

SAN JACINTO

REGIONAL WATERSHED MASTER DRAINAGE PLAN



Prepared for:
Harris County Flood Control District
San Jacinto River Authority
Montgomery County
City of Houston

APPENDIX H IMPLEMENTATION

**San Jacinto Regional Watershed
Master Drainage Plan**

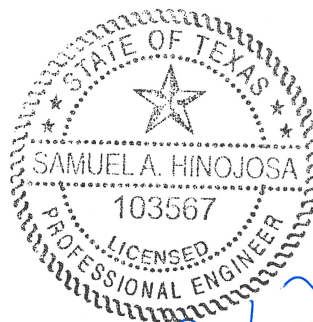
IMPLEMENTATION

Prepared for

**Harris County Flood Control District
San Jacinto River Authority
Montgomery County
City of Houston**

by

**Halff Associates, Inc.
TBPE Firm Registration No. 312**



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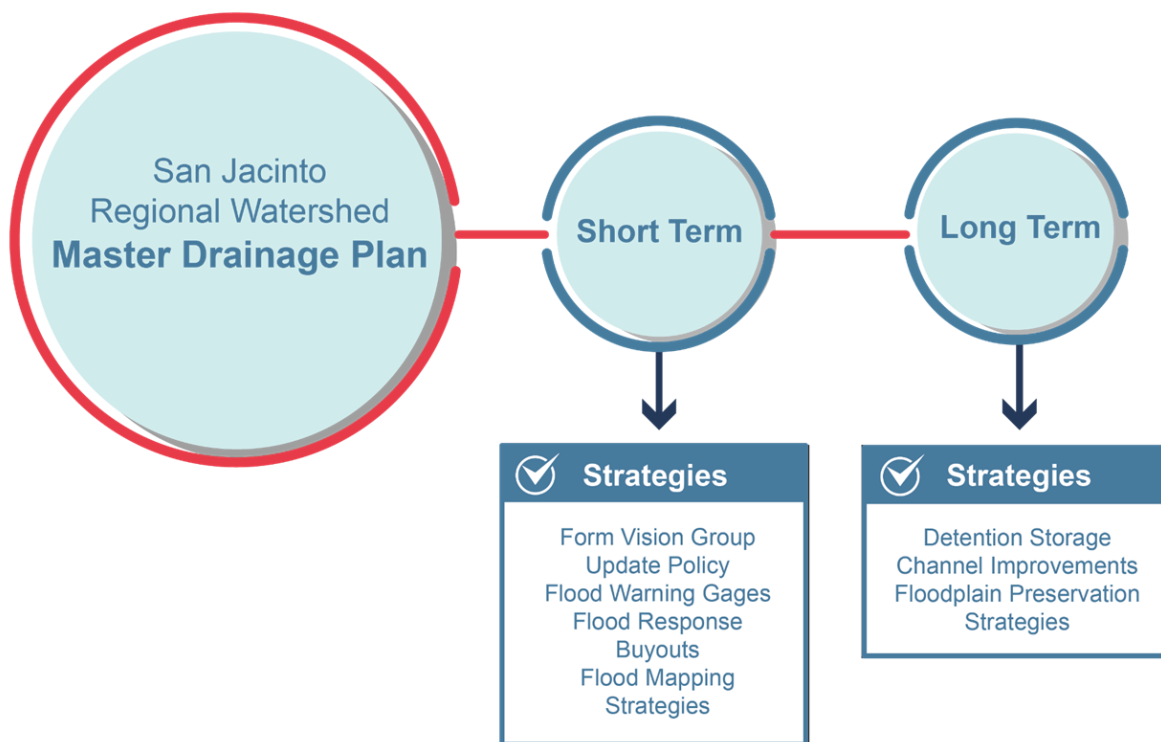
APPENDICES

Appendix H.1 – Implementation Matrix

1.0 Implementation Planning

A clear path to project implementation is needed to move the master drainage plan forward through the next several decades as policy and projects are developed and constructed. Planning and construction of the recommended projects is necessary to realize the flood risk reductions needed to protect people and property within the San Jacinto River basin.

The master drainage plan identifies both policies and projects that can be implemented within the San Jacinto Watershed to reduce flood risk. The recommendations are categorized into long-term and short-term solutions. Short-term solutions are those that can be implemented within the next five years and require less funding or have fewer constraints for implementation. Long-term solutions will take more than five years to begin implementation due to funding, construction time, and project constraints.



2.0 Short Term Project Implementation

Short-term projects identified in the master drainage plan include developing a Vision Group, updating policy, flood warning enhancements, improving flood response, structural buyouts, floodplain re-mapping of the basin, and tributary watershed protection studies. These projects can all be completed within a five-year timeframe (pending funding) and do not require the same level of capital investment as structural projects.

2.1 San Jacinto River Vision Group

As discussed in the introduction, the upper San Jacinto River watershed consists of many counties, municipalities, groups, and has a population of over 1.2 million people. Each of these entities has different drainage criteria, floodplain standards, and ability to construct and implement drainage projects. A Vision Group would establish a regional entity that could guide the implementation of drainage improvements and policy throughout the basin. The group could foster collaboration to evaluate the path forward in reducing vulnerabilities to flood hazards and improve resiliency. The establishment of the Vision Group could be completed in the short term and then be assigned the long term goal of implementing the master drainage plan.

The group would take ownership of the master plan, continually update the plan as projects are developed and constructed, and could develop common criteria that would be accepted by all agencies to ensure that future development in the watershed meets the same standards. The Vision Group could be made up of governing agencies, conservancy groups, private groups, and technical associations. The Vision Group could also explore the creation of a regional drainage district that would obtain right-of-way, develop drainage projects, and maintain streams and channels within the basin. The Vision Group could be a part of the San Jacinto Regional Flood Planning Group.

2.2 Policy

Drainage policy throughout the basin varies based on the governing entity. Each county and municipality has a separate drainage criteria. While the same word-for-word criteria may not be needed for each entity, a common base criterion for the basin would standardize the minimum requirements needed for future development. Policies that should be standardized would include:

- Requiring detention for new development and capital improvement projects;
- Developing standard methodology for developing discharge rates from developing areas that also address the “beat-the-peak” approach;
- Establishing common criteria needed for floodplain analysis and flood risk mitigation; and
- Establishing minimum finished floor elevations for new development or re-development based on Atlas 14 rainfall.

Based on the new Atlas 14 1% ACE water surface elevations as determined in this study, governing entities in the upper San Jacinto watershed should consider adopting higher minimum floor elevations until Atlas 14 maps can be established for the region. As discussed in **Appendix G**, detention policy should continue throughout the basin. Counties and municipalities should enforce detention policies that limit post-development runoff rates to pre-development runoff rates to protect downstream properties.

2.3 Flood Monitoring/Warning Enhancements

Rainfall, stage, and discharge gages recommended in the master drainage plan will enhance public information and flood level assessment capabilities during flood disasters. The 26 recommended gages would provide both the emergency managers and the public with additional information to determine flood risk and respond appropriately.

The recommended 26 gages can be installed and maintained in cooperation with the HCFCD, USGS and/or the SJRA who currently install and maintain gages. The governing entities or partner agencies should seek grant or local funding for the installations.

2.4 Flood Response

Overall, the recommendations in this section cover documentation and staffing, communication, flood monitoring and protection, and public education. A summary of the recommendations is provided below.

