SAN JACINTO

REGIONAL WATERSHED MASTER DRAINAGE PLAN

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

APPENDIX G
PRIMARY MITIGATION ALTERNATIVES

San Jacinto Regional Watershed Master Drainage Plan

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Harris County Flood Control District
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Montgomery County
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Sections 1.0, 2.0, 3.3, 3.5, 4.0 - 4.3, 5.2 - 5.4, 5.6, 5.7.3-5.7.4, 6.0 - 6.1
Appendices G.6 – G.8

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APPENDICES

1.0 Primary Mitigation Introduction

The purpose of this alternatives memorandum is to detail the process, results, and recommendations related to potential flood reduction projects in the San Jacinto River basin. The structural projects and policy discussions included are related to Task 6. Primary Mitigation Planning, which focuses on approaches to either reduce flooding or remove people and property from flood prone areas. The memo will provide a general overview of how specific areas were targeted for projects, how the projects were developed, their relative effectiveness at reducing flooding, both locally and regionally, determination of costs and benefits, and potential implementation challenges. The overview will be followed up with a specific discussion of each of the recommended projects that are intended to be a part of the long-term flood reduction strategy. The memo also highlights flood related policy and provide a high-level discussion about how those strategies can be employed to mitigate impacts related to existing flood damages and future development.

1.1 Goals

There are several goals for the alternatives analysis, which include the following:

- Identify areas with high concentrations of significant flood damages
- Determine project locations that have the highest potential for local and regional mitigation
- Perform H&H analysis to determine project effectiveness
- Identify estimated project costs, potential flood reduction benefits, and implementation challenges
- Develop a path toward plan implementation for the Master Drainage Plan

1.2 Alternatives Analysis Tasks

The alternatives analysis process included several major tasks. Each of these tasks will be discussed in detail in the sections below. The initial alternatives modeling approach was detailed in the *Revised Alternatives Development Process* memorandum, submitted by Halff Associates, Inc. (Halff) and Freese & Nichols, Inc. (FNI) in October 2019. Some modifications were made to the original plan, specifically the process of determining target volumes for each of the proposed projects. The updated process will be discussed in Section III. The alternatives analysis process includes the following tasks:

- Evaluate flood damages using the HCFCD Structural Inventory Tool
- Identify “Damage Centers” where there are high concentrations of structural flooding
- Determine conceptual volume reductions for a range of LOS improvements
- Compare reduction volumes to potential benefits
- Establish preliminary target volumes for each damage center
- Consider previously identified projects (Primary) and new project ideas (Secondary)
- Perform high level analysis to identify mitigation potential of suggested projects
- Select watersheds with highest potential for improvements
- Perform planning level H&H analysis for each project
- Calculate costs and benefits associated with each project
- Evaluate project combinations to build long-term master drainage plan

2.0 Potential for Regional Detention

Before modeling any proposed projects or evaluating flood risk at individual structures, the project team used the existing conditions hydraulic model to evaluate the relative impact that detention may provide on a regional basis. This evaluation included a sensitivity analysis of the contribution of each major subwatershed on the 1% ACE water surface elevations in Lake Houston and an evaluation of Lake Houston's impact on 1% ACE water surface elevations in the Kingwood area.

2.1 Watershed Volume Sensitivity

A high-level volume sensitivity test was conducted on a regional basis to determine how removing runoff from each watershed affects the regionally focused flood risk areas along the West Fork, East Fork, and Lake Houston. The analysis simulated the 1% ACE in the combined hydraulic model, removing discharge hydrographs from entire watersheds. This analysis assumes that during the 1% ACE, runoff from an entire watershed is retained within the watershed and prevented from being conveyed downstream.

Table 1 summarizes the water surface elevation reductions on the West Fork San Jacinto River for the 1% ACE frequency storm event. Removal of Spring Creek has the highest reductions at I-69, FM 1960, and at the Lake Houston Dam as it is the largest subwatershed. Removal of Caney Creek has the highest reduction at the confluence with the East Fork. This conceptual analysis shows that regional detention in the East Fork, Caney Creek, Peach Creek, Lake Creek and Spring Creek watersheds may have the highest potential for regional benefits downstream.

Table 1: Watershed Volume Sensitivity on West Fork San Jacinto River and Lake Houston

Reduction Location	1% ACE Water Surface Reduction by Basin Hydrograph Removed						
	Luce Bayou	East Fork	Caney Creek	Peach Creek	Lake Creek	Spring & Willow Creek	Cypress & Little Cypress Creek
West Fork at I-69	-0.02	-0.04	-0.03	-0.02	-3.08	-3.83	-1.06
East Fork Confluence	-0.65	-1.49	-0.57	-0.37	-1.13	-1.50	-0.52
Lake Houston at FM 1960	-0.62	-1.41	-0.54	-0.35	-1.08	-1.44	-0.50
Lake Houston Dam	-0.48	-1.10	-0.42	-0.27	-0.84	-1.12	-0.39

2.2 Kingwood Area Flood Risk

Many of the structures in the watershed that are at risk of flooding are located in the lower portion of the study area, along the West Fork from US-59 to FM 1960 and along the East Fork from the confluence with Caney Creek to FM 1960. This area, which generally includes Kingwood, has experienced significant flood damages. **Figure 1** below shows the terrain elevations along with the flood claims made in the area over the last several major storms, which include Memorial Day (2016), Hurricane Harvey (2017), and Tropical Storm Imelda (2019). While many of the flood damages are likely a result of local drainage internal to the Kingwood neighborhoods, it is likely that many others are a result of flooding from the West Fork, East Fork, and Lake Houston.

The terrain provides insight into why many of these areas flood, as well as which areas may flood from the West Fork and East Fork San Jacinto Rivers versus internal drainage. There is a distinct drop in the terrain along the banks of the West Fork shown in the ridge line of yellow between the red and green coloring. These elevations correlate to the existing floodplain and structures located below the yellow ridge are susceptible to flooding from the West Fork and East Fork San Jacinto Rivers. The less common but present instances of inundation in the higher elevations seen in **Figure 1** are being analyzed through the concurrent Kingwood Area Drainage Analysis project.

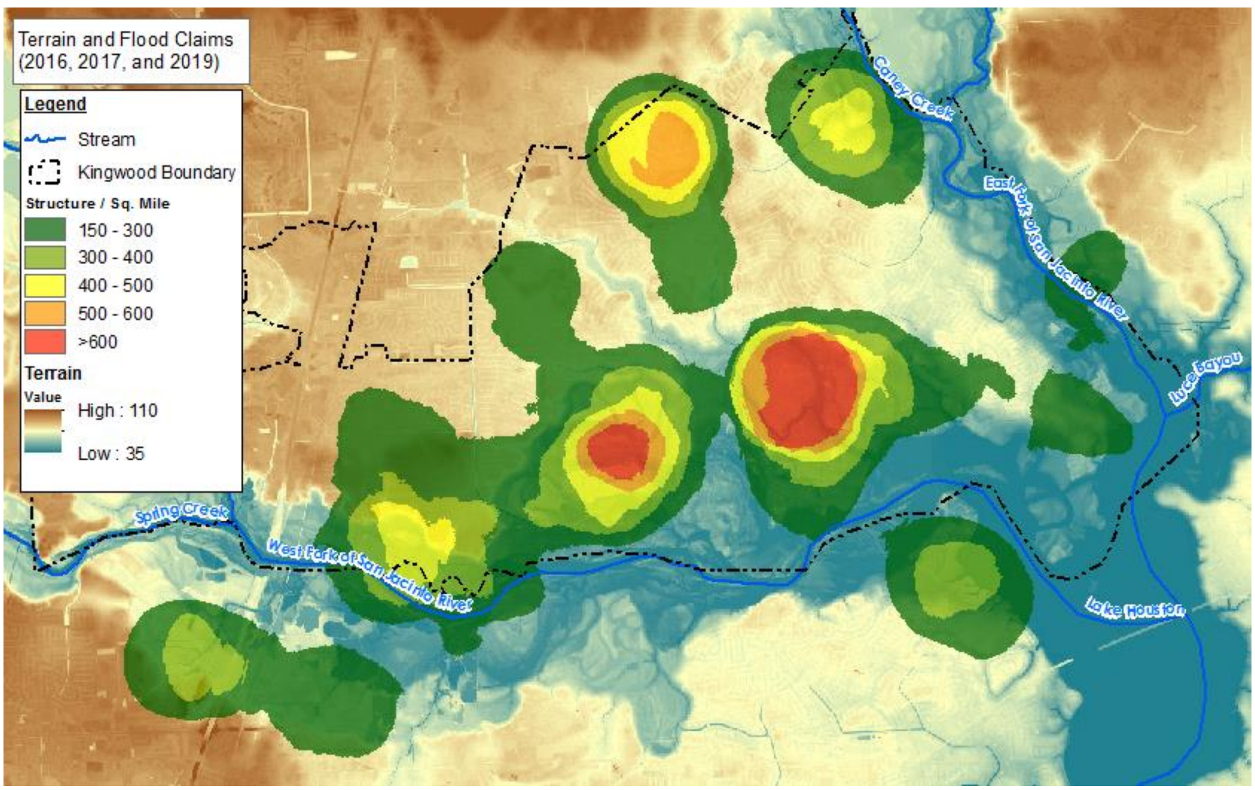

Figure 1: Kingwood Area Flood Claims

Profiles provided in the Calibration Summary provide a clear picture of flood risk along the West Fork and East Fork. Along the West Fork, there are relatively few structures that flood from the rivers during storms smaller than the 4% and 2% ACE storms. As flows approach the 1% ACE level there is a significant jump in the number of structures at risk. Between the 1% ACE and 0.2% ACE, the flood risk is even more pronounced. There is a similar pattern along the East Fork. Along the both the East Fork and West Fork, the Memorial Day storm closely approximates the 4% ACE flood elevations. The WSELs for Hurricane Harvey are more representative of between a 1% and 0.2% ACE event, which affected a significant number of structures.

Inundation mapping shown in **Figure 2** shows the 1% ACE (blue gradation) as well as the 0.2% ACE event (red gradation) based on Atlas 14 hydrology. While the difference in inundation extents appears small, the difference in elevation between the 1% ACE and 0.2% ACE ranges between 3.5 and 5.0 feet. The differences appear nominal in the inundation limits, but the number of potentially flooded structures jumps significantly between the various flood levels. For example, there are approximately 1,000 at-risk structures for the 100- and more than 2,330 for the 0.2% ACE event. As the level of storm diminishes, the number of structures drops off significantly as well. For the 4% ACE event, there are only about 80 structures identified as at-risk. The number of structures identified as at-risk drops to 30 for the 10% ACE.

These findings are consistent with observed flooding in Hurricane Harvey vs. the Memorial Day 2016 storm. Reports indicate that there were relatively few structures flooded by the West Fork and East Fork during the Memorial Day storm, which is the approximate equivalent of a 4% ACE event with only about 80 structures at risk. Hurricane Harvey resulted in widespread flooding in the area. The observed flood levels would result in between 1,000 and 2,300 structures potentially flooding along the banks of the rivers.

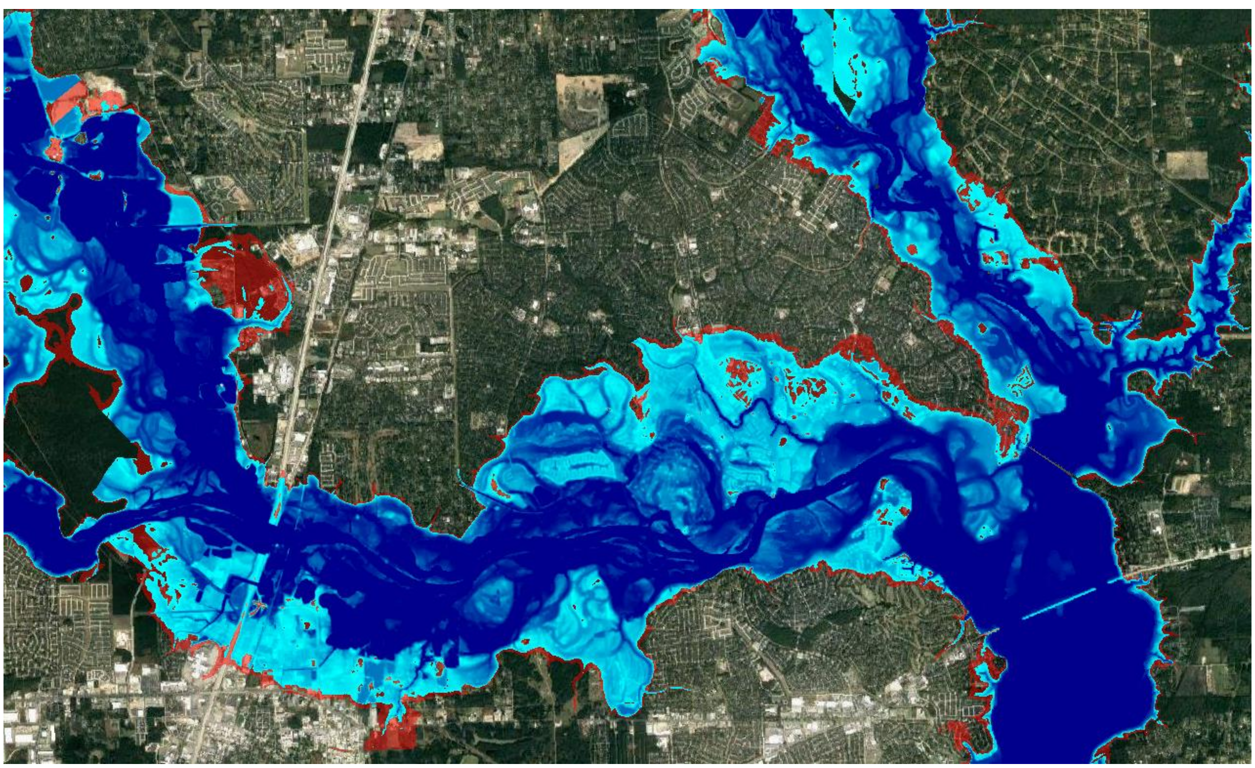

Figure 2: West Fork/East Fork Confluence Inundation Mapping (100- and 0.2% ACE)

As evidenced by the modeling and the resultant water surface profiles, Lake Houston has a significant influence on the WSEs in the lower portions of the both the East and West Forks. As shown on **Figure 3** below, the approximate zone of influence from the Lake Houston Dam is up to W. Lake Houston Parkway on the West Fork and near the Caney Creek confluence on the East Fork. Lake Houston plays a critical part in flood reduction approaches in Kingwood and limits the benefits that can be realized by flood reduction projects on the East and West Forks. The specific results will be discussed in **Section 5.0**.

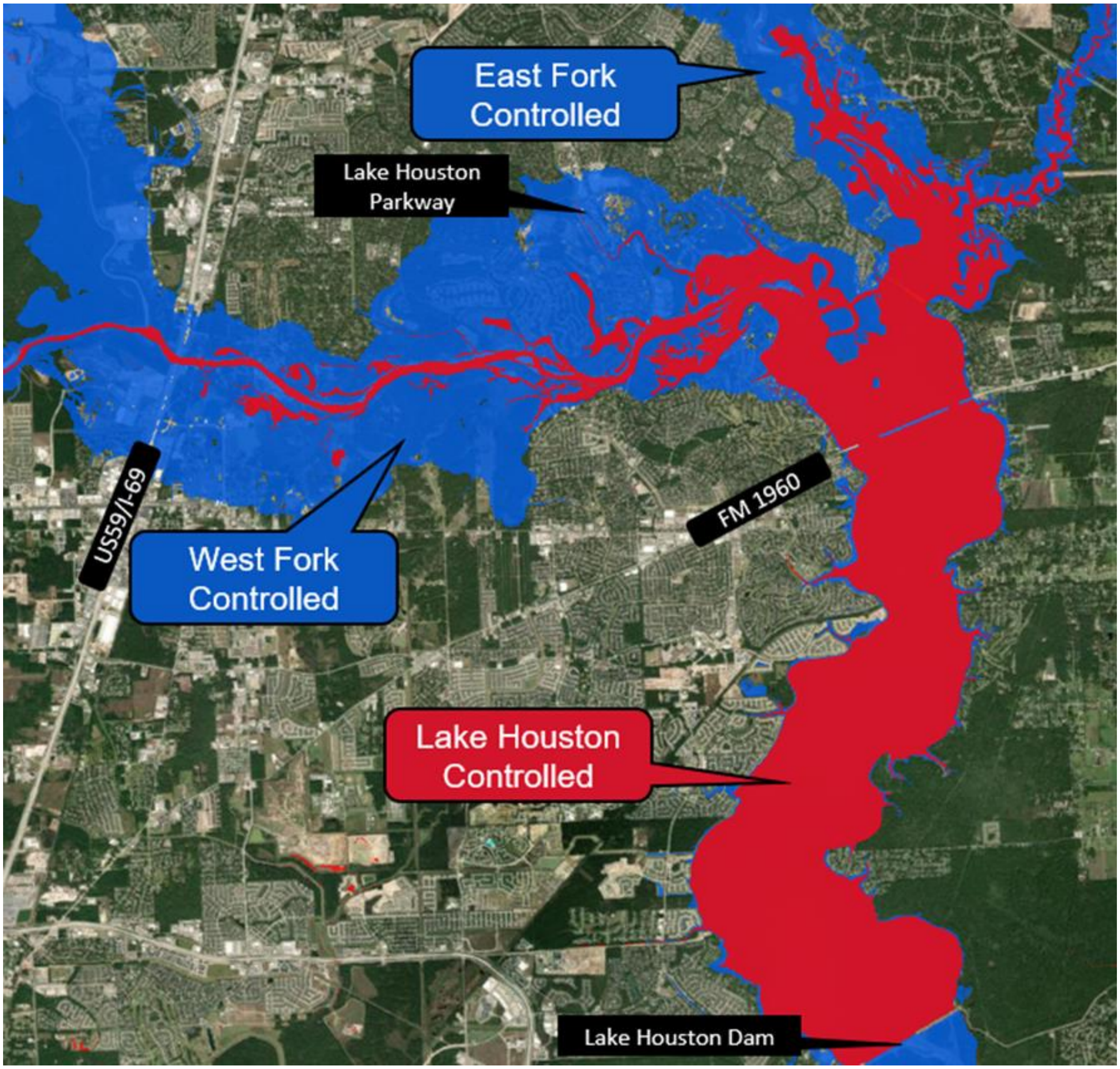

Figure 3: Lake Houston Zone of Influence on the Lower West Fork and East Fork

3.0 Damage Centers and Target Detention Volumes

Mitigation alternatives development required an analysis of the existing flood risk in the basin to determine how riverine flooding attributed to flood risk and loss of property value. The damage center identification process located concentrations of structures within the region that were suspectable to flood risk along the studied streams. The locations of the damage centers informed the alternative identification process to locate and size potential mitigation alternatives.

3.1 Structural Inventory

A structural inventory was developed for the entire basin to identify the structures that are within the existing floodplains developed as part of the SJMDP existing conditions effort. The inventory consisted of a list of structure, property descriptions, estimated elevations, and the potential for flood risk.

3.1.1 Data Input (Ex. Conditions Models, Structural Data, LiDAR, etc.)

The structural inventory consisted of HCFCD's structural inventory in Harris County supplemented with structure data from Houston-Galveston Area Council (H-GAC) lidar in areas outside Harris County. In total, the combined inventory includes a total of 108,006 building footprints within a 1,000-foot buffer of the 0.2% ACE floodplain extents along the main stems modeled for this project. Structures along unmodeled tributaries were not included. Structures smaller than 200 square feet were assumed to be sheds or small outbuildings and were removed.

The LiDAR surface used to assign elevation information to each structure is the same LiDAR surface used to generate the station-elevation information for each stream's hydraulic model. The centroid of each structure was used to assign a LiDAR elevation for that structure. For the purposes of this study, each structure's finished floor elevation was estimated to be one foot above its LiDAR elevation. After the first assignment of existing-conditions water surface elevations as documented below, the structures that appeared to flood in the 50% ACE and 20% ACE events were checked using Google Street View or aerial data as available to discern whether the structures were elevated or on piers. The finished floor elevations for these frequently flooded structures were then manually increased as needed to approximate the Google Street View observations.

Finally, each structure was stationed along the stream centerlines using the cross sections from the calibrated existing-conditions hydraulic model. The structure stations were then used to interpolate peak water surface elevations from the existing conditions hydraulic model frequency storm results. This included results for the 50% ACE, 20% ACE, 10% ACE, 4% ACE, 2% ACE, 1% ACE, and 0.2% ACE events. The flooding depth at each structure was then calculated as the water surface elevation minus the finished floor elevation. Structures along Spring Creek that are protected by a levee were manually assigned their corresponding levee elevation. The calculations were adjusted such that Spring Creek cannot flood these structures until first overtopping the adjacent levee elevation.

The results of this process were used to estimate the instances of structural flooding over a 50-year period based on H&H modeling results. This approach collapses data from multiple storm events into a single number and serves as a useful metric for comparing the relative severity of flooding in various locations throughout the watershed. It integrates (a) the number of structures flooding under each frequency storm over (b) the probability of each frequency storm. This information is then used to obtain the annualized

"**Instances of Structural Flooding.**" The annualized instances are then multiplied by 50 years to obtain the instances of flooding over a 50-year period.

Consider a group of structures that begin flooding in the 4% ACE event. The instances of structural flooding calculation will assign each of these structures an expected 3.4 instances of flooding over a 50-year project life. This group includes some structures that are just below the 4% ACE water surface (just above a 4% chance of flooding in any given year) and some that are just above the 10% ACE water surface (just below a 10% chance of flooding in any given year). On average, this group of structures has approximately a 7% chance of flooding in any given year. Over a 50-year period, this works out to each structure having a 97% chance of flooding at least once, an 87% chance of flooding at least twice, and a 69% chance of flooding at least three times. The instances of structural flooding calculation states that, taken as a group, there are even odds that each 4% ACE structure will flood 3.4 times over that 50-year period.

This process is similar to calculating the expected damages over a 50-year period using FEMA Benefit-Cost Analysis (BCA) methodology but does not account for the structure's monetary value. FEMA's BCA process integrates the probability vs. damages function to obtain annualized damages, while Instances of Flooding process integrates the probability vs. number of structures flooded curve to obtain an annualized number of flooded structures.

These expected instances were calculated for each river mile along each modeled major stream. As an example, consider the two river miles on Spring Creek shown in the table below. Although river mile 30 has more structures in the 0.2% ACE, 1% ACE, and 2% ACE floodplains than river mile 31, it has a similar number of instances of structural flooding expected over a 50-year period. This is because river mile 31 has 12 structures in the 10% ACE floodplain that are at risk of flooding multiple times over that 50-year period. If not for those 12 structures, river mile 31 would only have 25 instances of structural flooding expected over a 50-year period. The 12 structures flooded during the 10% ACE event at river mile 31 make up for the much smaller number of structures flooded in larger storm events at river mile 31 compared to river mile 30. This illustrates that the expected instances of flooding metric increases significantly the more frequently a structure is flooded.

The structural inventory results are summarized by watershed below in **Table 2**. Charts are also provided showing the instances of structural flooding over a 50-year period.

Table 2: Structural Inventory Results

Spring Creek River Mile	Estimated Cumulative Number of Structures Flooded in Each Frequency Event					Estimated Instances of Structural Flooding (50-year Period)
	0.2% ACE	1% ACE	2% ACE	4% ACE	10% ACE	
31	34	27	23	15	12	114
30	178	76	50	11	0	129

3.1.2 Data Assumptions and Limitations

This process is based on one-dimensional river modeling results, with water surface elevations interpolated between cross sections. The initial structural inventory runs indicated several areas with concentrations of structures that flood during relatively frequent events, like the 50% ACE and 20% ACE. Based on conversations with the study partners (HCFCD, SJRA, MCO, COH), it was determined that the improvements needed to address flooding for those structures would not be feasible and that buyouts are a better option for those structures. The volume targets for improvement will be detailed in **Section 3**. In order to avoid skewing the mitigation potential findings, the 50% ACE and 20% ACE results were dropped from the instances of structural flooding calculation. These structures are likely better candidates for buyouts, as discussed in **Section 6.2.**

Since only the main stems were modeled, this summary of structural flooding reflects only the main stems and does not include structures along tributaries or structures that experience localized flooding problems. Including additional structures and extending the hydraulic models into tributaries would increase the reported instances of structural flooding in the watershed. Finally, the structural flooding results are all based on the assumption that each structure's finished floor is 1 foot above the LiDAR topography at its centroid. The risk of flooding may therefore be overestimated for structures whose actual elevation is higher or underestimated for structures whose actual elevation is lower. Finished floor survey of each structure would be required to improve the accuracy.

3.1.3 Summary of Structural Inventory Results by Watershed

A summary of the structural inventory results is broken out by watershed in the table below. The cumulative number of structures flooded in the 0.2% ACE, 1% ACE, 2% ACE, 4% ACE, and 10% ACE events are provided. The final column lists the total instances of flooding expected over a 50-year period in each watershed; these incorporate the number of structures flooded by each frequency event and the probability of each frequency event.

Table 3: Structural Inventory Summary

Stream	Estimated Cumulative Structures Flooded in Each Frequency Event					Estimated Instances of Structural Flooding (50-yr Period)
	0.2% ACE	1% ACE	2% ACE	4% ACE	10% ACE	
Spring Creek	11,125	2,909	1,158	470	139	5,898
Willow Creek	1,854	854	388	241	115	1,988
Cypress Creek	8,688	2,920	1,464	708	212	6,405
Little Cypress Creek	3,708	1,704	1,000	427	82	3,412
East Fork SJR	2,035	1,073	712	461	186	3,090
West Fork SJR	8,275	3,719	1,659	732	161	6,670
Lake Creek	295	162	95	55	26	417
Peach Creek	1,713	1,115	843	581	325	3,939
Caney Creek	2,628	1,384	979	557	175	3,697
Luce Bayou	298	134	84	52	24	383
Tarkington Bayou	238	179	161	140	108	961
Jackson Bayou	105	20	1	1	1	37
Gum Gully	191	62	15	5	3	99

3.1.4 Instances of Flooding by Watershed

The charts in **Appendix G.1** depict how the number of flooded structures and the expected instances of structural flooding over a 50-year period break down by river mile along each stream. Each stream has one page showing the following information:

1. The number of flooded structures at each river mile. The height of each column represents the cumulative total of structures flooding in the 0.2% ACE event. The colors comprising each column represent how many of those structures flood in the 1% ACE, 2% ACE, 4% ACE, and 10% ACE events.
2. The instances of structural flooding at each stream cross sections. The dots represent the incremental instances of structural flooding at each cross section in the existing-conditions HEC-RAS model. The line represents the cumulative total of instances of structural flooding over a 50-year period in the upstream direction.
3. The instances of structural flooding at each river mile. The height of each column represents the total number of structural flooding events expected at that river mile across a nominal 50-year project life. This provides a basis for comparison from one river mile to the next and forms the basis for the damage center identification process discussed in the next section.

3.2 Damage Center Identification

Once the structural inventory was developed, the structures potentially inundated in the frequency events were tabulated to locate and identify conceptual "damage centers," that is, large groupings of structures at risk of flooding. These damage centers were used as a basis for evaluating conceptual ranges of upstream detention volumes that could effectively reduce flood risk.

3.2.1 Criteria for Damage Center Identification

To identify effective locations for flood mitigation projects, structures at risk of flooding were manually grouped together into conceptual damage centers based on hotspots where structures are concentrated. These hotspots were first charted based on existing conditions results, with the number of structures and expected instances of flooding over a 50-year period broken down by river mile. The highest peaks and clusters of structural flooding were identified and grouped together. A total of 48 damage centers were identified based on these charts and are summarized in **Figure 4**. Each damage center is named with its watershed ID and numbered from downstream to upstream; for example, Spring Creek's second damage center is named "J100_002." Detailed information regarding each damage center is provided in **Appendix G.1**; charts of existing conditions structural flooding by river mile are provided in **Appendix G.2**.

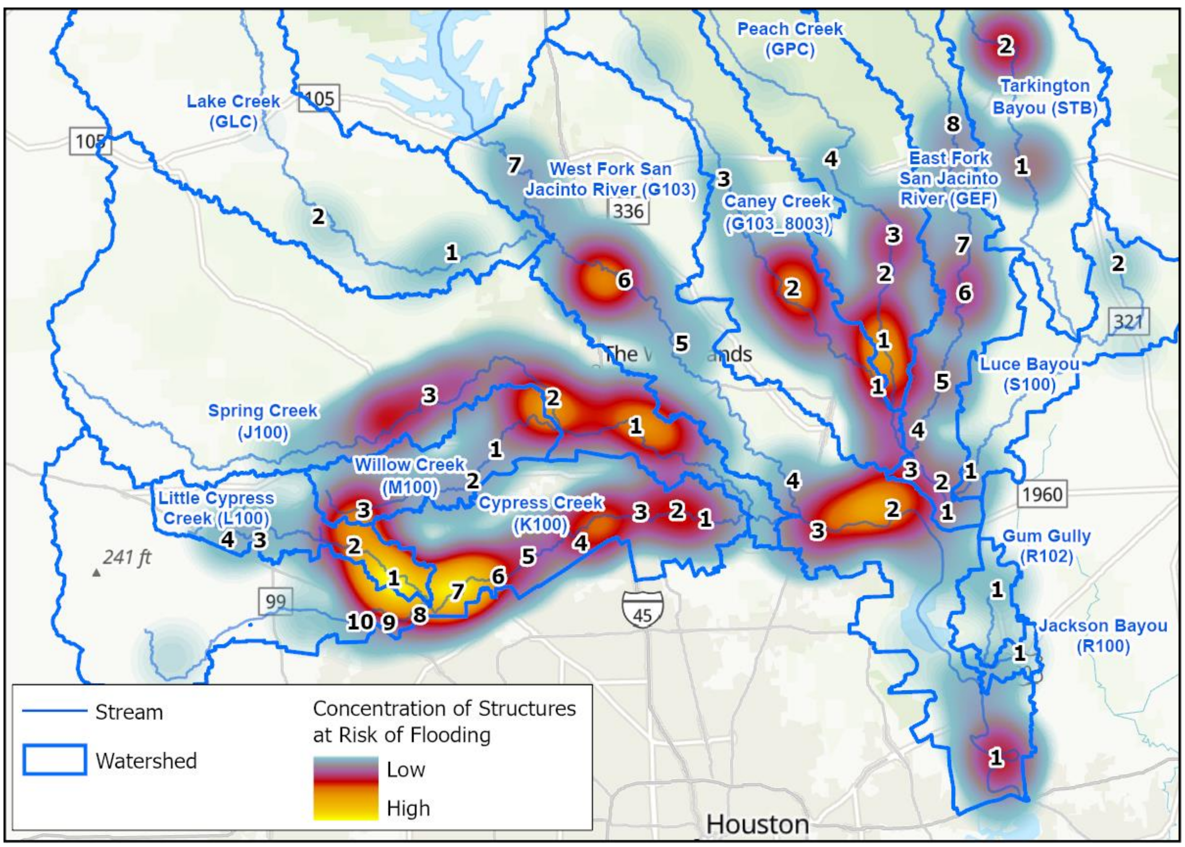

Figure 4: Summary of Damage Centers

The damage centers with the highest instances of structural flooding expected over a 50-year period are generally located along Spring Creek, Cypress Creek, the West Fork of the San Jacinto River near Kingwood, and the confluence of Caney Creek and Peach Creek.

3.2.2 Summary of Damage Centers by Watershed

A summary of the damage center instances of structural flooding is broken out by damage center in the table below. The cumulative number of structures flooded in the 0.2% ACE, 1% ACE, 2% ACE, 4% ACE, and 10% ACE events are provided. The final column lists the total instances of flooding expected over a 50-year period in each watershed; these incorporate the number of structures flooded by each frequency event and the probability of each frequency event. This forms the basis for the target volume determination discussed in **Section 0**.

The table below and the detailed damage center information provided in **Appendix G.1** were created based on draft existing conditions results. After the initial damage center and target volume determination exercises, minor revisions were made to the existing conditions models that slightly changed the estimated structures and instances listed below. Because the model changes were minor and because the purpose of these exercises is to estimate general volume ranges required for flood risk reduction, the damage center and target volume determination exercises have not been updated to reflect final existing conditions results. The final existing conditions results are accounted for in and following **Section 4.0**.

Table 4: Summary of Flooding Instances Per Watershed

Stream	Damage Center ID	Estimated Structures Flooded in Each Frequency Storm					Estimated Instances of Structural Flooding (50-yr Period)
		0.2% ACE	1% ACE	2% ACE	4% ACE	10% ACE	
Spring Creek	J100_001	3,275	668	199	50	12	1,253
	J100_002	1,478	525	206	102	38	1,042
	J100_003	1,026	708	515	237	65	1,644
Willow Creek	M100_001	332	115	67	37	14	298
	M100_002	375	112	57	35	13	290
	M100_003	294	199	166	134	80	861
Cypress Creek	K100_001	268	115	79	55	24	371
	K100_002	427	143	43	37	30	376
	K100_003	421	154	59	33	7	292
	K100_004	881	621	439	213	42	1,379
	K100_005	500	205	67	6	1	259
	K100_006	179	89	54	38	0	192
	K100_007	2,246	720	316	126	41	1,426
	K100_008	384	151	75	54	27	417
	K100_009	118	66	48	31	11	195
	K100_010	341	50	26	17	3	156
Little Cypress	L100_001	2798	1346	784	286	16	2,389
	L100_002	499	199	112	60	27	501
	L100_003	45	22	19	15	9	99

Stream	**Damage Center ID**	**Estimated Structures Flooded in Each Frequency Storm**					**Estimated Instances of Structural Flooding (50-yr Period)**
		0.2% ACE	**1% ACE**	**2% ACE**	**4% ACE**	**10% ACE**	
	L100_004	112	46	21	10	2	87
East Fork	GEF_001	323	91	48	35	17	280
	GEF_002	421	101	48	35	17	304
	GEF_003	21	5	3	3	0	15
	GEF_004	373	238	166	106	30	638
	GEF_005	242	176	153	121	68	756
	GEF_006	165	110	61	38	22	292
	GEF_007	205	160	105	46	19	360
West Fork	G103_001	371	303	231	117	52	826
	G103_002	2343	1149	202	23	1	1,187
	G103_003	890	644	302	118	31	1,054
	G103_004	89	62	36	22	2	125
	G103_005	175	140	113	32	0	247
	G103_006	2063	705	390	227	31	1,600
	G103_007	295	177	93	49	1	310
Lake Creek	GLC_001	103	71	41	19	12	169
	GLC_002	55	46	29	18	2	97
Peach Creek	GPC_001	961	637	483	373	212	2,435
	GPC_002	162	98	71	36	15	262
	GPC_003	277	169	134	103	69	714
	GPC_004	24	17	11	10	8	73
Caney Creek	G1038003_001	299	287	224	102	22	649
	G1038003_002	1439	749	526	309	87	1,985
	G1038003_003	126	101	86	58	16	315
Luce Bayou	S100_001	140	70	45	33	16	223
	S100_002	21	16	12	8	3	48
Tarkington Bayou	STB_001	73	50	42	39	32	275
	STB_002	111	97	92	82	67	567
Jackson Bayou	R100_001	92	18	0	0	0	27

3.3 Target Volume Determination

A preliminary volume reduction analysis was conducted at each damage center to determine target volumes that would be required to reduce structural flooding at that damage center. While the hydrologic and hydraulic models would ultimately be used to evaluate the detention facilities, the preliminary analysis provided guidance as to potential volumes needed for the watersheds and provide a scale for the size of projected detention facilities.

Potential detention volumes were calculated by comparing volumes and flow rates of the various frequency storm events (10% ACE, 1% ACE, etc.). The detention volume required to reduce the flow from any frequency storm event to a lower storm event was calculated by summing the volume of the larger event that was higher than the peak flow of the smaller event. In the example graph shown in **Figure 5**, the 1% ACE (Blue) has a peak flow of 49,000 cfs and the 10% ACE (Yellow) has a peak flow of 22,000 cfs. The potential volume required to reduce the 49,000 cfs to 22,000 cfs is approximately 33,000 acre-feet, which is shown as the red hatched area.

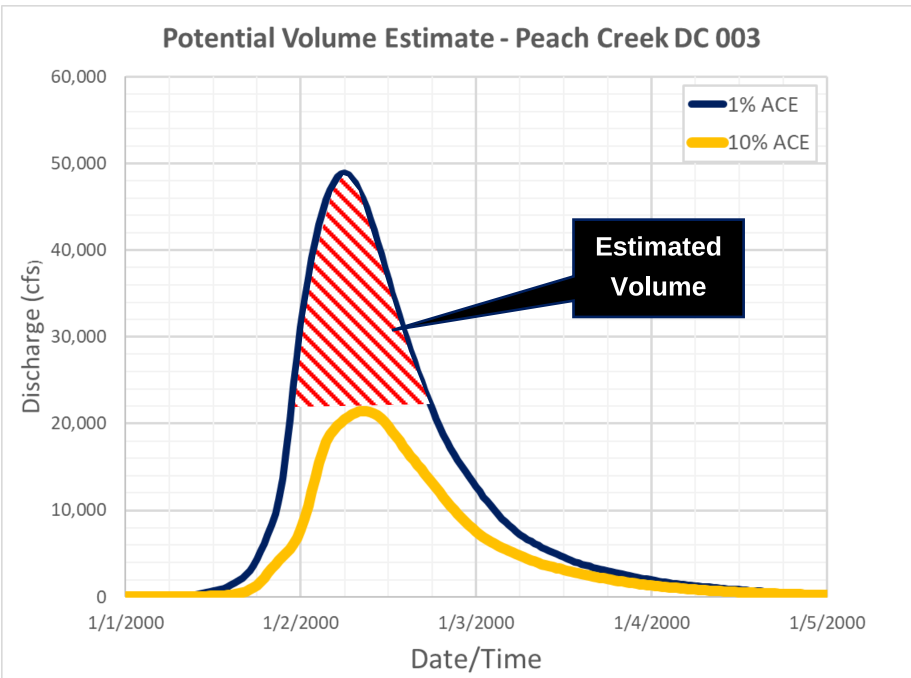

Figure 5: Detention Volume Calculation Graph

Volumes were estimated for each frequency storm event for each damage center and tabulated to evaluate the potential volume needed for the both the individual damage centers and then entire watersheds. **Table 5** summarizes the potential volumes for Peach Creek damage center 3. Tables for all damage centers are included in Appendix A. The tables can be used to evaluate the potential volume needed for all design storm events. The design storm frequency row (e.g. 1% ACE) is matched to the targeted frequency (e.g. 10% ACE), to determine the volume (e.g. 33,426 acre-feet). At a glance, the table shows how much storage volume is needed to reduce current 1% ACE flows to 10% ACE flows.

Table 5: Potential Volumes in Peach Creek

		Estimated Detention Volume Required (acre-ft)						
Design Frequency Storm Event	0.2% ACE	99,371	86,429	73,751	57,112	41,941	26,567	
	1% ACE	56,396	44,511	33,426	18,455	7,036		
	2% ACE	41,378	30,167	19,797	6,597			
	4% ACE	28,627	17,856	9,075				
	10% ACE	14,937	5,534					
	20% ACE	6,532						
		50% ACE	20% ACE	10% ACE	4% ACE	2% ACE	1% ACE	0.2% ACE
		Target Frequency Storm Event						

This volume analysis is an initial pass to provide guidance for locating detention facilities in the detailed modeling phase. There are some limitations to this volume analysis, including:

- The volume calculated for the damage center is obtained from the cross section just upstream of the damage center location. This assumes that the detention volume calculated can be placed directly upstream of the damage center location. In some cases, this property may not be available. If the detention facility must be placed significantly further upstream, the required volume to achieve the desired reduction may increase.
- The calculation using only volume above the peak discharge assumes that a pond can be configured to only detain above this discharge. While this may not be feasible in all locations, the analysis provides a conceptual target volume that informs the future detailed modeling effort.

3.4 Benefits and Level-of-Service Improvements

At each damage center, each conceptual detention volume discussed above was used to estimate a corresponding benefit. The full alternatives analysis documented in Section 4.0 incorporates the value of each structure and standard FEMA depth-damage curves to estimate benefits as dollars of reduced flood damages; however, at this stage, the conceptual range of potential benefits at each damage center was expressed as an estimated reduction in instances of structural flooding over a 50-year period. At this stage, the detention volumes were not explicitly modeled using HEC-HMS or HEC-RAS. Instead, the benefit of each detention volume was estimated based on existing conditions results.

Section 3.1 describes how the annual probability of each frequency event and the number of structures flooded under each frequency event (from the 10% ACE to the 0.2% ACE) were used to calculate the annualized instances of structural flooding for each stream. This process was also followed to determine the existing-conditions annualized instances of structural flooding within each damage center.

Each conceptual detention volume is expected to lower peak water surface elevations through the damage center for a range of frequency events. For example, a detention volume that reduces the existing 0.2% ACE peak flow through a damage center to the existing 1% ACE peak flow could be designed to also reduce the 1% ACE flow to the 2% ACE flow, the 2% ACE flow to the 4% ACE flow, and so on. Therefore, when calculating the annualized instances of structural flooding for this example, the number of structures that will flood under the post-project 0.2% ACE event can be assumed to match the number of structures that flood under the pre-project 1% ACE event. This pattern continues for the smaller storm events. As another example, a smaller detention facility can be designed to reduce the existing 4% ACE flow to the 10% ACE flow, the 10% ACE flow to the 20% ACE flow, and so on. However, because it is a smaller detention facility, it may not be possible to design it to reduce the 0.2% ACE flow to the 1% ACE flow. Therefore, this analysis conservatively assumes that smaller design volumes targeted toward a smaller event (such as the 4% ACE) cannot reduce the number of structures flooding under larger events (such as the 2% ACE, 1% ACE, and 0.2% ACE).

Table 6 shows the resulting conceptual benefit calculations for Damage Center 2 on Spring Creek as an example. The remainder of tables are provided in Appendix A. Along the top of the table is the number of structures currently flooding in that damage center under each frequency event; these numbers are used to calculate the existing-conditions instances of structural flooding over a 50-year period. On the left side of the table, detention volumes in acre-feet are listed for each combination of starting flow (e.g. “500-yr,” or 0.2% ACE) and target flow (e.g. “100-yr”, or 1% ACE). Each detention volume is assumed to reduce the number of structures flooding under each frequency event as shown, and the adjusted numbers are used to calculate the reduced instances in structural flooding over a 50-year period. This reduction in the instances of structural flooding over a 50-year period is the conceptual benefit resulting from that detention volume in acre-feet.

The “B/V” metric, the total benefit divided by the total volume in thousands of acre-feet, shows that smaller volumes generally provide the highest benefit per unit of volume. For example, the table below shows that the first 20,606 acre-feet of volume can reduce the 1% ACE flow to the 2% ACE flow, providing a benefit of 502 reduced instances of flooding. This represents a B/V of 24. If this volume is nearly tripled to 52,195 acre-feet, the 1% ACE flow can be reduced to the 4% ACE flow, but this only provides a benefit of 672 reduced instances of flooding. This represents a B/V of only 13. Each damage center generally shows the highest B/V for the smallest detention volume, and the B/V decreases with each additional unit of volume. This illustrates the diminishing returns provided by additional detention volume.

