DRAFT Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study

Flood Infrastructure Fund Category 1

Project ID 21-0016

Prepared for:

Texas Water Development Board

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Acknowledgements

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1 Executive summary

1.1 Overview

As part of the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP) completed in 2020, two regional detention basins were recommended to be constructed along Birch Creek and Walnut Creek to reduce the potential for flood risk throughout the Spring Creek watershed. The master plan recommended completing feasibility studies for both projects to further investigate the potential for funding and constructing the basins as well as optimizing the design.

The Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study was sponsored and funded by the San Jacinto River Authority (SJRA), Harris County Flood Control District (HCFCD), the City of Humble, and MUDs within the Woodlands, with partial funding from the Texas Water Development Board Flood Infrastructure Fund (FIF) as a Category 1 study. The purpose of the study was to perform a conceptual level design analysis of detention basins for each of the two identified project sites, including identifying benefits and costs associated with individual and joint project implementation. This analysis allows regional stakeholders to determine the most feasible project(s) for future implementation.

The study area includes Waller County, Montgomery County, Harris County, the City of Pinehurst, the City of Tomball, the City of Houston, and the City of Humble. All are participants in the National Flood Insurance Program (NFIP) and are currently enforcing floodplain management standards at least equivalent to NFIP minimum standards. The study extents and modeled streams are shown in Figure 1-1.

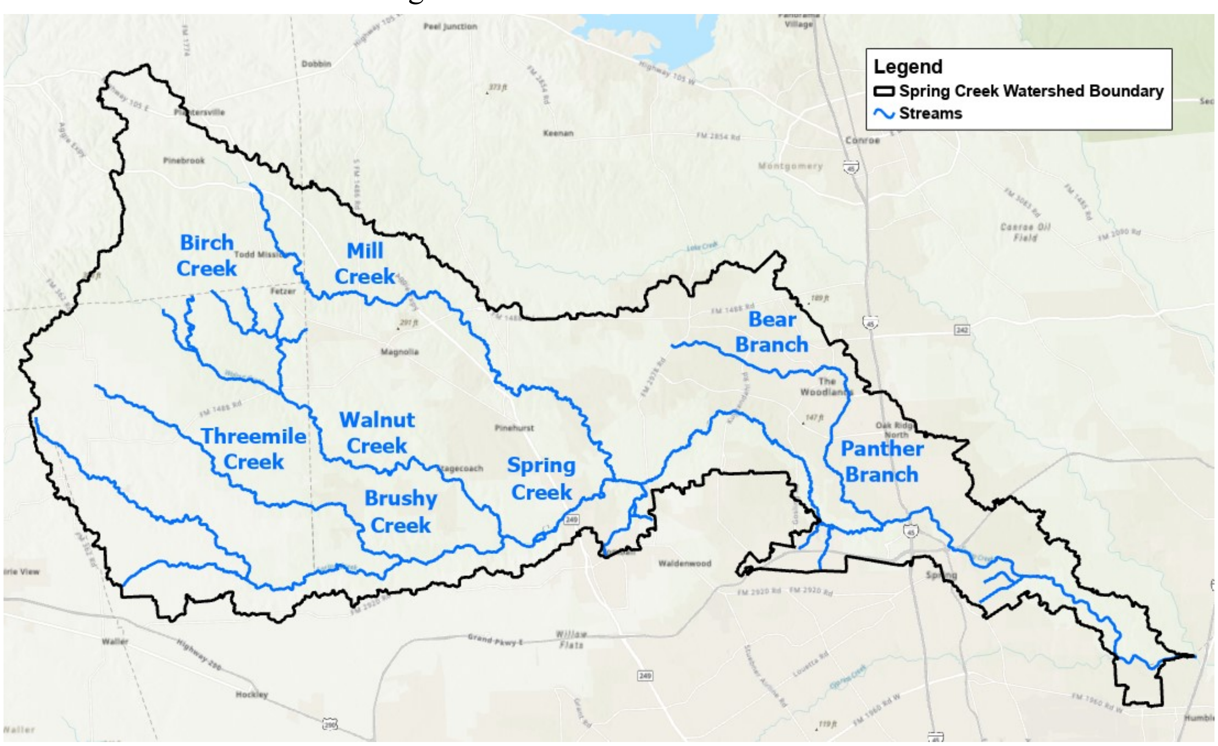


Figure 1-1 Spring Creek Watershed

The two detention basins will store flood waters during storm events by constructing embankments across the floodplains for each creek and restricting flow through specified outlets. The design of the embankments considered multiple alignments to manage the required fill, environmental permitting for crossing streams and potential wetlands, geotechnical investigation of nearby soils, embankment design options, spillway options to meet high and low flow requirements, required freeboard, and other dam safety permitting specifications.

A desktop environmental investigation was conducted to determine the necessary steps for permitting the detention basins and potential cost for mitigating any conflicts. The result of this investigation modified the recommended dam alignment to minimize potential stream mitigation and reduce the required permitting.

HEC-HMS and HEC-RAS models were used to determine the extents of flooding within the watershed as well as the benefits of the proposed detention basins. The analysis used the latest HCFCD models for the watershed as a basis and were modified as necessary within the Walnut and Birch Creek watersheds to reflect existing conditions. The analysis showed that there are currently over 800 residential and commercial structures susceptible to flooding within the Atlas 14 1% ACE (Annual Chance Exceedance) event and over 9,000 within the Atlas 14 0.2% ACE floodplain. This indicates that structure flooding is generally infrequent along Spring Creek; however, when large storm events occur, there is the potential for widespread damages.

Costs for each recommended project were tabulated accounting for land acquisition, construction, engineering, utility relocation, environmental permitting, and operations and maintenance of the facilities.

A benefit cost analysis was conducted using the FEMA BCA Toolkit to determine the flood mitigation benefits of each project separately as well as if combined into one application. The analysis included both the standard (buildings, contents, and displacement) and social benefits to calculate a total benefit of each project.

1.2 Recommendations

The recommended dams required for the detention basins included earthen embankments with 3.5:1 H:V upstream and 3:1 H:V downstream side slopes and maintenance access along the top of the dam. The design includes a large ogee spillway for extreme events and a cast in place box outfall for the more frequent storm events. All land within the limits of the probable maximum flood is recommended to be acquired either in fee or easement. As the conceptual design shows, the projects are implementable, permittable, and constructable as outlined in TWDB requirements. The opinion of probable construction cost for each basin is summarized in Table 1-1.

Table 1-1 Opinion of Probable Construction Costs

	Walnut Creek	Birch Creek	Birch+Walnut
Construction	$82,884,938	$64,043,650	$146,928,588
Engineering[1]	$12,432,740	$9,606,547	$22,039,287
Land Acquisition[2]	$95,463,459	$30,812,821	$126,276,280
Environmental	$2,290,500	$875,700	$3,166,200
Utilities	$0	$0	$0
Total	**$193,071,637**	**$105,338,718**	**$298,410,355**

[1] Engineering including geotechnical, survey, design, and construction management is assumed to be 15% of the total construction cost.
[2] The average cost of full acquisition and easements only was used for the total cost estimate; this is further explained in Section 6.2.

The hydraulic analysis showed that the proposed detention basins at Walnut Creek and Birch Creek will reduce flood risks in the Spring Creek watershed. The basins mitigate downstream flooding, benefiting numerous residential and non-residential structures. These projects produce no negative impact beyond the project extents in accordance with TWDB project criteria. Table 1-2 summarizes the benefits for each recommended project in accordance with TWDB grant requirements.

Table 1-2 Recommended Project Flood Risk Benefit

Mitigation Measurement	Walnut	Birch	Birch &Walnut
Structures with reduced 1% ACE flood risk. [1]	738	802	629
Structures removed from 1% ACE flood risk.	225	160	335
Structures with reduced 0.2% ACE flood risk. [2]	9,032	9,207	8,762
Structures removed from 0.2% ACE flood risk.	484	303	795
Residential structures removed from 1% ACE flood risk.	122	103	192
Population removed from 1% ACE flood risk.	458	336	655
Critical facilities removed from 1% ACE flood risk (#).	1	1	1
Farm & ranch land removed from 1% ACE (acres)	4.82	3.87	7.16
Pre-Project Level-of-Service	10% ACE	10% ACE	10% ACE
Post-Project Level-of-Service	10% ACE	10% ACE	10% ACE
Cost/ Structure removed.	$272,315	$227,513	$264,080
Percent Nature-based Solution	0%	0%	0%
Negative Impact	No	No	No
Negative Impact Mitigation	-	-	-
Social Vulnerability Index (SVI)	0.42	0.42	0.42
Water Supply Benefit (Y/N)	No	No	No
Traffic Count for Low Water Crossings	0	0	0
Low water crossings removed from 1% ACE flood risk	0	0	0
Reduction in road closure occurrences in 1% ACE	0	0	0
Length of roads removed from 1% ACE (mi).	0	0	0
Estimated reduction in fatalities	0	0	0
Estimated reduction in injuries	0	0	0

[1] 1% ACE = 100-year event
[2] 0.2% ACE = 500-year event

The economic feasibility of the project was also assessed by performing a benefit-cost analysis (BCA). The results demonstrated that both detention basins have a favorable benefit-cost ratio, indicating that the economic benefits of flood risk reduction outweigh the costs of construction and maintenance. The costs and benefits for each project are summarized in Table 1-3.

Table 1-3 Benefit Cost Ratios

	Walnut Creek	Birch Creek	Combined
Benefits	$201,787,435	$185,346,694	$211,741,440
Cost	$193,071,637	$105,338,718	$298,410,355
BCR	1.05	1.76	0.71

The analysis shows that the individual projects both have the potential for benefit cost ratios greater than 1.0 meaning that the projects have the potential to be cost effective. This also indicates that specific federal funding sources may be available for funding portions of the total construction cost.

The combined project benefit cost is less than 1.0 due to a significant cost increase for two detention basins and the relatively small increase in social benefits (the projects still benefit the same population). This indicates that while both projects would provide downstream flood relief and a combination of projects provides the most relief, when seeking federal funding, separate applications should be submitted.

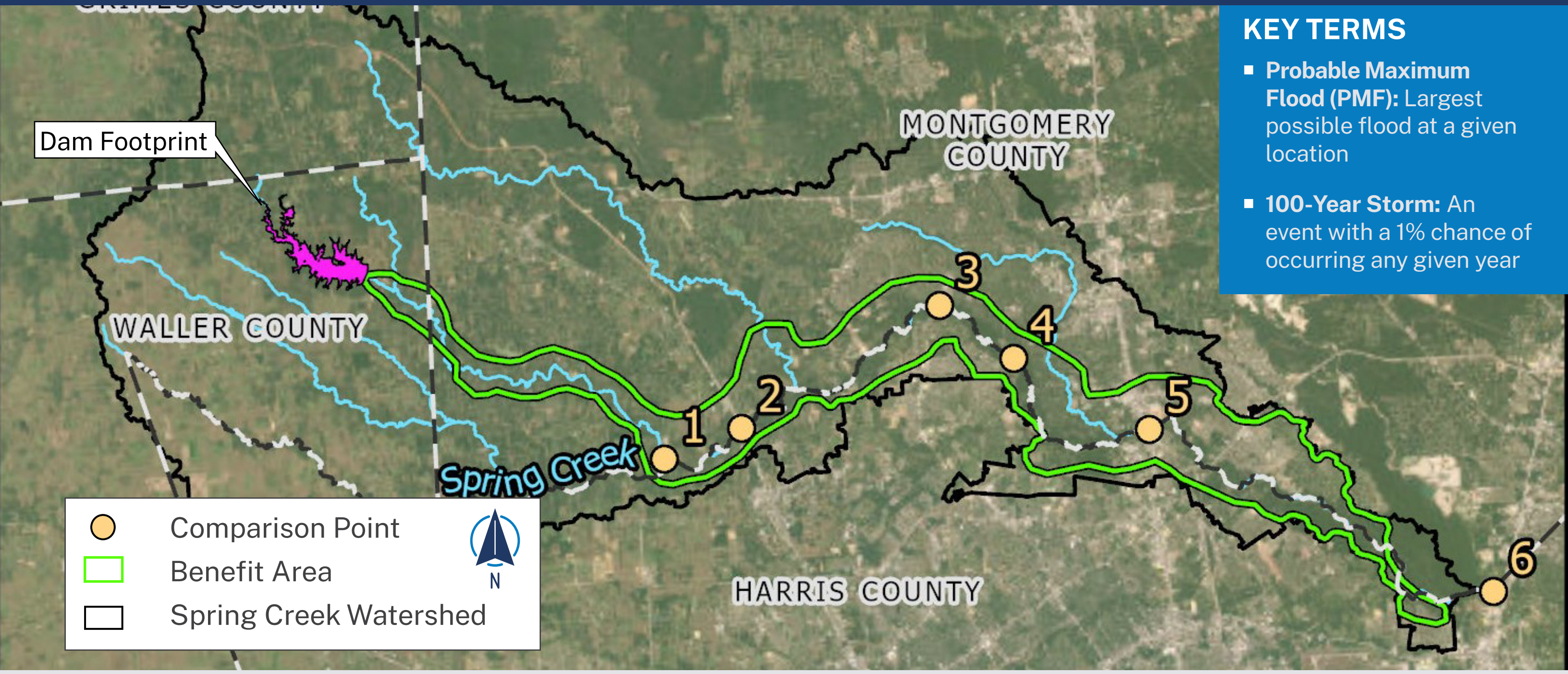
1.3 Next steps

Based on these findings, it is recommended to advance the Walnut Creek and Birch Creek detention basins to the detailed design phase, which will involve more precise engineering analyses, coordination with landowners, acquisition of property, permitting, and the development of construction plans. Efforts should be made to secure funding from various sources, including federal, state, and local agencies, with potential funding opportunities such as FEMA's Hazard Mitigation Grant Program and the Texas Water Development Board's Flood Infrastructure Fund. In securing funding and completing the next phases of the design process, the entities within the area need to identify the potential owner for these projects to construct, maintain, and manage the facilities. This entity would need the jurisdiction to purchase land within the area as well as the ability and experience in maintaining and managing flood control dam facilities.