Documentation and Staffing

- Develop a flood emergency response plan and follow as much as possible
- Keep contact information up to date
- Perform regular review of the plan and conduct tabletop exercises and drills
- Implement staffing redundancy for emergency management personnel

Communication

- Work with local service providers to improve radio and cellular coverage
- Link social media accounts so users can see information from a variety of sources
- Add flood stage gages to critical roadways
- Improve internal alerts for infrastructure flooding or failure

Flood Monitoring and Protection

- Identify areas that require monitoring and install gages at those locations
- Work with other agencies to integrate gages into a larger, regional system
- Leverage flood monitoring to provide timely alerts to the public
- Identify all crossings where flood barriers would be appropriate and prioritize the crossings
- Install barriers at frequently flooded crossings

Public Education and Information Dissemination

- Develop a public education strategy that includes social media, radio, TV, and face-to-face discussion
- Develop information dissemination strategies for public safety and flood awareness
- Leverage pre-developed resources from agencies like TWDB
- Work with local school districts to provide children with emergency preparedness and disaster readiness information

2.5 Buyouts

Structures identified within the 50% ACE and 20% ACE are susceptible to frequent flooding and mitigating flood risk with detention or channelization can be very expensive. Acquiring the property and removing it from the floodplain and from potential flood risk is often the most cost-effective approach. There are over 600 structures identified within the 20% ACE floodplain at an anticipated buyout cost of \$190 million. The

counties and regional groups should seek funding and develop a voluntary buyout program for these frequently flooded structures.

2.6 Floodplain Re-Mapping

The updated modeling for the existing flood hazard assessment showed that current FEMA effective elevations and floodplains used within the basin are outdated. The average 1% ACE (100-year) water surface elevation increased between 0.5 and 4.5 feet in the watershed meaning structures built to current effective standards could still be at risk of flooding during an Atlas 14 1% ACE storm. While floodplain maps are purposed with determining flood insurance rates, updated maps can provide better information regarding flood risk.

Floodplain mapping within Harris County is being updated as part of the MAAPnext initiative. The modeling developed as part of this master drainage plan could be used as a basis for updating the floodplain maps for the main streams outside of Harris County. Since the master drainage plan models have been developed and calibrated, much of the effort needed for a re-mapping effort for the main stems is already complete.

Modeling of the tributaries was not included with this study; however, since the main stem water surface elevations were determined to be higher than the effective base flood elevations due to Atlas 14 rainfall, the tributary elevations will likely increase a similar magnitude. Re-modeling the tributaries and re-mapping the watershed would provide the agencies and public updated potential flood risk and better prepare them for the anticipated growth in the region. Montgomery County and the surrounding counties should pursue funding for mapping updates with the TWDB or FEMA.

2.7 Watershed Protection Studies

The master drainage plan provides an existing flood hazard assessment and flood risk mitigation for the main streams in the watershed. However, it did not analyze the flood risk of the numerous tributaries to these rivers. Watershed protection studies for each of the tributaries would further analyze the flooding potential on the tributaries of the main stems and identify local drainage improvements needed. Goals of the studies could include:

- Evaluation of existing flood risk within the watershed;
- Development of flood risk reduction alternatives including potential constraints; and
- Development of a watershed wide plan for reducing flood risk.

Harris County has existing watershed protection studies within five of the basins located within the county limits (Spring Creek, Little Cypress, Luce Bayou, Jackson Bayou and Willow Creek). Cypress Creek has major tributaries regional drainage plan that identified projects to reduce flood risk. Tributary watershed protection studies outside Harris County could be developed to identify and address the flood risk. The table below recommends the order in which planning studies should be conducted based on population projections identified as part of this study's future flood risk planning assessment. Although Harris County has a study on Spring Creek, the study is focused within the county limits. The majority of the Spring Creek watershed lies within Montgomery County which has limited flood information and outdated floodplain maps that are not representative of development throughout the watershed. Identifying risk and potential projects early would help accommodate future development.

Table 1: Watershed Protection Study Priority

Rank	Watershed	Population Increase (2018 to 2070)
1	Spring Creek	510,455 (178%)
2	West Fork	450,837 (135%)
3	Caney Creek	182,619 (227%)
4	Peach Creek	73,295 (253%)
5	Lake Creek	72,251 (257%)
6	East Fork	23,824 (54%)
7	Luce Bayou, Tarkington Bayou	10,644 (51%)

3.0 Long Term Project Prioritization

Recommendations for structural project prioritization include the development of project scoring which includes the identification of evaluation metrics and weighting the metrics for project scoring.

3.1 Project Metrics

Recommendations for flood reduction projects were based on a variety of metrics, including reductions in the number of structures subject to flood risk, reduction in inundation area, reduction in roadway inundation, reduction of monetary damages, project costs, project challenges, and more. Numerous potential metrics were presented to the project stakeholders (HCFCD, SJRA, Montgomery County, and the City of Houston) at various workshops and included the following:

- Historical Damages
- Predicted Damages
- Reduction in structural flooding
- Project cost
- Design life
- Maintenance costs
- Project feasibility
- Constructability
- Public benefit
- Public safety
- Multi-use potential
- Social vulnerability
- Low- to moderate-income (LMI) areas
- Reduction in road flooding
- Community/agency favor
- Erosion control
- Impact to water quality
- Implementation schedule

Nine metrics were selected for the final project weighting based on the relation to the detention/channel projects selected and the ability to numerically evaluate the assigned score. The metrics selected are described below:

- **Watershed Historical Damages** – The number of historical damages for the given watershed based on information provided by Montgomery County and Harris County for the 2015, 2016, and 2017 storm events. This metric scores each project based on the history of flooding within the basin where the project is located and the most benefit is realized. A high score means the watershed has received more historical flooding complaints than other basins.
- **Watershed Predicted Damages** – The number of predicted instances of flooding over a 50-year period in the given basin based on the existing-conditions frequency storm analysis and the structural inventory tool. This metric scores each project based on the potential for flooding within the basin. A high score means the watershed has the highest potential instances of flooding compared to the other basins.
- **Flooding Instance Reduction** – The benefit of the project based on the reduction of predicted instances of flooding over a 50-year period throughout the entire watershed. This metric scores projects based on how well they reduce flooding within the watershed. A high score means the project provides more reduction than other projects.
- **Structures Removed from the 1% ACE Floodplain** – The second benefit of the project; the number of structures where the 1% ACE water surface elevation is reduced below the structures' finished floor elevation. Structures removed would see less potential for flooding as well as a

potential reduction in insurance premiums. A high score means the project removes more structures from the 1% ACE floodplain.