Table 6: Volume-Benefit Comparison Example—Damage Center 2 on Spring Creek

Damage center: **DC_J100_002** *Station range:* 136198 to 107035 *Mile range:* 25.8 to 20.3

		Existing conditions	1478	525	206	102	38	0	0	**1042**	**Flood instances (50-yr)**		

Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**80,577**	525	206	102	38	0	0	0	**692**	9	80,577	692
500yr	50yr	**125,545**	206	102	38	0	0	0	0	**927**	7	44,968	235
500yr	25yr	**166,508**	102	38	0	0	0	0	0	**1005**	6	40,963	78
500yr	10yr	**215,926**	38	0	0	0	0	0	0	**1035**	5	49,418	30
500yr	5yr	**248,159**	0	0	0	0	0	0	0	**1042**	4	32,234	8
500yr	2yr	**273,914**	0	0	0	0	0	0	0	**1042**	4	25,755	0
100yr	50yr	**20,606**	1478	206	102	38	0	0	0	**502**	24	20,606	502
100yr	25yr	**52,195**	1478	102	38	0	0	0	0	**672**	13	31,588	171
100yr	10yr	**93,178**	1478	38	0	0	0	0	0	**730**	8	40,983	57
100yr	5yr	**119,211**	1478	0	0	0	0	0	0	**747**	6	26,033	17
100yr	2yr	**149,399**	1478	0	0	0	0	0	0	**747**	5	30,188	0
50yr	25yr	**17,194**	1478	525	102	38	0	0	0	**358**	21	17,194	358
50yr	10yr	**52,838**	1478	525	38	0	0	0	0	**482**	9	35,644	124
50yr	5yr	**76,981**	1478	525	0	0	0	0	0	**511**	7	24,143	29
50yr	2yr	**101,258**	1478	525	0	0	0	0	0	**511**	5	24,278	0
25yr	10yr	**21,654**	1478	525	206	38	0	0	0	**280**	13	21,654	280
25yr	5yr	**43,433**	1478	525	206	0	0	0	0	**356**	8	21,779	76
25yr	2yr	**65,193**	1478	525	206	0	0	0	0	**356**	5	21,760	0
10yr	5yr	**11,731**	1478	525	206	102	0	0	0	**152**	13	11,731	152
10yr	2yr	**30,013**	1478	525	206	102	0	0	0	**152**	5	18,282	0
5yr	2yr	**11,314**	1478	525	206	102	38	0	0	**0**	0	11,314	0

A scatterplot was then created for each damage center illustrating each pair of conceptual detention volume and the associated estimated benefit. An example plot for Damage Center 2 on Spring Creek is provided below. Volume on the x-axis represents approximate detention required to reduce "start" peak flow to "target" peak flow, estimated as the volumetric difference between the existing "start" hydrograph and the existing "target" peak flow rate. This relationship was demonstrated on **Figure 6**. Benefit on the y-axis represents the expected reduction in instances of structural flooding over a 50-year project life. Refer to **Appendix G.1** for a full set of volume-benefit curves and detailed summary tables.

A given volume may provide a range of benefits depending on the targeted storm events. For example, reducing the 4% ACE peak flow to the 50% ACE peak flow at this location would take a detention volume of approximately 65,000 acre-feet and would provide a benefit of 350 fewer instances of structural flooding over a 50-year period. In comparison, reducing the 1% ACE peak flow to the 4% ACE peak flow at this location would take a lower detention volume of 52,000 acre-feet, but would provide a higher benefit of 670 fewer instances of structural flooding over a 50-year period. This may be because there are many more structures at risk of flooding during the 1% and 2% ACE storms than there are structures at risk of flooding during the 4% ACE storms and lower. The dashed line that follows the outer edge of these points is the Pareto front, which represents the maximum benefit that could be expected for any given detention volume.

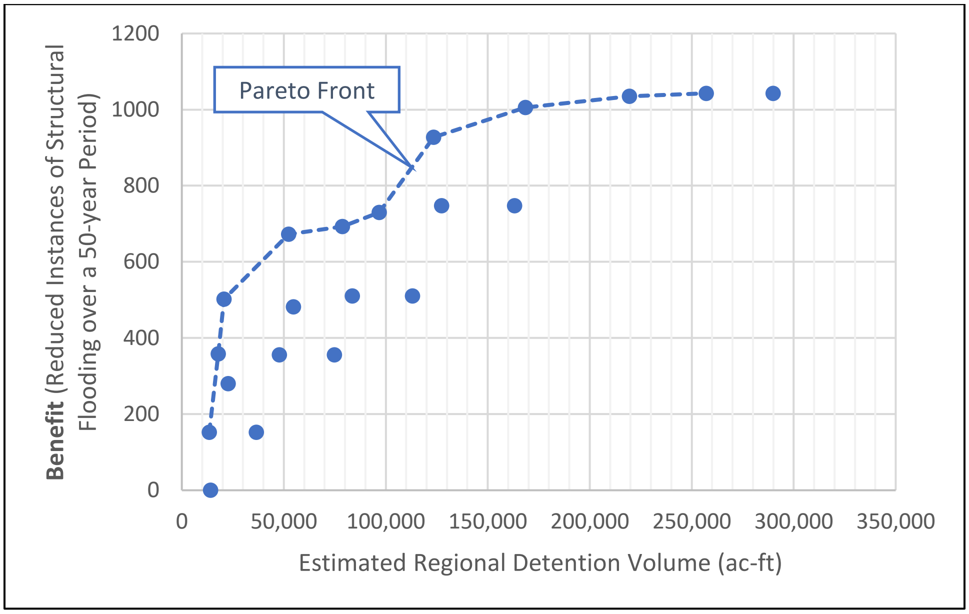

Figure 6: Spring Creek Damage Center 2 Benefit/Volume Scatter Plot

Therefore, each damage center plot illustrates the approximate tradeoff between volume and benefit at that location without identifying a single optimal point. As expected, the smallest volumes generally provide the smallest benefits and the largest volumes generally provide the largest benefits. The dashed line that follows the outer edge of these points is the Pareto front, which represents the maximum benefit that could be expected for any given detention volume. Strictly maximizing benefit would require reducing the 0.2% ACE peak flow to the 50% ACE peak flow with the maximum detention volume, which would not be feasible to construct. The smallest, most easily constructed volume at the other end of the curve would reduce the 20% ACE peak flow to the 50% ACE peak flow. This small volume may provide some benefit, but the Pareto front shows that a significant increase in benefit could be achieved with a slight increase in volume. These volume increases provide diminishing returns as the Pareto front flattens out, to the point where large increases in volume lead to only nominal increases in benefit.

On many of these curves, the approximate inflection point is associated with incremental reductions in flow—for example, approximately 52,000 acre-feet of volume would reduce the 1% ACE peak flow to the 4% ACE peak flow and reduce instances of structural flooding over a 50-year period by approximately 670. Increasing volume beyond the inflection point appears to provide diminishing benefits. For damage centers where more structures are flooded in more frequent storms, the inflection point may be associated with higher volumes—for example, reducing the 1% ACE peak flow to the 10% ACE peak flow.

Increasing volume beyond the inflection point appears to provide diminishing benefits. The identified optimal volumes are listed in the table below and were considered as a starting point for identifying available land upstream of each damage center. Complete volume-benefit curves and comparison tables for each damage center are provided in **Appendix G.1**.

Table 7 summarizes the approximate inflection points on each damage center's Pareto front. These represent the points where increased detention volume provides diminishing benefits. Note that the identified volumes are not each individually required to provide meaningful reductions in damage at each damage center. Many damage centers are located near one another and could each benefit from a common detention volume located upstream. These conceptual volumes and benefits must also be verified through detailed hydrologic and hydraulic modeling of each flood mitigation alternative and benefit-cost analyses. These procedures are discussed in **Section 4.0**.

Table 7: Approximate Inflection for Target Detention vs. Benefit

Stream	Damage Center	Target Detention Volume (ac-ft)	Benefit (Reduction in Estimated 50-year Instances of Flooding)	Starting Flow and Target Flow
Spring Creek	J100_001	61,913	968	0.2% ACE to 1% ACE
	J100_002	52,195	672	1% ACE to 4% ACE
	J100_003	31,690	1,283	1% ACE to 4% ACE
Willow Creek	M100_001	5,297	205	1% ACE to 4% ACE
	M100_002	2,732	190	1% ACE to 4% ACE
	M100_003	296	682	1% ACE to 4% ACE
Cypress Creek	K100_001	13,217	274	1% ACE to 4%ACE
	K100_002	6,172	184	1% ACE to 2%ACE
	K100_003	5,324	142	1% ACE to 2%ACE
	K100_004	27,374	1,075	1% ACE to 4%ACE
	K100_005	8,118	122	1% ACE to 2%ACE
	K100_006	7,353	104	1% ACE to 2%ACE
	K100_007	19,747	964	0.2% ACE to 1% ACE
	K100_008	3,274	212	1% ACE to 2%ACE
	K100_009	4,506	105	1% ACE to 2%ACE
	K100_010	4,192	58	1% ACE to 2%ACE
Little Cypress	L100_001	4,535	2,092	0.2% ACE to 2% ACE
	L100_002	5,688	354	1% ACE to 4%ACE
	L100_003	1,974	77	1% ACE to 4%ACE
	L100_004	1,482	58	1% ACE to 4%ACE
East Fork	GEF_001	71,441	133	1% ACE to 2%ACE
	GEF_002	71,684	138	1% ACE to 2%ACE
	GEF_003	23,994	7	1% ACE to 2%ACE
	GEF_004	57,020	493	1% ACE to 4%ACE
	GEF_005	53,811	603	1% ACE to 4%ACE
	GEF_006	52,154	226	1% ACE to 4%ACE
	GEF_007	45,685	284	1% ACE to 4%ACE
West Fork	G103_001	156,085	456	1% ACE to 2%ACE
	G103_002	131,594	608	1% ACE to 2%ACE
	G103_003	94,444	590	1% ACE to 2%ACE
	G103_004	93,913	70	1% ACE to 2%ACE

Stream	Damage Center	Target Detention Volume (ac-ft)	Benefit (Reduction in Estimated 50-year Instances of Flooding)	Starting Flow and Target Flow
	G103_005	78,449	137	1% ACE to 2%ACE
	G103_006	68,756	780	1% ACE to 2%ACE
	G103_007	49,558	171	1% ACE to 2%ACE
Lake Creek	GLC_001	32,684	131	1% ACE to 4%ACE
	GLC_002	38,002	77	1% ACE to 4%ACE
Peach Creek	GPC_001	17,846	1,916	1% ACE to 4%ACE
	GPC_002	21,530	202	1% ACE to 4%ACE
	GPC_003	19,644	560	1% ACE to 4%ACE
	GPC_004	11,485	57	1% ACE to 4%ACE
Caney Creek	G1038003_001	27,255	527	1% ACE to 4%ACE
	G1038003_002	15,504	1,493	1% ACE to 4%ACE
	G1038003_003	12,986	252	1% ACE to 4%ACE
Luce Bayou	S100_001	14,573	168	1% ACE to 4%ACE
	S100_002	502	38	1% ACE to 4%ACE
Tarkington Bayou	STB_001	7,406	218	1% ACE to 4%ACE
	STB_002	300	432	4% ACE to 20% ACE
Jackson Bayou	R100_001	110	23	0.2% ACE to 1% ACE

3.5 Watershed Mitigation Potential

Based on the damage center, volume, and regional reduction analysis, the watersheds were divided into three tiers of watershed mitigation potential. The tiers were based on the availability of open land to construct large detention facilities, potential to provide benefit within the watershed (reduced instances of flooding), and potential to provide regional reduction in flood risk downstream. These tiers were used to guide selection of locations for detailed modeling as described in the section below and is not related to project ranking.

- High Potential
    - Spring Creek has a significant number of potential damages within the watershed with approximately 6,000 expected instances of flooding over a 50-year period. The watershed also has available land for regional detention on several of its tributaries including Walnut Creek, Birch Creek, Threemile Creek, and Mill Creek. Removing runoff from Spring Creek also showed the highest benefit of water surface elevation reduction downstream in the West Fork and Lake Houston.
    - East Fork San Jacinto River has over 5,000 expected instances of flooding over a 50-year period primarily in the lower portion of the watershed. The upper portion of the East Fork is located within the Sam Houston National Forest and therefore has significant amount of open space available for regional detention. The watershed is also a major contributor to Lake Houston and removing its runoff would provide reduction to the flows into Lake Houston.
    - Peach Creek has over 10,000 expected instances of flooding over a 50-year period primarily in the lower portion of the watershed. The upper portion is relatively undeveloped

and therefore has open space available for regional detention. Removing runoff from this watershed would also provide regional benefit to both the East Fork downstream of the confluence and Lake Houston.

- Caney Creek has over 12,000 expected instances of flooding over a 50-year period, primarily in the lower portion of the watershed. The upper portion is relatively undeveloped and therefore has open space available for regional detention. Removing runoff from this watershed would also provide regional benefit to both the East Fork downstream of the confluence and Lake Houston.

- Moderate Potential
  - Lake Creek is a large contributor to the West Fork below Lake Conroe. The watershed has available open space, particularly north of SH 105 and removing its watershed would provide regional benefit through the West Fork and in Lake Houston. However, in this watershed, there are only 1,200 expected instances of flooding over a 50-year period which will reduce the local benefit of any regional facilities.
- Low Potential
  - Luce Bayou has a low number of expected instances of flooding over a 50-year period compared to the other watersheds. While the basin is mostly undeveloped providing ample space for detention, the terrain is relatively flat and therefore would require significant excavation and land to achieve similar volumes. The basin also has an overflow near the confluence with Tarkington into Cedar Bayou which removes large portions of the watershed's runoff prior to entering Lake Houston. The HCFCD is studying the lower portions of Luce Bayou and there is a program for the Cedar Bayou Bond Implementation Program to address flooding in Cedar Bayou. Therefore, removing this volume would not provide regional benefit to Lake Houston.
  - The West Fork watershed has 14,000 expected instances of flooding over a 50-year period, concentrated near Interstate 45 and near Lake Houston. However, the watershed however has limited available space for detention, except upstream of Lake Conroe, which would not provide flood risk benefit downstream of the lake. The volumes needed directly on the West Fork are significantly higher than other regions. Channelization on the West Fork should be explored rather than detention/mitigation solutions.
  - Willow Creek has a large number of flooding instances at 7,800. The watershed does not have significant space for regional detention that would provide benefit along the creek and downstream. Removing runoff from this watershed also has limited regional benefit since it is a small contributor to Spring Creek. The creek is also being studied as part of the ongoing CDBG watershed protection studies by the HCFCD.
  - Little Cypress Creek has 7,000 expected instances of flooding over a 50-year period. The watershed does not have significant space for regional detention that would provide benefit along the creek and downstream. Removing runoff from this watershed has limited regional benefit since it is a small contributor to Cypress Creek. The HCFCD also has implemented the Little Cypress Frontier Program which includes a public-private partnership to excavate regional detention.
  - Cypress Creek has 7,200 expected instances of flooding over a 50-year period. The basin is mostly developed except for the upstream end in northwest Harris County and eastern

Waller County. There is a significant overflow to the Addicks Watershed in Harris County for storm events greater than the 4% ACE. Detention at the upstream end where there is available land would likely only reduce the overflows into Addicks and not any flows into Lake Houston. While an overflow reduction into Addicks is worthwhile, it is outside the scope of this study. HCFCD has several ongoing studies in this watershed identifying both regional and local detention options.

- Jackson Bayou is a small contributor to the San Jacinto River downstream of the Lake Houston Dam. The basin does not experience significant flooding on the mainstem, has limited available land for regional detention, and removing runoff from the watershed does not provide regional benefit due to the location downstream of Lake Houston Dam.

The high-level analysis of the watershed potential shows that Spring Creek, East Fork San Jacinto, Caney Creek, Peach Creek, and Lake Creek were each identified as watersheds that could both benefit locally from regional detention basins (based on the damage center analysis) and provide reductions in water surface elevations through the lower portions of the San Jacinto watershed closer to Lake Houston (based on the watershed volume sensitivity analysis). These watersheds were further explored in the detailed modeling phase of this study. **Table 8** summarizes the watershed mitigation potential for projects in each watershed.

Table 8: Watershed Mitigation Potential

	Benefit in Watershed	Open Space	Regional Reductions	Potential
Luce Bayou		✓		Low
East Fork	✓	✓	✓	High
Peach Creek	✓	✓	✓	High
Caney Creek	✓	✓	✓	High
West Fork	✓			Low
Lake Creek		✓	✓	Moderate
Spring Creek	✓	✓	✓	High
Willow Creek	✓			Low
Little Cypress	✓			Low
Cypress Creek	✓			Low
Jackson Bayou				Low

The volume/benefit curves were compared within each watershed to determine target volumes needed. The curves helped assess the potential volumes that provide significant benefit without excessive volume. Each curve had an inflection point where additional volume did not provide significant additional benefit. The curve below shows the volume and benefit values for one of the damage centers in the Spring Creek watershed. The curve has an inflection point at approximately 50,000 acre-feet. This range gives an approximation to a target volume needed in the Spring Creek watershed that would provide the most effective flood risk reduction to this damage center.

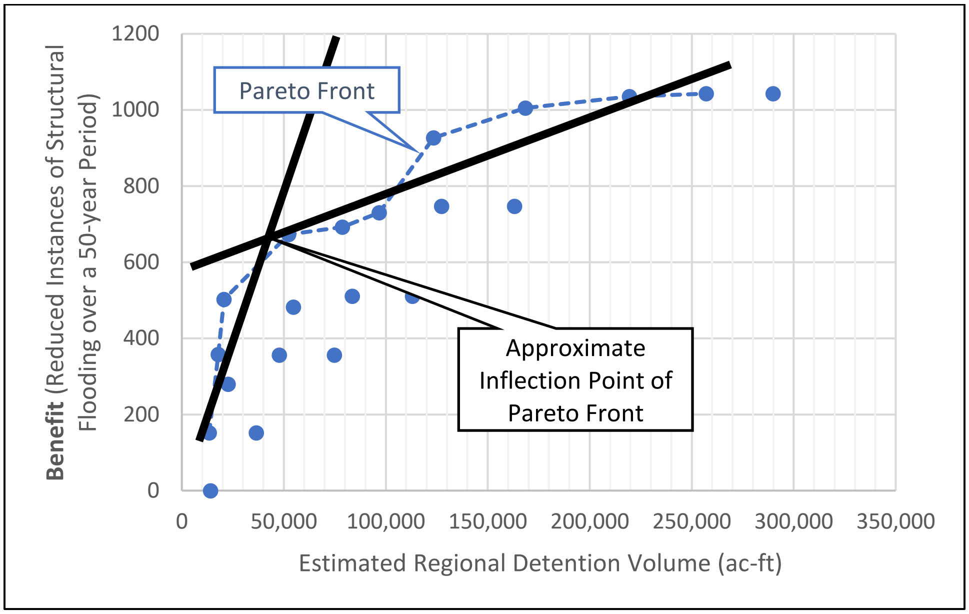

Figure 7: Approximate Watershed Mitigation Volume

A similar analysis was conducted for each watershed to understand the potential watershed wide volumes needed for the moderate potential and high potential tier watersheds. The results of the analysis per watershed are summarized in **Table 9**. These volumes were the starting volumes targeted for each watershed when locating potential detention facility sites.

Table 9: Watershed Potential Volume

Watershed	Potential Target Volume
Spring Creek	50,000 acre-feet
Lake Creek	150,000 acre-feet
Caney Creek	40,000 acre-feet
Peach Creek	30,000 acre-feet
East Fork San Jacinto	100,000 acre-feet

4.0 Flood Mitigation Alternatives Analysis

The goal of the flood mitigation alternative analysis was to develop flood mitigation solutions that would reduce the flood risk throughout the Upper San Jacinto watershed. The analysis considered previous projects that had been recommended to reduce flood risk as well as provide water supply. Flood mitigation projects that had been previously proposed by others in historical reports were considered primary alternatives and were evaluated to see if they were implementable.

4.1 Overview (Primary vs. Secondary)

Flood protection, mitigation, and water supply strategies been proposed across the San Jacinto River watershed over the past several decades. The project team reviewed and summarized historical drainage studies were reviewed and summarized in the existing conditions report. These historical reports included both analysis of the existing conditions watershed and potential mitigation alternatives to improve flood risk, manage the region's water supply, and determine the impacts of sedimentation. The summary provided a comprehensive understanding of the purpose and goals of past studies and identified proposed alternatives that were previously considered. The alternatives proposed in the historical reports were considered as primary flood mitigation alternatives.

The project team developed additional alternative projects that had not been previously identified in historical reports. These alternative projects were considered as secondary flood mitigation alternatives. The focus of the secondary alternatives was to reduce flood risk at the damage centers that were identified as part of this project, which may not have existed at the time of the historical analyses.

4.2 Previously Recommended Projects

Previously recommended projects were taken from historical reports of the San Jacinto River watershed. Since 1947, over 30 projects have been proposed to reduce flood risk and or provide water supply were proposed in the watershed. These historical projects primarily consisted of water supply reservoirs which would have some magnitude of flood storage. These proposed reservoirs did not give any indication of the location of flood risk reduction targets. The projects generally had minimal flood mitigation storage with their primary intent being water supply. Other previously recommended projects considered channelization, vegetation clearing, bridge modifications, sedimentation management, and property buyouts. The projects are shown in the figure below and summarized in **Appendix B**.

Other considerations were given in reviewing the previously recommended projects. These considerations included opportunities and challenges to implementing the projects under current conditions as they were originally proposed. The opportunities considered included: the ability to reduce flood damages, the opportunity to improve sediment issues, and the opportunity for ancillary uses. The challenges that were considered included property acquisition, site conflicts (environmental, transportation, utilities, etc.), and operations and maintenance.

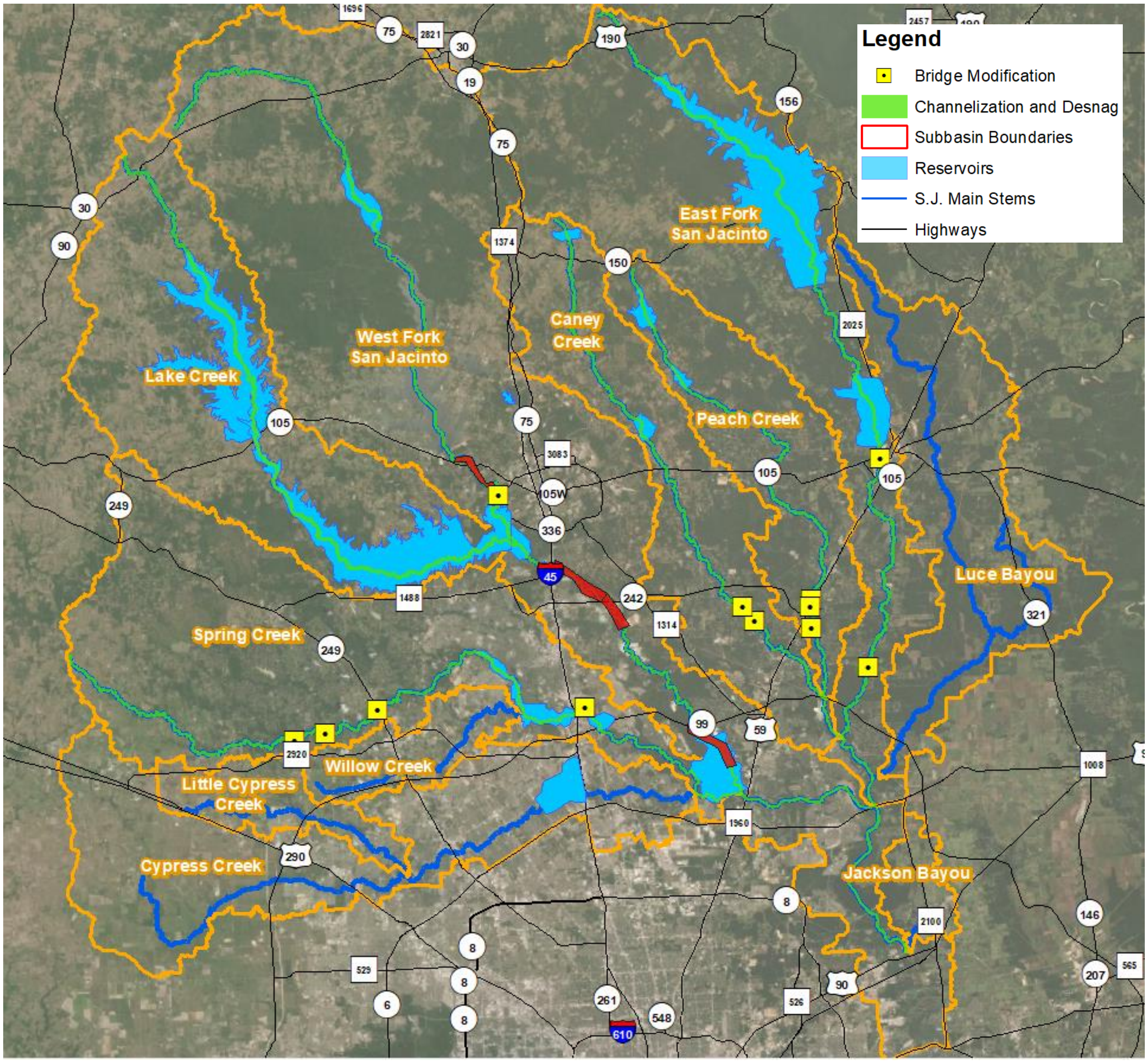

Figure 8: Previously Proposed Projects

After a thorough review, many of the previously recommended projects were found to be infeasible for construction and did not provide they flood mitigation benefits that are needed in the watershed. Only four primary alternatives were found to be feasible for further analysis. These included alternatives on Spring Creek, Lake Creek, Peach Creek, and the East Fork of the San Jacinto River.

4.3 Types of Mitigation Measures Considered

Secondary flood mitigation alternatives were derived from a combination of the location of flood damage centers and previously recommended projects. Project types that were considered included large detention facilities and channelization and are summarized in Section 5. Other approaches that were considered more generally include floodplain preservation, buyouts, and detention policy.

4.4 Opportunities and Challenges

Beyond the tangible flood reduction, project costs, and structural benefits, there are a variety of considerations for each of the projects that were identified. Among these are ROW acquisition, environmental impacts, utilities and roadways that may be impacted, and potential partnership and funding opportunities. This section provides an overview of these considerations.

4.4.1 ROW

The right-of-way needs for detention may vary widely depending on the development criteria behind each of the proposed detention basins. Initially, the necessary ROW was identified based on the 1% ACE inundation area behind the dams. After further discussion and consideration, the study team determined that acquiring all property up to the Probable Maximum Flood (PMF) inundation area would be prudent. Ownership of all the property to that level would prevent development in an area that could potentially become inundated during a major rainfall event, such as Hurricane Harvey with the Addicks and Barker Reservoirs in Harris County. Identifying the parcels needed for both levels gives future owners of these facilities a range of costs and levels of protection that can be weighed against the risks of building in these areas.

The process included the intersection of the inundation area with parcel data to identify the total number of parcels that may need to be acquired for the proposed project. The parcel was assumed to be fully acquired if more than 20% of the parcel was inundated by the 1% ACE and PMF events, and partially acquired if less than 20% of the parcel was inundated. This provides a conservative cost assumption without acquiring the entirety of every large parcel that is touched by the flood pool. The estimated cost to acquire the right-of-way was assumed to by 2.5 times the market value. The factor of 2.5 accounts for uncertainty in the current appraisal district estimate, contingency, legal costs, acquisition, relocation, and demolition. The factor was discussed with the study partners, including HCFCD's ROW Department to ensure that it was reasonable. This assumes an outright land acquisition, but area behind the reservoir could also be obtained through flooding easements; this was not considered as part of this study.

4.4.2 Environmental

A desktop environmental assessment was performed for each proposed project area. The assessment considered potential wetlands and Waters of the United States that may be impacted within the footprint of the proposed embankment or excavation. The National Wetlands Inventory, which is a high-level desktop dataset, was used to identify wetlands and the National Hydrologic Dataset was used to identify Waters of the US. It should be noted that wetlands and stream mitigation will need to be identified in detail through both a detailed desktop analysis using local datasets as well as field observation. Further analysis will need to be conducted in a feasibility phase to evaluate wetland and stream mitigation measures, quality of wetlands and streams, and degrees of aquatic and/or habitat loss. In addition, streams that may be impacted through the channel conveyance improvements or detention embankment will need to be evaluated to determine if the USACE will claim jurisdiction, as well as the quality and extent of the impacts. A permitting and mitigation strategy will need to be developed which will depend on the impacts.

The project team was unable to locate any records of previously observed federally listed endangered species in the area. This does not mean no impact is anticipated, just that no federally listed endangered species have been documented.

Additional investigation of U.S. Fish and Wildlife (USFWS) and TPWD (Texas Parks and Wildlife Department) threatened and endangered species, Texas Historical Commission (THC) cultural resources, and hazardous materials will need to be considered during preliminary and final design. Regarding cultural resources, an initial archeological review of each project site found that archeological surveys have previously been conducted in several proposed project footprints for development or roadway projects. There may be potential to find cultural material along streams and upper terraces. These costs have not been specifically quantified in the cost estimates but may be covered by the contingency.

The USACE may require an Environmental Impact Statement for each detention site identified. This process can take three to five years. Substantial channel improvements may also require an Individual Permit from the USACE; these costs were not specifically included in the estimates because the alternatives were designed to be benched above the ordinary high-water mark. Sites in the Sam Houston National Forest will likely also require a NEPA review process, which potentially requires an Environmental Impact Statement. Detention sites on the forest may also yield environmental benefits if coordinated with forest management goals.

4.4.3 Utilities/Roadways

Major utilities and roadways were identified in the project areas. Major pipeline utilities to be impacted by the project dam embankment or channelization were identified using Texas Railroad Commission data. Roadways to be inundated by more than 1 foot as a result of the detention flood waters were also identified. Detailed utility investigation will be needed during the preliminary engineering and design stages and coordination with TxDOT and the local county will be required to address any roadway changes that may be needed.

4.4.4 Potential Partnerships

Potential partners were identified based on the proposed physical location of the project, as well as those jurisdictions that may benefit from the proposed projects. Potential partners consisted of counties, cities, agencies, and districts. They may also include parks and conservation entities which could benefit from a multi-use facility. The identified partners were those who can support the projects either financially or politically. When looking at project funding options, it should be noted that multi-jurisdictional partnerships can improve the likelihood of a successful grant application.

4.5 Project Costs

An estimate of costs were developed for each proposed project; however, there is still substantial lack of site-specific technical information and scope clarity in the estimate, resulting in major estimate assumptions. These include technical information and quantities, heavy reliance on cost engineering judgment, and local bid tabs. While certain construction elements can be estimated with a higher degree of confidence, there is still a great deal of uncertainty relative to major construction components. The costs presented provide a reasonable estimate of potential funding needed for the projects but are not necessarily detailed construction costs of a fully defined and developed project. This uncertainty is reflected in the 30% contingency. The most significant cost component of each detention project is the right-of-way acquisition.

4.5.1 Construction Cost Estimates

The construction costs estimates were derived based on 2020 unit costs from a number of sources including recent bid tabs for HCFCD, Harris County, and TxDOT projects. Quantities were derived from the project extents and include:

- Mobilization – The mobilization of equipment and workers to operate the project site (5% of construction cost).
- Temporary Erosion and Sediment Control – The measures and equipment needed to control erosion and sediment during construction (2% of construction cost).
- Site Preparation and Site Maintenance – The measures needed to prepare the site for construction and to maintain the site during construction.
- Care of Water – The measures that need to be taken to maintain the flow of water and provide any other care of water during construction.
- Clearing and Grubbing – The measures to be taken to remove debris, vegetation, and any other surface elements.
- Utility Conflicts/Relocation – The relocation of any major oil/gas pipeline utility conflicts.
- Site Preparation – The measures needed to prepare the site for construction
- Excavation – The effort to excavate material that needs to be removed from the site for construction purposes. A cost of $10 per cubic yard was assumed for both detention and channel excavation. For detention alternatives, excavation is assumed to remain on-site and used to construct the embankment. For channel alternatives, this quantity of excavation would best be disposed of through an arrangement with developers or other interested buyers rather than disposal in a landfill. If this excavation volume were disposed of in a landfill as is typical for smaller channel projects, the unit cost could increase to at least $20 per cubic yard or as much as $35 per cubic yard depending on the landfill and disposal requirements
- Embankment – The placement of material including excavation from onsite borrow for the construction of the detention facility.
- Drainage – The construction of internal drainage features of the dam embankment.
- Spillway – The construction of a roller compacted concrete spillway.
- Erosion Control – The placement of rock rip rap at the principal outfall of the structure to provide erosion protection.
- Instrumentation – Placement of information equipment that will assist in the operation and maintenance of the structure.
- Topsoil – Placement of topsoil upon embankment of the detention facility or channel.
- Seeding – The placement of vegetation seeding upon the cleared and grubbed area, embankment, and/or onsite borrow area to stabilize the soil.
- Site Restoration – The measures to restore the site upon completion of construction.
- Access Roadway – The placement of an asphalt road on the dam embankment or along the channel with access to the nearest public roadway.

4.5.2 Cost Uncertainty

As previously discussed, there is a degree of uncertainty in the project estimates provided in this report. This includes construction and utility relocation costs, as well as variations in the potential ROW needs and environmental concerns.

4.5.2.1 Construction Costs

Construction pricing may vary depending on economic conditions, availability of materials, access to the project site, fill import and/or disposal logistics for excavated material, and more. As the industry has seen over the past several years, an increase in roadway or development projects may create a spike in concrete costs, just as the recent uptick in channel repair projects has increased rock rip rap costs. Given that these projects will be built over several decades, there is uncertainly into future material demands, and subsequent cost increases may be. In order to counter these uncertainties, a 30% contingency was included on construction unit costs. In addition, each of the project summaries (**Section 5.0**) include a 20-year escalation to provide some idea of how the costs might change over the next two decades.

4.5.2.2 ROW Acquisition

The highest cost component of each identified detention project is the right-of-way acquisition. As discussed in **Section 4.4.1**, the ROW costs were based on the market value provided by each of the County Appraisal Districts multiplied by a factor of 2.5 to account for uncertainty in the current appraisal district estimate, contingency, legal costs, acquisition, relocation, and demolition. Even though it is appropriate for this level of planning study, there are several areas of uncertainty with this approach. These include the following:

- The market value provided may not be consistent with an actual appraised value
- The amount of property acquired may vary as the projects are further evaluated and refined. The exact limits of property acquisition will also need to be determined by the dam and facility owner.
- Some properties may have willing sellers while others may require the use of eminent domain
- Costs may increase depending on when the project is built and the surrounding development

Because the right-of-way acquisition cost is the highest cost component of each detention project included in this study, and because there is uncertainty regarding the limits of property acquisition, this study presents both the 1% ACE and PMF flood pool acquisition costs for each detention project. In either case, the size and construction limits of the dam itself remains the same; the only difference is in the upstream property acquired. The 1% ACE flood pool area represents the minimum anticipated acquisition area required to construct the project. Beyond the 1% ACE, the dam owner may purchase the entire 0.2% ACE flood pool, the entire PMF flood pool, or potentially designate the 0.2% ACE or PMF flood pool as an inundation easement at a lower cost. The PMF flood pool area represents the maximum anticipated acquisition area required to construct the project.

4.5.2.3 Utility and Roadway Relocations

Utility relocation has been accounted for at a conceptual level assuming $1 million per utility relocation using readily available data from the Texas Railroad Commission, but more detailed information is required to refine these estimates. The possibility of water, wastewater, and telecommunications utilities is currently not specifically included and is assumed to be covered by the 30% contingency.

Existing roadways cross some of the proposed dam flood pools and may need to be permanently closed, relocated around the flood pool, elevated as a bridge, or relocated and elevated where appropriate. Most existing roads within the proposed dam flood pools are already crossing the current 1% ACE floodplain and thus were designed with a bridge or culvert crossing to provide a certain level of service. Such roads located at the upstream limits of the flood pool could remain in place with minimal to no impact to the level of service, while roads located at the downstream limits of the flood pool in higher-risk areas may need to be relocated or raised to maintain the existing level of service. Other roads may simply be closed provided that they are not the only access to a property, do not create a hardship in increased travel time for users, and are not critical to emergency response. Due to the conceptual nature of this study and the number of potential roadway configurations given these considerations, this study does not include the cost of potential roadway relocations.

4.5.2.4 Environmental Costs

There is also a degree of risk and uncertainty associated with environmental permitting and mitigation. Section 4.4.2 discusses the potential stream and wetland impacts associated with these projects. Environmental considerations include, though are not necessarily limited to the following:

- The actual wetlands coverage could be significantly different than the NWI coverage
- The quality of the stream or wetland impacts permitting and is not apparent using NWI data
- There may be impacts to USFWS or TPWD threatened and endangered species, THC cultural resources, or potential hazardous materials.
- The specific mitigation strategy could include mitigation banks or mitigating in place
- Changes to the permitting requirements could create additional challenges

4.5.2.5 Future Development

As the San Jacinto Basin continues to develop, changes to the hydrology of the basin, potentially including the specific sites identified for the projects, could alter the project location, configuration, effectiveness and goals. As these projects move toward feasibility and design, changes to the surrounding area should be considered as they may limit project effectiveness and/or increase project cost.

4.5.2.6 Maintenance

Long-term maintenance costs should also be considered. For each large detention dam, an annual maintenance cost equal to 1% of construction cost can be assumed that would include mowing, monitoring of instrumentation, regular inspections, and occasional minor repairs. This estimate would not include major repairs. For channelization projects, a lower annual maintenance cost of 0.5% can be assumed to include mowing, monitoring, and clearing of debris. These costs are not currently accounted for in the project cost estimates or benefit-cost analyses but are included in the project discussion.

4.5.3 Potential Risk Inventory

There is a degree of risk and uncertainty associated with the development and evaluation of the proposed projects. Risks associated with the projects include, but are not limited to the following:

- Future development in the watershed could continue to occur, between the timeframes of feasibility study and actual construction, potentially increasing runoff volumes and requiring relocation or reduction of the detention volumes.
- Environmental or archeological coordination could reveal additional mitigation costs in addition to the wetlands and stream mitigation costs that are currently assumed.
- Other large utilities may exist in the project area and require relocation, increasing project cost.

4.6 Benefits

The primary benefits of these mitigation projects are long-term reduction to structural flood damages. For a straightforward comparison to project costs, project benefits must be measured in dollars of reduced flood damages over the project life. This calculation was performed using spreadsheet calculations that follow the same principles used in FEMA's Benefit-Cost Analysis (BCA) Toolkit.

4.6.1 Structural Inventory Update

To facilitate calculation of pre-project and post-project flood damages, the structural inventory discussed previously was updated to incorporate appraisal district valuation data for the improvement (structure) value and the parcel's market value. Parcel data sources for the watershed varied by county. The sources and tax year for each county are shown in the table below.

Table 10: Structural Inventory

County	Source	Year
Harris	HCAD	2019
Montgomery	MCAD	2019
Waller	TNRIS	2019
Walker	TNRIS	2019
Liberty	TNRIS	2019
Grimes	TNRIS	2019
San Jacinto	TNRIS	2019

The parcels were combined into a single dataset to be used in the benefit cost analysis for this study. Multiple adjustments were necessary. Small gaps and overlaps in the parcels, primarily along county boundaries, were removed. In some instances, many duplicates of a single parcel were aggregated into a single parcel. For example, a multi-story apartment building with 10 units may be represented by 10 duplicate parcels, each with their own improvement value, but the benefit-cost analysis process requires a single improvement value per structure. This issue was resolved by summing the individual improvement values for the duplicate parcels into a single representative parcel with an aggregated improvement value.

The relationship between structures and parcels is not strictly one-to-one. Some structures span multiple parcels, and some parcels contain multiple structures. Properly apportioning the parcels' improvement values to the structures required the following assumptions:

- Some structures spanning multiple parcels were primarily located on one parcel, with only a sliver extending onto an adjacent parcel. Slivers representing less than 10% of the original building footprint area were assumed to be insignificant and were removed. Structures that still spanned multiple parcels were assigned the sum of the improvement values of the underlying parcels.

- For parcels that included multiple structures, the parcel's total improvement value was apportioned to each structure using its fraction of the total structure area. For example, consider a parcel with an improvement value of $1,000,000 containing three structures totaling 10,000 square feet. A structure in this parcel that is 2,000 square feet would receive a value of one-fifth of the total improvement value, or $200,000.
- A small number of parcels had blank improvement values. For these structures, a median improvement value of $170,000 was assumed. Finally, structures with a value of under $100 per square foot were increased to use this minimum value. Based on prior experience with FEMA grant reviewers, this adjustment is allowed in order to prevent less valuable structures from being disadvantaged in the benefit-cost analysis process.

4.6.2 Estimation of Structural Benefit

Each structure in the inventory was assigned an existing condition water surface elevation based on its river station. Structural damages are based on depth of flooding, which was calculated as the water surface elevation minus the finished floor elevation.

The depth of flooding during each frequency storm was then translated to flood damage expressed as a percentage of the structure's value. This was accomplished by interpolation of standard USACE depth-damage curves for residential and non-residential structures. (For this project, structures below 10,000 square feet were classified as residential. The remaining structures were classified as non-residential.) These depth-damage curves relate flooding depth to multiple types of damage associated with structural flooding, including structural damage, damage to contents, and displacement costs. The generic USACE single-story, no basement depth-damage curve was used for residential structures. Several non-residential structure types from the FEMA BCA Toolkit 6.0 were averaged and applied for non-residential structures. This process resulted in a list of expected flood damages for each frequency storm, which has a defined probability of occurring in any given year. This probability versus expected damages curve was then integrated using the trapezoidal rule to obtain an annualized damages value. The annualized structural damages were then converted to a net present value using a typical 50-year project life for drainage improvement projects and the FEMA-required discount rate of 7 percent. This discount rate for flood damage calculations, which converts future benefits to present dollar value, is mandated by the Office of Management and Budget and is intended to reflect the average rate of return of a typical investment.

For each proposed alternative, the same process was performed to assign peak water surface elevations and calculate the corresponding structural damage was performed. The difference between net present value existing and proposed damages represents the project benefit in 2020 dollars. Assigning project benefits in this manner allows for a direct comparison of each alternative's benefit and cost.

Table 11 summarizes the net present value of expected structural damages over a 50-year period under existing conditions along each modeled stream. These existing-conditions damages are the basis for the benefit calculations of each individual alternative and the selected combined alternatives.

Table 11: Net Present Value of Structural Damages

Stream	Expected Structural Damages (NPV, 50-yr Period) ($M)
Spring Creek	339.3
Willow Creek	119.1
Cypress Creek	373.1
Little Cypress Creek	196.6
East Fork SJR	128.2
West Fork SJR	396.7
Lake Creek	16.5
Peach Creek	163.5
Caney Creek	140.9
Luce Bayou	20.0
Tarkington Bayou	75.1
Jackson Bayou	3.9
Gum Gully	6.3
Total	1,979.2

Charts depicting the location of existing structural damages per river mile, along with the reduction anticipated from the combined recommended alternatives, are attached as part of **Appendix G.2 and G.4**. These charts are similar to the existing conditions flooding charts presented in Section 2, but these charts document existing flood risk and benefits in units of dollars of structural damage rather than the number of instances of structural flooding.

The pre- and post-project damages used to determine the benefits can be seen for each of the major streams on a per mile basis. This allowed the team to identify areas of high damages and the corresponding benefits in those areas. **Figure 9** shows the summary of benefits for Spring Creek. Similar summaries of damages are included for each stream in **Appendix D**.

