a 15 percent increase overall for both events from existing condition results.

Future Conditions Vulnerability Analysis

The vulnerability analysis uses the data from the future condition flood exposure analysis to determine the vulnerability of exposed structures and population to flooding. Consistent with the existing condition vulnerability analysis, the future condition vulnerability uses the 2018 SVI data developed by the CDC. An SVI rating represents the relative level of a community's vulnerability compared to similar communities. SVI values between 0.75 and 1 denote populations with high vulnerability. *Figure 2.25* shows the SVI results of structures within the future condition 1 percent annual chance (100-year) floodplain. Although the distribution of SVI values is similar to existing conditions, clusters are generally larger and denser due to the increase of at risk buildings in future conditions.

Figure 2.25 Social Vulnerability Index of Buildings within Future 100-Year Floodplain



Vulnerability of Critical Facilities

The increased flood risk associated with future conditions denotes greater risk for the critical facilities serving communities in these future flood scenarios. Increased losses following flooding of a greater magnitude results in more need for communities to receive support and access; however, it is coupled with an equally escalated vulnerability for the facilities needed to provide essential services.

Summary of Future Conditions Flood Exposure Analysis and Vulnerability

The future flood risk, exposure, and vulnerability for the Lower Colorado-Lavaca Region are summarized in *TWDB-Required Table 3*. The *TWDB Table 3* provides the results of the future flood exposure and vulnerability analysis by county as outlined in the Technical Guidelines for Regional Flood Planning.

Table 2.13 outlines the files in the TWDB-required geodatabase included with this chapter. These deliverables comply with Exhibit D: Data Submittal Guidelines for Regional Flood Planning.

Table 2.13 Geodatabase Layers Indicative of Future Condition Flood Risk in the Lower Colorado-Lavaca Region

Item Name	Description	Feature Class Name	Data Format Polygon/Line/ Point/GDB Table
Future Flood Hazard	Perform future condition flood hazard analyses to determine the locations and magnitude of both 1% and 0.2% annual chance flood events	FutFldHazard	Polygon
Future Flood Mapping Gaps	Gaps in the future condition inundation boundary mapping	FutFld_Map_ Gaps	Polygon
Future Exposure	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polygons) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpPol	Polygon
	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as polylines) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpLn	Line
	High-level, region-wide information was identified in the flood hazard analysis, indicating features (best represented as points) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpPt	Point
	High-level, region-wide information was identified in the flood hazard analysis, indicating all features (represented as points) that may be at risk for the future condition 1% and 0.2% annual chance flood events	FutFldExpAll	Point
	High-level, region-wide information was identified in the flood hazard analysis, indicating all active well features (represented as points) that may be at risk for the future condition 1% and 0.2% annual chance flood events	Fut_RRC_ActiveWells	Point