Exhibit C

Technical Guidelines for Regional Flood Planning[1]

NOTE: REMAINS SUBJECT TO NON-SUBSTANTIAL CHANGE

April 2021

First Cycle of Regional Flood Plan Development (2020–2023)

[1] This document augments existing statute and rules that govern regional flood planning. Provisions of Title 31 of TAC Chapters 361 and 362 serve as the foundation for much of the information in this document and are not superseded or abridged by anything contained within or excluded from this document.

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PART 1 – Orientation

1.1 Background

The TWDB designated 15 regional flood planning areas each of which then began with a designated regional planning group that will develop a regional flood plan for their region by January 2023. The TWDB will bring the regional flood plans together to produce the first state flood plan by September 1, 2024. While the regional flood plan development will be directed by the flood planning groups, in order to ensure that the regional flood plans will follow a consistent and credible approach, the Executive Administrator prepared the following guidelines to assist with the planning process. These guidelines augment the Texas Water Code and the administrative rules related to regional flood planning and are part of the regional flood planning grant contracts.

1.2 Purpose

These guidelines build upon and provide additional information and greater detail about how to implement the administrative rules, including regarding the required methods, content, and format of information to be contained and presented in each Regional Flood Plan (Plan) to meet rule and contractual requirements including the Scope of Work (SOW). For convenience, the sections of this document include excerpts directly from regional flood planning rules and the Exhibit A: Scope of Work followed by 'Additional Guidance' content provided by the Executive Administrator (EA).

While each regional plan will be unique to its region, this guidance is intended to ensure that the 15 regional flood plans are developed in a generally consistent and similar manner to produce information that may be combined and aggregated, at the state level, to support the development of a meaningful and credible state flood plan. The intent is to ensure that the 15 regions generally produce and provide 'apples to apples' data across the entire state including key information that will support the TWDB's development of a statewide ranking of all recommended flood projects in the state flood plan.

Depending upon the nature or importance of particular flood planning rules or contract tasks, this guidance intentionally varies in its degree of specificity and flexibility. This is to strike a reasonable balance between ensuring consistency across regions and yet giving the regional flood planning groups (RFPG) some room to maneuver to find the best ways to approach this new flood planning process. Some sections of this guidance provide very specific direction about certain work that must be performed and/or information that must be delivered, whereas other sections give the RFPGs significantly more flexibility and latitude in how they may meet the regional flood planning requirements. By providing examples, templates, and flexibility where possible, this guidance aims to assist the RFPGs in being successful during this first planning cycle. How the RFPGs apply this guidance, the innovative ways they may choose to develop their plans, including the choices they make within the latitude of this first guidance document, will help to shape the next regional flood planning cycle including informing the next version of this guidance.

The draft regional flood plans and the final adopted regional flood plans will be reviewed by TWDB based on statute, regional flood planning rules, as well as requirements that are included in this and all other contract documents including the SOW.

This document augments existing statute and rules that govern regional flood planning. Provisions of Title 31 of TAC Chapters 361, and 362 serve as the foundation for information in this document and are not superseded or abridged by anything contained within or excluded from this document**.**

For your reference, the Texas Water Code excerpts below list specific statutory requirements for regional and state flood plans.

Texas Water Code Section 16.062

A regional flood plan must:

(1) use information based on scientific data and updated mapping; and
(2) include:

(A) a general description of the condition and functionality of flood control infrastructure in the flood planning region;
(B) flood control projects under construction or in the planning stage;
(C) information on land use changes and population growth in the flood planning region;
(D) an identification of the areas in the flood planning region that are prone to flood and flood control solutions for those areas; and
(E) an indication of whether a particular flood control solution:

(i) meets an emergency need;
(ii) uses federal money as a funding component; and
(iii) may also serve as a water supply source.

Texas Water Code Section 16.061

The state flood plan must:

(1) provide for orderly preparation for and response to flood conditions to protect against the loss of life and property;
(2) be a guide to state and local flood control policy; and
(3) contribute to water development where possible.

The state flood plan must include:

(1) an evaluation of the condition and adequacy of flood control infrastructure on a regional basis;
(2) a statewide, ranked list of ongoing and proposed flood control and mitigation projects and strategies necessary to protect against the loss of life and property from flooding and a discussion of how those projects and strategies might further water development, where applicable;
(3) an analysis of completed, ongoing, and proposed flood control projects included in previous state flood plans, including which projects received funding;
(4) an analysis of development in the 100-year floodplain areas as defined by the Federal Emergency Management Agency; and
(5) legislative recommendations the board considers necessary to facilitate flood control planning and project construction.

1.3 General format and content of this document

This guidance consists of three Parts:

Part 1 – Orientation includes background orientation material and a *General Document Cross-Reference* (below) that illustrates how the administrative rules, contract scope of work, and guidance documents, all relate and align with one other.

Part 2 – Scope of Work Task-Specific General Guidelines includes general guidance organized by Contract Scope of Work tasks and related rules sections. Each task in this section is organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements. The section identifies various summary table that are required to be included in the technical memo and the flood plan. An excel template file "Exhibit C Tables" is made available with this guidance document that includes the summary tables that are required to be included.

Part 3 – Technical Guidance includes broader 'technical guidelines' that describe more substantial technical approaches and methodologies that must be followed and that apply more broadly to multiple analyses that will occur under multiple scope of work tasks and/or administrative rule items.

Tables – Example data is presented in tables for the purpose of making data entry clearer.

Note that, throughout the document, verbatim statute, rule, and Scope of Work language that is included at the top of most sections (for convenience) is 'greyed' in order to distinguish it as such.

1.4 General guidance

1. The regional flood plan must include an Executive Summary including key findings and recommendations.
2. This guidance document includes the minimum reporting requirements where information and data are available. It is understood that during the first planning cycle, the RFPGs may not be able to generate all information requested in the guidance documents. The RFPGs must document reasonable effort for generating the requested information in the case where they are not able to include it. An RFPG may present more information and findings in their plan than is required by this guidance.
3. RFPGs must submit all data identified in Exhibit D: Data Submittal Guidelines to the TWDB.
4. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields but will not have any data. This geodatabase template is not to be altered, reduced, or limited in any manner that would detract from the original template. These templates must be maintained and returned in a manner that will allow the TWDB to easily assemble a statewide dataset from the 15 templates when they are provided, populated with data, back to the TWDB. If region specific need for any changes arise, TWDB will review those requests from RFPGs.
5. All maps that are included as part of each regional flood plan, either within the published plan document or as a supplement to the plan, must be submitted with underlying GIS data utilized to prepare them.
6. The regional flood plan is intended to include data reflective of a ***planning level*** analysis.
7. It is understood that not all communities have the level of details requested in the technical guidelines. Many rural counties and smaller cities have limited detailed data and further have limited staff available to process through the data. There may be a disparity between communities who had the prior level of details and expertise required to identify flood projects, for example, and those that did not. These guidelines seek to work towards reducing that gap in

upcoming years and planning cycles by identifying areas where further evaluations and resources are needed to reduce the risk of flooding in all of Texas.

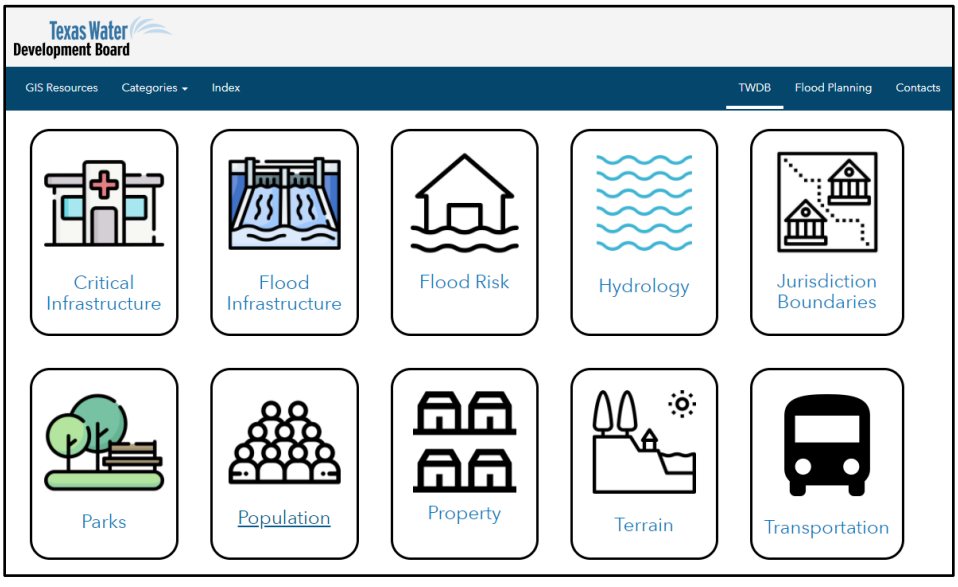
8. RFPGs may request an exception (waiver) to certain requirements and selected study approaches of this guidance document. The requested approach must adhere to all statutory and rule requirements and will be subject to the approval of the Executive Administrator.

1.5 Documents and files that accompany and are integral to implementing this guidance

1. **Exhibit C Tables**: An excel template file called "Exhibit C Tables" accompanies this guidance document and includes the summary tables that are required to be included in the technical memo, the draft regional flood plan, and the final regional flood plan document. The excel spreadsheet must be filled in and submitted with the technical memo, draft flood plan and the final flood plan with associated information.
2. **Exhibit D Data Submittal Guidance Document:** This is a separate document that supports this guidance. To help link guidance found in this document to Exhibit D, references to specific datasets (which are described in detail in Exhibit D) will be made using curly brackets ("{ … }"). The reference will point to the File # and Feature Class name listed in Exhibit D Table 1. For example, {7. ExFldHazard} points to File # 7, the feature class for Existing Flood Hazard.
3. **BCA Input Tool:** The TWDB funded and guided the development of a user-friendly benefit-cost analysis (BCA) input interface and analysis tool in the form of a spreadsheet document that works in conjunction with the FEMA BCA Toolkit. The BCA input tool is being provided alongside this guidance document.
4. **Data Hub**: To support the RFPGs, the TWDB Flood Data team has assembled a wide array of flood-related data. The data, all of which come from publicly available sources, has been centralized into a single, easy-to-use Data Hub:

   https://twdb-flood-planning-resources-twdb.hub.arcgis.com/

Figure 1: TWDB Flood Planning Data Hub



To download from the Hub, first navigate to the category by selecting the corresponding icon, and then select the data tile of interest. An index is also available here.

1.6 General document cross-reference

Regional Flood Planning Contract Document References				2023 Regional Flood Plan Chapter, Associated TAC Sections, and Content		
TWDB Contract Reimbursement Accounting Number ('CAS')	**Exhibit A** – Scope of Work Task	**Exhibit C** – Technical Guidelines for Regional Flood Planning	**Exhibit D** – Data Submittal Guidelines for Regional Flood Planning (File # in Table 1): Required Spatial Data)	Regional Flood Plan Chapter Number	Primary TAC Section	General Content
1	1	1	1–6	**1**	361.30; 361.31; 361.32	Planning Area Description
2	2A	2	7–12	**2**	361.33	Existing Condition Flood Risk Analyses
3	2B		13–17		361.34	Future Condition Flood Risk Analyses
4	3A	3	--	**3**	361.35	Evaluation and Recommendations on Floodplain Management Practices
5	3B		18		361.36	Flood Mitigation and Floodplain Management Goals
6	4A	4	--	**4**	361.37	Flood Mitigation Needs Analysis
7	4C		1–18		Contract	Technical Memorandum
8	4B		19–22	**5**	361.38	Identification of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects
9	5	5	23, 24		361.39	Evaluation and Recommendation of Flood Management Evaluations and Flood Management Strategies and Associated Flood Mitigation Projects
10	6A	6	--	**6**	361.40	Impacts of Regional Flood Plan
11	6B		--		361.41	Contributions to and Impacts on Water Supply Development and the State Water Plan
12	7	7	--	**7**	361.42	Flood Response Information and Activities
13	8	8	--	**8**	361.43	Administrative, Regulatory, and Legislative Recommendations
14	9	9	--	**9**	361.44	Flood Infrastructure Financing Analysis
15	10	10	--	**10**	361.21; 361.12(a)(4)	Public Participation and Plan Adoption

1.7 Definitions

Communities Served: the number of cities or other political divisions included in a flood project area or watershed.

Critical Facilities: Hospitals, schools (K through 12th), schools for children with special needs, fire stations, police stations, emergency shelters, water and wastewater treatment plants, power generating facilities, power transmitting facilities, assisted living facilities, nursing homes, and others as identified by RFPGs. FEMA provides the following definition regarding critical facilities, described here in the FEMA glossary (www.fema.gov/glossary/critical-facility): "A critical facility provides services and functions essential to a community, especially during and after a disaster. Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, and similar facilities. The State of Texas provides the following definition, as described here (statutes.capitol.texas.gov/Docs/GV/htm/GV.421.htm): "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.

Flood Exposure: For the purposes of flood planning, flood exposure analyses will identify who and what might be harmed by flood including each structure located in flood hazard area within the region. FEMA defines 'exposure' as the people, property, systems, or functions that could be lost to a hazard. Generally, exposure includes what lies in the area the hazard could affect (FEMA, 2017).

Flood Hazard: For the purposes of flood planning, flood hazard analyses will determine the location, extent, magnitude, and frequency of flooding. FEMA defines a flood hazard as the potential for inundation that involves risk to life, health, property, and natural floodplain resources and functions. It is comprised of three elements: severity (magnitude, duration, and extent of flooding), probability of occurrence, and speed of onset of flooding (Wright, 2007).

Flood Readiness and Resilience: non-structural projects/programs aimed at improving flood preparedness and response to flood events including: plan activation, chain of command, emergency functions, evacuation procedures, flood early warning systems, and/or resilience measures to be implemented to reduce flood damage.

Flood Risk: Flood risk a component of hazard, exposure, and vulnerability. For the purposes of this regional flood planning effort, flood risk analyses will comprise a three-step process of flood hazard, flood exposure, and vulnerability analyses

Flood Vulnerability: For the purposes of flood planning, vulnerability analyses will identify vulnerabilities of communities and critical facilities located within the region. Social Vulnerability Index (SVI) is intended as the proxy for resilience for this planning cycle. FEMA defines vulnerability as the measure of the capacity to weather, resist, or recover from the impacts of a hazard in the long term as well as the short term. Vulnerability depends upon many factors such as land use, extent and type of construction, contents and use, the nature of populations (mobility, age, health), and warning of an impending hazardous event and willingness and ability to take responsive actions (Wright, 2007).

Level of Service of Asset (LOS): a measure of the level of protection a flood infrastructure asset provides in terms of annual exceedance probability.

Low Water Crossing (LWC): a roadway creek crossing that is subject to frequent inundation during storm events or subject to inundation during a 50 percent annual chance (2-year) storm event. During the first planning cycle, the RFPGs have the flexibility to utilize the community's discretion to identify a roadway creek crossing as LWC.

Planning Level: Work performed for this study will generally be done at regional planning level. Planning level for an evaluation will support the decision to proceed with further study of the area. Planning level for a project will support the decision to proceed with design and funding of a project. Any required cost estimate will be at a planning level.

Population Served: estimate of population included in a flood project service area or watershed determined in GIS.

Project Service Area: limits of jurisdiction for a project (i.e., city, county, etc.). If project is multi-jurisdictional, it will include the sum of all jurisdictions included.

Remaining Life of Asset: the remaining time that a flood infrastructure asset is able to achieve an acceptable value of defined performance in terms of its serviceability function or structural strength with an assumed current and consistent level of O&M.

Repetitive Loss:[2] any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling 10-year period, since 1978.

Rural Project: Project that qualifies as rural per the definition provided in the "Prioritization" section of the TWDB 2020 Flood Intended Use Plan (FIUP) which is defined as a) all entities within the project benefit area are outside MSAs and have populations <10,000; or b) a district or municipality with a service area of 10,000 or less in population; or c) a county in which no urban area exceeds 50,000 in population.

Social Vulnerability Index (SVI): the U.S Centers for Disease Control and Prevention (CDC) SVI ranks each Census tract (subdivisions of counties) on 15 social factors, including poverty, lack of vehicle access, and crowded housing that influence a community's ability to prepare for, respond to, and recover from a disaster.

[2] FEMA.gov definition

PART 2 – Scope of work task-specific general guidelines

This Part includes guidance sections specifically aligning with and addressing the following SOW tasks (corresponding agency rules are also shown for convenience and reference):

- **Task 1** – Planning area description (361.30, 361.31, 361.32)
- **Task 2** – Flood risk analyses
  - Task 2A – Existing condition flood risk analyses (361.33)
  - Task 2B – Future condition flood risk analyses (361.34)
- **Task 3** – Floodplain management practices and flood protection goals
  - Task 3A – Evaluation and recommendations on floodplain management practices (361.35)
  - Task 3B – Flood mitigation and floodplain management goals (361.36)
- **Task 4** – Assessment and identification of flood mitigation needs
  - Task 4A – Flood mitigation needs analysis (361.37)
  - Task 4B – Identification of potential flood management evaluations and potentially feasible flood management strategies and flood mitigation projects (361.38)
  - Task 4C – Prepare and submit technical memorandum
- **Task 5** – Evaluation and recommendation of flood management evaluations and flood management strategies and associated flood mitigation projects (361.39)
- **Task 6** – Impact and contribution of the regional flood plan
  - Task 6A – Impacts of regional flood plan (361.40)
  - Task 6B – Contributions to and impacts on water supply development and the state water plan (361.41)
- **Task 7** – Flood response information and activities (361.42)
- **Task 8** – Administrative, regulatory, and legislative recommendations (361.43)
- **Task 9** – Flood infrastructure financing analysis (361.44)
- **Task 10** – Public participation and plan adoption
- **Task 11** – Implementation and comparison to previous regional flood plan (361.45)

In general, each section of this Part 2 of the guidance document includes three parts:

1. A statement explaining the intended goal of each task.
2. An aggregation of largely verbatim excerpts from the most relevant agency rule sections and the SOW language associated with the work tasks, for convenience only. In some cases, rules and SOW were divided into multiple parts and slight modification occurred. All underlying agency rules and the SOW still apply to all work performed and supersedes the guidance document and should be referred back to regularly.
3. An 'Additional Guidance' section that may include:
   a. Additional descriptions or background to assist in meeting the rule and SOW requirements and interpreting the intent of the rule and scope
   b. Requirements that 'shall or must' be followed.
   c. Suggested 'may or consider' language to assist RFPGs in understanding ways to complete the work but that are not obligatory.
   d. Examples presented to clearly illustrate what is expected and/or considered acceptable or preferable depending on the language used in the associated section.
   e. References to "off-the-shelf" templates provided by the TWDB (MS Excel and GIS geodatabase template) so that regions and their consultants do not have to create them and to facilitate or organize the work effort and/or to ensure more consistent data presentation or submission across the state.
   f. Data requirement references, including reference to Exhibit D, that must also be followed and met.

2.1 Task 1 – Planning area description (361.30, 361.31, 361.32)

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

In general, the goal of this task is for RFPGs to describe the flood planning region, inventory and assess natural features and constructed major flood infrastructure, and describe proposed or ongoing flood mitigation projects in the region.

Information included in rules and scope of work:

Regional flood plans shall include brief, general descriptions of the following:

1. social and economic character of the region such as information on development, population, economic activity and economic sectors most at risk of flood impacts;
2. the areas in the FPR that are flood-prone and the types of major flood risks to life and property in the region;
3. key historical flood events within the region including associated fatalities and loss of property;
4. political subdivisions with flood-related authority and whether they are currently actively engaged in flood planning, floodplain management, and flood mitigation activities;
5. the general extent of local regulation and development codes relevant to existing and future flood risk;
6. agricultural and natural resources most impacted by flooding; and
7. existing local and regional flood plans within the FPR.

Regional flood plans shall include an **assessment of existing infrastructure**. Regional flood plans shall include a general description of the location, condition, and functionality **of natural features and constructed major infrastructure** within the FPR including, but not limited to:

1. rivers, tributaries, and functioning floodplains;
2. wetlands;
3. playa lakes;
4. sinkholes;
5. alluvial fans;
6. vegetated dunes;
7. levees;
8. sea barriers, walls, and revetments;
9. tidal barriers and gates;
10. stormwater tunnels;
11. stormwater canals;
12. dams that provide flood protection;
13. detention and retention ponds;
14. weirs;
15. storm drain systems; and
16. any other flood-related infrastructure.

For **non-functional or deficient** natural flood mitigation features or major flood infrastructure:

1. explain, in general, the reasons for the features or infrastructure being non-functional or deficient.

2. provide a description of the condition and functionality of the feature or infrastructure including whether and when the natural flood feature or major flood infrastructure may become fully functional, and
3. provide the name of the owner and operator of the major flood infrastructure.

Regional flood plans shall include a general description of the location, source of funding, and anticipated benefits of **proposed or ongoing flood mitigation projects in the FPR** including:

1. new structural flood mitigation projects currently under construction;
2. non-structural flood mitigation projects currently being implemented; and
3. structural and non-structural flood mitigation projects with dedicated funding to construct and the expected year of completion.

Regional flood plans shall include a tabulated list and GIS map of existing infrastructure and their conditions. Regional flood plans shall include a tabulated list and GIS map of proposed or ongoing flood mitigation projects currently under construction, being implemented; and with dedicated funding to construct and the expected year of completion.

Additional guidance:

The assessment of **existing major infrastructure and natural features** may be described in the form of overarching prose and general description of conditions along with the tabulated data of locations of types of infrastructure. The RFPGs will have discretion in determining the scale of what constitutes "major" infrastructure to be included in the plan. For example, the inventory is not expected to include each small detention pond in a region, rather the major regional detention ponds. It should include all major public infrastructure.

A summary and location of all low water crossings (LWC) in the region identified by local communities must be included in Table 1.

For storm drain systems, identification of the existence, or not, of storm drainage systems and general location in each entity will suffice. For entities that do not have their drainage systems mapped, a general location and reference to the existence, or not, of storm drainage systems in each entity will suffice.

The summary of non-functional or deficient natural flood mitigation features or major flood infrastructure may be included in the same table and in a map format that includes general information on condition of infrastructure and owners.

Following are the definitions of functional, non-functional, and deficient infrastructure intended for this plan:

Functional: The infrastructure is serving its intended design level of service.

Non-functional: The infrastructure not providing its intended or design level of service

Deficient: The infrastructure or natural feature is in poor structural or non-structural condition and needs replacement, restoration, or rehabilitation.

While describing a deficient storm drain system or other infrastructure for an entity, RFPGs shall include approximate percent deficiency of the storm drain system or the infrastructure in the description.

Regarding high hazard dams in the State, the RFPGs must follow all state including the Texas Commission of Environmental Quality's (TCEQ) confidentiality requirements associated with them.

Please refer to Exhibit D: Data Submittal Guidelines for GIS data and additional information requested for each infrastructure {3. ExFldInfraPol, 4. ExFldInfraLn, 5. ExFldInfraPt}.

RFPGs must submit information summarizing existing flood infrastructure and natural features utilizing Table 1 template provided below and the GIS geodatabase template provided by TWDB.

RFPGs must submit information summarizing proposed or ongoing flood mitigation projects {6. ExFldProjs} currently under construction, being implemented, or with dedicated funding to construct and the expected year of completion utilizing Table 2 template is provided below and the GIS geodatabase template will be provided by TWDB.

These are minimum reporting requirements however, an RFPG may present more information utilized in the development of their plan.

Table 1: Existing flood infrastructure summary table (with examples)

Existing Infrastructure ID	RFPG No.	RFPG Name	Counties	HUC8s	HUC12s [B]	Watersheds [B]	Feature Name	Infrastructure Type	Description	Natural or Constructed or Combination	Construction Date [A]	Infrastructure Dimensions [A]				
												Diameter (ft)	Height (ft)	Width (ft)	Length (ft)	Area (acre)
01000001	1	Canadian Upper Red	Flood	12090108	120901080403,120901080405	Catchment	City of Howdy Storm drain System	Storm drain systems	5,000ft of storm drainpipes of 1ft to 3ft diameter, 500 ft of constructed drainage ditches, 25 inlets.	Constructed	2005	1-3			5,000	
01000002	2	Canadian Upper Red	Flood	12090108	120901080403,120901080405	Basin	Lake Neal	Dam/ Reservoir	Regional flood control reservoir with 400,000 acre-ft of storage capacity.	Constructed	1965					15,000

A This field may be left blank during the 1st planning cycle. However, RFPGs are strongly encouraged to provide this information when applicable and available.
B Leave blank if too many for text field length (254 characters).

Information provided in this table are imaginary example datasets utilized to depict reporting structure. RFPGs are to assess and determine the existing infrastructure in their regions.

Existing flood infrastructure summary table (continued)

Existing Infrastructure ID	Level of Service (2-year, 10-year, 25-year, 50-year, 100-year, 500-year, Unknown)	Condition (Functional, Non-functional, Unknown)	Condition Description	Deficiency (Deficient, Non-deficient, Unknown)	Deficiency Description	Owning Entity	Operating Entity	Associated FMEs [A]	Associated FMSs [A]	Associated FMPs [A]
01000001	2-year	Non-functional	1200ft of the storm drain system does not meet the City requirement of 25-year LOS.	Deficient	500ft of pipes and approximately 12% of inlets are in poor condition.	City of Howdy	City of Howdy			
01000002	500-year	Functional		Unknown	NA	River Authority	River Authority			

[A] *This field may be left blank during the 1st planning cycle. However, RFPGs are strongly encouraged to provide this information when applicable and available.*

Information provided in this table are imaginary example datasets utilized to depict reporting structure. RFPGs are to assess and determine the existing infrastructure in their regions.

Table 2: Summary of proposed or ongoing flood mitigation projects

Existing Project ID	RFPG No.	RFPG Name	Project Name	Description	Counties	HUC8s	HUC12s [A]	Watersheds [A]	Project Status	Project Cost	Dedicated Funding for Construction (Yes/No)	Source of Funding	Expected Year of Completion	Anticipated Benefit

[A] *Leave blank if too many for text field length (254 characters).*

Summary of proposed or ongoing flood mitigation projects currently under construction, being implemented, and or with dedicated construction funding.

2.2 Task 2 – Flood risk analyses

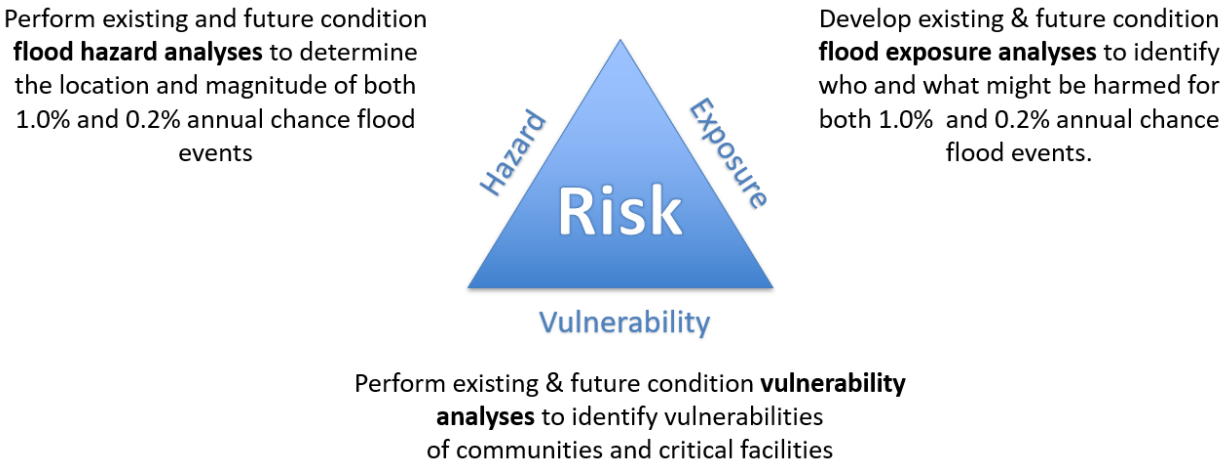
This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

The goal of this section is for RFPGs to perform existing and future condition flood risk analyses for the region comprising:

1. flood hazard analyses that determine 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 vulnerabilities of communities and critical facilities.

Figure 2: Flood risk analyses



2.2.A Task 2A – Existing condition flood risk analyses (361.33)

2.2.A.1 Existing condition flood hazard analysis

This task is intended to identify and compile a comprehensive outlook of existing condition flood hazards in the region including riverine flooding, urban flooding, coastal flooding, playa flooding and possible flood-prone areas of risks. This effort and the resulting map(s) are not regulatory in nature but are, instead, intended to gather and present a single, coherent, continuous set of best available information on actual flood risk throughout the region.

This task is primarily a data gathering and assessment task of all available flood hazard information, and determination of best available information for use in this first flood planning cycle. However, the RFPGs may choose to perform some limited modeling, as the available RFPG budget resources permit, to complete or improve the risk data coverage. The plan should incorporate findings from ongoing studies including but not limited to Texas General Land Office (GLO, www.glo.texas.gov) studies, other Flood Infrastructure Fund studies in the event that the study results become available in time for the RFPG to incorporate into the regional plan.

Information included in rules and scope of work:

RFPGs shall perform existing condition flood hazard analyses to determine the location and magnitude of both 1% annual chance and 0.2% annual chance flood events as follows:

1. Collect data and conduct analyses sufficient to characterize the existing conditions for the planning area;
2. Identify areas within each FPR where hydrologic and hydraulic model results are already available and summarize the information including the age of the map and modeling information for each area;
3. Utilize best available data, hydrologic and hydraulic models for each area;
4. Prepare a map showing areas identified by the RFPG as having an annual likelihood of inundation of more than 1% and 0.2%, the areal extent of this inundation, and the sources of flooding for each area; and
5. Prepare a map showing gaps in inundation boundary mapping and identify known flood-prone areas based on location of hydrologic features, historic flooding and/ or local knowledge.

Additional guidance:

To assist the RFPGs in this effort, the TWDB has prepared a statewide, ArcGIS dataset that compiles the most recent flood hazard data of riverine and coastal flooding available in Texas, which we are referring to as the initial, statewide "floodplain quilt". The RFPGs are expected to utilize this information just as a default starting point but will need to review and potentially re-prioritize the quilt data as appropriate by location and incorporate additional information available in their respective regions. Local regulatory floodplains located in any area will supersede the other less detailed floodplain coverages for the same location. The RFPG, with the support of their technical consultant, must assess the quality of the flood risk coverage data for each location and determine the best available information for use in the plan.

Please refer to Part 3 Technical Guidance of this document for more information regarding the initial riverine and coastal flooding risk data compilation by TWDB or the initial, statewide floodplain quilt to be utilized as a starting point for this task. Section 3.5 provides detail on modeling and mapping, including discussion of Atlas 14 data.

Please refer to the Section 3.5 of this document for the mapping and modeling guidance.

The following types of flooding hazard data must be considered and included as follows:

Riverine flooding:

Riverine flooding is caused by bank overtopping when the flow capacity of rivers is exceeded locally. The rising water levels generally originate from high-intensity rainfall creating soil saturation and large volumes of runoff either locally and/or in upstream watershed areas.

RFPGs will identify the best available riverine floodplain maps for each watershed in the region based on date, detail, and accuracy of modeling and mapping and include that in the existing condition flood hazard feature {7. ExFldHazard}.

Pluvial flooding including Urban flooding:

Urban flooding is caused when the inflow of stormwater in urban areas exceeds the capacity of drainage systems to infiltrate stormwater into the soil or to carry it away. The inflow of stormwater results from (a) heavy rainfall, which can collect on the landscape (pluvial flooding) or cause rivers and streams to overflow their banks and inundate surrounding areas; or (b) storm surge or high tides, which push water onto coastal cities. Floodwater inundation and movement are influenced by (a) land development, which disturbs natural drainage patterns and creates hardened, impervious surfaces that inhibit

infiltration of stormwater; and (b) stormwater systems that are undersized for current needs and thus increase exposure to drainage hazards. (National Academies of Sciences, Engineering, and Medicine, 2019).

RFPGs will identify known localized and urban flooding areas for each watershed in the region based on date of source data, detail and accuracy of modeling and mapping, and include that in the existing condition flood hazard feature {7. ExFldHazard}.

Note that the TWDB anticipates that the initial statewide floodplain quilt provided to the RFPGs will not include localized or urban flood risk information.

Coastal flooding:

Coastal flooding occurs when normally dry, low-lying land is flooded by seawater. RFPGs will identify the best available coastal floodplain maps for each watershed in the region based on date of source data, detail and accuracy of modeling and mapping, and include that in the existing condition flood hazard feature {7. ExFldHazard}.

