8 Benefits and impacts of implementing the plan

Quick facts

An estimated 640,507 people, 155,905 buildings, and 199 low water crossings would be removed from the 1 percent (100-year) annual chance floodplain if all 615 recommended flood mitigation projects are implemented.

An estimated 202,832 people, 58,387 buildings, and 378 low water crossings would be removed from the 1 percent (100-year) annual chance floodplain if all 897 recommended flood management strategies are implemented.

Three regions (Region 11 Guadalupe, Region 12 San Antonio, and Region 15 Lower Rio Grande) identified potential water supply benefits for 37 recommended flood mitigation projects with an estimated water supply amount of 2,001 acre-feet per year. One region (Region 14 Upper Rio Grande) recommended a flood management strategy with potential water supply benefit with an estimated water supply amount of 70 acre-feet per year.

Together, implementing the recommended flood risk reduction solutions (Chapter 7) and the floodplain management recommendations (Chapters 2 and 5) will help reduce current flood risk and, importantly, prevent the creation of or increase in future flood risk.

Each regional flood planning group was tasked with summarizing the impacts and contributions that its regional flood plan could have if the plan is implemented as recommended based on before-and-after comparisons. These comparisons estimate how much the region's existing flood risk will be reduced by implementing the plan. To quantify the impact, these comparisons were performed for the 1 percent (100-year) annual chance flood event. All 15 planning groups determined that their plan, when implemented, will not negatively affect neighboring areas located near the flood planning regional boundaries.

8.1 Benefits of implementing recommended flood risk reduction solutions

While flood mitigation projects, flood management strategies, and flood management evaluations mitigate flood risk in different ways, the combined effect of all these recommended actions will, directly or indirectly, reduce flood risk and protect life and property throughout the state. Implementation of this plan describes conditions if all recommended flood risk reduction solutions are fully funded and completed.

For clarity and brevity, this chapter summarizes implementing all the recommended mitigation solutions with a focus on the resulting flood risk reduction benefits associated with a 1 percent (100-year) annual chance flood event.

8.1.1 Benefits of recommended flood management evaluations

For many flood planning regions, the data compilation step of the first region-wide planning process resulted in identifying significant data gaps in areas of potentially high flood risks that didn't have floodplain management or enforcement, detailed hydrologic and hydraulic models, or accurate flood inundation mapping. Lack of data or outdated information can lead to unanticipated exposure to flood hazard and, therefore, lack of awareness, general unpreparedness, and greater vulnerability.

The planning groups developed and recommended flood management evaluations to address people and property exposed to existing flood risks within the 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplains. While studies themselves don't directly mitigate flood risk, they do encompass a large expanse of people and property that could potentially benefit from knowing their flood risk and implementing mitigation solutions identified by these studies.

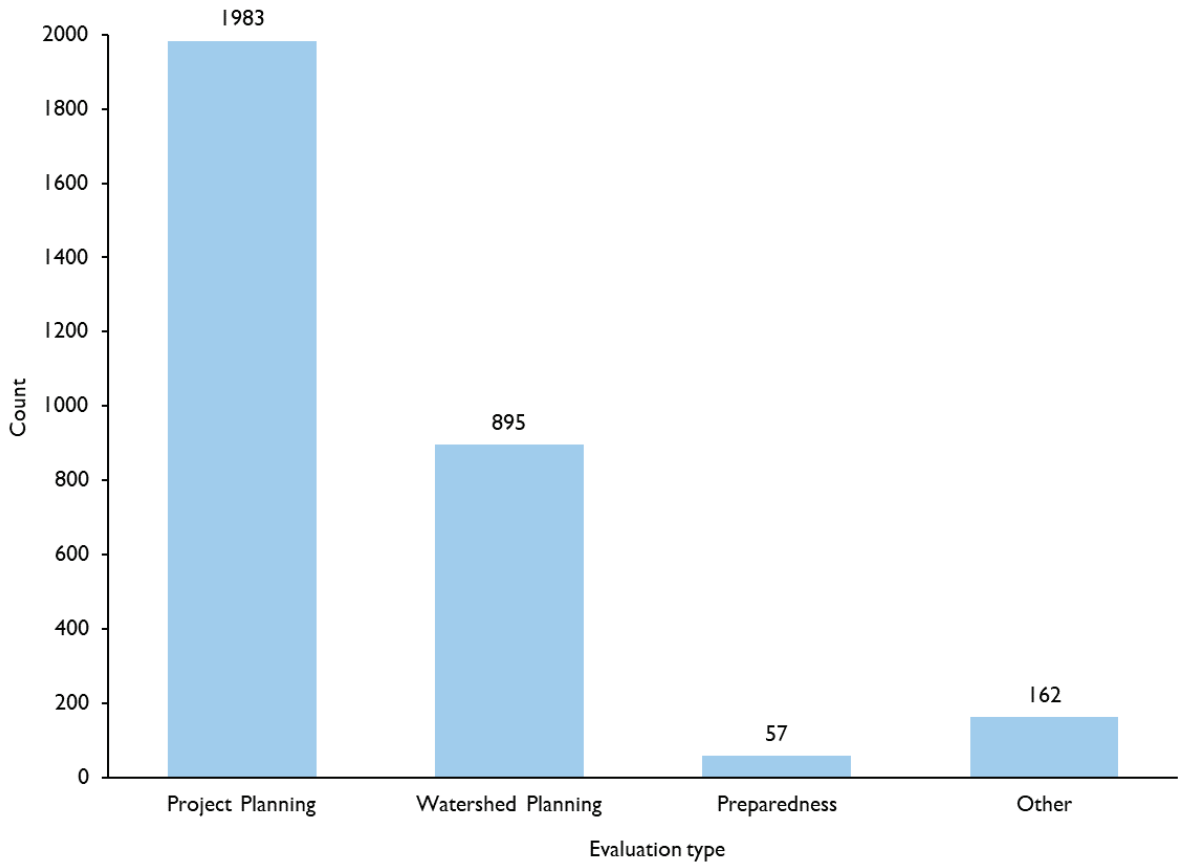
The large number of flood management evaluations highlights the work needed throughout the state to assess the general flood risk. The number of studies also underscores the need to better define flood risk and identify and implement risk reduction solutions.