- **Benefit Cost Ratio (BCR)** – The benefit-cost ratio based on reduction in structural flood damages as identified for the individual projects. Projects with structural BCRs over 1.0 may be candidates for federal funding. Projects with structural BCRs over 0.75 may also qualify for hundreds of millions of dollars in additional social benefits under FEMA grant requirements. A high score means the project has a higher BCR as compared to the other projects.
- **Roadway Benefits** – The total reduction of roadway overtopping depths in feet for each roadway and each frequency event in the basin. Each recommended project provides benefits to transportation crossings throughout the watershed by reducing the discharge and therefore depths of roadway overtopping during the frequency events. A higher score means a higher reduction of overtopping depths.
- **Social Vulnerability Index (SVI)** - Social vulnerability refers to the resilience of communities when confronted by external stresses on human health, stresses such as natural or human-caused disasters, or disease outbreaks as defined by the CDC. SVI is assigned by the CDC at the census-block level and ranges from 0 to 1. The index considers various factors, including socioeconomic status, household composition, race/ethnicity/language, and housing/transportation. Each project's SVI score was assigned based on the average SVI of the benefitted structures from the project. A higher score in the SVI category means the project provides benefits to more socially vulnerable communities.
- **Low to Moderate Income (LMI)** – The percent of the population within the census block that qualifies as LMI as identified by the US Census Bureau. The LMI score was assigned based on the average LMI of the benefitted structures from the project. A higher score in the LMI metric means the project benefits more low- to moderate-income people.
- **Cost** – The total cost of the project can affect the ability to fund the project, whether with local or federal funding. A higher score means that the overall project cost is lower than the other project costs.

3.2 Metric Scoring

The metrics for each project were normalized on a scale of 0 to 4 based on the score quartile relative to the other projects. For example, the Walnut Creek Detention project removes 1,296 structures from the 1% ACE floodplain. Compared to all other projects, this project is the one that removes the most structures from the 1% ACE floodplain and therefore receives a score of 4.0 for this category. The DC2-Channel on Spring Creek only removes the fewest number of structures (196) from the 1% ACE floodplain. Therefore, it receives a score of 0. The FM 1097 Detention project on Caney Creek removes 454 structures from the 1% ACE floodplain, placing it in the 1st quartile for this metric. Therefore, it receives a score of 1.0. Other methods of scoring were considered; however, they did not change the overall scoring. **Appendix H.1** includes the detailed implementation matrix.

3.3 Metric Weighting

The identified metrics are weighted based on initial discussions with the stakeholders who expressed that the overall goal of the identified projects is to reduce flood risk within the basin. The assigned metric weight is multiplied by the normalized metric score to achieve an overall project score. The weighting assigned is based on an overall weight of 100%.

Historical and predicted structural damages in the project basin were weighted at an overall 20%. This helped prioritize projects that are in areas that are in the most flood-prone areas. Structure benefits received a combined weight of 40% as this was most important to the stakeholders; these benefits include both instance reduction and removal from the 1% ACE floodplain. The BCR indicates how the overall cost compares to the structural benefits and may also provide a funding mechanism and was therefore weighted at 10%. SVI and LMI both indicate socially vulnerable areas that may score lower with BCRs due to property value; therefore these were both weighted at 10%. Benefits to roadways throughout the project was not a primary goal of the stakeholders but is an additional benefit. Therefore, roadway benefits were weighted at 5% to allow for consideration of benefits to transportation and mobility. Since the cost of all projects is generally expensive, the cost metric was only given a 5% weighting.

Table 2: Metric Weighting Summary

Metric	Weight
Historical Damages	10%
Predicted Damages	10%
Flooding Instance Reduction	20%
Structures Removed from the 1% ACE Floodplain	20%
BCR	10%
Roadway Benefits	5%
SVI	10%
LMI	10%
Cost	5%

In the project ranking process, the weighting was adjusted to understand the sensitivity of the overall project ranking to the chosen weights. In general, the overall rankings did not change even with drastic changes to the chosen weightings.

3.4 Project Ranking

The metric score was multiplied by the metric weighting and summed to receive the overall project score. These projects were then ranked based on the overall score with the top score receiving the top ranking.

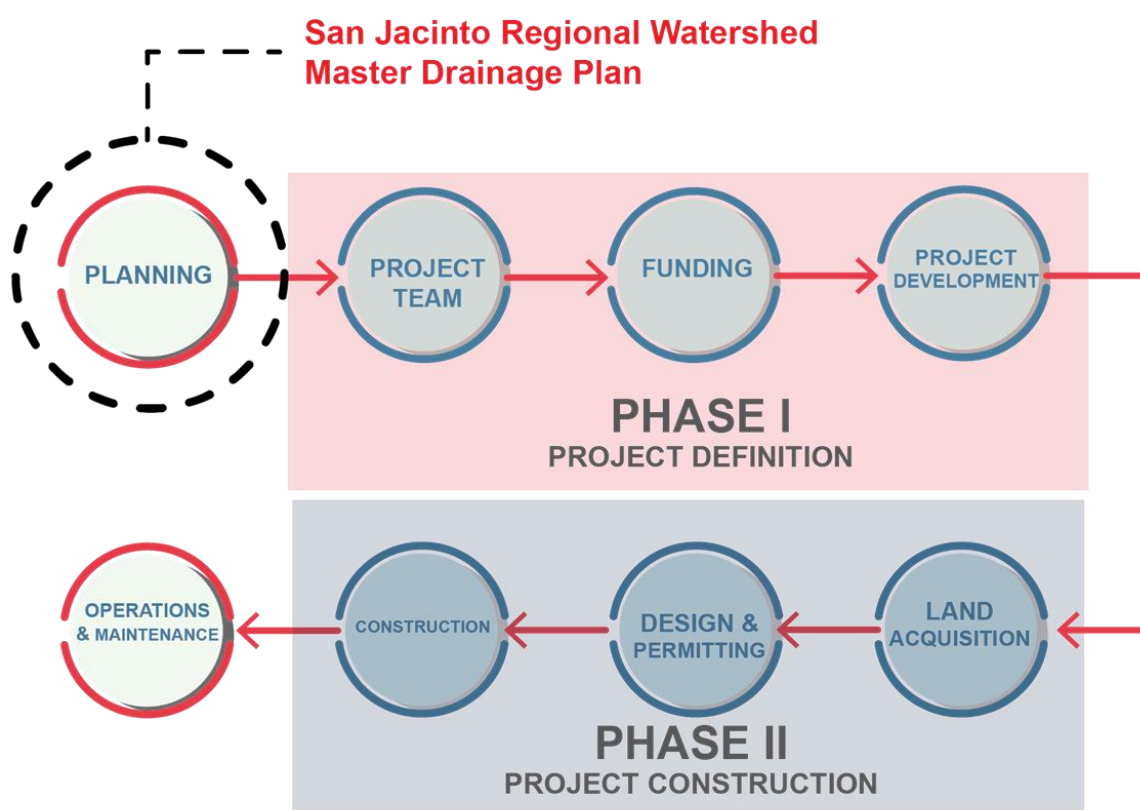
Rank	Project	Score	Cost Range (\$M)
1	Caney - Detention at SH 105	2.80	114–149
2	Spring - Walnut Creek Detention	2.50	97–132
3	Spring - I-45 Channel *	2.50	85
4	East Fork - Winters Bayou Detention	2.40	134–167
5	Peach - SH 105 Detention	2.35	356–433
6	Peach - I-69 Channel *	2.35	159
7	West Fork - Kingwood Benching	2.05	837
8	Caney - Detention at FM 1097	2.00	105–131
9	Spring - Birch Creek Detention	1.85	80–120
10	Caney - I-69 Channelization *	1.80	189
11	Peach - Walker Creek Detention	1.75	201–218
12	Lake - Garrett's Creek Detention	1.43	107–131
13	West Fork - River Plantation Channel *	1.43	187
14	Spring - Woodlands Channelization (200-ft) *	0.90	56
15	Lake - Caney Creek Detention	0.85	98–163
16	Lake - Little Caney Creek Detention	0.50	98–128