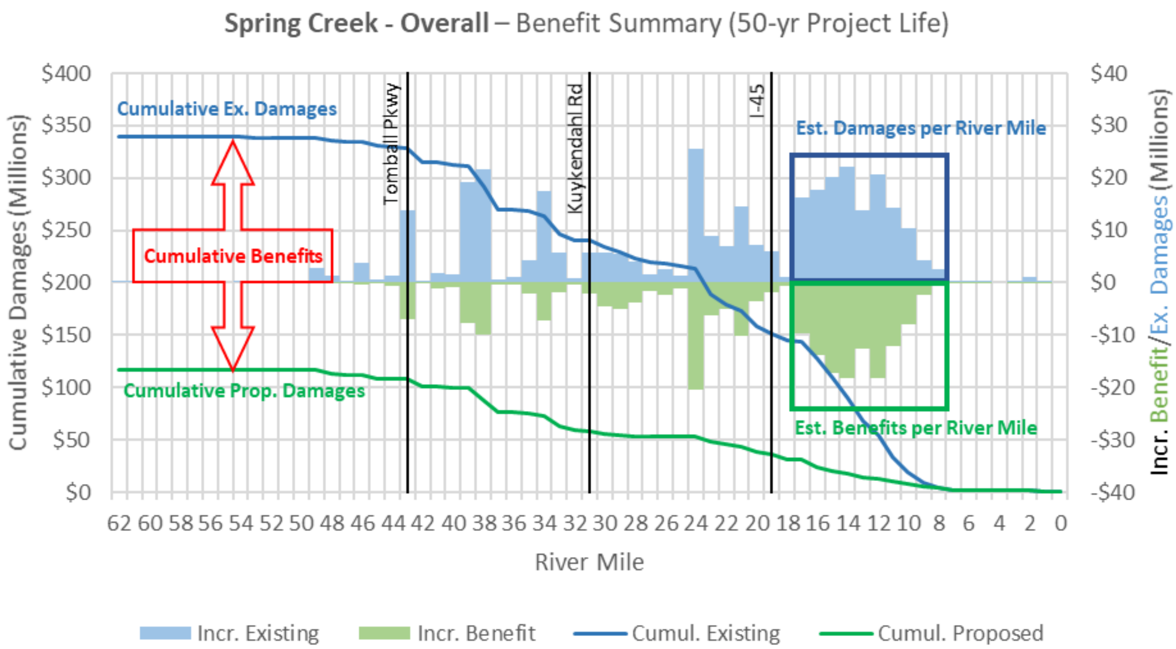

Figure 9: Sample Summary of Benefits (Spring Creek)

4.6.3 Key Assumptions and Limitations

The process of damage center identification and alternative modeling is based on one-dimensional river modeling results and assumed finished floor elevations based on LiDAR. Unlike in the damage center analysis, the 50% ACE and 20% ACE results were included in calculation of flood damages and benefits, as is typical for the FEMA BCA process. This process also does not include any structures along tributaries that drain into the main stems. The actual benefit of any given project may be higher if these tributaries and the corresponding structures were modeled and considered.

4.6.4 Additional Metrics

Besides benefits from reduction in structural flooding, flood mitigation projects can lead to multiple tangible and intangible benefits.

4.6.4.1 Roadway Benefits

Roadways that are overtopped during rainfall events can lead to increased travel times for commuters and emergency vehicles, and even completely trap certain areas. The costs of increased travel time can be accounted for using regional traffic models and economic impact studies. Evaluating this type of damage is not within the current scope of work for this study. However, the Houston-Galveston Area Council (H-GAC) investigated the economic impact of bridges that are flooded during the existing conditions 10% ACE and 0.2% ACE events using the REMI TranSight model and the U.S. Department of Transportation's Vulnerability Assessment Scoring Tool (VAST). H-GAC's preliminary existing-conditions analysis indicates that the economic impact of roadway flooding is small relative to expected structural flooding damages. For example, if existing roads that are overtopped during the 10% ACE event are closed for one day, H-GAC's model shows $1.25 million in lost personal income and $990,000 in reduced gross domestic product. These impacts are two orders of magnitude below the expected structural damages during the 10% ACE event of approximately $189 million. H-GAC's model also shows that roads overtopped during the 0.2% ACE storm lead to 2.2 million in lost personal income and 1.7 million in reduced gross domestic product. These impacts are three orders of magnitude below the expected structural damages during the 0.2% ACE storm of approximately $9.7 billion.

4.6.4.2 Social Benefits

FEMA's BCA Toolkit measures the economic impact of mental stress, anxiety, and lost productivity induced by flooding events. FEMA typically allows these social benefits to be applied only if the project's structural damage evaluation results in a benefit-cost ratio between 0.75 and 1. This allows social benefits to buoy a project that falls just below a benefit-cost ratio of 1. Structural and social benefits must therefore be calculated separately, with social benefits only applied when the structural BCR criteria is satisfied.

These economic impacts are based on the number of residents and workers per household. For each residential structure that sees any reduction in flood risk due to a project, the FEMA-standard economic impact of reduced mental stress and anxiety is $2,443 per resident, and the economic impact of restoring lost productivity is $8,736 per worker. In the study area, US Census averages for persons per household generally range between 2.5 and 3, depending on the city or county. Assuming a conservative average of 2.5 residents and 1 worker per residential structure yields a social benefit of $14,843 per residential structure with reduced flood risk according to FEMA methodology. FEMA allows these social benefits to be included if the structural benefits presented previously result in a structural BCR of between 0.75 and 1.

Given that each of the projects being considered as part of this study would benefit several thousand residential structures, any project that qualifies for social benefits should receive hundreds of millions of dollars of social benefits, resulting in a competitive BCR above 1.0. The BCRs listed for each project in this report are structural BCRs and do not include social benefits in order to allow for a more direct comparison between projects.

4.6.4.3 Environmental Benefits

In FEMA funding applications, environmental benefits may be quantified for area that is improved from a developed condition back to a natural condition. Similar to social benefits, FEMA typically allows these environmental benefits to be applied only if the project's structural damage evaluation results in a benefit-cost ratio between 0.75 and 1. The alternatives proposed as part of this study are not expected to have significant environmental benefits. However, some of the alternatives analyzed may be coordinated with separate environmental restoration efforts. For example, a wetlands restoration of wildlife habitat in the Sam Houston National Forest may be paired with an alternative from this study in a manner that achieves both goals, allowing environmental benefits to augment the structural benefits.

Per FEMA methodology, environmental benefits are calculated on a per-acre basis, with benefits ranging from $554 per acre per year for forested area to $39,545 per acre per year for riparian area. These benefits would be difficult to quantify at this stage of study, but these benefits may be able to be added during future project development phases.

5.0 Flood Mitigation Alternatives

A total of 25 flood mitigation alternatives were explored and conceptually modeled for this study. These generally consist of dry dam construction to provide an inline detention basin along the mainstem or tributary of one of the studied streams, or channelization of the mainstem by providing a wide channel bench set several feet above the channel flowline in an effort to stay above the ordinary high-water mark. Offline detention was considered in the early stages of the project but was not found to be very effective at this regional scale.

The typical dam embankment and principal spillway sections shown below were used to calculate quantities for each dry dam detention alternative. The typical channel cross sections are shown and discussed under the following individual alternative sections, but generally consist of a several-hundred-foot wide channel bench set above the ordinary high-water mark that returns to existing grade at a slope of 4 to 1.

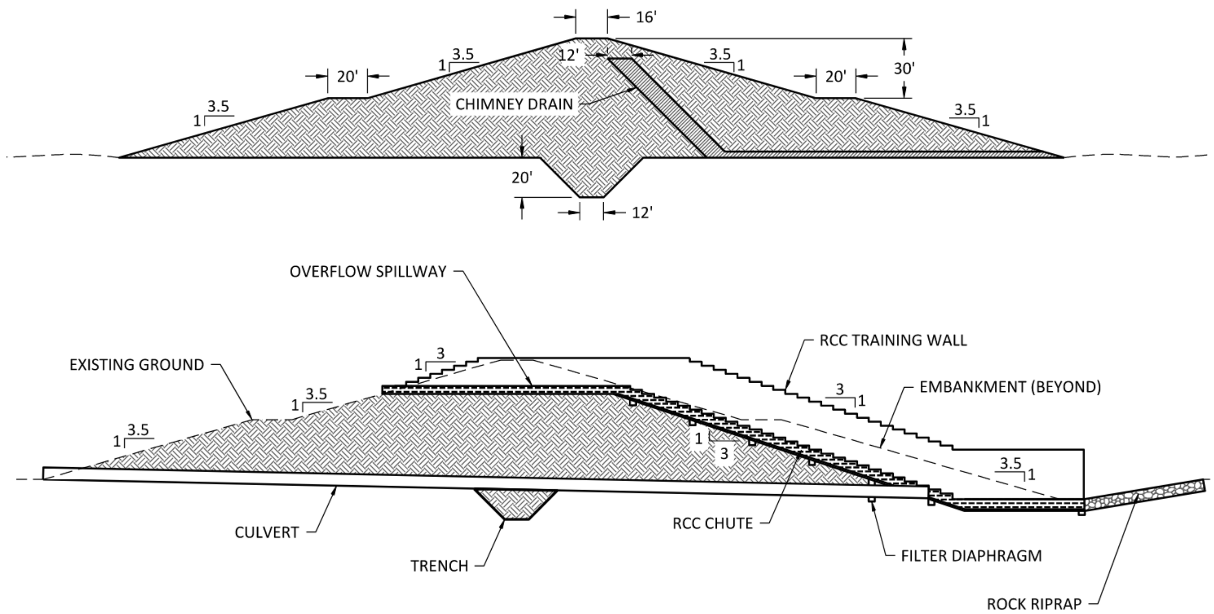

Figure 10: Typical Dam Embankment and Principal Spillway Sections

Each alternative was modeled individually to determine the benefits on the watershed as a whole. Evaluation of the specific impact of each alternative on the damage centers was not conducted. Instead, the project team assessed benefits throughout the entire watershed. For example, the Spring Creek alternatives primarily benefit structures along Spring Creek but can also benefit structures downstream of its confluence with the West Fork San Jacinto River, or structures at the downstream end of Willow Creek, which drains into Spring Creek.

Each channelization alternative, taken individually, is likely to result in adverse downstream impacts. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. Each detention alternative identified in this study is more than enough to mitigate the adverse downstream impact for the recommended channelization alternatives. This topic is discussed in more detail in **Appendix H: Implementation**.

5.1 Spring Creek

Seven mitigation alternatives were explored on the Spring Creek watershed. The alternatives included three detention facilities on tributaries to Spring Creek and four channelization options along the mainstem. The alternatives targeted reducing flooding instances in the damage centers in the watershed.

5.1.1 Walnut Creek Detention

5.1.1.1 Description/Specifications

The Walnut Creek Detention Facility near FM 1488 is one of three detention areas explored in the Spring Creek watershed to reduce flood risk downstream. The proposed inline detention basin is located on Walnut Creek, a tributary to Spring Creek, approximately 0.5 miles north of the FM 1488 crossing and 35 miles west of Magnolia, Texas. The basin is located in the upper half of the Spring Creek watershed and captures flow from a drainage area of approximately 21 square miles. The location of the proposed detention is shown in **Figure 11**.

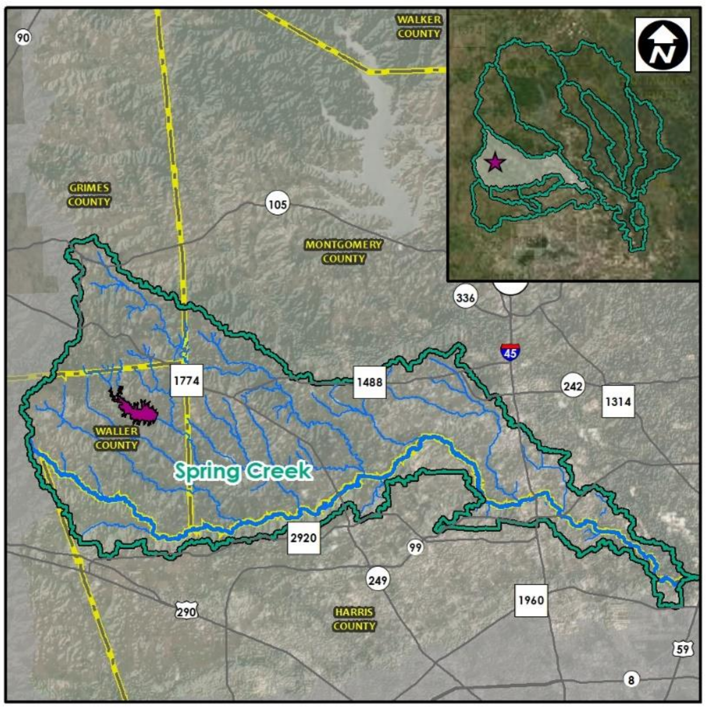

Figure 11: Walnut Creek Detention near FM 1488

Several sites within the watershed were initially screened as potential detention locations. The site near FM 1488 on Walnut Creek was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allows for the volume necessary to be achieved within a smaller footprint, therefore minimizing ROW acquisition.

The goal of the detention facility is to reduce flooding in the Spring Creek watershed by constructing a 1.2-mile-long earthen impoundment that captures runoff from Walnut Creek. The facility is planned to be an inline structure where all flow passes through the impoundment outfall. The facility will be a dry dam that passes low flows and everyday rain events to match existing conditions, and only detains water during larger storm events. The control structure is a 46-foot high concrete dam with a primary outfall consisting of 2 – 4' x 4' RCBC and a secondary spillway approximately 200' in length. The impoundment will require approximately 0.7 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,218 acres below the 1% ACE water surface elevation, which includes Walnut Creek and its tributaries. The basin will provide approximately 12,159 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.1.1.2 H&H Modeling Considerations

The Walnut Creek Detention near FM 1488 was modeled as a reservoir in the HEC-HMS model for the San Jacinto River basin. The reservoir was modeled with 2 – 4' x 4' low flow culverts. The 200' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, while maintaining an acceptable water surface elevation.

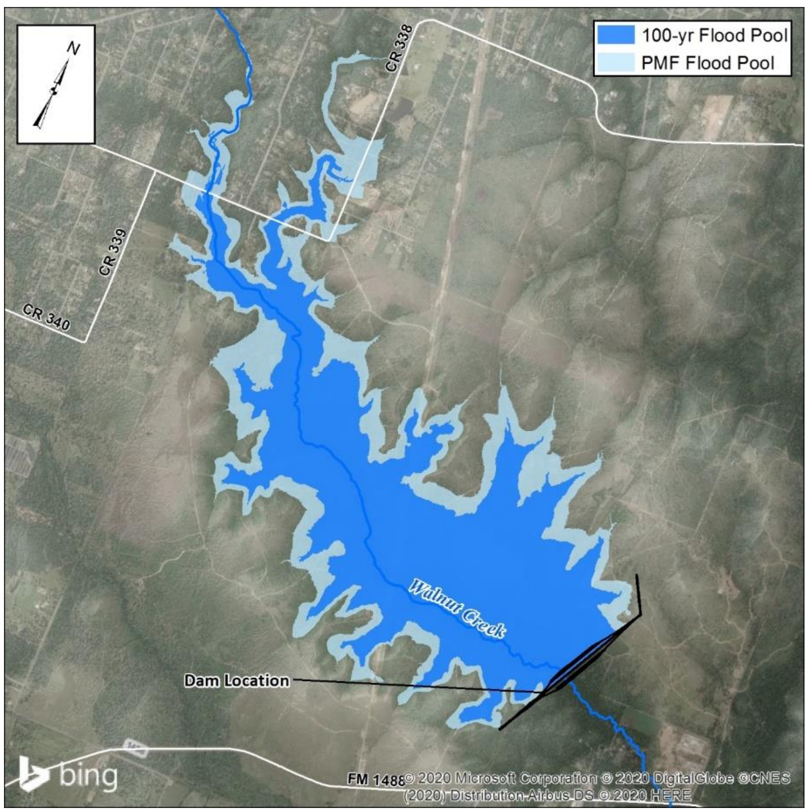

Figure 12: Walnut Creek Detention Detail

Table 12 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 12: Spring Creek at Walnut Creek H&H Modeling Summary

Frequency Storm	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
50% ACE	3,781	669	1,920	245.8'
20% ACE	5,538	740	3,111	249.2'
10% ACE	7,360	796	4,499	252.1'
4% ACE	10,187	864	6,929	255.9'
2% ACE	12,697	911	9,287	258.8'
1% ACE	15,632	955	12,159	261.5'
0.2% ACE	24,129	6,172	17,401	265.5'

The detention basin will provide a reduction in water surface elevations and flows along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 1.05 feet between Cypress Rosehill Road and Riley Fuzzel Road. Downstream of Riley Fuzzel Road, the reduction is less than 0.5 feet. The target volume for Spring Creek reduces the 1% ACE to the 2% ACE which corresponds to a water surface reduction of approximately 2 feet.

5.1.1.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 15,632 cfs to 955 cfs downstream of the dam, which is below the existing 50% ACE. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5 feet for 41.2 miles along Spring Creek with a maximum water surface reduction of 2.07 feet near the Walnut Creek confluence with Spring Creek.

By reducing the flows downstream, the basin removes 1,205 structures from the 1% ACE floodplain and provides a potential reduction in 1,653 flooding instances. Most benefits would be realized between the Walnut Creek and West Fork confluences with Spring Creek. The net present value of benefits based on a 50-year project life within the watershed is approximately $101.2M. The distribution of benefits between watersheds and counties is shown below.

Table 13: Walnut Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Spring	16.8	68.1	**84.9**
Willow	6.8	0.0	**6.8**
West Fork	9.2	0.4	**9.6**
Total	**32.7**	**68.5**	**101.2**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 14**.

Table 14: Improved Roadway Level of Service.

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.02	<50% ACE	No Change
Cardinal Rd	0.02	<50% ACE	No Change
Sanders Cemetery Rd	0.10	<50% ACE	No Change
Cypress Rose Hill Decker	0.74	10% ACE	No Change
Tomball Parkway SH 249	1.69	1% ACE	No Change
Burlington Northern Railroad	1.43	4% ACE	No Change
Union Pacific Railroad	1.22	10% ACE	4% ACE
FM 2978	1.09	2% ACE	No Change
Kuykendahl Rd	1.20	0.2% ACE	No Change
Gosling Rd	0.91	0.2% ACE	No Change
Interstate 45	1.57	1% ACE	No Change
Union Pacific Railroad	0.95	4% ACE	2% ACE
Riley Fuzzell	0.61	10% ACE	No Change

The proposed detention facility also provides regional benefit outside the Spring Creek watershed. The model shows a reduction in WSEL at the confluence with Willow Creek of 0.8 feet as well as a reduction in the WSEL at the confluence with Cypress Creek of 0.4 feet. However, the project does not show any direct benefit downstream of Spring Creek in Lake Houston, which experiences reductions of less than one inch.

Only the mainstem of Spring Creek was modeled as part of this study; therefore, these benefits do not include the potential benefits to structures or roadways along Walnut Creek or other tributaries.

5.1.1.4 Real Estate

This alternative would require 30 parcels to be acquired for a total of 1,218 acres if the parcels inundated in the 1% ACE are purchased. 37 parcels would need to be acquired for a total of 1,383 acres if the parcels inundated in the PMF elevation are purchased. The majority of the required parcels are currently private property.

5.1.1.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 1.3 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 15**.

Table 15: Walnut Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	20-inch Oil Pipeline	Magellan	1.3 miles	Refined Liquid Product
Road	Lazy Ridge Road		1.3 miles	

5.1.1.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 6 acres of potential wetlands within the footprint of the proposed dam and a potential 832 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

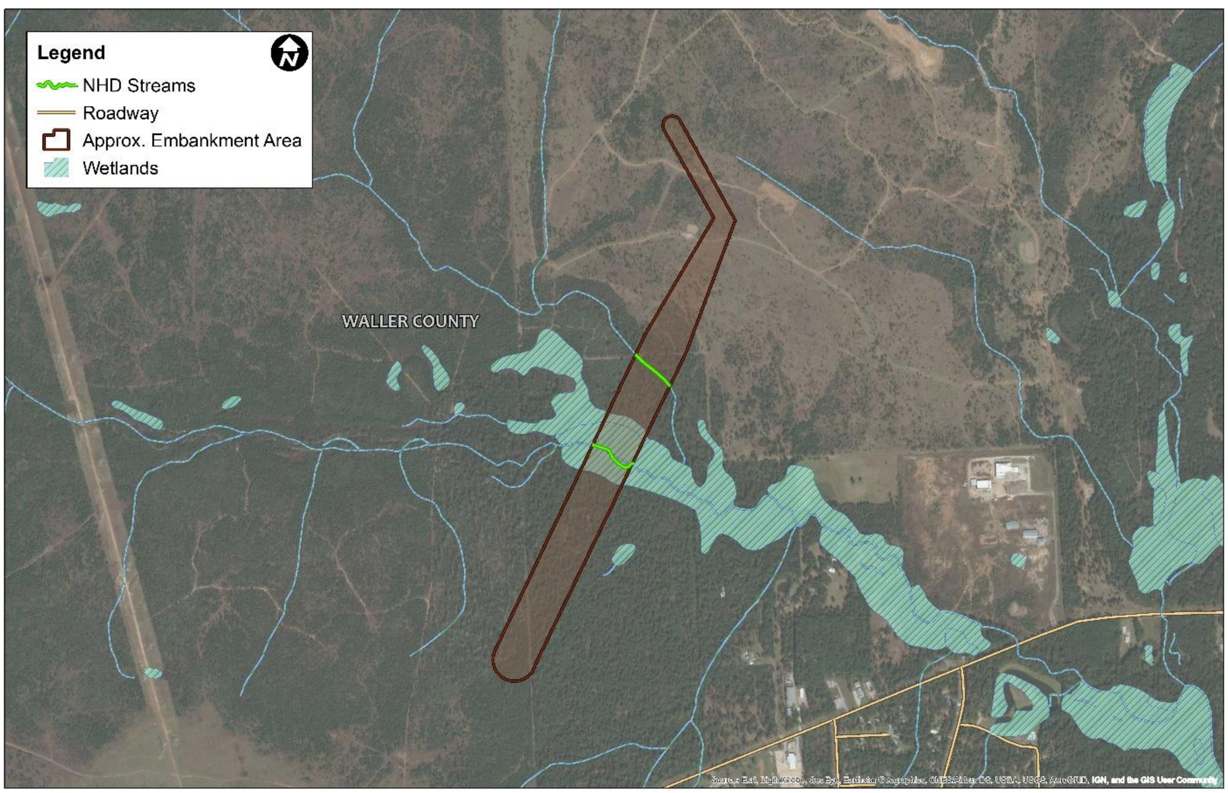

Figure 13: Spring Creek at Walnut Creek Dam Embankment Maximum Footprint

5.1.1.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at 1% of the construction cost of the dam, or approximately $400,000. This cost is not included in the overall OPCC.

5.1.1.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 16**. The approximate costs range from $97M to $132M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.7 to 1.04 depending on the ROW acquired. If FEMA funding is pursued and the project's final structural BCR falls between 0.75 and 1, this project may qualify for additional social benefits that will substantially increase the overall BCR above 1. If this project were to qualify for social benefits, the total social benefits would be approximately $330M according to FEMA BCA methodology. This would increase the total BCR for this alternative to between 3 and 4.

Table 16: Walnut Creek Detention at FM 1488 Estimated Cost and Benefit-Cost Ratio (BCR)

Item	Cost
Construction	$37 M
Design	$4 M
Environmental	$8 M
Right-of-Way	$49 – 84 M
TOTAL	**$97 M - $ 132 M**
BCR:	**0.77 – 1.04**
20-Year Escalation	**$147 M - $200 M**

5.1.1.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Waller County - The project is located within Waller County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Montgomery County – While the project is located outside Montgomery County, the project would benefit residents within the County. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility. SJRA is currently pursuing this project through a TWDB Flood Infrastructure Fund (FIF) grant application.
- MUD 386 - The project is located upstream of UD 386 and would provide direct benefits to the residents. The Township could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- City of Tomball – The project is located upstream of the City of Tomball and would provide direct benefits to the residents. The City could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- The Woodlands Township – The project is located upstream of the Woodlands Township and would provide direct benefits to the residents. The Township could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Woodlands Water Agency– The MUDs managed by the Agency will directly benefit from this project. The Agency could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.
- FEMA – FEMA has grants available to local communities for projects that reduce or eliminate long-term risk of flood damage to structures. Funds could be acquired to assist with funding the project and long-term maintenance of the facility. A BCR of greater than 1 is typically required to obtain FEMA funding. This can be a mix of structural and social benefits as well as other benefits that were not evaluated in detail as part of this project, for example roadway benefits or environmental benefits.
- USACE – The US Army Corps of Engineers funds flood risk management civil works projects through congressional authorization and generally requires a benefit-cost ratio of greater than 1.0.

5.1.2 Mill Creek Detention

5.1.2.1 Description/Specifications

The Mill Creek Detention Facility at FM 1488 is one of three detention areas explored in the Spring Creek watershed to reduce flood risk downstream. The proposed inline detention basin is located on Mill Creek, a tributary to Spring Creek, less than 1-mile northwest of the FM 1488 crossing and 2.5 miles north east of Magnolia, Texas. The basin is located in the upper half of the Spring Creek watershed and captures flow from a drainage area of approximately 47 square miles. The location of the proposed detention is shown in **Figure 14.**

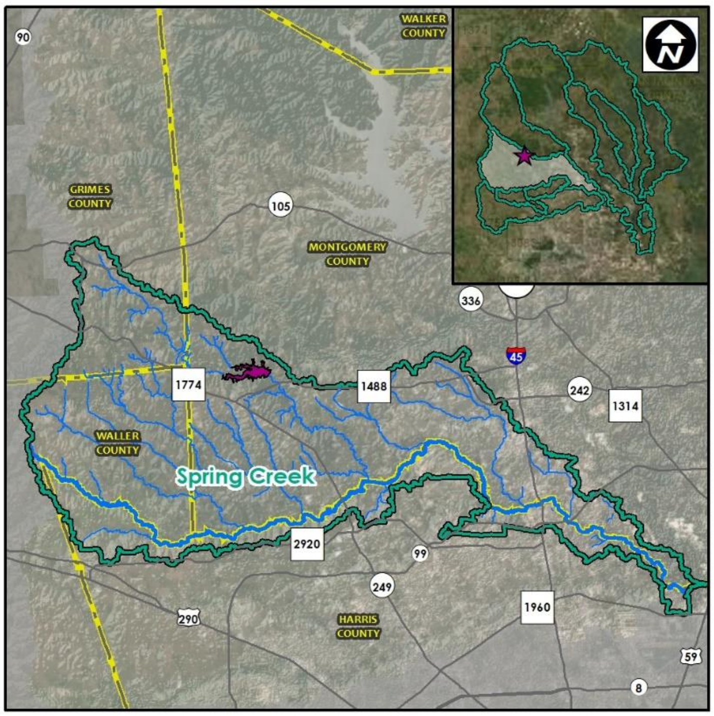

Figure 14: Mill Creek Detention at FM 1488

Several sites within the watershed were initially screened as potential detention locations. The site at FM 1488 on Mill Creek provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention facility is to reduce flooding in the Spring Creek watershed by constructing a 0.9-mile-long earthen impoundment that captures runoff from Mill Creek. The facility is planned to be an inline structure where all flow passes through the impoundment outfall. The facility will be a dry dam that passes low flows and everyday rain events to match existing conditions, and only detains water during larger storm events. The control structure is a 44-foot high concrete dam with a primary outfall consisting of 4 – 10’ x 10’ RCBC and a secondary spillway approximately 200’ in length. The impoundment will require approximately 0.5 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 989 acres below the 1% ACE water surface elevation, which includes

Mill Creek and its tributaries. The basin will provide approximately 11,159 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.1.2.2 H&H Considerations

The Mill Creek Detention at FM 1148 was modeled as a reservoir in the HEC-HMS model for the San Jacinto River basin. The reservoir was modeled with 4 – 10’ x 10’ low flow culverts. The 200’ spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, while maintaining an acceptable water surface elevation.

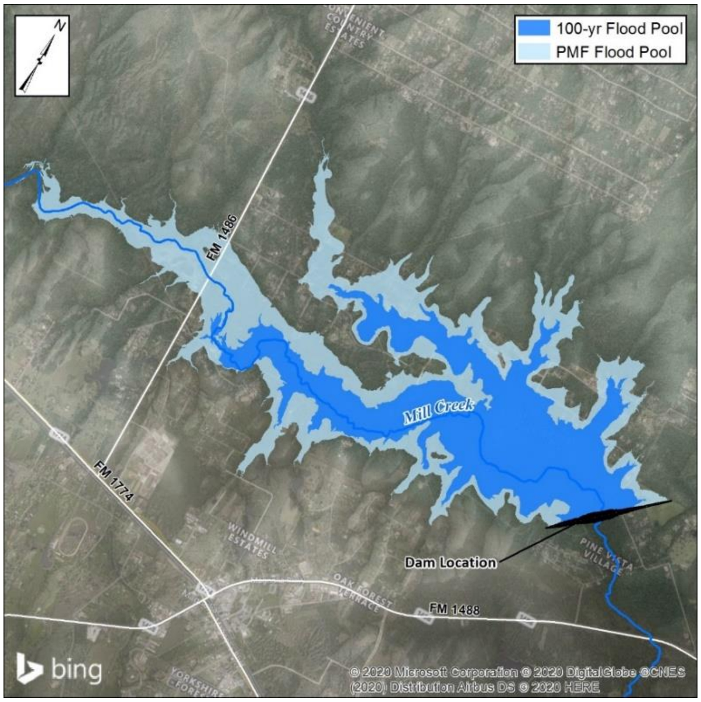

Figure 15: Mill Creek Detention Detail

Table 17 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 17: Spring Creek at Mill Creek H&H Modeling Summary

Frequency Storm	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
50% ACE	4,155	3,514	479	201.4’
20% ACE	6,100	4,993	987	204.3’
10% ACE	8,153	6,385	1,989	207.9’
4% ACE	11,468	8,025	4,348	213.0’
2% ACE	14,551	9,084	7,127	217.0’
1% ACE	18,316	10,013	10,958	220.8’
0.2% ACE	29,101	20,560	18,031	225.9’

The detention basin will provide a reduction in water surface elevations and flows along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 0.75 feet between Tomball Parkway and Riley Fuzzel Road. Downstream of Riley Fuzzel Road, the reduction is less than 0.5 feet. The target volume for Spring Creek reduces the 1% ACE to the 2% ACE which corresponds to a water surface reduction of approximately 2 feet.

5.1.2.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 18,316 cfs to 10,013 cfs downstream of the dam, which is between the existing 10% ACE and 4% ACE . The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 23.8 miles along Spring Creek with a maximum water surface reduction of 1.28 feet near the Mill Creek confluence with Spring Creek.

By reducing the flows downstream, the basin removes 885 structures from the 1% ACE floodplain and provides a potential reduction in 1,015 flooding instances. Most benefits would be realized between the Mill Creek and West Fork confluences with Spring Creek. The net present value of benefits based on a 50-year project life within the watershed is approximately $65.1M. The distribution of benefits between watersheds and counties is shown below.

Table 18: Mill Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Spring	11.2	42.3	**53.5**
Willow	5.1	0.0	**5.1**
West Fork	6.2	0.3	**6.5**
Total	**22.5**	**42.6**	**65.1**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 19**.

Table 19: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.00	<50% ACE	No Change
Cardinal Rd	0.00	<50% ACE	No Change
Sanders Cemetery Rd	0.00	<50% ACE	No Change
Cypress Rose Hill Decker	0.00	10% ACE	No Change
Tomball Parkway SH 249	0.08	1% ACE	No Change
Burlington Northern Railroad	0.37	4% ACE	No Change
Union Pacific Railroad	0.74	10% ACE	4% ACE
FM 2978	0.89	2% ACE	No Change
Kuykendahl Rd	0.93	0.2% ACE	No Change
Gosling Rd	0.69	0.2% ACE	No Change
Interstate 45	1.28	1% ACE	No Change
Union Pacific Railroad	0.74	4% ACE	2% ACE
Riley Fuzzell	0.49	10% ACE	No Change

The proposed detention facility also provides regional benefit outside the Spring Creek watershed. The model shows a reduction in WSEL at the confluence with Willow Creek of 0.5 feet as well as a reduction in the WSEL at the confluence with Cypress Creek of 0.25 feet. However, the project does not show any direct benefit downstream of Spring Creek in Lake Houston, which experiences reductions of less than one inch.

Only the mainstem of Spring Creek was modeled as part of this study; therefore, these benefits do not include the potential benefits to structures or roadways along Mill Creek or other tributaries.

5.1.2.4 Real Estate

This alternative would require 129 parcels to be acquired for a total of 913 acres if the parcels inundated in the 1% ACE are purchased. 234 parcels would need to be acquired for a total of 1,950 acres if the parcels inundated in the PMF elevation are purchased. Majority of the required parcels are currently private property.

5.1.2.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.4 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 20**.

Table 20: Mill Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	12-inch Oil Pipeline	Sunoco	2.5 miles	Crude Oil
Utility	11-inch Oil Pipeline	Explorer	2.0 miles	Crude Oil
Utility	5-inch Gas Pipeline	1486 Gas Pipeline	1.5 miles	Natural Gas
Utility	24-inch Gas Pipeline	Texas Eastern Transmission	0.9 miles	Natural Gas
Roadway	FM 1486		0.4 miles	

5.1.2.6 Environmental Mitigation

The desktop environmental analysis using NWI data does not show any potential wetlands within the footprint of the proposed dam and a potential 1,250 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

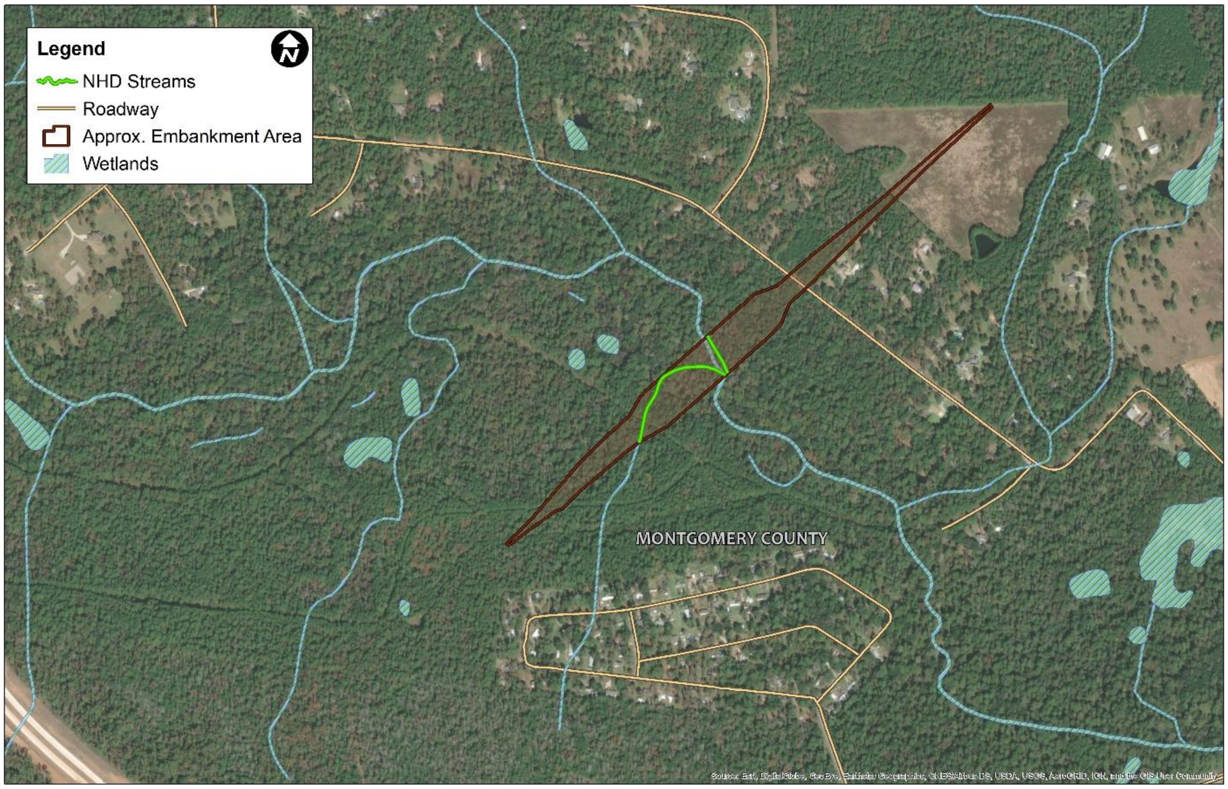

Figure 16: Spring Creek at Mill Creek Dam Embankment Maximum Footprint

5.1.2.7 Operations and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at 1% of the construction cost of the dam, or approximately $300,000. This cost is not included in the overall OPCC.

5.1.2.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 21**. The approximate costs range from $99M to $131M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.50 to 0.67.

Table 21: Mill Creek Detention at FM 1488 Estimated Cost and Benefit-Cost Ratio (BCR)

Item	Cost
Construction	$30 M
Design	$4 M
Environmental	$8 M
Right-of-Way	$58 M - $89 M
TOTAL	**$99 M - $ 131 M**
BCR:	**0.50 – 0.67**
20-Year Escalation	**$150 M - $198 M**

5.1.2.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- The Woodlands Township – The project is located upstream of the Woodlands Township and would provide direct benefits to the residents. The Township could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- MUD 386 - The project is located upstream of UD 386 and would provide direct benefits to the residents. The Township could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Woodlands Water Agency– The MUDs managed by the Agency will directly benefit from this project. The Agency could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.1.3 Birch Creek Detention

5.1.3.1 Description/Specifications

The Birch Creek Detention Facility near FM 1488 is one of three detention areas explored in the Spring Creek watershed to reduce flood risk downstream. The proposed inline detention basin is located on Birch Creek, a tributary to Spring Creek, approximately 1 mile north of the FM 1488 crossing and 3.5 miles west of Magnolia, Texas. The basin is located in the upper half of the Spring Creek watershed and captures flow from a drainage area of approximately 15 square miles. The location of the proposed detention is shown in **Figure 17**.

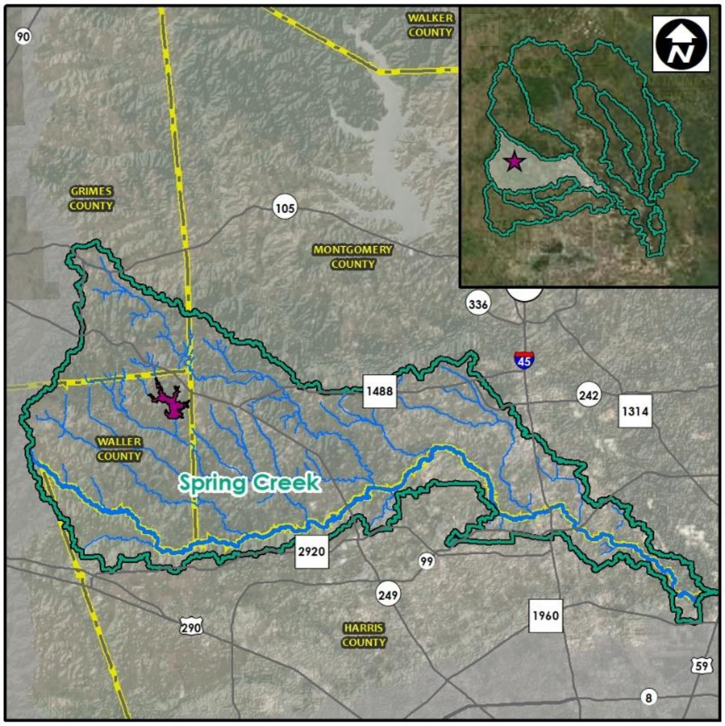

Figure 17: Birch Creek Detention near FM 1488

Several sites within the watershed were initially screened as potential detention locations. The site near FM 1488 on Birch Creek provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention facility is to reduce flooding in the Spring Creek watershed by constructing a 0.7-mile-long earthen impoundment that captures runoff from Birch Creek. The facility is planned to be an inline structure where all flow passes through the impoundment outfall. The facility will be a dry dam that passes low flows and everyday rain events to match existing conditions, and only detains water during larger storm events. The control structure is a 41-foot high concrete dam with a primary outfall consisting of 2 - 4' x 3' RCBC and a secondary spillway approximately 200' in length. The impoundment will require over 0.46 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 873 acres below the 1% ACE water surface elevation, which includes Birch Creek and its tributaries. The basin will provide approximately 7,731 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.1.3.2 H&H Considerations

The Birch Creek Detention near FM 1488 was modeled as a reservoir in the HEC-HMS model for the San Jacinto River basin. The reservoir was modeled with 2 – 4' x 3' low flow culverts. The 200' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, while maintaining an acceptable water surface elevation.

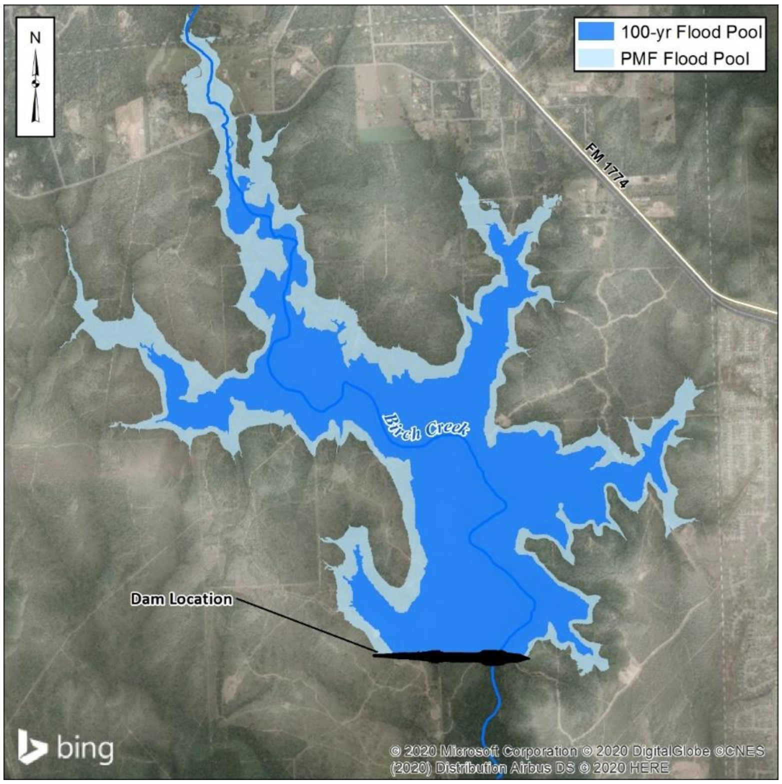

Figure 18: Birch Creek Detention Detail

Table 22 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 22: Spring Creek at Birch Creek H&H Modeling Summary

Frequency Storm	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
50% ACE	2,727	455	1,228	240.9’
20% ACE	3,915	505	2,017	243.8’
10% ACE	5,101	545	2,945	246.3’
4% ACE	6,936	593	4,579	249.6’
2% ACE	8,560	627	6,171	252.1’
1% ACE	10,470	871	7,731	254.2’
0.2% ACE	16,037	3,207	11,856	258.5’

The detention basin will provide a reduction in water surface elevations and flows along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 0.70 feet between Cypress Rosehill Road and Riley Fuzzel Road. Downstream of Riley Fuzzel Road, the reduction is less than 0.5 feet. The target volume for Spring Creek reduces the 1% ACE to the 2% ACE which corresponds to a water surface reduction of approximately 2 feet.

5.1.3.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 10,470 cfs to 871 cfs downstream of the dam, which is below the existing 50% ACE. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 25.9 miles along Spring Creek with a maximum water surface reduction of 1.13 feet near the Walnut Creek confluence with Spring Creek.