Possible flood prone areas:

These are areas to be identified by the RFPG, that have not been previously identified as mapped flood hazard areas, and are identified, for example, by local knowledge of historic flooding. This would include areas identified via input received during public meetings.

Once the RFPGs have identified all available riverine, urban, coastal, and other flood-prone areas in the region, an initial, comprehensive region map must be created identifying all of these flood risk areas and made available for the public to view for their input.

Utilizing this initial flood hazard map, at least one public meeting must be held to identify additional flood hazards in the region that may not have been identified in the initial map(s) generated by the RFPG. It is recommended that the initial flood hazard map be posted on the RFPG webpage for public input as well. This public meeting should occur only after the RFPG and their consultant have already identified and summarized the initial existing flood risk information on a map. This initial, easily legible, and clearly identified flood risk map should be shared at these public meetings to allow members of the public to identify, and preferably in some manner mark or label, the locations of any flood risk (including the approximate date of occurrence) that may not have already been identified or otherwise captured in the initial map. This meeting can also be utilized for other purposes including, for example, to receive other relevant stakeholder feedback as well.

Another area for RFPG consideration is levee protected areas area subject to internal flooding or ponding due to lack of pumping capacity when there is not a gravity outfall available.

Using the initial risk map and considering the public feedback, RFPGs will identify the full extent of likely flood prone areas within each region, including with associated data source and event date information for identification of the flood risk, and include that in the existing condition flood hazard feature/map. {7. ExFldHazard}.

Gap analysis:

Once identification of flood hazard locations and flood prone areas is completed, RFPGs will prepare a map showing any remaining gaps in flood risk inundation boundary mapping and will identify known flood-prone areas based on the location of hydrologic features, historic flooding and/or local knowledge for areas that lack modeling and mapping. This gap analysis should identify areas with, for example, clearly outdated modeling and/or mapping, absence of modeling and/or mapping, and areas with modeling and/or mapping that requires update. These areas should be identified as polygon features. The RFPGs will need to review conflicting or overlapping datasets to determine which is considered

"best available" for each area within the region. Gaps in mapping identified in this task can be later recommend as locations for potential Flood Management Evaluations in Task 4B.

RFPGs are to utilize their own discretion in deciding which flood risk information is outdated since this will depend on various factors including but not limited to date of existing hydrologic and hydraulic (H&H) models and mapping, change of land use and impervious cover in the area, change in rainfall pattern and availability of updated hydrology information.

Submittal requirements:

1. General description of and GIS coverage map of comprehensive existing condition flood risk in the region with identification of each type of flooding (e.g., riverine, coastal etc.).
2. Total land areas (square miles) of each flood risk by flood risk type, county, region, and frequency should be summarized.
3. All data identified in data submittal requirements. Please refer to the Exhibit D Data Submittal Guidelines for information required to be provided.
4. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields but will not have any data.
5. One GIS data layer (Existing Condition Flood Hazard {7. ExFldHazard} that shows boundaries of 1 percent and 0.2 percent annual chance riverine flood risk, urban flood risk, coastal flood risk and possible flood prone area. The boundaries should have attributes identifying flood risk type, frequency of flooding, source of data, owner of the source of data, date of analysis performed, date of mapping performed, whether data was collected via written or oral public input and date of public meeting or data collection. **The 0.2 percent annual chance flood risk layer should not incorporate the 1 percent annual chance flood risk area to avoid overlapping polygons** (the 0.2 percent annual chance floodplain layer will have donut holes for 1 percent annual chance floodplain).
6. One GIS data layer {8. Fld_Map_Gaps} that shows the gaps in inundation boundary mapping.
7. All maps must be submitted with underlying GIS data utilized to prepare them.

2.2.A.2 Existing condition flood exposure analysis

Once identification of flood hazard locations is completed, all structures located within the 1 percent, 0.2 percent annual chance flood risk areas and possible flood prone areas should be determined via GIS analyses (i.e., intersecting the flood hazard layer with GIS data features including but not limited to buildings, roadways, population estimate, agricultural areas, etc.). Determination of roadway crossings at risk of flooding will require consideration of water surface elevations during the storm events and the roadway deck elevation of the roadway crossing. RFPGs will identify the low water crossings (LWC) amongst all the roadway crossings in 1 percent annual chance flood risk. For the first planning cycle, it will suffice to include the LWCs identified in in Task 1.

This analysis should include determinations of day and night population estimates that are located within the flood hazard areas; with the higher of the day or night estimate to be utilized in estimating the population in the floodplain or in flood-prone area. **The RFPGs may request the TWDB to perform analysis to estimate population** in the floodplain or in flood prone areas. RFPGs will provide their existing condition flood hazard layer to the TWDB for computation of population estimate in flood hazard areas.

Please refer to the Section 3.4 of this document for additional guidance for determination of population estimate.

Information included in rules and scope of work:

The RFPGs shall develop high-level, region-wide and largely GIS-based, existing condition flood exposure analyses, using the information identified in the flood hazard analysis to identify who and what might be harmed within the region for, at a minimum, both 1% annual chance and 0.2% annual chance flood events as follows:

1. analyses of existing development within the existing condition floodplain and the associated flood hazard exposure;
2. for the floodplain as defined by FEMA or as defined by an alternative analysis if the FEMA-defined floodplain is not considered best available; and
3. may include only those flood mitigation projects with dedicated construction funding and scheduled for completion prior to adoption of the next state flood plan.
4. all existing condition flood exposure analyses shall consider the population and property located in areas where existing levees or dams do not meet FEMA accreditation as inundated by flooding without those structures in place. Provisionally accredited structures may be allowed to provide flood protection, unless best available information demonstrates otherwise.
5. The existing condition flood exposure analyses shall consider available datasets to estimate the potential flood hazard exposure including, but not limited to:
    a. number of residential properties and associated population;
    b. number of non-residential properties;
    c. other public infrastructure;
    d. major industrial and power generation facilities;
    e. number and types of critical facilities;
    f. number of roadway crossings;
    g. length of roadway exposed; and
    h. agricultural area and value of crops exposed.
6. The existing condition flood exposure analyses shall include a qualitative description of expected loss of function, which is the effect that a flood event could have on the function of inundated structures (residential, commercial, industrial, public, or others) and infrastructure, such as transportation, health and human services, water supply, wastewater treatment, utilities, energy generation, and emergency services.

Submittal requirements:

1. General description, summary, and GIS coverage map of buildings, roadways crossings, length of roadway segments, agricultural land and other identified items that are located withing the flood hazard area identified in 'Existing condition flood hazard analysis'. This required information should be summarized by region, type of flood risk, county, Hydraulic Unit Code (HUC)-8, existing flood authority boundaries as applicable and other categories as determined by RFPGs.
2. All data identified in data submittal requirements. Please refer to the Exhibit D Data Submittal Guidelines for information required to be provided.
3. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields but will not have any data.
4. GIS data layers {9. ExFldExpPol, 10. ExFldExpLn, 11. ExFldExpPt} that identify residential properties and associated population, non-residential properties, public infrastructure, major industrial and power generation facilities, critical facilities and with descriptions, roadway crossings, roadway segments and their respective lengths, and agricultural area and value of

crops exposed that are at risk of, both 1 percent annual chance and 0.2 percent annual chance flood events.

5. Structures within the boundary of flood events occurring more frequently or less frequently than the 1 percent or 0.2 percent annual exceedance probability (e.g., 0.4, 2, 4, 10, or 50 percent) can be identified at the discretion of the RFPG.
6. All maps must be submitted with the underlying GIS data utilized to prepare them.

2.2.A.3 Existing condition vulnerability analysis

Once the existing flood exposure analysis is completed, the populations and structures exposed to flooding within the identified hazard layer should be analyzed to determine their vulnerability to flooding.

This task requires the RFPGs to identify the critical infrastructure amongst the items identified in the flood exposure analysis and compute Social Vulnerability Index (SVI) value for each structure identified in during the flood exposure analysis. The U.S Centers for Disease Control and Prevention calculates SVI using 15 U.S. census variables to help local officials identify communities that may need support before, during, or after disasters (www.atsdr.cdc.gov/placeandhealth/svi/index.html). SVI is intended as the proxy for resilience for this planning cycle. The higher the SVI, the higher the vulnerability; the lower the SVI, the higher the resilience.

TWDB will provide the RFPGs building data with SVI values identified for each building.

This flood planning guidance document is asking for minimal information pertaining to the vulnerability analysis for this planning cycle. The RFPGs may, at their discretion, incorporate more information for their region. For reference, FEMA's release of the National Risk Index provides a risk score at the census block level and takes into account resilience (www.fema.gov/flood-maps/products-tools/national-risk-index)

Information included in rules and scope of work:

1. RFPGs shall identify resilience of communities located in flood-prone areas identified as part of the existing condition flood exposure analyses, utilizing relevant data and tools.
2. RFPGs shall identify vulnerabilities of critical facilities to flooding by looking at factors such as proximity to a floodplain or other bodies of water, past flooding issues, emergency management plans, and location of critical systems like primary and back-up power.

All data produced as part of the existing condition flood exposure analysis and the existing condition vulnerability analysis shall include:

1. underlying flood event return frequency;
2. type of flood risk;
3. county;
4. HUC-8;
5. existing flood authority boundaries;
6. Social Vulnerability Indices for counties and census tracts; and
7. other categories as determined by RFPGs or to be designated by the EA.

The information developed by the RFPG under this section shall be used to assist the RFPG establish priorities in subsequent planning tasks, to identify areas that need FMEs, and to efficiently deploy its resources.

Additional guidance:

Specific information for some critical facilities may be subject to U.S. Homeland Security restrictions with regard to sharing data.

Computation of SVI:

The SVI will already be computed in the buildings data provided by TWDB. For any new buildings, use the following procedure:

1. Download the 2018 SVI shapefile for Texas, available through the TWDB Flood Planning Data Hub. The shapefile contains SVI information for each of the individual census tracts in Texas.
2. Overlay the exposure feature layer {12. ExFldExpAll} with the SVI shapefile. The SVI for each census tract is reported in the GIS field "RPL_themes". This field has values between 0 and 1, with a high score (closer to 1) denoting greater vulnerability.
3. Compute SVI value for all features (structure, low water crossings, critical infrastructure etc.) identified in the exposure feature layer.

Submittal requirements:

1. Summary and general description of critical infrastructure in the region, SVI average per County, and locations of high SVI areas (over 0.75) within the region.
2. GIS coverage map of all critical infrastructure in region.
3. GIS coverage map of all features (structure, low water crossings, critical infrastructure etc.) with high SVI (over 0.75) in the region.
4. Please refer to the Exhibit D: Data Submittal Guidelines for information requested.
5. GIS data layer {12. ExFldExpAll} that identifies critical facilities including any schools (K-12), hospitals, police stations, fire stations etc. located in region.
6. GIS data layer {12. ExFldExpAll} that identifies SVI for each item (structure, low water crossing, critical infrastructure etc.) identified in Existing Condition Flood Exposure Analysis.

Once Task 2A Existing Condition Flood Risk Analyses is complete, RFPGs must include a summary table with findings summarizing flood risk by county (template below).

These are minimum reporting requirements, however, an RFPG may present additional information utilized in the development of their plan.

Table 3: Existing condition flood risk summary table (by county)

	County	Area in Flood Planning Region (sqmi)	1% annual chance flood risk								0.2% annual chance flood risk							
			Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)
1																		
2																		
3																		
4																		
5																		
	Total	0	0	0		0	0	0	0	0	0	0		0	0	0	0	0

Existing condition flood risk summary table (continued)

	County	Area in Flood Planning Region (sqmi)	Possible flood prone areas								Average SVI of features in floodplain or flood prone areas
			Area (sqmi)	Number of Structures in Flood-Prone Area	Residential Structures in Flood-Prone Area	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	
1											
2											
3											
4											
5											
	Total	0	0	0		0	0	0	0	0	

2.2.B Task 2B – Future condition flood risk analyses (361.34)

Information included in rules and scope of work:

RFPGs shall perform future condition flood risk analyses for the region comprising:

1. flood hazard analyses that determines 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 vulnerabilities of communities and critical facilities.

Additional guidance:

The future condition flood risk analysis shall include two scenarios/components:

1. Increased Flood Hazard: Identification of the future condition flood hazard layer based on a projected increase in impervious cover, anticipated change in relative sea level and/or land subsidence, anticipated sedimentation in flood control structures, and other factors that may result in increased or altered flood hazards in the future. Flood exposure and vulnerability analyses will be performed based on that future condition flood hazard layer.
2. Additional Exposure/Vulnerability: Identification of 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 the region continues.

The RFPGs must perform a future condition flood risk analysis for the first scenario listed above. For the second scenario, the RFPGs shall consider future development within the planning region. This shall include a summary and qualitative description of the potential areas located within the existing flood hazard area that face an increase in future flood risk due to placement of new development in the area will suffice. However, it is up to the RFPGs discretion to determine further extent and depth of this analysis.

2.2.B.1 Future condition flood hazard analysis

This task is intended to identify and compile a comprehensive outlook of future condition flood hazards in the region including riverine flooding, urban flooding, coastal flooding, playa flooding and other possible flood-prone areas of risks including how they will change in extent and nature from the existing flood hazard.

First step of this task will be to identify areas within each FPR where future condition hydrologic and hydraulic model results and maps are already available, and to summarize the information; it is recognized that the future condition may vary from one watershed to another within a region. The Plan should document the source of flood hazard data, associated dates, timeframe of future condition (fully developed land use condition, 30-year., 50-year., etc.) and a brief description of each existing dataset compiled for the future condition flood hazard analysis.

The RFPGs are encouraged to consider future rainfall patterns including specific information provided by the State of Texas climatologist on future condition rainfall pattern (Nielsen-Gammon, 2020; Nielsen-Gammon and Jorgensen, 2021; available from climatexas.tamu.edu/products/texas-extreme-rainfall/index.html).

For areas where future condition flood hazard data is not already available, future condition flood hazard analyses may be performed utilizing one of the following four methods [3]: The RPGs may request TWDB to do a desktop analysis to generate future condition flood hazard boundary where future condition information is not available.

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

Additional information on each of these methods are provided below.

Information included in rules and scope of work:

RFPGs shall perform a future condition flood hazard analysis to determine the location of both 1% annual chance and 0.2% annual chance flood events as follows:

1. collect data and conduct analyses sufficient to characterize the future 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, and existing flood regulations and policies based on:
    a. current land use and development trends and practices and associated projected population based on the most recently adopted state water plan decade and population nearest the next Regional Flood Plan adoption date plus approximately 30 years or as available at the geographic area;
    b. reasonable assumptions regarding locations of residential development and associated population growth;
    c. anticipated relative sea level change and subsidence based on existing information;
    d. anticipated changes to the functionality of the existing floodplain;
    e. anticipated sedimentation in flood control structures and major geomorphic changes in riverine, playa, or coastal systems based on existing information;
    f. assumed completion of flood mitigation projects currently under construction or that already have dedicated construction funding; and
    g. other factors deemed relevant by the RFPG.
2. identify areas within each FPR where future condition hydrologic and hydraulic model results are already available and summarize the information;
3. utilize best available data, hydrologic and hydraulic models for each area;
4. where future condition results are not available, but existing condition hydrologic and hydraulic model results are already available, the RFPGs shall modify hydraulic models to identify future conditions flood risk for 1% and 0.2% annual chance storms based on simplified assumptions utilizing the information identified in paragraph (1)(A)item 1.a of this subsection.
5. prepare a map showing areas of 1% and 0.2% annual chance of inundation for future conditions, the areal extent of this inundation, and the sources of flooding for each area.

[3] These estimated flood plain changes will be used solely for the purpose of recognizing the *general magnitude* of potential future increases in flood risk under the equivalent of a “do-nothing” or “no-action” alternative and within the regional flood planning context will not, in any way, be used for developing new flood extent maps for any regulatory purposes.

6. prepare a map showing gaps in inundation boundary mapping and identify known flood-prone areas based on location of hydrologic features, historic flooding, and/ or local knowledge.

Additional guidance:

For areas where future condition flood hazard data is not already available, future condition flood hazard analyses may be performed utilizing one of the following four methods:

Method 1: Increase water surface elevation based on projected percent population increase (as proxy for development of land areas)

Relate the increase in population in contributing draining area to stream segments and relate the percent increase in population growth to percent increase in impervious cover, resulting in an increase in water surface elevation (WSE). This relationship between population growth and resulting changes to flood event elevations will require certain assumptions about development and estimating correlations between impervious cover changes and changes to flood elevations and will vary based on topography, land use and soil type within a watershed. The RFPGs are expected to establish this general relationship for their region or by watershed area and document the assumptions made for this approach (Brophy-Price and Rolband, 2010). It is also acknowledged that increase in population growth may not always result in increase in impervious cover. However, this is one of the simplified approaches that can be utilized for an approximation. The population projection information for the regions will be provided by the TWDB based on the most recently adopted state water plan. Table 4 shows an example relationship.

Table 4: Example relationship between 30-year population growth, impervious cover and increase in flood water surface elevation

Estimated Population increase within watershed	Estimated, corresponding Increase in Impervious Cover	Estimated, corresponding Increase in Water Surface Elevation for a 1% annual Chance Event (ft)	Estimated, corresponding Increase in Water Surface Elevation for a 0.2% annual Chance Event (ft)
1%	2%	0.1	0.05
5%	7%	0.25	0.1
10%	12%	0.5	0.25
15%	17%	0.75	0.5
25%	25%	1.0	0.75

This table is provided only as a conceptual example and does not reflect any recommended comparison based on any real data. The RFPGs are expected to establish this, potentially non-linear, relationship for their region or multiple areas within their region.

Map the future condition 1 percent and 0.2 percent annual chance floodplain utilizing the increased water surface elevation. Provide data, justify, and document the correlation developed between increase in population to increase in impervious cover to increase in WSE.

The proposed approach must be well-documented.

Method 2: Utilize the existing condition 0.2 percent annual chance floodplain as a proxy for the future one percent level

As a simple proxy, the RFPG may, for some areas, consider using the existing condition 0.2 percent annual change floodplain as the future condition 1 percent annual chance floodplain. This method has the benefit of having a reliable 0.2 percent annual chance floodplain backed by modeling and mapping. However, this method will not generate a future condition 0.2 percent annual chance floodplain.

RFPGs will have to utilize an alternate approach to develop a proxy for the 0.2 percent 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 percent annual chance floodplain, (i.e., flood-prone areas).

This approach would generally be more appropriate for urban/suburban areas with high growth rates and may not be applicable for areas with minimal to no growth.

The proposed approach must be well-documented.

Method 3: Combination of methods 1 and 2 or an RFPG-proposed method

RFPGs may utilize a combination of the methods identified above or may propose an alternative method to determine comprehensive future condition flood risk for their region.

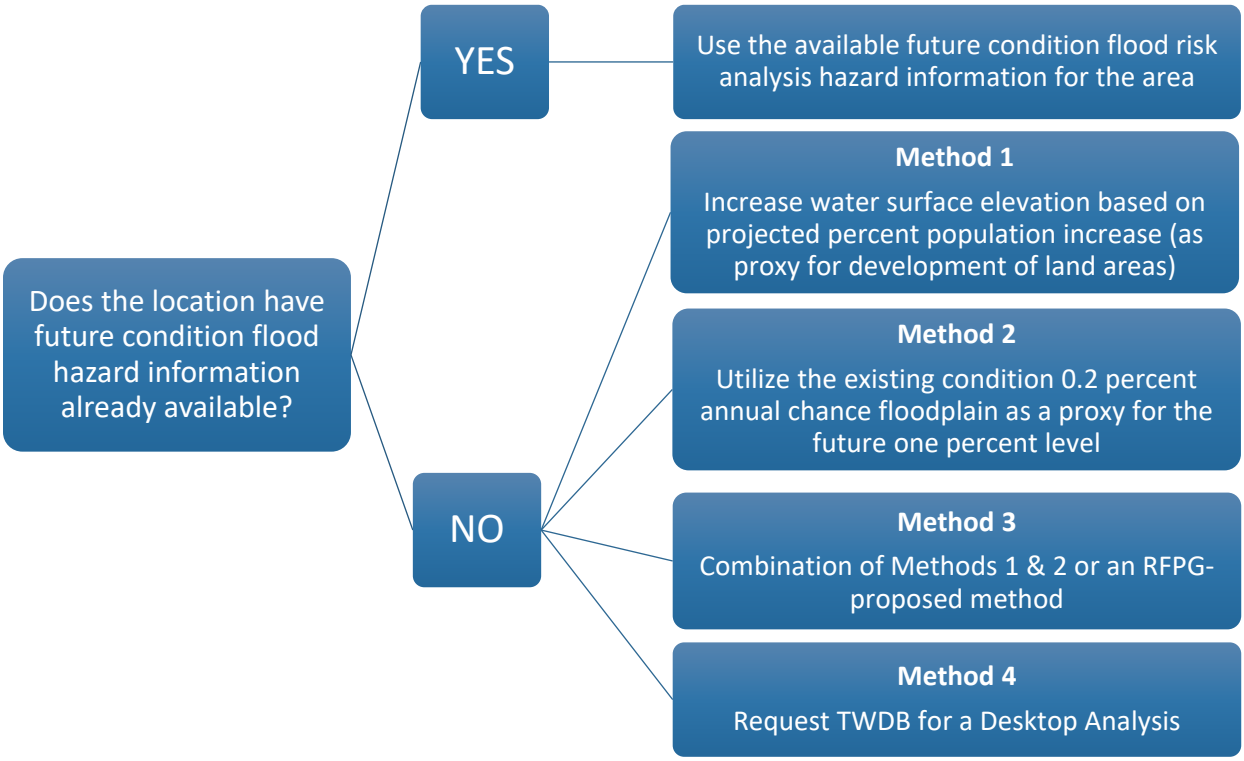
The proposed approach must be well-documented, and the approach or method requires preview and written approval by the EA (e.g., via email) of proposed assumptions, process, and justification prior to proceeding with carrying out such a proposed combination and/ or new method.

Method 4: Request TWDB for a Desktop Analysis

The RPGs may request TWDB to do a desktop analysis to generate future condition flood hazard boundary where future condition information is not available. The RFPGs will provide TWDB with the existing condition flood hazard area boundary, and additional information to determine the preferred method for desktop analysis.

Please refer to the flowchart in Figure 3 for future condition flood risk analyses options.

Figure 3: Future condition flood risk analysis flowchart



Submittal requirements:

1. General description and GIS coverage map of comprehensive future condition flood risk in the region with identification of each type of flooding (e.g., riverine, coastal etc.).
2. A GIS coverage map showing the extent of increase if flood hazard compared to existing condition.
3. Total land areas (square miles) of flood risk by flood risk type, counties, regions, and frequency should be summarized in a table.
4. All data identified in the data submittal requirements. Please refer to the Exhibit D: Data Submittal Guidelines for information required to be provided.
5. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields but will not have any data.
6. GIS data layer that shows boundaries of future condition 1 percent and 0.2 percent annual chance riverine flood risk, urban flood risk, coastal flood risk and possible flood prone area {13. FutFldHazard}. The boundaries should have attributes identifying flood risk type, frequency of flooding, source of data, owner of the source of data, date of analysis performed, date of mapping performed, if data collected via public input, data of public meeting or data collection. The 0.2 percent annual chance flood risk layer should not incorporate the 1 percent annual chance flood risk area to avoid overlapping polygons (the 0.2 percent annual chance floodplain layer will have donut holes for 1 percent annual chance floodplain).
7. All maps should be submitted with underlying GIS data utilized to prepare them in accordance with the contract guidance documents.

2.2.B.2 Future condition flood exposure analysis

Once identification of future condition flood hazard locations is completed, all structures located within the 1 percent, 0.2 percent annual chance flood risk areas, and possible flood prone areas should be determined via GIS analyses (i.e., intersecting the flood hazard layer with GIS data features including but not limited to buildings, roadways, population estimate, agricultural areas, etc.). Determination of low water crossings at risk of flooding will require consideration of water surface elevations during the storm events and the roadway deck elevation of the roadway crossing. RFPGs will identify the low water crossings (LWC) amongst all the roadway crossings in 1% annual chance flood risk. For the first planning cycle, it will suffice to include the LWCs identified in in Task 1.

This analysis should include determinations of day and night population estimates that are located within the flood hazard areas; with the higher of the day or night estimate to be utilized in estimating the population in the floodplain or in flood-prone area. The procedure outlined in 2.2.A.2 for calculating exposed population also applies for future condition, except a future hazard layer should be used instead of the current condition.

Information included in rules and scope of work:

The RFPGs shall use the information identified in the future condition flood hazard analysis to develop and perform high-level, region-wide, and largely GIS-based, future condition flood exposure analyses to identify who and what might be harmed within the region for, at a minimum, both future condition 1.0% annual chance and future condition 0.2% annual chance flood events as follows:

1. analyses of existing and future developments within the future condition floodplain and the associated flood hazard exposure; and

2. to include only those flood mitigation projects with dedicated construction funding scheduled for completion prior to the next Regional Flood Plan adoption date plus 30 years or as determined in Task 1 – Planning area description.
3. Identification of flood prone areas associated with the hazard exposure analyses shall be based on analyses that rely primarily on the use and incorporation of existing and available:
    a. FIRMs or other flood inundation maps and GIS related data and analyses;
    b. available hydraulic flood modeling results;
    c. model-based or other types of geographic screening tools for identifying flood prone areas; and
    d. other best available data or relevant technical analyses that the RFPG determines to be the most updated or reliable.

Submittal requirements:

1. General description, summary, and GIS map of buildings, roadways crossings, length of roadway segments, agricultural land and other identified items that are located withing the flood hazard area identified in 'Future condition flood hazard analysis'. This required information should be summarized by region, type of flood risk, counties, HUC-8, existing flood authority boundaries, as applicable, and other categories as determined by RFPGs.
2. General description and GIS coverage map of additional total areas, structures, population, agricultural land etc. added to 1 percent and 0.2 percent annual chance flood risk in the 30 years based on future condition flood risk analyses.
3. All data identified in data submittal requirements. Please refer to the Exhibit D: Data Submittal Guidelines for information required to be provided.
4. The TWDB will provide an empty GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase will be pre-populated with all feature classes and fields.
5. GIS data layers that identify residential properties and associated population, non-residential properties, public infrastructure, major industrial and power generation facilities, critical facilities and what they are, roadway crossings, length of roadway segments and their respective lengths, and agricultural areas and value of crops exposed that are at risk of, both 1 percent annual chance and 0.2 percent annual chance flood events. {14. FutFldExpPol, 15. FutFldExpLn, 16. FutFldExpPt}
6. Structures at risk of storm frequency events other than future 100-year and 500-year (1 percent and 0.2 percent annual chance event) such as 2-year, 5-year, 10-year, 25-year, and 50-year storm events can be provided at the RFPGs discretion.
7. All maps must be submitted with the underlying GIS data utilized to prepare them.

2.2.B.3 Future condition vulnerability analysis

Once the future condition flood exposure analysis is completed, the populations and structures exposed to flooding within the identified hazard layer should be analyzed to determine their vulnerability to flooding.

This task requires the RFPGs to identify, describe, and summarize vulnerability of the critical infrastructure amongst the items identified in flood exposure analysis. Also, RFPGs shall compute the Social Vulnerability Index (SVI) value for each structure in the floodplain and flood-prone areas identified in during the flood exposure analysis. SVI is intended to serve as the proxy for resilience for this planning cycle. The higher the SVI, the higher the vulnerability; the lower the SVI, the higher the resilience.

TWDB will provide the RFPGs building data with CDC's SVI values identified for each building. This guidance document requires a rather minimal amount of information pertaining to the vulnerability

analysis for this first planning cycle. The RFPGs may, at their discretion, incorporate more information for their region.

Information included in rules and scope of work:

1. RFPGs shall identify resilience of communities located in flood-prone areas identified in the future condition flood exposure analysis utilizing relevant data and tools.
2. RFPGs shall identify vulnerabilities of critical facilities to flooding by looking at factors such as proximity to a floodplain, proximity to other bodies of water, past flooding issues, emergency management plans, and location of critical systems like primary and back-up power.

All data produced as part of the future condition flood hazard analysis and future condition flood exposure analysis shall be summarized in the Regional Flood Plan in accordance with guidance provided by the EA in this technical guidance document and shall include:

1. underlying flood event return frequency;
2. type of flood risk;
3. county;
4. HUC-8;
5. existing flood authority boundaries;
6. Social Vulnerability Indices for counties and census tracts; and
7. other categories to be designated by the EA.

The information developed by the RFPG under this section shall be used to assist the RFPG establish priorities in subsequent planning tasks, to identify areas that need FMEs, and to efficiently deploy its resources.

Additional guidance:

Computation of SVI:

1. Download the 2018 SVI shapefile for Texas, available through the TWDB Flood Planning Data Hub. The shapefile contains SVI information for each of the individual census tracts in Texas.
2. Overlay the exposure feature layer with the SVI shapefile. The SVI for each census tract is reported in the GIS field "RPL_themes". This field has values between 0 and 1, with a high score (closer to 1) denoting greater vulnerability.
3. Compute SVI value for all features (structure, low water crossings, critical infrastructure etc.) identified in the exposure feature layer.

Submittal Requirements:

1. Summary and general description of critical infrastructure in the region and SVI average per County, and locations of high SVI areas within the region.
2. GIS coverage map of all critical infrastructure in region.
3. GIS coverage map of all features (structure, low water crossing, critical infrastructure etc.) with high SVI (over 0.75) in the region.
4. Please refer to the Exhibit D: Data Submittal Guidelines for information requested.
5. GIS data layer {17. FutFldExpAll} that identifies critical facilities including any schools, hospitals, police stations, fire stations etc. located in region.
6. GIS data layer {17. FutFldExpAll} that identifies SVI for each feature (structure, low water crossing, critical infrastructure etc.) identified in Future Condition Flood Exposure Analysis.

Once Task 2B Future Condition Flood Risk Analyses is complete, the plan must include a summary table with findings (template below).

These are minimum reporting requirements however, an RFPG may present additional information utilized in the development of their plan.

Table 5: Future condition flood risk summary table, by county.

	County	Area in Flood Planning Region (sqmi)	1% annual chance flood risk								0.2% annual chance flood risk							
			Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)	Area in Floodplain (sqmi)	Number of Structures in Floodplain	Residential Structures in Floodplain	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)
1																		
2																		
3																		
4																		
5																		
	Total	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0

Future condition flood risk summary table (continued)

	County	Area in Flood Planning Region (sqmi)	Possible flood prone areas							
			Area in Floodplain (sqmi)	Number of Structures in Flood-Prone Area	Residential Structures in Flood-Prone Area	Population	Roadway Stream Crossings (#)	Roadways Segments (miles)	Agricultural Areas (sqmi)	Critical Facilities (#)
1										
2										
3										
4										
5										
	Total	0	0	0	0	0	0	0	0	0

2.3 Task 3 – Floodplain management practices and flood protection goals

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

2.3.A Task 3A – Evaluation and recommendations on floodplain management practices (361.35)

Goals:

The goal of this task is for RFPGs to evaluate and make recommendations on floodplain management practices within the flood planning region. The intent of regional flood planning is twofold,

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

Floodplain management, land use, infrastructure design, and other practices play a key role in accomplishing both of these intents, specifically in preventing the creation of additional flood risk in the future.

Information included in rules and scope of work:

Recognizing the extent to which past development decisions may have increased flood risks, including residual risks, and considering broad floodplain management and land use approaches that will avoid increasing flood risks, and avoid negatively affecting neighboring areas, the RFPG shall:

1. consider the extent to which a lack of, insufficient, or ineffective current floodplain management and land use practices, regulations, policies, and trends related to land use, economic development, and population growth, allow, cause, or otherwise encourage increases to flood risks to both:
    a. existing population and property, and
    b. future population and property.
2. take into consideration the future flood hazard exposure analysis, consider the extent to which the 1% annual chance floodplain, along with associated flood risks, may change over time in response to anticipated development and associated population growth and other relevant man-made causes, and assess how to best address these potential changes.
3. based on the analyses in paragraphs (1) - (2) of this subsection, make recommendations regarding forward-looking floodplain management and land use recommendations, and economic development practices and strategies, that should be implemented by entities within the FPR. These region-specific recommendations may include minimum floodplain management and land use standards and should focus on how to best address the changes in paragraph (2) of this subsection for entities within the region. These recommendations shall inform recommended strategies for inclusion in the Regional Flood Plan.
4. RFPGs may also choose to adopt region-specific, minimum floodplain management or land use or other standards that impact flood-risk, that may vary geographically across the region, that each entity in the FPR must adopt prior to the RFPG including in the Regional Flood Plan any FMEs, FMSs, or FMPs that are sponsored by or that will otherwise be implemented by that entity.