** Each channel project requires upstream detention to be constructed first to prevent downstream impacts caused by increased conveyance. It is recommended to construct upstream detention as identified in the master drainage plan rather than have separate detention only for the channel conveyance. The volume provided by any upstream detention alternative is generally more than enough to offset for the increase in channel conveyance. However, if channel improvements are constructed without upstream detention, a separate detention facility will be required, which may drastically increase channel project costs.*

The rankings of four projects were manually adjusted based on the need for detention prior to channelization. The Peach I-69 Channel project was originally ranked at #2 based on its score of 2.55. However, before this channel can be constructed, either the Peach SH 105 Detention project (score of 2.15) or the Peach Walker Creek Detention project (score of 1.75) must be constructed upstream. Because the Peach SH 105 Detention is the higher-scoring detention alternative in the basin, its score of 2.15 was averaged with the Peach I-69 Channel score of 2.55 to produce an average score of 2.35. This average score was used to move the Peach SH 105 Detention up to rank #5, since it must be constructed first, and to move the Peach I-69 Channel project down to rank #6. The same procedure was used to adjust the ranking of West Fork River Plantation Channel, with an original score of 1.90 and original rank of #9, and the ranking of Lake Garrett's Creek Detention, with an original score of 0.95 and original rank of #13. The relative ranking of other projects was not adjusted because detention alternatives in the remaining basins already score higher than channel alternatives in those basins.

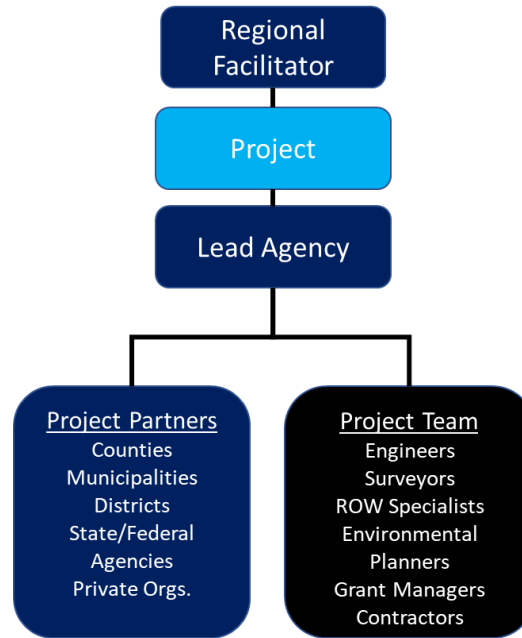
4.0 Long Term Project Implementation

The project ranking provides a potential project list and ranking for moving projects towards design. However, the projects do not necessarily have to be implemented in the recommended order, with the caveat that each channelization project must be preceded by one upstream detention project. Funding opportunities, community goals, and construction constraints may shift the implementation order. The completion of the master drainage plan completes the first step of the implementation process, Planning. The Planning effort has identified the projects needed to reduce flood risk and identified project types, locations, constraints, and costs. The plan provides a basis for seeking funding, performing feasibility studies, and establishing future study requirements. The remaining steps are Project Definition and Project Construction as outlined below:



4.1 Develop Project Team

The total project cost for the 16 identified projects can be daunting for communities. However, several communities will likely champion the efforts for each project. Implementation of the identified plan will require many roles and responsibilities for the project partners and key stakeholders. The first step of implementation is identifying the potential project team. This team will be dedicated to finding funding, conducting feasibility studies of the projects, developing design drawings, acquiring the necessary right-of-way, and constructing the projects. A sample project team organization chart is included below.



4.1.1 Regional Facilitator

The role of the Regional Facilitator would be to coordinate the projects among the different project lead agencies. The Regional Facilitator would be a regional resource for all projects and policies within the watershed. Roles and responsibilities would include:

- Providing regional assistance in pursuing funding opportunities;
- Coordinating among project lead agencies to ensure projects are progressing;
- Providing technical review resources for project analysis, design, and construction;
- Providing accountability for project leads and partners with key stakeholders; and
- Coordinating the development of common criteria and standards for drainage policy.

The Regional Facilitator is likely an entity that would not be listed in the below roles. The facilitator would not work directly with engineers and contractors throughout the project process but serve as a key resource for the other governmental agencies. The facilitator could be an existing agency, the TWDB San Jacinto Watershed Regional Flood Planning Group (RFPG), a dedicated committee of the RFPG, a new drainage district, or a council/task force comprised of many agencies such as a council of governments.

4.1.2 Lead Agency

Each identified project will require a Lead Agency to champion the project from the current planning level through a feasibility study, design, construction and maintenance. The Lead Agency will spearhead project funding and coordination of the project partners. Roles and responsibilities would include:

- Coordinating with the Regional Facilitator on project goals;
- Identifying and securing project funding opportunities;
- Conducting engineering analysis and design on the proposed projects;
- Acquiring Right-of-Way needed for project construction;
- Mitigating utility and environmental impacts;
- Constructing the project; and
- Long term maintenance.

Potential Lead Agencies were identified for each of the 16 projects. The agencies were determined based on the ability to lead the effort and the primary project beneficiary agency. The lead agency may also be primarily responsible for operation and maintenance of the project after construction. The proposed Lead Agencies are listed in the table below.

Rank	Project	County Location	Potential Lead Agency
1	Caney - Detention at SH 105	Montgomery	Montgomery County
2	Spring - Walnut Creek Detention	Waller	Montgomery County HCFCD
3	Spring - I-45 Channel *	Harris/Montgomery	Montgomery County HCFCD
4	East Fork - Winters Bayou Detention	San Jacinto	San Jacinto County Liberty County
5	Peach - SH 105 Detention	Montgomery	Montgomery County
6	Peach - I-69 Channel *	Montgomery	Montgomery County
7	West Fork - Kingwood Benching	Harris County	HCFCD
8	Caney - Detention at FM 1097	Montgomery	Montgomery County
9	Spring - Birch Creek Detention	Waller	Montgomery County HCFCD
10	Caney - I-69 Channelization *	Montgomery	Montgomery County
11	Peach - Walker Creek Detention	Montgomery/San Jacinto	Montgomery County
12	Lake - Garrett's Creek Detention	Grimes	Montgomery County
13	West Fork - River Plantation Channel *	Montgomery	Montgomery County
14	Spring - Woodlands Channelization (200-ft) *	Harris/Montgomery	HCFCD
15	Lake - Caney Creek Detention	Grimes	Montgomery County
16	Lake - Little Caney Creek Detention	Montgomery	Montgomery County

4.1.3 Project Partners

Project Partners are needed to support the development, implementation, and maintenance of the recommended projects. Partners can provide both funding as well as regulatory support throughout the project implementation. Roles for the partners may include:

- Providing monetary funding support for matching funds for grant opportunities;
- Providing support for seeking grant and funding opportunities;
- Providing right-of-way property acquisition assistance as needed;
- Providing monetary support for operation and maintenance of the project after construction;
- Public engagement for residents in benefited or affected areas; and
- Assisting in project feasibility studies as well as design/engineering.