By reducing the flows downstream, the basin removes 815 structures from the 1% ACE floodplain and provides a potential reduction in 1,084 flooding instances. Most benefits would be realized between the Walnut Creek and West Fork confluences with Spring Creek. The net present value of benefits based on a 50-year project life within the watershed is approximately $66.0M. The distribution of benefits between watersheds and counties is shown below.

Table 23: Birch Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Spring	10.9	44.4	**55.3**
Willow	4.3	0.0	**4.3**
West Fork	6.1	0.3	**6.4**
Total	**21.3**	**44.7**	**66.0**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 24**.

Table 24: Improved Roadway Level of Service.

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.02	<50% ACE	No Change
Cardinal Rd	0.02	<50% ACE	No Change
Sanders Cemetery Rd	0.07	<50% ACE	No Change
Cypress Rose Hill Decker	0.45	10% ACE	No Change
Tomball Parkway SH 249	0.94	1% ACE	No Change
Burlington Northern Railroad	0.80	4% ACE	No Change
Union Pacific Railroad	0.67	10% ACE	4% ACE
FM 2978	0.59	2% ACE	No Change
Kuykendahl Rd	0.69	0.2% ACE	No Change
Gosling Rd	0.48	0.2% ACE	No Change
Interstate 45	0.99	1% ACE	No Change
Union Pacific Railroad	0.49	4% ACE	2% ACE
Riley Fuzzell	0.44	10% ACE	No Change

The proposed detention facility also provides regional benefit outside the Spring Creek watershed. The model shows a reduction in WSEL at the confluence with Willow Creek of 0.5 feet as well as a reduction in the WSEL at the confluence with Cypress Creek of 0.25 feet. However, the project does not show any direct benefit downstream of Spring Creek in Lake Houston, which experiences reductions of less than one inch.

Only the mainstem of Spring Creek was modeled as part of this study; therefore, these benefits do not include the potential benefits to structures or roadways along Birch Creek or other tributaries.

5.1.3.4 Real Estate

15 parcels would need to be acquired for a total of 873 acres if the parcels inundated in the 1% ACE are purchased. 71 parcels would need to be acquired for a total of 1,984 acres if the parcels inundated in the PMF elevation are purchased. The majority of the required parcels are currently private property.

5.1.3.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.3 miles of roadways are located within the preliminary 1% ACE elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 25**.

Table 25: Birch Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	28-inch Gas Pipeline	Galloway Energy	0.5 miles	Natural Gas
Roadway	Riley Road	Waller County	0.3 miles	

5.1.3.6 Environmental Mitigation

The desktop environmental analysis using NWI data does not show any potential wetlands within the footprint of the proposed dam and a potential 1,370 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

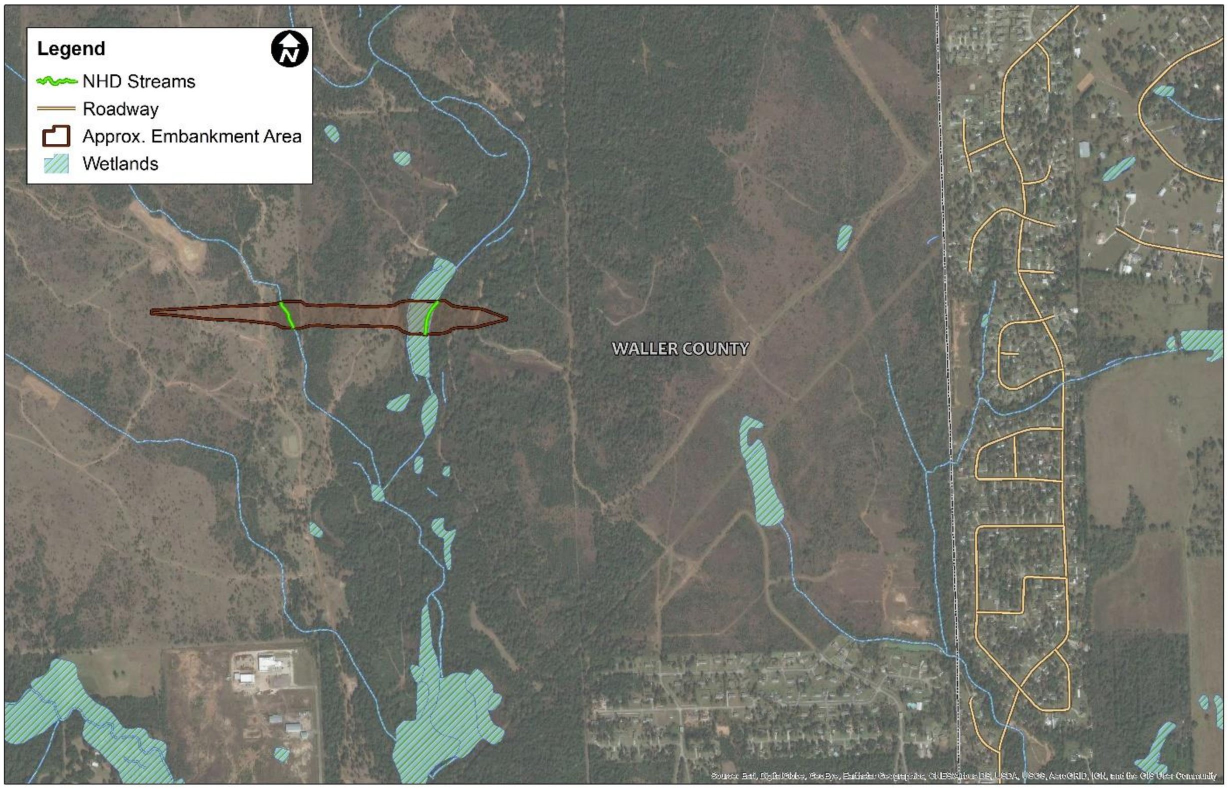

Figure 19: Spring Creek at Birch Creek Dam Embankment Maximum Footprint

5.1.3.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at 1% of the construction cost of the dam, or approximately $250,000. This cost is not included in the overall OPCC.

5.1.3.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 26**. The approximate costs range from $80M to $120M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.55 to 0.83 depending on the ROW acquired. If FEMA funding is pursued and the project's final structural BCR falls between 0.75 and 1, this project may qualify for additional social benefits that will substantially increase the overall BCR above 1. If this project were to qualify for social benefits, the total social benefits would be approximately $330M according to FEMA BCA methodology. This would increase the total BCR for this alternative to between 3 and 4.

Table 26: Birch Creek Detention at FM 1488 Estimated Cost and Benefit-Cost Ratio (BCR)

Item	Cost
Construction	$23 M
Design	$3 M
Environmental	$6 M
Right-of-Way	$48 – 88 M
TOTAL	**$80 M - $ 120 M**
BCR:	**0.55 – 0.83**
20-Year Escalation	**$121 M- $181 M**

5.1.3.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Waller County - The project is located within Waller County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Montgomery County – While the project is located outside Montgomery County, the project would benefit residents within the County. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility. SJRA is currently pursuing this project through a TWDB Flood Infrastructure Fund (FIF) grant application.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- City of Tomball – The project is located upstream of the City of Tomball and would provide direct benefits to the residents. The City could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- The Woodlands Township – The project is located upstream of the Woodlands Township and would provide direct benefits to the residents. The Township could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Woodlands Water Agency– The MUDs managed by the Agency will directly benefit from this project. The Agency could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.
- FEMA - FEMA has grants available to local communities for projects that reduce or eliminate long-term risk of flood damage to structures. Funds could be acquired to assist with funding the project and long-term maintenance of the facility. A BCR of greater than 1 is typically required to obtain FEMA funding. This can be a mix of structural and social benefits as well as other benefits that were not evaluated in detail as part of this project, for example roadway benefits or environmental benefits.
- USACE – The US Army Corps of Engineers funds flood risk management civil works projects through congressional authorization and generally requires a benefit-cost ratio of greater than 1.0.

5.1.4 Woodlands Channelization (500-ft)

5.1.4.1 Description/Specifications

The Woodlands 500-foot Channelization improvement option is one of four channel improvement alternatives explored in the Spring Creek watershed to reduce flood risk. The proposed channel improvement is located on Spring Creek from just upstream of Kuykendahl Road to the Willow Creek confluence with Spring Creek. The extents of the proposed channel improvement are shown in **Figure 20**.

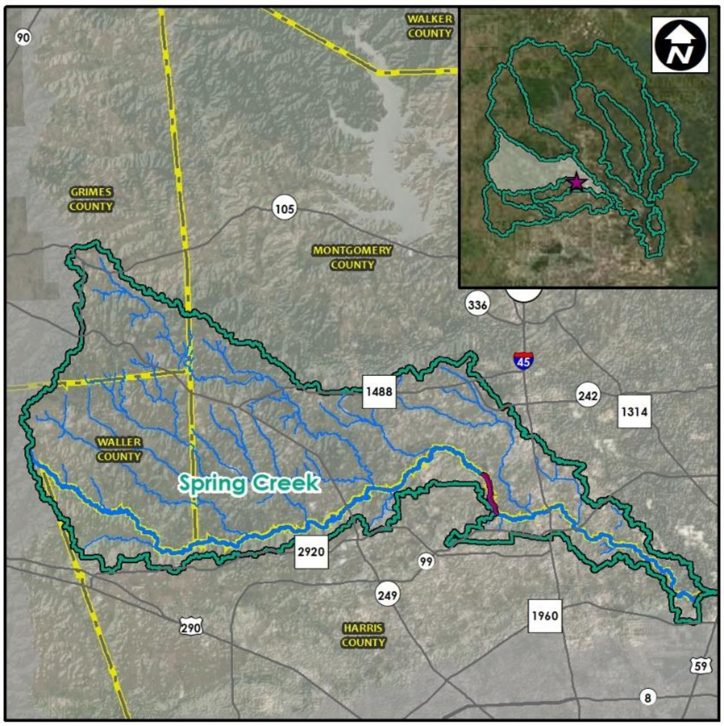

Figure 20: Overview—Woodlands Channelization (500-ft) on Spring Creek

Several sites within the watershed were initially screened as potential areas that could benefit from channel improvements. The region from just upstream of Kuykendahl Road to the Willow Creek confluence was chosen based on several factors, including its ability to reduce water surface elevations in damage centers, availability of undeveloped land, and terrain that allows for an efficient increase in channel capacity.

The goal of the channel improvement is to reduce flooding in the Spring Creek watershed by constructing a 9.7-mile long, 500-feet-wide benched improvement that lies approximately 4 feet above the natural flowline of the existing channel. The benched improvement will require approximately 6.0 million cubic yards of excavation. The proposed channel improvement will also require 577 acres of additional right-of-way. The channel improvement will reduce the 1% ACE water surface elevation by approximately 3.5 - 8 feet through the extents of the improvement.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of

approximately 12,500 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing both the Walnut Creek Dam and Birch Creek Dam. Alternatively, this detention could be provided by first constructing the Walnut Creek Dam or Birch Creek Dam along with additional offline detention volume. The efficacy of offline detention will be highly dependent on its location in the watershed. Refer to **Appendix H: Implementation** for details.

5.1.4.2 H&H Considerations

The Woodlands Channelization (500-ft) alternative from just upstream of Kuykendahl Rd to the Willow Creek confluence was modeled in the HEC-RAS model for the San Jacinto River basin. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

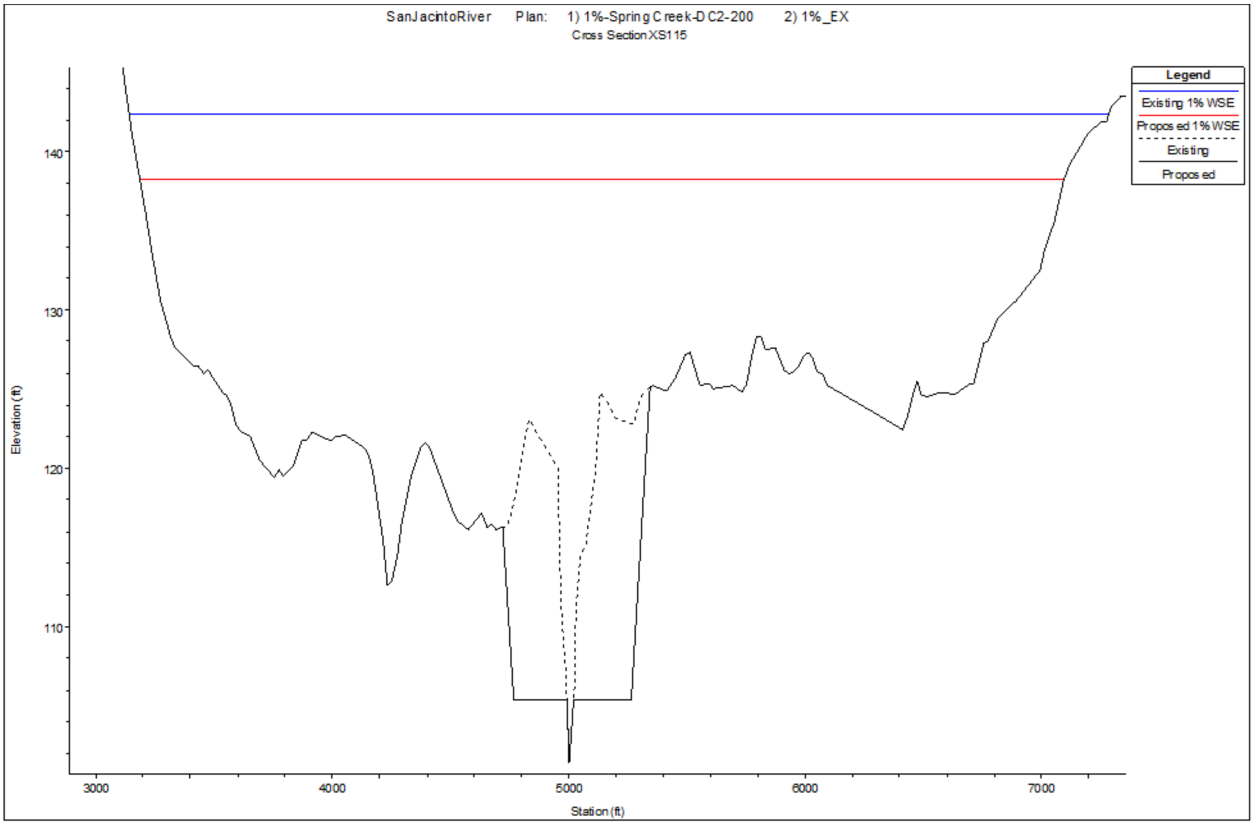

Figure 21: Cross Section—Woodlands Channelization (500-ft) on Spring Creek

Table 27 summarizes the reduction in peak water surface elevations at key locations through the extent of the channel improvements.

Table 27: H&H Modeling Summary—Woodlands Channelization (500-ft) on Spring Creek

Location	Reduction in Water Surface Elevation (feet)			
	10% ACE	2% ACE	1% ACE	0.2% ACE
Kuykendahl Rd	7.4	8.2	8.3	8.2
Gosling Rd	5.0	5.1	4.7	4.0
Willow Creek Confluence	3.9	3.5	3.1	2.0

The channel improvement will provide a reduction in water surface elevations along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 5.7 feet between FM 2978 and Gosling Road.

5.1.4.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 10% ACE and 4% ACE water surface elevations for a length of approximately 9.7 miles. The increase in channel capacity reduces the 1% ACE water surface elevation by at least 0.5-feet for 12.7 miles along Spring Creek with a maximum water surface reduction of 8.9 feet upstream of Kuykendahl Rd.

By increasing the channel capacity, the proposed improvement removes 357 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 776. Most of the benefits would be realized between Kuykendahl Rd and the Willow Creek confluence. The net present value of benefits based on a 50-year project life within the watershed is approximately $48.1M. The distribution of benefits between watersheds and counties is shown below.

Table 28: Woodlands Channelization (500-ft) Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Spring	26.5	4.0	**30.6**
Willow	17.5	0.0	**17.5**
Total	**44.0**	**4.0**	**48.1**

The project does not provide an increase in the level of service (LOS) of crossing roadways and railroads along the creek, but it does achieve significant reductions in water surface elevations at multiple crossings. The proposed channel improvements do not provide regional benefit outside the Spring Creek watershed.

Table 29: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.00	<50% ACE	No Change
Cardinal Rd	0.00	<50% ACE	No Change
Sanders Cemetery Rd	0.00	<50% ACE	No Change
Cypress Rose Hill Decker	0.00	10% ACE	No Change
Tomball Parkway SH 249	0.00	1% ACE	No Change
Burlington Northern Railroad	0.01	4% ACE	No Change
Union Pacific Railroad	0.02	10% ACE	No Change
FM 2978	0.16	2% ACE	No Change
Kuykendahl Rd	8.31	0.2% ACE	No Change
Gosling Rd	4.69	0.2% ACE	No Change
Interstate 45	-1.18	1% ACE	No Change
Union Pacific Railroad	-0.65	4% ACE	No Change
Riley Fuzzell	-0.65	10% ACE	No Change

5.1.4.4 Real Estate

119 parcels would need to be acquired for the total of 104 acres of additional right-of-way is required. The required area currently lies within the 1% ACE floodplain.

The proposed channel improvements could potentially impact land protected by the Bayou Land Conservancy (BLC). Coordination with the BLC will be required to finalize the location of the improvements. The specific locations impacted are listed below.

- Creekside Park Preserve
- Dawnwood Preserve
- Gorgan's Point Preserve
- Harris County Creekside Preserve
- Spring Acres Preserve

5.1.4.5 Relocations

Pipelines and visible electric lines were identified within the extents of the proposed channel. Most of the utilities are buried but may need relocation depending on location and depth. There are no roadways located within the preliminary channel extents that may need modification. Additional buried utilities could potentially be within the channel extents; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 30**.

Table 30: Potential Utility Relocations—Woodlands Channelization (500-ft) on Spring Creek

Relocation Type	Name	Owner	Length	Notes
Utility	6-inch Gas Pipeline	Energy Transfer	0.1 miles	Natural Gas
Utility	30-inch Gas Pipeline	Gulf South	0.1 miles	Natural Gas

5.1.4.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 52.8 acres of potential wetlands within the footprint of the proposed channel improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

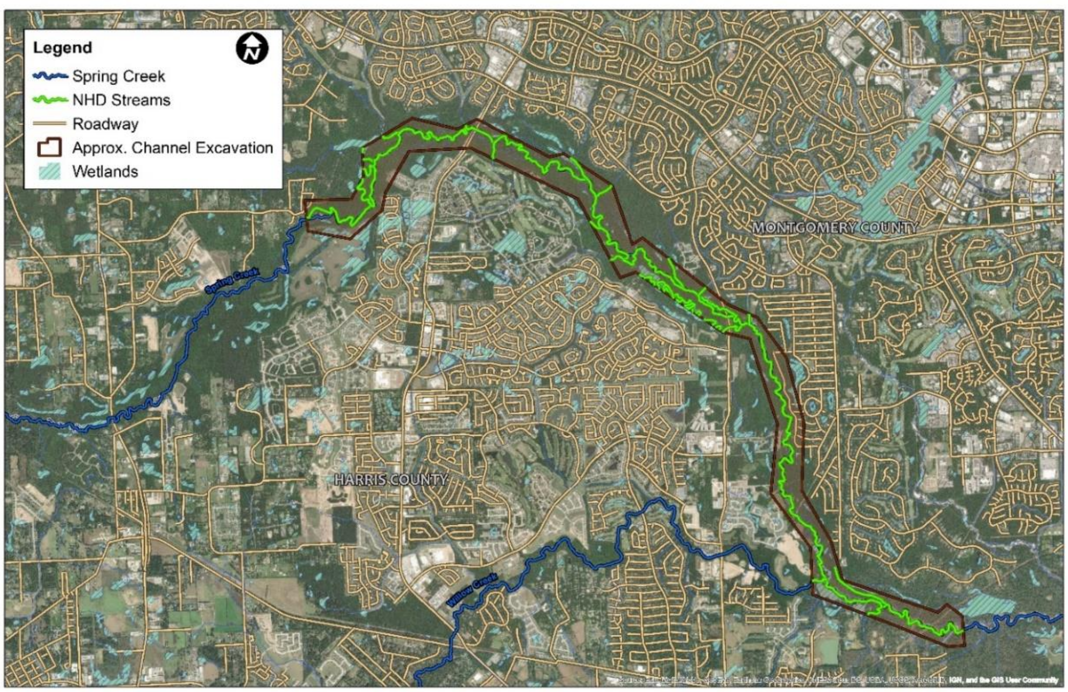

Figure 22: Spring Creek at Woodlands Channelization (500-ft) Maximum Footprint

5.1.4.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed channel improvement. Regular mowing of the channel, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the project. Annualized maintenance costs for the channel improvements are estimated at $383,000 based on an assumed annual mowing and maintenance cost of $400 per acre for the benched channel area and $1,200 per acre for the sloped area down to the bench. This cost is not included in the overall OPCC.

5.1.4.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 31**. The approximate cost of the channel improvement is $149M. The BCR for the project based on the calculated benefits is 0.32.

Table 31: Estimated Cost and Benefit-Cost Ratio (BCR)—Woodlands Channelization (500-ft) on Spring Creek

Item	Cost
Construction	$124 M
Design	$15 M
Environmental	$7 M
Right-of-Way	$4 M
TOTAL	**$149 M**
BCR:	**0.32**
20-Year Escalation	**$226 M**

5.1.4.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Harris County - The project is located within Harris County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding,

maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

- The Woodlands Township – The project is located upstream of the Woodlands Township and would provide direct benefits to the residents. The Township could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Woodlands Water Agency– The MUDs managed by the Agency will directly benefit from this project. The Agency could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.1.5 Woodlands Channelization (200-ft)

5.1.5.1 Description/Specifications

The Woodlands Channelization (200-ft) alternative is one of four channel improvement alternatives explored in the Spring Creek watershed to reduce flood risk. The proposed channel improvement is located on Spring Creek from just upstream of Kuykendahl Rd to the Willow Creek confluence with Spring Creek. The extents of the proposed channel improvement are shown in **Figure 23**.

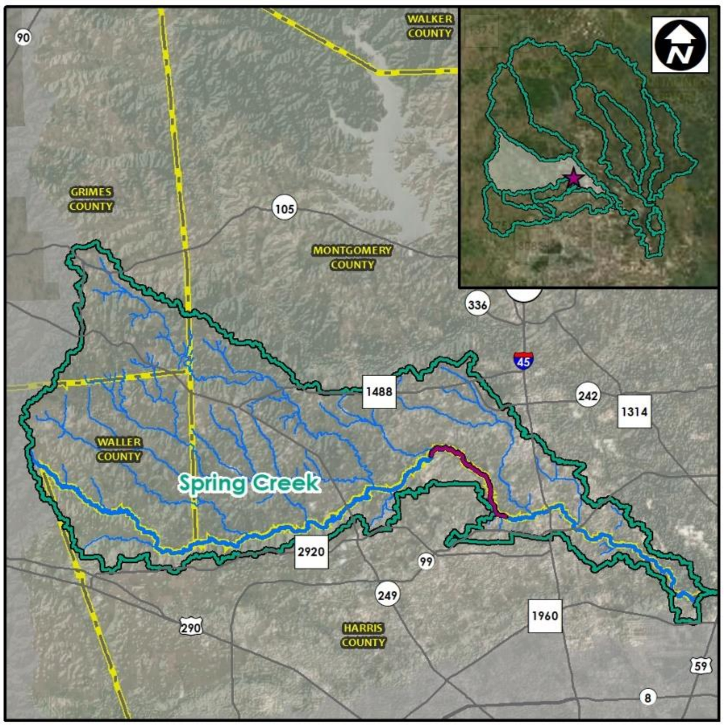

Figure 23: Overview—Woodlands Channelization (200-ft) on Spring Creek

Several sites within the watershed were initially screened as potential areas that could benefit from channel improvements. The region from just upstream of Kuykendahl Rd to the Willow Creek confluence was chosen based on several factors, including its ability to reduce water surface elevations in damage centers, availability of undeveloped land, and terrain that allows for an efficient increase in channel capacity.

The goal of the channel improvement is to reduce flooding in the Spring Creek watershed by constructing a 8.9-miles long, 200-feet-wide benched improvement that lies approximately 4 feet above the natural flowline of the existing channel. The benched improvement will require approximately 1.88 million cubic yards of excavation. The proposed channel improvement will also require 155 acres of additional right-of-way. The channel improvement will reduce the 1% ACE water surface elevation by approximately 2.5 – 4.0 feet through the extents of the improvement.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 7,200 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing either the Walnut Creek Dam or Birch Creek Dam. Refer to **Appendix H: Implementation** for details.

5.1.5.2 H&H Considerations

The Woodlands Channelization (200-ft) alternative from just upstream of Kuykendahl Rd to the Willow Creek confluence was modeled in the HEC-RAS model for the San Jacinto River basin. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

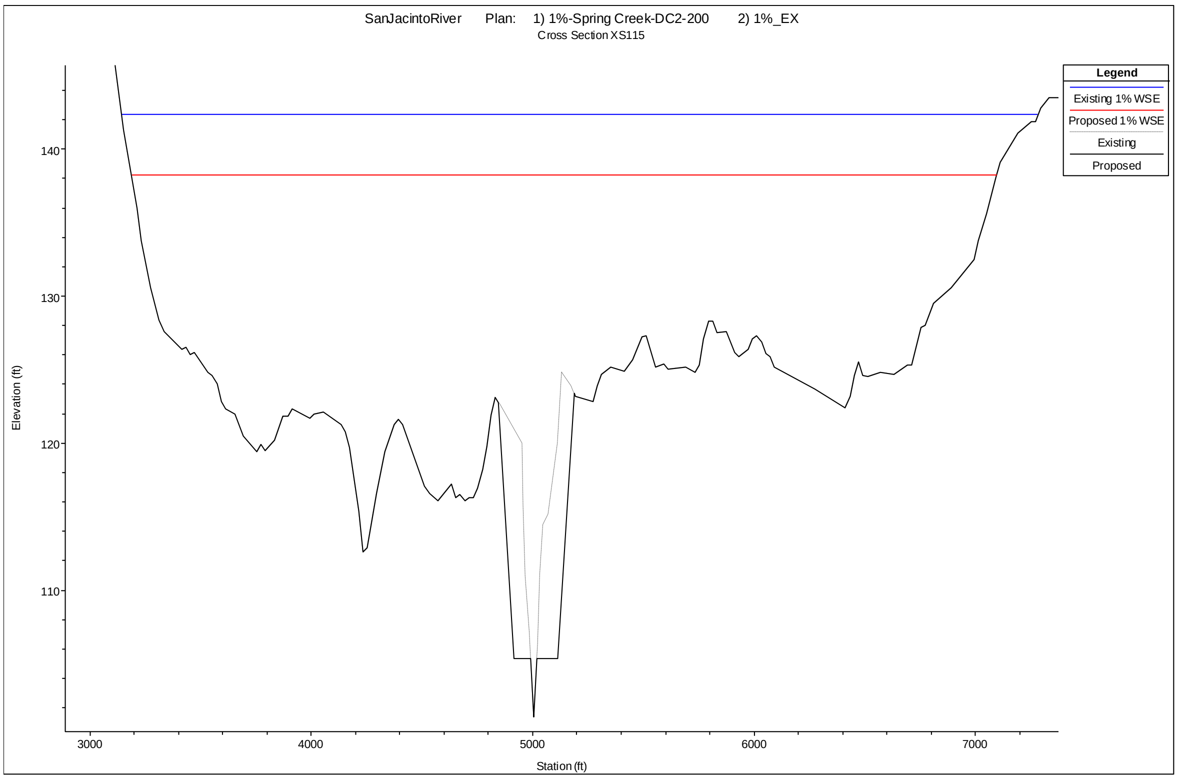

Figure 24: Cross Section— Woodlands Channelization (200-ft) on Spring Creek

Table 32 summarizes the reduction in peak water surface elevations at key locations through the extent of the channel improvements.

Table 32: H&H Modeling Summary— Woodlands Channelization (200-ft) on Spring Creek

Location	Reduction in Water Surface Elevation (feet)			
	10% ACE	2% ACE	1% ACE	0.2% ACE
Kuykendahl Rd	3.8	4.0	4.1	4.1
Gosling Rd	2.9	2.5	2.2	1.7
Willow Creek Confluence	1.7	1.3	1.2	0.7

The channel improvement will provide a reduction in water surface elevations along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 2.8 feet between FM 2978 and Gosling Road.

5.1.5.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 4% ACE and 2% ACE water surface elevations for a length of approximately 8.8 miles. The increase in channel capacity reduces the 1% ACE water surface elevation by at least 0.5-feet for 11.8 miles along Spring Creek with a maximum water surface reduction of 4.3 feet near Kuykendahl Rd.

By increasing the channel capacity, the proposed improvement removes 221 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 477. Most of the benefits would be realized between Kuykendahl Rd and the Willow Creek confluence. The net present value of benefits based on a 50-year project life within the watershed is approximately $34.7M. The distribution of benefits between watersheds and counties is shown below.

Table 33: Woodlands Channelization (200-ft) Benefits Summary ($M)

Watershed	**Benefits ($M)**		
	Harris County	**Montgomery County**	**Total**
Spring	17.5	7.2	**24.7**
Willow	10.0	0.0	**10.0**
Total	**27.6**	**7.2**	**34.7**

The project does not provide an increase in the level of service (LOS) of crossing roadways and railroads along Spring Creek, but it does achieve significant reductions in water surface elevations at multiple crossings. The proposed channel improvements do not provide regional benefit outside the Spring Creek watershed.

Table 34: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.00	<50% ACE	No Change
Cardinal Rd	0.00	<50% ACE	No Change
Sanders Cemetery Rd	0.00	<50% ACE	No Change
Cypress Rose Hill Decker	0.00	10% ACE	No Change
Tomball Parkway SH 249	0.00	1% ACE	No Change
Burlington Northern Railroad	0.01	4% ACE	No Change
Union Pacific Railroad	0.01	10% ACE	No Change
FM 2978	0.09	2% ACE	No Change
Kuykendahl Rd	4.05	0.2% ACE	No Change
Gosling Rd	2.23	0.2% ACE	No Change
Interstate 45	-0.67	1% ACE	No Change
Union Pacific Railroad	-0.38	4% ACE	No Change
Riley Fuzzell	-0.38	10% ACE	No Change

5.1.5.4 Real Estate

113 parcels would need to be acquired for the total of 142 acres of additional right-of-way is required. The required area currently lies within the 1% ACE floodplain.

The proposed channel improvements could potentially impact land protected by the Bayou Land Conservancy (BLC). Coordination with the BLC will be required to finalize the location of the improvements. The specific locations impacted are listed below.

- Dawnwood Preserve
- Gorgan's Point Preserve
- Spring Acres Preserve

5.1.5.5 Relocations

Pipelines and visible electric lines were identified within the extents of the proposed channel. Most of the utilities are buried but may need relocation depending on location and depth. There are no roadways located within the preliminary channel extents; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 35**.

Table 35: Potential Utility Relocations— Woodlands Channelization (200-ft) on Spring Creek

Relocation Type	Name	Owner	Length	Notes
Utility	6-inch Gas Pipeline	Energy Transfer	0.1 miles	Natural Gas
Utility	30-inch Gas Pipeline	Gulf South	0.1 miles	Natural Gas

5.1.5.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 11.0 acres of potential wetlands within the footprint of the proposed channel improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

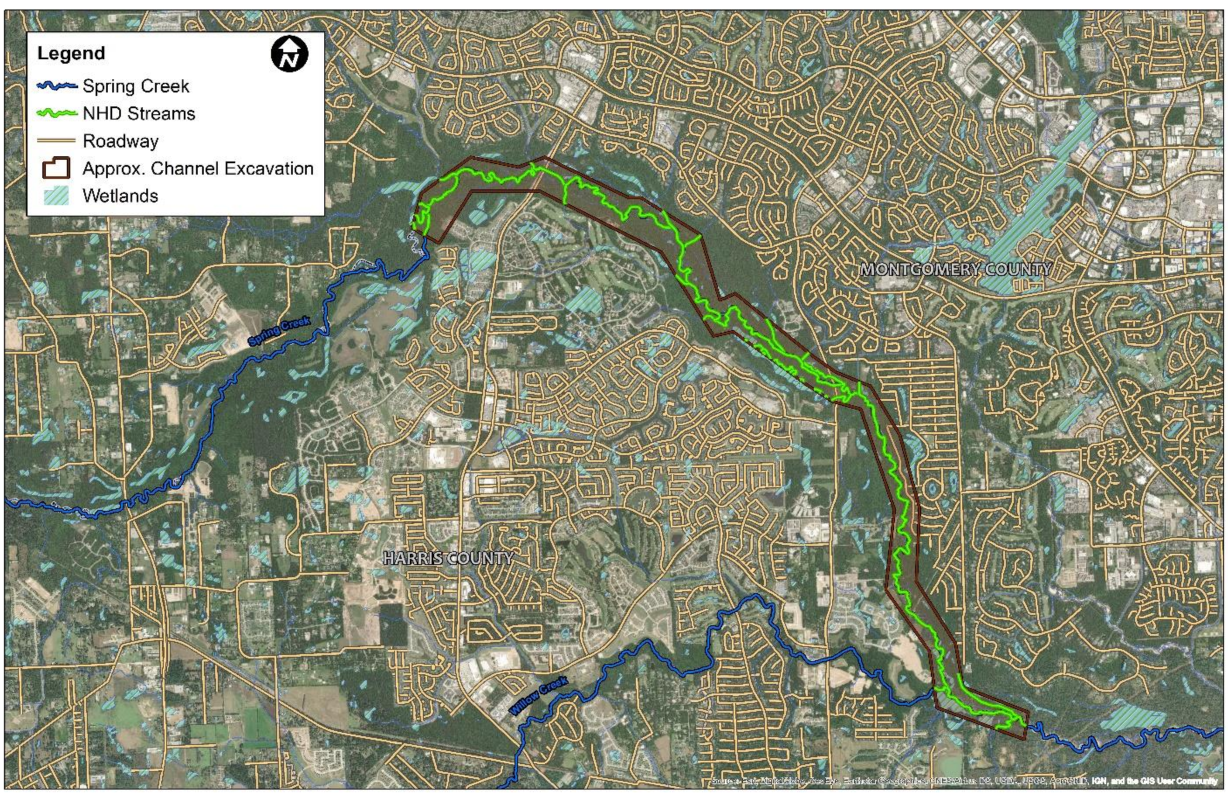

Figure 25: Spring Creek at Woodlands Channelization (200-ft) Excavation Maximum Footprint

5.1.5.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed channel improvement. Regular mowing of the channel, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the project. Annualized maintenance costs for the channel improvements are estimated at $194,000. This cost is not included in the overall OPCC.

5.1.5.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 36**. The approximate cost of the channel improvement is $56M. The BCR for the project based on the calculated benefits is 0.62.

Table 36: Estimated Cost and Benefit-Cost Ratio (BCR)— Woodlands Channelization (200-ft) on Spring Creek

Item	Cost
Construction	$47 M
Design	$6 M
Environmental	$1 M
Right-of-Way	$2 M
TOTAL	**$56 M**
BCR:	**0.62**
20-Year Escalation	**$85 M**

5.1.5.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- The Woodlands Township – The project is located upstream of the Woodlands Township and would provide direct benefits to the residents. The Township could serve as a project sponsor to

work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

- Woodlands Water Agency– The MUDs managed by the Agency will directly benefit from this project. The Agency could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.1.6 I-45 Channelization

5.1.6.1 Description/Specifications

The I-45 Channel Improvement option is one of four channel improvement alternatives explored in the Spring Creek watershed to reduce flood risk. The proposed channel improvement is located on Spring Creek from I-45 to approximately 4 miles downstream of Riley Fuzzel Rd. The extents of the proposed channel improvement are shown in **Figure 26**.

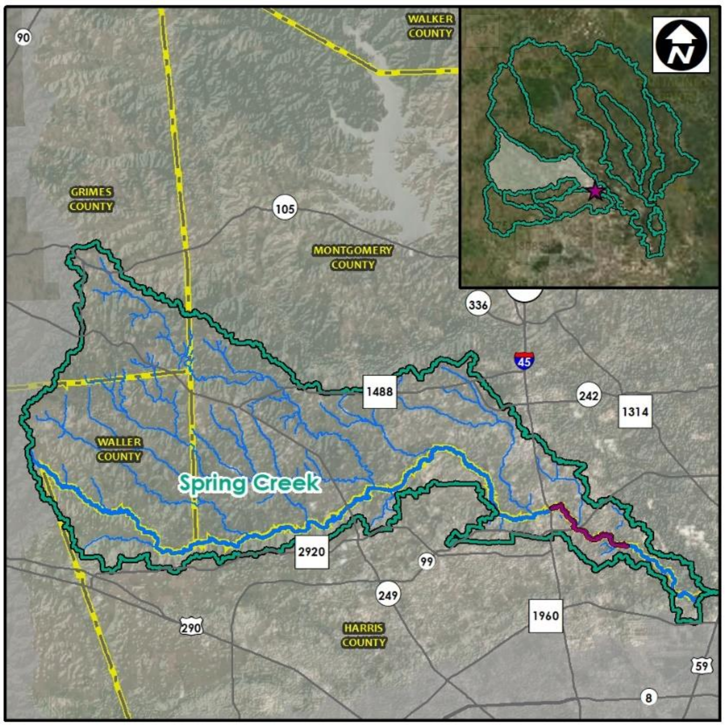

Figure 26: I-45 Channel on Spring Creek

Several sites within the watershed were initially screened as potential areas that could benefit from channel improvements. The region from I-45 to approximately 4 miles downstream of Riley Fuzzel Rd provided was chosen based on several factors, including its ability to reduce water surface elevations in damage centers, availability of undeveloped land, and terrain that allows for an efficient increase in channel capacity.

The goal of the channel improvement is to reduce flooding in the Spring Creek watershed by constructing a 6.9-mile-long, 300-foot-wide benched improvement that lies approximately 4 feet above the natural flowline of the existing channel. The benched improvement will require approximately 3.65 million cubic yards of excavation. The proposed channel improvement will also require 188 acres of additional right-of-way. The channel improvement will reduce the 1% ACE water surface elevation by approximately 4 feet through the extents of the improvement.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of

approximately 8,000 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing the Walnut Creek Dam. Refer to the implementation chapter for details.

5.1.6.2 H&H Considerations

The I-45 channel improvement from I-45 to approximately 4 miles downstream of Riley Fuzzel Rd was modeled in the HEC-RAS model for the San Jacinto River basin. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

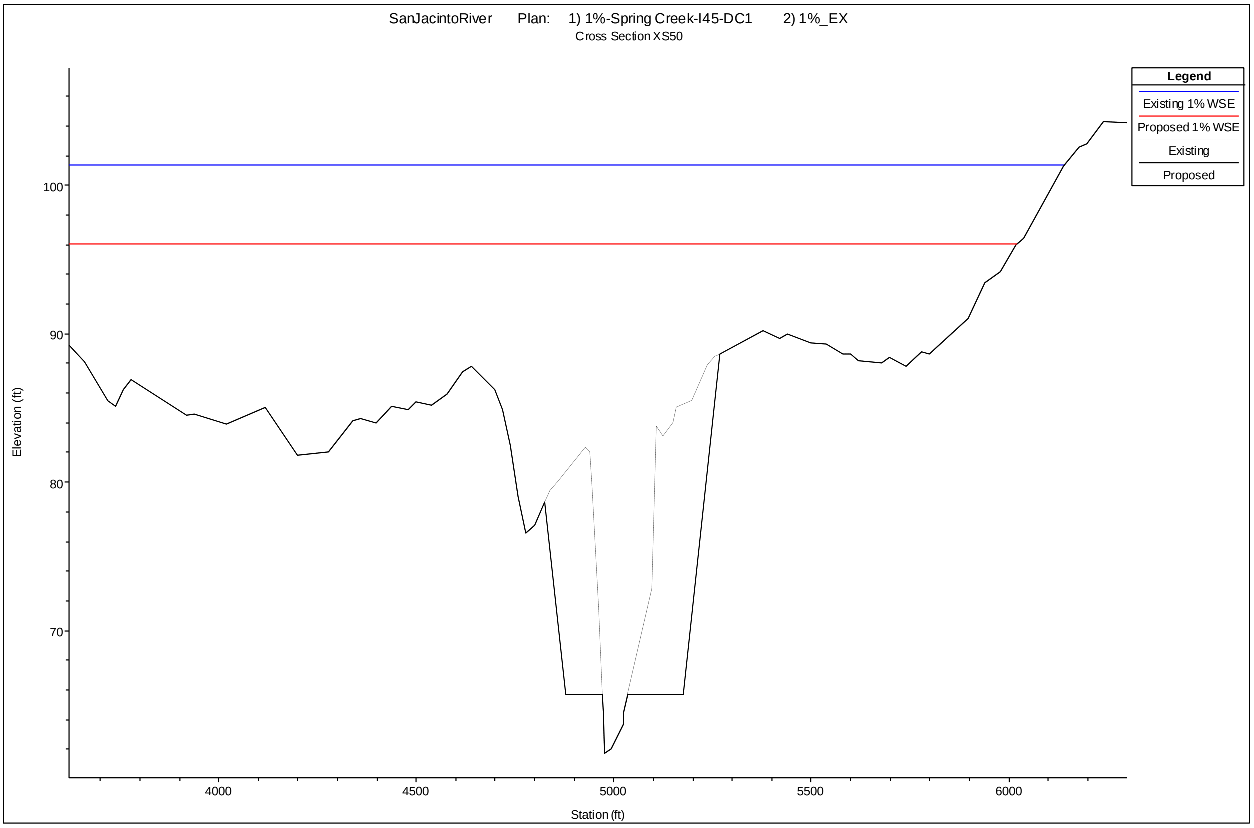

Figure 27: Cross Section—Interstate 45 Channel Improvement on Spring Creek

Table 37 summarizes the reduction in peak water surface elevations at key locations through the extent of the channel improvements.

Table 37: Spring Creek H&H Modeling Summary – Interstate 45 Channel Improvement

Location	Reduction in Water Surface Elevation (feet)			
	10% ACE	2% ACE	1% ACE	0.2% ACE
I-45	4.3	3.6	4.2	1.6
BR Railroad	4.7	4.8	5.2	3.5
Riley Fuzzel	6.5	5.8	5.1	3.7

The channel improvement will provide a reduction in water surface elevations along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.9 feet between I-45 and approximately 3 miles downstream of Riley Fuzzel Road.

5.1.6.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 4% ACE and 2% ACE water surface elevations for a length of approximately 6.9 miles. the dam. The increase in channel capacity reduces the 1% ACE water surface elevation by at least 0.5-feet for 10.7 miles along Spring Creek with a maximum water surface reduction of 5.5 feet just downstream of I-45.

By increasing the channel capacity, the proposed improvement removes 1,240 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,739. Most of the benefits would be realized between downstream of I-45 and near Riley Fuzzel Rd. The net present value of benefits based on a 50-year project life within the watershed is approximately $99.4M. The distribution of benefits between watersheds and counties is shown below.

Table 38: I-45 Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Spring	13.1	85.1	**98.2**
Willow	1.1	0.0	**1.1**
Total	**14.3**	**85.1**	**99.4**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 39**.

Table 39: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.00	<50% ACE	No Change
Cardinal Rd	0.00	<50% ACE	No Change
Sanders Cemetery Rd	0.00	<50% ACE	No Change
Cypress Rose Hill Decker	0.00	10% ACE	No Change
Tomball Parkway SH 249	0.00	1% ACE	No Change
Burlington Northern Railroad	0.00	4% ACE	No Change
Union Pacific Railroad	0.00	10% ACE	No Change
FM 2978	0.00	2% ACE	No Change
Kuykendahl Rd	0.01	0.2% ACE	No Change
Gosling Rd	0.02	0.2% ACE	No Change
Interstate 45	4.33	1% ACE	0.2% ACE
Union Pacific Railroad	4.92	4% ACE	1% ACE
Riley Fuzzell	5.06	10% ACE	2% ACE

The proposed channel improvements do not provide regional benefit outside the Spring Creek watershed.