Walnut Creek Detention

https://springcreekstudy.com/

A proposed dry bottom dam facility located on Walnut Creek



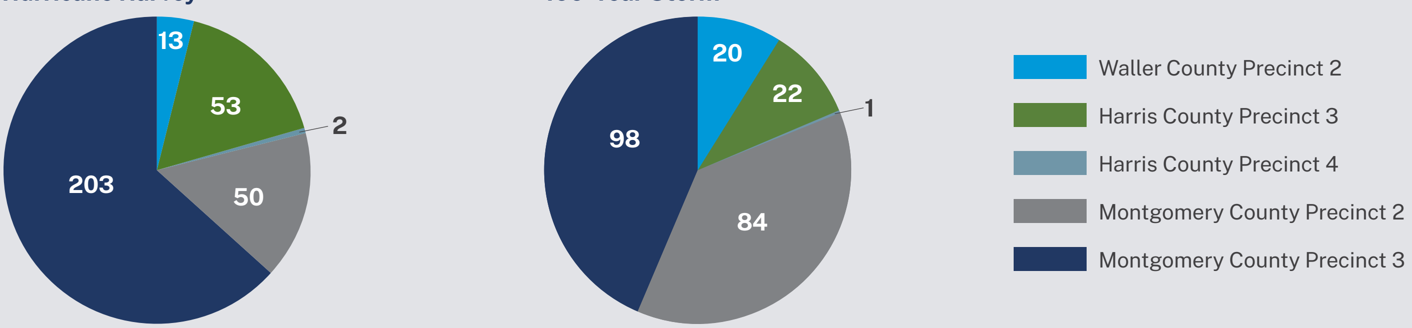
KEY TERMS

- **Probable Maximum Flood (PMF):** Largest possible flood at a given location
- **100-Year Storm:** An event with a 1% chance of occurring any given year

ESTIMATED BENEFITS

Structures Anticipated to No Longer Flood **Hurricane Harvey**

Structures Anticipated to No Longer Flood **100-Year Storm**



ADDITIONAL BENEFITS

- Reduced flooding for 9,032 structures in 500-Year event
- Removed 484 structures from flooding in 500-Year

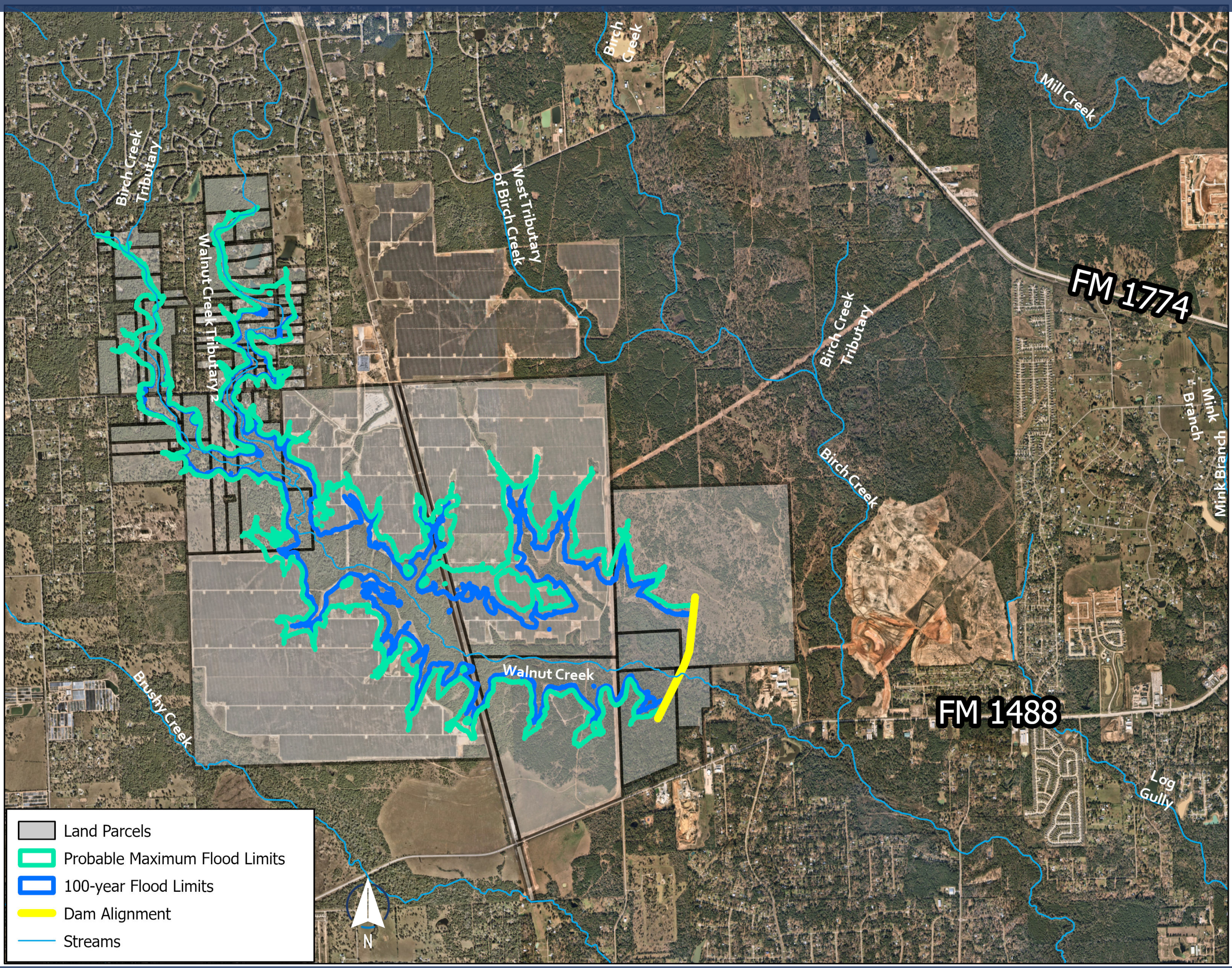
ESTIMATED COSTS

Design Cost	$12M
Environmental Cost	$2M
Construction Cost	$83M
Land Cost	$95M
TOTAL COSTS	**$193M**
TOTAL BENEFITS	**$202M**

PROJECT BENEFIT-COST RATIO: 1.05

Reduction in Flood Elevations After Project Construction

Comparison Point	Location	100-YR (ft)
1	On Walnut Creek	-2.80
2	SH 249	-0.77
3	Kuykendahl	-0.54
4	Gosling	-0.50
5	I-45	-0.38
6	West Fork Confluences	-0.22



PROJECT DETAILS

- Type: Dry dam detention facility
- 100-year volume provided: 7,300 acre-feet
- Maximum height: 39.1 feet
- Dam Length: 3,373 feet
- Maximum inundation area: 1,370 acre
- 100-year inundation area: 940 acre
- Spillway Elevation: 254.7 feet
- Top of Dam Elevation: 263.6 feet

CHALLENGES

- Current solar farm overlaps portions of the proposed facility
- USACE coordination required due to minor environmental stream and wetland impacts
- Private land owners within project footprint

POTENTIAL PARTNERS

- Montgomery Co.
- MUDs
- SJRA
- The Woodlands
- HCFCD
- TWDB
- GLO
- FEMA
- USACE
- Future Flood Control District
- Waller County

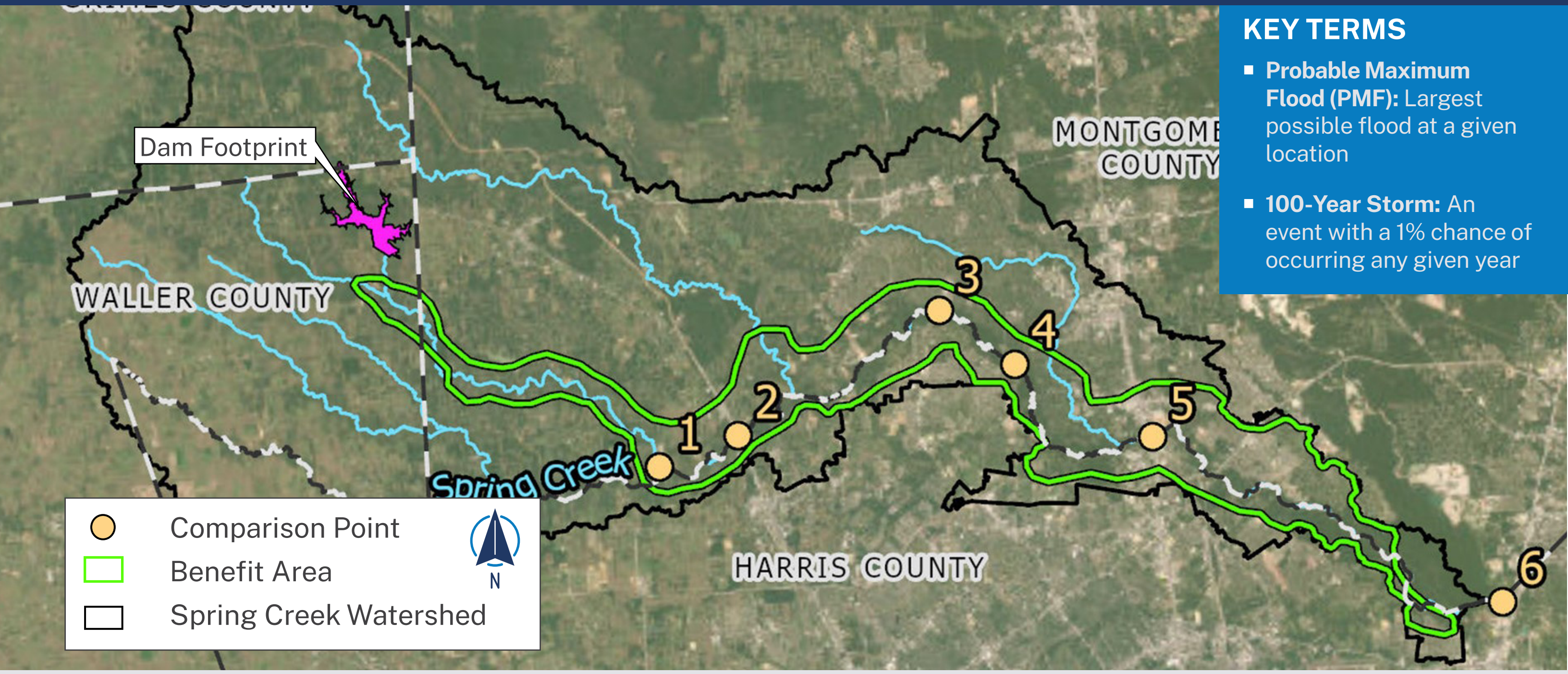
NEXT STEPS

- **Coordinate with the solar farm for potential shared project**
- **Identify potential dam owner and operator**
- **Identify funding partners**
- **Seek funding for land acquisition, design and construction**
- **Acquire land using local and other funding sources**
- **Final engineering and design of proposed facility**
- **Construction and operation of dam facility**

Birch Creek Detention

https://springcreekstudy.com/

A proposed dry bottom dam facility located on Birch Creek



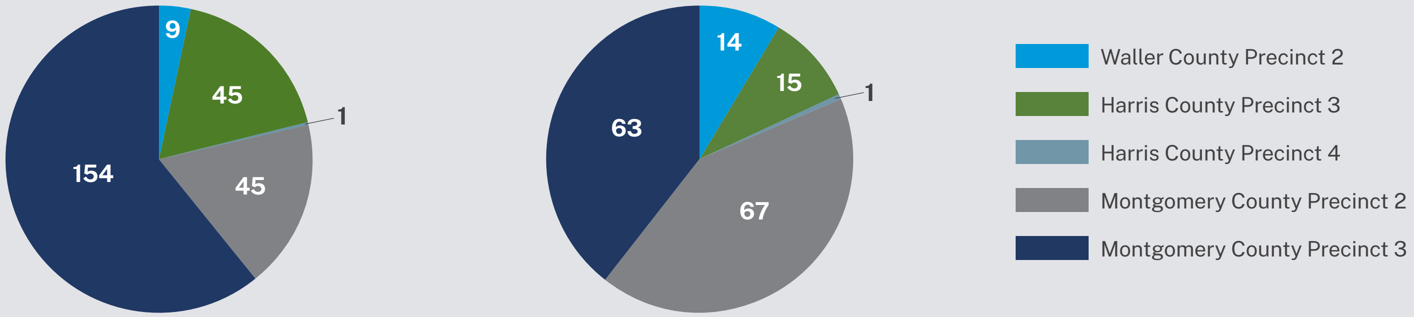
KEY TERMS

- **Probable Maximum Flood (PMF):** Largest possible flood at a given location
- **100-Year Storm:** An event with a 1% chance of occurring any given year

ESTIMATED BENEFITS

Structures Anticipated to No Longer Flood **Hurricane Harvey**

Structures Anticipated to No Longer Flood **100-Year Storm**



ADDITIONAL BENEFITS

- Reduced flooding for 9,207 structures in 500-Year event
- Removed 303 structures from flooding in 500-Year

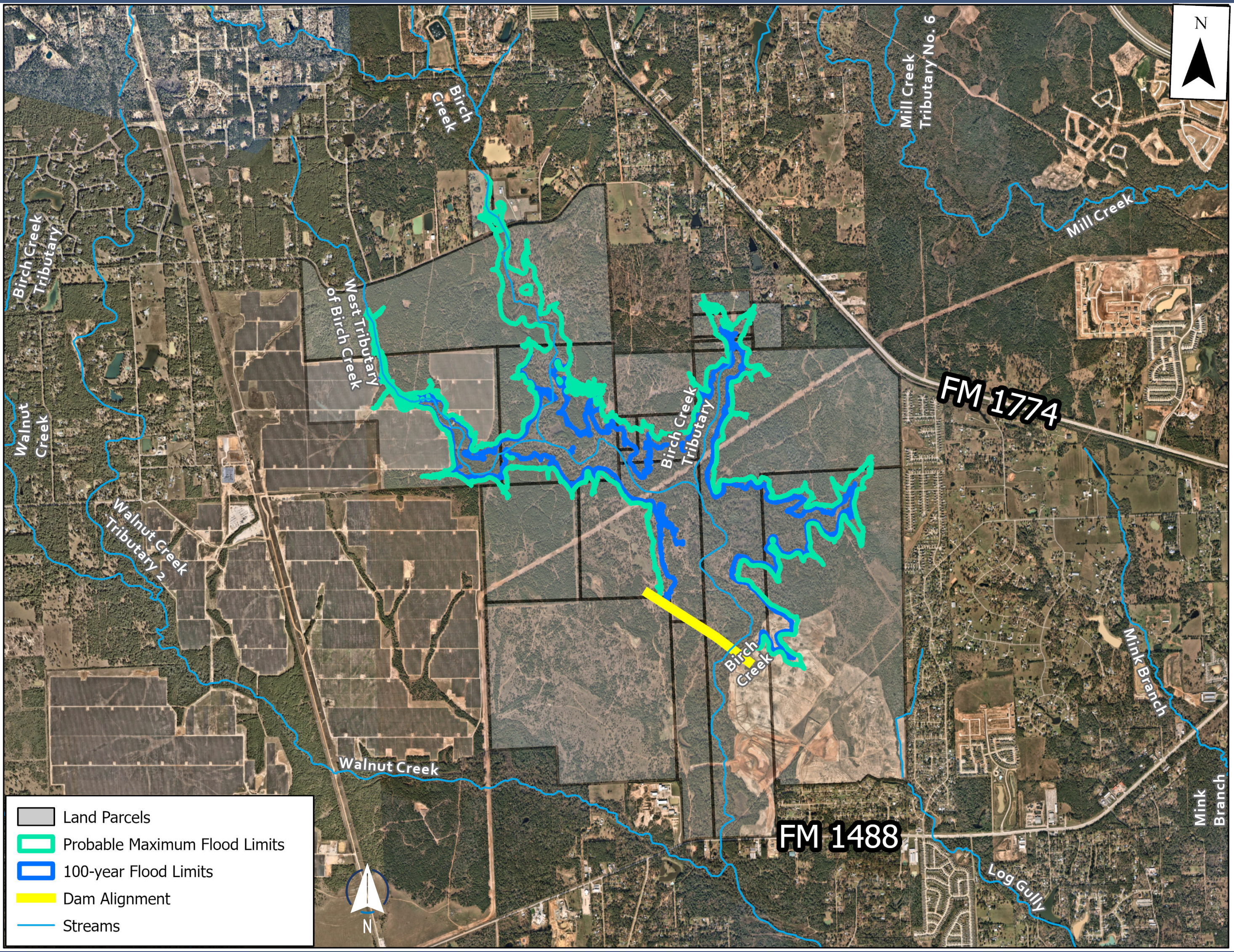
ESTIMATED COSTS

Design Cost	$10M
Environmental Cost	$1M
Construction Cost	$64M
Land Cost	$31M
TOTAL COSTS	**$105M**
TOTAL BENEFITS	**$185M**

PROJECT BENEFIT-COST RATIO: 1.76

Reduction in Flood Elevations After Project Construction

Comparison Point	Location	100-YR (ft)
1	On Walnut Creek	-1.99
2	SH 249	-0.54
3	Kuykendahl	-0.36
4	Gosling	-0.33
5	I-45	-0.23
6	West Fork Confluences	-0.14



PROJECT DETAILS

- Type: Dry dam detention facility
- 100-year volume provided: 4,800 acre-feet
- Maximum height: 35.4 feet
- Dam Length: 3,168 feet
- Maximum inundation area: 920 acre
- 100-year inundation area: 690 acre
- Spillway Elevation: 251.2 feet
- Top of Dam Elevation: 259.1 feet

CHALLENGES

- Future Woodhaven Development overlaps portions of the proposed facility
- USACE coordination required due to minor environmental stream and wetland impacts
- Private land owners within project footprint

POTENTIAL PARTNERS

- Montgomery Co.
- MUDs
- SJRA
- The Woodlands
- HCFCD
- TWDB
- GLO
- FEMA
- USACE
- Future Flood Control District
- Waller County

NEXT STEPS

- **Coordinate with developers for potential shared project**
- **Identify potential dam owner and operator**
- **Identify funding partners**
- **Seek funding for land acquisition, design and construction**
- **Acquire land using local and other funding sources**
- **Final engineering and design of proposed facility**
- **Construction and operation of dam facility**