Many of the recommended flood management evaluations have overlapping boundaries resulting in duplicated data, including affected population and structures within the 1 percent (100-year) annual chance floodplain. Total recommended flood management evaluation boundaries cover approximately 81 percent (217,415 square miles) of the total land area of Texas (268,697 square miles).

Performing the recommended flood management evaluations would represent significant progress in addressing flood data knowledge gaps and high flood risk areas. Many parts of the state have limited and/or outdated floodplain mapping.

In the amended regional flood plans, the regional planning groups recommended a total of 3,097 flood management evaluations that are organized into four broad categories: engineering project planning; flood preparedness studies; watershed planning; and other (Figure 8-1). The overall impacts of each recommended flood management evaluation will vary and depend on whether specific on-the-ground mitigation solutions can be identified and implemented. However, until all recommended flood management evaluations are performed, their ultimate impacts may not be fully known. Taken together, these flood management evaluations represent the areas across the state that regional flood planning groups considered most in need of flood risk identification.

Figure 8-1. Summary of recommended flood management evaluations by evaluation type



Engineering project planning

Approximately 64 percent (1,983) of the flood management evaluations recommended by the regional flood planning groups were categorized as engineering project planning evaluations. The total study area of all engineering project planning flood management evaluations is 85,561 square miles, or approximately 32 percent of the land area of Texas. These studies fall into two main categories, feasibility assessments and preliminary engineering. These studies investigate, identify, recommend, and formulate specific, best flood risk reduction solutions for particular flood risks. The preliminary engineering studies may include up to 30 percent of engineering project design. Examples of evaluations include storm drain upgrades, culvert upsizing, and channel modifications. Typical impacts or outcomes from projects identified through such evaluations include reducing properties at risk of flooding, reducing existing facilities exposure, and reducing roadway overtopping.

Watershed planning

Approximately 29 percent (895) of the recommended flood management evaluations were categorized as watershed planning evaluations, or studies that identify the risk of flooding, refine and update outdated flood risk information in the watershed, identify, evaluate and recommend flood risk reducation solutions. They also help establish accurate floodplain modeling and mapping and evaluation of potential flood mitigation measures, as well as include watershed studies, flood insurance studies, and city-wide or county-wide drainage master plans. Watershed planning can help to better distribute resources equitably throughout the region to implement plans, programs, and projects that maintain watershed function and prevent adverse flood effects.

Other

Approximately 5 percent (162) were categorized as other flood management evaluations. This category was reserved for additional types of studies or assessments needed to either identify and quantify flood hazard or evaluate and recommend flood risk reduction solutions. The types of studies in this category varied across regions but generally included dam evaluations, property acquisition evaluations, developing geographic information system inventories on existing infrastructure, and other general data collection. While these activities may not directly mitigate flooding issues, they support increased awareness of the condition of stormwater infrastructure, leading to better prioritization for the maintenance, repair, and associated flood risk mitigation benefits. Typical impacts or eventual outcomes of these types of evaluations include

- projects that reduce the impact of flooding on people and structures through acquisition of repetitive loss areas;
- potential increase of green space, functioning floodplains, and recreational areas; and
- meaningful reductions in flood risk resulting from maintenace and repair to existing infrastructure.