5.1.6.4 Real Estate

137 parcels would need to be acquired for the total of 181 acres of additional right-of-way is required. The majority of the required area currently lies within the 1% ACE floodplain.

The proposed channel improvements could potentially impact land protected by the Bayou Land Conservancy (BLC). Coordination with the BLC will be required to finalize the location of the improvements. The specific locations impacted are listed below.

- Bald Cypress Preserve
- Magnolia Preserve
- Peckinpaugh Preserve
- Spring Creek Bend Preserve

5.1.6.5 Relocations

Pipelines and visible electric lines were identified within the extents of the proposed channel. Most of the utilities are buried but may need relocation depending on location and depth. There are no roadways located within the preliminary channel extents that may need modification. Additional buried utilities could potentially be within the channel extents; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 40**.

Table 40: Potential Utility Relocations—Interstate 45 Channel Improvement on Spring Creek

Relocation Type	Name	Owner	Length	Notes
Utility	16-inch Oil Pipeline	Magellan	0.1 miles	Refined Liquid Product
Utility	24-inch Gas Pipeline	Trunkline	0.1 miles	Natural Gas
Utility	30-inch Gas Pipeline	Natural Gas Pipeline Company of America	0.1 miles	Natural Gas
Utility	30-inch Gas Pipeline	Natural Gas Pipeline Company of America	0.1 miles	Natural Gas
Utility	20-inch Gas Pipeline	DCP Operating	0.1 miles	HVL

5.1.6.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 35.2 acres of potential wetlands within the footprint of the proposed channel improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

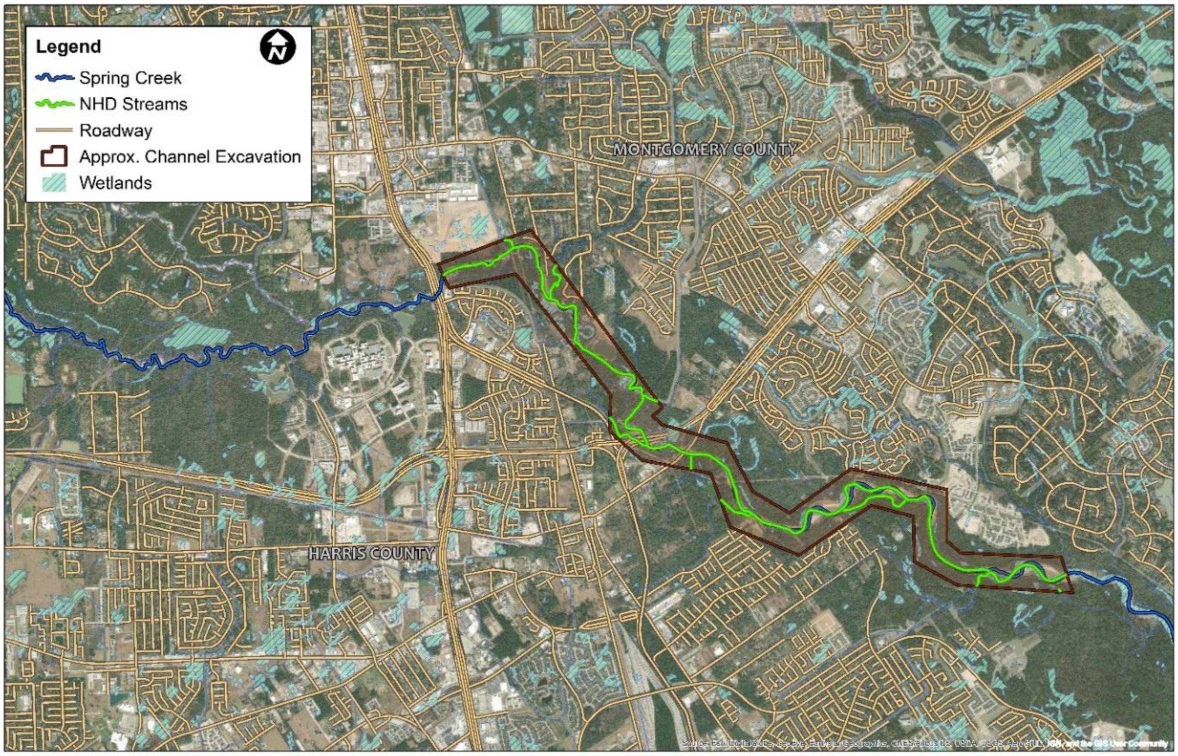

Figure 28: Spring Creek at Interstate 45 Channel Excavation Maximum Footprint

5.1.6.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed channel improvement. Regular mowing of the channel, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the project. Annualized maintenance costs for the channel improvements are estimated at no more than 0.5% of the construction cost of the channel, or approximately $187,000. This cost is not included in the overall OPCC.

5.1.6.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 41**. The approximate cost of the channel improvement is $85M. The BCR for the project based on the calculated benefits is 1.17.

Table 41. Estimated Cost and Benefit-Cost Ratio (BCR)—Interstate 45 Channel on Spring Creek

Item	Cost
Construction	$69 M
Design	$8 M
Environmental	$4 M
Right-of-Way	$4 M
TOTAL	**$85 M**
BCR:	**1.17**
20-Year Escalation	**$129 M**

5.1.6.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for one TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.
- FEMA - FEMA has grants available to local communities for projects that reduce or eliminate long-term risk of flood damage to structures. Funds could be acquired to assist with funding the project and long-term maintenance of the facility. A BCR of greater than 1 is typically required to obtain FEMA funding. This can be a mix of structural and social benefits as well as other benefits that

were not evaluated in detail as part of this project, for example roadway benefits or environmental benefits.

- USACE – The US Army Corps of Engineers funds flood risk management civil works projects through congressional authorization and generally requires a benefit-cost ratio of greater than 1.0.

5.1.7 Gosling Channelization

5.1.7.1 Description/Specifications

The Gosling Channel Improvement option is one of four channel improvement alternatives explored in the Spring Creek watershed to reduce flood risk. The proposed channel improvement is located on Spring Creek from Gosling Rd to approximately 0.5 miles upstream of I-45. The extents of the proposed channel improvement is shown in **Figure 29**.

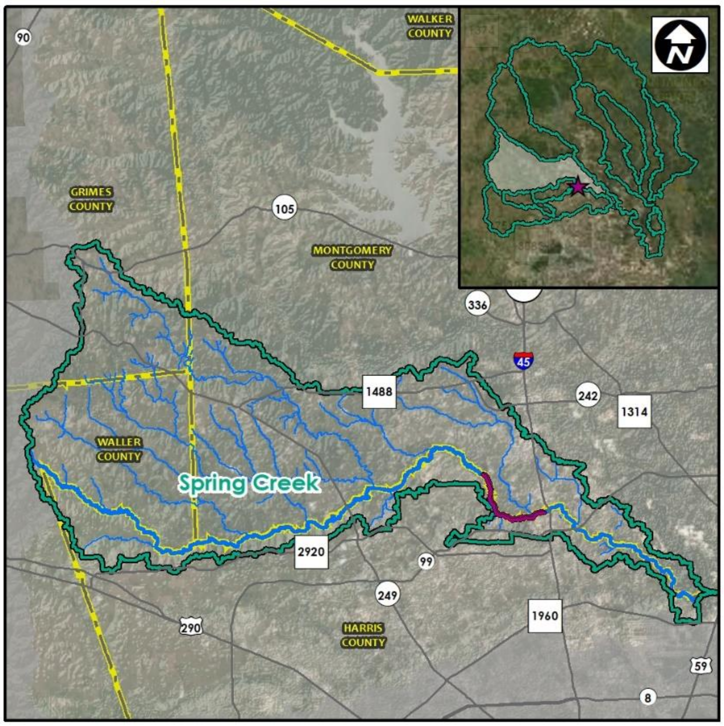

Figure 29: Gosling Channel on Spring Creek

Several sites within the watershed were initially screened as potential areas that could benefit from channel improvements. The region from Gosling Rd to approximately 0.5 miles upstream of I-45 provided was chosen based on several factors, including its ability to reduce water surface elevations in damage centers, availability of undeveloped land, and terrain that allows for an efficient increase in channel capacity.

The goal of the channel improvement is to reduce flooding in the Spring Creek watershed by constructing a 5.2-mile-long, 500-foot-wide benched improvement that lies approximately 4 feet above the natural flowline of the existing channel. The benched improvement will require approximately 5.44 million cubic yards of excavation. The proposed channel improvement will also require 311 acres of additional right-of-way. The channel improvement will reduce the 1% ACE water surface elevation by approximately 3-5.5 feet through the extents of the improvement.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of

approximately 9,000 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing the Walnut Creek Dam. Refer to **Appendix H: Implementation** for details.

5.1.7.2 H&H Considerations

The Gosling channel improvement from Gosling Rd to approximately 0.5 miles upstream of I-45 was modeled in the HEC-RAS model for the San Jacinto River basin. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

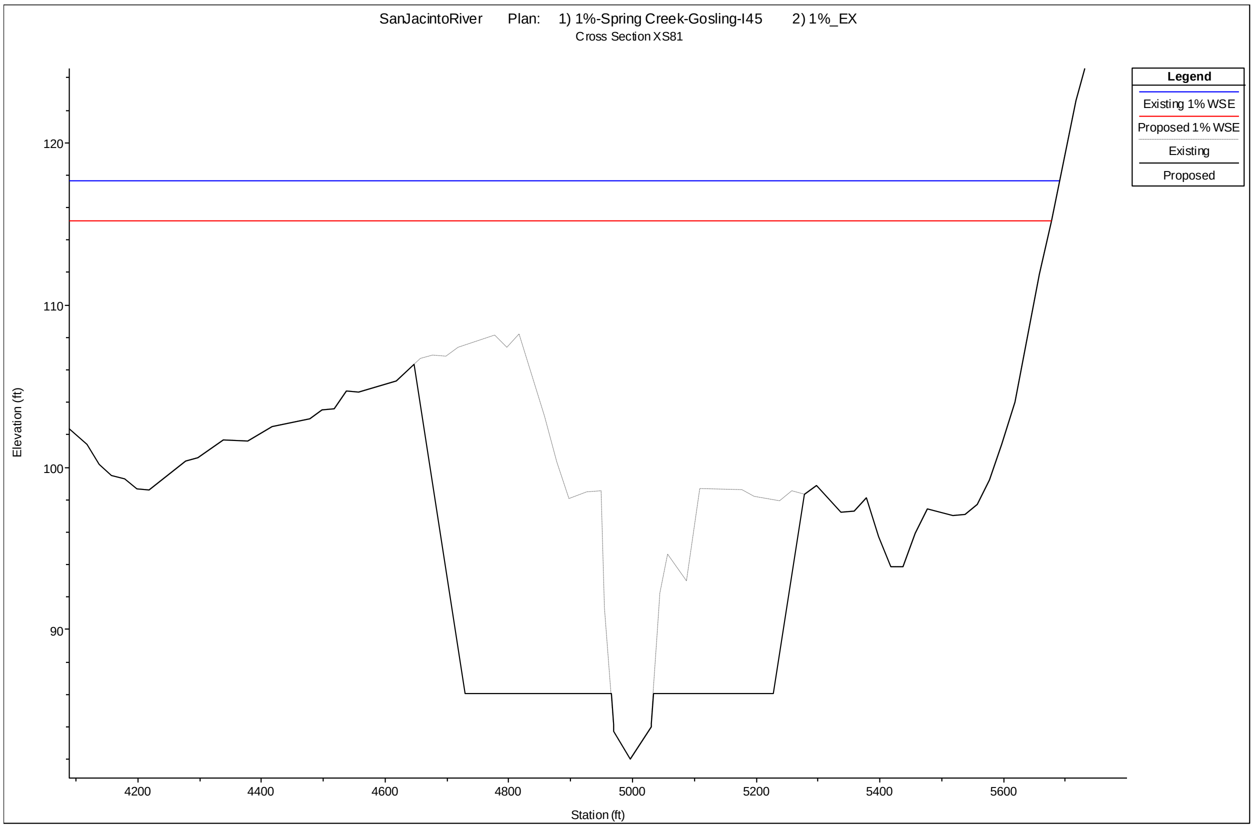

Figure 30: Cross Section—Gosling Channel Improvement on Spring Creek

Table 42 summarizes the reduction in peak water surface elevations at key locations through the extent of the channel improvements.

Table 42: Spring Creek H&H Modeling Summary – Gosling Channel Improvement

Location	Reduction in Water Surface Elevation (feet)			
	10% ACE	2% ACE	1% ACE	0.2% ACE
Kuykendahl Rd	0.1	0.4	0.3	0.3
Gosling Rd	5.2	5.8	5.6	4.7
Willow Creek Confluence	7.9	7.0	6.2	4.4
Panther Branch Confluence	1.1	1.2	0.9	0.9

The channel improvement will provide a reduction in water surface elevations along Spring Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.4 feet between Kuykendahl Road and I-45.

5.1.7.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 10% ACE and 4% ACE water surface elevations for a length of approximately 5.2 miles. The increase in channel capacity reduces the 1% ACE water surface elevation by at least 0.5-feet for 10.0 miles along Spring Creek with a maximum water surface reduction of 6.8 feet just upstream of the Willow Creek confluence.

By increasing the channel capacity, the proposed improvement removes 676 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 991. Most of the benefits would be realized between Kuykendahl Rd and the Panther Branch confluence. The net present value of benefits based on a 50-year project life within the watershed is approximately $63.2M. The distribution of benefits between watersheds and counties is shown below.

Table 43: Gosling Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Spring	18.8	22.5	**41.2**
Willow	22.0	0.0	**22.0**
Total	**40.8**	**22.5**	**63.3**

The project does not provide an increase in the level of service (LOS) of crossing roadways and railroads along Spring Creek, but it does achieve significant reductions in water surface elevations at multiple crossings. The proposed channel improvements do not provide regional benefit outside the Spring Creek watershed.

Table 44: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
FM 1736	0.00	4% ACE	No Change
FM 1488	0.00	0.2% ACE	No Change
DS FM 1488	0.00	50% ACE	No Change
DS FM 1488	0.00	<50% ACE	No Change
Field Store Rd	0.00	20% ACE	No Change
US Kickapoo Rd	0.00	<50% ACE	No Change
Kickapoo Rd	0.00	4% ACE	No Change
Margerstadt Harvester	0.00	10% ACE	No Change
Hegar Rd	0.00	50% ACE	No Change
Nichols Murrell Rd	0.00	<50% ACE	No Change
DS Nichols Murrell Rd	0.00	<50% ACE	No Change
Roberts Cemetery	0.00	<50% ACE	No Change
Cardinal Rd	0.00	<50% ACE	No Change
Sanders Cemetery Rd	0.00	<50% ACE	No Change
Cypress Rose Hill Decker	0.00	10% ACE	No Change
Tomball Parkway SH 249	0.00	1% ACE	No Change
Burlington Northern Railroad	0.00	4% ACE	No Change
Union Pacific Railroad	0.00	10% ACE	No Change
FM 2978	0.00	2% ACE	No Change
Kuykendahl Rd	0.34	0.2% ACE	No Change
Gosling Rd	5.58	0.2% ACE	No Change
Interstate 45	-0.61	1% ACE	No Change
Union Pacific Railroad	-0.33	4% ACE	No Change
Riley Fuzzell	-0.34	10% ACE	No Change

5.1.7.4 Real Estate

160 parcels would need to be acquired for the total of 250 acres of additional right-of-way is required. The majority of the required area currently lies within the 1% ACE floodplain.

The proposed channel improvements could potentially impact land protected by the Bayou Land Conservancy (BLC). Coordination with the BLC will be required to finalize the location of the improvements. The specific locations impacted are listed below.

- Dawnwood Preserve
- Grogan's Point Preserve
- Montgomery County Preserve
- Spring Acres Preserve

5.1.7.5 Relocations

Pipelines and visible electric lines were identified within the extents of the proposed channel. Most of the utilities are buried but may need relocation depending on location and depth. There are no roadways located within the preliminary channel extents that may need modification. Additional buried utilities could potentially be within the channel extents; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 45**.

Table 45: Gosling Channelization Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	12-inch Gas Pipeline	Copano	0.6 miles	Natural Gas
Utility	8-inch Oil Pipeline	Enterprise	0.1 miles	Crude Oil
Utility	6-inch Gas Pipeline	Energy Transfer	0.1 miles	Natural Gas
Utility	30-inch Gas Pipeline	Gulf South	0.1 miles	Natural Gas
Utility	5-inch Oil Pipeline	ExxonMobil	0.1 miles	Refined Liquid Product
Utility	8-inch Oil Pipeline	Genesis	0.1 miles	Crude Oil
Utility	36-inch Gas Pipeline	Tennesee	0.1 miles	Natural Gas
Utility	36-inch Gas Pipeline	Tennesee	0.1 miles	Natural Gas

5.1.7.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 42.9 acres of potential wetlands within the footprint of the proposed channel improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

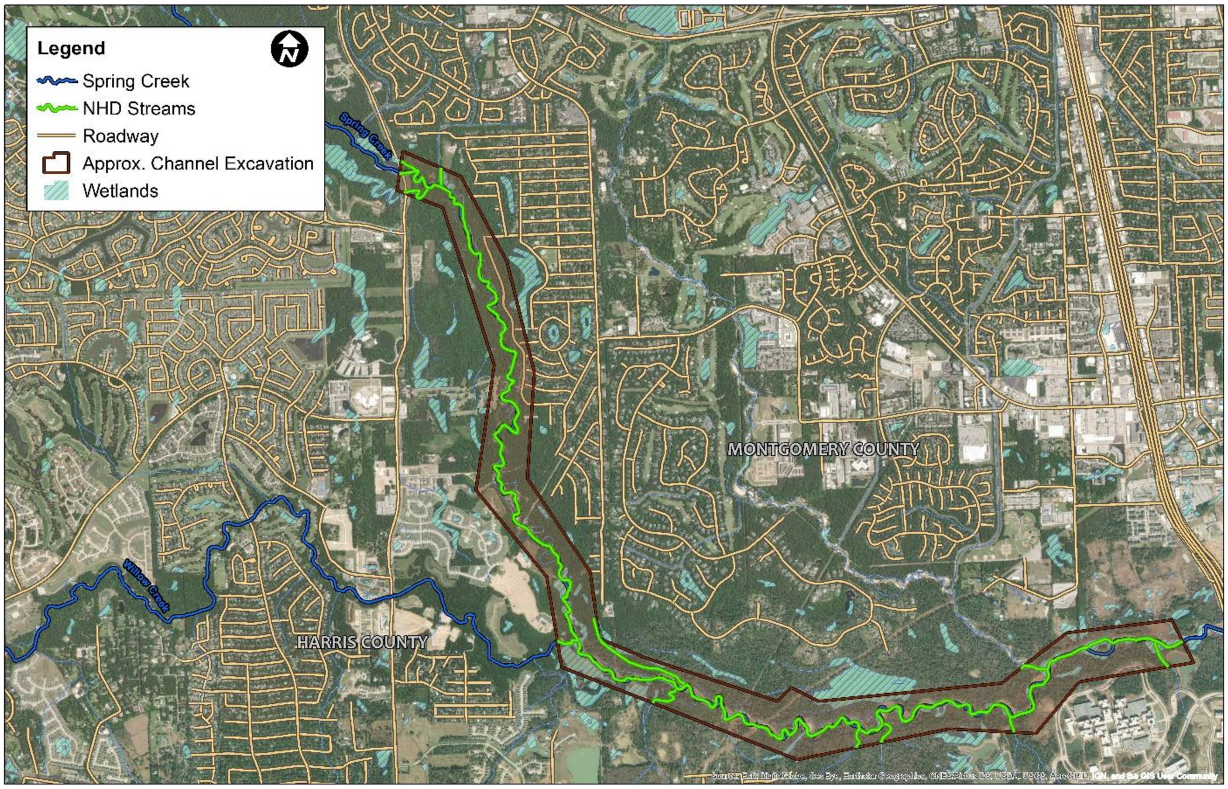

Figure 31: Spring Creek at Gosling Channel Excavation Maximum Footprint

5.1.7.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed channel improvement. Regular mowing of the channel, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the project. Annualized maintenance costs for the channel improvements are estimated at approximately $278,000 based on an assumed annual mowing and maintenance cost of $400 per acre for the benched channel area and $1,200 per acre for the sloped area down to the bench. This cost is not included in the overall OPCC.

5.1.7.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in Table 46. The approximate cost of the channel improvement is $132M. The BCR for the project based on the calculated benefits is 0.48.

Table 46. Estimated Cost and Benefit-Cost Ratio (BCR)—Gosling Channel on Spring Creek

Item	Cost
Construction	$103 M
Design	$12 M
Environmental	$5 M
Right-of-Way	$12 M
TOTAL	**$132 M**
BCR:	**0.48**
20-Year Escalation	**$200 M**

5.1.7.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.1.8 Spring Creek Recommendation

5.1.8.1 Description

The project team recommends construction of the dams on Walnut Creek and Birch Creek due to their effectiveness in reducing flood damages through the upper portion of Spring Creek in the Woodlands area, along with channelization of Spring Creek downstream of I-45 due to its relatively high benefit-cost ratio that benefits structures downstream of I-45. The team also recommends the 200-ft-wide channelization through the Woodlands area (Damage Center 2) from just upstream of Kuykendahl Rd to the Willow Creek confluence with Spring Creek as this provides additional benefit, but the structural benefit-cost ratio of this options is lower than the others. The sections that describes each individual alternative is listed below.

- Walnut Creek Detention – Section 5.1.1
- Birch Creek Detention – Section 5.1.3
- Woodlands Channelization (200-ft) – Section 5.1.5
- Interstate 45 Channelization – Section 5.1.6

The location of the proposed detention locations and extents of each channel improvement are shown below.

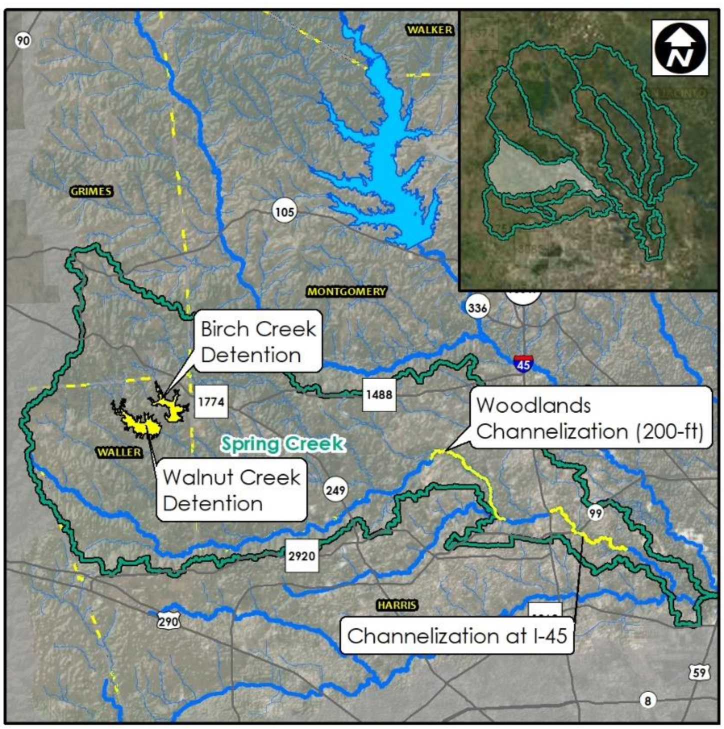

Figure 32: Spring Creek Recommended Alternatives

The goal of the recommended alternatives is to reduce flooding in the Spring Creek watershed by combining the benefits of two proposed dams on Spring Creek tributaries with two regions of channel improvement on the Spring Creek mainstem. While any combination of alternatives will be less efficient in reducing flood risk when compared to an individual alternative, this combination of alternatives performs well and provides significant benefit to the Spring Creek watershed.

5.1.8.2 H&H Considerations

A summary of the proposed dam and channel improvement alternatives is shown in **Table 47** and **Table 48** respectively. The two channel improvement options were modeled in HEC-RAS and the two dam alternatives were modeled in HEC-HMS. Flow data from the proposed HEC-HMS model was combined with the proposed HEC-RAS geometry to arrive at a comprehensive model for the Spring Creek watershed.

Table 47: Detention Summary – 1% ACE

Alternative	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
Walnut Creek Dam	15,632	955	12,159	261.5’
Birch Creek Dam	10,470	871	7,731	254.2’

Table 48: Channel Improvement Summary

Alternative	Location	Improvement Length (mi)	Bench Width (ft)	Bench Height (ft)
Woodlands Channelization (200-ft)	Kuykendahl Rd to Willow Creek	8.9	200	4.0
Interstate 45	I-45 to 4 miles DS Riley Fuzzel	5.3	300	4.0

The combination of detention basins with the two regions of channel improvements provides significant reduction in water surface elevations and flows along Spring Creek, with increased reductions through the regions of each channel improvement. The average reduction in water surface elevation along Spring Creek is summarized in **Table 49**.

Table 49: Average Reduction in Water Surface Elevation

Location	Frequency Event			
	10% ACE	2% ACE	1% ACE	0.2% ACE
Cypress Rose Hill – FM 2978	1.5’	2.2’	2.4’	2.5’
FM 2978 - Kuykendahl	3.1’	4.1’	4.2’	4.5’
Kuykendahl – Gosling	4.9’	5.2’	5.3’	4.8’
Gosling – I-45	3.1’	3.3’	3.4’	3.1’
I-45 – DS Riley Fuzzell	5.8’	5.8’	5.8’	4.4’

5.1.8.3 Project Benefits

The combination of alternatives reduces the 1% ACE existing conditions water surface elevations to elevations of approximately the existing conditions 2% ACE in regions outside of the proposed channel improvements. Within the extents of the channel improvements the existing 1% ACE water surface elevations are reduced to approximately 4% ACE water surface elevations.

By reducing flows from Spring Creek tributaries and increasing channel capacity in several areas, the proposed improvements remove 2,465 structures from the 1% ACE floodplain and provide a potential reduction in flooding instances of 4,056. Benefits are realized on most of the developed area of Spring Creek, beginning at the Walnut Creek confluence and extending to the confluence with the West Fork San Jacinto River. The net present value of benefits based on a 50-year project life within the watershed is approximately $243.3M. The distribution of these benefits along Spring Creek and at the downstream end of Willow Creek is shown in **Figure 33**. The proposed improvements provide some regional benefit along the West Fork that is not shown in **Figure 33**.

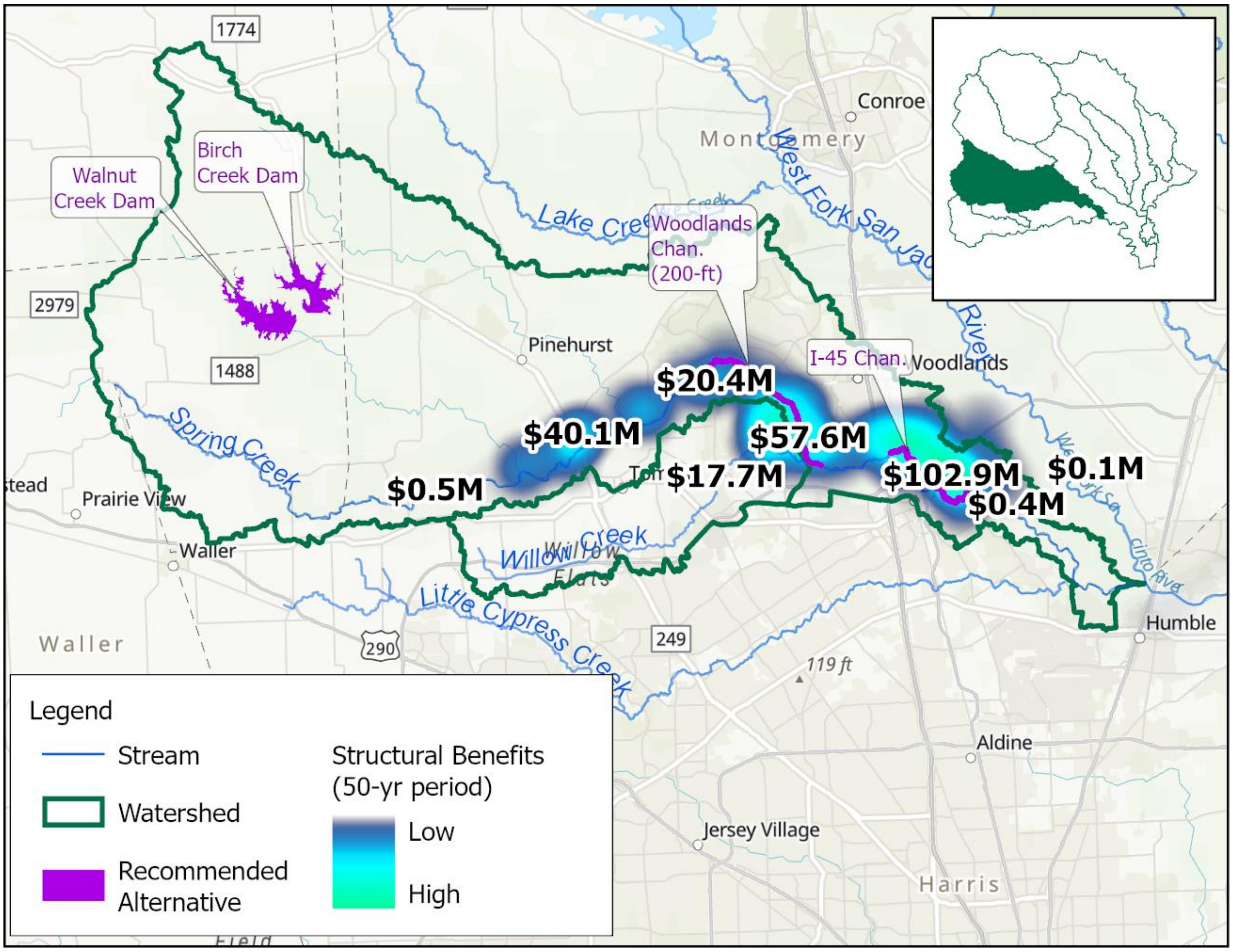

Figure 33: Spring Creek Benefits – Recommended Alternatives

5.1.8.4 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 50**. The approximate costs range from $314M to $389M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.62 to 0.77.

Table 50: Estimated Cost and BCR – Spring Creek Recommended Alternatives

Item	Walnut Creek Dam	Birch Creek Dam	I-45 Channel	Woodlands 200' Channel	Overall
Construction	$37 M	$23 M	$69 M	$47 M	$176 M
Design	$4 M	$3 M	$8 M	$6 M	$21 M
Environmental	$8 M	$6 M	$4 M	$1 M	$19 M
Right-of-Way	$49 – 84M	$48 – 88 M	$4 M	$2 M	$103 – 178 M
TOTAL COST	**$97 – $132 M**	**$80 M – $120 M**	**$85 M**	**$56 M**	**$318 – $393 M**
TOTAL BENEFIT	**$101.2 M**	**$66.0 M**	**$99.4 M**	**$34.7 M**	**$243 M**
BCR:	**0.77 – 1.04**	**0.55 – 0.83**	**1.17**	**0.62**	**0.62 – 0.77**
20-Year Escalation	**$147 M – $200 M**	**$121 M – $181 M**	**$129 M**	**$85 M**	**$482 M – $595 M**

5.2 Lake Creek

Four mitigation alternatives were explored on the Lake Creek watershed. The alternatives included three detention facilities on tributaries to Lake Creek upstream of SH 105, and one mainstem detention facility. The alternatives targeted reducing flooding instances both in Lake Creek and in the West Fork downstream of the confluence.

5.2.1 Caney Creek Detention

5.2.1.1 Description/Specifications

The majority of damage centers in the Lake Creek watershed are located in the southern half of the watershed. The Caney Creek detention basin is one of four detention areas that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on the Caney Creek tributary to Lake Creek, north of SH 105, and just inside the Grimes County. The basin is at the approximate midpoint of the Lake Creek watershed and captures flow from a drainage area of approximately 59 square miles. The location of the proposed detention shown in **Figure 34**.

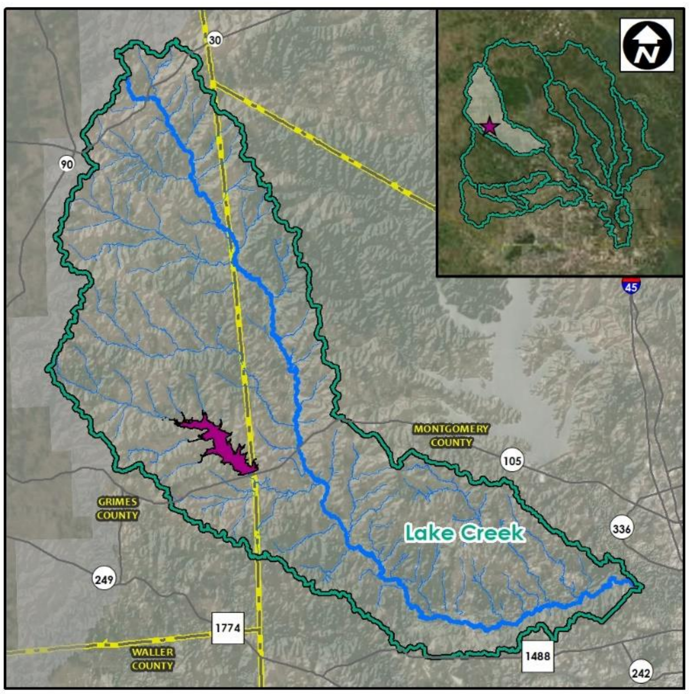

Figure 34: Lake Creek Detention – Caney Creek

Several sites within the watershed were initially screened as potential detention locations. The site at SH 105 provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Lake Creek and West Fork watershed by constructing a 0.76-mile-long earthen impoundment that captures runoff from Caney Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 52- foot high concrete dam with a primary outfall consisting of 3-5’ x 5’ RCB and a secondary spillway approximately

200' in length. The impoundment will require over 825,000 cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,890 acres below the 1% ACE water surface elevation, which includes Caney Creek. The basin will provide approximately 19,750 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.2.1.2 H&H Considerations

The Lake Creek Detention at Caney Creek was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. Storage areas were added to the sides of overtopped cross sections and adjoining tributaries to model volume outside the existing modeled cross sections. The dam was modeled as a lateral structure with 3 – 5' x 5' low flow culverts. The 200' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

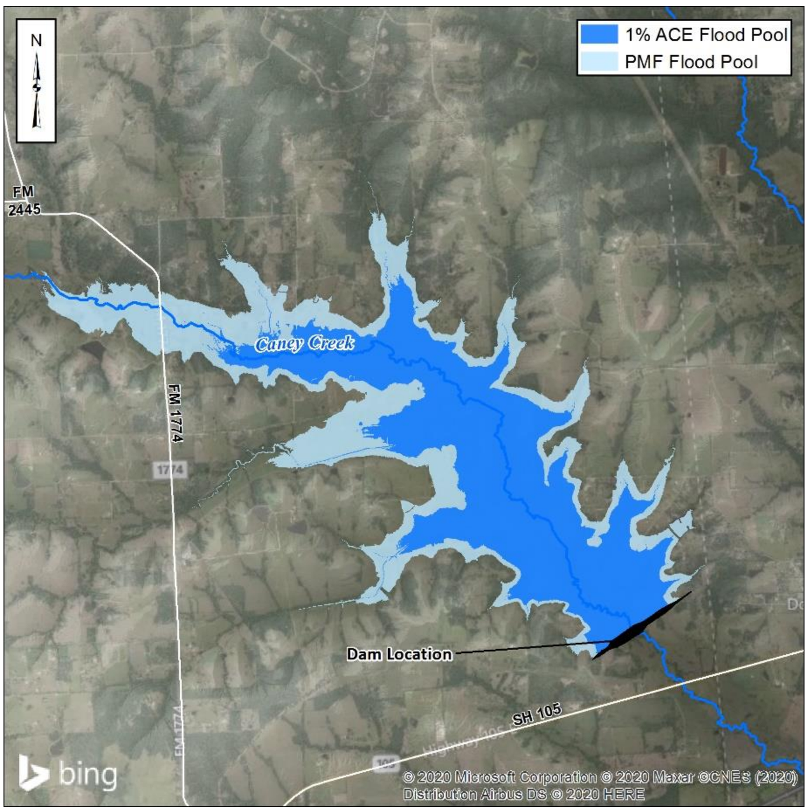

Figure 35: Lake Creek Detention at Caney Creek

Table 51 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 51. Lake Creek at Caney Creek H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (ac-ft)	WSEL (ft)
50% ACE	2850	900	2520	232.5
20% ACE	4700	1080	4780	236.6
10% ACE	6570	1200	7240	239.7
4% ACE	9650	1330	11290	243.5
2% ACE	12580	1420	15120	246.4
1% ACE	16120	1510	19750	249.3
0.2% ACE	26360	1680	33190	255.7

The detention basin will provide a reduction in water surface elevations and flows along Lake Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 1.2 feet between Caney Creek and the confluence with West Fork. The reduction maintains an average of 0.7 ft for West Fork through River Plantation.

5.2.1.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 68,650 cfs to the existing 2% ACE of 57,700 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 35.1 miles along Lake Creek and an additional 27.9 miles along the West Fork, with a maximum water surface reduction of 1.6 feet at the damage center just upstream of Fish Creek Thoroughfare.

By reducing the flows downstream, the basin removes 323 structures from the 1% ACE floodplain and provides a potential reduction in reduction in flooding instances of 686. Most of the benefits would be realized between Woodforest and River Plantation. The net present value of benefits based on a 50-year project life within the watershed is approximately $42.1M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 52: Caney Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	16.6	21.9	**38.5**
Lake Creek	0.0	3.6	**3.6**
Total	**16.6**	**25.5**	**42.1**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 53**.

Table 53. Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
CR 339	0.00	50% ACE	No Change
FM 149	0.00	2% ACE	No Change
Johnson Rd	0.00	<50% ACE	No Change
TX-105	0.00	2% ACE	No Change
Timber Rock Railroad	0.00	4% ACE	No Change
FM 149	1.11	50% ACE	No Change
Superior Road	1.01	<50% ACE	No Change
Honea Egypt Road	1.53	50% ACE	No Change
Sendera Ranch Dr.	1.57	4% ACE	2% ACE

The proposed detention facility reduces the WSEL at the confluence with the West Fork by 0.8 feet and at SH 242 by 0.8 feet. There is also a reduction in Lake Houston by approximately 0.1 feet.

5.2.1.4 Real Estate

123 parcels would need to be acquired for a total of 1,920 acres if purchased below the 1% ACE water surface elevation. 220 parcels would need to be acquired for a total of 4,200 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.2.1.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 4.9 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 54**.

Table 54: Caney Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Roadway	FM 1774		0.54 miles	2-lane asphalt
Roadway	CR 204	Grimes County	0.96 miles	2-lane gravel
Roadway	CR 206	Grimes County	0.71 miles	2-lane gravel
Roadway	CR 209	Grimes County	0.42 miles	2-lane gravel
Roadway	CR 313	Grimes County	0.92 miles	2-lane gravel
Roadway	Askew Rd	Grimes County	0.27 miles	2-lane asphalt
Roadway	Lakecrest Dr	Grimes County	0.12 miles	2-lane asphalt
Roadway	Rolling Oaks Dr	Grimes County	0.35 miles	2-lane asphalt
Roadway	Ridgewood Dr	Grimes County	0.31 miles	2-lane asphalt
Roadway	Oaktree Ct	Grimes County	0.01 miles	1-lane gravel
Roadway	Meadow Ct	Grimes County	0.12 miles	1-lane gravel
Roadway	Hillside Ct	Grimes County	0.10 miles	1-lane asphalt

5.2.1.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 10 acres of potential wetlands within the footprint of the proposed dam and a potential 660 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

Figure 36: Caney Creek Dam Embankment Maximum Footprint

5.2.1.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $350,000.

5.2.1.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 55**. The approximate costs range from $98M to $163M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.26 to 0.43.

Table 55. Estimated Cost and Benefit-Cost Ratio (BCR)—Caney Creek Detention on Lake Creek

Item	Cost
Construction	$34 M
Design	$4 M
Environmental	$7 M
Right-of-Way	$54 M - $118 M
TOTAL	**$98 M - $163 M**
BCR:	**0.26 - 0.43**
20-Year Escalation	**$149 M - $247 M**

5.2.1.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is not located within Montgomery County but would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.2.2 Little Caney Creek Detention

5.2.2.1 Description/Specifications

The majority of damage centers in the Lake Creek watershed are located in the southern half of the watershed. The Little Caney Creek detention basin is one of four detention areas that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on Little Caney Creek, north of SH 105 and along the border of Grimes and Montgomery County. The basin is at the approximate midpoint of the Lake Creek watershed and captures flow from a drainage area of approximately 37 square miles. The location of the propose detention shown in **Figure 37**.