5. Consider example floodplain management and infrastructure protection standards provided by TWDB.

Additional guidance:

Evaluation of floodplain management practices

This task is intended as qualitative assessment of floodplain management, land use, infrastructure design, and other practices within and across the region. This task will identify areas with existing floodplain management practices, identify common and compare contrasting practices within the region, and acknowledge locations that may lack floodplain management. A GIS coverage map must be submitted depicting the areas with any established floodplain management practices and the entities that regulate and enforce those floodplain practices {18. ExFpMP}.

A summary of key floodplain management practices in the region summarized by their respective regulatory entities should be provided. The region may generally characterize and describe existing floodplain management practices as none (no floodplain management practices in place), low (regulations meet the minimum NFIP standards), moderate (some higher standards, such as freeboard, detention requirements, or fill restrictions), strong (e.g., significant regulations that exceed NFIP standard with enforcement, or community belongs to the Community Rating System) . TWDB's Flood Science and Community Assistance division is available to serve as a technical resource for this task and may be able to answer questions about a community's NFIP status or flood damage prevention ordinances/orders.

The RFPGs must compile list of all cities, counties and political subdivision with flood-related authorities in the region and at a minimum identify whether the entity adopted any floodplain management regulations, adopted minimum regulations pursuant to Texas Water Code Section 16.3145 and/ or if the community is a NFIP participant, as depicted in Table 6.

Table 6: Existing floodplain management practices

Entity [A]	**Floodplain management regulations (Yes/ No/ Unknown)** [A]	**Adopted minimum regulations pursuant to Texas Water Code Section 16.3145? (Yes/ No)** [A]	**NFIP Participant (Yes/ No)** [A]	Higher Standards adopted (Yes/ No) [B]	Floodplain Management Practices (Strong/Moderate/Low/None) [B]	Level of enforcement of practices (High/ Moderate/ Low/ None) [B, C]	Existing Stormwater or Drainage Fee (Yes/ No) [B]	Web Link to entity regulations [B]
County 1								
County 2								
City 1								
City 2								
District								

[A] *At a minimum, the RFPGs must list all counties, cities and districts in the region with flood related authority in the region and identify whether entity they have any established floodplain management practices.*

[B] *This field may be left blank during the 1st planning cycle. However, RFPGs are strongly encouraged to provide this information when applicable and available.*

[C] *The following may serve as a guide for evaluating enforcement:*

high – actively enforces the entire ordinance, performs many inspections throughout construction process, issues fines, violations, and Section 1316s where appropriate, and enforces substantial damage and substantial improvement;
moderate – enforces much of the ordinance, performs limited inspections and is limited in issuance of fines and violations;
low – provides permitting of development in the floodplain, may not perform inspections, may not issue fines or violations;
none – does not enforce floodplain management regulations.

RFPGs should identify the communities in the region that already have stormwater or drainage fees. RFPGs may consider recommending fees or revenue generation options as a means of implementing projects.

When providing a summary list, RFPGs shall distinguish between confirming that no floodplain regulations exist and stating the relevant regulations were not assessed for certain communities. RFPGs shall also characterize how many communities meet minimum Texas Water Code Section 16.3145 requirements, how many communities participate in the NFIP, and how many communities have any level of higher standards.

The RFPGs shall coordinate with these political subdivisions, to the extent possible, to gather information on floodplain management regulations and policies in the region and shall evaluate the regulations and policies for sufficiency and effectiveness. In cases where gathering regulations and policies from all entities in the region is infeasible, the RFPG may gather the information from a representative sample of political subdivisions with flood-related authority. RFPGs shall include a written summary of the regulations and policies gathered and a written summary of the findings from the RFPG's evaluation of sufficiency and effectiveness.

Beyond a general assessment, RFPGs may choose to associate the names of specific political subdivisions or areas with the floodplain management practices identified in this evaluation. The purpose is not to call out or admonish any entities, but rather to identify practices or lack thereof that can potentially permit or otherwise contribute to increasing flood risk, especially for those practices that have the potential to negatively affect neighboring areas. The purpose should be to identify improvements to floodplain management practices that could be implemented in the future.

Recommendations on floodplain management practices

Floodplain management is defined in Title 31 Texas Administrative Code §361.10 as, "**The operation of an overall program of corrective and preventative measures for reducing flood damage**." These measures can take a variety of forms and generally include building, subdivision, zoning, land use, or other special-purpose ordinances such as flood damage prevention ordinances. Floodplain management can include the minimum requirements necessary to comply with the National Flood Insurance Program (NFIP) but may also include a variety of standards higher than NFIP minimums that local entities may choose to adopt. In Texas, authority for enforcing floodplain management regulations lies with local governments such as cities and counties. It is important to note that RFPGs themselves do not have the authority to enact or enforce floodplain management, land use, or other infrastructure design standards. Any standards considered, recommended, and adopted by the RFPG in this task would be aimed at encouraging implementation by local entities in the region with flood-related authority.

The RFPGs may choose to recommend and/ or adopt region-wide floodplain management standards., including those that will achieve more consistent approaches across the region either or both in the form of:

a. general *recommendations* (2.3.A(3)) for consideration by entities in the region, or
b. specific, *minimum standards* that should be adopted (2.3.A(4))

These recommendations should also consider the goals developed by the RFPG in Task 3B. The Plan must clearly state during its plan development process whether these RFPG standards are either:

a. (2.3.1(3)) *recommendations* for consideration by local entities' floodplain management standards or
b. they represent RFPG *adopted* region-specific, minimum standards that are required to be adopted by local entities prior to the RFPG including any FMEs, FMSs, or FMPs that are

sponsored by or that will otherwise be implemented by that entity in the regional flood plan (2.3.1(4)).

The TWDB encourages the RFPGs to recommend or adopt region-specific minimum floodplain management standards.

In order to provide the RFPGs some baseline information regarding floodplain management practices and infrastructure flood protection goals across Texas, the TWDB had a survey performed of 27 Texas communities in diverse geographic locations across the state to identify a range of typical minimum and most stringent floodplain management practices regarding flood mitigation, floodplain management, and infrastructure flood protection. Based on the stakeholder questionnaire responses, related research, and professional engineering experience, this section of the guidance document provides summaries of some minimum and some of the most stringent specifications of floodplain management and infrastructure flood protection standards *that are already being followed by various entities across Texas*. This section of the guidance document also includes examples of floodplain management and infrastructure standards for the planning regions to consider when developing their own.

Table 7 below summarizes examples of infrastructure flood protection standards for the RFPGs to consider. These example recommendations should be coupled with no negative impact considerations.

Table 7: Example floodplain management and infrastructure flood protection standards

Infrastructure	Type / Condition	Example Flood Protection Standard
Residential and Commercial Buildings	New Construction	Finished floor elevations 1 foot above 100-year Water Surface Elevation (WSE)
	Pre-Existing (Retrofit)	
	Coastal New Construction	Finished floor elevations 1 foot above the highest elevation of either the riverine or coastal BFE including the combined riverine and coastal effects
	Coastal Pre-Existing (Retrofit)	
Critical Facilities [A]	New Construction	Finished floor elevations above the 500-year WSE
	Pre-Existing (Retrofit)	
	Coastal New Construction	Finished floor elevations 1 foot above the highest elevation of either the riverine 500-year or coastal 100-year WSE including the combined riverine and coastal effects
	Coastal Pre-Existing (Retrofit)	
Roadways	New Construction	5-year below top of curb and 100-year no more than 1 foot above the top of curb and contained within the right-of-way
	Pre-Existing (Retrofit)	
	Coastal New Construction	
	Coastal Pre-Existing (Retrofit)	
Culverts / Bridges	New Construction	Minor Roadways: Pass the 25-year and 100-year with no more than 1 foot of overtopping Major Roadways: Pass 100-year
	Pre-Existing (Retrofit)	
	Coastal New Construction	
	Coastal Pre-Existing (Retrofit)	
Storm Drainage Systems	New Construction	Convey 25-year flow underground and 100-year in the right-of-way
	Pre-Existing (Retrofit)	
	Coastal New Construction	
	Coastal Pre-Existing (Retrofit)	
Detention Facilities	New Construction	Detain proposed condition peak discharge for the 25-year and 100-year below or equal to the existing condition peak discharge
	Pre-Existing (Retrofit)	
	Coastal New Construction	
	Coastal Pre-Existing (Retrofit)	

Infrastructure	Type / Condition	Example Flood Protection Standard
Dams	Greater than 6 feet in height as well as other requirements based on hazard and size	TCEQ requirements [B]
Levees / Floodwalls	Earthen embankments and floodwalls compliant with FEMA 44 CFR 65.10	FEMA requirements [C]
Property acquisition		Property acquisition considered in the flood planning will conform to property acquisition and relocation for open space (44 C.F.R Part 80) requirements.

A FEMA provides additional regulations for reference regarding critical facilities (https://www.fema.gov/glossary/critical-facility):

> *"A critical facility provides services and functions essential to a community, especially during and after a disaster. Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, and similar facilities. These facilities should be given special consideration when formulating regulatory alternatives and floodplain management plans. A critical facility should not be located in a floodplain if at all possible. If a critical facility must be located in a floodplain it should be provided a higher level of protection so that it can continue to function and provide services after the flood. Communities should develop emergency plans to continue to provide these services during the flood."*
>
> *"Under Executive Order (EO) 11988, Floodplain Management, Federal agencies funding and/or permitting critical facilities are required to avoid the 0.2 percent (500-year) floodplain or protect the facilities to the 0.2 percent chance flood level."*

B The TCEQ Dam Safety regulations as per Texas Administrative Code Title 30 Chapter 299 Dams and Reservoirs.

[C] *Federal requirements of FEMA in* 44 CFR 65.10(b):

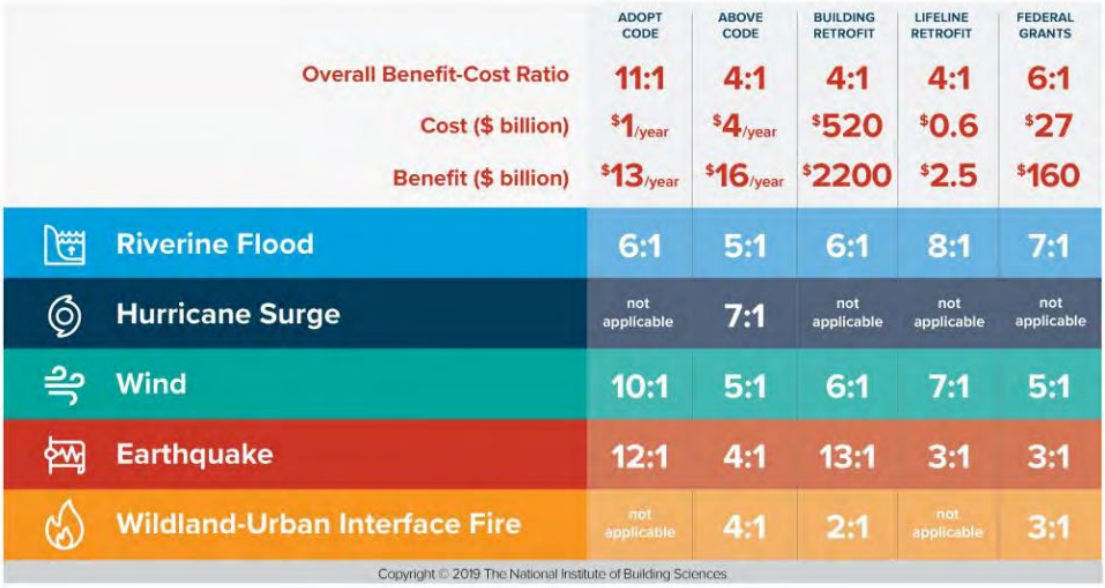
> *"For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided. The following requirements must be met…(1) Freeboard..(2) Closures…(3) Embankment protection…(4) Embankment and foundation stability…(5) Stability…(6) Interior drainage…(7) Other design criteria…"*

Further, EO 13990, signed Jan 2021, reinstated the Federal Flood Risk Management Standard (FFRMS) established by EO 13690 in 2015 that modified the original 1977 EO 11988 with increased requirements for federal funds and flood risk requirements.

Another good Texas source for higher standards is from the Texas Floodplain Managers Association (TFMA) who performs occasional surveys of Texas communities to assess higher freeboard standards, which can be accessed at www.tfma.org/page/TFMAReports.TFMA also publishes *A Guide for Higher Standards in Floodplain Management* (TFMA, 2018). FEMA also encourages communities to adopt higher standards and offers discounts for all flood insurance policies in the community that adopts those higher standards through the Community Rating System (CRS) program. More information is available at www.fema.gov/floodplain-management/community-rating-system.

Conducted by the National Institute of Building Sciences, the *Natural Hazard Mitigation Saves: 2019* report (Porter et al., 2019) provides estimates of mitigation savings from adopting current residential and building codes, exceeding those codes, and addressing retrofits. The summary of findings in the 2019 report are displayed in the figure below.

Figure 4: Natural hazard mitigation saves: 2019 (report summary)



Reproduced from: Porter et al, 2019. National Institute of Building Sciences.

With a riverine flood for example, if codes regulating floodplain development were adopted that did not previously exist within a certain community, those codes would create compliance costs (staff to administer the codes, higher construction costs, etc.). However, the benefits of reduced future flood damages are estimated to be significantly higher. So, beneficial savings estimated at 6:1 for adoption of residential and building codes and additional savings of 5:1 for adoption of higher building standards, it is recommended that higher building standards for infrastructure flood protection be considered.

An important consideration for the RFPGs in this task will be how to recommend or adopt floodplain management standards in a manner that does not undermine or otherwise conflict with local control of establishing flood regulation or enforcement and otherwise conforms in line with existing legal frameworks and requirements. 31 TAC 361 rules do not grant the RFPGs or political subdivisions any additional regulatory powers or authorities so the authority of existing regulatory entities/bodies may remain limited regardless of what a RFPG recommends as a standard. If RFPGs find that there are legal, regulatory, or other barriers to implementation of standards, the RFPG may choose to make related legislative, regulatory, administrative, or other recommendations (in Chapter 8 of the plan) that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation under Task 8.

Freeboard requirement or structural elevation (i.e., raising up) of newly constructed or substantially improved/damaged buildings in flood risk areas is one prominent example of a floodplain management practice. Using stakeholder questionnaire responses, research, and professional engineering experience in various geographic locations across Texas, the table below identifies examples of the minimum and most stringent specifications regarding structural elevation and freeboard requirements *that are already being followed by various entities across Texas*. Note that the coastal regulations below are only

applicable to those near the Gulf of Mexico. While non-coastal elevation requirements are for the top of the bottom floor, coastal elevation requirements are for the lowest horizontal structural member.

Table 8: Freeboard requirements or structural elevation standards used in Texas for buildings

Infrastructure	Type / Condition	Minimum	Most stringent
Residential Buildings	New Construction	Equal to BFE	500-year plus 2 feet
	Pre-Existing (Retrofit)	Equal to BFE	No Substantial Improvements allowed without 500-year plus 2 feet
	Coastal New Construction	Equal to BFE	500-year plus 3 feet
	Coastal Pre-Existing (Retrofit)	Equal to BFE	500-year plus 3 feet
Commercial Buildings	New Construction	Equal to BFE	500-year plus 2 feet
	Pre-Existing (Retrofit)	Equal to BFE	500-year plus 2 feet
	Coastal New Construction	Equal to BFE	500-year plus 3 feet
	Coastal Pre-Existing (Retrofit)	Equal to BFE	500-year plus 3 feet
Critical Facilities	New Construction	Equal to BFE	500-year plus 3 feet
	Pre-Existing (Retrofit)	Equal to BFE	500-year plus 3 feet
	Coastal New Construction	Equal to BFE	500-year plus 3 feet
	Coastal Pre-Existing (Retrofit)	Equal to BFE	500-year plus 3 feet

According to the stakeholder responses and research, the minimum standards for structural elevation (above) are based on federal requirements of the National Flood Insurance Program, included in the 44 CFR , example below:

> *"44 CFR 60.3(c)(2) [Communities must] Require that all new construction and substantial improvements of residential structures within Zones A1-30, AE and AH zones on the community's FIRM have the lowest floor (including basement) elevated to or above the base flood level…"*

FEMA provides additional regulations for reference regarding critical facilities, described here in the FEMA glossary (https://www.fema.gov/glossary/critical-facility):

> *"A critical facility provides services and functions essential to a community, especially during and after a disaster. Typical critical facilities include hospitals, fire stations, police stations, storage of critical records, and similar facilities. These facilities should be given special consideration when formulating regulatory alternatives and floodplain management plans. A critical facility should not be located in a floodplain if at all possible. If a critical facility must be located in a floodplain it should be provided a higher level of protection so that it can continue to function and provide services after the flood. Communities should develop emergency plans to continue to provide these services during the flood.*
>
> *Under Executive Order (EO) 11988, Floodplain Management, Federal agencies funding and/or permitting critical facilities are required to avoid the 0.2 percent (500-year) floodplain or protect the facilities to the 0.2 percent chance flood level."*

Another example of standards that greatly impact future flood risk are public infrastructure design standards. The table below identifies examples of the minimum and most stringent specifications regarding infrastructure design standards requirements *that are already being followed by various entities across Texas*. As noted above, coastal regulations are only applicable to a few entities.

Table 9: Infrastructure design standards requirements used in Texas for public infrastructure

Infrastructure	Type / Condition	Minimum	Most stringent
Roadways	New Construction	2-year below top of curb	Ultimate condition 100-year with 1 foot of freeboard
	Pre-Existing (Retrofit)		
	Coastal New Construction		
	Coastal Pre-Existing (Retrofit)		
Storm Drainage Systems	New Construction	2-year capacity	Ultimate condition 100-year capacity
	Pre-Existing (Retrofit)		
	Coastal New Construction		
	Coastal Pre-Existing (Retrofit)		
Detention Facilities	New Construction	No increase in 25-year peak flow	No increase in peak flow for the 2-, 5-,10-, 25-, 50-, and 100-year
	Pre-Existing (Retrofit)		
	Coastal New Construction		
	Coastal Pre-Existing (Retrofit)		
Dams	Greater than 6 feet in height as well as other requirements based on hazard and size	TCEQ requirements	Designed to convey 100 percent of the Probable Maximum Flood
Levees / Floodwalls	Earthen embankments and floodwalls compliant with FEMA 44 CFR 65.10	FEMA requirements	FEMA requirements plus 3 feet of freeboard

The minimum standards for dams are based on state requirements of the TCEQ Dam Safety regulations as per Texas Administrative Code Title 30 Chapter 299 Dams and Reservoirs while the minimum standards for levees are based on federal requirements of FEMA in 44 CFR 65.10(b):

> *"For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided. The following requirements must be met…(1) Freeboard...(2) Closures…(3) Embankment protection…(4) Embankment and foundation stability…(5) Stability…(6) Interior drainage…(7) Other design criteria…"*

The Texas Department of Transportation (TxDOT) has minimum roadway and transportation system standards that apply to state roads and other transportation facilities and some county/municipal roads that receive state funding. Their hydraulic and floodplain standards are located in the TxDOT Hydraulic Design Manual (Thomason, 2019).

The RFPGs may also consider recommending that construction of infrastructure avoid high risk and sensitive areas such as floodways, floodplains, coastal dunes, and areas downstream of dams or levees or floodwalls, and/or, for example, that special care should be practiced in these areas to minimize risk to life and property.

Where possible, the RFPG should recommend and/or adopt floodplain management standards that apply consistently across the region, even if that means consistently based on defined variability, for example, tied to underlying sub-regional characteristics that are relevant to flood risk. Floodplain management recommendations or minimum standards may vary geographically across the flood

planning region if the RFPG concludes that unique characteristics of different areas necessitate unique recommended and/or required standards. For example, the RFPGs may wish to consider the unique needs of urban vs. rural areas, or areas with detailed vs. approximate floodplain mapping and modeling, or upstream vs. downstream areas. If the RFPG recommends standards that vary geographically or in some other way, the Plan must contain a clear description of how the specific sub-regional areas are defined (Example: source of data used to determine urban vs. rural status).

Floodplain management ***recommendations*** in the Plan may be fairly general (e.g., "The RFPG recommends that communities adopt and enforce specific freeboard requirements") whereas ***adopted*** minimum standards that must be specific enough for local entities to be able to clearly understand and adopt nearly verbatim (e.g., "Communities must adopt and enforce a minimum of one foot of freeboard for all new residential and non-residential construction and substantially improved or damaged structures in the 1 percent annual chance floodplain as defined by FEMA"). If the RFPG requires them, minimum standards must be adopted by entities in order for FMEs, FMSs, or FMPs associated with them to be included in the plan.

Note that in the subsequent Task 3B, the RFPG will be responsible for setting overarching goals for the region. Tasks 3A and 3B will likely need to be discussed and executed in tandem due to the interrelated nature of these tasks. For example, if the RFPG sets an overarching goal of limiting floodplain encroachment or reducing any increases in future flood risk by regulating development in floodplains, the RFPG would need to consider standards in this task that would help the region progress towards those identified goals under Task 3B.

Submittal requirements:

1. General description and summary of existing floodplain management practices in the region.
2. A summary of key floodplain management practices in the region summarized by their respective regulatory entities.
3. Summary of **recommendations** and/or **adopted standards** on Floodplain Management Practices and Infrastructure protection standards for the entire region or by specific areas (HUC-8s) in the region, as applicable. Summarize the recommendations and/or adopted standards including the area where they apply and associated regulatory authority for each recommendation if applicable.
4. GIS coverage map depicting the areas with established floodplain management practices and the entities that regulate and enforce those floodplain practices and locations that lack floodplain management.
5. All maps must be submitted with the underlying GIS data utilized to prepare them.

These are minimum reporting requirements however, an RFPG may present additional information utilized in the development of their plan.

2.3.B Task 3B – Flood mitigation and floodplain management goals (361.36)

Goals:

The goal of this task is for RFPGs to define the overarching flood mitigation and floodplain management goals for their regional flood plans. These goals will guide the overall approach and recommendations in the plan and, to ensure the coherence of the entire plan, may also be used in developing the recommendations for floodplain management in the previous task.

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 in 31 TAC §362.3. RFPGs must identify specific and achievable

flood mitigation and floodplain management goals that, when implemented, will demonstrate progress towards this overarching goal.

Information included in rules and scope of work:

Considering the Guidance Principles under Title 31 Texas Administrative Code §362.3, Tasks 1-3A, input from the public, and other relevant information and considerations, RFPGs shall:

1. identify specific and achievable flood mitigation and floodplain management goals along with target years by which to meet those goals for the FPR to include, at a minimum, goals specifically addressing risks to life and property.
2. recognize and clearly state the levels of residual risk that will remain in the FPR even after the stated flood mitigation goals in paragraph (1) of this section are fully met.
3. structure and present the goals and the residual risks in an easily understandable format for the public including in conformance with guidance provided below.
4. use these goals to guide the RFPG in carrying out the flood mitigation needs analysis and the identification, evaluation, and recommendation of FMEs, FMSs, and FMPs.
5. when appropriate, choose goals that apply to full single HUC8 watershed boundaries or coterminous groups of HUC8 boundaries within the FPR.
6. Identify both short-term goals (10 years) and long-term goals (30 years).

Additional guidance:

The RFPGs must utilize the Guidance Principles, the existing condition flood risk analyses, future condition flood risk analyses, and the consideration of current floodplain management and land use approaches, input from the public, and other relevant information and considerations in developing and defining the goals for the region.

RFPGs must, at a minimum, identify 10-year short-term goals and 30-year long-term goals. Groups may, at their discretion, identify additional goals for other timeframes as long as they follow the guidance herein regarding goal requirements and format.

In selecting the flood risk reduction and protection goals for the region, the RFPG will inherently also be determining the accepted 'residual' flood risk of the flood planning region since, conceptually, these two, together, comprise the totality of flood risk faced by the region. Any flood risk not avoided or reduced through meeting a goal will remain as a residual risk. It is not possible to protect against all potential flood risks.

The RFPGs must consider and identify residual risk for each goal identified. Simply put, if the goal, for example, is to protect all life and property from all 1 percent flood events, the residual risk being accepted would be the remaining risk to life and property resulting from all flood events that exceed a 1 percent likelihood.

The table below contains examples of specific and achievable short- and long-term plan goals.

Table 10: Examples of potential regional flood plan goals and means of presenting them

Short term (10 year)	Long term (30 year)
Reduce 5-year moving average of flood-related fatalities in the flood planning region by 50% by 2033.	Eliminate the occurrence of all flood-related fatalities in the flood planning region by 2053.
Reduce 5-year moving average of flood-related injuries in the flood planning region by 75% by 2033.	Eliminate the occurrence of flood-related injuries in the flood planning region by 2053.
Reduce exposure of existing structures in the current 1% annual chance floodplain by elevating, acquiring, relocating, or otherwise providing flood protection to 1,000 structures by 2033.	Reduce exposure of existing structures in the current 1% annual chance floodplain by elevating, acquiring, relocating, or otherwise providing flood protection to 10,000 structures by 2053.
Remove 50% of the existing structures from 1% annual chance floodplain in the region by 2033.	Remove 95% of the existing structures from 1% annual chance floodplain in the region by 2053.
Remove 50% of the low water crossings from 10% annual chance flood risk in the region by 2033.	Remove 90% of the low water crossings from 10% annual chance flood risk in the region by 2053.
By 2033, increase the coverage of flood hazard data across the region by completing studies in 50% of the areas identified as having current gaps in flood mapping.	By 2053, have complete coverage of flood hazard data across the region by completing studies in 100% of the areas identified as having current gaps in flood mapping and have an ongoing, funded maintenance plan for updates.
By 2033, enroll all current non-participating communities into the National Flood Insurance Program.	Maintain 100% community enrollment with no suspensions or sanctions.
By 2033, 25% of all communities have adopted higher than NFIP-minimum standards.	By 2053, 50% of all communities have adopted higher than NFIP-minimum standards.
By 2033, RFPGs will consider and incorporate nature-based practices in their flood risk reduction projects.	
By 2033, RFPG adopts minimum stormwater infrastructure design standards applicable across the region.	
By 2033, 50% of the region's population is part of a municipality that has a dedicated municipal drainage charge, drainage district fee, or other continuous funding mechanism.	By 2033, 90% of the region's population is part of a municipality that has a dedicated municipal drainage charge, drainage district fee, or other continuous funding mechanism.
By 2033, 50% of the communities have a documented, operational, and fully funded stormwater asset management plan and system.	By 2033, 75% of the communities have a documented, operational, and fully funded stormwater asset management plan and system.
Reduce flood-related loss of natural and cultural resources within the FPR by 2033.	Maximize safe economic development within flood prone areas.
Reduce any increases in future flood risk to life and property from development by regulating development in future conditions floodplains.	Eliminate any increases in future flood risk to life and property from development by regulating development in future conditions floodplains.

This table contains examples of regional flood mitigation and floodplain management goals for consideration only and does not reflect any TWDB-recommended goals. The RFPGs are expected to deliberate and gather data necessary to establish their own goals for their region.

Where possible, the regional flood planning groups should establish goals that apply to the full flood planning region. In cases where tailoring goals to specific geographic areas is necessary, the group must choose goals that apply to no less than an entire HUC-8 watershed or coterminous groups of HUC-8 watersheds within the region.

The regional flood plan must contain the group's overarching goals and must contain a written or other clear summary of the residual risk, including 'transformed' risk, that would remain in the region even

after the stated goals are met. For example, if a goal is to restrict future development within the existing condition 1 percent annual chance floodplain, there will still be residual flood risk for existing structures. Transformed risk is defined by U.S. Army Corps of Engineers (USACE) as the change in the nature of flood risk for some area associated with the presence of flood hazard reduction infrastructure. Flood risk is often reduced by the construction of flood mitigation structures but, as a result, may also be 'transformed' into a different type of risk, for example, in the form of risk from structural failure of that mitigation infrastructure (e.g., a dam or levee).

As another example, if a goal is to reduce the flood risk to existing structures in the current 1 percent annual chance floodplain by elevating, acquiring, relocating, or otherwise providing flood protection to 1,000 structures, even after that goal is fully met, there will still be a residual flood risk to these structures from a larger, less frequent flood events and to the other structures that were not provided the same protection.

Regional flood planning groups are not required to establish both short-term and long-term goals for all goal categories. For example, if a group chooses a short-term goal of, "By 2033, enroll all current non-participating communities into the National Flood Insurance Program," an associated long-term goal may not be needed. However, it is recommended that if regional flood planning groups identify long-term goals, where possible, the groups attempt to also establish short-term goals to reflect anticipated progress towards the long-term goal.

Submittal requirements:

1. General description, and summary table of flood mitigation and floodplain management goals.
2. All data identified in data submittal requirements. Please refer to the Exhibit D: Data Submittal Guidelines for information required to be provided {19. Goals}.
3. The TWDB will provide an empty GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase will be pre-populated with all feature classes and fields.

Once identification of floodplain management and flood mitigation goals is completed, the RFPG must include a summary table with goals (example template below), and description of residual risk associated with those goals, that is also easy for the public to understand and comment on. These are minimum requirements however, an RFPG may present additional information utilized in the development of their plan.

Table 11: Regional flood plan flood mitigation and floodplain management goals

Goal ID	Goal	Term of Goal	Target Year	Applicable To	Residual Risk	How will the Goal be Measured	Overarching Goal(s)	Associated Goal IDs
01000001	Remove 50% of the low water crossings from 1% annual chance flood risk in the region by 2023.	Short Term (10 year)	2023	HUC 8 Watershed #			Protect against the loss of life	01000002
01000002	Remove 90% of the low water crossings from 1% annual chance flood risk in the region by 2053.	Long Term (30 year)	2053	Entire RFPG			Protect against the loss of life	01000001
01000003								
01000004								
01000005								
01000006								

This table contains examples of regional flood mitigation and floodplain management goals and does not reflect any TWDB recommended goals based on real data. The goals are included to reflect reporting requirements. The RFPGs are expected to deliberate and gather data necessary to establish goals for their region.

2.4 Task 4 - Assessment and identification of flood mitigation needs

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

2.4.A Task 4A – Flood mitigation needs analysis (361.37)

Goals:

The goal of this task is for RFPGs to conduct a two-piece, big picture analysis to guide the RFPG's subsequent efforts (under Task 4B) by identifying:

1. The region's flood prone areas where the greatest **flood risk knowledge gaps** exist and where the RFPG should consider identifying potentially feasible flood risk studies as **FMEs**. (See Task 4B), and,
2. The areas of greatest **known flood risk** and flood mitigation needs in the regions and resulting need of potential strategies and projects, as **FMSs and FMPs**, to reduce those known risks. See Task 4B).

Information included in rules and scope of work:

Based on the analyses and goals developed by the RFPG and any additional analyses or information developed using available screening-level models or methods, the RFPG shall identify locations within the FPR that the RFPG considers to have the greatest flood mitigation and flood risk study needs by considering:

1. the areas in the FPR that the RFPG identified as the most prone to flooding that threatens life and property;
2. the relative locations, extent, and performance of current floodplain management and land use policies and infrastructure located within the FPR, particularly within the locations described in paragraph (1) of this subsection;
3. areas identified by the RFPG as prone to flooding that don't have adequate inundation maps;
4. areas identified by the RFPG as prone to flooding that don't have hydrologic and hydraulic models;
5. areas with an emergency need;
6. existing modeling analyses and flood risk mitigation plans within the FPR;
7. flood mitigation projects already identified and evaluated by other flood mitigation plans and studies;
8. documentation of historic flooding events;
9. flood mitigation projects already being implemented; and
10. any other factors that the RFPG deems relevant to identifying the geographic locations where potential FMEs and potentially feasible FMSs and FMPs shall be identified and evaluated.

The RFPG shall conduct the analysis of this section in a manner that will ensure the most effective and efficient use of the resources available to the RFPG.

Additional guidance:

Relying partially on the region-wide flood risk analyses performed in Task 2B, the RFPGs must identify areas that do not currently have flood risk data of sufficient quality (e.g., outdated information) or at adequate resolution or detail to identify and compare alternatives that might mitigate the associated flood risks. This will be a screening level type determination since, by the nature of these areas being identified, many likely will not have any well-established flood risk information. The RFPGs must prepare

a summary characterizing the gaps in flood risk information in the region and will prepare and submit a map of those flood prone areas with poorly defined or inadequate flood risk information to the extent that it would prevent the RFPG from identifying potentially feasible FMSs and/or FMPs to mitigate flood risks. Areas with recent H&H models, for example, would not fall into this category.