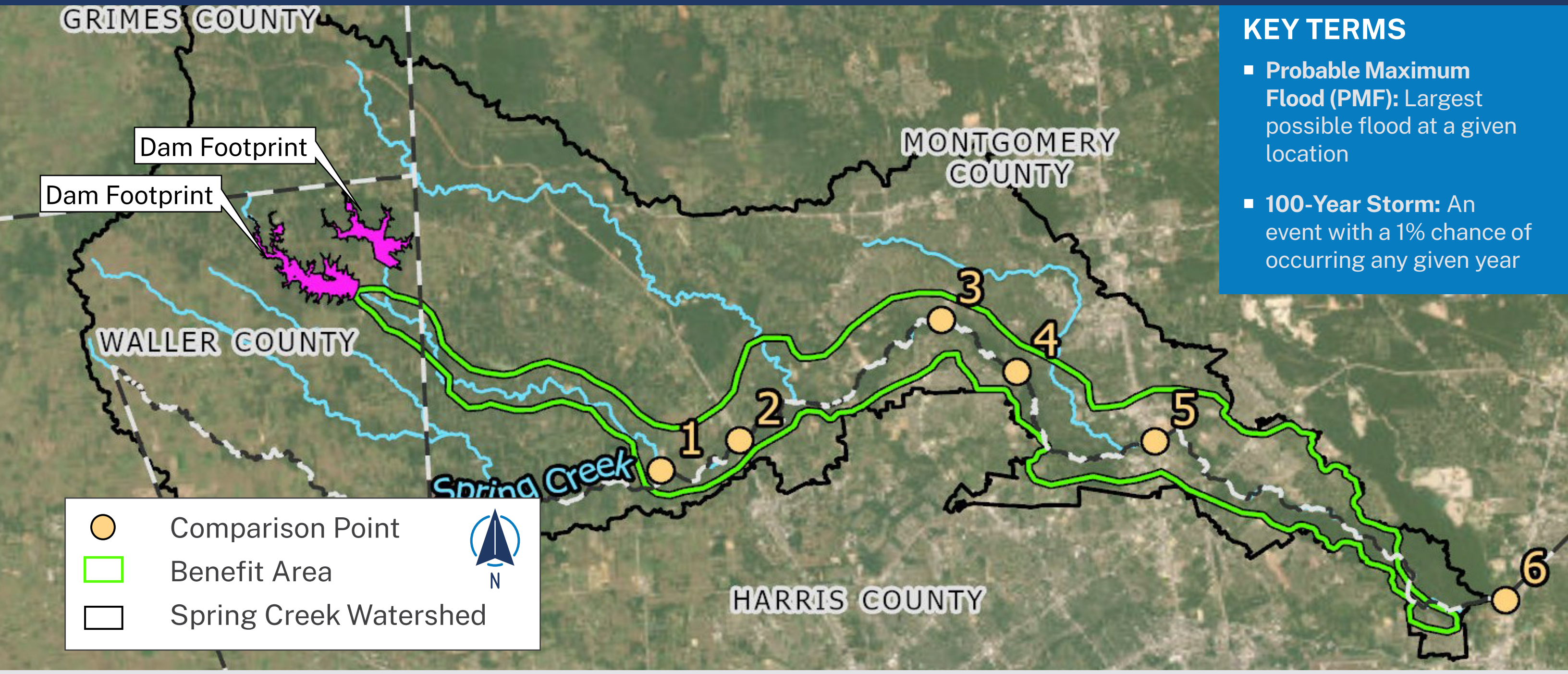
Walnut Creek & Birch Creek Detention

https://springcreekstudy.com/

A proposed dry bottom dam facility located on Walnut and Birch Creek

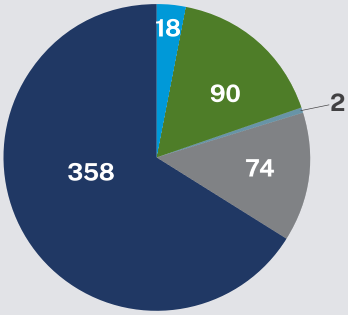
KEY TERMS

- **Probable Maximum Flood (PMF):** Largest possible flood at a given location
- **100-Year Storm:** An event with a 1% chance of occurring any given year

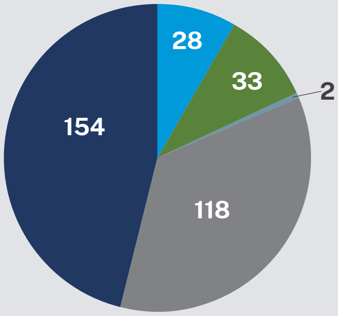


ESTIMATED BENEFITS

Structures Anticipated to No Longer Flood
Hurricane Harvey



Structures Anticipated to No Longer Flood
100-Year Storm



ADDITIONAL BENEFITS

- Reduced flooding for 8,762 structures in 500-Year event
- Removed 795 structures from flooding in 500-Year

ESTIMATED COSTS

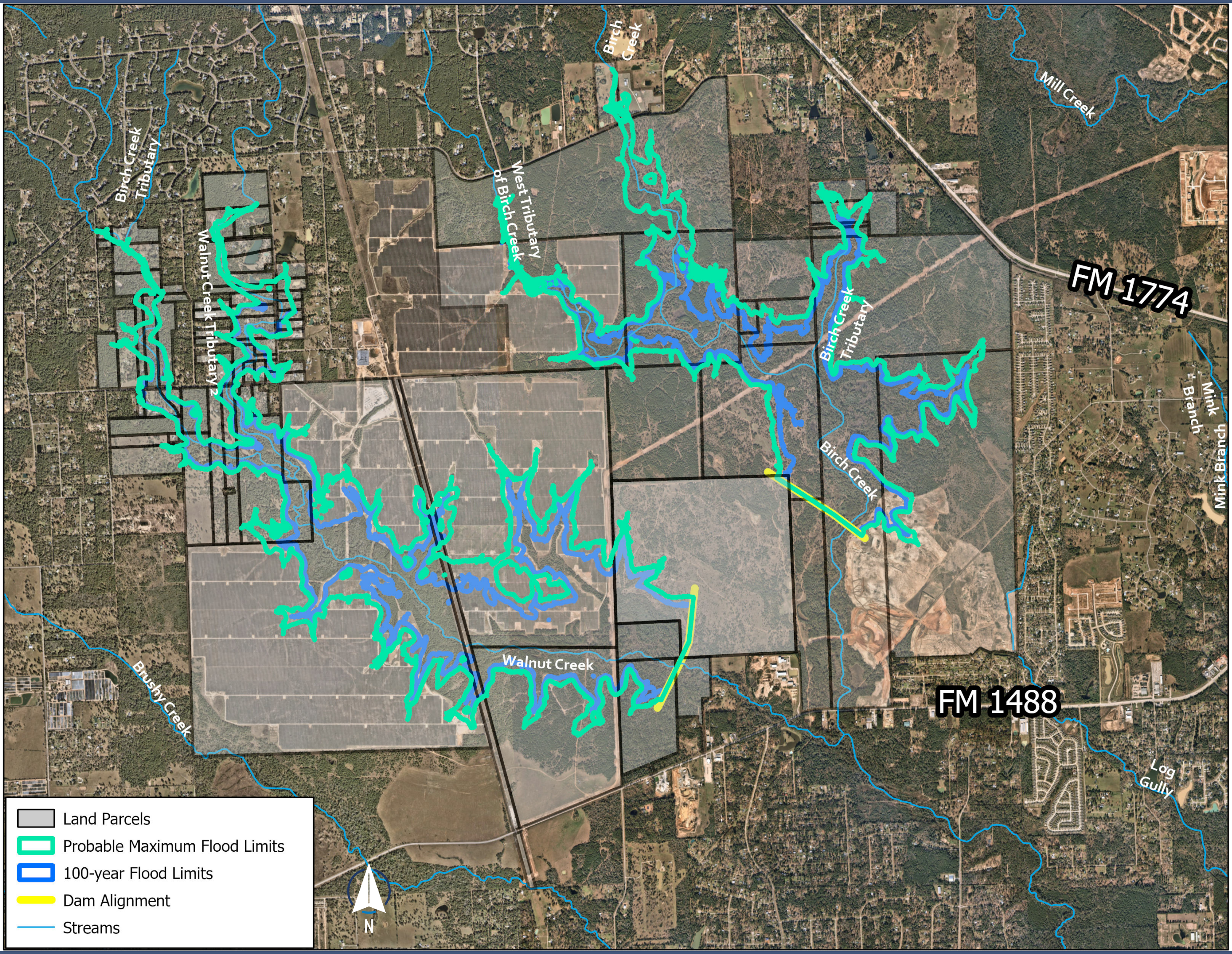
Design Cost $22M
Environmental Cost $3M
Construction Cost $147M
Land Cost $126M

TOTAL COSTS $298M
TOTAL BENEFITS $212M

PROJECT BENEFIT-COST RATIO: 0.71

Reduction in Flood Elevations After Project Construction

Comparison Point	Location	100-YR (ft)
1	On Walnut Creek	-3.64
2	SH 249	-1.2
3	Kuykendahl	-0.88
4	Gosling	-0.82
5	I-45	-0.67
6	West Fork Confluences	-0.36



PROJECT DETAILS (BIRCH / WALNUT)

- Type: Dry dam detention facility
- 100-year volume provided: 12,100 acre-feet
- Maximum height: 35.4 feet / 39.1 feet
- Dam Length: 3,168 feet / 3,373 feet
- Maximum inundation area: 920 acre / 1,370 acre
- 100-year inundation area: 690 acre / 940 acre
- Spillway Elevation: 251.2 feet / 254.7 feet
- Top of Dam Elevation: 259.1 feet / 263.6 feet

CHALLENGES

- Future Woodhaven Development and solar farm overlaps portions of the proposed facilities
- USACE coordination required due to minor environmental stream and wetland impacts
- Private land owners within project footprint

POTENTIAL PARTNERS

- Montgomery Co.
- MUDs
- SJRA
- The Woodlands
- HCFCD
- TWDB
- GLO
- FEMA
- USACE
- Future Flood Control District
- Waller County

NEXT STEPS

- **Coordinate with developers and the solar farm for potential shared project**
- **Identify potential dam owner and operator**
- **Identify funding partners**
- **Seek funding for land acquisition, design and construction**
- **Acquire land using local and other funding sources**
- **Final engineering and design of proposed facility**
- **Construction and operation of dam facility**

2 Introduction and background

Spring Creek serves as the boundary between the rapidly urbanizing counties of Montgomery, Harris, and Waller, and has a history of widespread flooding in large storm events caused by heavy rainfall and high flows within the watershed. Regional organizations act on behalf of the public to develop strategies to implement effective flood mitigation projects.

In 2020, the Harris County Flood Control District (HCFCD), Montgomery County, City of Houston, and San Jacinto River Authority (SJRA) initiated the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP). This plan was the first comprehensive regional study of the upper watershed. The primary objectives of this study were to identify existing flood risks within the upper San Jacinto River basin, including Lake Houston, and evaluate flood risk reduction alternatives on a regional scale. The study identified 25 flood mitigation projects along major streams and recommended 16 for future implementation based on their cost-effectiveness, benefits, and feasibility. The recommended projects are shown in Figure 2-1.

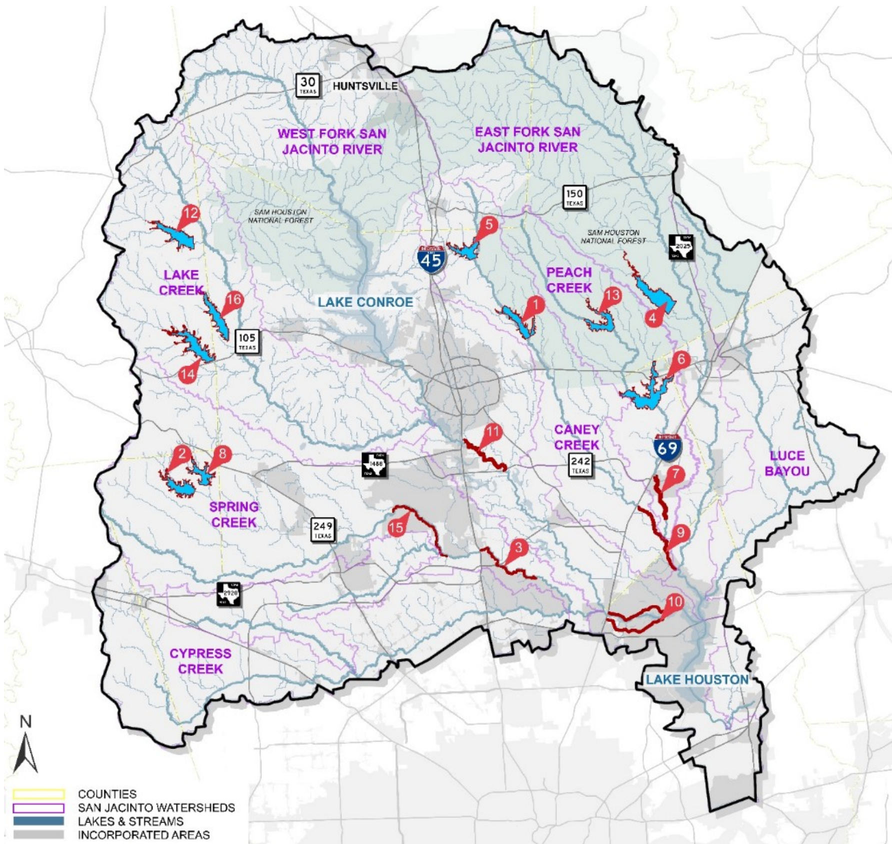


Figure 2-1 San Jacinto River Watershed Recommended Project Locations

A sub-task of the master plan involved identifying locations for regional detention within the Spring Creek watershed, leading to the recommendations for regional detention basins on Walnut and Birch Creeks. These proposed projects aim to reduce flooding along Spring Creek and provide mitigation volume for recommended future conveyance improvement projects. The recommendations for the Spring Creek watershed are shown in Figure 2-2.

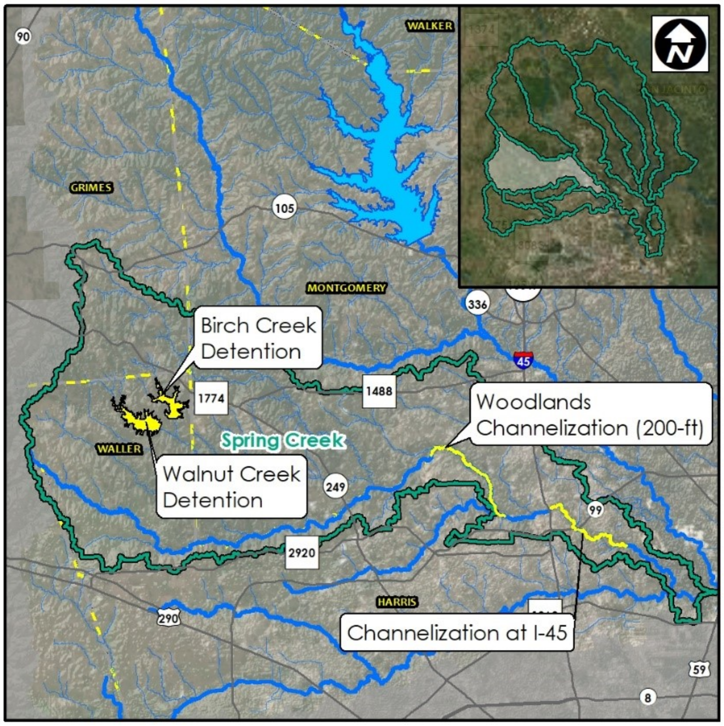


Figure 2-2 Spring Creek Watershed Recommended Project Locations (SJRWMDP)

The proposed Walnut Creek and Birch Creek detention basins were prioritized for implementation within the master drainage plan due to their substantial benefits and apparent land availability. Stakeholders within the watershed championed these projects, advancing them to the next phase of conceptual engineering by applying for and receiving a grant from the Texas Water Development Board (TWDB). This phase of study is intended to provide additional detail on the project extents, dam configuration, as well as the benefits and cost of each project.

2.1 Key stakeholders

This conceptual engineering feasibility study is funded by a grant from the Flood Infrastructure Fund (FIF), administered by the TWDB, as authorized by the 86th Texas Legislature and approved by Texas voters through a constitutional amendment in November 2019. The local partners associated with this study included:

- Harris County Flood Control District
- City of Humble
- The Woodlands Municipal Utility District No. 1
- Montgomery County Municipal Utility District No. 7
- Montgomery County Municipal Utility District No. 46
- Montgomery County Municipal Utility District No. 60
- Harris-Montgomery Counties Municipal Utility District No. 386

The San Jacinto River Authority managed and provided in-kind services towards the project. Other entities in the region within the benefit area for the projects include Montgomery County, Waller County, Harris County, City of Tomball, and the Woodlands Township. Coordination with these entities will likely be needed in future project phases for full project implementation.