Flood preparedness studies

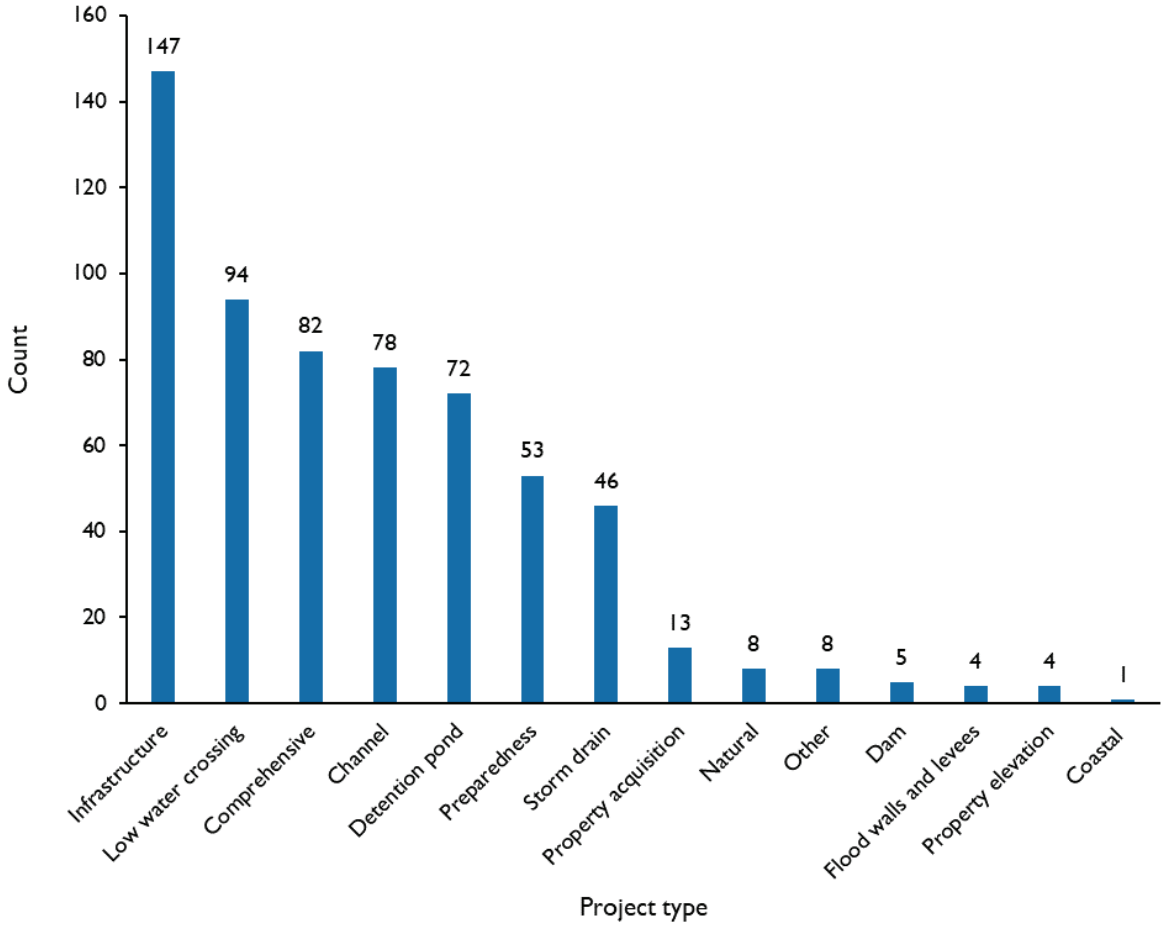
Approximately 2 percent (57) were categorized as flood preparedness studies. These involve comprehensive assessments to evaluate the level of readiness and resilience of a community or area in the face of potential flooding events. Assessments may include conducting pre-emptive evaluations and strategies to better prepare an area or community in the event of flood and can include inundation studies, dam compliance assessments, and hazard/vulnerability assessments.

8.1.2 Benefits of implementing recommended flood mitigation projects

The recommended flood mitigation projects are intended to reduce the risk and impact of flooding through structural and non-structural solutions. The regional flood planning groups recommended 615 flood mitigation projects spanning 14 project categories (Figure 8-2). These proposed projects have

capital costs or other non-recurring costs and reduce flood risk. By removing or reducing flood risk exposure, flood mitigation projects reduce flood risk for people, property, and infrastructure. Implementing these projects could have a profound, long-term impact on reducing flood risk and flooding impacts.

Figure 8-2. Summary of recommended flood mitigation projects by project type



To the extent possible within the time and resource constraints of the first planning cycle, the planning groups developed and recommended flood mitigation projects to address exposure to existing flood risks within the 1 percent (100-year) and 0.2 percent (500-year) annual chance floodplains (Table 8-1). Many of the population and structures within the recommended project areas may benefit from implementation of the projects. In some cases, structures would be entirely removed from the flood risk. In other instances, the flood mitigation projects may only lessen the flooding impact on a structure (e.g., lowering the maximum flood water elevation).