The areas of greatest flood risk can be determined based on factors including, but not limited to, depth of flooding, velocity of flood flow as applicable, number of structures, population, historic events, and critical infrastructure in the floodplain. In determining the greatest mitigation needs, the RFPGs should consider ongoing and planned flood risk reduction projects with funding.

The RFPGs will prepare a summary of the greatest flood risk and mitigation needs in the region, identify, and document the assumptions and process utilized to identify the greatest flood risk and prepare and submit a map of areas with greatest flood risk in the region.

2.4.B Task 4B – Identification and evaluation of potential flood management evaluations and potentially feasible flood management strategies and flood mitigation projects (361.38)

Goals:

The goal of this task is for RFPGs to identify and evaluate potential Flood Management Evaluation (FME)s, and potentially feasible Flood Mitigation Project (FMP)s and Flood Management Strategy (FMS)s. While the evaluation of FMEs, FMSs and FMPs can be initiated in Task 4, they will be completed during Task 5.

A Flood Management Evaluation (FME) is a proposed flood study of a specific, flood-prone area that is needed in order to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs.

A Flood Mitigation Project (FMP) is a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring cost and when implemented will reduce flood risk, mitigate flood hazards to life or property. The RFPGs are strongly encouraged to consider nature-based flood risk reduction solutions in their overall approach.

A Flood Management Strategy (FMS) is a proposed plan to reduce flood risk or mitigate flood hazards to life or property. The RFPG has some flexibility on how they choose to utilize FMSs in the regional flood planning process. For example, RFPGs could choose not to recommend any FMSs. At a minimum, RFPGs should include as FMSs any proposed action that the group would like to identify, evaluate, and recommend that does not qualify as either a FME or FMP.

To include a potential project as an FMP, the RFPGs must be able determine ‘no negative impact’ of that project as required by the statue. If the RFPG is unable to determine ‘no negative impact’ for a project, it is recommended that a potential project be included in the plan as an ‘FME’ for further study of the project area.

It is expected that a wide range of project types will be recommended by the RFPGs to the TWDB. The following list of **types** (also listed in section 3.2) is provided as guidance for use as FME, FMS, and FMPs, but other types identified by the RFPGs, that are not already listed, should be included by the RFPG.

1. Flood Management Evaluations
    a. Watershed Planning
        i. Hydrologic and Hydraulic Modeling
        ii. Flood Mapping Updates
        iii. Regional Watershed Studies

   b. Engineering Project Planning
      i. Feasibility Assessments
      ii. Preliminary Engineering (alternative analysis and up to 30 percent design)
   c. Studies on Flood Preparedness
   d. Other
2. Flood Mitigation Projects – Structural[4]
   a. Low Water Crossings or Bridge Improvements
   b. Infrastructure (channels, ditches, ponds, stormwater pipes, etc.)
   c. Regional Detention
   d. Regional Channel Improvements
   e. Storm Drain Improvements
   f. Reservoirs
   g. Dam Improvements, Maintenance and Repair
   h. Flood Walls / Levees
   i. Coastal Protections
   j. Natural 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
   k. Comprehensive Regional Project – includes a combination of projects intended to work together
   l. Other
3. Flood Mitigation Projects – Non-Structural[5]
   a. Property or easement acquisition
   b. Elevation of Individual Structures
   c. Flood Readiness and Resilience
   d. Flood Early Warning Systems, including stream gauges and monitoring stations
   e. Floodproofing
   f. Regulatory Requirements for Reduction of Flood Risk
   g. Other

Under Task 5, the RFPG makes its recommendations of FMEs, FMSs, and FMPs that were evaluated under Task 4B. Analyses under this section must also be performed in accordance with the technical guidance provided in Part 3 of this document.

Information included in rules and scope of work:

A Flood Management Evaluation (FME) is a proposed flood study of a specific, flood-prone area that is needed in order to assess flood risk and/or determine whether there are potentially feasible FMSs or FMPs. A Flood Mitigation Project (FMP) is a proposed project, either structural or non-structural, that has non-zero capital costs or other non-recurring cost and when implemented will reduce flood risk, mitigate flood hazards to life or property. A Flood Management Strategy (FMS) is a proposed plan to reduce flood risk or mitigate flood hazards to life or property. An FMS may or may not require associated FMPs to be implemented and one FMP may be associated with multiple FMSs.

The RFPG shall identify and evaluate potential FMEs and potentially feasible FMSs and FMPs, including nature-based solutions, some of which may have already been identified by previous evaluations and

[4] FMPs will include permitting, detailed design, construction, and implementation phases of the project.
[5] FMPs will include permitting, detailed design, construction, and implementation phases of the project.

analyses by others. If no potentially feasible FMSs are identified or recommended for an identified need, then the RFPG shall document the reason. An FME may eventually result in detailed hydrologic and hydraulic analyses and identification of projects or strategies that could be amended into an Regional Flood Plan as FMSs or FMPs.

When evaluating FMSs and FMPs the RFPG will, at a minimum, identify one solution that provides flood mitigation associated a with 1% annual chance flood event. In instances where mitigating for 1% annual chance events is not feasible, the RFPG shall document the reasons for its infeasibility, and at the discretion of the RFPG, other FMS and FMPs to mitigate more frequent events may also be identified and evaluated based on guidance to be provided by the EA.

A summary of the RFPG process for identifying potential FMEs and potentially feasible FMSs and FMPs shall be established and included in the draft and final adopted Regional Flood Plan.

The RFPG shall then identify potentially feasible FMSs and FMPs in accordance with the RFPG's established process.

For areas within the FPR that the RFPG does not yet have sufficient information or resources to identify potentially feasible FMSs and FMPs, the RFPG shall identify areas for potential FMEs that may eventually result in FMPs.

The RFPG shall evaluate potentially feasible FMSs and FMPs understanding that, upon evaluation and further inspection, some FMSs or FMPs initially identified as potentially feasible may, after further inspection, be reclassified as infeasible.

FMPs will be ranked in the state flood plan and

1. shall represent discrete, projects;
2. shall not entail an entire capital program or drainage masterplan; and
3. may rely on other flood-related projects.

Evaluations of potentially feasible FMSs and FMPs will require associated, detailed hydrologic and hydraulic modeling results that quantify the reduced impacts from flood and the associated benefits and costs. Information may be based on previously performed evaluations of projects and related information. Evaluations of potentially feasible FMS and FMPs shall include the following information and be based on the following analyses:

1. A reference to the specific flood mitigation or floodplain management goal addressed by the feasible FMS or FMP;
2. A determination of whether FMS or FMP meets an emergency need;
3. An indication regarding the potential use of federal funds, or other sources of funding, as a component of the total funding mechanism;
4. An equitable comparison between and consistent assessment of all FMSs and FMPs that the RFPGs determine to be potentially feasible;
5. A demonstration that the FMS or FMP will not negatively affect a neighboring area;
6. A quantitative reporting of the estimated benefits of the FMS or FMP, including reductions of flood impacts of the 1% annual chance flood event and other storm events identified and evaluated if the project mitigates to more frequent event, to include, but not limited to:
    a. Associated flood events that must, at a minimum, include the 1% annual chance flood event and other storm events identified and evaluated;
    b. Reduction in habitable, equivalent living units flood risk;
    c. Reduction in residential population flood risk;

d. Reduction in critical facilities flood risk;
e. Reduction in road closure occurrences;
f. Reduction in acres of active farmland and ranchland flood risk;
g. Estimated reduction in fatalities, when available;
h. Estimated reduction in injuries, when available;
i. Reduction in expected annual damages from residential, commercial, and public property; and
j. Other benefits as deemed relevant by the RFPG including environmental benefits and other public benefits.

7. A quantitative reporting of the estimated capital cost of projects in accordance with guidance provided by the EA;
8. Calculated benefit-cost ratio for FMPs in accordance with guidance to be provided by the EA and based on current, observed conditions;
9. For projects that will contribute to water supply, all relevant evaluations, as determined by the EA based on the type of contribution, and a description of its consistency with the currently adopted State Water Plan;
10. A description of potential impacts and benefits from the FMS or FMP to the environment, agriculture, recreational resources, navigation, water quality, erosion, sedimentation, and impacts to any other resources deemed relevant by the RFPG;
11. A description of residual, post-project, and future risks associated with FMPs including the risk of potential catastrophic failure and the potential for future increases to these risks due to lack of maintenance;
12. Implementation issues including those related to rights-of-way, permitting, acquisitions, relocations, utilities and transportation; and
13. Funding sources and options that exist or will be developed to pay for development, operation, and maintenance of the FMS or FMP.

Evaluations of potential FMEs will be at a reconnaissance or screening-level, unsupported by associated detailed hydrologic and hydraulic analyses. These will be identified for areas that the RFPG considers a priority for flood risk evaluation but that do not yet have the required detailed hydrologic and hydraulic modeling or associated project evaluations available to evaluate specific FMSs or FMPs for recommendation in the Regional Flood Plan. These FMEs shall be based on recognition of the need to develop detailed hydrologic models or to perform associated hydraulic analyses and associated project evaluations in certain areas identified by the RFPG. Evaluations of potential FMEs shall include the following analyses:

1. A reference to the specific flood mitigation or floodplain management goal to be addressed by the potential FME.
2. A determination of whether FME may meet an emergency need.
3. An indication regarding the potential use of federal funds, or other sources of funding as a component of the total funding mechanism.
4. An equitable comparison between and consistent assessment of all FMEs.
5. An indication of whether hydrologic and or hydraulic models are already being developed or are anticipated in the near future and that could be used in the FME.
6. A quantitative reporting of the estimated benefits, including reductions of flood risks, to include:

a. Estimated habitable, living unit equivalent and associated population in FME area;
b. Estimated critical facilities in FME area;
c. Estimated number of roads closures occurrences in FME area;

d. Estimated acres of active farmland and ranchland in FME area; and
e. A quantitative reporting of the estimated study cost of the FME and whether the cost includes use of existing or development of new hydrologic or hydraulic models.

7. For FMEs, RFPGs do not need to demonstrate that an FME will not negatively affect a neighboring area.
8. RFPGs shall evaluate and present potential FMEs and potentially feasible FMSs and FMPs with sufficient specificity to allow state agencies to make financial or regulatory decisions to determine consistency of the proposed action before the state agency with an approved Regional Flood Plan.
9. Analyses shall clearly designate a representative location of the FME and beneficiaries including a map and designation of HUC-8 and county location.

Additional guidance:

Flood management evaluations (FMEs)

Based on other work performed in Task 3 and 4, this task is intended to identify areas that require technical studies such as H&H modeling to better quantify flood risk or to update outdated flood risk information. FMEs may include hydrologic and hydraulic modeling and mapping for identification and/or update of flood risk. The FMEs, may also include feasibility studies and alternative analyses to consider potentially feasible solutions (e.g., FMSs or FMPs) that could be implemented and/or recommended in the next regional flood plan, for example.

Not every conceivable FME will be recommended. The RFPG and their technical consultant must decide which identified potential FMEs will be recommended in their regional plan in order to ensure that the recommended FMEs are sensible so that limited resources can be directed efficiently and accordingly to implement those studies.

FMEs will be identified under Task 4 and recommended under Task 5 in the regional plan but are not anticipated to actually be performed by the RFPG during the same regional flood planning cycle during which they are identified. FMEs are to be recommended in the regional plans to make clear what additional studies, and funds to support them, are needed to adequately evaluate all flood prone areas within a region. The step of identifying FMEs is a recognition that the regional flood planning process has significant financial, technical, and time constraints. However, that does not preclude performance of the FMEs by others, with other sources of funds for example, or incorporating the timely results of such evaluations into the final regional flood plan. If an equivalent FME is performed outside of the regional flood planning process, for example through efforts by the GLO's Combined River Basin Flood Studies, and the results incorporated into the plan, that particular FME would no longer be recommended as a FME in the plan since the results of it would already be reflected in the plan. The FMEs that are performed after adoption of the regional plan may then support recommendations of FMSs and FMPs in the next regional plan, for example.

Please refer to Part 3 of this document for guidance regarding cost estimates. A planning level cost estimate for each identified FME will suffice.

Submittal requirements for FMEs:

1. General description and GIS coverage map of identified FMEs in the region.
2. A GIS coverage map showing the extent of all identified FME study areas in the region with an indication whether the identified FME area is associated with a previously studied area that requires an update or if the identified study area does not have any existing or anticipated flood mapping, models, etc., and therefore requires an initial study.

3. Total number of and study area extent (square miles) of each FME by flood risk type, counties, regions, and flood frequency should be summarized in a table.
4. A planning level cost estimate for each FME study.
5. Identify who will sponsor the FME including directly financing and implementing it. This may involve more than one entity and could rely on a variety of sources of the funds.
6. All data identified in the data submittal requirements as outlined in the Exhibit D: Data Submittal Guidelines.
7. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields but will not have any data.
8. GIS data layer that shows boundaries of all identified FMEs and associated data {21. FME}.
9. All maps should be submitted with underlying GIS data utilized to prepare them.

The potential FMEs must be provided in a summary table with findings (template below) in the plan.

These are minimum reporting requirements however, a RFPG may present additional information utilized in the development of their plan.

Table 12: Potential flood management evaluations identified by RFPG

FME ID	FME Name	Description	Associated Goal No.	Counties	HUC8s	HUC12s [A]	Watersheds [A]	Study Type	FME Area (sqmi)	Flood Risk Type	Sponsor	Entities with Oversight	Emergency Need	Estimated Study Cost	Potential Funding Sources and Amount	Estimated number of structures at flood risk	Residential structures at flood risk	Estimated Population at flood risk	Critical facilities at flood risk (#)	Number of low water crossings at flood risk (#)	Estimated number of road segment closures (#)	Estimated length of roads at flood risk (Miles)	Estimated farm & ranch land at flood risk (acres)	Existing or Anticipated Models (year)	Existing or Anticipated Maps (year)

[A] *Leave blank if too many for text field length (254 characters).*

Flood mitigation projects (FMPs)

(See associated rule and scope language at top of this guidance section)

This section focuses on flood mitigation 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.

Flood mitigation project is defined in Title 31 TAC §361.10(n) as, "A proposed project, both structural and non-structural, that has a non-zero capital costs or other non-recurring cost and that when implemented will reduce flood risk, mitigate flood hazards to life or property." Mitigation is one phase out of the four phases of emergency management: mitigation, preparedness, response, and recovery. For a description of each of these phases and example projects, see Section 2.7 Task 7 – Flood Response Information and Activities.

The regional flood planning process will focus primarily on mitigation and may include preparedness with regard to identifying and recommending FMPs by the RFPG. Projects for which the primary purpose is addressing response and recovery needs will not be considered FMPs in this planning process.

H&H models required for evaluation of the FMPs must adhere to all Mapping and modeling guidelines and No Negative Impact requirements.

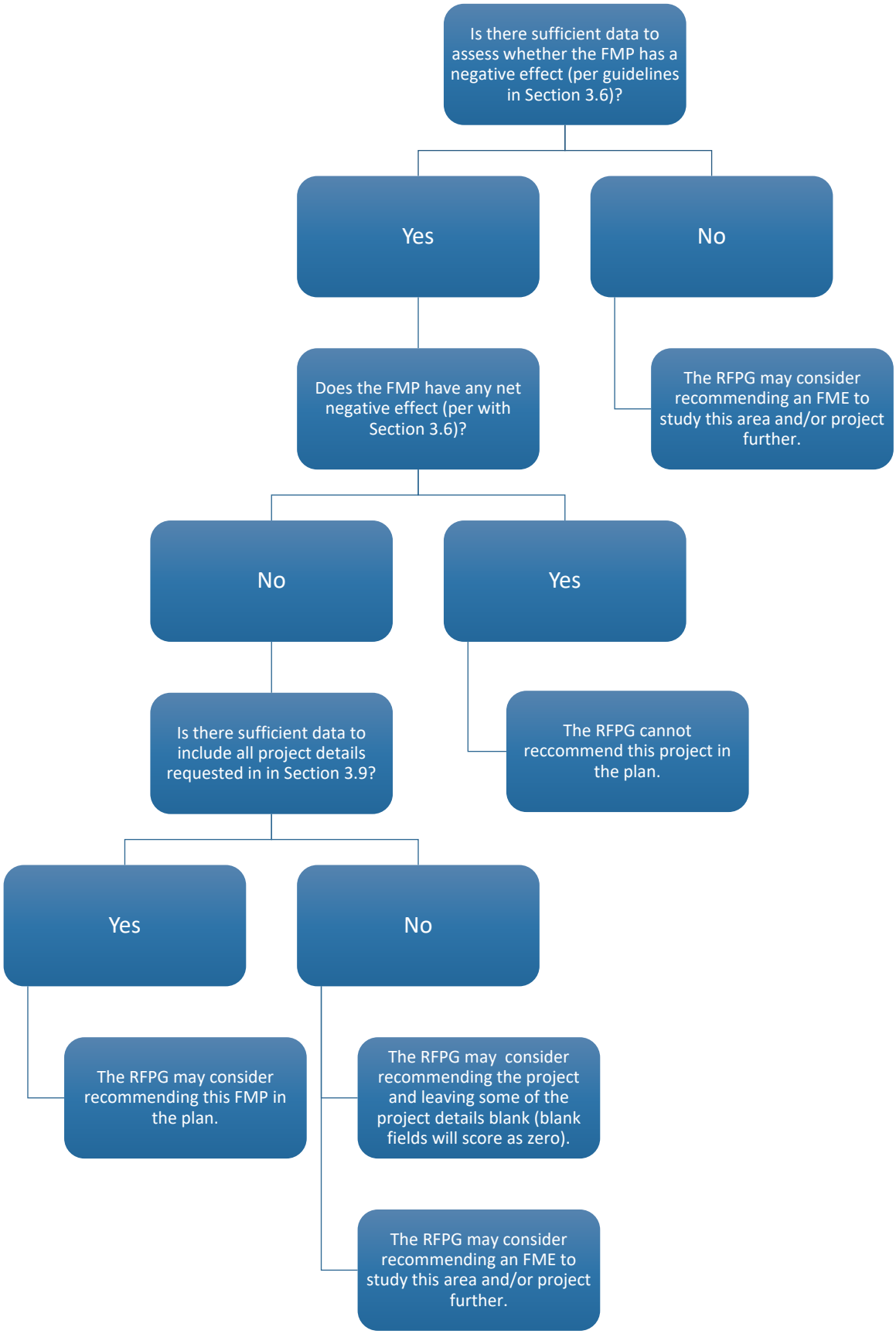
Please refer to Part 3 of this document for guidance regarding cost estimate, benefit-cost analysis (BCA), population estimate, and no negative impact. A planning level cost estimate for each identified FME will suffice.

FMPs that were previously identified and evaluated by others prior to and/or outside of the regional flood planning process and that are being considered by the RFPG for inclusion in the regional flood plan must be reassessed by the RFPGs prior to inclusion in the regional plan. These FMPs must meet or be updated to adhere to the requirements in this guidance and other relevant regional flood planning contract requirements.

The relationship and interdependencies between recommended FMS and the FMPs must be captured in the datasets provided to the TWDB. It is important that all these relationships and interdependencies are logical and clear in the data and in the regional plan so that readers understand what is required to successfully implement each piece of a regional flood plan.

For example, a single FMS, to "construct a network of largescale regional detention facilities to reduce urban flooding in Apple County" may, in turn, rely on constructing five recommended FMPs that are five separate detention facilities ('A' through 'E') in five different locations across the county. If, in turn, there is also one large 'upstream' drainage/collection channel FMP that must also be constructed to actually redirect flood water into the detention facility 'E' only, the dependance of that one detention facility E on that one collection channel FMP must be reflected in the geodatabase. If, in turn, there is an ASR facility being recommended and that relies on water held in detention facility 'E', that interdependence must also be reflected in the data provided to the TWDB so that it is clear that the ASR project shouldn't be implemented unless both the channel and the detention facility E were also both constructed.

Figure 5: FMP flowchart



Submittal requirements for FMPs:

1. General description and GIS coverage map of identified FMPs in the region.
2. A GIS coverage map showing the extent of all identified FMPs in the region with RFPG boundary, counties, HUC-12, major roadways, stream segments, contributing drainage area, relevant hydrologic and hydraulic features including but limited to detention ponds, storm drain system, dams etc.
3. Total number and project area (square miles) of FMPs by flood risk type, counties, and project type should be summarized in a table.
4. Planning level cost estimate for each FMP identified.
5. Identify who will sponsor and own the FMP including directly financing and implementing it. This may involve more than one entity and could rely on a variety of sources of the funds.
6. All data identified in the data submittal requirements. Please refer to the Exhibit D: Data Submittal Guidelines for information required to be provided.
7. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields, but will not have any data. GIS data layer that shows boundaries of all identified FMPs and associated data. {22. FMP}
8. The GIS geodatabase must show all relationships/links between each recommended FMP and any FMSs that may rely on that FMP to be implemented and/or any other FMPs that the FMP relies on or that may rely on that FMP. A single FMP may support more than one FMS or FMP and a single FMS may rely on more than one FMP to implement.
9. All maps should be submitted with underlying GIS data utilized to prepare them.
10. Completed 'Exhibit_C_Tables' Excel workbook for FMPs

Once identification of potential FMPs is complete, please include a summary table with findings (template below).

These are minimum reporting requirements however, an RFPG may present additional information utilized in the development of their plan.

Table 13: Potentially feasible flood mitigation projects identified by RFPG

FMP ID	FMP Name	Description	Associated Goals (ID)	Counties	HUC12s [B]	Watersheds [B]	Project Type	Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa, Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Project Cost ($)	Potential Funding Sources and Amount	Flood Risk								
															Area in 100-year (1% annual chance) Floodplain	Area in 500-year (0.2% annual chance) Floodplain	Estimated number of structures at 100-year flood risk [A]	Residential structures at 100-year flood risk [C]	Estimated Population at 100-year flood risk	Critical facilities at 100-year flood risk (#)	Number of low water crossings at flood risk (#)	Estimated number of road closures (#)	Estimated length of roads at 100-year flood risk (Miles)	Estimated farm & ranch land at 100-year flood risk (acres) [D]

A Estimated number of structures at 100-year flood risk will require consideration WSE and estimated finished flood elevation of buildings.

[B] Leave blank if too many for text field length (254 characters).

[C] For planning purpose, residential structures at flood risk will include residential buildings at flood risk that are greater than 500 square feet unless the RFPGs have more specific information.

[D] Estimated farm & ranch land at 100-year flood risk (acres) should only include farm and ranch land that are negatively impacted by flooding events and should not include land that benefits from floodplains for example rice fields.

Potentially feasible flood mitigation projects identified by RFPG (continued)

FMP ID	Reduction in flood risk												Pre-Project Level-of-Service	Post-Project Level-of-Service	Cost/ Structure removed	Percent Nature-based Solution (by cost)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Social Vulnerability Index (SVI)	Water Supply Benefit (Y/N)	Traffic Count for Low Water Crossings [E]	BCR
	Number of structures with reduced 100-year (1% annual chance) Flood risk	Number of structures removed from 100-year (1% annual chance) Flood risk	Number of structures removed from 500-year (0.2% annual chance) Flood risk	Residential structures removed from 100-year (1% annual chance) Flood risk	Estimated Population removed from 100-year (1% annual chance) Flood risk	Critical facilities removed from 100-year (1% annual chance) Flood risk (#)	Number of low water crossings removed from 100-year (1% annual chance) Flood risk (#)	Estimated reduction in road closure occurrences	Estimated length of roads removed from 100-year flood risk (Miles)	Estimated farm & ranch land removed from 100-year flood risk (acres) [D]	Estimated reduction in fatalities (if available) [E]	Estimated reduction in injuries (if available) [E]										

[D] Estimated farm & ranch land at 100-year flood risk (acres) should only include farm and ranch land that are negatively impacted by flooding events and should not include land that benefits from floodplains for example rice fields.

[E] This field may be left blank during the 1st planning cycle. However, RFPGs are strongly encouraged to provide this information when applicable and available.

Flood management strategies (FMSs)

(See associated rule and scope language at top of this guidance section)

Flood Management Strategy is defined in 31 TAC §361.10(m) as, "A proposed plan to reduce flood risk or mitigate flood hazards to life or property. A flood management strategy may or may not require associated Flood Mitigation Projects to be implemented." The RFPG has some flexibility on how they choose to utilize FMSs in the regional flood planning process.

For example, RFPGs could choose not to recommend any FMSs. At a minimum, RFPGs should include as FMSs any proposed action that the group would like to identify, evaluate, and recommend that does not qualify as either a FME or FMP. For example, if the RFPG wanted to call attention to the need for increased public awareness of flood risk, the RFPG could identify, evaluate, and recommend increased public awareness efforts as an FMS in the regional flood plan. Due to the flexibility and varying nature of RFPG's potential utilization of FMSs, Table 14 has many optional fields that may or may not be applicable to certain types of FMSs. These fields are only required to be populated as applicable.

This section focuses on flood management strategies 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.

If applicable, any H&H model required for evaluation of the FMSs must adhere to all mapping and modeling guidelines and No Negative Impact requirements.

FMSs that were previously identified and evaluated by others prior to and/or outside of the regional flood planning process and that are being considered by the RFPG for inclusion in the regional flood plan must be re-assessed by the RFPGs prior to inclusion in the regional plan. These FMSs must meet or be updated to adhere to the requirements in this guidance and other relevant regional flood planning contract requirements.

Please also refer to Part 3 of this document for guidance regarding strategy project types, cost estimates, population estimates and no negative impact.

Submittal requirements for FMSs:

1. General description and GIS coverage map of identified FMSs in the region.
2. A GIS coverage map showing the extent of all identified FMSs in the region, including applicable strategy area and areas that would benefit from the strategy, with RFPG boundary, counties, HUC-12s, major roadways, stream segments, contributing drainage areas, relevant stormwater features, including but limited to, streams, detention ponds, storm drain systems, dams, and levees.
3. Total number and strategy area (square miles) of FMSs by flood risk type, counties, and strategy type should be summarized in a table.
4. Planning level cost estimate for each FMS identified.
5. Identify who will sponsor the FMS including directly financing and implementing it. This may involve more than one entity and could rely on a variety of sources of the funds.
6. All data identified in the data submittal requirements as outlined in the Exhibit D: Data Submittal Guidelines. {25. FMS}
7. The TWDB will provide a GIS geodatabase template for the RFPGs to fill in with region-specific data. The geodatabase template will be pre-populated with all feature classes and fields but will not have any data. GIS data layer that shows boundaries of all identified FMSs and associated data.

8. The GIS geodatabase must show all associated relationships between a recommended FMS and any FMPs that may be required to support the implementation of that FMS. A FMP may support more than one FMS and one FMS may rely on more than one FMP to implement.
9. All maps should be submitted with underlying GIS data utilized to prepare them.
10. Completed, separate 'Exhibit_C_Tables' Excel workbook for FMSs.

The regional flood plan will include a summary table with findings (template below).

These are minimum reporting requirements however, an RFPG may present additional information utilized in the development of their plan.

Table 14: Potentially feasible flood management strategies identified by RFPG

FMS ID	FMS Name	Description	Associated Goals (ID)	Counties	HUC10s [C]	Watersheds [C]	Strategy Type	Strategy Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa, Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Strategy Cost ($)	Potential Funding Sources and Amount	Flood Risk [A]								
															Area in 100-year (1% annual chance) Floodplain	Area in 500-year (0.2% annual chance) Floodplain	Estimated number of structures at 100-year flood risk [A]	Residential structures at flood risk	Estimated Population at flood risk	Critical facilities at flood risk (#)	Number of low water crossings at flood risk (#)	Estimated number of road closures (#)	Estimated length of roads at flood risk (Miles)	Estimated farm & ranch land at flood risk (acres) [B]
1	Flood County Acquisition	Property acquisition program in Flood County	Goal B	Flood	1234567890	Purple Creek, Blue Creek	Property Acquisition	250	Riverine, Urban	Flood County	Flood County	N	75,000,000	Federal, State, Local, Private	60	80	500	450	1,200	5	5	10	7	100
2	Public Awareness Campaign	Public awareness of flood risk to the public	Goal C	All	All	All	Education	(Region area)	All	X River Authority	List of entities in region	N	1,000,000	Private, Local	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	Blue Creek Detention	Provide detention in Blue Creek Watershed	Goal A	Flood	1234567890	Purple Creek	Regional Detention	150	Riverine	Flood County	Flood County	Y	10,000,000	Federal, State, Local	12	20	350	250	700	3	5	10	7	100
4	Coastal Resiliency	Improve resilience in Coastal County	Goal C	Salty	1234567891	Salty Bay	Coastal Protections	125	Coastal	Island City	Island City	Y	15,000,000	Federal, State, Local, Private	80	125	10,000	25,000	70,000	12	2	50	400	25
5	Green River Diversion	Diversion of flood flow from upper watershed to lower watershed in Green River Basin	Goal A	Red, Yellow	12345677888, 1234567889	Upper Red	Infrastructure	200	Urban, Riverine	Green River Authority	List of entities in Red and Yellow Counties	Y	50,000,000	Federal, State, Local, Private	20	30	100	95	300	1	8	12	25	25,000
6	Promotion of Rainwater Harvesting	Promotion of Rainwater Harvesting with Rain Forecast Based release	Goal D	All	All	All	Regulatory Incentive	(Region Area)	All	Council of Governments	List of entities in region	N	200,000	Federal, State, Local, Private	500	800	125,000	300,000	800,000	80	50	200	3,000	5,000

[A] Estimated number of structures at 100-year flood risk will require consideration WSE and estimated finished flood elevation of buildings. If not available, the RFPGs may leave these columns blank.

[B] Estimated farm & ranch land at 100-year flood risk (acres) should only include farm and ranch land that are negatively impacted by flooding events and should not include land that benefits from floodplains for example rice fields.

[C] Leave blank if too many for text field length (254 characters).

Potentially Feasible Flood Management Strategies Identified by RFPG (continued)

FMS ID	Reduction in Flood Risk												Cost/ Structure removed	Consideration of Nature-based Solution (Y/N)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)
	Number of structures with reduced 100-year (1% annual chance) Flood risk	Number of structures removed from 100-year (1% annual chance) Flood risk	Number of structures removed from 500-year (0.2% annual chance) Flood risk	Habitable structures removed from 100-year (1% annual chance) Flood risk	Estimated Population removed from 100-year (1% annual chance) Flood risk	Critical facilities removed from 100-year (1% annual chance) Flood risk (#)	Number of low water crossings removed from 100-year (1% annual chance) Flood risk (#)	Estimated reduction in road closure occurrences	Estimated length of roads removed from 100-year flood risk (Miles)	Estimated active farm & ranch land removed from 100-year flood risk (acres)	Estimated reduction in fatalities (if available) [D]	Estimated reduction in injuries (if available) [D]					
1	0	375	0	375	1,000	0	0	0	0	0			200,000	Y	N	N	N
2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	150	100	125	100	280	2	3	4	3	2			44,444	Y	N	N	N
4	6,000	3,000	15,000	3,000	8,250	9	2	38	250	10			833	Y	N	N	N
5	10	85	5	85	255	1	5	9	20	20,000			555,556	Y	Y	Y	N
6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N	N	Y

[D] This field may be left blank during the 1st planning cycle. However, RFPGs are strongly encouraged to provide this information when applicable and available.

2.4.C Task 4C – Prepare and Submit Technical Memorandum

Goals:

The goal for this task is for RFPGs to submit their mid-point deliverable, the Technical Memorandum.

Information included in rules and scope of work:

1. Prepare a concise Technical Memorandum to include:
    a. A list of existing political subdivisions within the FPR that have flood-related authorities or responsibilities;
    b. A list of previous flood studies considered by the RFPG to be relevant to development of the RFP;
    c. A geodatabase and associated maps in accordance with TWDB Flood Planning guidance documents that the RFPG considers to be best representation of the region-wide 1.0% annual chance flood event and 0.2% annual chance flood event inundation boundaries, and the source of flooding for each area, for use in its risk analysis, including indications of locations where such boundaries remain undefined;
    d. A geodatabase and associated maps in accordance with TWDB Flood Planning guidance documents that identifies additional flood-prone areas not described in (c) based on location of hydrologic features, historic flooding, and/or local knowledge;
    e. A geodatabase and associated maps in accordance with TWDB Flood Planning guidance documents that identifies areas where existing hydrologic and hydraulic models needed to evaluate FMSs and FMPs are available;
    f. A list of available flood-related models that the RFPG considers of most value in developing its plan;
    g. The flood mitigation and floodplain management goals adopted by the RFPG per §361.36;
    h. The documented process used by the RFPG to identify potentially feasible FMSs and FMPs;
    i. A list of potential FMEs and potentially feasible FMSs and FMPs identified by the RFPG, if any; and
    j. A list of FMSs and FMPs that were identified but determined by the RFPG to be infeasible, including the primary reason for it being infeasible.
2. Approve submittal of the Technical Memorandum to TWDB at a RFPG meeting subject notice requirements in accordance with 31 TAC §361.21(h). The Technical Memorandum must be submitted to TWDB in accordance with Section I Article I of the contract.