2.2 Study area

Spring Creek forms a boundary between Harris County, Montgomery County, and Waller County and serves over 300 square miles of drainage area before merging with the West Fork San Jacinto River just upstream of Lake Houston. The creek retains a natural state, featuring a meandering low flow channel along with an expansive and densely vegetated floodplain and ranges between 203 and 37 feet in elevation. Spring Creek also acts as the outfall for both the Willow Creek and Cypress Creek watersheds prior to its confluence with the West Fork. Most of the drainage area lies within Montgomery County and includes four major tributaries: Threemile Creek, Walnut Creek, Mill Creek, and Panther Branch.

Figure 2-3 Spring Creek channel downstream of I-45

The watershed has experienced rapid development due to the northward expansion of the Houston metropolitan area in recent decades. The eastern portion of the watershed, primarily encompassing areas within Spring and The Woodlands, is predominantly developed. The Woodlands spans most of the Panther Branch watershed and consists mainly of residential properties. Key features include Lake Woodlands and Bear Branch Reservoir, which serve as regional detention for the township. The Magnolia area within the Mill Creek watershed is undergoing significant growth, along with the City of Tomball and its surrounding areas, which directly drain to Spring Creek. Development within the Walnut Creek, Birch Creek, and Threemile Creek watersheds remains relatively sparse but is expanding rapidly under considerable growth pressure in Waller County. Several large lot subdivisions exist along Riley Road, Joseph Road, and FM 1488.

The watershed has a documented history of flooding in recent decades, including the severe 1994 flood that recorded the highest elevation within the creek, Hurricane Harvey resulting in over 28 inches of rainfall within the watershed, and consecutive years of flooding during the Memorial Day 2015 and Tax Day 2016 events.

Figure 2-4 Spring Creek at I-45 During Hurricane Harvey

Comprehensive modeling for this study encompassed the entire watershed, including the major tributaries of Threemile Creek, Walnut Creek, Birch Creek, Mill Creek, and Panther Creek. This study was conducted within the boundary of HUC 10-1204010202. The entire study extents are illustrated in Exhibit 1 and Figure 2-5 below.

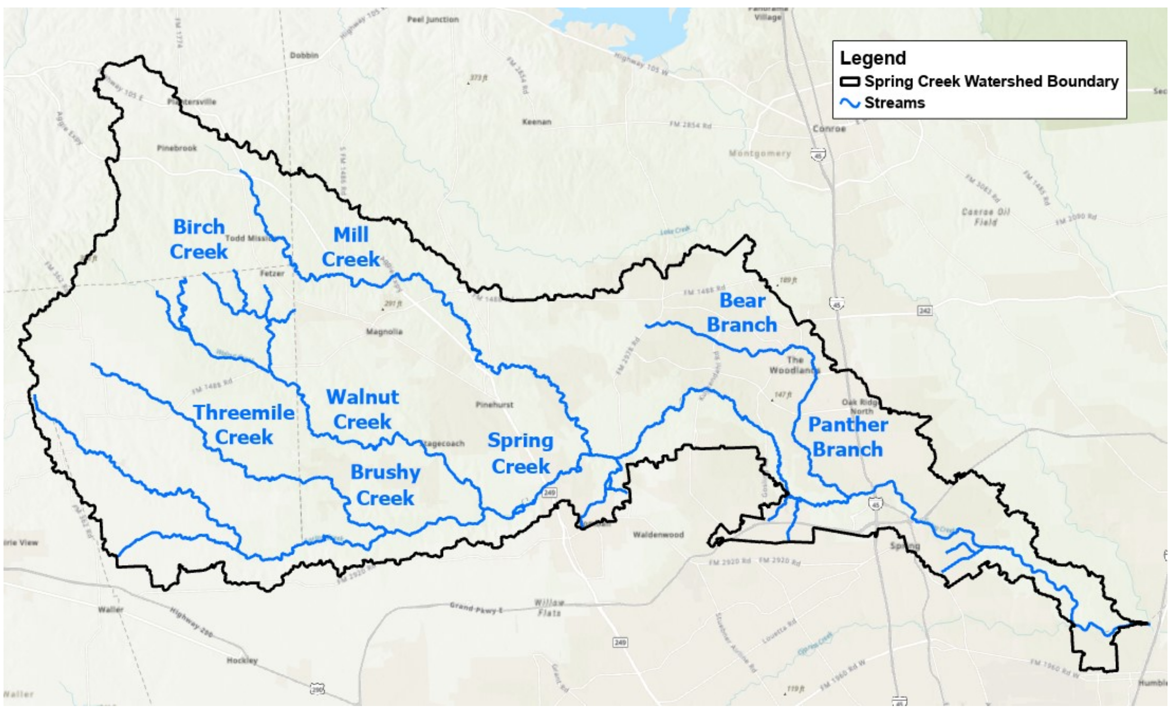


Figure 2-5: Spring Creek Watershed Overview

2.2.1 Proposed Walnut Creek detention basin

The Walnut Creek watershed consists of approximately 75 square miles within both Waller and Montgomery Counties before flowing into Spring Creek just upstream of SH 249. The proposed detention basin will impound floodwaters on Walnut Creek by constructing a dam located 0.6 miles upstream of FM 1488. The maximum area inundated by the detention basin from the SJRWMDP was proposed to be approximately 1,490 acres and benefited over 9,000 structures.

During the study, a large solar farm was constructed onsite that covers a portion of the proposed basin. Other land use within the basin footprint includes undeveloped land as well as rural and large residential lots. A location map for the proposed detention basin is included in Figure 2-6.

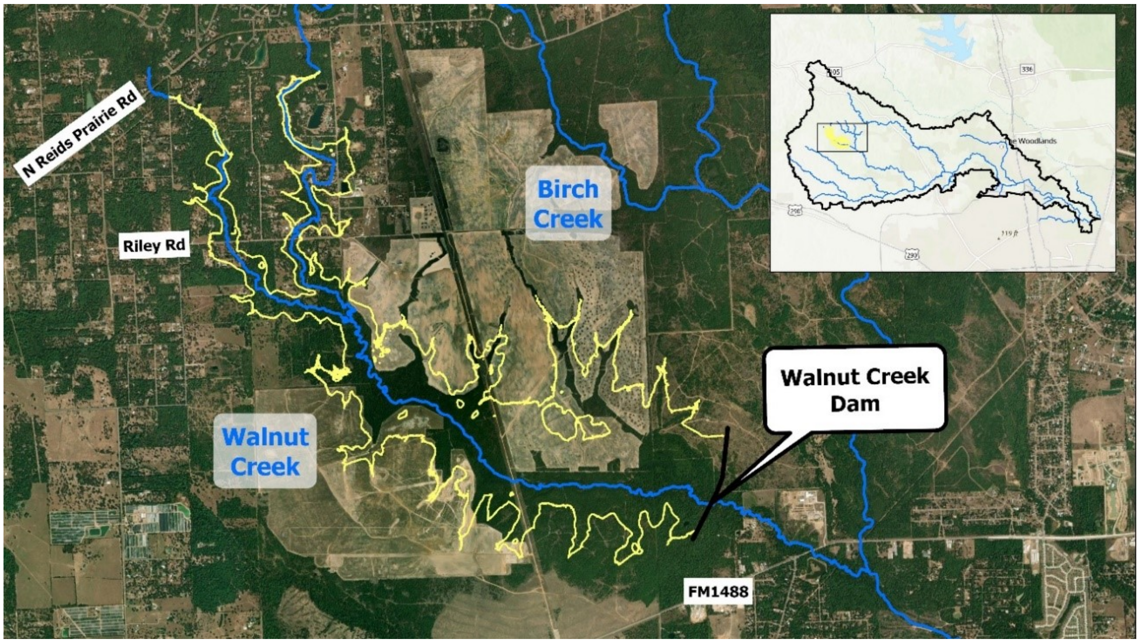


Figure 2-6: Location of Proposed Walnut Creek Detention Basin

2.2.2 Proposed Birch Creek detention basin

The Birch Creek watershed consists of approximately 15 square miles within both Waller and Grimes Counties before flowing into Walnut Creek just downstream of FM 1488. The detention basin will impound floodwaters on Birch Creek by constructing a dam located 1.2 miles upstream of FM 1488. The maximum area inundated by the detention basin from the SJRWMDP was proposed to be approximately 1,060 acres and benefited over 9,000 structures. Most of the land within the basin footprint is undeveloped or rural lots. Residential development has begun construction in portions of the study area. A location map for the proposed detention basin is included in Figure 2-7.

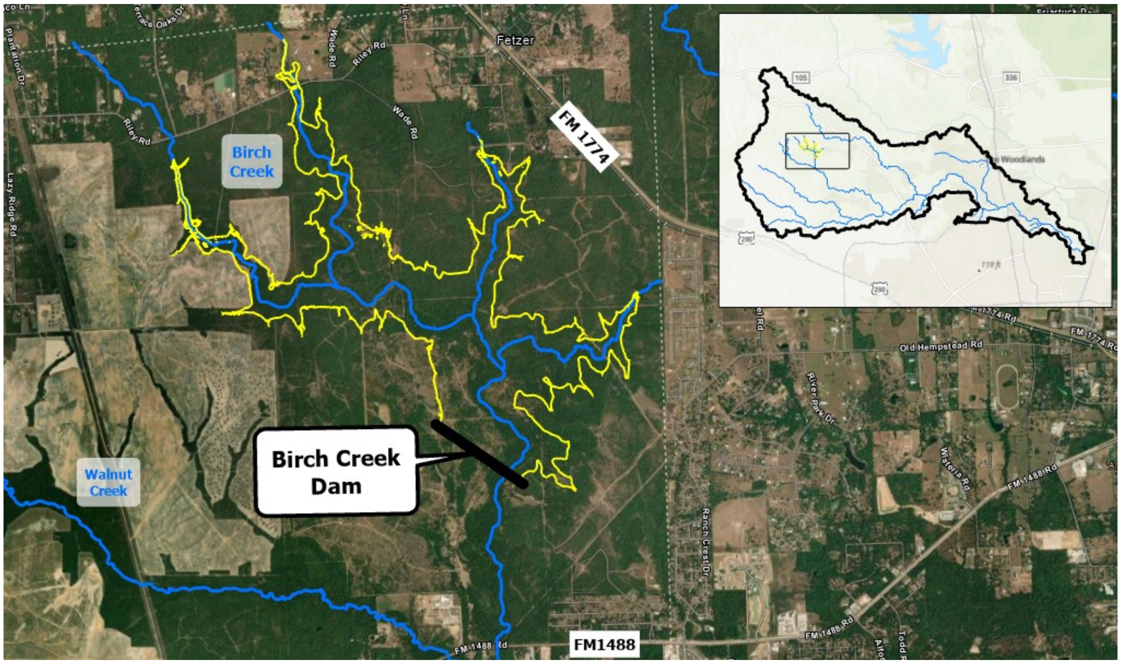


Figure 2-7: Location of Birch Creek Dam

2.3 Study goals

The objective of this study was to further assess the feasibility for each of the two sites as potential detention basins. It also aims to further identify benefits and costs to determine the most feasible and economical projects for future implementation. Specific tasks include the following:

- Performing environmental due diligence to assess any potential environmental issues with the proposed sites and adjust the recommended locations as necessary. Environmental investigations included desktop wetlands assessment, cultural resources survey, pre-application meeting with the USACE, and development of environmental mitigation costs.
- Performing a geotechnical analysis along the FM1488 right of way to obtain information regarding soil properties for the conceptual design of the dam embankment. This area was chosen due to the proximity to the sites as well as accessibility since the sites were on private land.
- Assessing the conceptual design of the dams required for the detention basins. Conceptual design included the assessment of the dam features including the alignment, embankment type, spillway configuration, and total storage.
- Developing an opinion of probable project costs for each detention basin including the embankment, spillway, land, environmental, and utility costs. Cost will also include operations and maintenance as well as financing over a 30-year period.
- Conducting a hydraulic analysis for the two detention basins to quantify the flow and water surface elevation benefits for the basins.
- Conducting a benefit cost analysis for the project utilizing the total construction and financing cost as well as all potential benefits utilizing the latest FEMA BCA toolkit.
- Conducting three public engagement meetings to present the project scope, initial layout of the proposed projects, and a final summary meeting of the findings of the project.

3 Project coordination and outreach

Coordination occurred throughout the project to engage the project stakeholders as well as receive feedback from both impacted and benefited residents. These took place in the form of workshops, project coordination, and public meetings.

3.1 Project coordination meetings

Around 15 coordination meetings occurred with the primary project partners to discuss project status and provide/gather input on the goals and product of the study. Several project workshops were held that included discussion of the updates to the hydrologic and hydraulic analysis, dam design recommendations, and potential project hurdles such as coordination with large landowners within the proposed basin footprint.

3.2 Website

Coordination with the public was performed throughout the feasibility study through an active website describing the project scope, status, and schedule as well as public meetings held during different phases of the project.

The project website (springcreekstudy.com) keeps the public informed of the overall project scope, the project schedule, initial and final findings, and study recommendations. It also provided an avenue for the public to provide input on the study and submit questions or comments. The website was updated as changes to the schedule and project status occurred.

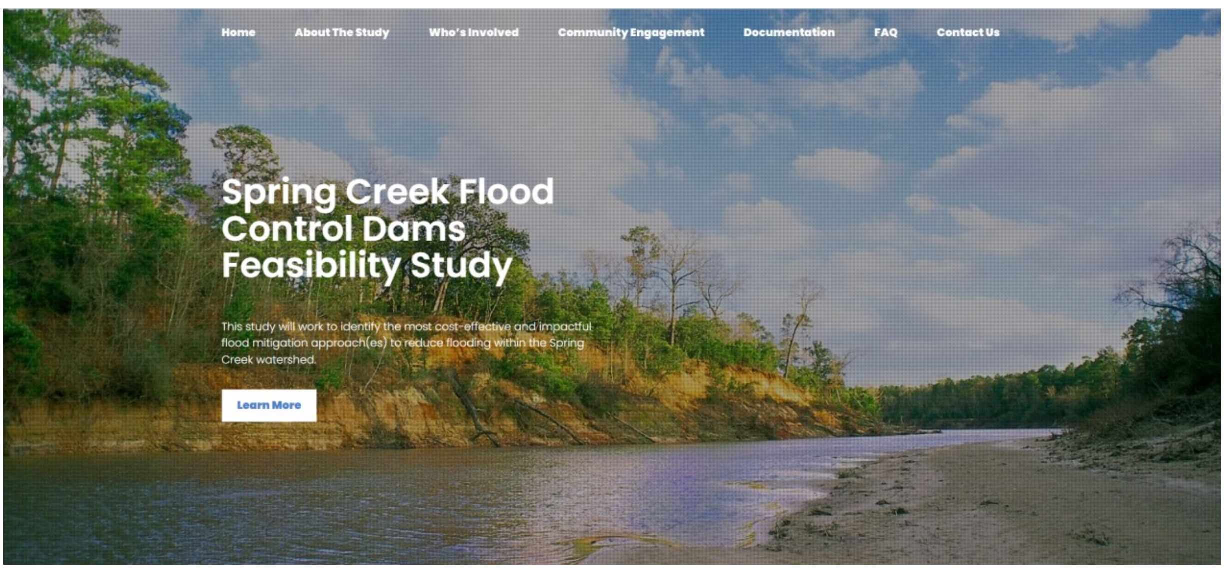


Figure 3-1 Project Website

3.3 Public meetings

The first public meeting was held on April 7, 2022, in Waller County. The meeting provided an overview of the project goals, scope of work, and background on the recommended detention basin layouts. Meeting attendees consisted primarily of local landowners that would be impacted by the project. General public comments pertained to the extents of the project in relation to the landowner's property and the need for the proposed detention basins within Waller County.

Figure 3-2 Public Meeting in Waller County (April 7, 2022)

The second public meeting was held on May 2, 2023 in The Woodlands. The meeting provided an update to the project regarding the optimization of the basin footprints, cost, and downstream benefits. The meeting was attended by landowners from the downstream areas on Spring Creek that would benefit from the project and local landowners that would be impacted by the project. Public comments included a mix of support for the facilities due to the downstream benefits and concern for the extents of the project in relation to the landowner's property. Some upstream owners were concerned about the use of their property for the detention basins.

Figure 3-3 Public Meeting in the Woodlands (May 2, 2023)

A third round of public meetings were held in April 2025. The meetings presented the findings and recommendations of the feasibility study with meetings in Waller County and The Woodlands. Attendees included both upstream and downstream residents which expressed interest in the timing of the projects, next steps, and information regarding the proposed detention basins. Exhibits were provided to residents that showed the structures that would benefit from the projects, a conceptual layout of the dam structures, and detailed figures of the inundation limits.