Project partners may include smaller cities and municipalities, utility districts, and transportation authorities that may receive benefits from the proposed projects but do not have the capabilities or jurisdictional ability to lead the project implementation. Project partners may also include private entities that can provide funding or oversight of the implementation.

4.1.4 Project Team

The Project Team consists of the agencies and private companies that would assist in the project design, permitting and construction. The team includes engineers, planners, surveyors, and construction contractors that would be hired by the Lead Agency and Project Partners.

The Project Team roles may include:

- Preliminary engineering reports and analysis for project feasibility;
- Assisting in acquiring right-of-way for project construction;
- Navigating required environmental permitting;
- Developing construction design plans;
- Constructing the project;
- Managing construction; and
- Seeking and managing grant funding.

4.2 Identify Funding Sources

Once a project team is established, the group can seek funding opportunities for the project. Two projects have the potential for federal funding based on the potential for having BCRs greater than 1.0: Spring Creek Walnut Creek Detention and Spring Creek I-45 Channel. The team should approach federal agencies to begin feasibility studies and evaluate potential federal funding opportunities. The USACE solicits projects every year for potential study and petition for funding to Congress.

The other projects do not have a direct potential funding sources identified. Grants, bonds, loans, or other funding mechanisms from state or federal sources may be required for implementation. Some of these are listed in **Section 5.0**.

4.3 Project Development

Project development includes development of an Advanced Feasibility Study or Preliminary Engineering Report (PER), which will gather detailed survey, geotechnical, environmental, utility, and other information and prepare a detailed evaluation of an individual project. From this analysis, the options presented in the feasibility study will be refined and a conceptual design and cost will be prepared. In addition, specific right-of-way needs will be identified.

4.4 Land Acquisition

Land acquisition is required for both the detention and channelization projects. The needs vary widely depending on the development policy behind each of the proposed detention basins. The land identified as part of the detention alternative analysis ranged from the 1% ACE flood pool to the PMF flood pool. The Lead Agency should discuss the land required with the local and federal regulatory agencies to determine which land should be purchased. The agencies should then begin to identify potential tracts within the proposed detention basin area for acquisition. Ownership and availability of the land may change between the project initiation and the actual acquisition. Development may also encroach on the identified areas making acquisition more difficult. The land available for the detention facilities may alter the proposed detention locations presented in this plan. The agencies should consider monitoring the potential sale of property in the vicinity of the proposed projects and consider acquiring it before it is developed.

Land acquisition also includes identifying the owner of the project. While the lead agency may be the main implementor of the project, the agency may not have the ability to purchase the land for the basin. In the case of the Walnut and Birch Creek reservoirs, HCFCD and Montgomery County are the primary beneficiaries of the project, but do not have jurisdiction in Waller County where the project is proposed to be located. Inter-local agreements or separate agencies may be required to purchase the land.

4.5 Design and Permitting

During the land acquisition process, the project team can begin designing and permitting the proposed project. Design will include developing the plan drawings for construction as well as operations and maintenance procedures. Permitting will include all utility and environmental permits needed for the construction. The proposed detention projects will require approval from the TCEQ and will require an emergency action plan.

The USACE may require an Environmental Impact Statement for each detention site identified. This process can take three to five years. Sites in the Sam Houston National Forest will likely also require a NEPA review process, which potentially requires an Environmental Impact Statement. Detention sites in the forest may also yield environmental benefits if coordinated with forest management goals.

4.6 Construction

Construction of both the dam and channelization projects may likely take several years. Construction will include mobilization of the project, constructing temporary access to the dam locations, and the actual construction of the dam or channel.

4.7 Operations and Maintenance

Once constructed, the projects will need to be maintained regularly. For both the detention basins and channel projects, regular mowing, monitoring of instrumentation, regular inspections, and repair will be needed throughout the project life. The constructed dams will require regular certification with the TCEQ. The owning entity of the project would be responsible for the upkeep.

5.0 Project Funding

The efforts and funding needed to reduce the region's vulnerability to flood hazards is ambitious. Identifying potential funding sources is important for project implementation success. The potential funding sources for each project depend upon the readiness to implement the project as well as the project implementation schedule. The proposed flood mitigation projects are large in scale and will require long schedules to implement. After implementation, operation and maintenance costs will also need to be funded. Alternatives proposed in this plan that would require funding include: Project definition studies, flood mitigation projects (detention and channelization), operation and maintenance of projects, policy and criteria updates, flood monitoring/warning systems, and watershed protection studies.

There are many different means to fund the alternatives as proposed in this plan. Funding sources may include HUD/GLO (CDBG-DR and CDBG-MIT), FEMA, NRCS, TWDB and others. Each program may have differing procurement, administrative, and environmental requirements, which may impact the overall cost and schedule of the projects. This section discusses the various funding streams and a high-level overview of the potential uses, cost-sharing opportunities, and requirements. It should be noted that this does not constitute a specific recommendation for grant funding. Continued evaluation of funding opportunities and applications for specific grants or other sources will need to be conducted by the project's lead agency. Sources of funding are either generally federal, state, local, or private partnerships. The figure below provides a summary of some federal and state funding sources and the eligible activities.

FLOODING MITIGATION FUNDING ALTERNATIVES							
	NON-DISASTER FUNDING				DISASTER FUNDING		
Funding source	PDM/BRIC ¹	FMA	CWSRF	FIF ³	CDBG-MIT	CDBG-DR	HMGP
Funding agency	FEMA	FEMA	EPA	TEXAS	HUD	HUD	FEMA
Administered by	TDEM	TWDB	TWDB	TWDB	GLO	GLO & TDA	TDEM
ELIGIBLE PLANNING ACTIVITIES							
Hazard mitigation planning	✓ ²	✓	✓	✓	✓		✓
Planning (H&H studies, alt. analysis, BCA)			✓	✓	✓	✓	✓
Engineering design	✓	✓	✓	✓	✓	✓	
ELIGIBLE MITIGATION ACTIVITIES							
Levees, flood walls or related infrastructure	✓		✓	✓	✓		✓
Regional detention and/or retention basins	✓	✓	✓	✓	✓	✓	✓
Local detention and/or retention basins	✓	✓	✓	✓	✓	✓	✓
Local drainage improvements	✓	✓	✓	✓	✓	✓	✓
Local channel conveyance improvements	✓	✓	✓	✓	✓	✓	✓
Roadway bridges, culverts and pipes	✓	✓	✓	✓	✓	✓	✓
Floodplain development ordinances				✓	✓		✓
Property buyouts or relocations	✓	✓	✓	✓	✓	✓	✓
Property elevation	✓	✓	✓	✓	✓	✓	
Reconstruction of noncompliant structures			✓				
Flood-proofing and/or flood retrofits	✓	✓	✓		✓	✓	✓
Flood awareness training and/or education	✓		✓	✓	✓		✓
Flood warning system	✓		✓	✓	✓		✓

1. Building Resilient Infrastructure and Communities (BRIC) will replace PDM next year and will likely be on the same cycle. It will not be an appropriation from Congress, but it will be a Disaster Relief Fund built based on six percent of presidential disasters. Anticipate similar requirements as PDM, including flood mitigation projects.