Additional guidance:

For the lists and requested documentation described in (a) and (b), RFPGs must provide the information in written format and may provide a limited version of associated GIS data or deliverables. For the lists and requested documentation described in (f) through (j), RFPGs must provide the information in written format and are required to provide a limited version of associated GIS data or deliverables.

For the geodatabases described in (c), (d), and (e), RFPGs shall provide associated GIS data and feature layers identified in Exhibit D Table 1.

GIS dataset and feature layers submitted with the technical guidelines may be enhanced in draft flood plan.

2.5 Task 5 – Recommendation of flood management evaluations and flood management strategies and associated flood mitigation projects (361.39)

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

The goal of this task is for RFPGs to recommend FMEs, FMSs, and FMPs for inclusion in the regional flood plan.

2.5.A Flood management evaluations (FMEs)

Information included in rules and scope of work:

RFPGs shall recommend FMEs that the RFPG determines are most likely to result in identification of potentially feasible FMSs and FMPs that would, at a minimum, identify and investigate one solution to mitigate for flood events associated with a 1% annual chance flood event and that support specific RFPG flood mitigation and/or floodplain management goals.

Additional guidance:

The RFPGs will identify and recommend specific FMEs for the region. FMEs will be identified under Task 4 and recommended under Task 5 in the regional plan **but are not generally anticipated to actually be performed by the RFPG during the same regional flood planning cycle during which they are identified.**

The RFPGs may, at their discretion and based on their limited resources, work to carry out a limited number of FMEs for immediate study during this planning cycle and explain the reason for doing so, based information compiled during Task 4. If completed by the RFPG or others during the current planning cycle, those (former) FMEs would no longer need to be recommended since their results would already be incorporated into the regional flood plan.

FMEs are to be recommended in the regional plans to make clear what additional studies, and funds to support them, are needed to adequately evaluate all flood prone areas within a region. The step of identifying FMEs is a recognition that the regional flood planning process has significant financial, technical, and time constraints. However, that does not preclude performance of the FMEs by others, with other sources of funds for example, or incorporating the timely results of such evaluations into the final regional water plan. If an equivalent FME is performed outside of the regional flood planning process, for example through GLO efforts, and the results incorporated into the plan, that particular FME would no longer be recommended as a FME in the plan since the results of it would already be reflected in the plan. The FMEs that are performed after adoption of the regional plan may then support recommendations of FMSs and FMPs in the next regional plan, for example.

RFPGs are encouraged to consider the results of the vulnerability analyses performed in Task 2 in recommending FMEs.

The recommended FMEs will be similarly eligible for future state funding alongside recommended FMPs. FMEs are the necessary studies that are required to identify and determine what FMPs can be recommended. This is based on a recognition that some local or regional areas of the state may begin the regional planning process with more flood risk, flood planning, and flood project information than others. The recommended FMEs of areas with less prior information will then serve to inform the next

planning cycle, and so forth. Note that during the inaugural cycle of the Flood Infrastructure Funding (FIF) program, FME-type studies were generally prioritized ahead of infrastructure construction projects and received significant grant funding shares.

Not every conceivable FME will be recommended in the regional plan. The RFPG and their technical consultant must decide which identified potential FMEs will be recommended in their regional plan in order to ensure that the recommended FMEs are sensible so that, subsequently, limited resources can be directed efficiently and accordingly to implement those flood studies and associated technical evaluations.

Submittal requirements for FMEs:

1. General description and summary of the RFPG approach in recommending FMEs
2. General description and summary of the FMEs recommended by RFPGs.
3. A GIS coverage map of recommended FMEs during this planning cycle depicting FME study area, RFPG boundary, counties, HUC-12s, streams, reservoirs, major roadways, and other features identified by RFPGs.
4. Complete the RFPG Recommendation fields in the blank {21. FME} GIS Geodatabase feature class provided by TWDB.
5. Please refer to the Exhibit D: Data Submittal Guidelines for information requested.
6. A table of FMEs recommended by the RFPG as per template provided below.

Table 15: Flood management evaluations recommended by RFPG

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s[A]	Watershed Names[A]	FME Study Area (sqmi)	Flood Risk Type	Sponsor	Entities with Oversight	Emergency Need	Estimated Study Cost	RFPG Recommendation (Y/N)	Reason for Recommendation

[A] *Leave blank if too many for text field length (254 characters).*

2.5.B Flood mitigation projects (FMPs)

Information included in rules and scope of work:

RFPGs shall recommend FMPs to reduce the potential impacts of flood and RFPG goals that must, at a minimum, mitigate for flood events associated with at 1 percent annual chance (100-year flood) where feasible. In instances where mitigating for 100-year events is not feasible, FMS and FMPs to mitigate more frequent events may be recommended based on guidance to be provided by the EA. Recommendations shall be based upon the identification, analysis, and comparison of alternatives that the RFPG determines will provide measurable reductions in flood impacts in support of the RFPG's specific flood mitigation and/or floodplain management goals.

RFPGs shall provide additional information in conformance with guidance to be provided by the EA which will be used to rank recommended FMPs in the state flood plan.

Recommended FMPs may not negatively affect a neighboring area or an entity's water supply.

Recommended FMPs that will contribute to water supply may not result in an overallocation of a water source based on the water availability allocations in the most recently adopted State Water Plan.

Specific types of FMEs, FMSs, or FMPs that should or should not be included in regional flood plans must be in accordance with guidance to be provided by the EA.

Additional guidance:

The RFPGs will recommend specific FMPs in the regional flood plan. The primary function of each recommended FMP must be flood risk reduction and they must include quantifiable flood risk reduction benefits. The RFPGs will also identify the reason for their recommendation, based on evaluations initiated in Task 4 and completed Task 5.

This section of the regional flood plan should focus primarily on FMPs 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.

Any H&H model required for evaluation of the FMPs must adhere to all mapping and modeling guidelines and No Negative Impact requirements.

To the extent possible, FMPs that were previously identified and evaluated by others prior to and/or outside of the regional flood planning process and that are being considered by the RFPG for inclusion in the regional flood plan should be developed or updated in a manner that closely resembles the requirements in this guidance and other relevant regional flood planning contract requirements.

RFPGs are encouraged to consider the results of the vulnerability analyses performed in Task 2 in recommending FMPs.

Project details:

RFPGs will provide information for each recommended FMP requested in the project details section in Part 3 of this document. This task will be initiated in Task 4A and completed in Task 4. The general project data section will be completed in Task 4A.

If the RFPGs do not have pertinent information in this planning cycle, it is acceptable to leave it blank. However, those fields will score as zero. If a field is not applicable, please add NA or Not Applicable.

Submittal requirements:

1. General description and summary of the RFPG approach in recommending FMPs.

2. A GIS coverage map of recommended FMPs during this planning cycle depicting FMP project areas, RFPG boundary, counties, HUC-12s, streams, reservoirs, major roadways, and other features identified by RFPGs and proposed project features.
3. Completed project details spreadsheet for all recommended FMPs. A blank project details spreadsheet is provided by TWDB and the guidance on how to determine the project details is included in Part 3 of this guidance document {Project Details}.
4. Complete the RFPG Recommendation fields in the blank 'FMP' GIS Geodatabase feature class provided by TWDB.
5. Please refer to the Exhibit D: Data Submittal Guidelines for information requested.
6. A table of FMPs recommended by the RFPG as per template provided below.

Table 16: Potentially feasible flood mitigation projects recommended by RFPG

FMP ID	FMP Name	Description	Associated Goals (ID)	Counties	HUC8s	HUC12s [A]	Watershed Name [A]	Project Type	Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa, Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Project Cost ($)	Potential Funding Sources and Amount	Cost/ Structure removed	Percent Nature-based Solution (by cost)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)	BCR	Social Vulnerability Index (SVI)	RFPG Recommendation (Y/N)	Reason for Recommendation

[A] *Leave blank if too many for text field length (254 characters).*

2.5.C Flood management strategies (FMSs)

Information included in rules and scope of work:

RFPGs shall recommend FMSs to reduce the potential impacts of flood and RFPG goals that must, at a minimum, mitigate for flood events associated with at 1 percent annual chance (100-year flood) where feasible. In instances where mitigating for 100-year events is not feasible, FMS and FMPs to mitigate more frequent events may be recommended based on guidance to be provided by the EA. Recommendations shall be based upon the identification, analysis, and comparison of alternatives that the RFPG determines will provide measurable reductions in flood impacts in support of the RFPG's specific flood mitigation and/or floodplain management goals.

Recommended FMSs or FMPs may not negatively affect a neighboring area or an entity's water supply.

Recommended FMSs or FMPs that will contribute to water supply may not result in an overallocation of a water source based on the water availability allocations in the most recently adopted State Water Plan.

Specific types of FMEs, FMSs, or FMPs that should or should not be included in regional flood plans must be in accordance with guidance to be provided by the EA.

Additional guidance:

This section of the regional flood plan should primarily focus on FMSs 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.

Any H&H model required for evaluation of the FMSs must adhere to all mapping and modeling guidelines and No Negative Impact requirements.

To the extent possible, FMSs that were previously identified and evaluated by others prior to and/or outside of the regional flood planning process and that are being considered by the RFPG for inclusion in the regional flood plan should be developed or updated in a manner that closely resembles the requirements in this guidance and other relevant regional flood planning contract requirements.

Please also refer to Part 3 of this document for guidance regarding strategy types, cost estimates, population estimates and no negative impact.

Submittal requirements for FMSs:

1. General description and summary of the RFPG approach in recommending FMSs.
2. A GIS coverage map of recommended FMSs during this planning cycle depicting FMS areas, RFPG boundary, counties, HUC-12s, streams, reservoirs, major roadways, and other features identified by RFPGs and proposed project features.
3. Complete the RFPG Recommendation fields in the blank 'FMS' GIS Geodatabase feature class provided by TWDB.
4. Please refer to the Exhibit D: Data Submittal Guidelines for information requested.
5. A table of FMSs recommended by the RFPG as per template provided below.

The regional flood plan will include a summary table with findings (template below).

These are minimum reporting requirements however, an RFPG may present additional information utilized in the development of their plan.

Table 17: Potentially feasible flood management strategies recommended by RFPG

FMS ID	FMS Name	Description	Associated Goals (ID)	Counties	HUC8s	HUC12s [A]	Watershed Name [A]	Project Type	Strategy Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa, Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Project Cost ($)	Potential Funding Sources and Amount	Cost/ Structure removed	Consideration of Nature-based Solution (Y/N)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)	RFPG Recommendation (Y/N)	Reason for Recommendation

[A] *Leave blank if too many for text field length (254 characters).*

2.6 Task 6 – Impact and contribution of the regional flood plan

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

The goal of this task is for RFPGs to summarize the impacts of implementation of the regional flood plan.

2.6.A Task 6A – Impacts of regional flood plan (361.40)

Information included in rules and scope of work:

The regional flood plans must include:

1. 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.
2. A statement that the FMPs in the plan, when implemented, will not negatively affect neighboring areas located within or outside of the FPR.
3. A general description of the types of potential positive and negative socioeconomic or recreational impacts of the recommended FMSs and FMPs within the FPR; and
4. A 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.

Additional guidance:

The presentation of information related to item 1 above should be 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 percent change in flood risk faced by various elements including critical infrastructure etc. These two comparisons (one comparison each for a 1 percent event and another for a 0.2 percent event) should illustrate both how much the region's existing flood risk will be reduced through 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 etc.

The RFPGs must include a statement that the plan, when implemented, will not negatively affect neighboring areas located within or outside of the FPR. The plan content should speak, separately, to the anticipated overall impacts of the plan on each of the categories; environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

The RFPGs will identify and report the following information in this task:

1. Total area in need of flood risk identification or update vs. total area that will be evaluated via the completion of the FMEs recommended in this flood plan.
2. Total number of structures in the 1 percent and 0.2 percent annual chance floodplains before and after the implementation of the plan.
3. Total estimated population in 1 percent and 0.2 percent annual chance floodplains and in flood prone areas before and after the implementation of the flood plan.
4. Number of low water crossings removed from flood risk after the implementation of plan.

5. Impact on future flood risk by avoiding increase of existing flood risk after the implementation of plan.
6. Overall impact on water supply.
7. Overall impact on the environment, agriculture, recreational resources, water quality, erosion, sedimentation, and navigation.

2.6.B Task 6B – Contributions to and impacts on water supply development and the state water plan (361.41)

Information included in rules and scope of work:

Regional flood plans must include a region-wide summary and description of the contribution that the regional flood plan would have to water supply development including a list of the specific flood management strategies and/or flood mitigation projects that would contribute to water supply; and a description of any anticipated impacts, including to water supply or water availability or projects in the state water plan, that the regional flood plan FMSs and FMPs may have.

Additional guidance:

RFPGs must present and summarize positive and negative impacts of the flood plan on the state water plan. RFPGs shall coordinate with RWPGs regarding this task.

RFPGs must present a table listing all the recommended FMSs, or FMPs in the flood plan that, if implemented, would measurably contribute to water supply if implemented including fields in the table that indicate the associated annual volumes of water and whether each one:

1. Involves directly increasing 'water supply[6]' volume available during drought of record which requires both availability increase and directly connecting supply to specific water user group(s) with an identified water supply need
2. Directly benefits 'water availability' by, for example, injecting into aquifer but no one takes it as supply directly
3. Indirectly benefits 'water availability' (e.g., indirectly recharges aquifers naturally)
4. Has no anticipated impact on water supply

RFPGs must present a table listing every recommended FMS or FMP in the flood plan that, if implemented, would negatively impact and/or measurably reduce:

1. water availability volumes that are the basis for the most recently adopted state water plan and/or
2. water supply volumes if implemented.

For example, a FMS or FMP that involves reallocating a portion of reservoir storage that is currently designated for water supply purposes to be used, instead, for flood storage, would measurably reduce the water availability at that water source in the most recently adopted state water plan. The related potential impacts of this reduction must be also be described (e.g., less water available for water user groups under drought of record conditions; an increase in needs and or unmet needs). Water volumes should be discussed and presented in terms of acre-feet per year.

[6] The meanings of terms 'water supply' and 'water availability' and 'needs', as referred to in this guidance, are to be understood and interpreted in the same manner as they are used in regional water planning.

2.7 Task 7 – Flood response information and activities (361.42)

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

The goal of this task is for RFPGs to summarize existing flood response and recovery activities in the region.

Information included in rules and scope of work:

RFPGs are to summarize the nature and types of flood response preparations within the FPR including providing where more detailed information is available regarding recovery. RFPGs must not perform analyses or other activities related to planning for disaster response or recovery activities.

Additional guidance:

FEMA defines four phases of emergency management: Mitigation, Preparedness, Response, and Recovery, see figure below.

Figure 6: The four phases of emergency management (FEMA, 1998)

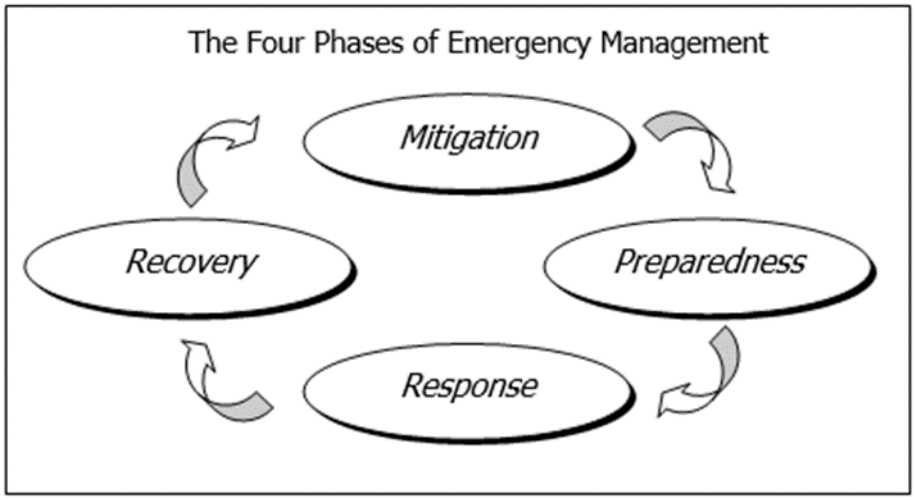


Table 18: Definition and examples of the four phases of emergency management [A]

	General definition	Example projects (not an exhaustive list)
Flood mitigation	"The implementation of actions, including both structural and non-structural solutions, to reduce flood risk to protect against the loss of life and property." (Title 31 Texas Administrative Code §361.10(k))	See Section 3.2(2-3) examples of structural and non-structural Flood Mitigation Projects.
Flood preparedness	Actions, aside from mitigation, that are taken before flood events to prepare for flood response activities	Developing emergency management and evacuation plans, preparing staging areas, and building flood early warning systems
Flood response	Actions taken during and in the immediate aftermath of a flood event	Conducting evacuations, providing shelters, closing flooded roads, and operating flood warning systems

	General definition	Example projects (not an exhaustive list)
Flood recovery	Actions taken after a flood event involving repairs or other actions necessary to return to pre-event conditions	Repairs to damaged infrastructure, storm event debris removal

[A] *Table adapted from Animals in Disaster, Module A, Awareness and Preparedness (FEMA, 1998)*

Flood mitigation is the primary focus of the regional flood planning process and plan development efforts with regard to identifying and recommending FMEs, FMSs and FMPs by the RFPG. The plan may include flood preparedness FMEs, FMSs and FMPs. Flood response, and recovery activities and efforts will not be included as FMSs or FMPs in the regional flood plans but the efforts related to flood preparedness, response, and recovery will be summarized in this chapter of the regional flood plan and the group can make general recommendations in Chapter 8 regarding additional efforts that should be put forth towards these types of activities if the RFPG considers current efforts inadequate.

In this task, the RFPG will consider and summarize the last three flood activity phases (above) and will need to coordinate with local, regional, state, and federal entities with flood preparedness, response, and recovery authority, including municipalities and counties, in the region. The Plan must contain a written summary of the current state of flood preparedness in the region to respond to future floods, including a summary of the roles and responsibilities of various entities. The Plan must also contain a written summary of entities involved and actions taken or planned for recovery from past flood disasters in the region.

The prior tasks in the development of the regional flood plans focus on recommending specific FMSs and FMPs that, if implemented prior to the onset of flood events, should directly reduce flood risk and thereby indirectly reduce the magnitude of flood response and recovery efforts that would be necessary during and following flood events.

The content of this section of the regional flood plans is focused on potential recommendations to include in Chapter 8 of the plan. The plan may discuss the intersection of some of the particular regional flood plan content including floodplain management recommendations, FMSs, FMPs, or other policy recommendations, where there may be direct links between those flood items in the plan that would be implemented prior to storm events and how they may directly or indirectly support reduce the need for or otherwise support preparation for and response to flood events.

Title 31 TAC §361.72(a)(4) states that the Board will not provide funds to the RFPGs for "analysis or other activities related to planning for disaster response or recovery activities…" Accordingly, this task is limited to a summary of existing preparations for flood response activities and existing recovery efforts and does not require RFPGs to propose new or modified flood preparedness, response, or recovery activities. At their discretion, the RFPG may also include policy recommendations related to this plan content, as appropriate in Chapter 8.

2.8 Task 8 – Administrative, regulatory, and legislative recommendations (361.43)

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

The goal of this task is for RFPGs to develop legislative, regulatory, administrative, or other recommendations.

Information included in rules and scope of work:

RFPGs must develop and include in their flood plans:

1. legislative recommendations that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation;
2. other regulatory or administrative recommendations that they consider necessary to facilitate floodplain management and flood mitigation planning and implementation;
3. any other recommendations that the RFPG believes are needed and desirable to achieve its regional flood mitigation and floodplain management goals; and
4. recommendations regarding potential, new revenue-raising opportunities, including potential new municipal drainage utilities or regional flood authorities, that could fund the development, operation, and maintenance of floodplain management or flood mitigation activities in the region.

Additional guidance:

These recommendations may address items that benefit and/or can be implemented at the local, regional, or state level. Recommendations, in general, are anticipated to be aimed at supporting flood risk reduction and supporting implementation of the regional flood plans, including exploring innovative ways of funding flood risk reduction activities. Recommendations may include suggested changes to the flood planning process for the TWDB to consider when implementing the next cycle of regional and state flood planning. The RFPGs may make policy recommendations for the legislature to consider.

2.9 Task 9 – Flood infrastructure financing analysis (361.44)

This section in organized in several parts: goals, excerpts from relevant rules and scope of work, followed by additional guidance and submittal requirements.

Goals:

The goal of this task is for RFPGs to indicate how sponsors will propose to finance recommended FMPs, and FMEs.

Information included in rules and scope of work:

RFPGs shall indicate how individual local governments, regional authorities, and other political subdivisions in their region that will sponsor flood risk mitigation efforts propose to finance the region's recommended FMSs, FMPs, and FMEs included in their flood plan. The assessment shall also describe what role that the RFPG proposes for the state in financing recommended FMSs, FMPs, and FMEs. As projects are implemented, those improvements and associated benefits shall be incorporated into and reflected in the subsequent RFPs.

Additional guidance:

This task requires obtaining the relevant information from sponsors of the recommended FMSs, FMPs, and FMEs that have capital costs, for example, in the form of a mailed survey or other means of collecting the required information. This information will provide an indication of potential funding needs, as they are needed over time, to implement the regional flood plans.

Below is a minimum set of information that must be submitted (in a template form that will be provided by TWDB to each region for their use) that can be used for performing the survey and aggregated and submitted to meet this requirement. Results should also include documentation of the effectiveness of survey methodology, percentage of survey completions, and whether an acceptable minimum percent survey completion was achieved.

Table 19: FMS, FMP, FME funding survey template format (with illustrative examples)

RFPG Number	Sponsor Entity Name	FMS or FMP or FME	FMS FMP FME - Name	Regional plan's unique FMS/FMP/FME identification number	Target year of full implementation	Estimated costs in plan			Estimated percent (share) of total FMS, FMP, or FME estimated cost			
									Sponsor Funding		Other Funding Needed (including state, federal and/ or other funding)	TOTAL (auto) sum must = 100%
						Non-construction costs	Construction-related costs	Total estimated cost	ANTICIPATED SOURCE of Sponsor funding (e.g., taxes; general revenue; dedicated revenue incl. fees)	FUNDING TO BE FINANCED BY SPONSOR (including local, county, or regional mechanisms available but not yet fully utilized)		
21	City of Howdy	FMP	Widen main downtown channel	2003	2028	$3,484,000	$8,129,000	$11,613,000	stormwater fees	**75%**	**25%**	**100%**
21	Major River Authority	FMP	Levee improvements	3001	2030	$37,544,000	$212,754,000	$250,298,000	fees	**50%**	**50%**	**100%**
21	James County	FME	Study southeast county flooding along Colorado River to identify solutions	4409	2024	$722,000	$0	$722,000	taxes	**50%**	**50%**	**100%**
21	James County	FMS	Study to develop county-wide floodplain development policy	4409	2024	$200,000	$0	$200,000	taxes	**100%**	**0%**	**100%**

These are minimum reporting requirements however, an RFPG may present more information gathered and/or utilized in the development of their plan. For example, this assessment could also include information about what existing funding mechanisms sponsors already have available or plan to implement to support the funding and implementation of recommended projects in the regional flood plan.

2.10 Task 10 – Adoption of plan and public participation

As required by 31 TAC §361 (in particular §361.21), the RFPGs must conduct all business in meetings posted and held in accordance with the Texas Open Meetings Act, Texas Government Code Chapter 551, with a copy of all materials presented or discussed available for public inspection prior to and following public meetings. Additional notice requirements referenced in 31 TAC §361.21 must also be followed when applicable.

The plan must be developed and adopted in accordance with 31 TAC §361.50 and §361.60–.61 the flood planning guidance principles 31 TAC §361.20 (31 TAC §362.3) including an explanation of how the plan satisfies each of the guidance principles including that the plan will not negatively affect a neighboring area.

The RFPGs must adopt RFPs and accommodate public participation including soliciting public input and considering and, when appropriate, addressing comments made by the public including indicating whether changes to the plan were made in response to public comments, during the Plan adoption process in accordance with all administrative rules, the Contract, statute and the RFPG bylaws.

This work includes all work required to prepare for and hold meetings and include public input and public participation in development of the Plan, including but not limited to:

1. holding regular RFPG meetings;
2. posting public notices;
3. holding public input meetings and public meeting on the draft plan as required by statute and rules;
4. solicit and consider public input;
5. technical work required to prepare for and participate in RFPG meetings, workshops, and any other committee or other meetings during the development of the Plan;
6. coordination with and collection of information from entities involved with flood planning in the region;
7. assembling, producing, and submitting the Technical Memorandum, Draft regional flood plan and final regional flood plan and responding to comments and resubmitting as necessary to ensure the plan can be approved by the TWDB; and,
8. interregional cooperation and efforts required to resolve issues including potential negative effects on neighboring areas within regions and between regions.

2.10.A Public meetings

At least one meeting is needed to identify flood risk in the region. This should be done once the consultant has already identified existing information on flood risk and summarized this information on a map. The legible and clearly identified flood risk map should be shared at these public meeting to allow members of the public to identify any flood risk that are not captured. This meeting can also be utilized to receive preliminary feedback to gather general suggestions and recommendations from the public as to the issues, provisions, and types of FMSs, FMPs, and FMEs that should be considered or addressed, or provisions that should be considered and potentially included during that regional flood planning cycle

At least one additional meeting is required to receive feedback to gather general suggestions and recommendations from the public as to issues, provisions, and types of FMSs, FMPs, and FMEs that should be considered or addressed or provisions that should be considered and potentially included during that regional flood planning cycle.

2.11 Contents of draft and final Regional Flood Plan documents

In addition to the content requirements described in the previous sections, to be considered administratively complete both the draft RFPs and final adopted RFPs must include:

1. An executive summary documenting key findings and recommendations that does not exceed 20 pages;
2. A statement, as required in 31 TAC §361.20, that the plan conforms with the guidance principles in Title 31 TAC §362.3, including an explanation of how the Plan satisfies the requirements of each of the principles; and
3. A statement as to whether or not the planning group met all requirements under the Texas Open Meetings Act and Public Information Act.

PART 3 – Technical guidance

3.1 Guidance principles (31 TAC §362.3)

Development of the regional and state flood plans shall be guided by the following principles. The regional and state flood plans:

(1) shall be a guide to state, regional, and local flood risk management policy;
(2) shall be based on the best available science, data, models, and flood risk mapping;
(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;
(4) shall, at a minimum, evaluate flood hazard exposure to life and property associated with 0.2 percent annual chance flood event (the 500-year flood) and, in these efforts, shall not be limited to consideration of historic flood events;
(5) shall, when possible and at a minimum, evaluate flood risk to life and property associated with 1.0 percent 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 percent annual chance flood event (the 100-year flood); and, in these efforts, shall not be limited to consideration of historic flood events;
(6) shall consider the extent to which current floodplain management, land use regulations, and economic development practices increase future flood risks to life and property and consider recommending adoption of floodplain management, land use regulations, and economic development practices to reduce future flood risk;
(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;
(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;
(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;
(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;
(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;
(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;

(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;
(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;
(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;
(16) shall include recommended strategies and projects that minimize residual flood risk and provide effective and economical management of flood risk to people, properties, and communities, and associated environmental benefits;
(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;
(18) shall contribute to water supply development where possible;
(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;
(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;
(21) shall be based on established terms of participation that shall be equitable and shall not unduly hinder participation;
(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;
(23) shall consider land-use and floodplain management policies and approaches that support short- and long-term flood mitigation and floodplain management goals;
(24) shall consider natural systems and beneficial functions of floodplains, including flood peak attenuation and ecosystem services;
(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;
(26) shall emphasize the fundamental importance of floodplain management policies that reduce flood risk;
(27) shall encourage flood mitigation design approaches that work with, rather than against, natural patterns and conditions of floodplains;
(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;
(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;
(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;
(31) shall include ongoing flood projects that are in the planning stage, have been permitted, or are under construction;

(32) shall include legislative recommendations that are considered necessary and desirable to facilitate flood management planning and implementation to protect life and property;
(33) shall be based on coordination of flood management planning, strategies, and mitigation projects with local, regional, state, and federal agencies projects and goals;
(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;
(35) shall consider protection of vulnerable populations;
(36) shall consider benefits of flood management strategies to water quality, fish and wildlife, ecosystem function, and recreation, as appropriate;
(37) shall minimize adverse environmental impacts and be in accordance with adopted environmental flow standards;
(38) shall consider how long-term maintenance and operation of flood strategies will be conducted and funded; and
(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.

3.2 Flood risk reduction project (FMEs, FMSs and FMPs) types

It is expected that a wide range of project types will be recommended by the RFPGs to the TWDB. The following list of **types** is provided as guidance for use in the FME, FMS, and FMP tables and GIS feature classes, but other types identified by the RFPGs, that are not already listed, should be included by the RFPG.

1. Flood Management Evaluations
    a. Watershed Planning
        i. Hydrologic and Hydraulic Modeling
        ii. Flood Mapping Updates
        iii. Regional Watershed Studies
    b. Engineering Project Planning
        i. Feasibility Assessments
    c. Preliminary Engineering (alternative analysis and up to 30 percent design)
    d. Studies on Flood Preparedness
    e. Other
2. Flood Mitigation Projects – Structural[7]
    a. Low Water Crossings or Bridge Improvements
    b. Infrastructure (channels, ditches, ponds, stormwater pipes, etc.)
    c. Regional Detention
    d. Regional Channel Improvements
    e. Storm Drain Improvements
    f. Reservoirs
    g. Dam Improvements, Maintenance and Repair
    h. Flood Walls / Levees
    i. Coastal Protections
    j. Natural Based Projects – living levees, increasing storage, increasing channel roughness, increasing losses, de-synchronizing peak flows, dune management, river restoration,

[7] FMPs will include permitting, detailed design, construction, and implementation phases of the project.

riparian restoration, run-off pathway management, wetland restoration, low impact development, green Infrastructure

k. Comprehensive Regional Project – includes a combination of projects intended to work together
l. Other

3. Flood Mitigation Projects – Non-Structural[8]
    a. Property or easement acquisition
    b. Elevation of Individual Structures
    c. Flood Readiness and Resilience
    d. Flood Early Warning Systems, including stream gauges and monitoring stations
    e. Floodproofing
    f. Regulatory Requirements for Reduction of Flood Risk
    g. Other

[8] FMPs will include permitting, detailed design, construction, and implementation phases of the project.

3.3 Compilation of flood risk data in Texas (floodplain quilt)

The floodplain quilt is prepared by TWDB to provide the RFPGs with a common starting point for their own compilation of riverine and coastal flood risk data in their regions. The RFPGs are expected to confirm, update, and otherwise enhance the initial floodplain quilt information as appropriate to prepare the deliverables required for their flood risk analyses tasks. The dataset in the floodplain quilt will be made available via the TWDB Flood Planning Data Hub.

3.3.A Background

The 86th Texas Legislature tasked the TWDB with developing and updating flood risk maps in the state, using current data and technology standards, to support development of a statewide flood plan. Considering this new legislation and the need for improved flood risk mapping as well as the current TNRIS Lidar Coverage for the state being nearly complete, the TWDB chose Base Level Engineering (BLE) as a key path forward for mapping flood risk in Texas. The TWDB plans to complete statewide BLE coverage by 2024. In the meantime, the TWDB understands the immediate need to provide the communities of Texas the most up to date and comprehensive flood hazard information that is available right now. Compiling flood risk data from available sources into one location is what the TWDB is working to accomplish with the floodplain quilt.

3.3.B Purpose

The floodplain quilt consists of multiple layers of data from different sources available throughout the state to 'quilt' together a dataset that can more easily inform Texans of the flood risk information coverage and availability in their area by referring to the floodplain quilt rather than trying to piece together and search for the disparate data on their own.