Public comments are included in Appendix E.

3.4 Landowner coordination

The proposed basin footprints would require acquisition of large tracts of land within Waller County. Early in the study, the SJRA reached out to the existing landowners to discuss the potential for coordination for use of the property. Conversations were held with large property holders to gage interest in providing support for the proposed projects.

4 Conceptual design

The basin configurations as proposed in the master planning effort were adjusted to account for potential soil conditions, iterations of the spillway and outlet structure, alignment of the embankment, and potential configuration of the embankment section. These considerations provided additional detail for a revised cost estimate and included conceptual schematics of the proposed dams. The full conceptual design analysis is included as Appendix B.

4.1 Alignment options

Dam alignments for the proposed dams were evaluated and optimized considering (1) the amount of soil borrow/fill required, (2) impacts to detention basin maximum storage, and (3) environmental permitting implications. The recommended alignments minimize the stream impacts outside the project site, tie into the surrounding topography, and maintain downstream flood benefits. The Walnut and Birch Creek alignment options are shown in Figure 4-1. Alternative 2 alignment was recommended for Walnut Creek as this alignment minimized the environmental stream impacts while maintaining the upstream volume. Alternative 3 for Birch Creek was recommended due to the reduction in fill material as well as the minimization of environmental stream impacts.

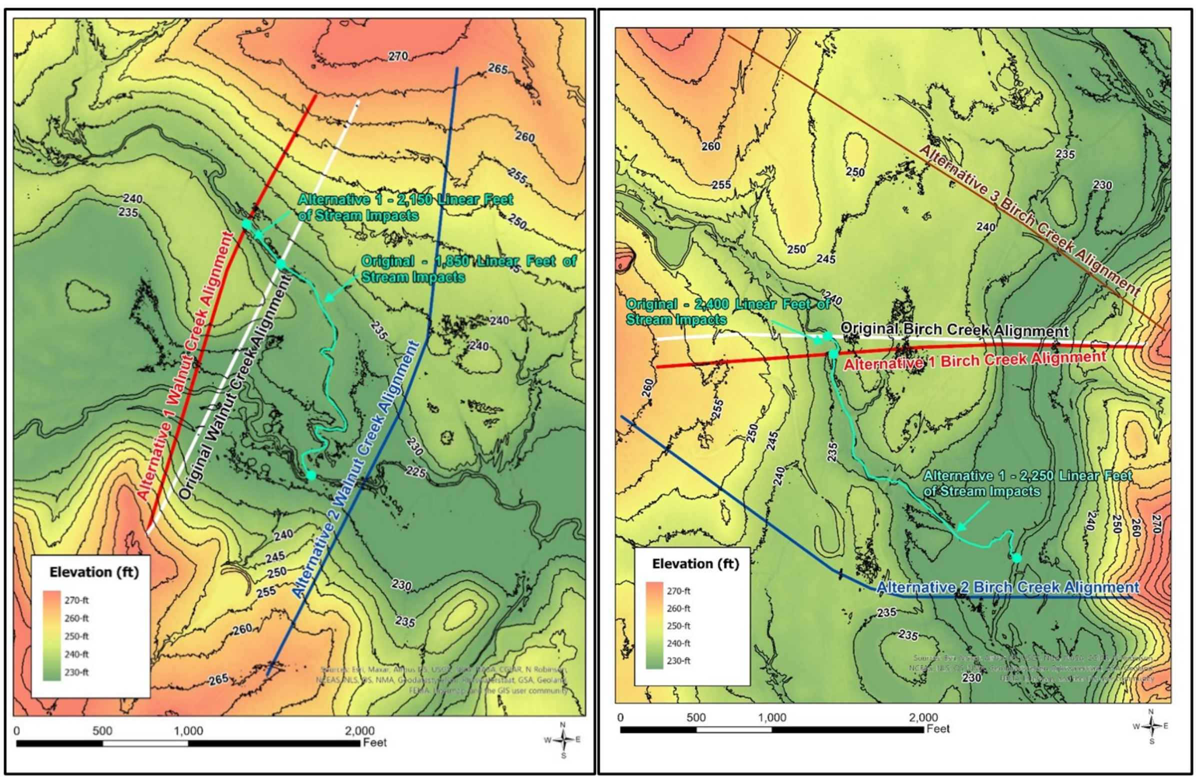


Figure 4-1 Walnut Creek (left) and Birch Creek (right) Dam Alignment Options

4.2 Hazard classification and freeboard

Based on the lidar data, the maximum capacities including all volume to the top of dam of the proposed Walnut and Birch Creek Dams are approximately 13,000 acre-feet and 9,000 acre-feet, respectively. This classifies the dams as intermediate sized dams per 30 Texas Administrative

Code (TAC) §299.13. The design flood for proposed high-hazard intermediate sized dams is interpolated from 75% to 100% of the PMF based on the maximum capacity of the dam. Assuming high-hazard classifications, 30 TAC §299.14 indicates design flood events of 83% and 80% of the Probable Maximum Flood (PMF) for the proposed Walnut and Birch Creek Dams, respectively. For simplicity, subsequent spillway design calculations assumed design flood events of 83% of the PMF for both dams.

Wave run-up heights were calculated for the proposed dams. The proposed dams will experience wave heights up to 1.5 feet with water surface elevations near the maximum water surface. As such, a 2-foot freeboard is sufficient for the proposed dams.

4.3 Spillway design

The spillway design objectives for both dams included the following:

- The spillway configuration should have appropriate freeboard during its design flood.
- Both dams should target volumes during the 1% ACE flood event to reduce discharges in Spring Creek.
- The auxiliary spillway crest elevation should be set at the peak 1% ACE flood level.
- The associated energy dissipation basin should be sized appropriately.

The proposed spillway configuration consists of a concrete structure positioned at the centerline of the stream. The concrete structure includes an ogee crested weir with a crest elevation at the 1% ACE elevation, with a single rectangular concrete conduit along the streambed. The combined concrete structure allows the ogee spillway and conduit to share a common energy dissipation basin. The conduit for each dam would detain the 1% ACE event prior to engaging the ogee weir, with the ogee weir functioning as the auxiliary spillway. Although a sharp crested weir was considered, it is less hydraulically efficient than the ogee crested weir and requires more weir length to pass the design flood. Additionally, a large single conduit (rather than multiple small conduits) was recommended to mitigate potential debris obstruction. Debris can pass more freely through the larger single conduit compared to multiple smaller conduits. An example of the ogee spillway and conduit structure configuration is shown in Figure 4-2.

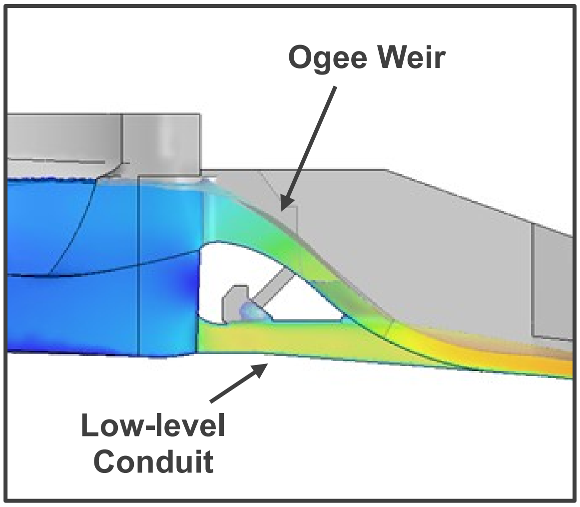


Figure 4-2 General Spillway and Conduit Configuration

The auxiliary spillway and conduit configurations at both dams were initially sized using HEC-HMS, Version 4.12 and then later confirmed as part of the overall hydrologic and hydraulic analysis. Design iterations were conducted to optimize the total required spillway length for both dams, thereby reducing the total project cost estimate. The recommended design parameters are shown in Table 4-1.

Table 4-1 Recommended Dam Hydraulic Design Configuration

Description	Walnut Creek	Birch Creek	Units
Top of Dam	263.6	259.1	ft
Peak 100 Year WSE (Water Surface Elevation)	254.7	251.2	ft-msl[1]
Peak 100 Year Discharge	2,700	2,300	cfs
PMF WSE	261.6	257.1	ft-msl
Opening Invert (also streambed)	224.5	223.7	ft-msl
Opening Size	6-ft by 17-ft	6-ft by 16-ft	Rise (ft) x Span (ft)
Ogee Spillway Control Elevation	254.7	251.2	ft-msl
Ogee Spillway Length	175	175	ft
Energy Dissipation Basin Lengths	45	35	ft

[1] Mean sea level

The energy dissipation basin configurations at both dams were designed in adherence with the Bureau of Reclamation Design of Small Dams guidance. The hydrologic and hydraulic conditions at both dams allow for the adoption of the Type III basin, shown in Figure 4-3. The Type III basin uses chute blocks, impact baffle blocks, and an end sill to shorten the jump length and dissipate the high-velocity flow within a shortened basin length. Shortening the hydraulic jump length means that flow transitions from supercritical to subcritical flow over a shorter longitudinal distance, in effect allowing for a shorter and smaller concrete energy dissipation basin. The basin relies on dissipation of energy by the impact blocks and on turbulence of the jump for its effectiveness. The Type III basin is recommended to shorten the jump length and, consequently, the footprint of the energy dissipation basin, thereby reducing the total project cost estimate.

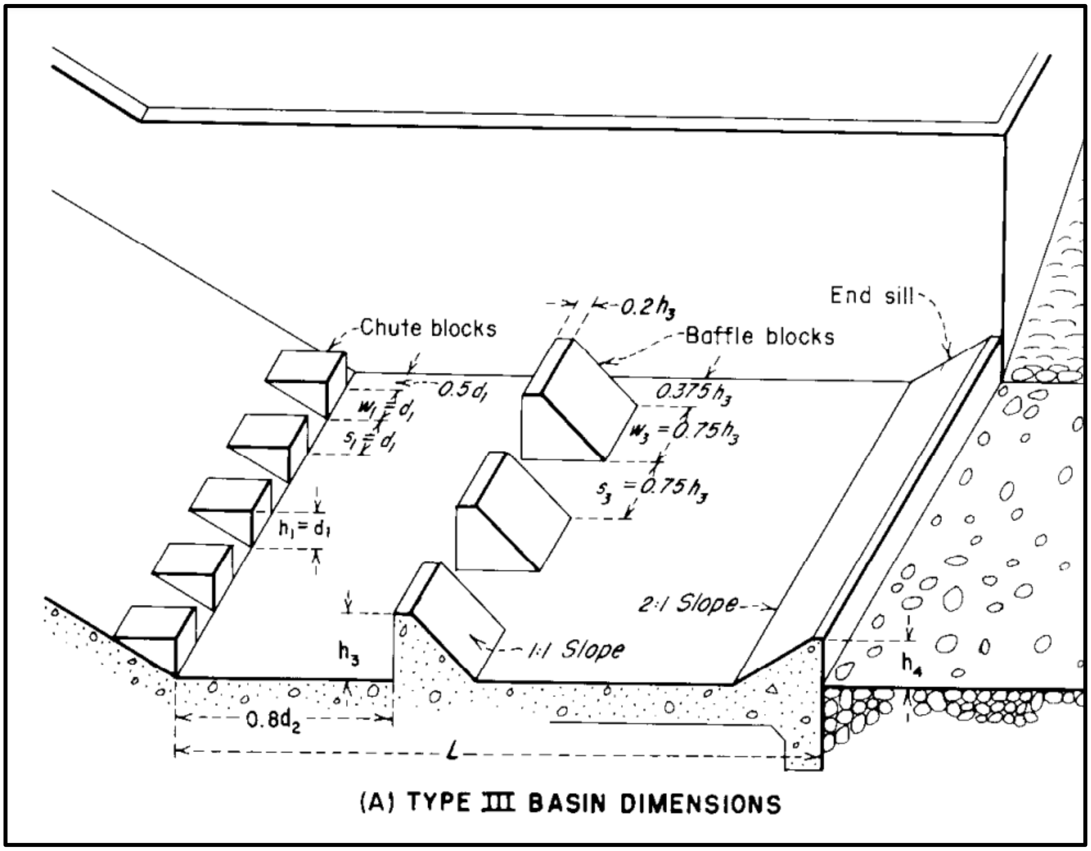


Figure 4-3 General Energy Dissipation Basin Configuration

Notably, five assumptions were used in the spillway design. They should be considered within future calculations and recommendations:

- Item 1: The analysis assumes fixed tailwater levels at the peak 100-year event during the 100-year routing event and at the peak 500-year event during the PMF event, rather than a discharge-tailwater curve. Future hydrologic analysis should be conducted to develop detailed flow-tailwater rating curves, which could reduce the sizes of the conduits required at both dams.
- Item 2: A constant ogee weir coefficient of 3.94 is used for all heads.
- Item 3: Current assumptions are conservative, using the 500-year event tailwater level for the energy dissipation basin calculations.
- Item 4: Erosion protection calculations downstream of the energy dissipation basin were not conducted.
- Item 5: Hydrologic and hydraulic calculations are needed to size a potential pilot channel upstream and downstream of the concrete opening.

The assumptions lean conservative for the purpose of this conceptual analysis. As such, future design calculations may reduce spillway sizes and/or shorten energy dissipation basin lengths. Recommended future calculations include rock riprap erosion protection calculations downstream of the energy dissipation basin, pilot channel sizing, and more detailed hydraulic modeling of the spillway configuration.

4.4 Geotechnical investigation

To support the design of the dams, field exploration and laboratory testing was performed. As the sites were inaccessible at the time of exploration, four standard penetration test borings were performed in a publicly accessible area approximately 1 mile downstream of the project site along FM 1488. Based on this investigation, it was found that the subsurface soils comprised of silty sands (SM), sandy lean clays (CL), clayey sands (SC), poorly graded sand with silt (SP-SM), sandy fat clay (CH), silty clay with sand (CL-ML), and silty clayey sand (SC-SM). Additional soil parameters, including total unit weight, soil permeability, undrained strength, drained strength, and soil dispersity, were obtained to support the embankment design. Generally, the soils are of medium plasticity and indicate a potential for dispersive behavior. The soils have relatively low permeability between 10^{-10} and 10^{-9} ft/s and are generally acceptable as fill material of 20% to 40% fines. Since physical access to the sites was not allowed, the borings were not taken in the project site vicinity.

4.5 Embankment design

Three embankment geometry concepts were considered for the project sites and have been analyzed for seepage and stability. The differences between each concept were based on type of seepage control and embankment internal zonation. The external configuration of the dam is the same for all three alternative options.

The general configurations of the dams are as follows. The upstream and downstream side slopes are 3.5:1 H:V and 3:1 H:V, respectively. A 3-foot-thick riprap layer was considered for the upstream face wave protection, and the downstream slope will be vegetated with grass. Both slope faces were considered to have 20 foot wide top-of-bench stability berms. The berms are flat areas along the embankment slopes that improve stability and reduce erosion. A gravel vehicular road, which will be located on the crest of the embankment and may include a vehicular turnaround on the crest , is anticipated to be used for dam operations, inspections, and maintenance.

The following are key features considered for the three alternative embankments, based on analyses completed to date:

- Upstream and downstream berms are included for all three alternative embankments for structural stability and to accommodate anticipated frequent drawdown on upstream slope face.
- Filter and drainage system is included in all three alternative embankments for erosion control based on the assumption that on-site borrow sources may exhibit potential for dispersion.
- Foundation seepage barriers are included in all three alternatives for embankment under-seepage control based on the assumption that pervious foundation materials will be encountered.
- An impervious core is included in Alternative 2 for seepage control based on the assumption that pervious on-situ borrow sources may be used as embankment shell fills.

The following three embankments were considered:

- Alternative 1 embankment geometry concept consists of a homogenous material of an acceptable permeability, a cutoff trench and sheet pile wall, and a chimney filter and blanket drain.
- Alternative 2 embankment geometry adds an impervious clay core with a filter aligned on the downstream face of the core. The foundation treatment against excessive seepage is similar to those of Alternative 1.
- Alternative 3 embankment geometry is similar to Alternative 1, but with a soil-bentonite cutoff wall foundation seepage barrier in place of the cutoff trench and sheet pile wall.

A schematic of the recommended Alternative 1 embankment configuration is presented as Figure 4-4. The other configurations are provided in Appendix B.