2. Limited to updating flood hazard components.

3. Flood Infrastructure Fund based on Flood Intended Use Plan published in March 2020.

5.1 Federal Funding

A significant amount of federal funding is available and may be for the foreseeable future. These funds are available through a variety of different agencies including the Federal Emergency Management Agency (FEMA), US Department of Housing and Urban Development (HUD), the Environmental Protection Agency (EPA), the US Army Corps of Engineers (USACE) and the Natural Resource Conservation Service (NRCS), a division of the US Department of Agriculture. Depending on the agency and scope, funding matches can range from 100% grant funding to low interest loans.

These types of funds are subject to procurement requirements that would likely include an RFQ process. Federal funding may also trigger additional environmental requirements, such as preparation of NEPA documentation and environmental clearance from the lead federal agency. It should be noted that some of the Federal funding sources require a current Hazard Mitigation Plan (HMP) in order to apply for funds. There are also opportunities to partner with the USACE to perform project definition studies or feasibility studies. Funding available but not presented in this report include: Sec 20, Flood Control Act of 1960, Floodplain Management Services; Sec 22, Water Resources Development Act; and Continuing Authorities Program.

5.1.1 Federal Emergency Management Agency (FEMA) Funding

FEMA has a variety of funding opportunities with eligible activities that range from Hazard Mitigation Planning to conveyance and detention improvements to flood warning system enhancements. Typically, FEMA funding sources require that a benefit-cost analysis (BCA) be performed and that the benefit-cost ratio (BCR) is equal to or greater than one.

5.1.1.1 Pre-Disaster Mitigation (PDM)

The PDM is a non-disaster related funding source that is relatively competitive. The PDM funding requires that the project have a positive BCA, which may make it infeasible for most of the proposed projects since the number of structures is low. An approved Hazard Mitigation Plan must be in place in order to be eligible for PDM funding and the cost-share is typically 75% federal to 25% local, though there are special conditions for impoverished areas that may push the cost share to 90%/10%. The communities in the upper San Jacinto River watershed do have approved Hazard Mitigation Plans. The FEMA PDM grants are administered at the State level by the Texas Department of Emergency Management (TDEM). For more information, visit <https://www.fema.gov/pre-disaster-mitigation-grant-program>.

5.1.1.2 Flood Mitigation Assistance (FMA)

The FMA includes planning and project grants, both aimed at reducing flood losses to structures. Structures must be insured by the NFIP, which may limit the prospects for this funding in some areas of the watershed. Typical projects for which the funds are used include the following: the acquisition of insured structures and real property; relocation; elevation of demolition of an insured structure; or flood reduction. As with the FMA, the cost-share is typically 75% Federal to 25% Local and there are also special conditions for impoverished areas that may push the cost share to 90%/10%. FMA funding is administered by the Texas Water Development Board (TWDB) at the state level. For more information, visit <https://www.fema.gov/flood-mitigation-assistance-grant-program>.

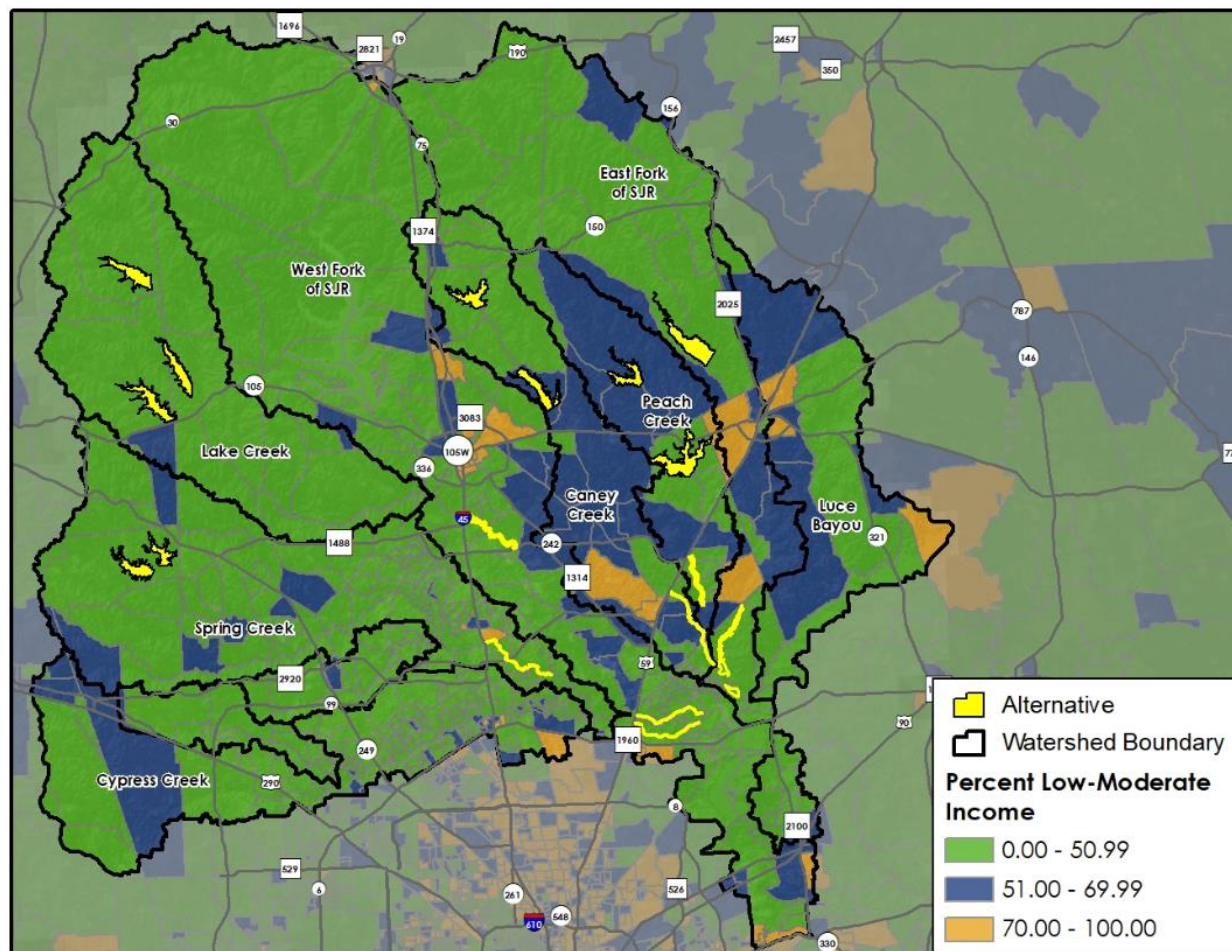
5.1.1.3 Hazard Mitigation Grant Program (HMGP)

The HMGP grants are based on a Presidential Disaster Declaration, with the amount of available funding based on total federal assistance. Like PDM, a positive BCA is required, likely making this source of funding

infeasible for most of the proposed flood mitigation projects. The cost-share is typically 75% Federal to 25% Local and there are no special conditions. Limited funding is available for initiative projects (public awareness, enhanced flood margining systems, etc.) and development of hazard mitigation plans. HMGP grants are administered by TDEM at the state level. For more information, visit <https://www.fema.gov/hazard-mitigation-grant-program>.