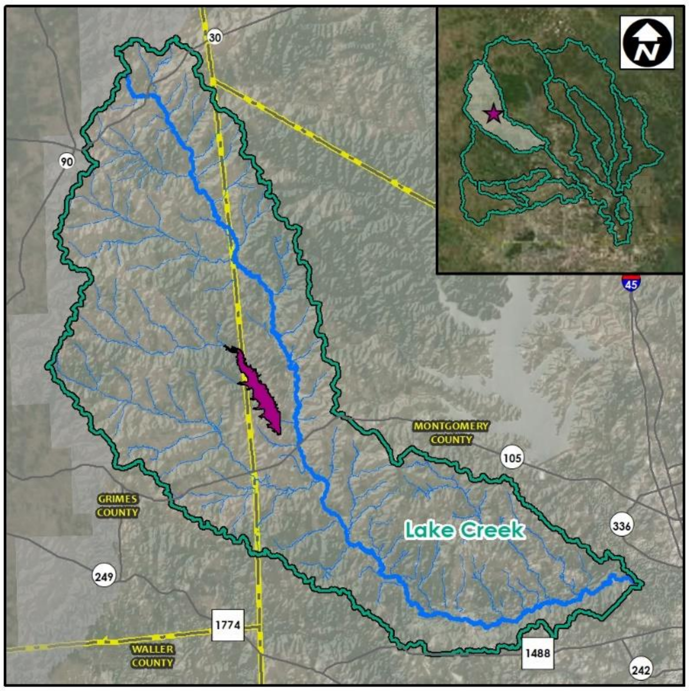

Figure 37: Lake Creek Detention – Little Caney

Several sites within the watershed were initially screened as potential detention locations. The site at Little Caney provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Lake Creek and West Fork watershed by constructing a 0.83-mile-long earthen impoundment that captures runoff from Little Caney Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 51-foot high concrete dam with a primary outfall consisting of 3-5’ x 5’ RCB and a secondary spillway approximately 200’ in length. The impoundment will require over 1.24 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,610 acres below the 1% ACE water surface elevation, which includes Little Caney Creek. The basin will provide approximately 17,500 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.2.2.2 H&H Considerations

The Lake Creek Detention at Little Caney Creek was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. Storage areas were added to the sides of overtopped cross sections and adjoining tributaries to model volume outside the existing modeled cross sections. The dam was modeled as a lateral structure with 3 – 5' x 5' low flow culverts. The 200' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

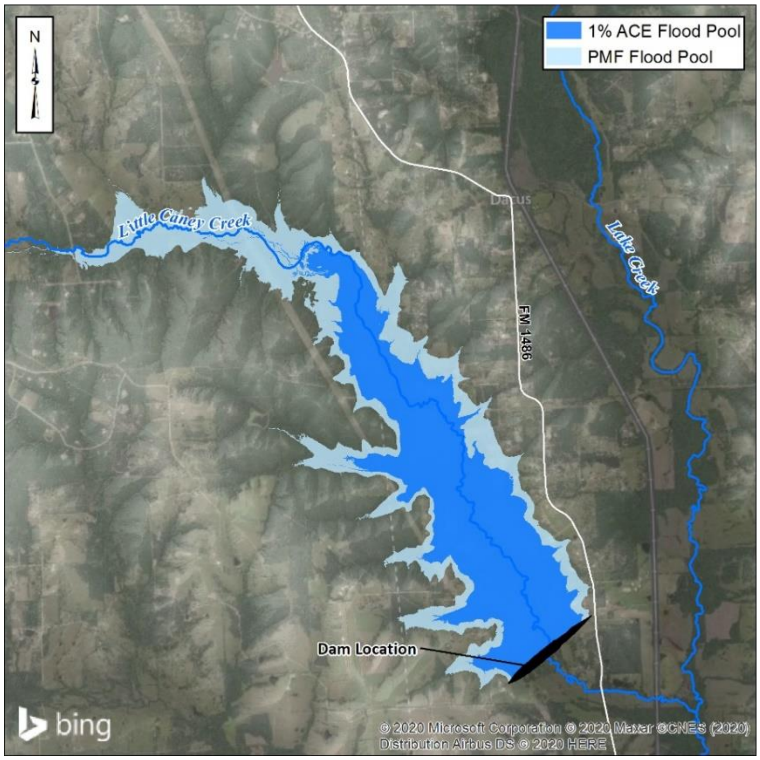

Figure 38: Little Caney Creek Detention

Table 56 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 56. Lake Creek at Little Caney Creek H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (ac-ft)	WSEL (ft)
50% ACE	2,070	850	1,770	227.0
20% ACE	3,900	1,100	3,760	231.1
10% ACE	5,800	1,260	5,960	234.3
4% ACE	8,790	1,440	9,620	238.4
2% ACE	11,490	1,570	13,040	241.7
1% ACE	14,630	1,700	17,160	245.0
0.2% ACE	23,690	4,880	26,050	251.0

The detention basin will provide a reduction in water surface elevations and flows along Lake Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 1.1 feet between Little Caney Creek and the confluence with West Fork. The reduction maintains an average of 0.5 ft for West Fork through River Plantation.

5.2.2.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 55,650 cfs to the existing 2% ACE of 46,400 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 40.1 miles along Lake Creek and an additional 19.9 miles along the West Fork, with a maximum water surface reduction of 2.3 feet just downstream of the confluence of Little Caney and Lake Creek.

By reducing the flows downstream, the basin removes 248 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 564. Most of the benefits would be realized between Woodforest and River Plantation. The net present value of benefits based on a 50-year project life within the watershed is approximately $35.0M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 57: Little Caney Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	12.5	18.4	**30.8**
Lake Creek	0.0	4.2	**4.2**
Total	**12.5**	**22.5**	**35.0**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 58**.

Table 58: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
CR 339	0.00	50% ACE	No Change
FM 149	0.00	2% ACE	No Change
Johnson Rd	0.00	<50% ACE	No Change
TX-105	2.33	2% ACE	No Change
Timber Rock Railroad	1.95	4% ACE	2% ACE
FM 149	0.93	50% ACE	No Change
Superior Road	0.84	<50% ACE	No Change
Honea Egypt Road	1.26	50% ACE	No Change
Sendera Ranch Dr	1.29	4% ACE	2% ACE

The proposed detention facility provides regional benefit outside the Lake Creek watershed. The model shows a reduction in WSEL at the confluence with the West Fork of 0.6 feet and a reduction in WSEL at Lake Houston of less than one inch.

5.2.2.4 Real Estate

111 parcels would need to be acquired for a total of 2,490 acres if purchased below the 1% ACE water surface elevation. 215 parcels would need to be acquired for a total of 3,740 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.2.2.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 3.5 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 59**.

Table 59: Little Caney Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	4-inch Gas Pipeline	Kinder Morgan Tejas	500 feet	Natural Gas
Utility	26-inch Gas Pipeline	Kinder Morgan Tejas	500 feet	Natural Gas
Utility	12-inch Gas Pipeline	Enterprise Products	500 feet	HVL
Utility	10-inch Oil Pipeline	BP	500 feet	Crude Oil
Utility	20-inch Oil Pipeline	Magellan	500 feet	Crude Oil
Utility	10-inch Oil Pipeline	Enterprise Products	500 feet	Crude Oil
Roadway	FM 1486		0.18 miles	2-lane asphalt
Roadway	Granite Ridge Dr	Grimes County	0.08 miles	2-lane asphalt
Roadway	Mount Mariah Rd	Montgomery County	1.57 miles	2-lane asphalt
Roadway	Post Oak Cemetery Rd	Montgomery County	0.66 miles	1-lane asphalt
Roadway	Mt. Mariah Cut Off Rd	Montgomery County	0.44 miles	2-lane asphalt
Roadway	Joe Adams Rd	Montgomery County	0.03 miles	1-lane asphalt
Roadway	Carpenter Rd	Montgomery County	0.27 miles	1-lane asphalt
Roadway	CR 3417	Montgomery County	0.04 miles	2-lane asphalt
Roadway	Denn Rd	Montgomery County	0.18 miles	2-lane asphalt

5.2.2.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 8.9 acres of potential wetlands within the footprint of the proposed dam and a potential 1,105 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

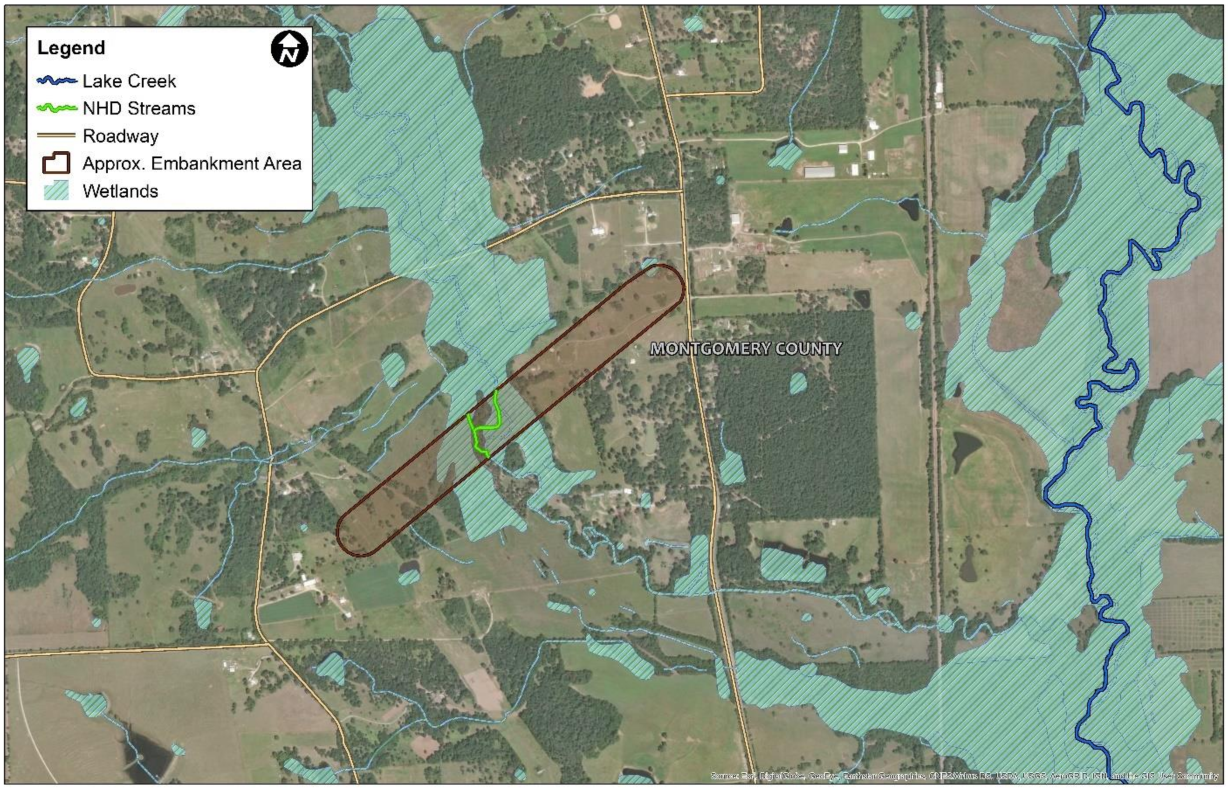

Figure 39: Little Caney Creek Dam Embankment Maximum Footprint

5.2.2.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $500,000.

5.2.2.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 60**. The approximate costs range from $98M to $128M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.27-0.36.

Table 60: Estimated Cost and Benefit-Cost Ratio (BCR)—Little Caney Creek Detention on Lake Creek

Item	Cost
Construction	$49 M
Design	$6 M
Environmental	$10 M
Right-of-Way	$33 M - $63 M
TOTAL	**$98 M - $128 M**
BCR:	**0.27 – 0.36**
20-Year Escalation	**$149 M - $195 M**

5.2.2.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Grimes County – The project is located within Grimes County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.2.3 Garrett's Creek Detention

5.2.3.1 Description/Specifications

The majority of damage centers in the Lake Creek watershed are located in the southern half of the watershed. The Lake Creek Detention Basin at Garrett's Creek is one of four detention areas that were explored in the upper watershed to reduce flood risk downstream within both Lake Creek and the West Fork. The proposed detention basin is located on Garrett's Creek, south of Richards and just inside of Grimes County on the border of Montgomery County. The basin is on the northern portion of the Lake Creek watershed and captures flow from a drainage area of approximately 31.5 square miles. The location of the proposed detention shown in **Figure 40**.

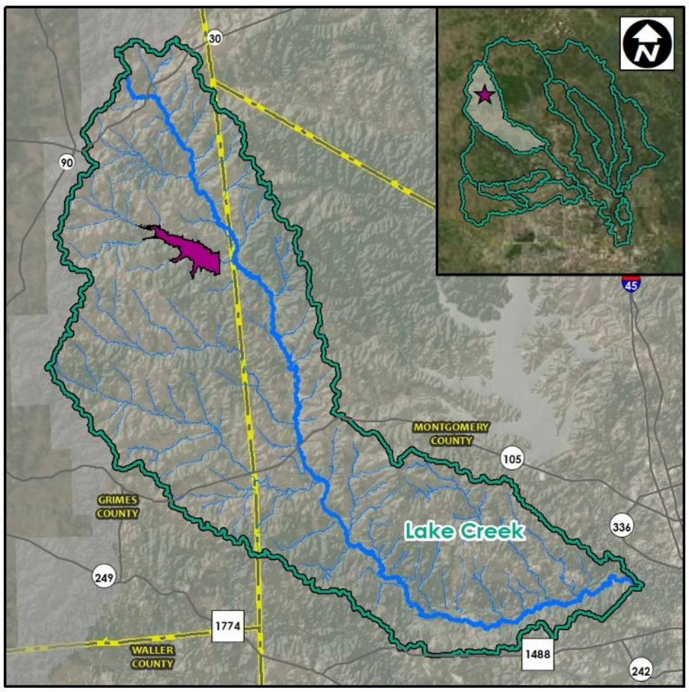

Figure 40: Lake Creek Detention – Garrett's Creek

Several sites within the watershed were initially screened as potential detention locations. The site at Garrett's Creek provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Lake Creek and West Fork watersheds by constructing a 1.2-mile-long earthen impoundment that captures runoff from Garrett's Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 43-foot high concrete dam with a primary outfall consisting of 3-5' x 5' RCB and a secondary spillway approximately 100' in length. The impoundment will require over 1.02 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,740 acres below the 1% ACE water surface elevation, which includes Garrett's Creek. The basin will provide approximately 16,850 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.2.3.2 H&H Considerations

The Lake Creek Detention at Little Caney Creek was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. Storage areas were added to the sides of overtopped cross sections and adjoining tributaries to model volume outside the existing modeled cross sections. The dam was modeled as a lateral structure with 3 – 5' x 5' low flow culverts. The 100' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

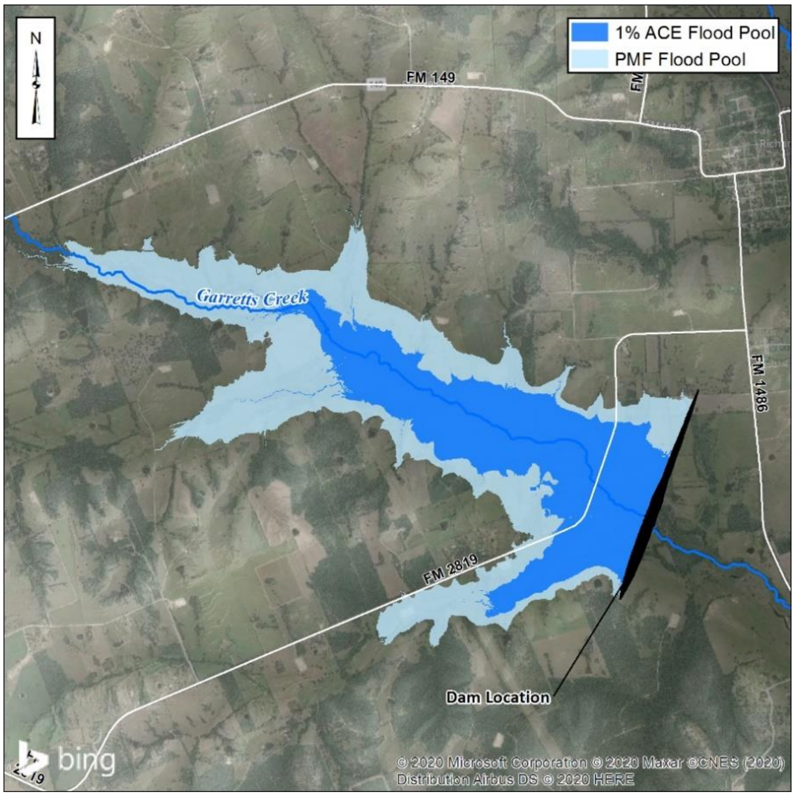

Figure 41. Lake Creek Detention at Garrett's Creek

Table 61 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 61: Lake Creek at Garrett's Creek H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (ac-ft)	WSEL (ft)
50% ACE	3700	1100	2330	267.1
20% ACE	6690	1300	4330	271.1
10% ACE	9630	1440	6450	274.2
4% ACE	14040	1580	9820	278.0
2% ACE	17830	1690	12940	280.8
1% ACE	22050	1760	16680	283.5
0.2% ACE	33650	4650	25590	288.8

The detention basin will provide a reduction in water surface elevations and flows along Lake Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 1.7 feet between Little Caney Creek and the confluence with West Fork. The water surface maintains a reduction of 0.5 ft for West Fork through River Plantation.

5.2.3.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 44,620 cfs to the existing 2% ACE of 27,120 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 53.2 miles along Lake Creek and an additional 20.8 miles along the West Fork, with a maximum water surface reduction of 2.9 feet at the confluence of Little Caney and Lake Creek.

By reducing the flows downstream, the basin removes 295 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 684. Most of the benefits would be realized between Woodforest and River Plantation. The net present value of benefits based on a 50-year project life within the watershed is approximately $39.8M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 62: Garrett's Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
East Fork	1.2	0.0	**1.3**
West Fork	12.2	20.5	**32.7**
Lake Creek	0.0	5.8	**5.8**
Total	**13.4**	**26.4**	**39.8**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 63**.

Table 63: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
CR 339	0.00	50% ACE	No Change
FM 149	0.00	2% ACE	No Change
Johnson Rd	2.10	<50% ACE	No Change
TX-105	2.99	2% ACE	1% ACE
Timber Rock Railroad	2.47	4% ACE	2% ACE
FM 149	1.29	50% ACE	No Change
Superior Road	1.10	<50% ACE	No Change
Honea Egypt Road	1.54	50% ACE	No Change
Sendera Ranch Dr	1.57	4% ACE	2% ACE

The proposed detention facility also provides regional benefit outside the Lake Creek watershed. The model shows a reduction in WSEL at the confluence with the West Fork of 0.7 feet. The reduction at the Lake Houston Dam is 0.1 feet.

5.2.3.4 Real Estate

36 parcels would need to be acquired for a total of 2,080 acres if purchased below the 1% ACE water surface elevation. 74 parcels would need to be acquired for a total of 3,750 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.2.3.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 4.6 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 64**.

Table 64: Garretts Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	20-inch Gas Pipeline	Enterprise Products	300 feet	HVL
Utility	8-inch Gas Pipeline	Phillips 66	300 feet	HVL
Roadway	FM 149		0.05 miles	2-lane asphalt
Roadway	FM 1486		2.17 miles	2-lane asphalt
Roadway	FM 2819		1.97 miles	2-lane asphalt
Roadway	CR 212	Grimes County	0.02 miles	2-lane gravel
Roadway	CR 769	Grimes County	0.35 miles	2-lane gravel

5.2.3.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 35 acres of potential wetlands within the footprint of the proposed dam and a potential 2,590 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

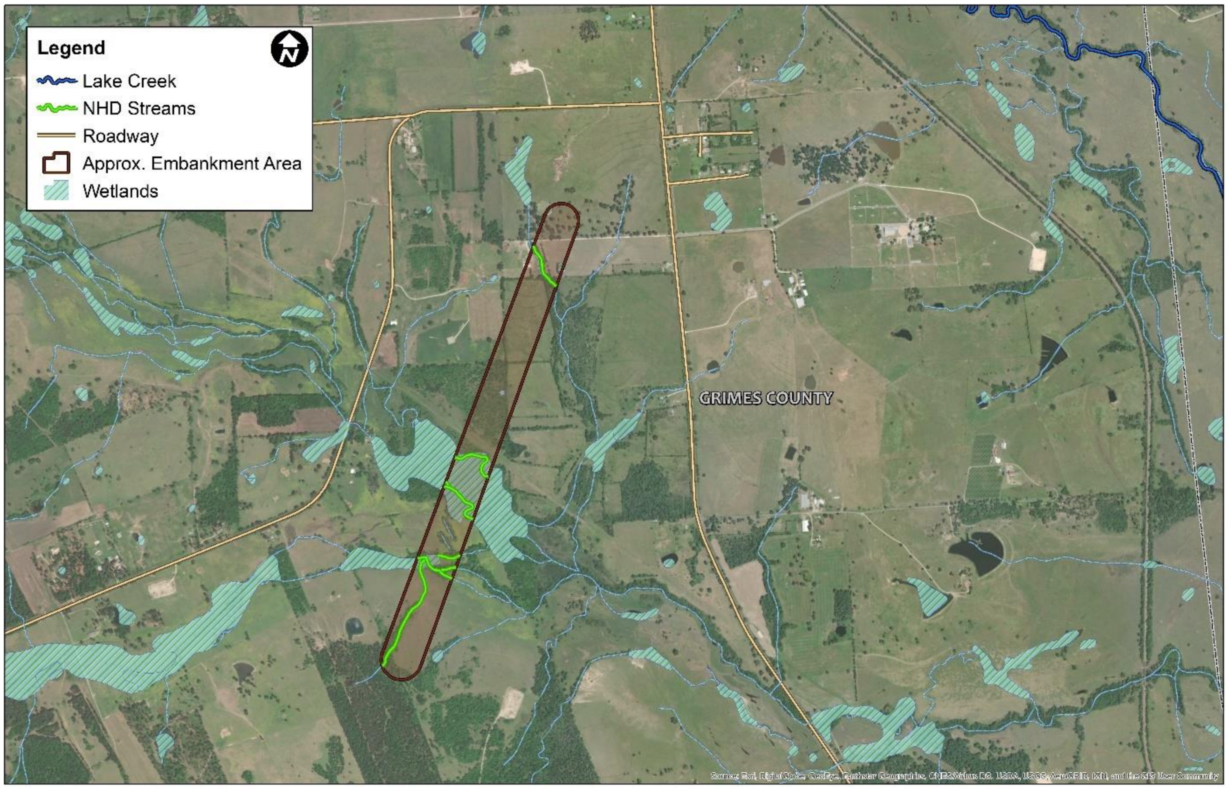

Figure 42: Garretts Creek Dam Embankment Maximum Footprint

5.2.3.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $550,000.

5.2.3.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 65**. The approximate costs range from $107M to $131M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.31-0.37.

Table 65. Estimated Cost and Benefit-Cost Ratio (BCR)—Garretts Creek Detention on Lake Creek

Item	Cost
Construction	$51 M
Design	$6 M
Environmental	$17 M
Right-of-Way	$32 M - $56 M
TOTAL	**$107 M - $131 M**
BCR:	**0.31 – 0.37**
20-Year Escalation	**$162 M - $198 M**

5.2.3.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located just outside of Montgomery County but would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Grimes – The project is located entirely within Grimes County. However, most of the benefit is downstream in Montgomery County. Coordination with Grimes County may be needed for right-of-way acquisition.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for one TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.2.4 Mainstem Detention

5.2.4.1 Description/Specifications

The majority of damage centers in the Lake Creek and West Fork watershed are located in the southern half of the watershed. The mainstem Lake Creek Detention Basin north of SH 105 is one of four detention areas that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on Lake Creek, north of SH 105 and along the border of Grimes and Montgomery County. The detention basin is at the approximate midpoint of the Lake Creek watershed and captures flow from a drainage area of approximately 147 square miles. The location of the propose detention shown in **Figure 43.**

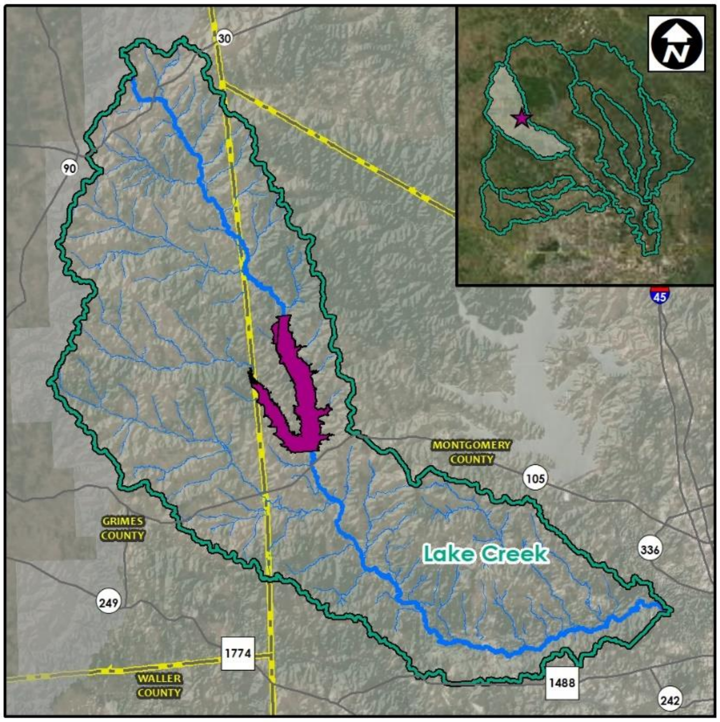

Figure 43: Lake Creek Detention – Mainstem

Several sites within the watershed were initially screened as potential detention locations. The site on the mainstem of Lake Creek provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Lake Creek and West Fork watershed by constructing a 1.25-mile-long earthen impoundment that captures runoff from Lake Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 58-foot high concrete dam with a primary outfall consisting of 5-5’ x 5’ RCB and a secondary spillway approximately 100’ in length. The impoundment will require over 2.99 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 4,950 acres below the 1% ACE water surface elevation, which includes Lake Creek. The basin will provide approximately 75,100 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.2.4.2 H&H Considerations

The Lake Creek Detention was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. Storage areas were added to the sides of overtopped cross sections and adjoining tributaries to model volume outside the existing modeled cross sections. The dam was modeled as an inline structure with 5 – 5' x 5' low flow culverts. The 100' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam. Spillway is two stage; a lower 100' stretch that is 8' in depth, above which it expands to 400' in total length, before raising another 13' to top of dam.

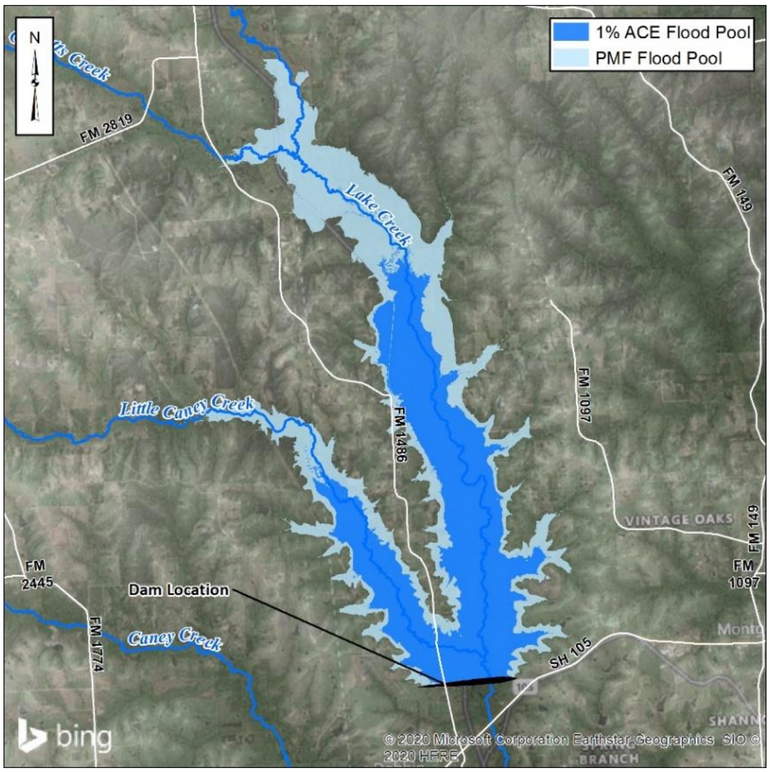

Figure 44: Lake Creek Detention on Mainstem

Table 66 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 66: Lake Creek H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (ac-ft)	WSEL (ft)
50% ACE	8,430	4,380	10,170	218.1
20% ACE	14,970	6,380	17,740	221.8
10% ACE	22,010	7,920	25,810	224.7
4% ACE	32,900	9,890	39,400	228.7
2% ACE	44,770	11,160	52,250	231.8
1% ACE	55,650	12,490	68,300	235.2
0.2% ACE	97,360	19,140	11,1440	242.4

The detention basin will provide a reduction in water surface elevations and flows along Lake Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 5.9 feet between SH 105 and the confluence with West Fork. The reduction maintains an average of 2.1 ft for West Fork from Lake Creek through River Plantation.

5.2.4.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 61,560 cfs to the existing 4% ACE of 28,650 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 36.1 miles along Lake Creek and an additional 35.9 miles along the West Fork, with a maximum water surface reduction of 10.5 feet just downstream of the confluence of Little Caney and Lake Creek.

By reducing the peak flows downstream, the basin removes 931 structures from the 1% ACE floodplain and provides a potential reduction in water surface elevation for 8,180 structures and a potential reduction in flooding instances of 1,694. Most of the benefits would be realized between Woodforest and River Plantation. The net present value of benefits based on a 50-year project life within the watershed is approximately $100.4M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 67: Mainstem Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	36.5	52.1	**88.6**
Lake Creek	0.0	11.9	**11.9**
Total	**36.5**	**64.0**	**100.4**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 68**.

Table 68: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
CR 339	0.02	50% ACE	No Change
FM 149	-0.17	2% ACE	No Change
Johnson Rd	-3.04	<50% ACE	10% ACE
TX-105	10.76	2% ACE	0.2% ACE
Timber Rock Railroad	9.94	4% ACE	0.2% ACE
FM 149	4.12	50% ACE	20% ACE
Superior Road	4.20	<50% ACE	No Change
Honea Egypt Road	5.95	50% ACE	No Change
Sendera Ranch Dr	6.16	4% ACE	1% ACE

The proposed detention facility also provides regional benefit outside the Lake Creek watershed. The model shows a reduction in WSEL at the confluence with the West Fork of 2.2 feet. The reduction at the Lake Houston Dam is 0.4 feet.

5.2.4.4 Real Estate

209 parcels would need to be acquired for a total of 5,560 acres if purchased below the 1% ACE water surface elevation. 483 parcels would need to be acquired for a total of 9,180 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.2.4.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 10.1 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 69.**

Table 69: Mainstem Lake Creek Detention Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	26-inch Gas Pipeline	Kinder Morgan Tejas	200 feet	Natural Gas
Utility	12-inch Gas Pipeline	Enterprise Products	1000 feet	HVL
Utility	10-inch Oil Pipeline	BP	200 feet	Crude Oil
Utility	20-inch Oil Pipeline	Magellan	200 feet	Crude Oil
Utility	10-inch Oil Pipeline	Enterprise Products	200 feet	Crude Oil
Roadway	FM 1486		1.89 miles	2-lane asphalt
Roadway	Granite Ridge Dr	Grimes County	0.08 miles	2-lane asphalt
Roadway	Mount Mariah Rd	Montgomery County	1.37 miles	2-lane asphalt
Roadway	Post Oak Cemetery Rd	Montgomery County	0.48 miles	1-lane asphalt
Roadway	Mt. Mariah Cut Off Rd	Montgomery County	0.55 miles	2-lane asphalt
Roadway	High Oaks Dr	Montgomery County	0.03 miles	2-lane asphalt
Roadway	Giles Rd	Montgomery County	0.27 miles	2-lane gravel
Roadway	Amberwood Dr	Montgomery County	0.72 miles	2-lane asphalt
Roadway	Gay Ln	Montgomery County	0.21 miles	2-lane asphalt
Roadway	Carpenter Rd	Montgomery County	0.13 miles	1-lane asphalt
Roadway	High Fire	Montgomery County	0.06 miles	2-lane asphalt
Roadway	Hill Creek Rd	Montgomery County	0.40 miles	2-lane asphalt
Roadway	Moore Ln	Montgomery County	0.32 miles	2-lane asphalt
Roadway	Johnson Rd	Montgomery County	1.41 miles	2-lane asphalt
Roadway	Bethel Rd	Montgomery County	0.59 miles	2-lane asphalt
Roadway	CR 3417	Montgomery County	0.01 miles	2-lane asphalt
Roadway	Denn Rd	Montgomery County	0.13 miles	2-lane asphalt
Roadway	Log Cabin Rd	Montgomery County	0.11 miles	2-lane asphalt
Roadway	Armadillo Rd	Montgomery County	0.15 miles	2-lane asphalt
Roadway	Gingham Rd	Montgomery County	0.36 miles	1-lane asphalt
Roadway	Walding Dr	Montgomery County	0.08 miles	1-lane asphalt
Roadway	Taylor St	Montgomery County	0.37 miles	2-lane asphalt

5.2.4.6 *Environmental Mitigation*

The desktop environmental analysis using NWI data shows 23.3 acres of potential wetlands within the footprint of the proposed dam and a potential 810 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

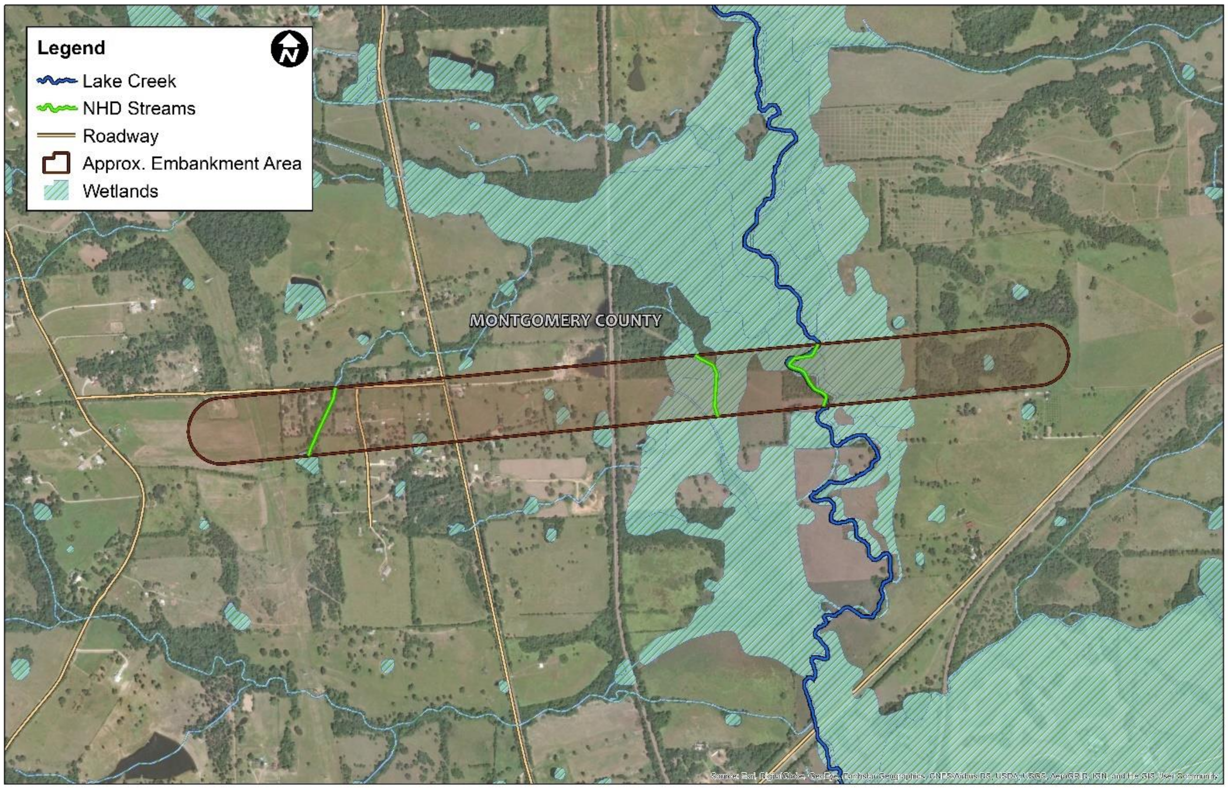

Figure 45: Mainstem Lake Creek Dam Embankment Maximum Footprint

5.2.4.7 *Operation and Maintenance*

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $950,000.

5.2.4.8 *Estimated Costs and Benefit-Cost Ratio (BCR)*

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 70**. The approximate costs range from $187M to $267M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.38 to 0.54.

Table 70. Estimated Cost and Benefit-Cost Ratio (BCR)—Mainstem Detention on Lake Creek

Item	Cost
Construction	$94 M
Design	$11 M
Environmental	$7 M
Right-of-Way	$74 M - $154 M
TOTAL	**$187 M - $267 M**
BCR:	**0.38 – 0.54**
20-Year Escalation	**$284 M - $405 M**

5.2.4.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for two TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.2.5 Lake Creek Recommendation

5.2.5.1 Description/Specifications

Of the four alternatives for the Lake Creek watershed analyzed in this study, the following combination of dam options are recommended for Lake Creek. The section that describes each individual alternative in detail is also listed.

- Caney Creek - Section 5.2.1
- Little Caney Creek – Section 5.2.2
- Garretts Creek – Section 5.2.3

The location of the proposed dams and extents of the channel improvements is shown in **Figure 46**.

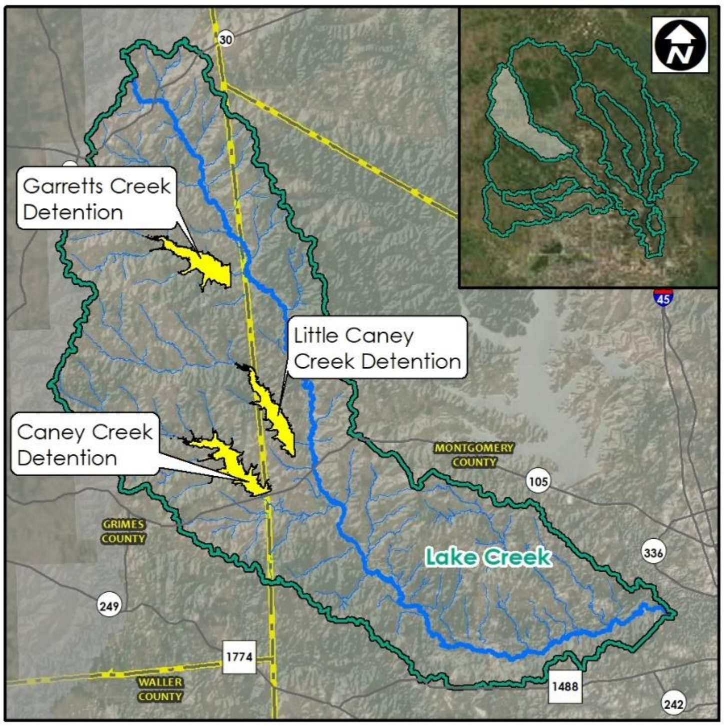

Figure 46: Lake Creek Recommended Alternatives

Each alternative was chosen based on several factors, including but not limited to, its ability to reduce water surface elevations in damage centers, availability of land for construction, and its benefit-cost ratio.

The goal of the recommended alternatives is to reduce flooding in the Lake Creek watershed by combining the benefits of three proposed dams on Lake Creek tributaries. While any combination of alternatives will be less efficient in reducing flood risk when compared to an individual alternative, this combination of alternatives performs well and provides significant benefit to the Lake Creek watershed.

5.2.5.2 H&H Considerations

A summary of the proposed dam and channel improvement alternatives is shown in Table 71. The three dam options were modeled in HEC-RAS. Flow data from the existing conditions HEC-HMS model was combined with the proposed HEC-RAS geometry to arrive at a comprehensive model for the Lake Creek watershed.

Table 71: 1% ACE Summary - Dams

Alternative	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
Caney Creek Dam	16,116	1,509	19,734	249.3
Little Caney Creek Dam	14,635	1,696	17,158	245.0
Garretts Creek Dam	20,680	1,757	16,678	283.5

The combination of detention basins provides significant reduction in water surface elevations and flows along Lake Creek and the West Fork San Jacinto River. The average reduction in water surface elevation along Lake Creek and West Fork San Jacinto River is summarized in **Table 72**.

Table 72: Average Reduction in Water Surface Elevation – Lake Creek

Location	Frequency Event			
	10% ACE	2% ACE	1% ACE	0.2% ACE
Garretts Creek – Little Caney Creek	1.26	2.11	2.52	3.26
Little Caney Creek – Caney Creek	2.41	4.05	4.78	5.70
Caney Creek – West Fork Confluence	2.16	3.50	3.92	5.11
West Fork: Lake Creek – I-45	1.53	2.17	2.55	2.65
West Fork: I-45 – Grand Parkway	1.30	1.89	1.93	2.54
West Fork: Grand Parkway – West Lake Houston Parkway	0.06	1.32	1.41	1.49

5.2.5.3 Project Benefits

The combination of alternatives reduces the 1% ACE existing conditions water surface elevations to elevations of approximately the existing conditions 4% ACE on Lake Creek and 2% ACE on West Fork San Jacinto River.

By reducing flows from Lake Creek, the proposed improvements remove 951 structures from the 1% ACE floodplain and provide a potential reduction in flooding instances of 1,767. Benefits are realized on most of the developed area of Lake Creek, beginning at the Garrett's Creek confluence and extending to the confluence with the West Fork San Jacinto River. Reduction in water surface elevation also occur on the West Fork San Jacinto River beginning at the Lake Creek confluence and extending to West Lake Houston Parkway. The net present value of benefits based on a 50-year project life within the watershed is approximately $102.0M. The distribution of these benefits along Lake Creek and the West Fork is shown in **Figure 47**. The proposed improvements provide substantial benefits to the West Fork San Jacinto River, with an approximately 0.3' reduction at Lake Houston in the 1% ACE event.

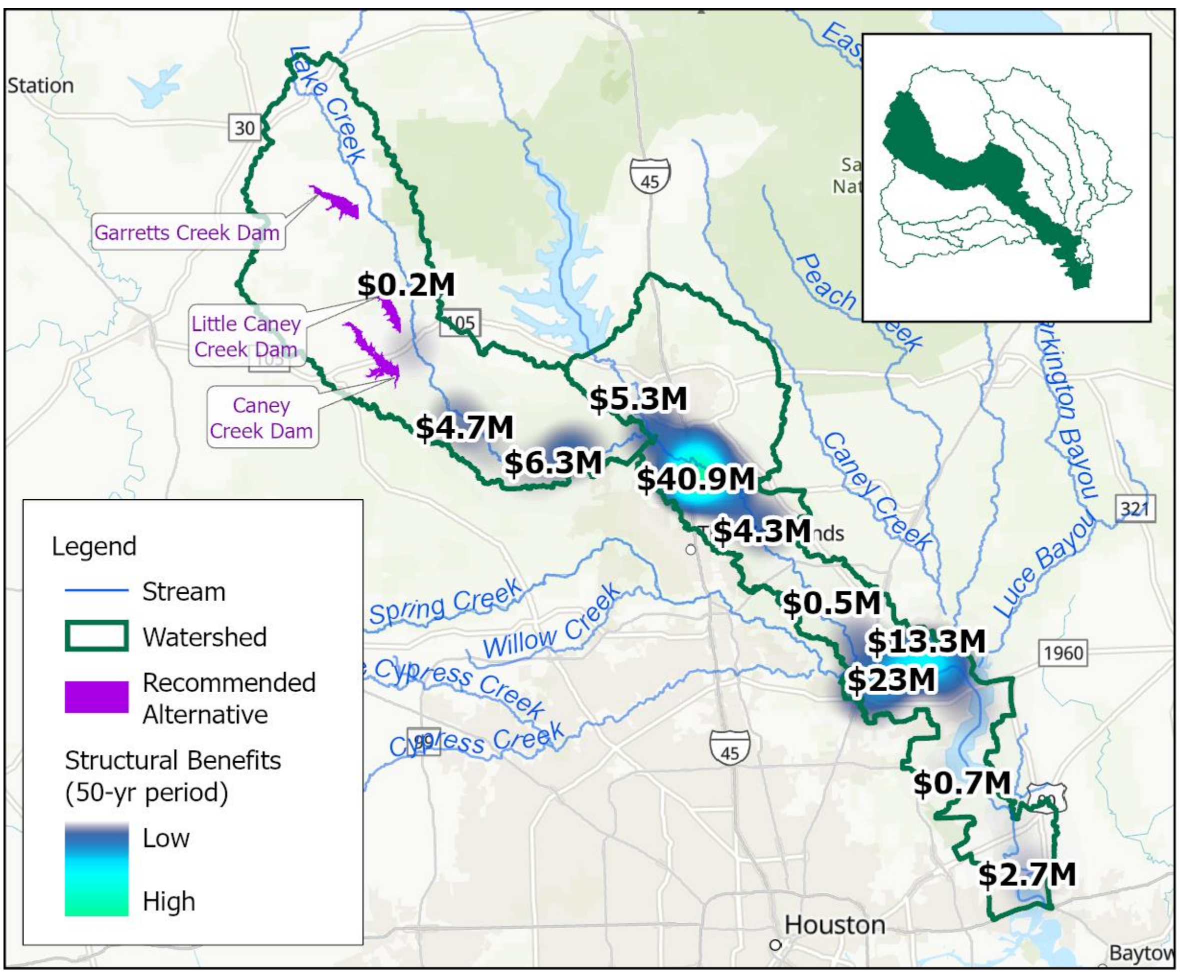

Figure 47: Lake Creek Overall Benefits

5.2.5.4 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 73**. The approximate costs range from $303 M to $422 M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.38 to 0.53.