3.3.C Floodplain Quilt data

The following data is included as a part of the Floodplain Quilt[9] provided by the TWDB:

1. Source: FEMA Map Service Center (MSC) (https://msc.fema.gov/portal/home)
    a. Effective Flood Hazard data
        i. Map of flood risk during the 1 percent annual chance and 0.2 percent annual storm events. This data includes both detailed and approximate study data.
    b. Pending Flood Hazard data
        i. Map of flood risk during the 1 percent annual chance and 0.2 percent annual storm events. Data is finalized, assigned an effective date, and delivered to communities five to six months prior to effective date. This data includes both detailed and approximate study data.
    c. Preliminary Flood Hazard data
        i. Map of flood risk during the 1 percent annual chance and 0.2 percent annual storm events. Issued for public review and awareness of proposed change. Next steps to effective map include addressing public comments and finalization. This data includes both detailed and approximate study data.
2. Source: FEMA/USGS/TWDB Estimated Base Flood Elevation Viewer (https://webapps.usgs.gov/infrm/estbfe/)
    a. Base Level Engineering data
        i. Estimated map of flood risk during the 1 percent annual chance and 0.2 percent annual storm events. All of this data is considered approximate.

[9] See the next section for how these datasets were ranked.

3. Source: First American Flood Data Services (FAFDS)
    a. The database is derived from digitized effective paper Flood Insurance Rate Maps (FIRMs). The dataset covers portions of the state where no digital FIRM data has been created and is not available on the National Flood Hazard Layer (NFHL). This data is not publicly published nor regularly maintained, but still may be considered as best available 'digital' data in certain areas. This data includes both detailed and approximate study data.
4. Potential Source: Fathom
    a. This flood risk data includes complete, but approximate, flood risk coverage for Texas developed from very large nationwide 2D hydrodynamic modeling data. A publicly available early derivative of this data, called Flood Factor, is published by First Street Foundation (https://firststreet.org/flood-factor/). TWDB is investigating the potential for developing a derivative data set that would utilize LiDAR topography for increased resolution in Texas, rather than the current national elevation data used. In either version, modeling of hydraulic structures such as dams, levees, and bridges/culverts are not included except for how those features are accounted for in the base topographic data. All of this data is considered approximate.
5. Potential Source: U.S. Army Corps of Engineers (USACE) or other federal sources
    a. USACE manages many large hydraulic structures in Texas and is involved in proposed infrastructure project development as well. As part of USACE's existing asset management, proposed project designs, and flood study work there may be flood risk mapping available to incorporate into the Floodplain Quilt. Only fairly large data sets (definition of fairly large TBD) are likely to be incorporated into the statewide Floodplain Quilt, other smaller federal data sources may be incorporated as desired by Regional Flood Planning Groups (RFPGs).
6. Potential Source: Regional or Local Flood Risk Data *(not currently available to the TWDB and therefore not included in the initial floodplain quilt)*

There are many parts of Texas where regional or local entities have flood risk data that is of better quality than any other listed sources. The TWDB does not currently intend to incorporate these sources into this statewide data set but will encourage the RFPGs and their consultants to identify these sources and overlay them when appropriate in certain areas.

3.3.D Data hierarchy

The TWDB has included below an initial ranking of the different data sets considering them through a regional flood 'planning lens'. This planning lens ranking considered which data, in general, might more likely be considered best available (from both a quality and coverage standpoint and relative to the other available datasets listed) at a large scale. The TWDB is not anticipating developing any hierarchy to support, for example, regulatory activities and does not, at this time, recommend use of this broadly ranked quilt dataset for regulatory activities. After an initial flood quilt is developed and available for use by RFPGs for planning activities, the TWDB may consider making additional adjustments and use in supporting regulatory activities.

In the default flood quilt data set being provided by the TWDB, the highest ranked data is currently being used for the quilt across the state including in places where lower ranked data exists. This approach to selection of primary data occurs in all areas where there is coverage from a higher ranked dataset including everywhere that there are multiple, overlapping datasets in a single location. This approach of stepping through each next-ranked dataset to displace lower ranked datasets in each location was consistently applied in developing the initial statewide quilt.

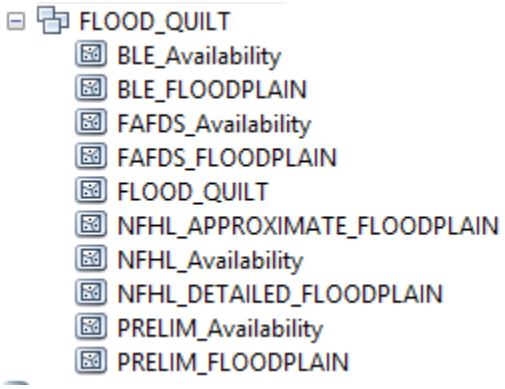
When RFPGs and their consultants perform more detailed assessments and investigations within each watershed in their region, they must document reasons for adjusting the current hierarchy layout and/or possibly make piecemeal adjustments for portions of the data sets, or even replace the quilt data with better, local data. Currently, for simplicity, no data set listed above (except for NFHL detail and approximate) is being broken into different components to be ranked separately, as explained below.

Below is the ranking order of the floodplain quilt data and a brief description of the reasoning behind it.

1. National Flood Hazard Layer (NFHL) Pending Data:
    a. This data will have flood hazard information comprised of the most recent detailed and approximate studies (compared to the other datasets) and are pending release as an Effective Flood Insurance Rate Map (FIRM). This data is (in a very broad sense) considered the best available data of the compiled data sets.
2. Preliminary Flood Hazard data
    a. Map of flood risk during the 1 percent annual chance and 0.2 percent annual storm events. Issued for public review and awareness of proposed change. Next steps to effective map include addressing public comments and finalization. This data includes both detailed and approximate study data.
3. National Flood Hazard Layer Effective Data (Detailed Study Areas only)
    a. This data has flood hazard information that includes detailed studies (Flood Zones AE, AO, AH, and VE) and is the current Effective FIRM. This layer includes LOMR information that was effective when TWDB downloaded the data from FEMA (as reflected in the metadata), up to date effective FEMA floodplain and LOMR information can be viewed through FEMA's NFHL Viewer separately.
4. Estimated Base Flood Elevation Viewer
    a. This data contains flood hazard information created by approximate base level engineering (BLE) data that can be used as best available information where approximate Zone A's on the effective FIRM exist, but they do not replace flood hazard data found in a detailed study area. Hence this data is ranked 3rd, in between detailed (rank 2) and approximate (rank 4) effective data.
    b. In general, only the highest rank data was included in a given study area whether that data had wider or skinnier floodplains. However, BLE and detailed studied effective data is represented slightly differently. In study areas with both detailed NFHL and BLE data, areas that were designated in 1 percent or 0.2 percent annual storm events in the BLE data, but not designated as such in detailed studied area are designated as 1 percent or 0.2 percent annual storm events in the floodplain quilt. This incorporates streams that were captured in the BLE modeling, but not in the detailed study, and also incorporates wider BLE floodplains with skinnier detailed study floodplains, resulting in a more comprehensive and conservative floodplain.
5. National Flood Hazard Layer Effective Data (Approximate Study Areas only)
    a. This data has flood hazard information that includes approximate studies (Flood Zone A) on the effective FIRM map. Where approximate Zone A's exist on the effective FIRM there is no effective detailed study information.
6. First American Flood Data Services (FAFDS)
    a. This data contains digitized flood hazard information from previously published FIRMs and FISs and is not available on the NFHL. Even if certain areas in this data set include detailed study (such as AE zones), it is likely very old and thus it is anticipated that BLE data will be more accurate. This is one example where a conflict may occur between best available 'planning' data and best available 'regulatory' data.

7. Other Potential Data Sources
    a. Other sources are not yet available, so they are not yet ranked. Conceptually, how they could be ranked are described below.
        i. Fathom – Depending on modeling and mapping resolutions (30m, 3m, etc.) of the Fathom product that may be utilized, this data is expected to rank somewhere between 4.5[10] (behind BLE) to 6.5 (not better than other data, but better than nothing).
        ii. USACE or other federal data – Dependent on level of detail, detailed federal data (say detailed flood risk modeling for a large reservoir or levee) could be better quality than any other data available. Rank is expected to range from 0.5 (best available) to 4.5 (behind BLE perhaps because its older data[11]).
        iii. Regional or Local flood risk data – Dependent on level of detail. Could range from 0.5 (best available) to 6.5 (not better than other data, but better than nothing).

Figure 7 : Geodatabase that constitute the floodplain quilt data package



[10] Potential ranks provided here are assuming ranks 1-5 above are not re-numbered. Thus 3.5 is between 3 and 4. If new data sets are formally added, then ranks will be re-numbered.

[11] TWDB acknowledges there will be difficult choices between older, detailed data and newer, approximate data. TWDB is offering a high-level statewide opinion on ranks but will encourage RFPGs to investigate those difficult choices at the regional or local level and adjust as needed, which may include piecemeal approaches where only portions of data sets are ranked above others. RFPGs will be expected to clearly document those decisions and the logic for each.

Figures 8-12 shows the current (Apr 2021) status of this preliminary, and still under-development, flood quilt for Texas. TWDB is working to fill in the remaining white (blank) spaces with Fathom's (or other) mapping data and is projecting an update that will show 100 percent statewide coverage (no blank areas) by late Spring/early Summer 2021.

Figure 8: Digitized Paper FIRMs Availability

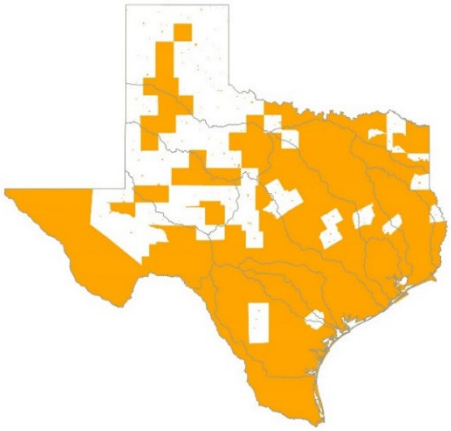


Figure 9: National Flood Hazard Layer Availability

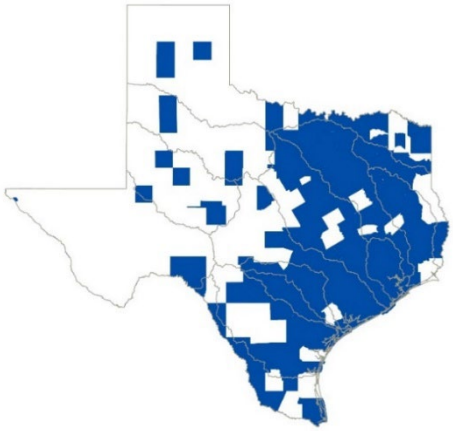


Figure 10: Base Level Engineering (BLE) Availability

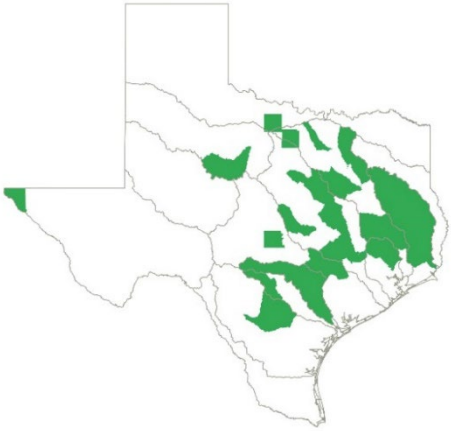


Figure 11: Flood Planning Data Availability Coverage

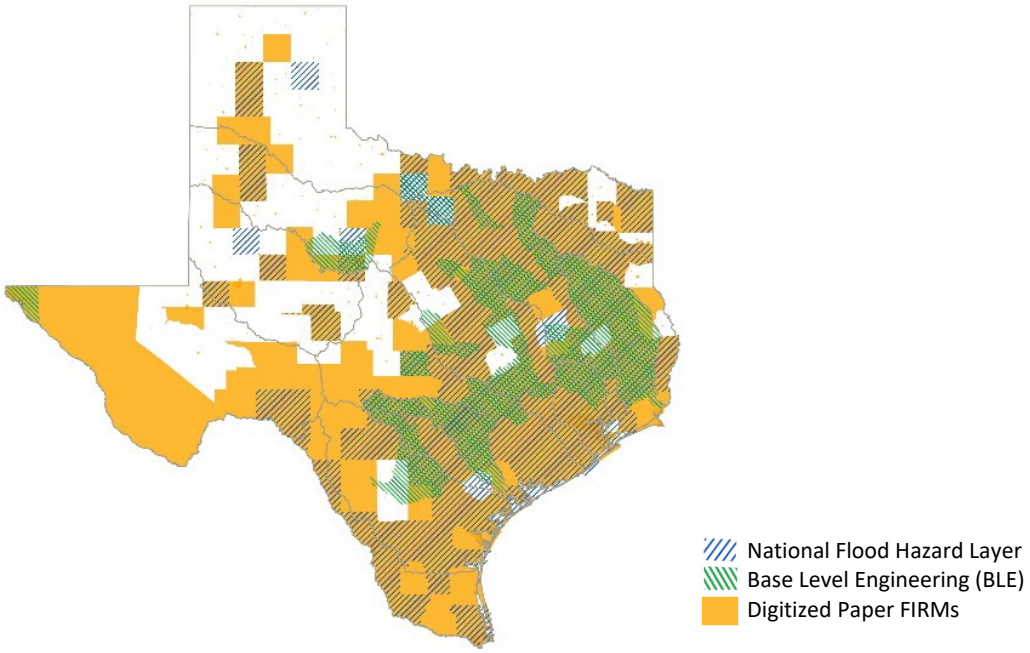
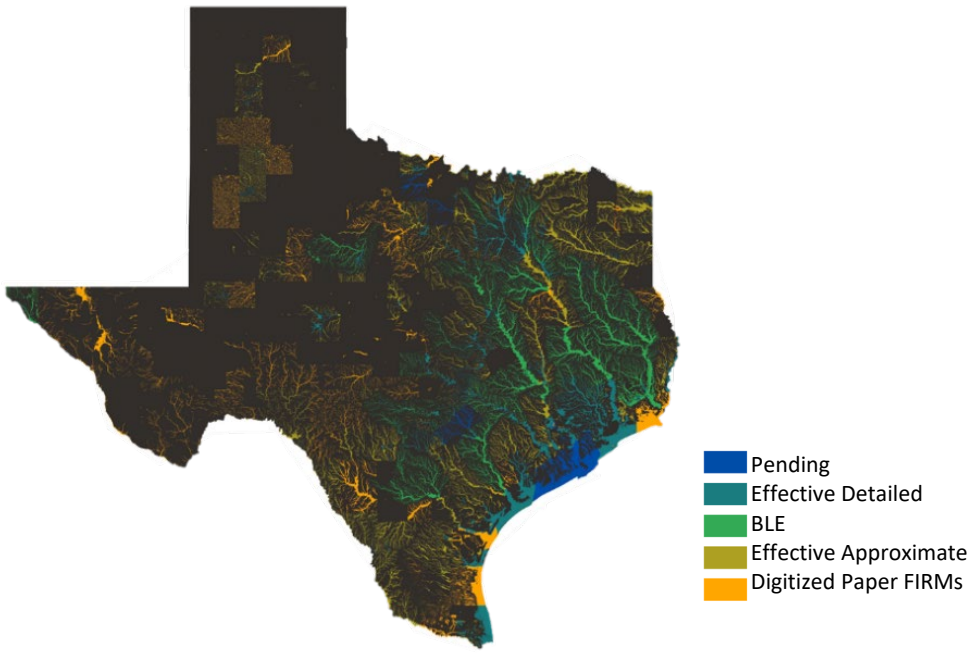


Figure 12: Flood Planning Data Quilt



3.4 Estimation of population in floodplain and flood prone areas

The RFPGs will estimate regionwide population that fall within the specific floodplains and in flood prone areas and also for project specific determinations of flood risk and flood risk reduction benefits.

Estimated population in the floodplain or in flood prone areas may be computed by summing the population for all buildings found within the floodplain or in flood prone areas. These buildings are identified by intersecting the existing hazard layers {7. ExFldHazard} with building data to be provided by TWDB.

TWDB will provide the building dataset to the RFPGs. Building data will come with population data already compiled, with TWDB calculating populations using the 2019 LandScan USA population dataset. LandScan provides both night and daytime population, and both will be included in the building data provided by TWDB. Those buildings located within the floodplain or in flood prone areas are to be stored in the exposure datasets created during Task2A {9. ExFldExpPol, 12. ExFldExpAll}.

Regional population analysis should include determinations of day and night population estimates that are located within the flood hazard areas. Once both day and nighttime population are separately summed, the maximum of the two is computed as the estimated population in the floodplain or in flood prone areas. The maximum population for a given structure should not be considered prior to summarizing at regional or project level.

Please note that this planning level population estimate located within the floodplain or flood prone areas does not take finished flood elevation of buildings, ingress-egress, or reduction for population in higher stories of a multi-story building into account. RFPGs must document the assumptions regarding planning level population estimate in the plan.

Population estimates computed utilizing the method detailed above accounts for population located in every building touched by the floodplain or flood prone area. It is acknowledged that this method will tend to slightly overestimate the population located in the floodplain and flood prone areas.

The RFPGs may request the TWDB to estimate population in the floodplain of flood prone area.

For project population estimates, RFPGs may use alternate methods or sources of data should they choose to do so (see Section 3.4.A for an example); however, RFPGs must utilize a consistent approach for computation of population estimate for all FMSs and FMPs in the region and clearly identify and document the approach(es) used and the reason for selecting those certain approaches. RFPGs may request TWDB for further flexibility regarding project specific population estimate.

3.4.A Alternate approach: Population estimate based on building household size

If the RFPG would prefer not to use TWDB-provided building population estimates, they may intersect the project specific building and hazard layers to identify all buildings exposed to the given hazard. Multiply the household size for the census block group in which the project is located (or the areal weighted average if intersecting multiple block groups) by the total number of residential buildings over 500 square feet to calculate the exposed population.-The average household size by RFPG is listed below for reference if any of the RFPGs chooses to utilize those instead.

Note: All buildings under 500 square feet in area are omitted from this analysis, i.e., they should generally not have any population nor should their area contribute to the total building area in any given cell. This helps avoids attributing population to sheds, etc., that often accompany residential properties.

Table 20 Average household size by RFPG

RFPG Number	RFPG Name	Average household size [A]
1	Canadian-Upper Red	2.65
2	Lower Red-Sulphur-Cypress	2.59
3	Trinity	2.74
4	Sabine	2.66
5	Neches	2.63
6	San Jacinto	2.81
7	Upper Brazos	2.62
8	Lower Brazos	2.72
9	Upper Colorado	2.86
10	Lower Colorado-Lavaca	2.61
11	Guadalupe	2.77
12	San Antonio	2.87
13	Nueces	2.97
14	Upper Rio Grande	2.94
15	Lower Rio Grande	3.32

[A] *Household size data comes from the 2015-2019 American Community Survey 5-year estimate.*

3.5 General mapping and modeling guidelines

The following section provides some general guidelines on flood risk modeling and mapping. Recommendations included in this section do not replace a thorough understanding of each model's abilities and limitations to perform hydrologic and hydraulic simulations in different physical environments. This technical guidance should not be interpreted as a detailed Drainage Criteria Manual. This document does not provide specific guidance on how to apply a specific model or methodology. Additionally, it is anticipated that the modeling and mapping guidelines will evolve over time as the state flood planning effort progresses and as new data becomes available.

TWDB gathered input from local jurisdictions, regional agencies and state agencies regarding flood modeling and mapping requirements. As one might expect, these requirements vary across organizations. The TWDB directed a survey of 27 entities across the State seeking input on current local regulations that relate to flood modeling and mapping practices. In total, 25 responses were received.

Based on feedback received through the TWDB questionnaire, this section provides recommendations aimed at the development of more consistent and improved flood modeling and mapping approaches within the state of Texas.

The flood planning process is to be based on best available science. For example, the Atlas 14 data should be utilized statewide for the flood planning process. However, given the recent nature of this available dataset, many local jurisdictions are still in the process of interpreting the data for local applicability and regulatory implementation. Even though certain municipalities may not have sorted out their particular regulatory implementation concerns, this best available rainfall data should still be used for regional flood planning. However, if prior watershed studies exist that do not include Atlas 14 and those studies are the best available for a certain area, that would be an example a reasonable decision to not use Atlas 14 initially, but perhaps listing an update of the study to Atlas 14 as a future need (FME). An explanation on why certain products were considered best available for regional flood planning is expected. The following section provides some guidance to the planning groups as to how to approach these datasets.

3.5.A Modeling software

In general, model selection depends on multiple factors, such as drainage standards, physical site conditions, data availability, and cost. Each modeler must choose a hydrologic or hydraulic (including coastal) model on a case-by-case basis. As a general recommendation, most questionnaire participants utilize and prefer the US Army Corps of Engineers' open-source Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) and Hydrologic Engineering Center – River Analysis System (HEC-RAS) programs. While HEC-HMS and HEC-RAS are the recommended programs for riverine flood modeling, other programs are permissible provided regional acceptance and justification of selection by the RFPG.

3.5.A.1 Hydrologic analysis

Hydrology involves the estimation of watershed runoff over a period of time or peak discharge for a given storm frequency or return period. Hydrologic analysis may include the quantification of peak discharge or runoff hydrographs. Common programs or methods used to quantify peak flow or discharge vary depending on local requirements, drainage area, and basin characteristics.

The most common hydrologic approaches include the Rational Method and Hydrograph methods. The Rational Method can be computed using tabular computations while hydrograph methods are typically performed using modeling software. The most common peak discharge methodologies include the Rational Method and Regional Regression. The recommended peak discharge methodology is the

Rational Method, but it should be limited for use of drainage areas less than 200 acres. Another important methodology that should be used, when applicable, is the statistical analysis of stream gage data. Other methods are parameter-based models, but statistical analysis of stream gages is modeling from directly observed data and should be used when applicable to a specific area. Further, comparing the results of several methods is often a useful tool to assess reasonableness of results.

The most common hydrologic analysis software is the USACE's HEC-HMS program. Other noted hydrograph approaches include those of the Modified Rational Method and a Rain-on-Mesh application using two-dimensional (2D) modeling software. Based on stakeholder feedback and research, the recommended hydrologic analysis software is HEC-HMS. While HEC-HMS is the recommended hydrologic program, other programs are permissible provided regional acceptance and justification of selection.

3.5.A.2 Hydraulic analysis

Hydraulic analysis involves estimation of runoff movement and extents. Hydraulic analysis may include the evaluation of water surface elevations, flood depth, velocities, and energy gradients. The most common hydraulic analysis software for riverine systems is the USACE's HEC-RAS program. HEC-RAS will likely remain as one of the preferred programs because the USACE distributes its models for free and because the model now includes 1D and 2D hydraulic capabilities. Other programs may be selected based on flow patterns. The recommendation of a specific hydraulic model should not be limited to a given model list; instead, the modeler must understand a model's strengths and weaknesses before proceeding. Today's computing power allows increased model resolution and accuracy (e.g., 1D vs. 2D or steady-state vs. dynamic simulations) at a relatively low cost. However, other circumstances justify the use of a simplified 1D, steady-state approach. As such, programs may be selected based on flow patterns, computing speed, and simulation capabilities.

The following are general recommendations regarding best default selection of models but the final decision in each case is ultimately up the RFPGs and their technical consultants to make based on the specific circumstances.

1D Hydraulics:

One-dimensional (1D) hydraulic analysis involves the evaluation of flow with the assumption that the flow is moving in one direction. 1D hydraulic analysis is generally utilized for storm drainage networks and confined floodplains. Stakeholder feedback and research of drainage criteria manuals do not indicate a trend in preferred 1D storm drainage programs. Some of the more popular 1D hydraulic programs include Bentley's StormCAD, Geopak Drainage, and SUDA programs; Autodesk's Civil 3D; and Innovyze's XPSWMM program. All these programs are proprietary and include fees for use. The least expensive of the proprietary programs is Bentley's StormCAD program, ranging in cost from $250-$4,000 depending on the modeling needs, because it can be a standalone program that does not require licensure of MicroStation or AutoCAD. There are a few, non-proprietary options for 1D storm drainage analysis, such as tabular computational options, EPA-SWMM, TxDOT's WinStorm program (no longer provided or supported by TxDOT), and Houston's HouStorm program. The recommendation for 1D storm drainage hydraulic analysis is to utilize regionally accepted programs and to provide a justification for the selection.

For 1D hydraulic analysis of open channel and riverine systems, the HEC-RAS program is recommended.

2D Hydraulics:

Two-dimensional (2D) hydraulic analysis involves the evaluation of flow with the assumption that the flow is multi-directional. 2D hydraulic analysis is generally utilized in urban areas, areas with low-lying or flat terrain, and areas of overland flooding. The most common 2D hydraulic analysis software is the

USACE's HEC-RAS program. Other noted 2D programs include Innovyze's XPSWMM, InfoWorks ICM, Streamline Technologies' ICPR, US Bureau of Reclamation's (USBR) SRH-2D and FLO-2D. Of these programs, HEC-RAS is the only non-proprietary software. As such, it is the recommended 2D hydraulic analysis program. It should be noted that the HEC-RAS program does include 2D capabilities, but it does not currently include capabilities to simulate underground or closed conduit systems (storm drainage networks). For situations where 2D hydraulic analysis is required to be coupled with underground conveyance, , the recommendation is to utilize regionally accepted programs and to provide justification of selection.

3.5.A.3 Coastal analysis

Based on the TWDB survey, the application of coastal hydraulics models appears to be limited in Texas. Only one entity described using FEMA's model to estimate wave heights—presumably to develop coastal letters of map revision—and another entity expressed a desire to use AdCIRC. Entities may not often use coastal models because they typically do not engage in coastal projects. However, the increased risks brought by a combination of sea level change, subsidence, and storm surge may require increased action by local entities to develop resilience and adaptation projects. The GLO, through their Community Development Block Grant Disaster Recovery Program, has funded the Texas Integrated Flooding Framework to develop guidelines and processes for a comprehensive, integrated framework to model, visualize, and plan for the risk of compound flooding in counties affected by Hurricane Harvey. This integrated framework will recommend a model coupling strategy to better understand coastal flooding hazards and associated risk for supporting Texas flood resiliency planning.

FEMA made a significant investment to apply state-of-the-art modeling approaches to quantify coastal flood risks. FEMA applied AdCIRC to simulate ocean circulation (water depths) for hundreds of storms in Texas. To account for wave breaking-induced water level changes (wave setup), FEMA couples AdCIRC with a wave model. For Texas, FEMA coupled AdCIRC with STWAVE, although recent storm surge studies use a combination of WAve Model (for offshore waves) and Delft University of Technology's SWAN (for nearshore waves). Notably, FEMA applies WHAFIS 4.0, a 1D wave model, to determine overland wave heights, which determines whether a flood zone carries VE or AE designation.

Given the prior modeling provided by FEMA's latest coastal studies, and the fact that they are publicly available, AdCIRC and SWAN have become the preferred ocean circulation and wave models. These models, however, typically require Aquaveo's SMS software to develop the computational mesh. A common practice consists in leveraging FEMA's mesh and editing tools, as needed. Of note, WHAFIS 4.0 is also publicly available and does not have heavy computational requirements. In addition, MIKE 21 (part of DHI's MIKE Modeling System) represents what may be the most robust and reliable system in a single software package. However, the system is a more expensive alternative.

3.5.B Modeling data

This section generally describes the types and common sources of data required for hydrologic and hydraulic modeling. The Regional Flood Planning process is to be based on best available science and each RFPG will be responsible for determining that. To this end, the latest LiDAR, land cover data, and rainfall data (e.g., Atlas 14) should be utilized wherever possible to support a consistent statewide flood planning process.

3.5.B.1 Frequency events

The stakeholder questionnaire asked the participants which flood frequency events are required in their jurisdiction. Eighty-eight percent of the participants require evaluation of the 1 percent annual chance (100-year) event. Sixty-eight percent of the participants require evaluation of the 10 percent annual chance (10-year) event and/or the 4 percent annual chance (25-year) event.

In general, floodplain mapping is performed with an emphasis on the 1 percent annual chance (100-year) event, while drainage infrastructure design is generally performed with an emphasis on either the 10 percent (10-year) or the 4 percent (25-year) and 1 percent (100-year) events. Additionally, current FEMA standards for critical facilities require elevation outside of the 0.2 percent annual chance (500-year) event floodplain. Based on stakeholder survey and the infrastructure flood protection recommendations, evaluation of four frequency events: 10 percent (10-year), 4 percent (25-year), 1 percent (100-year), and 0.2 percent (500-year) annual chance events is recommended.

Specific flood control infrastructure such as dams and levees also require the evaluation of the Probable Maximum Flood and Standard Project Flood. The minimum standards for dams are based on state requirements of the TCEQ Dam Safety regulations as depicted by the Texas Administrative Code Title 30 Chapter 299 Dams and Reservoirs while the minimum standards for levees are based on federal requirements of FEMA as depicted by 44 Code of Federal Regulations 65.10. Modeling these more extreme events may not be a significant component of the planning process but may be performed to conceptually size certain facilities for planning-level estimates.

3.5.B.2 Terrain

Flood risk modeling is greatly enhanced when generated using accurate topography. LiDAR or Light Detection and Ranging (LiDAR) data is a necessary component of flood risk identification and, where available, should be the basis for flood modeling. LiDAR uses remote sensing technology to measure distance by illuminating a target with a laser and analyzing the reflected light. LiDAR availability is greatly increasing across Texas with a projected statewide coverage by 2021. Availability of LiDAR can be determined at the Texas Natural Resources Information System (TNRIS) website (https://tnris.org/stratmap/elevation-lidar/). With improvements in technology, the most current LiDAR dataset should be utilized. It may also be necessary to supplement the LiDAR with field survey or as-built construction plans to refine the terrain.

3.5.B.3 Land cover

Watershed runoff is greatly impacted by land cover conditions such as the development conditions and soil information. Soil properties influence the relationship between rainfall and runoff since soils have differing rates of infiltration. Soil information (hydrologic soil textures and types) can be obtained from the U.S. Natural Resources Conservation Service (NRCS), Soil Survey Geographic databases (SSURGO). While this is a common source of information, it is not a required source.

The TWDB survey asked participants what development (or land use) conditions are considered for identifying and evaluating flood protection projects in their jurisdiction. The results indicate a fairly even split between existing development (current land use) conditions and fully developed conditions (future land use); however, the responses generally indicated a preference for fully developed conditions.

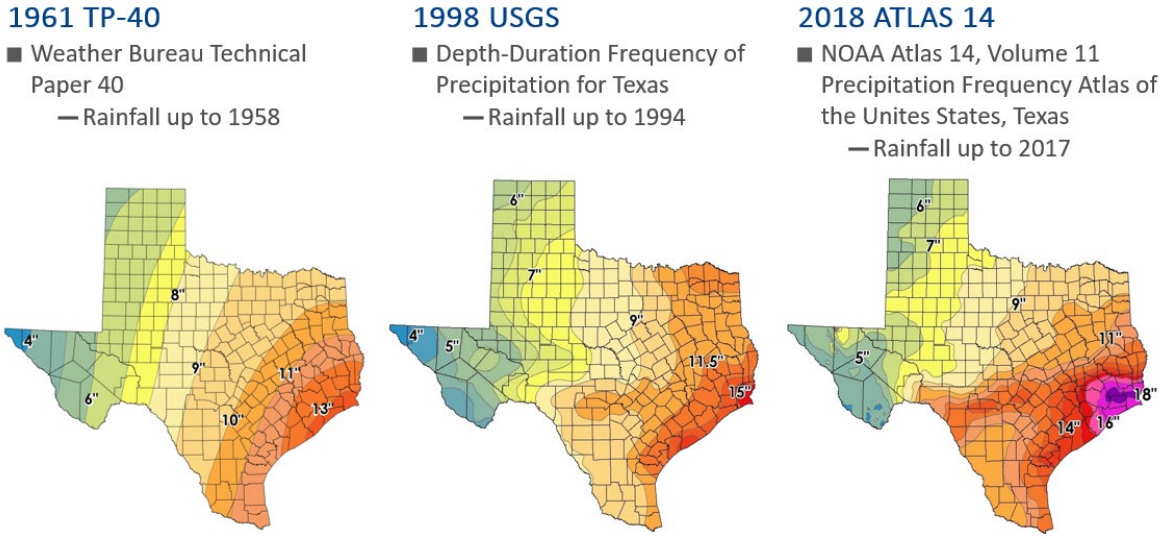
Research also indicates current trends of cities using future condition or fully developed land use (future development) conditions while counties generally require existing condition land use (existing development) conditions. A general concern voiced by counties is the perception that counties do not have the authority to develop or regulate land planning or zoning maps; therefore, future or fully developed land coverage maps are typically not available beyond the extra-territorial jurisdiction (ETJ) of communities. Existing condition land use condition maps are available with statewide coverage by the National Land Cover Database (NLCD). While this is a common source of information, it is not a required source. Until future land use planning data covering entire river basins is available, **utilizing existing land use conditions is recommended for existing condition flood hazard analyses for flood planning.** Should a given region have future land use projections they prefer to use, they are welcome to do so.