Types of structural projects

Approximately 87 percent (537) of all recommended flood mitigation projects were classified as structural projects. Many of these typically include advanced analysis with 30 percent to 100 percent level of engineering design. They include, for example, improvements to storm sewers, roadside ditch systems, detention basins, bridge elevations, channel grading, street reconstruction, and detention ponds.

Types of non-structural projects

Approximately 13 percent (78) of the recommended flood mitigation projects were classified as non-structural projects, which reduce the impact of flooding without relying solely on physical infrastructure solutions. These projects focus on strategies that do not involve constructing physical barriers or altering the natural flow of water. Non-structural flood mitigation includes, but is not limited to, measures such as acquisition of floodplain land for use as public open space, acquisition and removal of buildings located in a floodplain, relocation of residents of buildings removed from a floodplain, flood warning systems, educational campaigns, land use planning policies, watershed planning, flood mapping, and acquisition of conservation easements.[42]

Benefits to population and structures at flood risk

The benefits of implementing the recommended flood mitigation projects include removing people, private property, and public infrastructure from the1 percent (100-year) annual chance floodplain. These benefits would also include avoided injuries and deaths, although that is very difficult to estimate. Reducing flood risk to roadways, for example, will improve public safety at low water crossings, improve evacuation routes, and provide access to emergency services and critical facilities during flood events.

Project implementation would remove existing structures, those inundated for short periods or extended periods, located within flood hazard areas. Community members benefit from removing structures that are at risk of flooding, including residences, workplaces, industries, and critical infrastructure (Table 8-1). Several of the recommended flood mitigation projects appear to have overlapping boundaries, therefore the flood risk reduction benefits described are as reported by the flood planning groups and may contain overlaps.

During the first planning cycle, regional flood planning groups had the flexibility to utilize the community's discretion to identify a roadway creek crossing as a low water crossing. Life and property will be saved as the number of low water crossings are reduced, also reducing the frequency and duration of road closures due to severe flooding.

To determine if a project would create adverse flood impacts, planning groups evaluated flood risk reduction benefits for each. All recommended flood mitigation projects, when implemented, will not negatively affect areas located within their flood planning regional boundaries or neighboring areas. It will ultimately be the responsibility of local project sponsors and their engineers to ensure that final designs during construction do not result in any negative flood impacts.

[42] 31 TAC 363.402

Table 8-1. Anticipated benefits of flood mitigation project implementation on population and structures currently exposed to 100-year flood risk within project area

	Existing exposure within project area	Flood risk reduction[a]	Remaining flood risk
Population	1,974,127	640,507	1,333,620
All buildings[b]	637,178	155,905	481,273
Residential buildings	486,767	112,609	374,158
Critical facilities[c]	10,055	2,597	7,458
Low water crossings	1,060	199	861
Roadway miles	12,779	2,329	10,450
Road closures	19,251	5,567	13,684

Note: Quantities are as reported by the flood planning groups and may contain overlap between flood mitigation project boundaries

[a] As identified by the regional flood planning groups
[b] Includes all residential, agricultural, commercial, industrial, public, and vacant or unknown
[c] Includes hospitals, emergency medical services, fire stations, police stations, and schools

8.1.3 Benefits of implementing recommended flood management strategies

The regional flood planning groups recommended a total of 897 flood management strategies, each with associated implementation costs, across six broad categories (Figure 8-3). A subset of the recommended flood management strategies also included non-recurring, non-capital costs. For example, a community may recommend a strategy to buy out all properties located in the 1 percent (100-year) annual chance floodplain within its jurisdiction and require a study with a one-time cost to develop the program that would identify the properties and cost, etc. There are 771 recommended strategies that include non-recurring, non-capital costs, which are included in the list of ranked flood management strategies and are eligible for future state funding.

The recommended flood management strategies can reduce the risk and impact of flooding by improving floodplain management and public awareness, encouraging better floodplain management policies, educating people about the risks of flooding, providing warnings of current and potential flooding, and reducing the frequency and severity of flooding of roads and structures. The potential benefits of the recommended flood management strategies, as identified by the regional flood planning groups, are summarized in Table 8-2.