Table 73: Lake Creek Combined Alternatives Estimated Cost and BCR

Item	Caney Creek Dam	Little Caney Creek Dam	Garrett's Creek Dam	Overall
Construction	$34 M	$49 M	$51 M	$134 M
Design	$4 M	$6 M	$6 M	$16 M
Environmental	$7 M	$10 M	$17 M	$34 M
Right-of-Way	$54 – 119 M	$33 – 63 M	$32 – 56 M	$119 - $238 M
TOTAL COST	**$98 - $163 M**	**$98 M - $128 M**	**$107 M - $131 M**	**$303 M - $422 M**
TOTAL BENEFIT	**$42.1 M**	**$35 M**	**$39.8 M**	**$102.0 M**
BCR:	**0.26 – 0.43**	**0.27 – 0.36**	**0.31 – 0.37**	**0.38 – 0.53**
20-Year Escalation	**$149 M - $247 M**	**$149 M - $195 M**	**$162 M - $198 M**	**$460 M - $640 M**

5.3 Peach Creek

Three mitigation alternatives were explored on the Peach Creek watershed. The alternatives included two inline detention facilities along Peach Creek and one channelization project on the downstream end of the watershed. The alternatives targeted reducing flooding instances primarily in Peach Creek with some reductions downstream.

5.3.1 SH 105 Detention

5.3.1.1 Description/Specifications

The majority of damage centers in the Peach Creek watershed are located in the southern half of the watershed. The Peach Creek Detention Basin at SH105 is one of two detention area that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on the main stem of Peach Creek, south of SH 105 and 3.5 miles west of Cleveland, Texas. The basin is at the approximate midpoint of the Peach Creek watershed and captures flow from a drainage area of approximately 108 square miles. The location of the proposed detention shown in **Figure 48**.

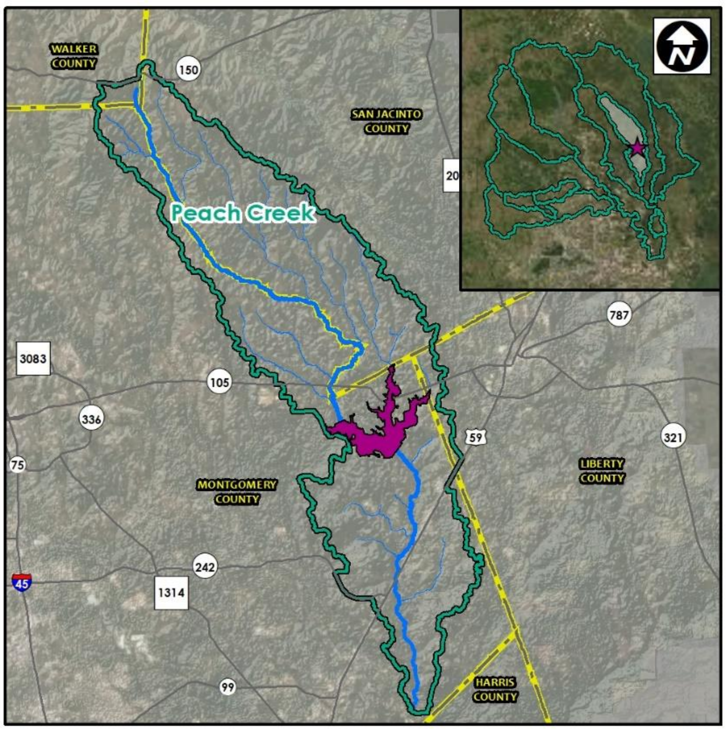

Figure 48: Peach Creek Detention at SH 105

Several sites within the watershed were initially screened as potential detention locations. The site at SH 105 provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Peach Creek watershed by constructing a 4.7-mile-long earthen impoundment that captures runoff from Peach Creek, Jayhawker Creek, and Bee Branch.

The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 46-foot high concrete dam with a primary outfall consisting of 5-12' x 12' RCB and a secondary spillway approximately 500' in length. The impoundment will require over 6.4 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 3,025 acres below the 1% ACE water surface elevation, which includes Peach Creek and the its tributaries. The basin will provide approximately 36,197 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.3.1.2 H&H Considerations

The Peach Creek Detention at SH 105 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. Storage areas were added to the sides of overtopped cross sections and adjoining tributaries to model volume outside the existing modeled cross sections. The dam was modeled as an inline structure with 5 – 12' x 12' low flow culverts. The 500' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

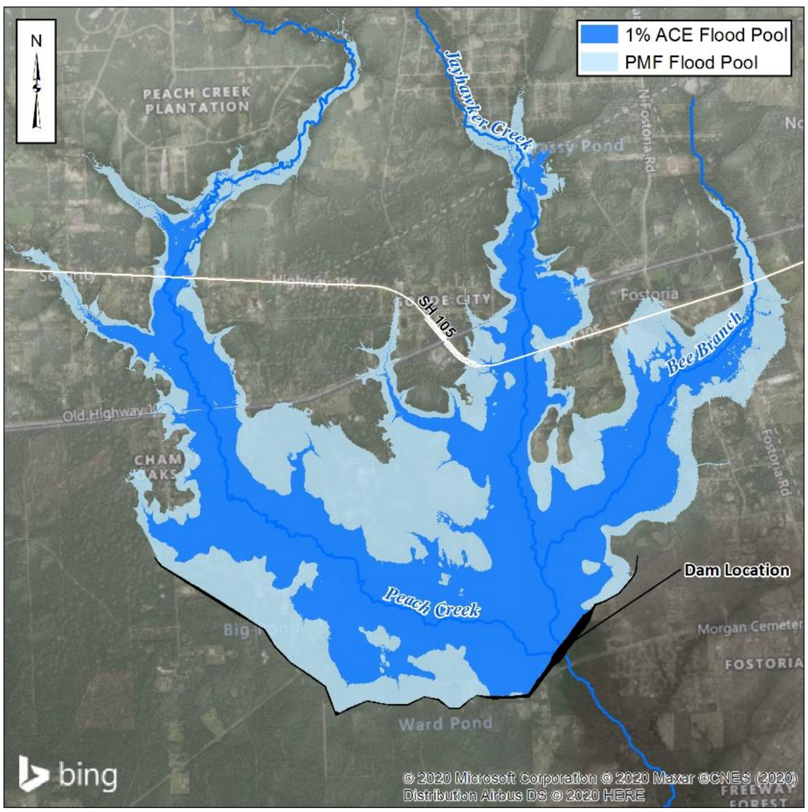

Figure 49: SH 105 Detention Detail

Table 74 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 74: Peach Creek at SH 105 H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	4,929	5,438	3,191	121.0
20% ACE	9,356	9,768	5,650	126.4
10% ACE	14,259	12,592	8,157	130.9
4% ACE	21,829	15,584	12,160	136.6
2% ACE	28,655	17,577	15,531	140.4
1% ACE	36,040	24,692	18,449	142.9
0.2% ACE	58,256	44,871	24,235	147.2

The detention basin will provide a reduction in water surface elevations and flows along Peach Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.9 feet between SH 105 and I-69. Downstream of I-69, the water surface elevation is reduced by 2.14 feet on average.

5.3.1.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 45,000 cfs to the existing 4% ACE of 25,000 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5 feet for 15.4 miles downstream of the detention facility with a maximum water surface reduction of 4.3 feet at I-69.

By reducing the flows downstream, the basin removes 400 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,768. Most of the benefits would be realized in the Woodbranch and Splendora areas. The net present value of benefits based on a 50-year project life within the watershed is approximately $81.5 M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 75: SH 105 Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Peach	0.0	74.1	**74.1**
Caney	2.3	5.2	**7.4**
Total	**2.3**	**79.2**	**81.5**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in the table below.

Table 76: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Tanyard Road	-0.12	<50% ACE	No Change
Browder Taylor Road	0.00	<50% ACE	No Change
SH 105	0.04	4% ACE	No Change
Old TX 105	-0.17	<50% ACE	No Change
Faulkner Road	-3.89	<50% ACE	No Change
Morgan Cemetery Road	3.96	<50% ACE	No Change
FM 2090	3.74	50% ACE	No Change
I 69	4.31	20% ACE	10% ACE
Woodbranch Drive	3.67	50% ACE	No Change
Roman Forrest Road	2.89	<50% ACE	No Change
FM 1485	1.02	20% ACE	No Change

The proposed detention facility also provides regional benefit outside the Peach Creek watershed. The model shows a reduction in WSEL at the confluence with Caney Creek of 1.15 feet. However, the project does not show any direct benefit at the confluence with East Fork and downstream in Lake Houston with reductions of less than one inch.

5.3.1.4 Real Estate

273 parcels would need to be acquired for a total of 3,883 acres if purchased below the 1% ACE water surface elevation. 505 parcels would need to be acquired for a total of 4,705 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.3.1.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 10.7 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 77**.

Table 77: Peach Creek Detention at SH 105 Potential Relocation Summary

Relocation Type	Name	Owner	Length (mi)	Notes
Roadway	SH 105	Montgomery County	1.46	2-lane asphalt road
Roadway	County Road 1284	Montgomery County	0.16	2-lane asphalt road
Roadway	Daw Collins Rd	Montgomery County	0.61	2-lane asphalt road
Roadway	Faulkner Rd	Montgomery County	1.79	2-lane asphalt road
Roadway	Fosters Bnd	Montgomery County	0.11	2-lane asphalt road
Roadway	Fostoria Rd	Montgomery County	0.96	2-lane asphalt road
Roadway	Morgan Cemetery Rd	Montgomery County	3.15	2-lane asphalt road
Roadway	Morgan Ln	Montgomery County	0.23	2-lane asphalt road
Roadway	Oak Bend Ct	Montgomery County	0.26	2-lane asphalt road
Roadway	Penny Rd	Montgomery County	0.25	2-lane asphalt road
Roadway	Slaughter Rd	Montgomery County	0.43	2-lane asphalt road
Roadway	Strickland Ln	Montgomery County	0.04	2-lane asphalt road
Roadway	Tallow Vista	Montgomery County	0.90	2-lane asphalt road
Roadway	Thomas T Trl	Montgomery County	0.01	2-lane asphalt road
Roadway	Walker Dr	Montgomery County	0.36	2-lane asphalt road
Utility	24-inch Gas Pipeline	Tennessee Gas Pipeline Co,L.L.C.	0.08	
Utility	30-inch Gas Pipeline	Tennessee Gas Pipeline Co,L.L.C.	0.08	
Utility	30-inch Gas Pipeline	Tennessee Gas Pipeline Co,L.L.C.	0.08	

5.3.1.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 6.9 acres of potential wetlands within the footprint of the proposed dam and a potential 900 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

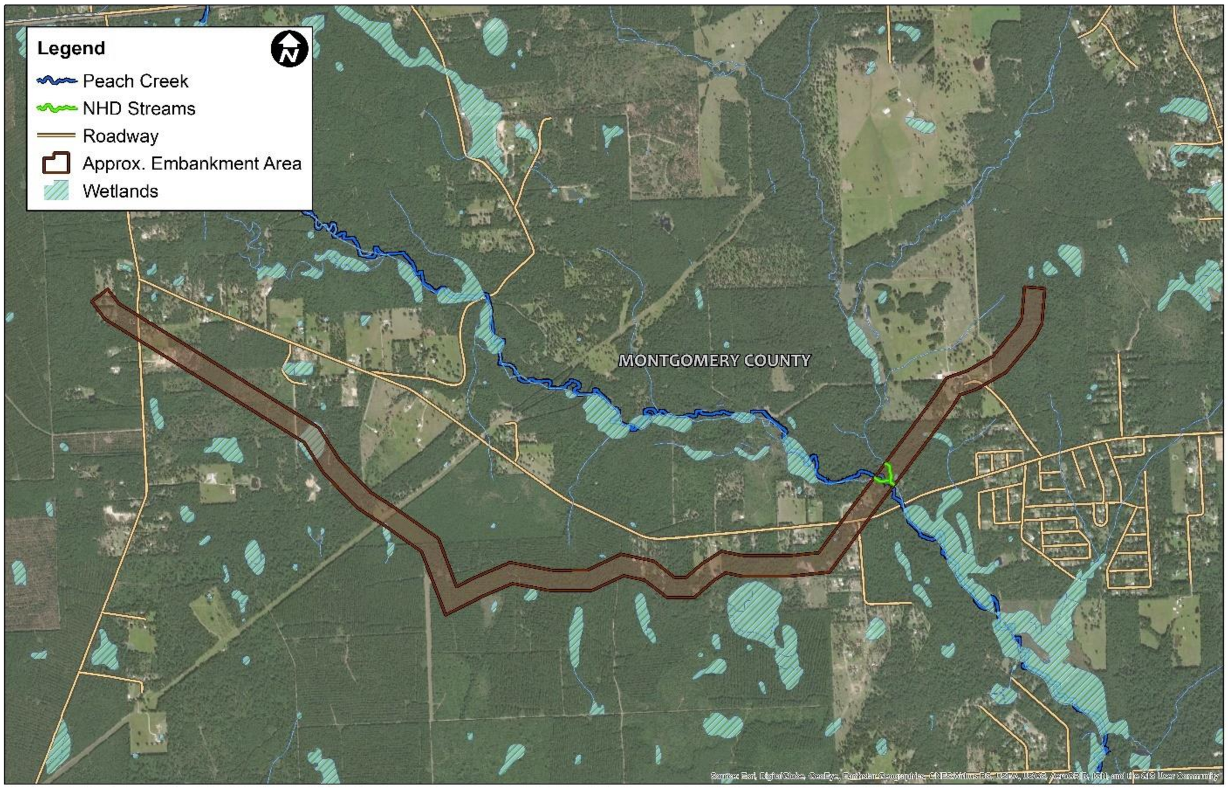

Figure 50: Peach Creek Detention at SH 105 Dam Embankment Maximum Footprint

5.3.1.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $2,150,000.

5.3.1.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 78**. The approximate costs range from $356M to $433M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.19 to 0.23.

Table 78: Estimated Cost and Benefit-Cost Ratio (BCR)—SH 105 Detention on Peach Creek

Item	Cost
Construction	$214 M
Design	$26 M
Environmental	$7 M
Right-of-Way	$110 M - $187 M
TOTAL	**$356 M - $433 M**
BCR:	**0.19 - 0.23**
20-Year Escalation	**$540 M - $657 M**

5.3.1.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.3.2 Walker Detention

5.3.2.1 Description/Specifications

The majority of damage centers in the Peach Creek watershed are located in the northern half of the watershed. The Peach Creek Detention Basin at Walker Branch is one of two detention area that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on the main stem of Peach Creek, north of SH 105 and 9 miles northwest of Cleveland, Texas. The basin is at the approximate midpoint of the Peach Creek watershed and captures flow from a drainage area of approximately 47.8 square miles. The location of the propose detention shown in **Figure 51**.

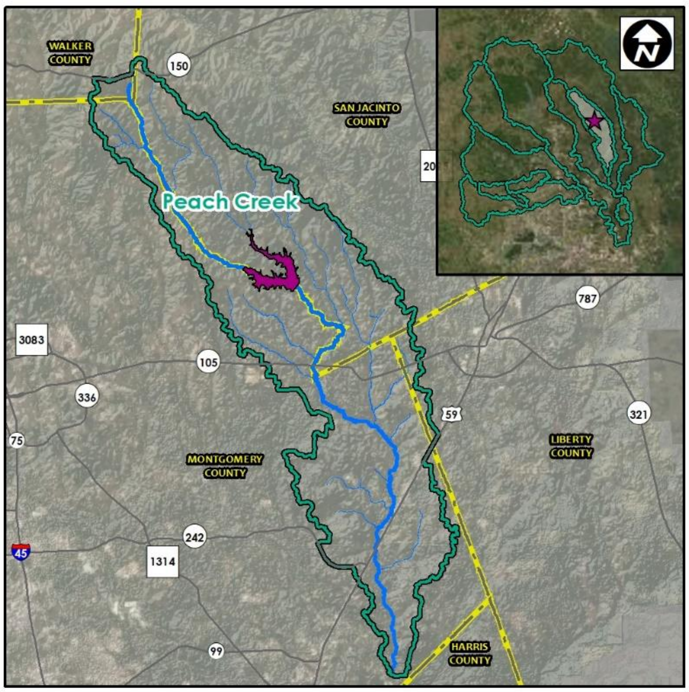

Figure 51: Peach Creek Detention at Walker Branch

Several sites within the watershed were initially screened as potential detention locations. The site at Walker Branch provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Peach Creek watershed by constructing a 3.2-mile-long earthen impoundment that captures runoff from Peach Creek and Boggy Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 51-foot high concrete dam with a primary outfall consisting of 3-12’ x 12’ RCB and a secondary spillway approximately 500’ in length. The impoundment will require over 4.7 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,235 acres below the 1% ACE water surface elevation, which includes Peach Creek and its tributaries. The basin will provide approximately 36,000 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.3.2.2 H&H Considerations

The Peach Creek Detention at Walker Branch was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. Storage areas were added to the sides of overtopped cross sections and adjoining tributaries to model volume outside the existing modeled cross sections. The dam was modeled as an inline structure with 3 – 12’ x 12’ low flow culverts. The 500’ spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

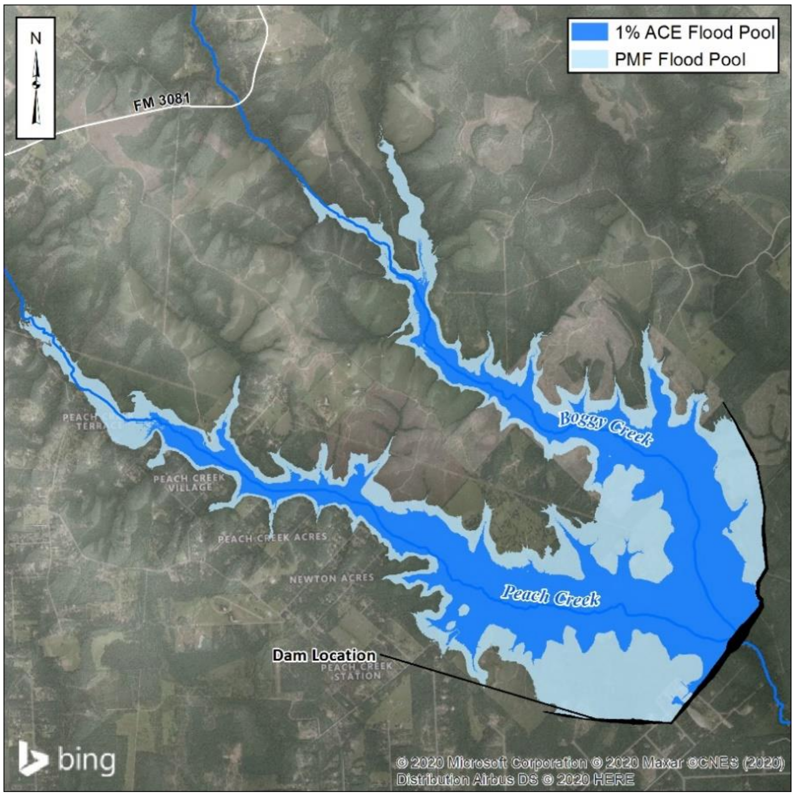

Figure 52: Walker Branch Detention Detail

Table 79 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 79: Peach Creek at Walker Branch H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	3,418	3,411	1,768	183.4
20% ACE	5,934	5,633	2,866	188.0
10% ACE	8,471	7,205	4,077	192.0
4% ACE	12,360	8,944	6,193	197.2
2% ACE	15,662	10,039	8,186	201.0
1% ACE	19,132	11,013	10,527	204.9
0.2% ACE	21,285	25,135	14,234	209.7

The detention basin will provide a reduction in water surface elevations and flows along Peach Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.73 feet between the dam and I-69. Downstream of I-69, the water surface elevation is reduced by 1.18 feet on average.

5.3.2.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 28,000 cfs to the existing 10% ACE of 11,000 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 30.5 miles downstream of the detention facility with a maximum water surface reduction of 6.99 feet just downstream of the dam.

By reducing the flows downstream, the basin removes 261 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,073. Most of the benefits would be realized in the Woodbranch, Patton Village, and Splendora areas. The net present value of benefits based on a 50-year project life within the watershed is approximately $56.3 M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 80: Walker Detention Benefits Summary ($M)

Watershed	Benefits ($M)			
	Harris County	Montgomery County	San Jacinto County	Total
Peach	0.0	49.3	1.3	**50.7**
Caney	2.3	3.3	0.0	**5.6**
Total	**2.3**	**52.6**	**1.3**	**56.3**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 81**.

Table 81: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Tanyard Road	-0.12	<50% ACE	No Change
Browder Taylor Road	0.00	<50% ACE	No Change
SH 105	4.76	4% ACE	1% ACE
Old TX 105	3.65	<50% ACE	No Change
Faulkner Road	3.85	<50% ACE	No Change
Morgan Cemetery Road	2.38	<50% ACE	No Change
FM 2090	2.04	50% ACE	No Change
I 69	2.09	20% ACE	10% ACE
Woodbranch Drive	1.89	50% ACE	No Change
Roman Forrest Road	1.56	<50% ACE	No Change
FM 1485	0.64	20% ACE	No Change

The proposed detention facility also provides regional benefit outside the Peach Creek watershed. The model shows a reduction in WSEL at the confluence with Caney Creek of 0.7. However, the project does not show any direct benefit at the confluence between Caney Creek and East Fork.

5.3.2.4 Real Estate

42 parcels would need to be acquired for a total of 1,801 acres if purchased below the 1% ACE water surface elevation. 60 parcels would need to be acquired for a total of 3,435 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.3.2.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 1.1 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 82**.

Table 82: Peach Creek Detention at Walker Branch Potential Relocation Summary

Relocation Type	Name	Owner	Length (miles)	Notes
Roadway	Holstein Dr	Montgomery County	0.58	2-lane asphalt road
Roadway	Hereford Way	Montgomery County	0.09	2-lane asphalt road
Roadway	Walker Dr	Montgomery County	0.46	2-lane gravel road
Utility	30-inch Y-Grade NGL	Enterprise Products Operating LLC	0.09	

5.3.2.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 9 acres of potential wetlands within the footprint of the proposed dam and a potential 1,365 linear feet of NHD streams. The affected streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

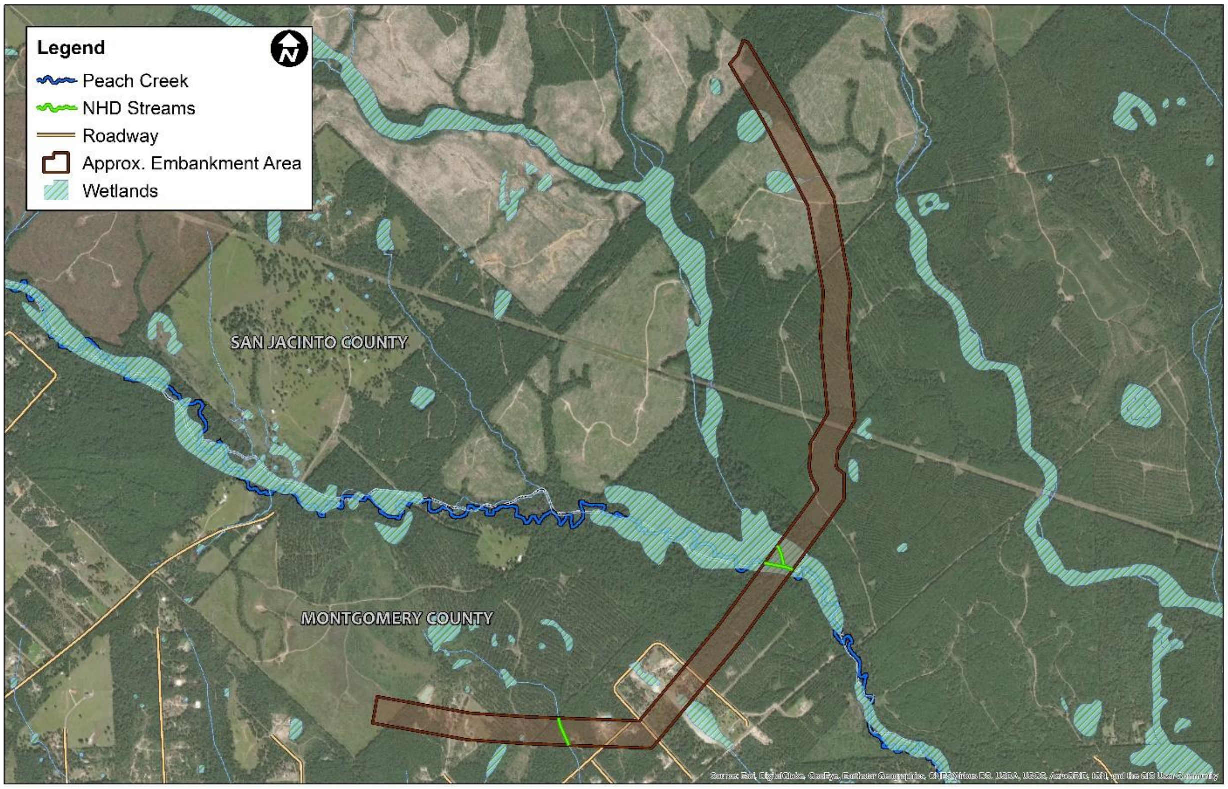

Figure 53: Peach Creek Detention at Walker Dam Embankment Maximum Footprint

5.3.2.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $1,600,000.

5.3.2.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 83**. The approximate costs range from $201M to $218M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.26 to 0.28.

Table 83: Estimated Cost and Benefit-Cost Ratio (BCR)—Walker Branch Detention on Peach Creek

Item	Cost
Construction	$160 M
Design	$19 M
Environmental	$9 M
Right-of-Way	$13 M - $30 M
TOTAL	**$201 M - $218 M**
BCR:	**0.26 – 0.28**
20-Year Escalation	**$305 M - $331 M**

5.3.2.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- San Jacinto County – The project is located within San Jacinto and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- TxDOT – The proposed project improves the level of service for one TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.3.3 I-69 Channelization

5.3.3.1 Description/Specifications

The majority of damage centers in the Peach Creek watershed are located in the southern half of the watershed. The Peach Creek channelization is one of the options explored in the upper watershed to reduce flood risk downstream. The proposed channelization is located on the main stem of Peach Creek, south of I-69 and 9.3 miles south of Cleveland, Texas. The channelization is at the approximate lower portion of the Peach Creek watershed. The location of the propose detention shown in **Figure 54**.

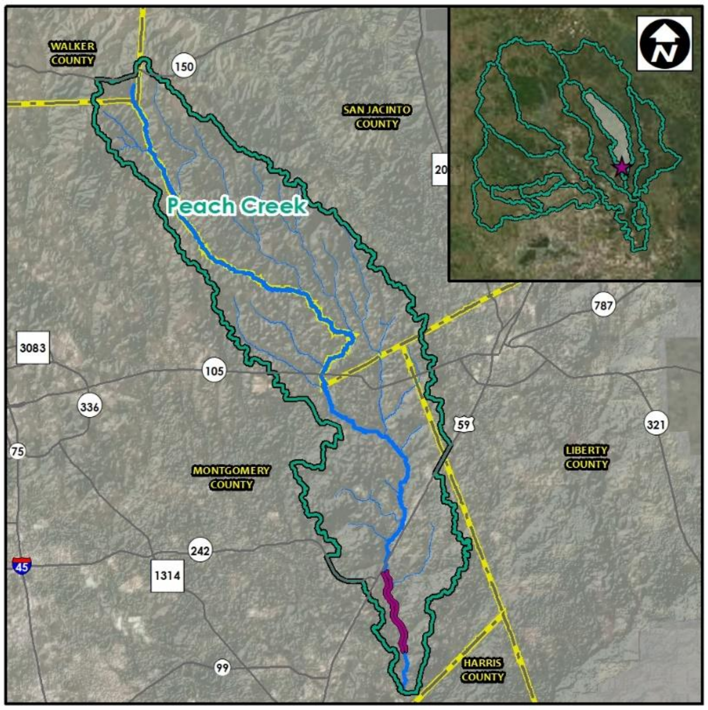

Figure 54: Peach Creek Channelization Downstream of I-69

Several sites within the watershed were initially screened as potential channel improvement locations. The site from I-69 to FM 1485 was chosen based on several factors, including its ability to reduce water surface elevations downstream of I-69 to the confluence with Caney Creek.

The goal of the channel improvement is to reduce flooding in the Peach Creek watershed by widening a 4.3-mile-long stretch to increase conveyance capacity of Peach Creek in order to lower the water surface elevation. The improvements are planned to widen Peach Creek to 800 feet starting 4 feet above the natural stream bed. It will require over 7 million cubic yards of excavation over a surface area of 417 acres.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 800 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing either of the recommended detention alternatives on Peach Creek. Refer to **Appendix H** for details.

5.3.3.2 H&H Considerations

The Peach Creek channelization downstream of I-69 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The existing cross sections were improved with the channel modification option. The cross sections located between I-69 and FM 1285 were modified by making the channel wider. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

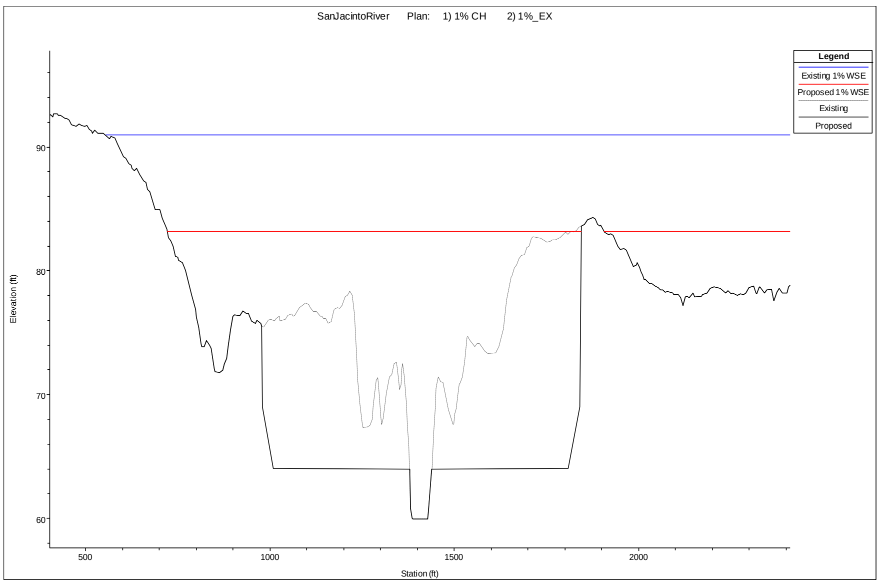

Figure 55: Cross Section Example of Channelization on Peach Creek

The proposed improvements will provide a reduction in water surface elevations along Peach Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 6.1 feet between I-69 and FM 1485.

5.3.3.3 Project Benefits

The channel improvement reduces the 1% ACE existing conditions water surface elevation to the existing 4% ACE. It reduces the 1% ACE water surface elevation by at least 0.5-feet for 6.2 miles along Peach Creek with a maximum water surface reduction of 10.4 feet at the downstream side of I-69.

By increasing channel capacity, the improvements remove 383 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,880. Most of the benefits would be realized in the Woodbranch, Patton Village, and Roman Forest. The net present value of benefits based on a 50-year project life within the watershed is approximately $73.6M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 84: I-69 Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Peach	0.0	72.1	**72.1**
Caney	-0.2	1.7	**1.5**
Total	**-0.2**	**73.8**	**73.6**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 85**.

Table 85: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Tanyard Road	-0.12	<50% ACE	No Change
Browder Taylor Road	0.00	<50% ACE	No Change
SH 105	0.04	4% ACE	No Change
Old TX 105	-0.01	<50% ACE	No Change
Faulkner Road	-0.01	<50% ACE	No Change
Morgan Cemetery Road	-0.01	<50% ACE	No Change
FM 2090	0.14	50% ACE	No Change
I 69	7.19	20% ACE	2% ACE
Woodbranch Drive	6.24	50% ACE	10% ACE
Roman Forrest Road	6.25	<50% ACE	20% ACE
FM 1485	-0.31	20% ACE	No Change

The proposed channelization also provides regional benefit outside the Peach Creek watershed. The model shows a reduction in WSEL at the confluence with Caney Creek of 0.12 feet, at the East Fork of 0.11 feet, and a reduction of 0.09 feet at the confluence with West Fork.

5.3.3.4 Real Estate

286 parcels would need to be acquired for a total of 506 acres if purchased below the 1% ACE water surface elevation. All parcels required are currently private property.

5.3.3.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 1.9 miles of roadways are located within the preliminary channelization area and may need removal, relocation, or raising. Additional buried utilities could potentially be within the channel improvement; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 86**.

Table 86: Peach Creek at I-69 Channelization Potential Relocation Summary

Relocation Type	Name	Owner	Length (miles)	Notes
Roadway	1485	Montgomery County	0.18	2-lane asphalt road
Roadway	Almarie Rd	Montgomery County	0.13	2-lane asphalt road
Roadway	Athens Dr	Montgomery County	0.00	2-lane asphalt road
Roadway	Chariot Ln	Montgomery County	0.03	2-lane asphalt road
Roadway	Creekside	Montgomery County	0.09	2-lane asphalt road
Roadway	Hunters Trl	Montgomery County	0.24	2-lane asphalt road
Roadway	Lantern	Montgomery County	0.003	2-lane asphalt road
Roadway	Magnolia	Montgomery County	0.01	2-lane asphalt road
Roadway	Maple	Montgomery County	0.09	2-lane asphalt road
Roadway	Marrella	Montgomery County	0.03	2-lane asphalt road
Roadway	Oak Hills Dr	Montgomery County	0.01	2-lane asphalt road
Roadway	Park Ln	Montgomery County	0.03	2-lane asphalt road
Roadway	Peach Creek Dr	Montgomery County	0.39	2-lane asphalt road
Roadway	Pine Dr	Montgomery County	0.11	2-lane asphalt road
Roadway	Roman Forest	Montgomery County	0.21	2-lane asphalt road
Roadway	Woodbranch Dr	Montgomery County	0.16	2-lane asphalt road
Utility	24-inch Gas Pipeline	Trunkline Gas Company, Llc	0.01	
Utility	30-inch Gas Pipeline	Natural Gas P/L Co Of Amer Llc	0.18	
Utility	30-inch Gas Pipeline	Natural Gas P/L Co Of Amer Llc	1.56	

5.3.3.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 28.4 acres of potential wetlands within the footprint of the proposed channelization. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

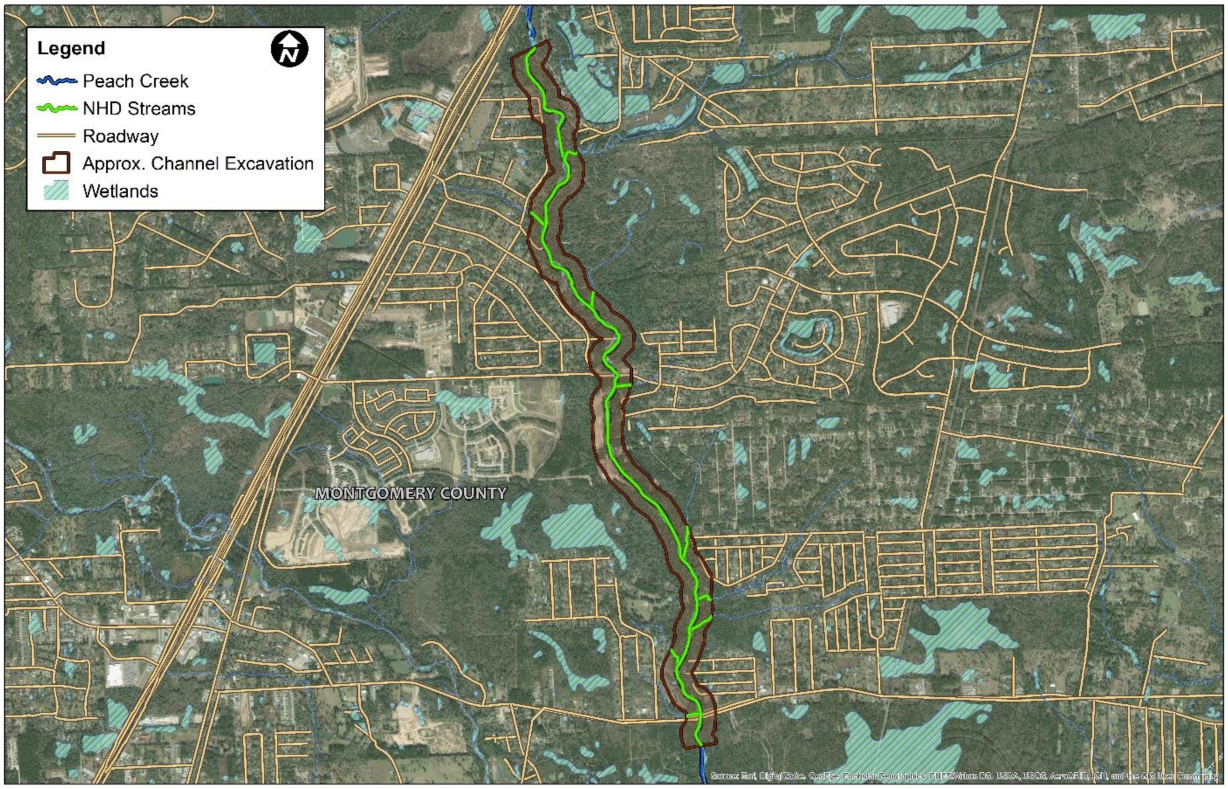

Figure 56: Peach Creek Channelization at I-69 Excavation Maximum Footprint

5.3.3.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the channel improvements are estimated at $650,000.

5.3.3.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 87**. The approximate cost for channelization is $159M. The BCR for the project based on the calculated benefits is 0.46.

Table 87: Estimated Cost and Benefit-Cost Ratio (BCR)—I-69 Channelization on Peach Creek

Item	Cost
Construction	$129 M
Design	$15 M
Environmental	$7 M
Right-of-Way	$8 M
TOTAL	**$159 M**
BCR:	**0.46**
20-Year Escalation	**$241 M**

5.3.3.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.3.4 Peach Creek Recommendation

5.3.4.1 Description/Specifications

Of the three alternatives for the Peach Creek watershed analyzed in this study, the following combination of dams and channel improvement options are recommended for Peach Creek. The section that describes each individual alternative in detail is also listed.

- SH 105 Dam – Section 5.3.1
- Walker Dam – Section 5.3.2
- I-69 Channelization – Section 5.3.3

The location of the proposed dams and extents of the channel improvements is shown in **Figure 57**.

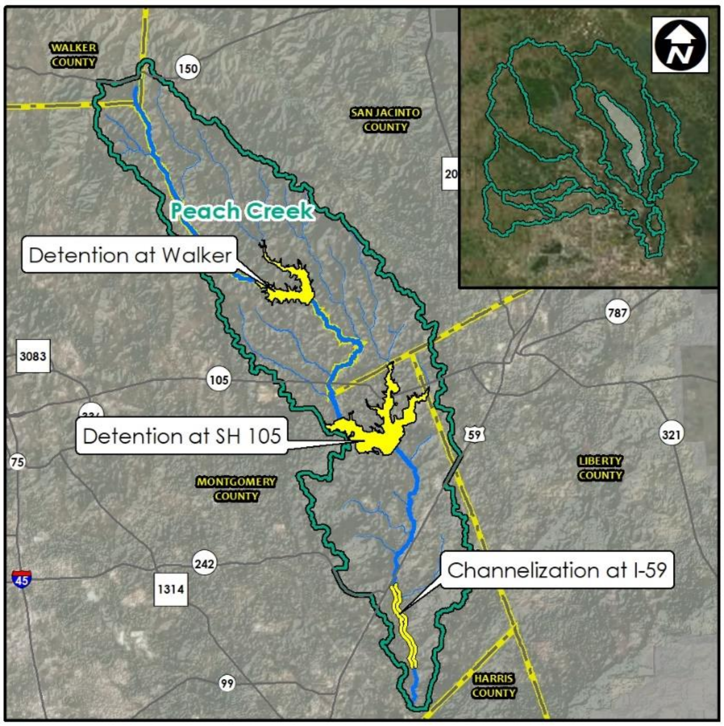

Figure 57: Peach Creek Recommended Alternatives

Each alternative was chosen based on several factors, including but not limited to, its ability to reduce water surface elevations in damage centers, availability of land for construction, and its benefit-cost ratio.

The goal of the recommended alternatives is to reduce flooding in the Peach Creek watershed by combining the benefits of two proposed dams on Peach Creek with one region of channel improvement on the Peach Creek mainstem. While any combination of alternatives will be less efficient in reducing flood risk when compared to an individual alternative, this combination of alternatives performs well and provides significant benefit to the Peach Creek watershed.

5.3.4.2 H&H Considerations

A summary of the proposed dam and channel improvement alternatives is shown in **Table 88** and **Table 89** respectively. The channel improvement option as well as the two dam options were modeled in HEC-RAS. Flow data from the existing conditions HEC-HMS model was combined with the proposed HEC-RAS geometry to arrive at a comprehensive model for the Peach Creek watershed.

Table 88: 1% ACE Summary Dams

Alternative	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
SH 105 Dam	21,603	17,051	14,734	139.8
Walker Dam	19,128	11,014	10,532	204.9

Table 89: Channel Improvement Summary

Alternative	Location	Improvement Length (mi)	Bench Width (ft)	Bench Height (ft)
I-69 Channelization	I-69 to FM 1485	4.3	800	16

The combination of detention basins with region of channel improvement provides significant reduction in water surface elevations and flows along Peach Creek, with increased reductions through the regions of channel improvement. The average reduction in water surface elevation along Peach Creek is summarized in **Table 90**.

Table 90: Average Reduction in Water Surface Elevation – Peach Creek

Location	Frequency Event			
	10% ACE	2% ACE	1% ACE	0.2% ACE
SH 105 – Old TX 105	1.5	3.0	3.7	3.5
Morgan Cemetery Rd – FM 2090	1.8	4.3	5.6	5.8
FM 2090 – FM 1485	6.7	8.1	8.7	8.7

5.3.4.3 Project Benefits

The combination of alternatives reduces the 1% ACE existing conditions water surface elevations to elevations between the existing conditions 4% ACE and 10% ACE in regions outside of the proposed channel improvements. Within the extents of the channel improvements the existing 1% ACE water surface elevations are reduced to approximately 20% ACE water surface elevations.

By reducing flows along Peach Creek and increasing channel capacity in one area, the proposed improvements remove 874 structures from the 1% ACE floodplain and provide a potential reduction in flooding instances of 3,170. Benefits are realized on the majority of Peach Creek downstream of the SH 105 Dam, and the benefits extend to the confluence with Caney Creek. The net present value of benefits based on a 50-year project life within the watershed is approximately $134.3 M. The distribution of these benefits along Peach Creek and the downstream end of Caney Creek is shown in **Figure 58**. The proposed improvements also provide some benefits along the East Fork and West Fork that are not shown in this figure. The average water surface elevation reduction is approximately 1.21' in the 1% ACE event from I-69 to the East Fork confluence.