3.5.B.4 Rainfall

On September 27, 2018, the National Oceanic and Atmospheric Administration (NOAA) published new precipitation-frequency values for Texas. This new publication, *NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas*, is a reassessment of historical rainfall data up to 2017, adding an additional twenty years of record to the USGS publications (Perica et al. 2018). Major events during this time period include Tropical Storm Hermine in 2010, Blanco River Memorial Day Flood in 2015, and Hurricane Harvey in 2017.

Rainfall data is commonly used to predict flood risk and as an input to analyze and design flood protection/mitigation infrastructure such as bridges, culverts, channels, storm drainage systems, detention facilities, and others. The Atlas 14 publication indicates that the 1 percent annual chance (100-year) 24-hour rain event may be greater than what we previously considered in many areas. The greatest rainfall changes occur in central Texas and along the Texas coast. Figure 13 below display the evolution of rainfall depths in Texas for the 24-hour, 1 percent annual chance (100-year) rain event. It is important to emphasize that changes depicted in the 24-hour, 100-year are not identical to changes in different durations (6-hour, 12-hour, 3-day, etc.) and different frequencies (2-year, 10-year, 500-year, etc.). There are some depth-duration-frequency (DDF) relationships where Atlas 14 shows less rainfall than prior studies and others where it shows an even greater increase than depicted for the 24-hour, 100-year.

Figure 13: Evolution of Texas rainfall (24-hour, 100-year precipitation)



As supported by the majority of the questionnaire participants, it is recommended that the NOAA Atlas 14 rainfall data be used for flood modeling associated with the state flood planning efforts and various rainfall durations should be evaluated based on a consideration of watershed size.

Calibration/Validation

Hydrologic and hydraulic modeling should be tested for accuracy and reasonableness via a calibration or validation process. If the watershed has sufficient stream gage records, these gage records should be utilized to replicate historical event runoff and high-water marks, as well as evaluate alignment to gage statistics. If gage data is unavailable, hydrologic results may be compared to regional regression results or compared to nearby studies with similar watershed characteristics.

3.5.C Approach to incorporating existing modeling tools, previously developed site-specific models/maps, previous model results, and previously evaluated flood mitigation projects.

Given the tight timeline for the first regional planning efforts, collection, assessment, and reliance on modeling results and previously identified mitigation projects will be necessary. Based on the responses to the TWDB survey of stakeholders across Texas, the RFPGs:

- may utilize most modeling sources if they consider them to be acceptable baseline models but
- the models and model results and projects identified and evaluated by those models should, to the extent practical within this cycle, meet these regional flood planning guidelines.

Potential baseline models may include but are not limited to FEMA models, FEMA CTP watershed studies, Base Level Engineering Studies (both 1D and 2D), USACE models, TWDB Flood Protection studies, local watershed studies (funded by the jurisdiction), land development studies (privately funded for permitting), Master Drainage Plans, Watershed Studies, and Mitigation Studies. It is likely that these available models utilize a variety modeling and mapping approaches; therefore, it is paramount that details of these models be provided in the data provided with the Plan and at least a preliminary assessment of how important a future update of these prior studies may be. It is recommended that model for incorporation include a listing of the development details as suggested by the recommended Modeling and Mapping Checklist.

3.5.D Modeling approach

While general in nature, the modeling approaches described below are intended to promote consistency among the regional flood plans. The following sections provide descriptions of flooding types and recommended modeling approaches to address them for various regions of Texas.

3.5.D.1 Riverine flooding

Riverine flooding occurs along rivers and streams when watershed runoff exceeds the capacity of the channel. This type of flooding may range from deep/confined floodplains to shallow/wide floodplains. Riverine flooding may be 1D or 2D depending on the watershed characteristics. Riverine flooding is very common and impacts the majority of the state flood planning regions. It should be noted, the FEMA FIRM maps primarily display floodplains resulting from riverine flooding. Additionally, flooding caused by flood control infrastructure such as dams and levees are often considered riverine flooding.

Hydrologic analysis for riverine flooding typically includes a hydrograph approach computed using HEC-HMS. A variety of unit hydrograph methodologies exist. The NRCS (previously SCS) Unit Hydrograph approach represents the most popular unit hydrograph methodology among respondents, followed by Snyder's and Clark's unit hydrograph approaches.

Hydraulic analysis for riverine flooding typically includes 1D, steady-state hydraulics. Varying physical site conditions such as riverine overflows or shallow channels with limited capacity may warrant enhanced hydraulic analysis such as unsteady analysis or 1D/2D model coupling.

3.5.D.2 Local/urban flooding

Local flooding (also referred to as urban flooding) occurs in the built environment when rainfall is either not adequately conveyed into a storm drainage system or the storm drainage system capacity is exceeded. Local drainage floodplains are not mapped on FEMA FIRM maps, but many communities have begun taking steps to better define and understand local flood risks. All urban areas in Texas are subject to local/urban flooding. Local/urban flooding generally includes evaluation of 1D storm drainage networks or 2D dynamic models that combine storm drainage networks with overland flooding.

Analysis for local/urban 1D flooding typically includes peak discharge computed using the Rational Method and 1D, steady-state hydraulics using programs (such as Bentley's StormCAD, Geopak Drainage, HouStorm), or hydraulic grade line spreadsheets. Varying physical site conditions such as downstream constraints and timing concerns may warrant dynamic modeling.

Analysis for local/urban 2D flooding typically includes hydrograph approaches computed using HEC-HMS and 2D dynamic hydraulics of overland and underground conveyance using programs such as Innovyze's XPSWMM, InfoWorks ICM, Streamline Technologies' ICPR, or US Bureau of Reclamation's (USBR) SRH-2D.

3.5.D.3 Flat terrain ponding (includes playa flooding)

Flat terrain ponding occurs when watershed runoff exceeds the capacity of low-lying areas primarily experienced in the Texas' High and Coastal Plains. It is worth noting that communities in the Panhandle (such as Lubbock and Amarillo) experience a high frequency of flat terrain flooding. This is due to the presence of playa lakes in these communities, which create a unique flood risk challenge that requires a different approach to identify flood risk than riverine or local flooding. Also, worth noting are coastal areas with flat terrain (such as Harris County and the Lower Rio Grande Valley) experience widespread, multi-directional flooding that also requires a different approach from riverine or local flooding.

Hydrologic analysis for flat terrain flooding typically includes hydrograph approaches computed using HEC-HMS. Hydrographs in flat terrain tend to be more elongated in comparison to the rapid runoff observed in the Hill Country. Common flat terrain unit hydrograph approaches include Clark's unit hydrograph and NRCS (previously SCS) unit hydrograph with reduction of peaking factors.

Hydraulic analysis for flat terrain flooding typically includes 2D hydraulics. Preferences of modeling software vary. The Houston area prefers HEC-RAS 2D or XPSWMM while Lubbock prefers ICPR. Varying physical site conditions and modeling needs may warrant alternate analysis such as closed conduit simulation and/or 1D/2D model coupling.

3.5.D.4 Coastal flooding

Coastal flooding in Texas occurs when winds from tropical storms and hurricanes push water inland—a phenomenon called storm surge. In addition to increased water levels, the effects of coastal flooding amplify due to the presence of waves. FEMA designates coastal flood hazards in two main categories: Zone VE (where waves are larger than 3 feet) and Zone AE. Flood maps further subdivide the coastal Zone AEs using the Limit of Moderate Wave Action (LiMWA) line, which define areas with wave heights larger than 1.5 feet. Coastal flooding represents significant risk to public safety, particularly along low-lying, coastal communities. Because these areas may experience coastal, riverine, or local flooding, FEMA's breakdown of coastal flood hazards helps communities identify appropriate mitigation opportunities.

The RFPG will consider compound flood information, the cumulative impact of riverine or localized flooding and coastal flooding, where available.

Hydrologic analysis is not conducted for coastal surge. In alignment with FEMA's current coastal analysis the preferred ocean circulation and wave models are AdCIRC and SWAN. Coastal hazards include localized effects such as wave runup, wave overtopping, and dune erosion. To quantify these hazards, FEMA applies methodologies that range from numerical and empirical models to graphical methods. The application of these methodologies is available in FEMA's Combined Coastal Riverine Floodplain Guidance Document (Federal Emergency Management Agency, 2020).

It is recommended that the impacts of tides (and relative sea level rise) be considered as boundary conditions of hydraulic modeling efforts in coastal watersheds. TxDOT has a new chapter in their

Hydraulic Design Manual published in 2019 on Coastal Hydraulic Design that references the GLO's Texas Coastal Resiliency Master Plan and both of these documents are considered best available guidance for coastal flooding.

3.5.E Mapping approach

It is recommended that LiDAR accuracy and resolution standards continue to align with the standards and guidelines provided by the US Geological Survey (USGS) and American Society for Photogrammetry and Remote Sensing (ASPRS). These standards are currently defined in the LiDAR Base Specification 2020 rev. A, dated August 2020 (https://www.usgs.gov/core-science-systems/ngp/ss/lidar-base-specification-online).

All electronic geospatial data must have spatial reference information and be projection defined (have its coordinate system identified and embedded in or associated with the data file). All GIS data submitted to TWDB should be in the following projection:

NAD_1983_2011_Texas_Centric_Mapping_System_Lambert

Raster data, such as aerial photographs may be submitted in their native projection, and maps must be in the appropriate projection/coordinate system for the area depicted.

All CAD/GIS data must be in known real world coordinate space, ideally in geographic/decimal degrees/NAD83, and must NOT be in page space or a custom site-specific projection.

3.5.F Modeling and mapping checklist

An engineer's certification of all modeling and mapping analyses is strongly recommended. It is also recommended that the supporting engineering report include discussion of the following topics.

1. Date of Study
2. General Study Information
    a. Model Software
    b. Study Type
3. Terrain Data
    a. Source/Date
    b. Accuracy
4. Land Cover
    a. Development Condition
    b. Land Use Source/Date
    c. Soils Source/Date
5. Rainfall
    a. Source/Date
    b. Storm Duration
    c. Temporal Distribution
6. Hydrologic Methodologies
    a. Basin Delineation
    b. Hydrologic Parameters/Computation
        i. Initial Loss
        ii. Hydrograph Approach
        iii. Routing
        iv. Storage/Diversions
        v. Areal Reduction
    c. Results

    d. Calibration/Validation
7. Hydraulic Methodologies
    a. Data Collection
        i. Field Conditions
        ii. Field Survey
    b. Parameter Estimation
        i. Roughness Coefficients
        ii. Boundary Conditions
        iii. Geometry Data
        iv. Flow Data
    c. Results
    d. Calibration/Validation
8. Mapping
    a. Projection / Datum
        i. Coordinate System
        ii. Horizontal Datum
        iii. Vertical Datum
        iv. Geoid
        v. Unit of Measurement
    b. Methods of Delineation
    c. Mapping Resolution

3.6 Definition of negative impact guidelines

One requirement placed on the Board in considering a Regional Flood Plan is whether the Plan affects a neighboring area. If the Board determines that an element of a Regional Flood Plan does negatively affect a neighboring area, the Board must coordinate with the affected area to adjust the plan to ensure that no neighboring area is negatively affected by the Plan as described in Texas Water Code 16.062(h) and (i). Additionally, the TWDB rules include a definition of Negative Effect to mean, "An increase in flood-related risks to life and property, either upstream or downstream of the proposed project. The RFPG may adopt a standard that is more restrictive than the standard provided in TWDB Technical Guidelines." 31 TAC 361.10. Recognizing that "negative effect" or "negatively affect" are not terms commonly used among flood planning professionals, this Guidance document uses the term, "Negative Impact" to meet the intent and requirements of the Texas Water Code and TWDB rules.

In developing these guidelines, the TWDB had a survey performed of various entities across Texas on what they consider to constitute "no negative impact". Based on the responses, research, and professional engineering experience the following information summarizes some examples of minimum and most stringent specifications regarding no negative impact that are already being used by entities in Texas. Although not specifically asked in the questionnaire, the specifications include considerations for one-dimensional (1D) and two-dimensional (2D) analysis. Many jurisdictions do not currently have regulations or standards regarding no negative impact. The table below excludes the jurisdictions that do not have regulations, and thus does not list 'no minimum standards' as a minimum.

Table 21: No negative impact Specifications already used by entities in Texas for the 100-year flood

Measurement	Minimum	Most Stringent
Water Surface Elevation – 1D Analysis	Maximum Increase of Water Surface Elevation = 1.0 foot at computation cross-sections	Maximum Increase of Water Surface Elevation = 0.0 feet at computation cross-sections
Water Surface Elevation – 2D Analysis	Maximum Increase of Water Surface Elevation = 0.5 feet in all computation cells	Maximum Increase of Water Surface Elevation = 0.0 feet in all computation cells
Discharge	Discharge increases are allowed as long as the water surface elevation increase does not exceed 1.0 feet	Maximum Increase in Discharge = 0.0 cubic feet/ second (cfs)
Velocity	Velocity increases are allowed as long as the water surface elevation increase does not exceed 1.0 feet	Maximum Increase in Velocity = 0.0 ft/second (fps)
Valley Storage / Flood Volume	Flood volume losses are allowed as long as the water surface elevation increase does not exceed 1.0 feet	Loss of Valley Storage / Flood Volume = 0.0 NCTCOG Corridor Development Certificate
Downstream Conveyance / Capacity	Must not exceed downstream conveyance or capacity	Downstream conveyance or capacity must have 1.0 feet of freeboard or no pressure flow in storm drainage systems

Using this information, the sections below provide recommended considerations to reduce the potential for negative impacts and meet the statutory requirement to: *"…not negatively affect a neighboring area,"* particularly as a result of structural flood mitigation projects.

3.6.A Definition

As stated by the Association of State Floodplain Managers in its white paper titled *NAI – No Adverse Impact Floodplain Management*, the minimum National Flood Insurance Program (NFIP) requirements standards, "were designed for the purposes of an insurance program and not necessarily to control escalating flooding" (Association of State Floodplain Managers, 2008). In accordance with the statutory requirement that a Regional Flood Plan not negatively affect a neighboring area, the recommended definition of No Negative Impact is as follows.

No Negative Impact means that a project will not increase flood risk of surrounding properties. Using best available data, the increase in flood risk must be measured by the 1 percent annual chance event water surface elevation and peak discharge. It is recommended that no rise in water surface elevation or discharge should be permissible and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of flood planning effort, a determination of **no negative impact** can be established if stormwater does not increase inundation of infrastructure such as residential and commercial buildings and structures.

Additionally, all of the following requirements should be met to establish **no negative impact**, as applicable:

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

The RFPGs have flexibility to consider and accept additional 'negative impact' for requirements 1 through 5 listed above based on engineer's professional judgement and analysis given any affected stakeholders are informed and accept the impacts. This should be well-documented and consistent across the entire region. Flexibility regarding negative impact remains subject to TWDB review.

The RFPGs must consider cumulative negative impacts of multiple projects if accepting any negative impact.

The no negative impact defined here is for the purpose of flood planning. This does not have any regulatory impact in relation to any FEMA, local or other regulatory requirements due to the approximate nature of planning.

The values in the table above reflect guidance for the 100-year flood, and flood planning efforts are generally focused on the 100-year assessment and mitigation. However, to ensure 'no negative impact' other storm frequencies analyzed during the planning process should also adhere to the maximum tolerances listed above. It is understood that models that assess impact at the planning level may subsequently undergo multiple revisions as specific mitigation actions proceed through preliminary design, final design, and even construction. At any of these future stages the modeling results may create more or less impact potential thus altering costs or designs, and in the most extreme cases

perhaps cause what was previously considered to be a feasible project during planning to no longer be feasible during design. RFPGs are thus strongly encouraged to assess the reasonableness of impact assessments at the planning level and do their best to anticipate potential future issues related to flood impact.

3.6.B Impact analysis checklist

An engineer's certification of no negative impact is required. It is also recommended that the supporting engineering report should include discussion of the following topics.

1. Description of the Analysis – Specific data for the analysis is located in the Modeling and Mapping Recommendations Memorandum.
2. Description of the Proposed Improvements – Including maps of existing and proposed project flood/drainage components.
3. Impacts of the Proposed Improvements – Including a description of the conditions prior to mitigation and alternatives analysis to evaluate impacts.
4. Description of Mitigation Measures – Including graphics/tables quantifying the existing condition flood risk in relation to the proposed condition flood risk.
5. No Negative Impact Certification

3.6.C Mitigation measures

Mitigation measures including but not limited regional detention, drainage easement or right of way acquisition may be utilized to alleviate negative impact. Projects with design level mitigation measures may be included in the regional flood plans and could be finalized at a later stage to conform to the 'No Negative Impact' requirements prior to funding or execution of project. For example, if a proposed FMP has 0.08ft increase in 1D Water Surface Elevation (WSE) for a 1 percent annual chance storm event and identifies the proposed location, area and volume of a regional detention pond with supporting hydrologic analyses that shows the increase in WSE will be reduced to 0.0 ft with the incorporation of regional detention, the project can be included as FMP.

3.7 Estimated costs of FMSs, FMPs and FMEs in the plan

The RFPGS will prepare a planning level cost estimate for all FMEs, FMPs and FMSs. The planning level costs must be rounded to nearest thousands.

One-time capital, other non-recurring costs, and recurring planning level costs must be prepared and presented separately and discretely for each separate FMS, FMP, and FME and must not be aggregated and presented as a single capital cost representing multiple projects/strategies/evaluations that, for example, would actually be located in multiple locations and/or would be funded by separate sponsors. RFPGs must not, for example, aggregate multiple discrete flood projects into a single cost estimate and then allocate shares of the resulting total cost, for example, pro rata across several entities or locations.

Below is a summary of the key costs that must be included if applicable to a recommended FMS, FMP, or FME to ensure costs reflect all reasonably expected expenses to implement. Portions of these costs, as noted, will also be used in the BCA analysis described in Section 3.8.

Table 22: Potential costs generally associated with FMSs, FMPs, and FMEs [A]

			FMS	FMP	FME
Non-recurring	Study costs and other (non-capital costs)	Non-engineering studies: (e.g., floodplain regulation development; flood authority or revenue raising studies; public awareness program)	x	x	x
		Engineering/technical/feasibility studies: (e.g. Hydrologic & hydraulic modeling/mapping; identification of potential flood risk reduction solutions; BCA and alternative analyses; project design; construction engineering)		x	x
		Surveying; geotechnical; testing		x	x
	Total study costs		x	x	x
	Construction-related (capital costs)	Design and Permitting		x	
	Construction-related (capital costs)	Environmental; archaeological & historical resources		x	
		Temporary and/or permanent easements; land acquisition		x	
		Mitigation; utility relocation		x	
		Legal assistance; fiscal services & costs (bond counsel); outreach		x	
		Direct construction costs of components/facilities		x	
		Buyouts; property elevations		x	
		Interest during construction		x	
		Project management (by engineer)		x	
		Inspection; pilot testing; warranty; manuals		x	
		(other special services or relevant costs)		x	
		Contingency(s)		x	
	Total construction costs			x	
TOTAL PROJECT COSTS [B]			x	x	x
Recurring		Debt service [interest rate & term (years)]		x	
		Operation & Maintenance		x	
		Other (i.e., public awareness campaign)	x		
TOTAL ANNUAL RECURRING COSTS			x	x	

A These are minimum reporting requirements, however, an RFPG may present additional information utilized in the development of their plan.

[B] To be listed as total project cost in the project database.

Capital costs include direct and indirect construction-related costs, as applicable, related to flood projects including, for example, but not limited to:

1. storm drain systems
2. detention ponds
3. diversion channels/ tunnels
4. flood walls
5. drainage ditches
6. upgrade of low water crossings
7. buyouts including relocation cost, demolition, abatement, etc.
8. structural elevation
9. dams/levees

Project cost estimates must be developed and presented as present costs in year 2020 dollars based on September 2020 price indices for commodities such as cement and steel as reported in the *Engineering News Record (ENR) Construction Cost Index* (https://www.enr.com/economics) and must include all reasonably anticipated construction-related costs, including expected construction bid prices for the flood-related infrastructure.

Note that if cost estimates are already available based on recently developed cost estimates outside of the flood planning process, those cost estimates must be updated to include all the required elements (see table above) and, as necessary, updated to 2020 year dollars by adjusting them based on the September 2020 price indices for commodities such as cement and steel as reported in the *Engineering News Record (ENR) Construction Cost Index.* For estimates developed in 2021 or later, this could include adjusting prices back to Sep 2020.

Interest during construction

To be based on total project costs drawn down at a constant rate per month during a construction period. Interest is the total interest accrued at the end of a construction period using a 3.5 percent annual interest rate less a 0.5 percent rate of return on investment of unspent funds.

Debt Service

Debt service cost to be based on financing of the total construction-related (capital) costs. The length of debt service should be assumed to be 20 years unless otherwise justified. For reservoirs, the period may be up to 40 years. Annual debt service should assume level debt service for all projects, and the annual interest rate for project financing is 3.5 percent. Terms of debt service must be reported in the summary of each project.

Annual Operating and Maintenance costs

Operations and maintenance unit costs must include labor and materials required to maintain projects such as regular repair and/or replacement of equipment.

Costs of flood projects that would also contribute to water supply

Flood project cost estimates for projects that would also contribute to water supply must include all flood project costs previously outlined (above) as well as any and all additional relevant costs and cost calculations that may be required specifically regarding the development of water projects as outlined in the most recently developed regional flood planning guidance document 'Exhibit C' and in accordance with 31 TAC 361.38(9). Additional costs may include items such as water rights permitting and water treatment; the additional cost calculations and considerations must include presenting the unit cost of water (i.e., dollars per acre-foot of water/year) that would be provided throughout a repeat of the drought-of-record.

3.8 Benefit-cost analysis

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 a project's total benefits divided by its total costs. The BCR is a numerical expression of the "cost-effectiveness" of a project. A project is generally considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs (Federal Emergency Management Agency, 2009).

Guidance:

1. It is preferable that BCR of a project be greater than one.A BCR greater than one is frequently a requirement for state and federal financial assistance. RFPGs may include projects with BCRs that are less than 1 with additional justification.
2. Acceptable and available methods:
    a. FEMA BCA Toolkit (https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis)
    b. US Army Corps of Engineers Hydrologic Engineering Center Flood Impact Analysis (HEC-FIA) software, Version 3.0 (https://www.hec.usace.army.mil/software/hec-fia/3.0_default.aspx)
    c. The TWDB funded and guided the development of a user-friendly benefitBCR input interface and analysis tool which is made available with this guidance document.
    d. Any other BCR calculation with appropriate documentation and an engineer's certification. This may be subject to review and approval by the EA.
3. When possible, the RFPGs may consider 'triple bottom line' in performing BCA. The triple bottom line approach considers the social, environmental (or ecological) and economic (financial) aspects of a project.

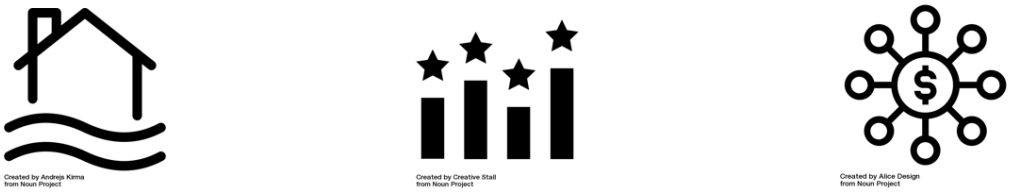
3.9 Project details

Texas Water Code Section 16.061 requires the state flood plan to include "A statewide, ranked list of ongoing and proposed flood control and mitigation projects and strategies necessary to protect against the loss of life and property…"

If the RFPGs do not have pertinent information in this planning cycle, it is acceptable to leave it blank. However, those fields will score as zero. If a field is not applicable, please add NA or Not Applicable.

The flood mitigation projects identified and recommended by each RFPG will be included in Texas's first ever State Flood Plan as a single ranked list. In order to enable the ranking of all recommended projects in a single list, the RFPGs will provide projects details for each project identified. The specific criteria used and the and weight of each ranking criteria to be used in the state ranking will be determined during the State Flood Planning phase via a transparent process with public input.

Figure 14: Regional & State Flood Planning Long-Range Planning Process



*Funding to implement projects can also come from local, federal, or other sources.

The data associated with each recommended flood mitigation project must be provided by the RFPGs to the TWDB, including:

1. General Project Data Required; and
2. Other data for potential use in ranking projects in the state flood plan (to be determined based on final criteria and ranking guidelines selected during state flood planning process after stakeholder input).

The intent is that RFPGs will populate all required project data into an excel-based tool as depicted in Appendix 1 of this document. Upon completion of the Appendix 1 tool, the spreadsheet and associated GIS files required will be provided to the TWDB for their use in developing the single ranked list for the SFP. A checklist of all project data required to complete these efforts is provided in Appendix 2.

3.9.A General project data

General Project Data will need to be provided for each project including the Project Name, Region, Project Type, BCR, Estimated Cost, and other data listed in Sections 3.9.B and 3.9.C of this document.

To develop a single ranked list for the State Flood Plan, the TWDB must collect data by which to rank projects across the state. The intent of any eventual ranking is to reflect the State Flood Plan primary

objective of protecting against loss of life and property [12] while also accommodating a sufficiently wide range of project types and project geographies.

The following list includes data that may be used by the TWDB in the project ranking process. It is anticipated that a final set of ranking criteria will be developed by the TWDB for review and comment by TWDB stakeholders.

1. **Severity Level - Pre-Project Average Depth of Flooding (100-year):** indication of severity based on the baseline/pre-project average 100-year flood depth.
2. **Severity Level - Community Need (% Population):** indication of severity based on a community's need by percentage of project community affected by population.
3. **Flood Risk Reduction:** indication of reduced flood risk by percentage of structures removed from the 100-year floodplain in post-project condition.
4. **Flood Damage Reduction:** indication of flood risk reduction (property protection) by a percentage of 100-year damage reduction calculation.
5. **Critical Facilities Damage Reduction:** indication of reduced flood risk by percentage of critical facilities removed from the 100-year floodplain in post-project condition.
6. **Life and Safety (Injury/Loss of life):** indication of life/injury risk percentage using estimates of area hazard rating, area vulnerability rating, and historical loss of life injury data for project.
7. **Water Supply Benefit:** indication of a project's direct or indirect water supply benefits to a specific supply need identified in the most recently approved state or regional water plan.
8. **Social Vulnerability:** based on the Center for Disease Control SVI data for Texas, by calculating an average project SVI by census tract and classifying the vulnerability level.
9. **Nature-Based Solution:** Indication of the percentage of project cost that qualifies as nature based as reported by RFPG.
10. **Multiple Benefit:** indication of significant, measurable, expected benefits to: recreation, agriculture, transportation, social and quality of life, local economic impacts, meeting sustainability goals, and/or project resilience goals.
11. **Operations and Maintenance:** Indication of expected level of O&M needs and annual costs provided.
12. **Administrative, Regulatory, and other implementation obstacles/difficulty:** indication of project limitations and/or requirements in terms of administrative, regulatory, and other implementation obstacles.
13. **Environmental Benefit:** Indication of expected level of environmental benefits to be delivered by project to agricultural resources, water quality, cultural heritage, habitat, air quality, natural resources, and soils/erosion and sedimentation.
14. **Environmental Impact:** indication of expected level of adverse environmental impacts due to project affecting water quality, cultural heritage, habitat, air quality, natural resource protection, agricultural resources, and erosion and sedimentation.
15. **Mobility:** Indication of project improvement and protection of mobility during flood events, with particular emphasis on emergency service access and major access routes.

[12] Texas Water Code Section 16.061

3.9.B General project data required

The following listing includes the General Project Data Required for each project to provide the general background information needed for consideration.

Table 23: General project data required

General project data required	
Project ID:	FMP ID
Project Description:	Brief Project Description
Flood Region:	TWDB RFPG Region
Project Type:	Project Type based on Section 3.2 in this document
Project Watershed:	Project Watershed
Rural Project:	Project qualifies as a rural project per TWDB definition
Project Cost:	Total Estimated Project Cost
Benefit- Cost Ratio:	BCR value determined in Economic Analysis
Project Status:	Planning, Preliminary, Final, Bid-Ready
Population Served:	# Population within Project Service Area Boundary
Communities Served by Project:	Number of jurisdictions (Cities) within project service area
# Structures in 100-year (1% annual chance) Floodplain:	Pre-project 100-year structures count
# Structures with reduced 100-year (1% annual chance) Flood risk:	Post-project 100-year flood risk reduction
# Structures with removed from 100-year (1% annual chance) Floodplain:	Post-project 100-year structures count removed from floodplain extents
Cost/ Structure removed:	Project cost/# structures removed
GIS Shapefile for project:	GIS shapefile of project service area limits or location
Percentage Nature-based Solution (by cost)	Percentage cost of Nature Based solution
Water Supply Benefit	Yes/No; If Yes, provide Annual Yield in Acre-feet
Pre-Project Level-of-Service	Pre-Project LOS: 2-year through 100-year (50% ACE-1% ACE)
Post-Project Level-of-Service	Post-Project LOS: 2-year through 100-year (50% ACE-1% ACE)
Traffic Count for Low Water Crossings	Traffic Count (AADT) for low water crossing projects

3.9.C Proposed Project Scoring Guidelines, Data Required, and Approach Instructions

The following listings provide proposed scoring guidelines and data requirements for each TWDB ranking criteria, as well as approach instructions to develop the values required for the ranking tool.

A proposed scoring system with scores between 0-10 have been applied to each of the 16 criteria. With this approach it is recommended that only the specified scores are used to ensure objectivity. However, it is recognized that criteria for some projects may be hard to define and could fall between two score descriptions. In this instance, it is advised that the lower score be selected.

3.9.C.1 Severity level: pre-project average depth of flooding (100-year)

Table 24: Criteria, specific data required and level guidelines

Criteria	Severity: Pre-Project Average Depth of Flooding (100-year)
Data Requirements	▪ **Pre-project 100-year floodplain shapefile with elevations;** ▪ **Structure shapefile;** ▪ **first floor structure elevations;** ▪ **streambed elevations;** ▪ **Project shapefile in GIS;** ▪ **land elevations (LiDAR or DEM);** ▪ **Traffic Count (AADT) for low water crossings;**

Proposed Scoring Guidelines:	Proposed score (out of 10):
baseline average flood depth > 3.5ft	**10**
baseline average flood depth > 2ft	**8**
baseline average flood depth > 1ft	**6**
baseline average flood depth > 0.5ft	**4**
baseline average flood depth < 0.5ft	**2**
not available (leave blank)	**0**

Approach for non-low water crossing projects:

1. To determine the Pre-Project Average depth of 100-year flooding (ft) measured in GIS at structures or crossings in GIS, overlay:
    a. baseline pre-project 100-year floodplain: digital format available from FEMA Map Service Center at https://msc.fema.gov/portal/advanceSearch;
    b. project shapefile;
    c. land elevations (LiDAR if available https://tnris.org/stratmap/elevation-lidar/); and
    d. structure shapefile (see below)
        i. TWDB is processing various data sources, including LiDAR, to create a state-wide building footprint dataset. This dataset will be made available in the Property category of the TWDB Flood Planning Data Hub. Inspect structures in floodplain and document water elevation depths for each structure compared to the first-floor structure elevations (difference represents the flooding depth).
    e. If first floor elevations are not available in the structures shapefile used, they may be available for purchase at this link: https://truefloodrisk.com/#/plans_n_pricing
    f. If first floor elevations are not used, the land elevation adjacent to the structure plus 0.5 ft may be used instead.
        i. Record the depths at each structure and calculate the average flooding depth for the project.
2. Report the value of the average flooding depth for the project and score the category accordingly.

Approach for low water crossing projects:

1. In GIS, overlay baseline pre-project 100-year floodplain, streambed elevation, dataset, and land elevation.
2. Generate a shapefile of a 300-foot buffer around the low water crossing location.
3. Within the buffer area, compare the water elevation to the streambed elevation dataset (calculate the difference which represents the flooding depth). In areas within the buffer where the streambed elevation data is not available, use the land elevation instead.

a. Report the value of the average flooding depth within the buffer area of the project and score the category accordingly.