Figure 8-3. Summary of recommended flood management strategies by strategy type

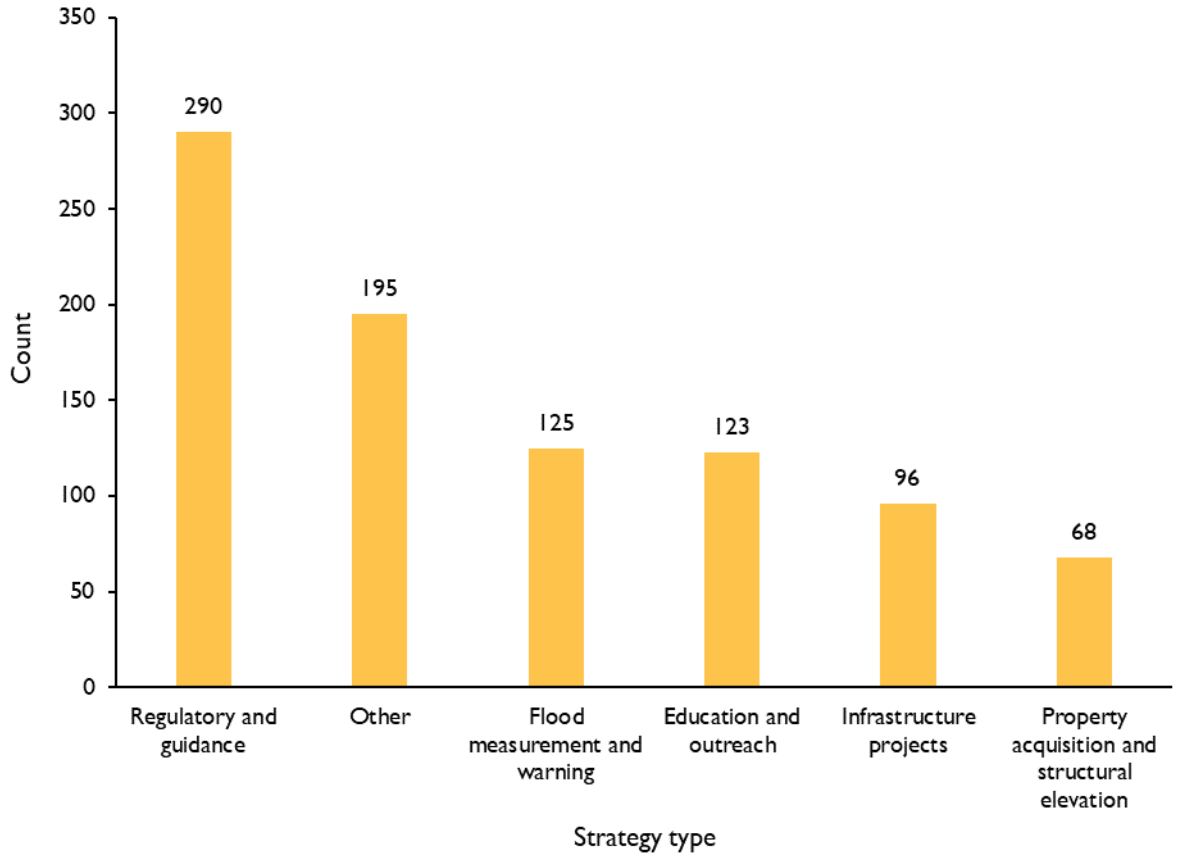


Table 8-2. Anticipated benefits of recommended flood management strategy implementation on existing 100-year flood event exposure

Flood exposure	Existing risk	Risk reduction[a]	Residual risk
Population	15,283,833	202,832	15,081,001
All buildings[b]	4,608,800	58,387	4,550,413
Residential buildings	3,632,286	40,137	3,592,149
Critical facilities	31,477	84	31,393
Low water crossings	34,391	378	34,013
Roadway miles	180,661	5,874	174,787
Road closures	54,648	199	54,449
Agricultural areas (acres)	36,924,302	974,284	35,950,018

Note: All quantities are counts unless otherwise noted. Quantities are approximate and may contain overlap between some strategy boundaries.

[a] As identified by the regional flood planning groups
[b] Includes all residential, agricultural, commercial, industrial, public, and vacant or unknown

Regulatory and guidance

Approximately 32 percent (290) of the recommended flood management strategies are considered regulatory and guidance strategies, which can play an important role in reducing current and future flood risk by improving regulation of development, stormwater regulations, and floodplain management practices.

These strategies may include participation in FEMA's National Flood Insurance Program, stormwater utility fee development, and stormwater management criteria, like higher standards, floodplain management staff acquisition and training, ordinance, land use and zoning, and green infrastructure programs.

Property acquisition and structural elevation

Eight percent (68) of the recommended flood management strategies relate to property acquisition and elevation. Property acquisition and structural elevation strategies remove or reduce exposure to flood risk. These types of strategies can feature voluntary buyout programs and structural elevation assistance programs. It is relevant to note that the property acquisition and elevation strategies include studies to develop programs for property acquisition. The actual projects to implement buyout or property acquisition or elevation are included with the flood mitigation projects.

Education and outreach

Fourteen percent (123) of the recommended flood management strategies are related to education and outreach. Public outreach creates community engagement and collaboration and may include public awareness or flood insurance campaigns and flood safety education for residents, elected officials, real estate agents, and developers.

Flood measurement and warning

Fourteen percent (125) of the strategies are related to flood warning systems that alert the public about impending dangerous conditions. Such systems can minimize injury and protect life by encouraging people to avoid flooded roads, seek appropriate shelter, and receive status updates on current weather and flooding conditions.