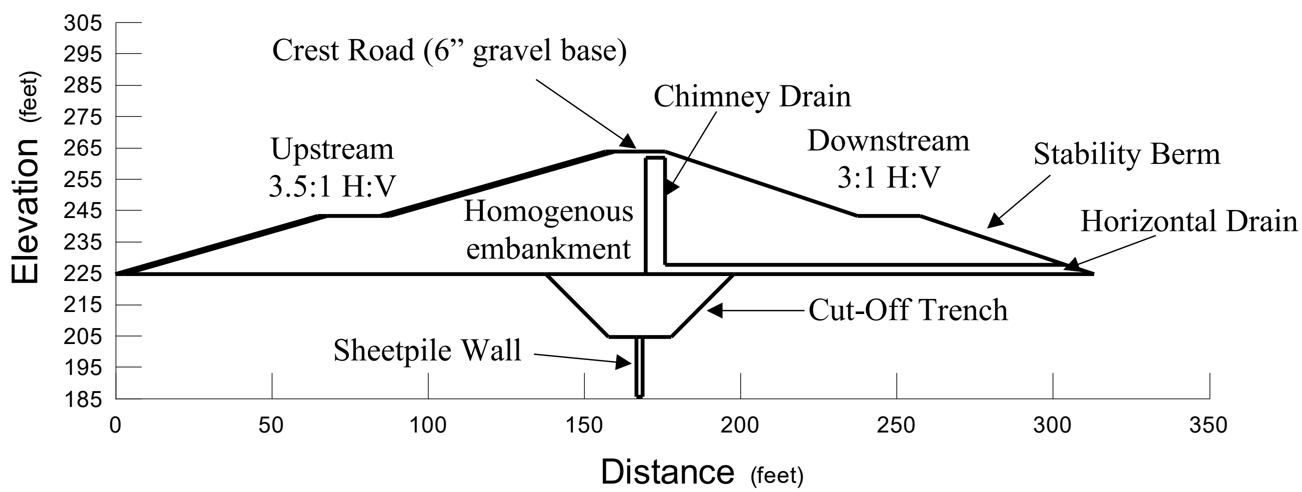


Figure 4-4 Alternative 1 Embankment Configuration

A summary of the design values for the alternative embankment sections, based on the seepage and slope stability analyses, is presented as Table 4-2. Plans and profiles of the sections are presented in Appendix B. It is anticipated that the embankment alternative selected for advanced design will be further developed during design advancement based on site-specific geotechnical investigations to incorporate settlement and other required analyses for the embankment sections.

Table 4-2 Key Embankment Features

Description	Walnut Creek	Birch Creek	Units
Feature	Walnut Creek Embankment Section Design Value	Birch Creek Embankment Section Design Value	
Length	3,373	3,168	feet
Maximum Height	39.1	35.4	feet
Design Crest Width	16	16	feet
Design Crest Elevation[1]	263.6	259.1	feet
Typical Upstream Slope	3.5H:1V	3.5H:1V	—
Typical Downstream Slope	3H:1V	3H:1V	—

[1]Elevation does not include allowance for settlement; settlement will be evaluated during design advancement and added to the design crest elevation. The US Bureau of Reclamation recommends 1% of maximum embankment height for preliminary camber design to account for potential settlement of the embankment fill.

Static deformation analysis (settlement, cracking) will be performed during the detailed design phase. The anticipated quantities of required import fill for Alternative 2 and specialized construction for Alternative 3 may present increased construction cost and permitting issues and construction complexities for the project. Due to the primary function of the project as dry detention dams, a zoned embankment with an impervious core (Alternative 2) may not be economical or critical to the safe operation of the dam.

Based on the preliminary site information and evaluation, Alternative 1, which consists of a homogenous material of an acceptable permeability, a cutoff trench and sheet pile wall, and a chimney filter and blanket drain, was recommended to be best suited among the three alternatives presented.

5 Environmental due diligence

A desktop assessment was conducted to identify environmental considerations for the next design phase. These include delineating potential waters of the U.S. (WOTUS), assessing threatened and endangered species (T&E), evaluating aquatic resources, and reviewing cultural resources. The full environmental findings and recommendations are included as Appendix A.

5.1 Waters of the United States

Halff conducted a desktop wetland assessment to identify the presence, location, and extent of potential waters of the U.S. within the project area and any associated potential environmental permitting requirements. According to the U.S. Army Corps of Engineers (USACE), waters of the U.S. include territorial seas, tidal waters, traditional navigable waters, interstate waters, and the adjacent, contributing, or impoundments of these waterbodies (e.g., rivers, creeks, streams, lakes, reservoirs). Special aquatic sites associated with these waterbodies are also considered waters of the U.S. and include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes.

Wetlands are typically the most common special aquatic resources present and are defined by the USACE as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (40 Code of Federal Regulations [CFR] 230.3(t)). Based on this definition, for an area to be considered a wetland it must possess the following three parameters under normal circumstances: 1) a predominance of plants adapted to live in water or saturated soils (i.e., hydrophytic vegetation), 2) soil characteristics of frequent saturation (i.e., hydric soils), and 3) the presence of hydrology showing evidence of regular flooding or ponding (i.e., wetland hydrology).

These cannot be accurately assessed without field work; however, publicly available data may provide a reasonable estimate of aquatic resources. Halff reviewed historic aerial photography (Google Earth 2024), U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) data (USFWS 2024), U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) data (USGS 2024), USGS topographic quadrangles (USGS 2023), and the most recent Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) data (FEMA 2019). The project area is defined by the parcels containing the sub-watersheds of Birch Creek and Walnut Creek, focusing primarily on the areas that may be inundated during flood events.

5.1.1 Walnut Creek

NWI wetlands intersecting the proposed Walnut Creek dam alignment include two PFO1A (temporarily flooded forested wetlands), one PFO1C (seasonally flooded forested wetland), and one PSS1C (seasonally flooded scrub-shrub wetlands) in addition to two streams (Walnut Creek and an unnamed tributary) identified in the NHD. The current dam alignment has a maximum length of 3,373 feet and would require placement of fill over approximately 12.0 acres (including 3.5 acres of wetlands), excluding access roads, laydown areas, or other appurtenances. In addition to the direct construction impacts, the planned flood detention reservoir on Walnut Creek may potentially cause temporary flooding of approximately 49.3 acres of NWI wetlands within the 500-year flood plain upstream of the dam alignment. Flooding these NWI wetlands may increase their hydroperiod but would likely not be considered a loss of these resources under Section 404 of the Clean Water Act (Section 404). Furthermore, any additional flooded areas upstream are unlikely to be inundated or saturated for a hydroperiod sufficient to result in creating additional jurisdictional aquatic features. Areas downstream of the dam may experience reduced hydrologic input, which may cause reduced aquatic functions.

According to the NHD and NWI, the proposed dam alignment will potentially impact an approximately 295-foot stream segment of Walnut Creek. Collectively, the Walnut Creek dam watershed includes approximately 15,296 linear feet of streams within the 0.2% ACE floodplain upstream of the proposed dam. Assuming that the project would not lead to permanent inundation, the stream reaches upstream of the dam would not be impacted.

5.1.2 Birch Creek

Potentially impacted NWI wetlands associated with the proposed dam alignment on Birch Creek include one PFO1A and one PFO1C. The current dam alignment has a maximum length of 3,168 feet and would require placement of fill over approximately 8.7 acres (including 0.9 acre of wetlands), excluding access roads, laydown areas, or other appurtenances. The planned flood detention basin on Birch Creek may potentially cause temporary flooding of approximately 50.7 acres of NWI wetlands within the 500-year flood plain upstream of the dam alignment. As with Walnut Creek, flooding these NWI wetlands may increase their hydroperiod but would likely not be considered a loss of these resources under Section 404. Furthermore, any additional flooded areas upstream are unlikely to be inundated or saturated for a hydroperiod sufficient to result in creating additional jurisdictional aquatic features. As with the Walnut Creek dam, areas downstream of the dam may experience reduced hydrologic input, which may cause reduced aquatic functions.

The NHD and NWI identify Birch Creek as the lone waterbody that would be directly impacted by the dam’s 267-foot crossing of the stream reach. Collectively, the Birch Creek detention basin watershed includes approximately 12,764 linear feet of streams within 0.2% ACE floodplain upstream of the proposed dam. Assuming that the project would not lead to permanent inundation, the stream reaches upstream of the dam would not be impacted.

5.2 Protected Species Assessment

Halff conducted a desktop assessment of federally and state protected species (i.e., threatened and endangered species, migratory birds, and bald and golden eagle) for the proposed project to determine which protected species are associated with the potential work areas and identify what permitting tasks may be required for the project. Halff drew data from the following resources:

- Mussels of Texas Project Database
- National Hydrography Dataset (NHD)
- National Wetland Inventory (NWI)
- TPWD Ecological Mapping Systems of Texas (EMST) and Rare, Threatened, and Endangered Species of Texas (RTEST) list
- USFWS IPaC and Environmental Conservation Online System (ECOS)
- United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Web Soil Survey

- U.S. Geological Survey (USGS) Texas Geologic Database

Habitat conditions within the study area were characterized using the Texas Geologic Map Database, Web Soil Survey, and EMST. The IPaC provides information on federally managed resources to streamline the environmental review process by generating an official species list based on the location in which the project occurs. The official species list identifies federally listed threatened and endangered species, proposed to be listed species, candidate species, and designated critical habitat that may occur within the boundary of the study area and/or may be affected by the project. This information is used to evaluate suitable habitat within the study area and potential environmental impacts that may result from the proposed project. Additionally, the RTEST by County generates information regarding potential occurrence of federally and state protected species and Species of Greatest Conservation Need (SGCN) on a county level.

The above resources identify listed species whose known ranges could extend into the study area, provide requisite habitat descriptions, and identify if USFWS-designated critical habitat exists within the vicinity. Potential for the proposed project to affect species listed by the USFWS under the ESA was evaluated by publicly available data compared to the study area's habitat conditions and project plans.

Based on our desktop assessment of the study area, publicly available data, and suitable habitat descriptions, USFWS identifies five species that are listed as threatened, endangered, proposed to be listed, or candidate species that may occur within the study area. TPWD's RTEST provides a more liberal species assessment that includes the potential for eleven federally protected species in addition to nineteen state listed species. In addition, several migratory birds were identified within the project area.

5.3 Permitting tasks

To determine permitting needs, formal field services including wetland delineation, threatened and endangered species assessment, aquatic resource functional assessment, cultural resource assessment, and environmental site assessment are necessary in future design phases. Wetland delineation will quantify aquatic features and identify what USACE permits are necessary. Assuming that impacts to aquatic resources are not negligible, the aquatic resource assessments calculate functional values for stream and wetland impacts requiring compensatory mitigation under the USACE permit. Functional assessments are calculated based on the aquatic resource's pre- and post-construction conditions to determine the degree to which ecological functions will be degraded by the project. The threatened and endangered species assessment will evaluate potential impacts to protected species and identify methods for mitigating take to the species. The cultural resource assessments will review historic properties and coordinate those findings with the appropriate state and federal agencies. Finally, environmental site assessments will ensure the project does not result in CERCLA liabilities that lead to ongoing concerns for the properties.

Each of these permitting tasks is integral to ensuring the project's compliance with federal, state, and local environmental regulations. Detailed field assessments provide the necessary data to inform the permitting process, ensuring that environmental impacts are accurately quantified and appropriately mitigated. These reports also facilitate communication with regulatory agencies and stakeholders.

5.4 Federal permitting

Based on preliminary discussions with USACE Galveston District staff, the project's scope and potential impacts to waters of the U.S. will require a CWA Section 404 permit and an Environmental Assessment (EA). The EA is a National Environmental Policy Act (NEPA) document that examines the purpose, need, and environmental outcomes of the project to determine whether a full Environmental Impact Statement (EIS) is necessary. The EA will provide a comprehensive analysis of the proposed project, exploring various alternatives and their potential environmental impacts. This process ensures that all feasible mitigation measures are considered and that stakeholders are informed about the project's environmental footprint with the goal of balancing development needs and environmental stewardship.

Approval of an EA would generally be expected to have an approximately 12 to 18-month timeline. Therefore, an EA might extend the typical timeline of a general Section 404 permit by up to 6 months. If a nationwide Section 404 permit is appropriate for the project, the EA might extend the federal permitting process at 6 to 12 months beyond what is typical. Both of these anticipated timelines are initiated at USACE receiving an administratively complete permit application that includes all necessary support documents.

Considering that there are no plans to acquire additional water rights or perform basin excavation, coordination between USACE and Texas agencies (i.e., TCEQ, TPWD) will likely be the extent of state environmental permitting.

Overall, the environmental due diligence process is designed to identify, assess, and mitigate potential environmental impacts of the project. This ensures compliance with regulatory requirements while protecting valuable natural resources.

6 Probable project cost

The project cost analysis included developing Class 4 Opinion of Probable Construction Cost (OPCC) estimates for the detention basins, estimating land costs, screening utilities, and assuming relocation or demolition of infrastructure and buildings. The task also included estimating environmental mitigation costs, annual operations, maintenance, and financing costs over 30 years, plus an additional 20 years without financing. The full cost analysis is included as Appendix C.

6.1 Construction cost

The cost estimate totals for both the Walnut Creek and Birch Creek detention basins are summarized in Table 6-1 and Table 6-2 to include all labor, materials and equipment reflecting the current scope of work as defined by the received documents detailed in Basis of Estimate Section of the Cost Analysis Appendix. The estimates reflect the preliminary nature of the projects, and costs have been derived using a unit cost estimating approach. The cost estimates include a contingency markup based on unknown project site conditions.

Table 6-1 Walnut Creek Construction Cost Estimate Summary (cost rounded)

Description	Cost Estimate
Mobilization	$4,465,200
Demolition and Temporary Measures	$3,419,000
Embankment	$29,333,850
Outlet	$10,970,775
Site Stabilization	$12,091,130
Construction Cost Subtotal	$60,279,955
Total Construction Cost[1]	**$82,884,938**

Table 6-2 Birch Creek Construction Cost Estimate Summary (cost rounded)

Description	Cost Estimate
Mobilization	$3,450,200
Demolition and Temporary Measures	$3,169,500
Embankment	$20,934,950
Outlet	$8,600,450
Site Stabilization	$10,422,100
Construction Cost Subtotal	$46,577,200
Total Construction Cost[1]	**$64,043,650**

[1]Includes 35% contingency and 2.5% for bond and insurance

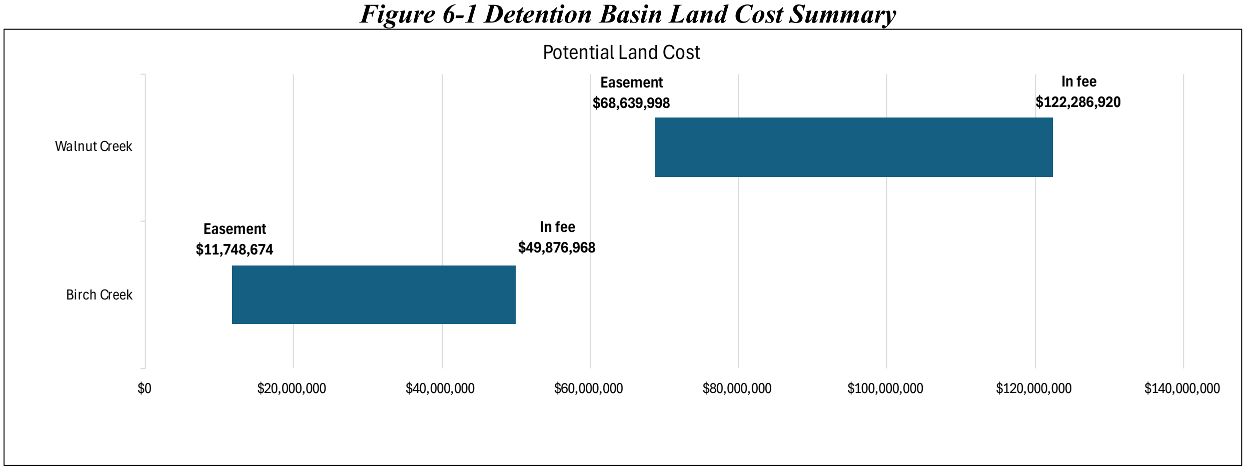
6.2 Land cost

The estimation of land costs for the proposed detention basins on Birch and Walnut Creek involves several key considerations, including land acquisition, purchase types, existing land use, roadway access, and future land use. These factors contribute to the overall costs, which have been evaluated to ensure accurate budgeting for the projects.