5.1.2 US Housing and Urban Development (HUD) Funding

As with the FEMA grants, there are several opportunities for funding through HUD Community Development Block Grants (CDBG). There is currently nearly \$4B in funding for flood prevention and resiliency efforts available through the Texas General Land Office (GLO), the agency that administers HUD funding at the state level. HUD funds typically do not have a BCR requirement, but they may have a Low-Moderate Income (LMI) emphasis that focuses on helping communities with limited resources recover. Funding opportunities may have different thresholds of percent LMI benefitting from the project. Typical thresholds are 51% or 71% LMI within the benefit area. LMI areas by census tract across the watershed are shown below. As with the FEMA funding, there are procurement requirements that will need an RFQ process to be met.



5.1.2.1 Community Development Block Grant – Disaster Relief (CDBG-DR)

The CDBG-DR is based on response to Federally declared disaster and includes a variety of potential activities, including detention and conveyance improvements. The grant does have an LMI emphasis that

may limit the applicability of this source in the watershed. The cost-share is typically 100% Federal to 0% Local. More information is at <https://recovery.texas.gov/local-government/resources/overview/index.html>.

5.1.2.2 Community Development Block Grant – Mitigation (CDBG-MIT)

The CDBG-MIT funds are also related to disaster declarations and are a little bit more flexible in that it has a lower threshold for the LMI component, which opens it to more of the watershed than the DR funding. Given the reduced requirement on LMI, the CDBG-MIT may be a viable funding source for several of the proposed flood mitigation projects in the watershed. As with the -DR funds, the cost-share is 100% Federal to 0% Local. Recommended future watershed protection studies could be partially funded through this grant program. For more information, visit <https://recovery.texas.gov/action-plans/mitigation-funding/index.html>.

5.1.3 Natural Resource Conservation Service (NRCS) Funding

NRCS's natural resources conservation programs help people reduce soil erosion, enhance water supplies, improve water quality, increase wildlife habitat, and reduce damages caused by floods and other natural disasters. NRCS funds have been used locally for conservation efforts or repair of damaged infrastructure. The funding requires projects to be completed relatively quickly.

5.1.3.1 NRCS Small Watershed Program (PL-556)

The Small Watershed Program is aimed at extending the service life of dams and is not applicable to flood mitigation projects in the watershed. For more information, visit <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcseprd397225>.

5.1.3.2 NRCS Regional Conservation Partnership Program (RCPP)

The RCPP is focused on conservation efforts, primarily in agricultural and nonindustrial private forests. The project requirements are not consistent with the proposed flood mitigation projects. For more information, visit <https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/rcpp/?cid=nrcseprd1477816>.

5.1.3.3 NRCS Watershed and Flood Prevention Operations (WFPO)

The WFPO program is intended to help government entities protect and restore watersheds up to 250,000 acres. While much of the focus is on erosion, sediment damage, and conservation, floodwater damage is also a component. In order to be eligible, the project must have the sponsorship of a public entity, be less than 250,000 acres (which is the case) and have at least 20% benefit to agriculture. The last requirement will need to be further investigated, but much of the upper portion of the watershed includes farming, some livestock, and potentially other agricultural uses. Property acquisition, permitting, and an approved Operations and Maintenance Plan are required, and the funding is subject to congressional appropriations. The requirements also call for an "approved watershed plan". This component will need to be investigated further to determine what constitutes approved. The master drainage plan should meet the requirement for the plan but may need to be approved by NRCS. For more information, visit https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/landscape/wfpo/?cid=nrcs143_00827 1.

5.1.4 Environmental Protection Agency (EPA) Funding

Funding from the EPA is administered through the Texas Water Development Board (TWDB) and is generally for water and wastewater infrastructure projects.

5.1.4.1 *Clean Water Act – State Revolving Fund (CWSRF)*

The CWSRF generally provides low interest loans for water and wastewater projects; however, in the last few years, a stormwater component has been added. This allows the loans to be used for planning, acquisition, design and construction of flood mitigation projects. Financial assistance can be provided to cities, counties, districts, and other political subdivisions. Some loan forgiveness may be available for disadvantaged communities, but since it is a loan, there is no cost share and the local entity will carry all financial responsibility. Given the size of the proposed flood mitigation projects, this may not be an attractive option for project construction. However, there \$525 million for 2020 and the TWDB, who administers the funds, is often looking for applicants. This may be an option for funding the planning and design portions of the projects.

5.2 State Funding

In addition to Federal funding options, there are also grant and loan opportunities at the state level, which are managed through the TWDB.

5.2.1 Texas Water Development Board (TWDB) Funding

The TWDB has several funding sources that may potentially be useful. Unlike Federal Funding sources, the TWDB administered funds do not require a BCA and do not have the same NEPA requirements. TWDB funding sources are a combination of grants and low interest loans. For more information, visit <https://www.twdb.texas.gov/>.

5.2.1.1 *Flood Protection Grant (FP)*

Flood protection grants are specifically designed for the planning purpose, including Hazard Mitigation Plans, Stormwater Planning, ordinances, etc. These are released every 12-18 months for application. Several studies have been performed in the watershed using flood protection grants, including the *West Fork San Jacinto River Flood Protection Study* by the San Jacinto River Authority which triggered the development of the San Jacinto Regional Watershed Master Drainage Plan. Recommended future watershed protection studies could be partially funded through this grant program. A minimum 50% local share is required.

5.2.1.2 *Development Fund (DFund)*

The Dfund is a State of Texas loan program, that is relatively simple and has minimal red tape. Flood control projects are eligible; however, given the dedicated funding source and other grant opportunities, the Dfund may not be an attractive option.

5.2.1.3 *Flood Infrastructure Fund (FIF)*

The Flood Infrastructure Fund (FIF) is administered by the TWDB. The FIF allows for loans at or below market rates for a variety of actions, including flood planning, grant application, and engineering for structural and non-structural solutions. In addition, the FIF offers grants that can be used as the local entities matching funds for other federal funding programs. The state will fund the FIF using approximately \$793M from the state's Rainy Day fund. Abridged applications were solicited by the TWDB in July 2020 and applications for various projects and studies were submitted from the watershed. It is expected that projects will be awarded and start in early 2021.

5.3 Local Funding

Several of the federal and state grant funding opportunities require local matches. While some loans may include loan forgiveness, local communities will still need to plan for some level of local funding especially for long term operations and maintenance of the flood mitigation projects.

5.3.1 Bonds

Bond funding can be used for flood protection and management. Bonds typically provide project specific financing that requires proposed improvements to be ready for construction and meet the priorities set by the funder. Although repayment terms can offer low or no interest financing, these sources do require full repayment.

5.3.2 Fees and Ad Valorem Taxes

A development impact mitigation fee is a tax that is imposed as a precondition for the privilege of developing land. Since the proposed projects address existing conditions are not meant for mitigating developing land, imposing a fee on new development to address pre-existing flooding conditions may be difficult to implement. Ad valorem taxes are based on the value of a transaction of a property. Sales taxes or property taxes are ad valorem taxes that could be considered for funding the projects.

5.4 Public Private Partnerships

While there is not an identified stream of funding available for private investment, it may be considered as an option if the opportunity is presented. The watershed includes several different industrial and commercial developments that were significantly damaged in recent flood events and whose owners may be looking for opportunities to reduce flood risk in the area. The project Lead Agency will need to investigate potential opportunities to partner with these entities.