Infrastructure

Approximately 11 percent (96) of the strategies are related to traditional infrastructure projects to reduce peak flow rates and lower water surface elevations and that require ongoing maintenance to support effectiveness and functionality of drainage systems. Flood management strategies in this category include studies to formulate infrastructure projects. The actual projects to construct infrastructure would have capital costs associated with them and are included with flood mitigation projects.

8.2 No negative impact

The TWDB is statutorily required to determine that each regional flood plan, and by extension the state flood plan, does not negatively affect a neighboring area before the TWDB may approve a regional plan. For regional flood planning purposes, this *negative impact* is defined as an "increase in flood-related risks to life and property, either upstream or downstream of the proposed project." The regional flood planning groups were required to evaluate and/or assess and certify that each recommended flood mitigation project and their overall plans would not cause flood-related negative impacts to surrounding areas based on criteria the TWDB developed and provided.

Local project sponsors and their engineers will be responsible for confirming that final designs and any modifications made during construction do not result in adverse flood impacts.

Potential negative effects are also a consideration for flood management evaluations and strategies. The planning-level assessment for these two categories included a review of the potential impacts based on the limited data available. The flood management evaluations (studies to be performed) must, as an inherent part of the work performed, consider potential negative effects of any proposed flood risk mitigation.

8.3 Contributions to and impacts on water supply

Statute requires the TWDB to determine that each regional flood plan adequately provides for the development of water supply sources, where applicable, before the TWDB may approve a regional plan. Regional flood plans must include region-wide summaries and a list of the flood management strategies and flood mitigation projects that would contribute to, negatively impact, or measurably reduce water supply.

Four planning groups recommended flood risk reduction solutions that may provide water supply benefits (Table 8-3). The source of the water supply benefits ranged from contributions to natural aquifer recharge to additional surface water inflows directed to reservoirs.

Regions 11 (Guadalupe), 12 (San Antonio) and 15 (Lower Rio Grande) identified potential water supply benefits for 37 recommended flood mitigation projects. Based on regional flood planning dataset, Region 11 estimated a water supply benefit amount of 1,204 acre-feet per year from 10 projects, which will inform the state water plan. Regions 12 and 15 did not identify water supply benefit amounts in the geodatabase; these regions identify estimated amounts for several projects in the body of the regional flood plans, totaling an unverified and approximate amount of 797 acre-feet per year.

Region 14 Upper Rio Grande recommended one flood management strategy with potential water supply benefit estimated at 70 acre-feet per year.

Examples of flood mitigation projects with potential water supply benefit identified by the flood planning groups include detention ponds, aquifer recharge, and natural area conservation easements. The proposed projects would need to proceed through feasibility, preliminary engineering, and final design phases to prove up the final quantities of water supply from these projects. This information is being shared with the TWDB's Water Supply Planning program and the regional water planning groups for their consideration in developing the 2026 regional water plans and the 2027 State Water Plan. While these represent modest potential contributions to water supply, the TWDB anticipates that future flood plans will identify additional potential water supply benefits as regional flood planning groups and water suppliers collaborate to identify innovative and synergistic strategies. Regional flood planning groups were also required to consider and report any impacts their plans may have on water supply, water availability, or projects in the state water plan. No plans reported any negative impacts.

Table 8-3. Recommended flood risk solutions with anticipated water supply benefit

Region	Project or strategy	Count	Estimated volume (acre-feet/year)	Example
11	Project	10	1,204	Edwards Aquifer Authority and San Marcos River Foundation Katz Recharge Conservation Easement
12	Project	2	177[a]	Currey Creek Regional Detention Facility
14	Strategy	1	70	Irrigation and Recharge Application of Captured Rainwater Runoff at Alpine
15	Project	25	620[a]	Weslaco Stormwater Improvement Plan - Texas Boulevard to Airport Drive, South of Business 83
Total		**38**	**2,071**	

[a] *Indicates where estimated water supply volumes are unverified and approximate*

8.4 Other impacts of plan implementation

Flooding is a natural process that has many benefits to both human and natural systems. For example, floodplain preservation promotes native species, maintains vital ecosystem services, and reduces the chance of flooding elsewhere. In addition to evaluating the benefits of implementing flood risk mitigation solutions, the planning groups generally described implementation impacts related to socioeconomics, the environment, agriculture, recreational resources, water quality, erosion and sedimentation, and navigation.

8.4.1 Socioeconomic impacts

Floods have well-known and sometimes long-lasting socioeconomic impacts. They are the most pervasive among natural disasters, yet their costs are routinely underestimated. The cost of recovering and rebuilding from a flood event is exorbitant compared to the resources spent to prepare and prevent flooding (NIBS, 2019).