For the Walnut Creek detention basin the land acquisition extends up to 1,370 acres, impacting 72 tracts, some of the land may include relocating or retrofitting 880 acres of solar panels costing up to $50 million in addition to land purchases for additional land and relocation of the solar panels. For the Birch Creek detention basin the land acquisition extends up to 920 acres, impacting 19 tracts.

Potential costs for each project will vary depending on individual negotiations with property owners and whether the acquisition will be in fee or as an easement. The range of potential land costs are summarized in Figure 6-1 below.

Figure 6-1 Detention Basin Land Cost Summary



6.3 Utility conflicts and relocations cost

The site review confirmed no utility conflicts with the proposed project, based on the best available data, including the Texas Railroad Commission web viewer. Two large natural gas pipelines cross the site but do not conflict with the proposed alignments. Gas line relocation costs are not included in the construction cost estimate, but if needed, it would be about $3 million per mile per line. Minor overhead utility adjustments may be required at the construction entrance, with costs included in the mobilization estimate. No other utility conflicts were identified, though further coordination with utility providers may be needed during final design and construction.

6.4 Environmental mitigation cost

The Walnut Creek project involves constructing an approximately 3,373-foot-long dam with an approximately 12.0-acre footprint, using fill material from two nearby upland borrow pits. Additionally, it involves construction of approximately 6,160 feet of road improvements and an 17.2-acre temporary construction area. Similarly, the Birch Creek project features an approximately 3,168-foot-long dam with an approximately 8.7-acre footprint, using fill from a 53-acre borrow pit, and includes 7,410 feet of road improvements and the same temporary construction area as that proposed for the Walnut Creek project.

Direct aquatic impacts for the Walnut Creek dam project include 3.5 acres of wetlands and 295 feet of streams. Likewise, the Birch Creek dam project's impacts include 0.9 acre of wetlands and 267 feet of streams. Projected aquatic resource mitigation costs for Walnut Creek may be as much as $2,290,500 for wetlands and streams. Similarly, projected aquatic resource mitigation costs for Birch Creek may be as much $875,700 for wetlands and streams. Considering that there are abundant credits in the area, these estimates are based on primary service area prices. However, should there be insufficient credits at the time of construction, the costs of compensatory aquatic mitigation may increase by 50% or more.

6.5 Total project cost

The total cost to construct each detention basin is influenced by land and easement acquisitions, utility relocations, and environmental requirements. The primary cost driver is the lack of site-specific geotechnical information, which affects assumptions about subsurface conditions, seepage control design, foundation design, and groundwater levels. Annual maintenance costs for dry detention basins are estimated to be approximately 2-5% of the initial construction cost. For this cost analysis, maintenance was assumed to be approximately 3.4%. This percentage accounts for routine activities such as inspections, vegetation management, and minor repairs. Non-routine maintenance, like sediment removal or significant structural repairs, will incur additional costs and should be budgeted for separately.

The total costs for each dam are shown in Table 6-3.

Table 6-3 Detention Basin Total Cost

	Walnut Creek	**Birch Creek**
Construction	$82,884,938	$64,043,650
Engineering[1]	$12,432,740	$9,606,547
Land Acquisition[2]	$95,463,459	$30,812,821
Environmental	$2,290,500	$875,700
Utilities	$0	$0
Total	**$193,071,637**	**$105,338,718**
Annual Maintenance	$2,800,000	$2,100,000

[1] Engineering including geotechnical, survey, design, and construction management is assumed to be 15% of the total construction cost
[2] The 50% mark of the land cost range was used for the total cost estimate

The purpose of this lifecycle cost estimate is to assess the full financial commitment associated with the two projects, including both construction and long-term maintenance costs. The analysis calculates total annual costs over a 50-year project life, which includes 30 years of O&M plus debt service followed by 20 years of continued operations and maintenance. Each project is evaluated independently with its own financing structure and O&M obligations. The results provide a clear, long-range financial outlook to support decision-making and resource planning.

Each project is assumed to be financed independently using a 30-year term loan at a fixed interest rate of 4.00%, which aligns with recent rates available to public entities (e.g., AA-rated municipal bonds). Level debt service is assumed, meaning the same payment is made each year, simplifying long-term financial planning. This structure assumes no refinancing, variable rates, or early payoff. All cost figures are presented in 2025 dollars, with no inflation applied. The debt service amounts are calculated using a standard amortization formula, annual payments over the loan period.

Table 6-4 Project Financing

	Walnut Creek	**Birch Creek**
Construction	**$193,071,637**	**$105,338,718**
Annual Maintenance	$2,800,000	$2,100,000
Debt Service Factor	0.05783	0.05783
Annual Debt Service	$11,165,000	$6,092,000
30-Year Debt Service Total	$334,950,000	$182,760,000
50-Year Operations & Maintenance Total	$140,000,000	$105,000,000
50-Year Lifecycle Cost	**$474,950,000**	**$287,760,000**

7 Hydrology and hydraulics

A hydrologic and hydraulic analysis was performed to size the two detention basins, identify the inundation limits upstream of the dams, and determine the downstream benefits. Hydrology was conducted using HEC-HMS version 4.8 and hydraulics using HEC-RAS version 5.0.7. Details of the hydrology and hydraulic analysis are included in Appendix D.

7.1 Modeling background

The Modeling Assessment & Awareness Project (MAAPnext), led by the Harris County Flood Control District (HCFCD) in partnership with FEMA, involved the development of new modeling and updated floodplain mapping for Harris County's 22 major watersheds, including the Spring Creek watershed. The effort incorporated most current terrain and rainfall data and utilized new hydrologic and hydraulic modeling methodologies to better depict flood risk in the region. This feasibility study leveraged the following HCFCD models and supporting documentation:

- HEC-RAS (v5.0.7) model for the Spring Creek Watershed including simulations for both the frequency and historical storm events including Hurricane Harvey (2017), Memorial Day (2015), and Tax Day (2016).
- HEC-HMS (v4.3) model for the Spring Creek Watershed including simulations for both the frequency and historical storm events

7.2 Hydrology

The HEC-HMS models prepared by the HCFCD were used as the basis to develop runoff hydrographs for the watershed. These models were updated as needed to incorporate the proposed projects. Updates included changes to the drainage basins within the vicinity of the proposed projects as well as parameters associated with the basin changes.

The major update to the hydrology was that drainage areas were subdivided for additional detail near the proposed project sites. The following parameters were revised and recalculated for the subdivided drainage areas.

- Hydrologic losses were calculated using the Green & Ampt method, with adjustments for vegetation using the Canopy Loss Method.
- Impervious cover values were updated based on land use types and recalculated for the subdivided drainage areas.
- The Clark Unit Hydrograph Method was used for hydrograph transformation, with updated time of concentration (Tc) and storage coefficient (R) values.

The HEC-HMS model was simulated for the frequency and historical storm events to develop the peak flows and hydrographs for the updated drainage areas.

7.3 Hydraulics

The HCFCD HEC-RAS model consisted of a 1D/2D representation of the entire watershed. The Spring Creek mainstem was modeled with 1D cross sections for the main channel and 2D zones for the floodplain. Tributaries north of Spring Creek were modeled using 1D cross sections. Tributaries south of Spring Creek, within Harris County, were modeled using combined 1D/2D sections. The HCFCD HEC-RAS model was updated on Birch Creek and Walnut Creek to assess existing conditions and prepare for proposed projects. The following updates were made to the HEC-RAS model:

- The 1D cross sections on the upstream end of Walnut Creek were replaced with a 2D area upstream of FM 1488 to better account for proposed detention basins.
- Hydrographs for drainage areas within the 2D area were added as internal boundary conditions.
- Breaklines were added to outline stream centerlines within the 2D area to match flow patterns.
- Cross sections were extended along Walnut Creek downstream of FM 1488 and cross sections were added on Walnut Creek from FM 1488 to the confluence with Birch Creek.
- An additional structure was added to include the FM 1488 crossing on Walnut Creek.
- 1D/2D Connections were placed at the downstream end of the 2D area to connect with storage areas upstream of Walnut and Birch Creek.

The revised existing conditions model was simulated for two historical storm events and results were compared to ensure the model would provide reasonable results when compared to observed conditions. Table 7-1 below shows the Harvey (2017) observed water surface elevations, as well as discharge and water surface elevations for the HCFCD model and the revised existing conditions model.

Table 7-1 Harvey (2017) WSE and Discharge Comparisons

	SH 249	**FM2978**	**Kuykendahl**	**I-45**
HCFCD Discharge	55,315	80,021	80,522	97,444
Revised Discharge	53,774	75,857	76,638	95,019
HCFCD WSEL	165.61	154.19	141.00	111.19
Revised WSEL	165.37	153.76	140.79	111.81
Observed WSEL	165.08	153.74	140.62	111.40

Table 7-2 below shows the Memorial Day (2016) observed water surface elevations, as well as discharge and water surface elevations for the HCFCD model and the revised existing conditions model.

Table 7-2 Memorial Day (2016) WSE and Discharge Comparisons

	SH 249	FM2978	Kuykendahl	I-45
HCFCD Discharge	45,954	65,310	63,959	67,631
Revised Discharge	46,839	63,941	62,511	66,918
HCFCD WSEL	164.68	152.96	138.39	108.14
Revised WSEL	164.12	152.37	138.61	108.61
Observed WSEL	164.66	152.90	139.19	108.25

The revised existing conditions model has similar results to the previous calibration as well as the observed conditions. These results showed that with the changes to the model, it remained calibrated and appropriate for the hydraulic analysis.

7.4 Existing conditions results

The models were simulated for the Atlas 14 10% ACE (Annual Chance Exceedance), 2% ACE, 1% ACE, and 0.2% ACE, also known as the 10-year, 50-year, 100-year, and 500-year, events to determine discharges and water surface elevations throughout the watershed. Spring Creek serves as the major conveyance for the main northern tributaries from Waller and Montgomery Counties as well as the minor tributaries in Harris County. Being a mostly natural stream watershed, it can take three to four days for the creek to rise and fall following a large rain event. Peak flows for the 1% ACE event range between 16,000 cfs upstream of Threemile Creek to just over 70,000 cfs at the confluence with Cypress Creek. Point flows in the creek increase at the junction of each major tributary in-between. However, following the confluence of Mill Creek, the peak flows do not increase as drastically due to the timing of the large watershed. This confirms that upstream detention would be more effective than downstream detention in reducing overall flows in the creek. Figure 7-1 shows how the flows combine throughout the watershed and the 1% ACE peak discharges at key locations in the creek.

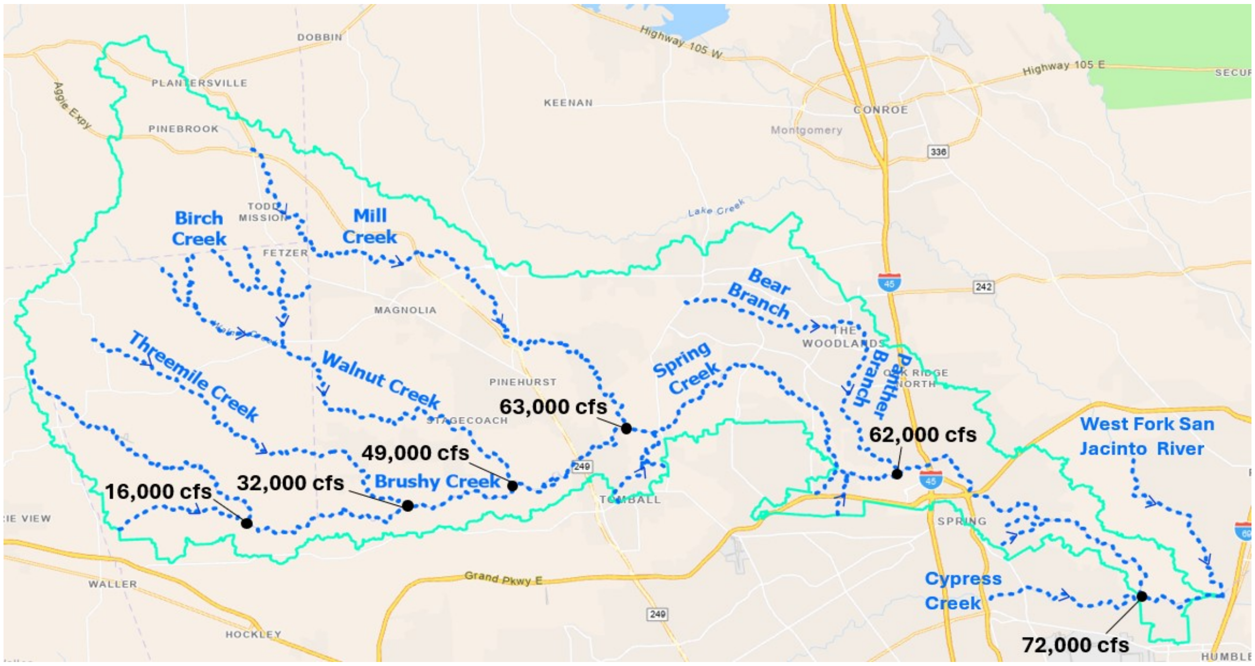


Figure 7-1 1% ACE Discharges within Spring Creek

The FEMA effective model is the current standard in the Spring Creek watershed. Discharges for the 1% ACE event were compared between the effective model, HCFCD model, and the revised model developed for the purpose of this study. In general, the revised model discharges are higher than the effective due to the application of Atlas 14 rainfall in the watershed but match well with the HCFCD discharges.

Table 7-3 1% ACE (100-year) Existing Conditions Discharge Comparisons

	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
Effective Discharge	-	44,311	44,311	54,138	49,790	57,889	76,749
HCFCD Discharge	23,646	53,004	49,458	60,143	56,818	63,757	70,074
Revised Discharge	18,334	48,330	46,808	58,220	56,087	60,814	69,337

Water surface elevations for the 1% ACE event were compared between the effective, HCFCD model and the revised model used for the study to identify major changes. In general, the revised model elevations are higher than the effective due to the application of Atlas 14 rainfall in the watershed. The increases in elevation show that the watershed has more potential for flood risk than that shown on current FEMA maps.

Table 7-4 1% ACE (100-year) Existing Conditions WSE Comparisons

	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
Effective WSEL	-	168.75	161.87	136.99	126.00	107.24	67.10
HCFCD WSEL	187.54	170.46	164.53	138.76	127.81	111.26	71.42
Revised WSEL	186.95	170.06	164.09	138.44	127.52	111.07	71.29

The resulting water surface elevations from the revised model were compared to assumed building finished floor elevations to identify the number of structures potentially flooded in each storm event. Spring Creek has a wide and deep floodplain and in general does not experience significant structure flooding until it reaches the 2% ACE event. This indicates that structure flooding in Spring Creek is infrequent; however, when large storm events occur, there is the potential for widespread damages.

Table 7-5 Potentially Flooded Structures

Event	Potentially Flooded Structures
10% ACE	42
2% ACE	292
1% ACE	848
0.2% ACE	9,603

While damages occur throughout the floodplain of Spring Creek, concentrations of flood damages tend to occur in the following areas:

- Walnut Creek – There are nearly a hundred structures within the Walnut Creek floodplain that are mostly single-family residential housing in rural subdivisions. Most structures are older homes likely built prior to floodplain regulations and are subject to frequent flooding due to the creek.
- SH 249 – In this location there are low lying older neighborhoods that are susceptible to flooding in the 50-year event, as well as a large amount of commercial and industrial facilities that are inundated in the larger events. Most structures here are located within Montgomery County.
- FM 2978 – There are multiple residential structures and commercial/industrial facilities in Montgomery County that are susceptible to flooding in the larger events. This includes communities on Dobbin-Huffsmith Road and sections of the Northgrove neighborhood.
- Kuykendahl Road – This area is mostly residential structures in Harris County that are susceptible to flooding in the 500-year event including the Creekside and Timmarron Lakes neighborhoods of The Woodlands.
- Between Gosling Rd and I-45 – There are multiple residential structures and a few commercial/industrial sites in Montgomery County that are susceptible to flooding in the larger events. Notable neighborhoods include Grogan's Point, Timber Lakes, and the commercial districts near Rayford Road.

- Grand Parkway – There are many residential structures around Grand Parkway in Montgomery County that are susceptible to flooding in the 500-year event including the Forest Village, Spring Trails, Fox Run, and Benders Landing neighborhoods.

A heat map of the areas with a high concentration of flood damages is shown in Figure 7-2.