5.5 Funding Recommendations

There are a variety of potential funding sources; however, many of them are not applicable or may not be feasible due to the types of projects or constraints within the watershed. Given those constraints, the following are recommended:

- **FEMA PDM and HMGP** – Grants for buyouts and flood warning systems should be explored.
- **CDBG-DR and CDBG-MIT** – These funding sources do have LMI threshold requirements. Further investigation is required to determine if the projects qualify.
- **NRCS WFPO**– Further investigate is required to determine if projects qualify; this should include face-to-face meeting with NRCS staff.
- **State funding sources including FP and FIF** – Several abridged applications were submitted in June 2020 for projects by various agencies. Watershed protection studies could be partially funded by flood protection grants.
- **Local funding** – Local matches may be required by several of the grant sources. Communities and agencies should consider budgeting for drainage studies and projects. Bonds may be considered to implement the projects. Since there is a significant investment in private infrastructure that is at risk of flooding, private partnerships may be explored.

6.0 Conclusions

The implementation plan for the San Jacinto River Watershed provides a path forward for implementing the strategies and projects to reduce flood risk within the watershed. The implementation includes an action plan for the region to continue to improve the watershed along with identified roles for entities to implement the plan. For the plan to be successful, a regional facilitator needs to be identified who can take on role of keeping the plan moving forward to address both short term and long term goals and also become a key resource for government agencies participating in the plan. As such, lead agencies for the proposed projects should also be identified and confirmed to begin plan implementation. Stakeholders and partners also need to be identified build collaboration and momentum. Consideration of the formation of a vision group for the upper San Jacinto River watershed may help guide project implementation and definitions of success. Participation in the TWDB flood region planning groups should be strongly considered.

While this master drainage plan provides a comprehensive assessment of the major streams in the upper San Jacinto River watershed, additional investigations are needed to address causes of widespread flooding on the tributaries.

Identifying potential funding sources is important for project implementation success. The potential funding sources are dependent upon the readiness to implement the project(s) as well as the schedule needed to implement the project(s). The proposed flood mitigation projects are large in scale and will require long schedules to implement. After implementation, operation and maintenance costs will also need to be funded. While potential funding sources have been identified, the project lead agency will need to initiate discussions with funding sources to confirm project eligibility.

Appendix H.1

Implementation Matrix

Appendix H.1
Project Ranking Matrix

				Watershed Flooding Counts		Project Benefits							
		Cost	Cost	Cost (\$M) ³	Watershed Historical Damages ¹	Watershed Predicted Damages ¹	Damage Reductions (\$M) ²	Instance Reduction ²	Structures Removed from 1% ACE ²	BCR ³	Roadway	SVI ³	LMI ³
		Low	High	5%	10%	10%		20%	20%	10%	5%	10%	10%
Spring	Walnut Creek	97	132	114.5	361	5,898	101.2	1,653	1,205	0.91	21.9	0.18	24.2
	Birch Creek	80	120	100.0	361	5,898	66.0	1,084	815	0.69	13.3	0.18	24.2
	Woodlands Channelization (56		56.0	361	5,898	34.7	477	221	0.62	0.4	0.19	21.5
	I-45 Channel	85		85.0	361	5,898	99.4	1,739	1,240	1.17	35.2	0.16	24.7
Lake	Caney Creek Detention	98	163	130.5	0	417	42.1	686	323	0.35	21.8	0.27	27.5
	Little Caney Creek	98	128	113.0	0	417	35.0	564	248	0.32	29.0	0.27	27.5
	Garrett's Creek Detention	107	131	119.0	0	417	39.8	684	295	0.34	49.3	0.27	27.5
Peach	Walker Creek Detention	201	218	209.5	1	3,939	56.3	1,070	260	0.27	94.2	0.56	47.4
	SH 105 Detention	356	433	394.5	1	3,939	81.5	1,766	399	0.21	86.4	0.58	48.3
	I-69 Channel	159		159.0	1	3,939	73.6	1,877	382	0.46	121.1	0.52	44.1
Caney	Detention at FM 1097	105	131	118.0	304	3,697	27.7	1,048	377	0.24	121.3	0.59	52.4
	Detention at SH 105	114	149	131.5	304	3,697	55.2	2,030	822	0.43	130.3	0.56	49.7
	I-69 Channelization	189		189.0	304	3,697	57.4	1,128	511	0.30	45.1	0.51	41.9
East Fork	Winters Bayou Dam	134	167	150.5	659	3,090	63.5	1,334	615	0.43	46.3	0.56	41.6
West Fork	River Plantation Channel	187		187.0	4759	6,670	44.4	1,016	383	0.24	4.1	0.30	29.0
	Kingwood Benching	837		837.0	4759	6,670	60.5	963	743	0.07	13.0	0.30	33.7
Missing data from surrounding counties could result in low numbers													

1. Weights watersheds that have higher damages both predicted and historical higher than those that have less damages
2. Weights the individual projects benefits. Benefits are divided into both monetary and individual counts.
3. Funding potential is separated into the BCR which opens FEMA and USACE funding opportunities and benefits to SVI/LMI areas which may open TWDB/GLO

Appendix H.1

Project Ranking Matrix

		Watershed Flooding Counts			Project Benefits						
		Cost (\$M)	Watershed Historical Damages ¹	Watershed Predicted Damages ¹	Instance Reduction ²	Structures Removed from 1% ACE ²	BCR ⁴	Roadway	SVI	LMI ⁵	Total Score
		5%	10%	10%	20%	20%	10%	5%	10%	10%	100%
Spring	Walnut Creek	3.0	2.0	3.0	3.0	4.0	4.0	1.0	0.0	0.0	2.50
	Birch Creek	3.0	2.0	3.0	2.0	3.0	3.0	1.0	0.0	0.0	1.85
	Woodlands Channelization (2)	4.0	2.0	3.0	0.0	0.0	3.0	0.0	1.0	0.0	0.90
	I-45 Channel	4.0	2.0	3.0	3.0	4.0	4.0	2.0	0.0	1.0	2.50
Lake	Caney Creek Detention	2.0	0.0	0.0	1.0	1.0	2.0	1.0	1.0	1.0	0.85
	Little Caney Creek	3.0	0.0	0.0	0.0	0.0	2.0	2.0	1.0	1.0	0.50
	Garrett's Creek Detention	2.0	0.0	0.0	1.0	1.0	2.0	3.0	1.0	1.0	0.95
Peach	Walker Creek Detention	1.0	1.0	2.0	2.0	1.0	1.0	3.0	3.0	3.0	1.75
	SH 105 Detention	0.0	1.0	2.0	3.0	2.0	0.0	3.0	4.0	3.0	2.15
	I-69 Channel	1.0	1.0	2.0	4.0	2.0	3.0	3.0	3.0	3.0	2.55
Caney	Detention at FM 1097	3.0	2.0	1.0	2.0	1.0	1.0	4.0	4.0	4.0	2.00
	Detention at SH 105	2.0	2.0	1.0	4.0	3.0	2.0	4.0	3.0	4.0	2.80
	I-69 Channelization	1.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	3.0	1.80
East Fork	Winters Bayou Dam	2.0	3.0	1.0	3.0	3.0	2.0	2.0	3.0	2.0	2.40
West Fork	River Plantation Channel	1.0	4.0	4.0	1.0	2.0	1.0	0.0	2.0	2.0	1.90
	Kingwood Benching	0.0	4.0	4.0	1.0	3.0	0.0	1.0	2.0	2.0	2.05
			Missing data from surrounding counties could result in low numbers								