Flooding not only results in destroyed infrastructure and property damage, but also has an adverse social impact on residents including lost work hours, impacts to essential services, and the cultural fabric of communities. The long- and short-term impacts of flooding on affected citizens' physical and mental health can even result in socioeconomic disparities. Implementing the 2024 State Flood Plan will improve the lives of Texans and provide significant benefits to the state's economy by alleviating negative impacts from floods.

8.4.2 Environmental impacts

Flooding, and flood solutions of all types, can impact the environment in a variety of ways. In addition to flood control, water quality, erosion, and sedimentation benefits, floodplain preservation and other nature-based solutions also support the environment by promoting habitat development for native plant and animal species. By removing structures from flood risk, property acquisition strategies will help prevent the release of pollutants, such as viruses, bacteria, and mold, associated with flooded homes and septic systems.

While land acquisition and development regulations can have a positive impact on the environment, recommended structural projects have the potential to harm ecosystems in undeveloped land, which

receives nutrients from flooding on a regular basis. Local, state, and federal permitting requirements will help ensure compliance with applicable regulations.

Texas Water Code § 5.506[43] ensures ecological soundness by providing adequate protection of the state's streams, rivers, and bays and estuaries. When developing flood mitigation projects and flood management strategies, some planning groups considered how recommended strategies or projects might support flows to satisfy its subsistence and base flow standards.

8.4.3 Agricultural impacts

Implementation of the recommended flood risk reduction solutions would remove approximately 1,020,496 acres of farm and ranchland from the 1 percent (100-year) annual chance floodplain statewide. While agricultural lands can benefit from seasonal flooding when fertile sediment is deposited in the floodplain, floodwater also has the potential to damage valuable crops and livestock, including drowned animals, delayed planting and harvesting, topsoil erosion, and damaged farm equipment.

Implementation of recommended flood management strategies may mitigate adverse impacts of flooding by reducing excessively high flows in rivers and streams and preventing floodwaters from inundating agricultural lands beyond their natural boundaries. Structural solutions like small flood control ponds and natural channels may serve dual purposes by mitigating floods and providing water supply for agricultural needs. The application of non-structural practices like conservation tillage, cover crops, and furrow dikes may also contribute to the reduction of peak flows, minimizing surface runoff, and enhancing soil infiltration. Additional regulatory measures and watershed planning initiatives can also improve flood risk awareness among agricultural stakeholders, facilitate insurance availability for structures, and manage future development within flood prone areas, thus safeguarding agricultural operations.

8.4.4 Recreational resources

The implementation of recommended flood risk reduction solutions statewide can significantly reduce flood risks while also enhancing recreational opportunities. Nature-based solutions within flood projects often offer the dual benefits of flood control and recreation enhancement. In recent years, usage of detention and retention spaces as recreational facilities, such as parks, and sports fields has become more commonplace. Waterfront parks designed to withstand flooding events can serve as safe recreational spaces while restoration efforts focusing on aquatic habitats improve flood resilience and the potential for outdoor recreation like fishing. Flood risk reduction solutions that incorporate nature-based solutions also often promote public awareness and education of flooding and flood risk.

8.4.5 Water quality impacts

The regional flood planning groups described a variety of potential impacts to water quality due to differing factors, such as the concentration of recommended flood risk reduction solutions near residential areas and away from bodies of water, as well as varied environmental permitting regulations and protective drainage and floodplain development criteria.

Flood mitigation solutions can reduce risk to water and wastewater treatment plants, which lowers the likelihood that treatment plants will flood and overflow, improving overall water quality downstream. In regions where mitigating flooding on agricultural land is a significant goal, water quality may also improve by reducing fertilizer in runoff and addressing nutrient load issues.

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[43] https://statutes.capitol.texas.gov/Docs/WA/htm/WA.5.htm

Similarly, **floodproofing** and structural flood mitigation projects can limit overflow from sanitary lift stations and the ensuing release of untreated sewage. Floodproofing and hardening buildings and public utilities further lowers the risk of structural flooding and the release of contaminants.

Some structural projects can improve the quality of water supply reservoirs by capturing stormwater runoff and pollutants. More time in stormwater retention facilities can allow contaminants and particulates to settle before the water is discharged back into the waterway and allowed to flow downstream. Some flood risk mitigation solutions may reduce the release of contaminants from industrial facilities during flood events. Water quality measures can be incorporated into many structural flood mitigation projects, such as installing trash racks or prepackaged stormwater treatment devices.

Other solutions that positively affect water quality include floodplain preservation and regulations and ordinances. Preserving natural floodplains promotes the natural filtration and treatment of water through the creation of natural riparian habitat with native vegetation adjacent to streams. Pollution prevention regulations and ordinances emphasize the proactive prevention of pollution at the source.

8.4.6 Erosion and sedimentation impacts

Erosion and sedimentation are complex issues that are interrelated with water quality. While water quality often relates to nutrient and bacterial loading, it also includes turbidity, which relates to sediment load.