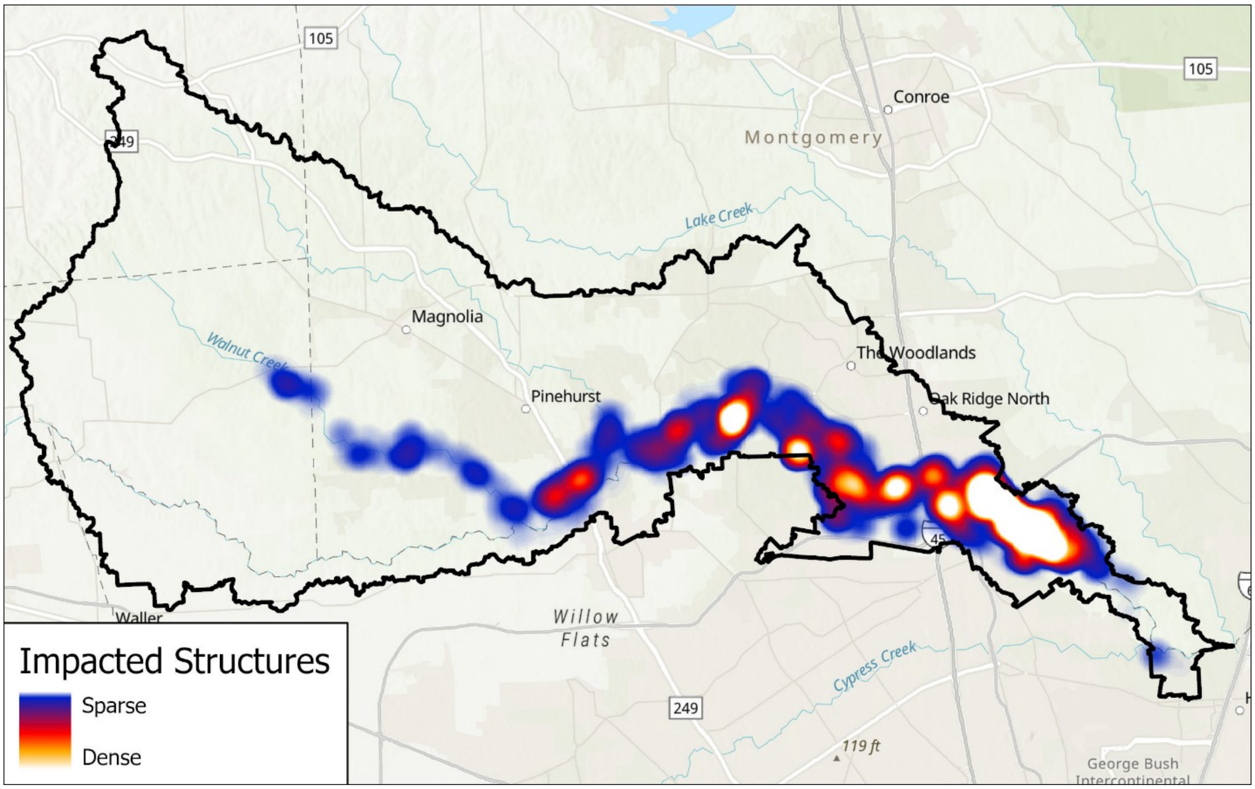


Figure 7-2 Impacted Structures Heat Map

The number of structures flooded for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events for each county are in Table 7-6.

Table 7-6 Potentially Flooded Structures by County

Event	Waller	Montgomery	Harris
10% ACE	4	30	8
2% ACE	17	251	24
1% ACE	32	743	73
0.2% ACE	60	7,575	1,968

7.5 Proposed projects

The detention basins were modeled using 2D connections along the proposed project alignments, and as ogee weirs with culvert openings for outlets. The detention basin elevations and footprints as presented in the SJRWMDP were initially simulated within the revised models to identify the design and benefits of the features. The initial simulations showed that the detention facilities as proposed in the SJRWMDP needed to be optimized to reduce costs and optimize benefits. An optimization analysis was performed to determine the optimal volume within both the Birch and Walnut Creek detention basins that would minimize cost while still providing benefits along Spring Creek. Several different volume iterations for each dam were simulated and resulting water surface elevations compared at Kuykendahl Road. These iterations showed that an optimal 1% ACE storage volume for Walnut Creek was approximately 6,500 acre-feet and 4,500 acre-feet for Birch Creek. The basins were resized accordingly by reducing the top of dam elevation and alignment. The resulting configuration of the optimized dry detention basins is shown in Table 7-7.

Table 7-7 Detention Basin Parameters

	Walnut Creek Detention Basin	Birch Creek Detention Basin
Spillway Elevation	254.7 ft	251.2 ft
Spillway Length	175 ft	175 ft
Top of Dam	263.6 ft	259.1 ft
Max Dam Height	39.1 ft	35.4 ft
1% ACE Inundation Area	940 ac	690 ac
1% ACE Storage Capacity	7,300 ac-ft	4,800 ac-ft
Opening Size	6’ x 17’ RCB	6’ x 16’ RCB

The dams were evaluated independently and in combination for both frequency storms and historical storm events. Tables provided in Appendix D show the reduction in flow and water surface elevations with the proposed detention basins in place. The detention basins reduce the number of impacted structures for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events. Table 7-8 show the number of benefited structures for each individual detention basin as well as the combined project scenario.

Table 7-8 Benefited Structures

	Birch		Walnut		Birch + Walnut	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
10% ACE	37	2	36	5	30	11
2% ACE	252	48	230	70	199	101
1% ACE	802	160	738	225	629	335
0.2% ACE	9,207	303	9,032	484	8,762	795

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

The facilities were also modeled with historical rainfall to assess potential benefits if they had been operational during events like Hurricane Harvey (2017), Memorial Day (2015), and Tax Day (2016). Table 7-9 show the potential benefited structures for the historical storm events.

Table 7-9 Potential Structural Benefits for Historical Storms

	Birch		**Walnut**		**Birch + Walnut**	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
Harvey	3,749	254	5,081	321	5,351	542
Memorial Day	1,230	160	1,234	233	1,237	359
Tax Day	241	14	235	13	286	93

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

In addition to the benefits shown in the tables above, the hydraulic analysis also showed that both detention basins produce no negative impacts to water surface elevations outside of the project footprint in accordance with the TWDB project criteria.

8 Benefit cost analysis

A benefit-cost analysis was performed using the FEMA BCA toolkit for each detention basin individually as well as a combined scenario. The benefit cost analysis evaluates flood damage benefits for structures within the floodplain of Spring Creek and was performed using standard FEMA practices.

8.1 Cost

The maximum cost for each project was used in the benefit cost analysis to determine the "worst case" scenario for the benefit cost ratio. Project cost for the individual as well as combined dams are summarized in Table 8-1.

Table 8-1 Project Costs Per Dam Alternative

Project	Cost
Birch Creek Dam	\$105 M
Walnut Creek Dam	\$193 M
Combined Dams	\$298 M

8.2 Benefits

Information from the hydraulic models including discharges and water surface elevations for existing conditions as well as with the proposed projects were extracted to perform the analysis. In addition, base data such as residential and non-residential structure footprints, location, terrain, and structure square footage were used within the analysis. The analysis was conducted using the FEMA BCA toolkit with the following assumptions:

- Period of Analysis: 50-years
- Interest Rates: 3.1 % discount rate
- Affected Structures: Identified all structures within the 500-year floodplain and assigned finished floor elevations by adding 1 foot to the base terrain data at the centroid of the structure. Affected structures were assigned flood depths for each of the modeled frequency events under existing conditions and each of the proposed alternatives.
- Damage Curves: Depth-damage curves were assigned based on either non-residential or residential structures using the USACE standard curves within the BCA toolkit.
- Structure size: Structure sizes were obtained from the relative county appraisal district information. Usable living space values were selected as the building size to exclude garages and other non-insurable structures.
- Replacement values: The FEMA standard \$100 per square foot multiplied by the structure size was used for the building replacement value.

- Contents: Structure contents were assumed using the standard FEMA values per unit cost associated with the building type.
- Displacement: Values represent the additional cost incurred when people are forced to relocate temporarily due to damage from a hazard. Residential displacement values account for the housing and meal costs from displacement and were based on the FY 2025 per diem rates provided by the U.S. General Services Administration. Non-Residential displacement values account for the rental and transportation costs for a structure's loss of function and were based on standard values by building type within the toolkit.
- Social Benefits: Values include the non-market benefits not captured in direct financial costs, but they reflect the broader public good. Social benefits were included within the benefit calculation as allowed by FEMA including mental stress and anxiety. All residential structures were assumed to have an average of 3 residents including 1 working resident based on the average information provided by the U.S. Census Bureau.

8.3 Benefit cost ratio

A benefit-cost analysis was performed for each detention basin and a combination of both using the water surface elevation results described in Section 7.4 in comparison to the damages calculated under existing conditions. The benefit value derived for each alternative was used along with the engineering opinion of probable project cost to generate the final benefit-cost ratio for each project, as shown in Table 8-2 through 8-4.

Table 8-2 Walnut Creek Detention Basin Benefit Cost Analysis

Building Type	Benefits		Total
	Standard	Social	
Residential	$42,899,652	$141,420,195	$184,319,847
Non-Residential	$17,467,588	$0	$17,467,588
		Total Mitigation Benefits	**$201,787,435**
		Total Project Cost	**$193,071,637**
		Project BCR	**1.05**

Table 8-3 Birch Creek Detention Basin Benefit Cost Analysis

Building Type	Benefits		Total
	Standard	Social	
Residential	$33,369,403	$141,163,155	$174,532,558
Non-Residential	$10,814,136	$0	$10,814,136
		Total Mitigation Benefits	**$185,346,694**
		Total Project Cost	**$105,338,718**
		Project BCR	**1.76**

Table 8-4 Walnut Creek and Birch Creek Detention Basins Benefit Cost Analysis

Building Type	Benefits		Total
	Standard	Social	
Residential	$49,527,304	$141,709,365	$191,236,669
Non-Residential	$20,504,771	$0	$20,504,771
		Total Mitigation Benefits	**$211,741,440**
		Total Project Cost	**$298,410,355**
		Project BCR	**0.71**

The analysis shows that the individual projects both have the potential for benefit cost ratios greater than 1.0 meaning that the projects have the potential to be cost effective. This also indicates that specific federal funding sources may be available for funding portions of the total construction cost.

The combined project benefit cost is less than 1.0 due to a significant cost increase for two detention basins and the relatively small increase in social benefits (the projects still benefit the same population). This indicates that while both projects would provide downstream flood relief and a combination of projects provides the most relief, when seeking federal funding, separate applications should be submitted. As shown in the tables above, separate projects would both have positive benefit cost ratios by maximizing the application of social benefits.

9 Potential funding opportunities

Due to the size of the projects, funding for the detention basins will require a combination of multiple funding sources from both local entities and partnerships with the state and federal governments. Each funding source may have specific requirements for meeting the source and stipulations as to the types of projects or parts of projects that it can fund. Below is a summary of current potential funding sources separated by agency.

9.1 Federal Emergency Management Agency (FEMA)

Assuming both projects retain a benefit cost ratio greater than 1.0 in subsequent detailed design efforts, FEMA funding can be a source for project design and construction. 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. The entity that applies must have an adopted Hazard Mitigation Plan.

9.1.1 Flood Mitigation Assistance (FMA)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $25 million
- Cost Share: 75% FEMA, 25% local
- Frequency: Annually
- Administrator: Texas Water Development Board
- Restrictions: BCR > 1.0

9.1.2 Hazard Mitigation Grant Program (HMGP)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $25 million
- Cost Share: 75% FEMA, 25% local
- Frequency: After federally declared disaster
- Administrator: Texas Division of Emergency Management
- Restrictions: BCR > 1.0

9.2 US Housing and Urban Development Funding (HUD/GLO)

The HUD Community Development Block Grants (CDBG) provide opportunities for communities following a major disaster. HUD funding is administered through the General Land Office (GLO) for Texas and can also be filtered through the local council of governments (Houston-Galveston Area Council [HGAC] for this region). HUD funding generally does not have a BCR requirement but may have a low-moderate income emphasis for the applying entity. Funding opportunities may have different thresholds of percent Low-Moderate Income (LMI) benefitting from the project.

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

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: Varies
- Cost Share: 100% HUD
- Frequency: After federally declared disaster
- Administrator: General Land Office
- Restrictions: Large emphasis on LMI communities

9.2.2 *Community Development Block Grant – Mitigation (CDBG-MIT)*

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: Varies
- Cost Share: 100% HUD
- Frequency: After federally declared disaster
- Administrator: General Land Office
- Restrictions: Large emphasis on LMI communities

9.3 Natural Resource Conservation Service (NRCS)

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.

9.3.1 *Watershed and Flood Prevent Operations (WFPO)*

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $5 million (unless otherwise approved by Congress)
- Cost Share: Varies
- Frequency: Annually
- Administrator: NRCS (US Department of Agriculture)
- Restrictions: Benefit area must include 20% agriculture

9.4 Congressional Allocation

Congress can directly allocate funding for a drainage infrastructure project through the annual appropriations process or by authorizing specific funding in legislation. This typically involves a member of Congress submitting a request—often in the form of a Community Project Funding (CPF) request or earmark—for a particular project in their district or state. If approved, the request may be included in one of the appropriations bills passed by Congress and signed into law by the President. Alternatively, Congress can include funding for such projects in larger infrastructure or disaster relief bills, directing federal agencies such as the Army Corps of Engineers or the Environmental Protection Agency to administer the funds. This process ensures that federal dollars are designated for targeted improvements, like stormwater management systems or flood mitigation infrastructure, that address local needs and protect communities.

Projects funded with direct allocation may have to follow the rules of the funding agency such as that USACE funding cannot be used for land acquisition.

9.5 Texas Water Development Board (TWDB)

The TWDB has several sources of funding available for flood mitigation projects and has recently increased awareness of these projects and programs through the regional flood planning initiative. These two projects were included in the latest amendment of the San Jacinto Regional Flood Plan which will make them eligible for state funding. Some of these funding sources are relatively new and standard requirements may be subject to change.

9.5.1 Flood Infrastructure Fund (FIF)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $19 million (current cycle)
- Cost Share: 30%-75%, low interest loans
- Frequency: Bi-annually
- Administrator: TWDB
- Restrictions: Subject to state legislature funding the program

9.6 Local funding

Local funds will need to be raised for the local share required on most state and federal sources as well as for the long-term operations and maintenance of the basins.

9.6.1 Bonds

Bond funding can be used for flood protection and management projects. Bonds typically provide project specific financing that requires proposed improvements to be ready for design and 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.

9.6.2 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 and are not meant for mitigating developing land, imposing a fee on new development to address pre-existing flooding conditions is not a legal use of impact fees. 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.

9.6.3 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 detention basins will provide ample space for recreational activities outside of storm events and dual use of the basins should be explored. The watershed also 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.

10 Conclusion and recommendations

The Spring Creek Watershed Flood Control Dams Feasibility Study has provided a comprehensive analysis of the potential benefits and feasibility of implementing two regional detention basins within the watershed. Funded partially by the Texas Water Development Board's Flood Infrastructure Fund (FIF), the study focused on the Walnut Creek and Birch Creek detention basins.

The study concluded that the proposed detention basins at Walnut Creek and Birch Creek are expected to effectively reduce flood risks in the Spring Creek watershed. These basins would mitigate downstream flooding, benefiting numerous residential and non-residential structures. Additionally, the study included extensive environmental due diligence, identifying potential impacts on wetlands, threatened and endangered species, and cultural resources. Mitigation measures have been proposed to address these impacts. The economic feasibility of the project was also assessed, with a benefit-cost analysis demonstrating that both detention basins have a favorable benefit-cost ratio individually, indicating that the economic benefits of flood risk reduction outweigh the costs of construction and maintenance. Furthermore, the study involved significant coordination with key stakeholders, including local counties and municipalities, utility districts, and the public, with public meetings and workshops held to gather input and address concerns.

Based on these findings, it is recommended to advance the Walnut Creek and Birch Creek detention basins to the detailed design phase, which will involve more precise engineering and geotechnical analyses, coordination with landowners for purchase of property as well as the development of construction plans. One of the important next steps includes identifying a project sponsor within the region that will continue to move the projects forward. Efforts should be made to secure funding from various sources, including federal, state, and local agencies, with potential funding opportunities such as FEMA's Hazard Mitigation Grant Program and the Texas Water Development Board's Flood Infrastructure Fund. It is also essential to implement the proposed environmental mitigation measures to address potential impacts on wetlands, species, and cultural resources, including obtaining necessary permits and coordinating with regulatory agencies. Finally, maintaining ongoing communication with stakeholders, including local communities and landowners, is crucial to ensure their concerns are addressed and to foster support for the project.