3.9.C.2 Severity level: community need

Table 25: Severity level: community need

Criteria	Severity-Community need (% Population)
Data Requirements	▪ population of community within floodplain ▪ Pre-project 100-year floodplain ▪ total population of community
Proposed Scoring Guidelines:	**Proposed score (out of 10):**
>75% of project community affected	10
50%-75% of project community affected	7
25%-50% of project community affected	4
<25% of project community affected	1
not available (leave blank)	0

Approach:

1. This category is based on an estimate of the population in the floodplain relative to the total population of community.
2. The community will be defined as the jurisdiction (City, County, etc.). Information on spatial boundaries and population statistics is available from the Texas Demographic Center (https://demographics.texas.gov/Data/TPEPP/Estimates/), or from the United States Census Bureau (https://www.census.gov/geographies/mapping-files.All.html)
3. An estimate of the population within the floodplain can be made in GIS based on the proportion of structures within the floodplain and the use of LandScan USA population data. See section 3.4 for details on calculating population using LandScan USA (https://landscan.ornl.gov/). The maximum of the daytime and nighttime population is considered the population in the floodplain.
    a. Calculate the percentage of the community affected, report the value, and score the category accordingly:

$$\%\ \text{project community affected} = \frac{\text{population in pre project floodplain}}{\text{total community population}} \times 100$$

3.9.C.3 Flood risk reduction

Table 26: Flood risk reduction

Criteria	Flood Risk Reduction
Data Requirements	▪ pre-project 100-year floodplain shapefile with elevations; ▪ post-project 100-year floodplain shapefile with elevations; ▪ # structures in pre-project 100-year floodplain; ▪ # structures in post-project floodplain; ▪ structure shapefile; ▪ land elevations (LiDAR)
Proposed Scoring Guidelines	**Proposed score (out of 10):**
Reduced risk to >75% of structures in floodplain	10
Reduced risk to <75% of structures in floodplain	7
Reduced risk to <50% of structures in floodplain	4
Reduced risk to <10% of structures in floodplain	1

Reduced risk to 0 structures in floodplain	**0**
not available (leave blank)	**0**

Approach:

1. This category will only be relevant and included in the scoring for projects which reduce risk to structures within the floodplain. For projects which do not reduce floodplain, for example low water crossing projects, the TWDB may elect to remove category from the scoring system and the weighted total score.
2. Count of structures should include all habitable structures.
3. In GIS, overlay baseline pre-project 100-year floodplain shapefile with post-project 100-year floodplain shapefile, along with the structure dataset (shapefile), and land elevations.
4. Calculate the percentage of structures removed from 100-year floodplain, report the value, and score accordingly:

$$\% \text{ removed} = \frac{(\#\ structures\ removed\ from\ floodplain)}{\#\ structures\ in\ floodplain\ pre\ project} * 100$$

3.9.C.4 Flood damage reduction

Table 27: Flood damage reduction

Criteria	**Flood Damage Reduction (Property Protection)**
Data Requirements	▪ **pre-project average depth of 100-year flooding (from 3.10.C.1.);** ▪ **post-project 100-year flood shapefile, elevations, or average depth/reduction;** ▪ **Project shapefile (GIS);** ▪ **land elevations (LiDAR);** ▪ **structure shapefile;** ▪ **first floor structure elevations;**

Proposed Scoring Guidelines:	**Proposed score (out of 10):**
flood damage reduction >95%	**10**
flood damage reduction > 75%	**8**
flood damage reduction > 50%	**6**
flood damage reduction > 25%	**4**
flood damage reduction < 25%	**2**
not available (leave blank)	**0**

Approach:

1. This category will use damage and benefit assessment data to determine flood risk reduction percentage of the project to assign a relative score. For ease of use, only direct flood damages relating to structures will be considered. This category will only be relevant and included in the scoring for projects which reduce risk to structures within the floodplain. For projects which do not reduce floodplain risk, for example low water crossing projects, the TWDB may elect to remove category from the scoring system and the weighted total score.
2. The Pre-Project Average Depth of Flooding (100-year, in feet) was calculated in 3.9.C.1.
3. Using the same methodology, calculate the Post-Project Average Depth of Flooding (100-year, in feet) using GIS at structures or crossings in GIS, by overlaying:
    a. post-project 100-year floodplain shapefile;
    b. project shapefile;
    c. land elevations (LiDAR if available https://tnris.org/stratmap/elevation-lidar/); and
    d. structure shapefile used in 3.9.C.1

4. Alternative to the GIS approach, if the average reduction in post-project 100-year flood depth is indicated by hydraulic modeling for the project reach and is available/reported, this depth reduction may be used for this criterion.
5. Using the Pre-Project Average Depth of Flooding (100-year) depth calculated for the project in 3.10.C.1., and property values of structures in the floodplain from the applicable County Appraisal District, use a USACE Damage Depth Function (DDF) to calculate total pre-project damages (100-year):
    a. Refer to DDF for 1-story structures, and 2-story structures without basements on pages 6-7 of the *Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships* (Johnson, 2000): https://planning.erdc.dren.mil/toolbox/library/EGMs/egm01-03.pdf
    b. Damages= % damages from DDF x property value
6. Using the Post-Project Average Depth of Flooding (100-year) depth calculated or determined above, repeat the calculation for the post-project average flood depth to calculate total post-project damages (100-year).
7. Calculate the flood damage reduction percentage, report the value, and score accordingly:

$$\frac{\text{total pre project damages} - \text{total post project damages}}{\text{total pre project damages}} \times 100$$

3.9.C.5 Critical facilities damage reduction

Table 28: Critical facilities damage reduction

Criteria	Flood Damage Reduction (Property Protection)
Data Requirements	▪ **pre-project average depth of 100-year flooding (from 3.9.C.1);** ▪ **post-project 100-year flood shapefile, elevations, or average depth/reduction;** ▪ **# critical facilities in pre-project 100-year floodplain;** ▪ **# critical facilities in post-project floodplain;**

Proposed Scoring Guidelines:	Proposed score (out of 10):
critical facilities reduction >95%	**10**
critical facilities reduction > 75%	**8**
critical facilities reduction > 50%	**6**
critical facilities reduction > 25%	**4**
critical facilities reduction < 25%	**2**
not available (leave blank)	**0**

Approach:

1. This category will only be relevant and included in the scoring for projects which reduce risk to critical facilities within the floodplain. For projects which do not reduce floodplain, for example low water crossing projects, the TWDB may elect to remove the category from the scoring system and the weighted total score.
2. In GIS, overlay the baseline pre-project 100-year floodplain shapefile with post-project 100-year floodplain shapefile, along with the critical facilities dataset ([Exist_Vuln]), and land elevations.
3. Calculate the percentage of critical facilities removed from the 100-year floodplain, report the value, and score accordingly:

$$\text{removed} = \frac{\#\text{ critical facilities in floodplain pre project} - \#\text{ critical facilities in flood plain post project}}{\#\text{ critical facilities in floodplain pre project}} \times 100$$

$$\%\text{ removed} = \times 100$$

3.9.C.6 Life and safety (injury / loss of life)

Table 29: Life and safety (injury / loss of life)

Criteria	Life and Safety (Injury / Loss of life)
Data Requirements	▪ **Structures shapefile;** ▪ **land/stream elevations (LiDAR);** ▪ **pre-project 100-year floodplain elevations;** ▪ **pre-project 100-year velocity (model, if available);** ▪ **flood-related death and injury data for affected county(ies) in past year: https://www.ncdc.noaa.gov/stormevents**

Proposed Scoring Guidelines:	Proposed score (out of 10):
life/injury risk percentage >50%	**10**
life/injury risk percentage >40%	**8**
life/injury risk percentage >30%	**6**
life/injury risk percentage >20%	**4**
life/injury risk percentage <20%	**2**
not available (leave blank)	**0**

Approach:

1. This category is based on the calculation of two parameters; a Hazard Rating and a Vulnerability Rating. The approach is based on principles used in the UK's DEFRA guidance for valuing the risk to life from flooding, which provides a simplified, less data intensive approach. It can be used for all types of projects, including low water crossings.
2. Calculate the "area hazard rating" using the average flood depth, average flood velocity and debris factor:
    a. Average flood depth: use the Severity (depth) approach to define the average flood depth at structures for non-low water crossing projects or within the buffer area of crossing for low water crossing projects.
    b. Average flood velocity can be obtained from model results, if available. If model data is not available, it can be estimated based on the flooding depth or historic evidence (i.e., a source of typical flood velocities in Texas).
    c. The debris factor is based on the flooding depth, velocity, and underlying land use. The lookup table provided below estimates the debris factor based on depth and land use:

Table 30: Debris factor lookup table

Debris factor lookup table [13]			
Depths	**Pasture / Arable**	**Woodland**	**Urban**
0 to 0.25m (0 to 0.8ft)	0	0	0
0.25m to 0.75m (0.8ft to 2.5ft)	0	0.5	1
Depth > 0.75m (2.5ft) and/or Velocity >2m/s (6.6 ft/s)	0.5	1	1

    d. Area Hazard Rating is calculated as:
        i. **Area Hazard Rating = depth(velocity+0.5) + debris factor**

[13] based on Table A.1 in Defra Flood and Coastal Defense Appraisal Guidance, Assessing the Valuing the Risk to Life from Flooding, UK

3. Calculate the "area vulnerability rating" using estimates of the speed of onset of flooding, the presence of a flood warning system, and the nature/development of the area. Each of these variables is scored between 1-3. The lookup table below provides estimated values of each variable. The vulnerability rating is the sum of each variable, calculated as:
    a. **Area Vulnerability Rating = (onset + flood warning + nature of area)**

Table 31: Area vulnerability lookup table

Area Vulnerability lookup table [14]			
Parameter	**Low risk area Score = 1**	**Medium risk area Score = 2**	**High risk area Score = 3**
Speed on onset	Onset of flooding is very gradual (many hours)	Onset of flooding is gradual (an hour or so)	Rapid flooding
Nature of area	Multi-story apartments	Typical residential area, commercial and industrial properties	Bungalows, mobile homes, busy roads, parks, single story
Flood warning score	Flood warning system in place for all possible sources of flooding	Flood warning system in place for some of the possible sources of flooding	No flood warning system
Area vulnerability = sum of scores for 'speed on onset', 'nature of area' and 'flood warning'			

1. Multiply the "Area Hazard Rating" by the "Area Vulnerability Rating" and convert to a life/injury risk percentage.
2. If the project area has a history of loss of life and/or injury caused by flooding, multiply the life/injury risk percentage by 1.5. If the area does not have an incident caused by flooding, multiply the life/injury risk percentage by 1.
3. Report the value and score accordingly.

3.9.C.7 Water supply benefit

Table 32: Water supply benefit

Criteria	**Water Supply benefit**
Data Requirements	▪ **Water Supply benefits to a specific need identified in the most recently approved state or regional water plan**

Proposed Scoring Guidelines:	**Proposed score (out of 10):**
Involves directly increasing water supply which requires both availability increase and directly connecting supply to user.	**10**
Directly benefits 'water availability', but no water user directly benefits (e.g. by injecting into aquifer, creating new raw water storage)	**7**
Indirectly benefits 'water availability (e.g., recharges aquifers through natural infiltration)	**4**
No impact on water supply	**0**
not available (leave blank)	**0**

[14] based on Table A.2 in Defra Flood and Coastal Defense Appraisal Guidance, Assessing the Valuing the Risk to Life from Flooding, UK

Approach:

1. A project's Water Supply component will be provided in the broader Project Description and General Project Data.
    a. If a project indicates a Water Supply Benefit, report the project specific water supply benefit provided, and score accordingly.
2. The estimated share of the cost associated with a project's Water Supply benefit components must be 5 percent or greater of the estimated total project cost.
3. Projects must reference the specific water supply need and water user group(s) in the most recently approved state or regional water plan.

3.9.C.8 Social vulnerability

Table 33: Social vulnerability

Criteria	Social vulnerability
Data Requirements	▪ SVI GIS Shapefile from CDC download; ▪ Project shapefile

Proposed Scoring Guidelines:	Proposed score (out of 10):
SVI between 0.75-1.00 (high vulnerability)	10
SVI between 0.5-0.75 (moderate to high vulnerability)	7
SVI between 0.25-0.5 (low to moderate vulnerability)	4
SVI between 0.01-0.25 (low vulnerability)	1
not available (leave blank)	0

Approach:

1. Download the 2018 SVI shapefile for Texas, available on the Flood Planning Data Hub. The shapefile contains SVI information for each of the individual census tracts in Texas.
2. Overlay the project shapefile with the SVI shapefile. The SVI for each census tract is reported in the GIS field "RPL_themes". This field has values between 0 and 1, with a high score (closer to 1) denoting greater vulnerability.
3. If the project shapefile intersects multiple census tracts, determine the SVI for all tracks and calculate the areal weighted-average SVI, report the value for the project, and score accordingly.

3.9.C.9 Nature-based solutions

Table 34: Nature-based solutions

Criteria	Nature-based Solutions
Data Requirements	▪ Percentage of project based on nature-based solutions by cost provided in general project data

Proposed Scoring Guidelines:	Proposed score (out of 10):
>75% of the project cost is nature-based	10
> 50% of the project cost is nature-based	7
>25% of the project cost is nature-based	4
<25% of the project cost is nature-based	1
not available (leave blank)	0

Approach:

1. The RFPGs will have flexibility in determining what percent of the project is nature based. RFPGs must be consistent in their approach for the entire region and provide justification for the basis of their determination.
2. This category is based on the proportion of the project that is a nature-based solution. The proportion is defined in cost terms whereby percentage of the project being nature-based is estimated by dividing the cost of the nature-based aspects of the project by the total project costs. Examples of nature-based solutions include: reforestation, green embankments; coastal mangroves, wetlands; urban parks, restorations.
    a. Using the reported Nature based infrastructure percentage calculation provided in the General Project Data, report the value and indicate score accordingly.

3.9.C.10 Multiple benefit

Table 35: Multiple benefit

Criteria	Multiple Benefit
Data Requirements	▪ Reported benefits in project description

Proposed Scoring Guidelines:	Proposed score (out of 10):
Project delivers benefits in four or more wider benefit categories	10
Project delivers benefits in three wider benefit categories	7
Project delivers benefits in two wider benefit categories	4
Project delivers benefits in only one wider benefit category	1
Project does not deliver any wider benefits	0
not available (leave blank)	0

Approach:

1. The scoring of this category is based on the number of different wider benefit categories which can be delivered by the project included in the project description.
2. The wider benefit categories may include:
    a. Recreation benefits such as trails, parks, or sports fields.
    b. Agricultural benefits such as field preservation, irrigation opportunities, or other benefits to forestry or farming lands.
    c. Transportation benefits such as improved roads, bike paths, navigation, or parking facilities.
    d. Social and quality of life benefits such as community centers, hospitals, or education benefits.
    e. Local economic impacts such as providing business continuity or job creation.
    f. Project's ability to meet specific sustainability goals based on the U.S. National Statistics for the U.N. Sustainable Development Goals (https://sdg.data.gov/)
    g. Project resilience goals that indicate that project is planned to withstand a long-term service life (i.e., >50-years) and is designed with increased resilience.
        i. Report the value (0-4+) and score accordingly.

3.9.C.11 Operations and maintenance

Table 36: Operations and maintenance

Criteria	Operations and Maintenance
Data Requirements	▪ O&M needs/annual costs provided in Project description
Proposed Scoring Guidelines:	**Proposed score (out of 10):**
Project will not require any ongoing operation and maintenance (low);	10
Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7
Project will require ongoing operation and maintenance outside of the owner's regular maintenance practices; long-term O&M requirements are undefined; and/or high annual O&M cost > 1% of project (high);	4
Project will require extensive and/or specialist operations and maintenance outside of owner's regular maintenance practices; project O&M needs are uncertain; and/or high annual O&M cost > 5% of project (extensive);	1
not available (leave blank)	0

Approach:

1. This category is based on the reported expected level of O&M effort for the project infrastructure owner (City, County, River Authority, etc.), owner's experience/qualifications to operate, and/or overall proportion of annual O&M costs to the total project cost. Category also accounts for risk/uncertainty relating to O&M requirements.
2. O&M levels and/or annual costs should be included in the project description and general project data.
    a. Report the value (low, regular, high, or extensive), and score accordingly.

3.9.C.12 Administrative, regulatory, and other implementation obstacles/difficulty

Table 37: Administrative, regulatory, and other implementation obstacles/difficulty

Criteria	Administrative, Regulatory and other implementation obstacles/difficulty
Data Requirements	▪ Anticipated project requirements; Administrative, Regulatory, and other implementation obstacles/difficulty
Proposed Scoring Guidelines:	**Proposed score (out of 10):**
Project has few administrative, regulatory and implementation limitations / requirements	10
Project has a typical number of administrative, regulatory and limitations / requirements	6
Project has a high number of administrative, regulatory and limitations / requirements	2
not available (leave blank)	0

Approach:

1. The scoring of this category is based on the reported anticipated number of administrative, regulatory, and environmental requirements a project must achieve to go ahead in the project description.
2. Most projects will fall into the "typical" category unless specific exceptions (for few), or additional regulation requirements (for high) are documented in the description.
3. Ranking Definitions:
    a. Few: project requires 2 or less local permits (i.e., City, County)
    b. Typical: project requires 2 or more local permits (i.e., City, County), and standard reviews by state (i.e., TCEQ), and/or 2 or less property acquisitions.
    c. High: project requires 3 or more local permits, state reviews (i.e., TCEQ), Federal Permits (USACE, USFWS, etc.), and/or 3 or more property acquisitions.
        i. Report the value (few, typical, high) and score accordingly.

3.9.C.13 Environmental benefit

Table 38: Environmental benefit

Criteria	**Environmental Benefit**
Data Requirements	▪ **Environmental benefits of project, included in project description**
Proposed Scoring Guidelines:	**Proposed score (out of 10):**
Project will deliver a high level of environmental benefits (benefits in 4+ categories)	**10**
Project will deliver a moderate level of environmental benefits (benefits in 2-3 categories)	**6**
Project will deliver a low level of environmental benefits (benefits in only 1 category)	**3**
Project does not provide any environmental benefits	**0**
not available (leave blank)	**0**

Approach:

1. The scoring of this category is based on the level of environmental benefit that a project is anticipated to provide which must be documented in the broader project description.
2. An environmental benefit is defined as an improvement on the current environmental condition (the condition prior to the project).
3. The potential environmental benefit categories include:
    a. water quality (i.e., project adds a new water quality pond, vegetated filter strips, rain garden(s), or flood level reduction reduces risk of wastewater overflows during storm events);
    b. cultural heritage (i.e., project removes a Texas Historical Commission (THC) identified site with antiquities from floodplain);
    c. habitat, biodiversity and ecology (i.e., project provides habitat protection, creates intertidal habitat, wetland areas, or wildlife corridors);
    d. air quality (i.e., project creates open space, recreation areas, or parks; includes tree and/or vegetation plantings; utilizes sustainable construction techniques with planning to minimize air quality impacts);
    e. natural resources (i.e., project includes protection measures for natural resources, creates habitat, coastal grazing marshes, wetlands, or woodlands);

f. agricultural resources/properties (i.e., agricultural properties removed from floodplain or floodway);
g. soil quality, erosion and sedimentation (i.e., project provides reduced velocities, and/or stream armoring; project increases organic matter/soil health to support increased infiltration)

4. Report the value and score accordingly.

3.9.C.14 Environmental impact

Table 39: Environmental impact

	Environmental Impact	
Data Requirements	▪ **Environmental impacts of project, included in project description**	
Proposed Scoring Guidelines:		**Proposed score (out of 10):**
Project has no adverse environmental impacts		**10**
Project will have adverse environmental impacts in 1 environmental category		**6**
Project will have adverse environmental impacts in 2-3 environmental categories		**3**
Project will have adverse environmental impacts in 4+ categories		**0**
not available (leave blank)		**0**

Approach:

1. The scoring of this category is based on the anticipated level of environmental impacts which must be documented in the broader project description.
2. An adverse environmental impact is defined as a negative change compared to the current environmental condition (the condition prior to the project), after appropriate mitigation has been implemented.
3. Environmental net impact categories include:
    a. Impacts to water quality (i.e., project includes work in a watershed identified by TCEQ's Watershed Action Planning list of impaired or special interest areas; increases velocities; increases surface water run-off pollution, or requires relocation of wastewater discharge into sensitive area);
    b. Impacts to cultural heritage (i.e., project work proposed in areas with Texas Historical Commission identified antiquities);
    c. Impacts to habitat, biodiversity and ecology (i.e., proposed work in area with endangered, protected, or sensitive species);
    d. Impacts to air quality (i.e., project requires tree and/or other vegetation removal; reduction of green spaces; increases air pollution during construction and/or operation);
    e. Impacts to natural resources (i.e., project impacts designated coastal natural resource areas, or wetland);
    f. Impacts to agricultural resources/properties (i.e., agricultural properties acquired for detention or channel improvements);
        i. Impacts to soils/erosion and sedimentation (i.e., increased velocities during more frequent events such as the 2-year storm)
4. Report the impact level and score accordingly.

3.9.C.15 Mobility

Table 40: Mobility

Data Requirements	▪ **Project Shapefile** ▪ **TxDOT Functional Classification Shapefile** ▪ **pre-project 100-year floodplain shapefile with elevations;** ▪ **post-project 100-year floodplain shapefile with elevations;**
Proposed Scoring Guidelines:	**Proposed score (out of 10):**
Project will protect major and minor access routes in floodplain and emergency service access to EMS, police stations, and fire stations. Allows emergency services access to their entire administrative area.	**10**
Project will protect all major access routes in floodplain and all emergency service access. Minor access routes are still flooded or have restricted access in local areas.	**7**
Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas (i.e. >50% of floodplain by area inaccessible).	**4**
Project provides no change to major, minor, or emergency access routes in the project area.	**0**
not available (leave blank)	**0**

Approach:

1. The scoring of this category is based on improved mobility during flood events, with particular emphasis on emergency service access and major access routes.
2. Overlay the Project shapefile with the pre- and post-project 100-year floodplain shapefiles, and a download of the TxDOT Functional Classification Shapefile: http://gis-txdot.opendata.arcgis.com/datasets/txdot-functional-classification
3. Roadway classifications are included in the TxDOT shapefile variable "FC_DESC":
    a. Major access routes: Major Collector, Principal Arterial, Interstate
    b. Minor access routes: Minor Collector, Minor Arterial
        i. Report the project value (no access change, minor access protection, major access protection, or major/emergency access protection) and score accordingly.

3.10 Project data submittal requirements

Please refer to the Exhibit D: Data Submittal Guidelines for flood planning data submittal requirements.

An excel template file "Exhibit C Tables" is attached with this guidance document that includes the summary tables that are required to be filled and submitted with the technical memo, draft flood plan and the final flood plan.

Map submittal requirements:

Following is a list the GIS coverage maps the RFPGs are required to submit with the flood plan. Each map should depict the RFPG boundary, counties, HUCs as applicable, major streams or rivers, major reservoirs as appliable, major watershed boundaries as applicable, major roadways, major cities or urban areas, and other features identified by the RFPG.

1. **Map 1:** Existing Flood Infrastructure (2.1 Task 1 – Planning Area Description)
2. **Map 2:** Proposed or Ongoing Flood Mitigation Projects (2.1 Task 1 – Planning Area Description)
3. **Map 3:** Non-Functional or Deficient Flood Mitigation Features or Infrastructure (2.1 Task 1 – Planning Area Description)
4. **Map 4:** Existing Condition Flood Hazard (2.2.A.1 Existing condition flood hazard analysis)
5. **Map 5:** Existing Condition Flood Hazard - Gaps in Inundation Boundary Mapping and Identify Known Flood-Prone Areas (2.2.A.1 Existing condition flood hazard analysis)
6. **Map 6:** Existing Condition Flood Exposure (2.2.A.2 Existing condition flood exposure analysis)
7. **Map 7:** Existing Condition Vulnerability and Critical Infrastructure (2.2A.3 Existing condition vulnerability analysis)
8. **Map 8:** Future Condition Flood Hazard (2.2.B.1 Future condition flood hazard analysis)
9. **Map 9:** Future Condition Flood Hazard - Gaps in Inundation Boundary Mapping and Identify Known Flood-Prone Areas (2.2.B.1 Future condition flood hazard analysis)
10. **Map 10:** Extent of Increase of Flood Hazard Compared to Existing Condition (2.2.B.1 Future condition flood hazard analysis)
11. **Map 11:** Future Condition Flood Exposure (2.2.B.2 Future condition flood exposure analysis)
12. **Map 12:** Future Condition Vulnerability and Critical Infrastructure (2.2.B.3 Future condition vulnerability analysis)
13. **Map 13:** Floodplain Management (2.3.A Task 3A – Evaluation and Recommendations on Floodplain Management Practices)
14. **Map 14:** Greatest Gaps in Flood Risk Information (2.4.A Task 4A – Flood Mitigation Needs Analysis)
15. **Map 15:** Greatest Flood Risk (2.4.A Task 4A – Flood Mitigation Needs Analysis)
16. **Map 16:** Potential Flood Management Evaluations (2.4.B Task 4B – Identification and Evaluation of Potential Flood Management Evaluations and Potentially Feasible Flood Management Strategies and Flood Mitigation Projects)
17. **Map 17:** Extent of Potential Flood Management Evaluations and Existing Mapping Needs (2.4.B Task 4B)
18. **Map 18:** Potential Flood Mitigation Projects (2.4.B Task 4B)
19. **Map 19:** Extent of Potential Flood Mitigation Projects (2.4.B Task 4B)
20. **Map 20:** Recommended Flood Management Evaluations (2.5.A Flood Management Evaluations)
21. **Map 21:** Recommended Flood Mitigation Projects (2.5.C Flood Mitigation Projects)

All maps should be submitted with underlying GIS data layers and map documents, include a north arrow, a reference scale, appropriate assumptions and/ or disclaimers. These are minimum submittal requirements. The RFPGs may choose to provide additional maps at their discretion.

3.11 References

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3.12 Appendix 1

Figure 15: FMP data entry tool interface - example of general project data:

	General Project Data														
Project Name	`	Project Description:	Flood Region	Project Type	FIUP Project Category	Project Watershed	Rural Applicant	Project Cost	Benefit Cost Ratio	Cost per Structure Removed	Pre-Project Level-of-Service	Post-Project Level-of-Service	# of Structures in 1% Annual Chance FP (Pre-Project)	Project Status
Project 1	1	Channel Project in Henderson County	Trinity Region	Regional	Category 1	Walnut Creek (Trinity Trib)	N	$20,000,000	5	200000	10-year	50-year	200	Planning
Project 2	2	Small Infrastructure Project in City of Lamesa, TX (Dawson County)	Colorado Upper Region	Local Rehab	Category 2	Sulfur Springs Draw	Y	$ 800,000	3	80000	2-year	25-year	25	Design
Project 3	3	Low Water Crossing at San Marcos River & Plant Road (232) in Caldwell County	Guadalupe Region	Low water crossing	Category 2	San Marcos River	Y	$500,000	2		2-year	25-year	4	Design

Figure 16: Example FMP data as shown in Section 4.3 (note that the scores are examples and are not representative of actual projects):

Project	Severity Ranking: Pre-Project Average Depth of Flooding (100-year)	Severity Ranking: Community Need (% Population)	Flood Risk Reduction	Flood Damage Reduction	Reduction in critical facilities flood risk	Life and Safety Ranking (Injury/Loss of life)	Water Supply Yield Ranking	Social Vulnerability Ranking	Green/Nature-Based Solutions Ranking	Multiple Benefit Ranking	Operations and Maintenance Ranking	Administrative, Regulatory and Other Obstacle Ranking	Environmental Benefit Ranking	Environmental Impact Ranking	Mobility Ranking	Total Score
Project 1 - Channel Project in Henderson County	4	4	4	8	4	4	10	4	4	7	4	2	6	3	10	78
Project 2 - Small Infrastructure Project in City of Lamesa, TX (Dawson County)	10	7	7	8	4	4	4	4	7	4	7	6	3	3	4	82
Project 3 - Low Water Crossing at San Marcos River & Plant Road (232) in Caldwell County	10	7	1	4	7	10	0	7	4	1	7	10	10	10	4	92

3.13 Appendix 2

Project Data Requirement Checklist

☐	1	Project ID: Project name provided by the Regional Flood Planning Group (RFPG)
☐	2	Project Description: Brief project description
☐	3	Flood Region: TWDB RFPG Flood Planning Region
☐	4	Project Type: Project type based on Section 1 guidance in this document
☐	5	Flood Intended Use Plan (FIUP) Project Category: FIUP Category 1, 2, or 4
☐	6	Project Watershed: Project watershed defined by TWDB
☐	7	Rural Project: Project qualifies as a rural project per TWDB definition
☐	8	Project Cost: Total estimated project cost
☐	9	Benefit- Cost Ratio: BCR value determined in Economic Analysis
☐	10	Project Status: Planning, Preliminary Design, Final Design, Bid-Ready
☐	11	Population Served: Population within Project Service Area Boundary
☐	12	Communities Served by Project: Number of jurisdictions (Cities) within project service area
☐	13	Number of Structures in 100-year (1% annual chance) Floodplain: Pre-project 100-year structures count
☐	14	Number of structures with reduced 100-year (1% annual chance flood risk: Post-project 100-year flood risk reduction
☐	15	Number of structures removed from 100-year (1% annual chance) floodplain: Post-project 100-year count of structures removed from floodplain extents
☐	16	Cost per structure removed: Project cost/number of structures removed
☐	17	Project shapefile in GIS: GIS shapefile of project service area limits and/or point location
☐	18	Percentage of Nature-based solution (by cost): Percent cost of nature-based solution
☐	19	Water Supply Benefit: (Yes/No); If Yes, list type of benefit: water availability, water supply, or both
☐	20	Pre-Project Level-of-Service (LOS): 2-year through 100-year (50% ACE-1% ACE)

☐	21	Post-Project Level-of-Service (LOS): 2-year through 100-year (50% ACE-1% ACE)
☐	22	Pre-project 100-year floodplain (1% annual chance) shapefile with elevations
☐	23	Structure shapefile (parcels shapefile if structures not available)
☐	24	First floor structure elevations
☐	25	Streambed elevations (LiDAR, DEM, or Hydraulic Model)
☐	26	Land elevations (LiDAR or DEM)
☐	27	Population of community within floodplain
☐	28	Post-project 100-year (1% annual chance) floodplain shapefile with elevations
☐	29	Pre-project average depth of 100-year flooding (calculated in Criteria 1- 4.2.1)
☐	30	Post-project 100-year flood shapefile, elevations, or average depth/reduction
☐	31	Pre-project 100-year velocity (from Hydraulic model, if available)
☐	32	Flood-related death and injury data for affected county(s) in past year: https://www.ncdc.noaa.gov/stormevents
☐	33	Social Vulnerability Index (SVI) GIS Shapefile from CDC download
☐	34	Percent of project nature-based solutions by cost provided in general project data
☐	35	Environmental Benefits to water quality, cultural heritage, habitat, air quality, natural resources, agricultural resources, and soils/erosion and sedimentation.
☐	36	Environmental Impacts of project to water quality, cultural heritage, habitat, air quality, natural resource protection, and erosion and sedimentation.
☐	37	Reported Benefits (Multiple):
☐	37-a	Recreation benefits such as trails, parks, or sports fields.
☐	37-b	Agricultural benefits such as field preservation, irrigation opportunities, or other benefits to forestry or farming lands.
☐	37-c	Transportation benefits such as improved roads, bike paths, navigation, or parking facilities.
☐	37-d	Social and quality of life benefits such as community centers, hospitals, or education benefits.
☐	37-e	Local economic impacts such as providing business continuity or job creation.
☐	37-f	Project's ability to meet specific sustainability goals based on https://sdg.data.gov/

☐	37-g	Project resilience goals that indicate that project has a long-term service life (i.e. >50-years) and is designed with increased resilience
☐	38	Report of anticipated project requirements; Administrative, Regulatory, and other implementation obstacles/difficulty Ranking (permits: local, state, federal)
☐	39	Estimated project design, modeling, constructability requirements (standard, challenging, highly complex)
☐	40	TxDOT Functional Classification Shapefile
☐	41	Traffic Count for Low Water Crossing Projects (AADT)
☐	42	Optional Items:
☐	42-a	Narrative of how the project is going to change the community and/or how the project relates to other projects or ongoing progress.
☐	42-b	Photos of flooding that may not be captured by modeling.