Erosion and sediment control measures that limit high velocities and protect the functionality of drainage infrastructure are considerations when designing and constructing flood mitigation projects. Maintenance will also be required to address long-term sedimentation, which reduces the conveyance capacity of storm sewers and channels.

Non-structural solutions like conservation practices can also reduce erosion and sediment transport at the source and in large downstream reservoirs. Protecting undisturbed areas or returning flood-impacted properties to a natural state also reduces erosion and sedimentation by reintroducing natural drainage and ecological processes.

8.4.7 Navigational impacts

Implementing recommended flood mitigation projects should not have any meaningful impact or relevance to navigation. There are some areas of potential commercial navigation impacts, such as the Houston Ship Channel, which is closely associated with Region 6 San Jacinto's recommended Galveston Bay Surge Protection Coastal Storm Risk Management project. Included in that project are several significant structural improvements aimed at increasing coastal protection and reducing flood risk throughout the region. Other important navigable waterways, like the Sabine-Neches waterway, are not expected to experience any impacts from the recommended flood risk mitigation solutions.

Canoeing, kayaking, and other recreational water activities can be impacted by flood mitigation, for example, when reservoir levels are actively managed to mitigate flood risk or when the rivers and reservoirs are at or above flood stage. Structural flood management strategies or flood mitigation projects that recommend building flood control structures or any other measures that capture the additional water could potentially increase recreational navigation.

8.5 Residual flood risk

The recommended flood risk reduction solutions will reduce the impact and extent of future flood-related damage. However, it's important to recognize that while we can reduce the risk and impact of flooding and prepare for these events, we can almost never eliminate the risk of flooding. There will always be a residual risk, which is risk that could not economically be addressed or risk that was never

targeted. For example, mitigating risk for a structure for only a 1 percent (100-year) annual chance flood event could mean that the same structure remains exposed to the risk of a 0.2 percent (500-year) annual chance flood event.

Flood risk reduction solutions must be designed for certain storm frequencies. Protecting against larger (and less frequent) storm events is more expensive, and a balance must be found between seeking protection from larger storm events and the available resources to do so. If a storm event occurs that is larger than the designed flood control infrastructure, flooding is inevitable and understanding that residual risk is extremely important. This is the nature of probabilistic risk and the impossibility of mitigating against less likely events.[44]

Predicting the exact nature, scale, and frequency of floods is inherently uncertain. Natural events can be more extreme than historical records indicate or than models predict. Even the most robust flood mitigation projects may be insufficient to handle unprecedented flood events. Flood risk reduction solutions are often engineered to address, manage or protect against certain design storm events or floods. These storm events, such as the 1 percent (100 year) annual chance storm event, are determined based on historical rainfall data. The relatively short period of record for some rainfall and stream gauges results in additional statistical uncertainty when estimating the larger and less frequent events. Additionally, while flood risk reduction solutions may be engineered based on historical data, a variable climate can alter flood patterns over time, leading to unexpected scenarios that might not have been accounted for during the initial solution design.

Common sources of residual flood risk are associated with flood events that exceed the design capacity of a levee, dam, or drainage system, as opposed to those resulting from actual structural failure. In these cases, the flood mitigation infrastructure itself, for example a levee built to protect against riverine flooding, can pose a new, residual risk—the unlikely hazard of catastrophic failure. While the new risk is less likely to occur than the risk it was built to protect against, the new risk poses a far greater threat if it occurs (e.g., sudden life-threatening flooding). Though quantifiable, residual risk often is presumed to be negligible or non-existent, creating a false sense of security for decision makers and the public. The National Levee Database identifies nearly two million Texans who are subject to residual flood risk associated with levees (USACE, n.d.). No available data exists for the residual risk associated with dams.

Unrecognized flood risk is effectively residual risk. Old and outdated flood hazard maps and flood risk information can create a false sense of safety and a perceived lack of flood risk in places with existing flood risk. Because flood risk maps represent the flood risk at the time the map was created, any land use, development, or mitigation changes that occur after the map is published are not accounted for. Further, the binary presentation of flood risk on Flood Insurance Rate Maps often conveys the false belief that areas outside the demarcated 1 percent (100-year) annual chance floodplain do not face flood risk.

Ultimately, while flood mitigation plans and projects can substantially decrease the risk of flood damage, a certain level of risk will always remain due to unpredictable factors and the challenges of accounting for future flood risks. This makes it imperative not only to design and proactively fund effective mitigation measures but also to incorporate adaptive strategies and proactive floodplain management to ensure new vulnerabilities are not inadvertently created.

[44]One way of determining the most economical level of mitigation is to consider the costs of various levels of mitigation versus the expected annual flood damage to the protected asset, which involves aggregating all potential damage to the asset from all flood event frequencies.

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