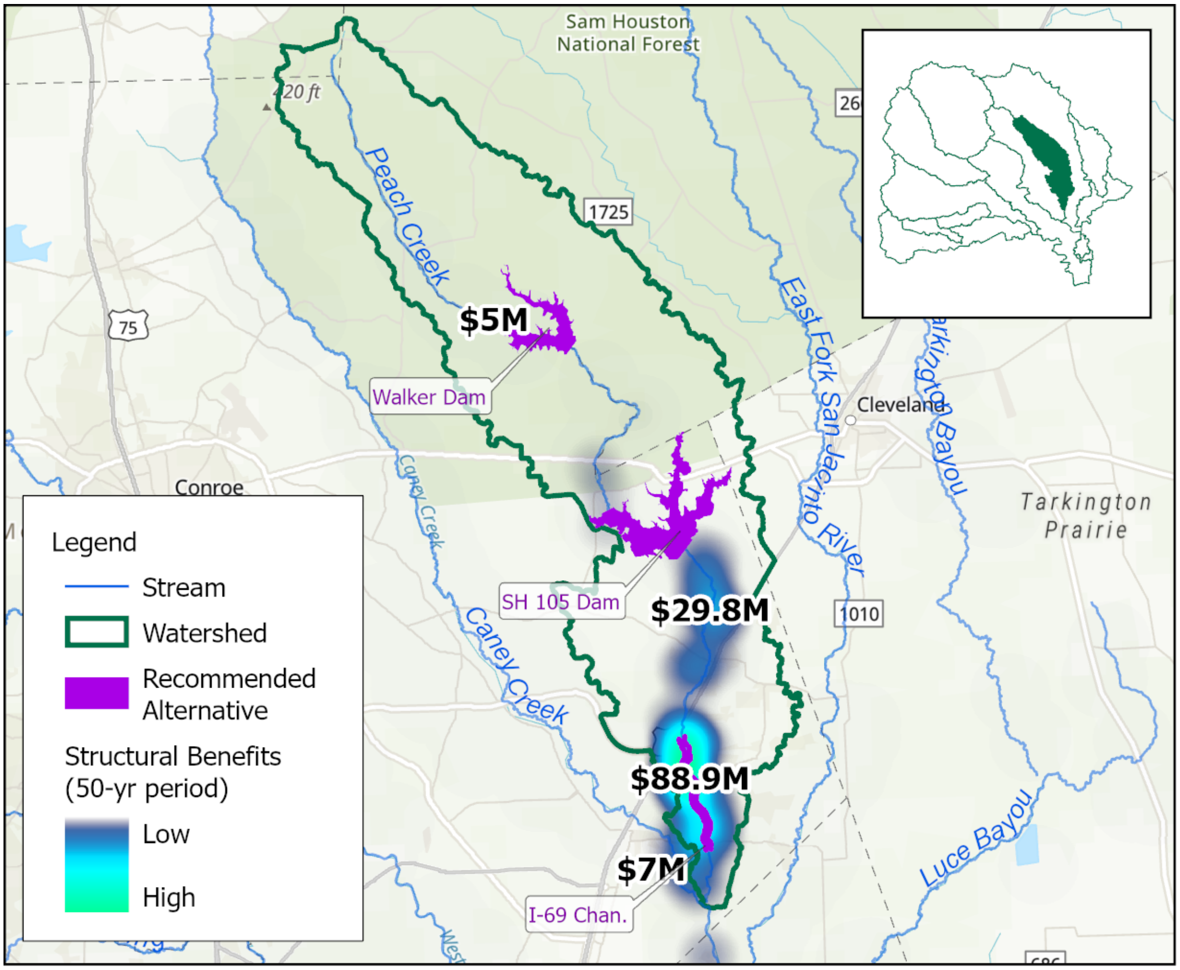

Figure 58: Peach Creek Overall Benefits

5.3.4.4 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 91**. The approximate costs range from $718 M to $812 M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.24 to 0.27.

Table 91: Peach Creek Combined Alternatives Estimated Cost and BCR

Item	SH 105 Dam	Walker Dam	I-69 Channel	Overall
Construction	$213 M	$160 M	$129 M	$502 M
Design	$26 M	$19 M	$15 M	$60 M
Environmental	$7 M	$9 M	$7 M	$23 M
Right-of-Way	$110 – 187 M	$13 – 30 M	$8 M	$131 – 225 M
TOTAL COST	**$356 - $433 M**	**$201 M - $218 M**	**$159 M**	**$716 – $810 M**
TOTAL BENEFIT	**$81.5 M**	**$56.3 M**	**$73.6 M**	**$134.3 M**
BCR:	**0.19 – 0.23**	**0.26 – 0.28**	**0.46**	**0.17 – 0.19**
20-Year Escalation	**$540 M - $657 M**	**$305 M - $331 M**	**$241 M**	**$1.09 B - $1.2 B**

5.4 Caney Creek

Three mitigation alternatives were explored on the Caney Creek watershed. The alternatives included two inline detention facilities along Caney Creek and once channelization project on the downstream end of the watershed. The alternatives targeted reducing flooding instances primarily in Caney Creek with some reductions downstream.

5.4.1 FM 1097 Detention

5.4.1.1 Description/Specifications

The majority of damage centers in the Caney Creek watershed are located in the southern half of the watershed. The Caney Creek Detention Basin at FM 1097 is one of two detention area that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on the main stem of Caney Creek, upstream of FM 1097 and 2.9 miles north-east of Willis, Texas. The basin is at the approximate top fifth of the Caney Creek watershed and captures flow from a drainage area of approximately 48.5 square miles. The location of the propose detention shown in **Figure 59.**

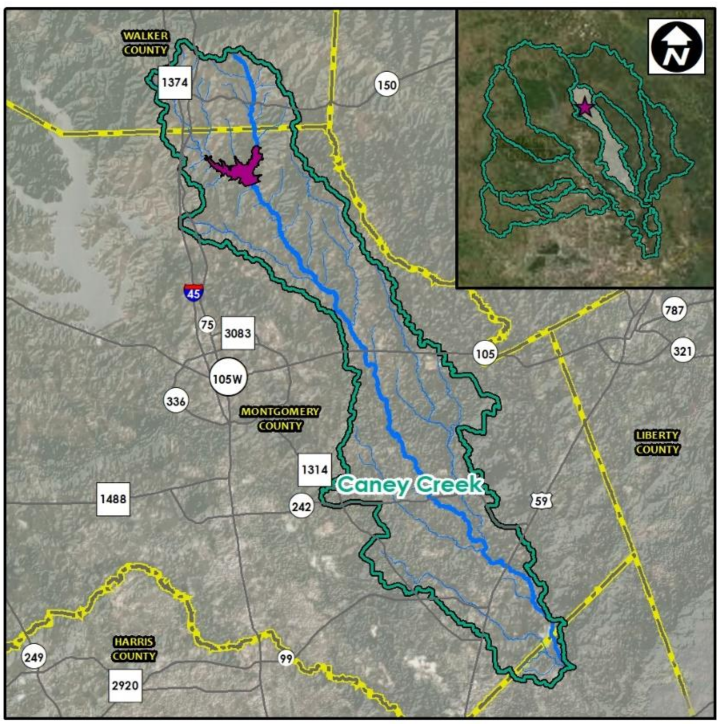

Figure 59: Caney Creek Detention at FM 1097

Several sites within the watershed were initially screened as potential detention locations. The site at FM 1097 was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Caney Creek watershed by constructing a 1.2-mile-long earthen impoundment that captures runoff from Caney Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 53-foot high concrete dam with a primary outfall consisting of 5-10' x 10' RCB and a secondary spillway approximately 500' in length. The impoundment will require over 1.49 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,514 acres below the 1% ACE water surface elevation, which includes Caney Creek and the its tributaries. The basin will provide approximately 13,900 acre-feet of storage capacity below the 1% AEC water surface elevation.

5.4.1.2 H&H Considerations

The Caney Creek Detention at FM 1097 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The dam was modeled as an inline structure with 5 – 10' x 10' low flow culverts modeled as gates. The 500' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

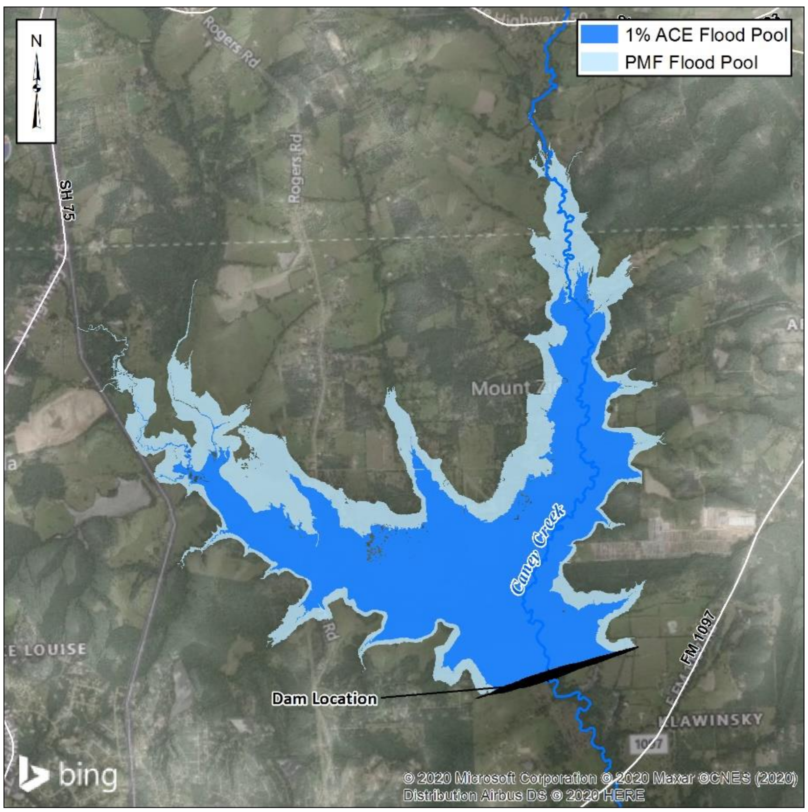

Figure 60: FM 1097 Detention Detail

Table 92 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 92: Caney Creek at FM 1097 H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	4,800	4,600	300	238.43
20% ACE	9,800	7,900	1,200	243.31
10% ACE	14,400	10,400	2,600	246.95
4% ACE	22,000	12,300	5,700	252.01
2% ACE	28,600	13,100	9,300	255.78
1% ACE	35,900	13,800	13,900	259.37
0.2% ACE	55,700	27,300	22,700	264.48

The detention basin will provide a reduction in water surface elevations and flows along Caney Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 2.6 feet between SH 105 and I-69. Downstream of I-69, the average reduction is approximately 0.8 feet.

5.4.1.3 Project Benefits

The detention facility reduces the 1% ACE (1% ACE) existing conditions flows of 31,200 cfs to less than the existing 4% ACE (4% ACE) of 13,800 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 40.0 miles downstream of the detention facility with a maximum water surface reduction of 5.65 feet between the detention facility and FM 1097.

By reducing the flows downstream, the basin removes 285 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 783. Most of the benefits would be realized in the neighborhoods around SH 242 and FM 1484, and New Caney upstream of I-69. The net present value of benefits based on a 50-year project life within the watershed is approximately $27.7M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 93: FM 1097 Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
Peach	0.0	1.0	**1.0**
Caney	0.6	26.1	**26.7**
Total	**0.6**	**27.1**	**27.7**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 94.**

Table 94: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
SH150	0.00	10% ACE	No Change
Bilnoski Road	0.39	<50% ACE	No Change
FM 1097	5.43	20% ACE	4% ACE
County Line Road	4.84	<50% ACE	No Change
Royal Bridge	4.95	<50% ACE	No Change
FM 1494	3.61	10% ACE	4% ACE
Millimac Road	2.67	<50% ACE	No Change
SH 105	2.76	2% ACE	1% ACE
Timber Rock Railroad	1.71	10% ACE	4% ACE
FM 2090	1.77	20% ACE	No Change
Hwy 242	1.25	10% ACE	No Change
Firetower Rd	0.96	50% ACE	No Change
Sycamore Lane	1.09	50% ACE	No Change
Hwy 59/I 69	1.54	2% ACE	1% ACE
Loop 494	1.39	2% ACE	No Change
Railroad	1.24	2% ACE	No Change
FM 1485	0.35	20% ACE	No Change

The proposed detention facility also provides regional benefit outside the Caney Creek watershed. The model shows a reduction in WSEL at the confluence with East Fork of the San Jacinto River of 0.19 feet. However, the project does not show any direct benefit downstream of the East Fork in Lake Houston with reductions of less than one inch.

5.4.1.4 Real Estate

95 parcels would need to be acquired for a total of 2,479 acres if purchased below the 1% ACE water surface elevation. 182 parcels would need to be acquired for a total of 5,480 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.4.1.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 4.1 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 95**.

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Table 95: Caney Creek Detention at FM 1097 Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Roadway	SH 75	TxDOT	0.00	2-lane asphalt road
Roadway	Dutch Rd (CR 1538)	Montgomery County	0.21	2-lane gravel road
Roadway	McCray Ln (CR 1547)	Montgomery County	0.20	2-lane gravel road
Roadway	Fieldstone Rd (CR 3802)	Montgomery County	0.06	2-lane gravel road
Roadway	Mt. Zion Rd (CR 3811 and CR 3810)	Montgomery County	0.69	2-lane asphalt road
Roadway	N Clark (CR 3812)	Montgomery County	0.45	2-lane gravel road
Roadway	Mt. Zion Acres (CR 3813)	Montgomery County	0.52	2-lane asphalt road
Roadway	Bradi Way (CR 3814)	Montgomery County	0.13	2-lane asphalt road
Roadway	Leo Cir (CR 3815)	Montgomery County	0.13	2-lane asphalt road
Roadway	Rodgers Rd (CR 3816)	Montgomery County	1.20	2-lane asphalt road
Roadway	Mize Rd (CR 5836)	Montgomery County	0.16	2-lane gravel road
Roadway	Freeman Rd (CR 5837)	Montgomery County	0.34	2-lane gravel road

5.4.1.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 1.2 acres of potential wetlands within the footprint of the proposed dam and a potential 1,291 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

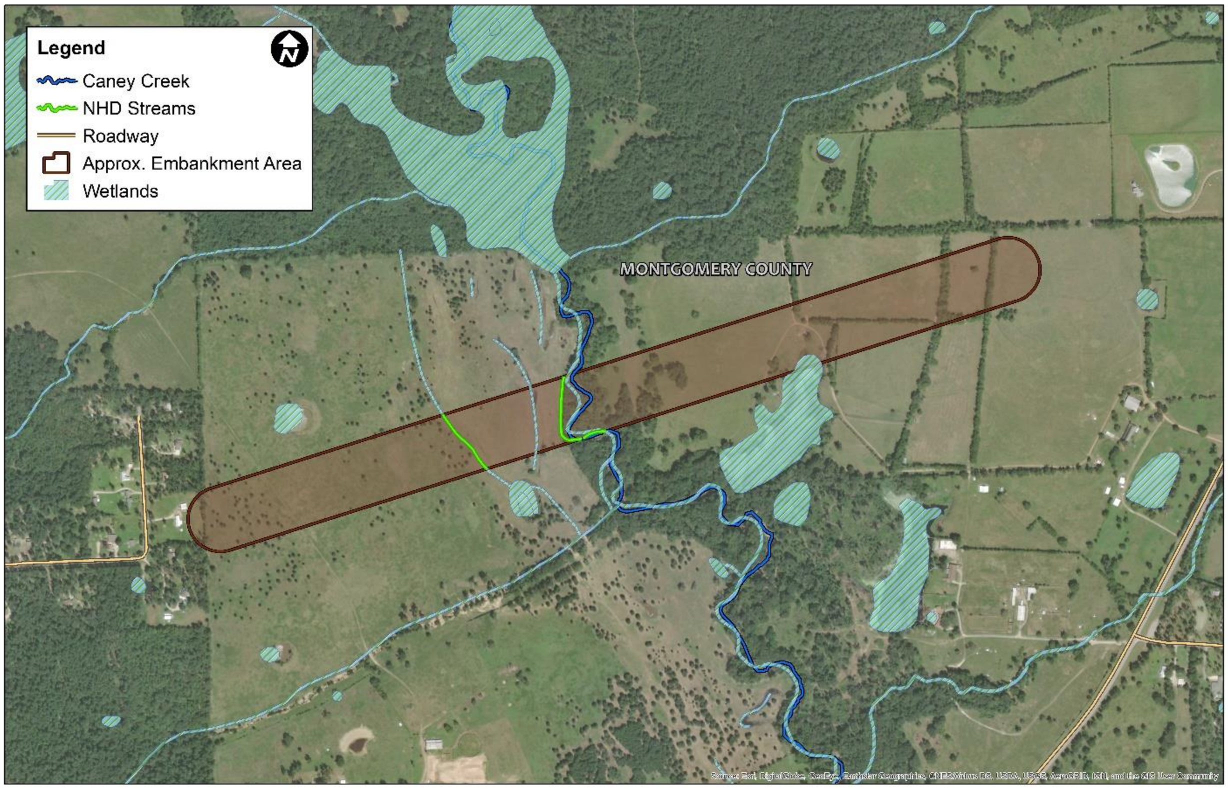

Figure 61. Caney Creek at FM 1097 Dam Embankment Maximum Footprint

5.4.1.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $1,100,000.

5.4.1.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 96**. The approximate costs range from $105M to $131M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.21 to 0.26.

Table 96: Estimated Cost and Benefit-Cost Ratio (BCR)—FM 1097 Detention on Peach Creek

Item	Cost
Construction	$65 M
Design	$8 M
Environmental	$8 M
Right-of-Way	$24 M - $50 M
TOTAL	**$105 M - $131 M**
BCR:	**0.21 – 0.26**
20-Year Escalation	**$159 M- $199 M**

5.4.1.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for three TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.4.2 SH 105 Detention

5.4.2.1 Description/Specifications

The majority of damage centers in the Caney Creek watershed are located in the southern half of the watershed. The Caney Creek Detention Basin at SH105 is one of two detention area that were explored in the upper watershed to reduce flood risk downstream. The proposed detention basin is located on the main stem of Caney Creek, north of SH 105 and 4.5 miles east of Conroe, Texas. The basin is upstream of the approximate midpoint of the Caney Creek watershed and captures flow from a drainage area of approximately 92.2 square miles. The location of the propose detention shown in **Figure 62**.

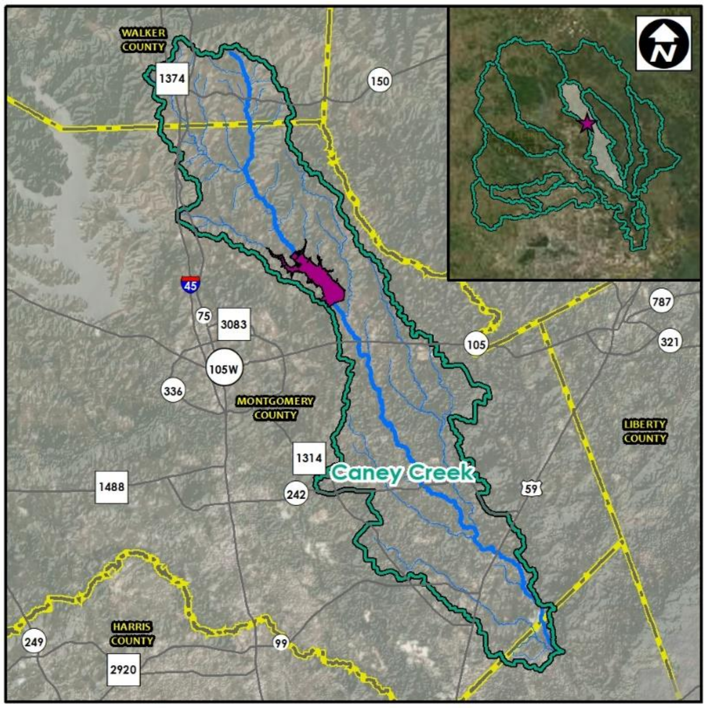

Figure 62: Caney Creek Detention at SH 105

Several sites within the watershed were initially screened as potential detention locations. The site at SH 105 was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and the steeper terrain allowed for necessary volume within a smaller footprint which minimizes ROW acquisition.

The goal of the detention pond is to reduce flooding in the Caney Creek watershed by constructing a 0.8-mile-long earthen impoundment that captures runoff from Caney Creek. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 62-foot high concrete dam with a primary outfall consisting of 5-8’ x 8’ RCB, 1-10’x10’ RCB, and a secondary spillway approximately 400’ in length. The impoundment will require over 1.2 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 1,502 acres below the 1% ACE water surface elevation, which includes Caney Creek and its tributaries. The basin will provide approximately 28,090 acre-feet of storage capacity below the 1% AEC water surface elevation.

5.4.2.2 H&H Considerations

The Caney Creek Detention at SH 105 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The dam was modeled as an inline structure with – 8' x 8' and 1-10'x10' low flow culverts modeled as gates. The 400' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, over the dam.

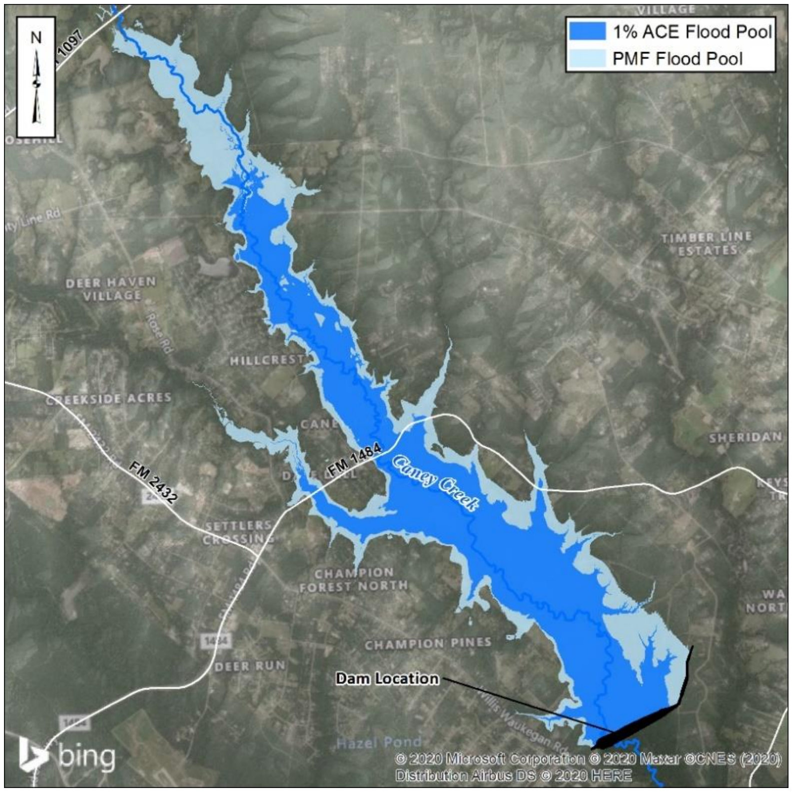

Figure 63: SH 105 Detention Detail

Table 97 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 97: Caney Creek at SH 105 H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	4,300	4,300	550	182.97
20% ACE	7,900	7,600	2,000	188.86
10% ACE	12,200	9,200	5,700	196.02
4% ACE	19,100	10,800	13,300	204.71
2% ACE	25,500	11,800	21,000	210.51
1% ACE	31,900	12,600	30,500	215.89
0.2% ACE	51,900	34,700	46,500	222.13

The detention basin will provide a reduction in water surface elevations and flows along Caney Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.5 feet between SH 105 and I-69. Downstream of I-69, the average reduction is about 1.0 feet.

5.4.2.3 Project Benefits

The detention facility reduces the 1% ACE (1% ACE) existing conditions flows of 31,900 cfs to less than the existing 4% ACE (4% ACE) of 19,100 cfs downstream of the dam. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 31.5 miles downstream of the detention facility with a maximum water surface reduction of 6.9 feet between the dam and SH 105.

By reducing the flows downstream, the basin removes 658 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,596. Most of the benefits would be realized in the neighborhoods around SH 242 and New Caney upstream of I-69. The net present value of benefits based on a 50-year project life within the watershed is approximately $55.2M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 98: SH 105 Detention Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	2.4	0.1	**2.4**
Peach	0.0	2.3	**2.3**
Caney	1.5	49.0	**50.4**
Total	**3.8**	**51.4**	**55.2**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 99**.

Table 99: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
SH150	0	10% ACE	No Change
Bilnoski Road	0	<50% ACE	No Change
FM 1097	0	20% ACE	No Change
County Line Road	0	<50% ACE	No Change
Royal Bridge	0	<50% ACE	No Change
FM 1494	-3.2	10% ACE	No Change
Millimac Road	6.13	<50% ACE	No Change
SH 105	6.09	2% ACE	1% ACE
Timber Rock Railroad	4.97	10% ACE	1% ACE
FM 2090	4.04	20% ACE	No Change
Hwy 242	2.38	10% ACE	4% ACE
Firetower Rd	2.26	50% ACE	No Change
Sycamore Lane	2.62	50% ACE	No Change
Hwy 59/I 69	3.24	2% ACE	1% ACE
Loop 494	2.91	2% ACE	1% ACE
Railroad	2.67	2% ACE	1% ACE
FM 1485	0.67	20% ACE	No Change

The proposed detention facility also provides regional benefit outside the Caney Creek watershed. The model shows a reduction in WSEL at the confluence with Peach Creek of 0.70 feet. However, the project does not show any direct benefit downstream of the East Fork in Lake Houston with reductions of less than one inch.

5.4.2.4 Real Estate

227 parcels would need to be acquired for a total of 3,086 acres if purchased below the 1% ACE water surface elevation. 402 parcels would need to be acquired for a total of 4,136 acres if purchased below the PMF elevation. All parcels required are currently private property.

5.4.2.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 3.1 miles of roadways are located within the preliminary PMF elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 100.**

Table 100: Caney Creek Detention at SH 105 Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	16-inch Natural Gas Pipeline	Kinder Morgan	0.50	
Roadway	FM 1484	TxDOT	0.23	2-lane asphalt road
Roadway	Rose Rd (CR 3865)	County	0.04	2-lane asphalt road
Roadway	CR 3924	County	0.08	2-lane asphalt road
Roadway	Forest Glen (CR 3927)	County	0.14	2-lane asphalt road
Roadway	Woodview (CR 3928)	County	0.10	2-lane asphalt road
Roadway	Parkwood Dr (CR 3929)	County	0.15	2-lane asphalt road
Roadway	White Oak (CR 3930)	County	0.11	2-lane asphalt road
Roadway	Champion Village Dr (CR 3933)	County	0.00	2-lane asphalt road
Roadway	Champion Village Rd (CR 3934)	County	0.21	2-lane asphalt road
Roadway	Champion Forest Loop (CR 3936)	County	0.19	2-lane asphalt road
Roadway	Nicholson Rd (CR 3937)	County	0.15	2-lane asphalt road
Roadway	Sandal Wood (CR 3938)	County	0.30	2-lane asphalt road
Roadway	Lakeside (CR 3969)	County	0.25	2-lane asphalt road
Roadway	Landry Ln (CR 6096)	County	0.21	2-lane asphalt road
Roadway	McRae Cir (CR 6359)	County	0.12	2-lane gravel road

5.4.2.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 4.4 acres of potential wetlands within the footprint of the proposed dam and a potential 1,058 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

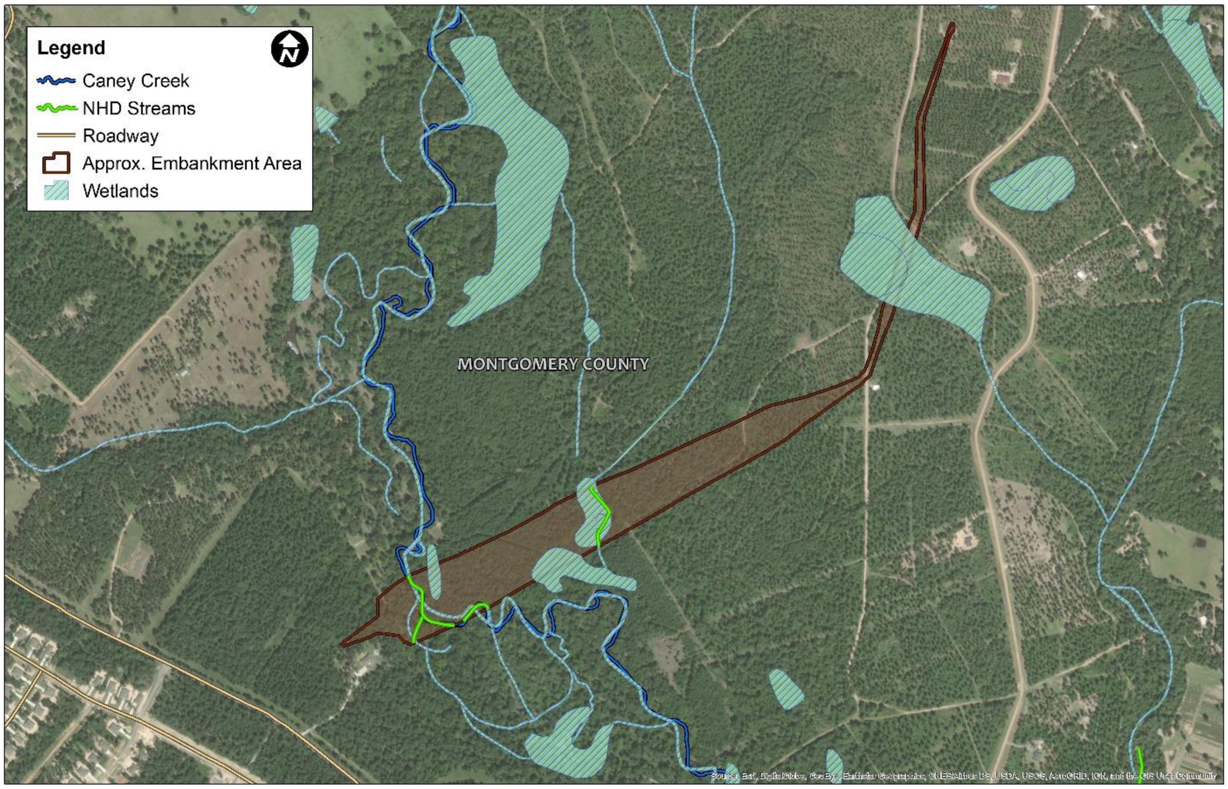

Figure 64: Caney Creek at SH105 Dam Embankment Maximum Footprint

5.4.2.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $650,000.

5.4.2.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 101**. The approximate costs range from $114M to $149M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.37 to 0.48.

Table 101: Estimated Cost and Benefit-Cost Ratio (BCR)—SH 105 Detention on Peach Creek

Item	Cost
Construction	$61 M
Design	$7 M
Environmental	$8 M
Right-of-Way	$38 M - $74 M
TOTAL	**$114 M - $149M**
BCR:	**0.37 – 0.48**
20-Year Escalation	**$173 M- $227 M**

5.4.2.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for three TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.4.3 I-69 Channelization

5.4.3.1 Description/Specifications

The majority of damage centers in the Caney Creek watershed are located in the southern half of the watershed. This Caney Creek channel improvements is the only channelization option explored to specifically reduce flood risk in the most downstream damage center. The proposed benching is located on the main stem of Caney Creek, 0.5 miles south of IH-69 and ends at the confluence with East Fork of San Jacinto River. The benching follows approximately the lowest fifth of the creek. The location of the proposed channel improvement is shown in **Figure 65**.

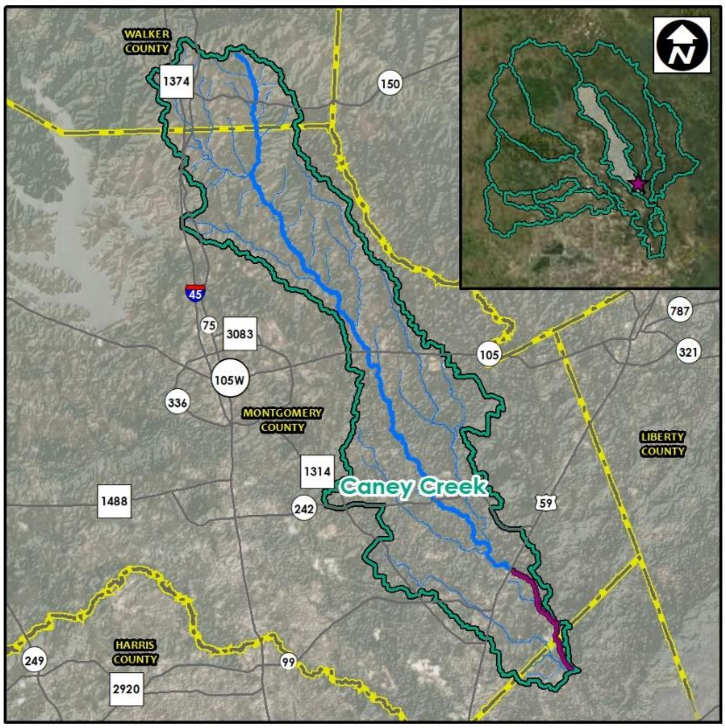

Figure 65: Caney Creek Channelization Downstream of I-69

Several sites within the watershed were initially screened as potential channel improvement locations. The site downstream of IH-69 provided was chosen based on several factors, including its ability to reduce flows in the downstream damage centers and limited development within the footprint.

The goal of the channel improvement is to reduce flooding in the Caney Creek watershed by benching a 7.8-mile-long stretch to increase conveyance capacity of Caney Creek in order to lower the water surface elevation. The improvements are planned to bench Caney Creek to 700 ft. The bench would start 1 foot above the natural stream bed at the confluence with East Fork of San Jacinto River and continue upstream at a slope of 0.1%. This would require 4.7 million cubic yards of excavation over a surface area of 629 acres.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 530 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing either of the recommended detention alternatives on Caney Creek. Refer to **Appendix H** for details.

5.4.3.2 H&H Considerations

The Caney Creek channel improvement downstream of I-69 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The channel was benched to 700ft from downstream of I-69 to the confluence with the East Fork of the San Jacinto River. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

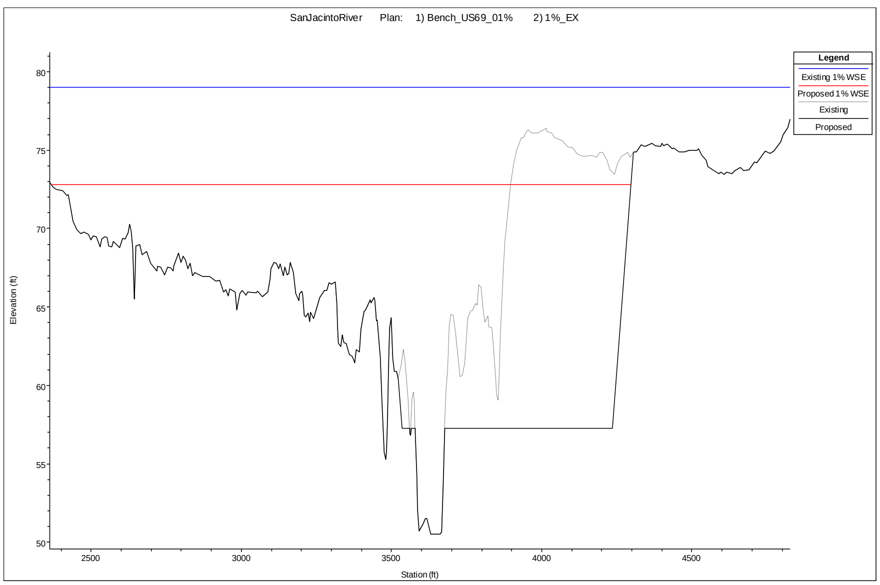

Figure 66: Representative Cross Section of Benching Improvement

The proposed improvements will provide a reduction in water surface elevations along Caney Creek for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 5.6 feet between I-69 and the confluence with the East Fork.

5.4.3.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 4% ACE and 10% ACE water surface elevations for a length of approximately 6.3 miles. The increase in channel capacity reduces the 1% ACE water surface elevation by at least 0.5-feet for 9.0 miles along Caney Creek with a maximum water surface reduction of 8.04 feet just downstream of I-69.

By increasing the channel capacity, the proposed improvement removes 509 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,122. Most of the benefits would be realized in the Baptist Encampment Road and New Caney areas. The net present value of benefits based on a 50-year project life within the watershed is approximately $57.4M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 102: I-69 Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	6.4	0.1	**6.5**
Peach	0.0	10.1	**10.1**
Caney	17.6	23.2	**40.9**
Total	**24.0**	**33.4**	**57.4**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 103**.

Table 103: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
SH150	0.00	10% ACE	No Change
Bilnoski Road	0.00	<50% ACE	No Change
FM 1097	0.00	20% ACE	No Change
County Line Road	-0.04	<50% ACE	No Change
Royal Bridge	-0.18	<50% ACE	No Change
FM 1494	0.06	10% ACE	No Change
Millimac Road	0.08	<50% ACE	No Change
SH 105	0.01	2% ACE	No Change
Timber Rock Railroad	0.01	10% ACE	No Change
FM 2090	0.18	20% ACE	No Change
Hwy 242	0.01	10% ACE	No Change
Firetower Rd	0.01	50% ACE	No Change
Sycamore Lane	0.33	50% ACE	No Change
Hwy 59/I 69	1.55	2% ACE	1% ACE
Loop 494	2.13	2% ACE	1% ACE
Railroad	2.10	2% ACE	1% ACE
FM 1485	5.68	20% ACE	2% ACE

The proposed channel project also provides regional benefit outside the Caney Creek watershed. The model shows a reduction in WSEL at the confluence with Peach Creek of 7.8 feet. However, the project does not show any direct benefit downstream of Caney Creek.

5.4.3.4 Real Estate

156 parcels would need to be acquired for a total of 515 acres if purchased below the 1% ACE water surface elevation. All parcels required are currently private property.

5.4.3.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed benching. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.6 miles of roadways are located within the updated bank stations of the channel and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 104**.

Table 104: Caney Creek Detention at I-69 Potential Relocation Summary

Relocation	Name	Owner	Length	Notes
Utility	30-inch Gas Pipeline	Transcontinental Gas P.L., CO, LLC	0.08 miles	
Utility	30-inch Gas Pipeline	Transcontinental Gas P.L., CO, LLC	0.16 miles	
Utility	30-inch Gas Pipeline	Transcontinental Gas P.L., CO, LLC	0.16 miles	
Utility	12.75-inch Highly Volatile Liquid Pipeline	Enterprise Products Operating LLC	0.16 miles	
Utility	20-inch Highly Volatile Liquid Pipeline	Enterprise Products Operating LLC	0.16 miles	
Utility	8.63-inch Highly Volatile Liquid Pipeline	Phillips 66 Pipeline, LLC	0.16 miles	
Utility	12.75-inch Gas Pipeline	Kinder Morgan Texas Pipeline, LLC	0.04 miles	
Utility	12.75-inch Gas Pipeline	Kinder Morgan Texas Pipeline, LLC	0.14 miles	
Utility	10.75-inch Highly Volatile Liquid Pipeline	Mustang Pipeline Company	0.16 miles	
Utility	6.63-inch Highly Volatile Liquid Pipeline	Mustang Pipeline Company	0.16 miles	
Roadway	FM 1485	TX DOT	0.16 miles	2-lane asphalt road
Roadway	Pin Oak Loop (CR 979)	Montgomery	0.13 miles	2-lane gravel road
Roadway	CS 1120172	Montgomery	0.05 miles	2-lane gravel road
Roadway	CS 1121251	Montgomery	0.03 miles	2-lane gravel road
Roadway	CS 1122531	Montgomery	0.04 miles	2-lane gravel road
Roadway	CS 1131698	Montgomery	0.10 miles	2-lane gravel road
Roadway	SH 99	TX DOT	0.14 miles	Not Yet Constructed

5.4.3.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 133 acres of potential wetlands within the footprint of the proposed dam. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. The affected wetlands would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

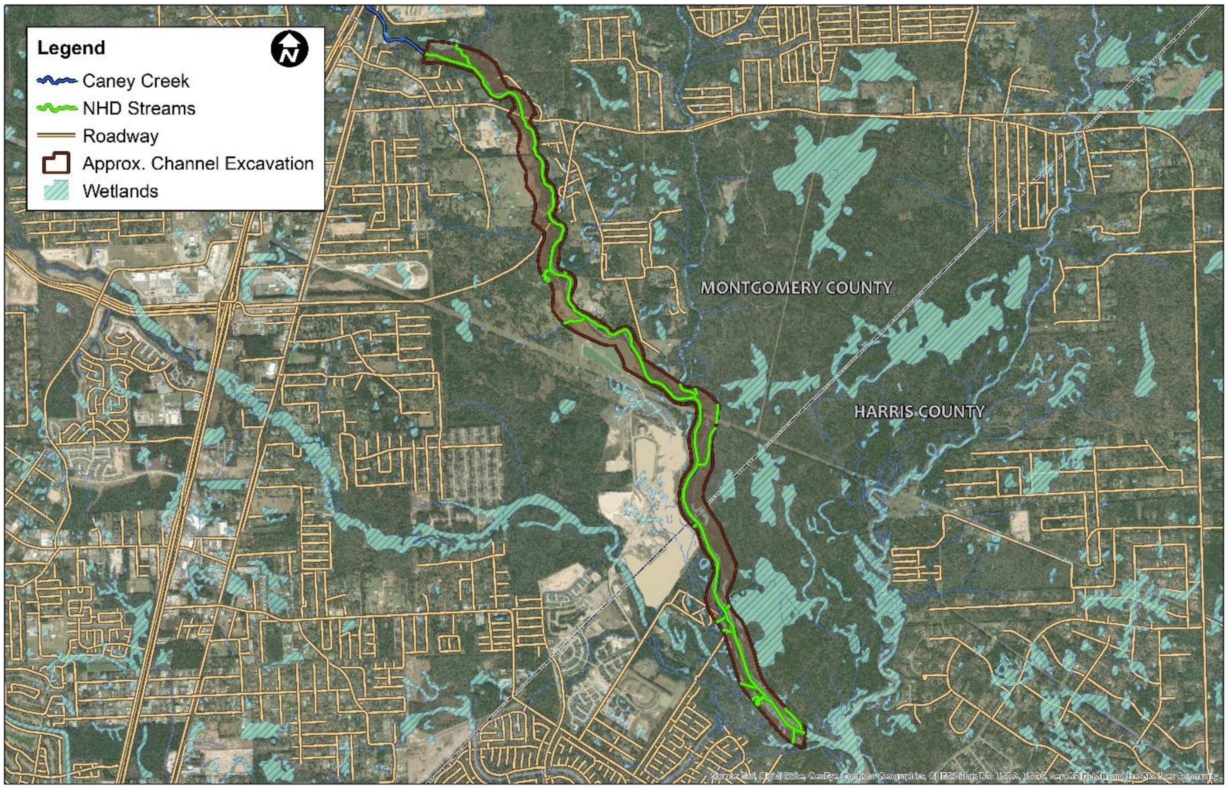

Figure 67: Caney Creek at I-69 Channel Excavation Maximum Footprint

5.4.3.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed channel improvements and mitigation basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $800,000.

5.4.3.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 105**. The approximate cost is $189M. The BCR for the project based on the calculated benefits is 0.30.

Table 105. Estimated Cost and Benefit-Cost Ratio (BCR)—I-69 Channelization on Caney Creek

Item	Cost
Construction	$146 M
Design	$18 M

Environmental	$20 M
Right-of-Way	$6 M
TOTAL	**$189 M**
BCR:	**0.30**
20-Year Escalation	**$287 M**

5.4.3.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for two TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.4.4 Caney Creek Recommendation

5.4.4.1 Descriptions/Specifications

Of the three alternatives for the Caney Creek watershed analyzed in this study, the following combination of dams and channel improvement options are recommended for Caney Creek. The section that describes each individual alternative in detail is also listed.

- FM 1097 Dam – Section 5.4.1
- SH 105 Dam – Section 5.4.2
- I-69 Channelization – Section 5.4.3

The location of the proposed dams and extents of the channel improvements is shown in **Figure 68**.

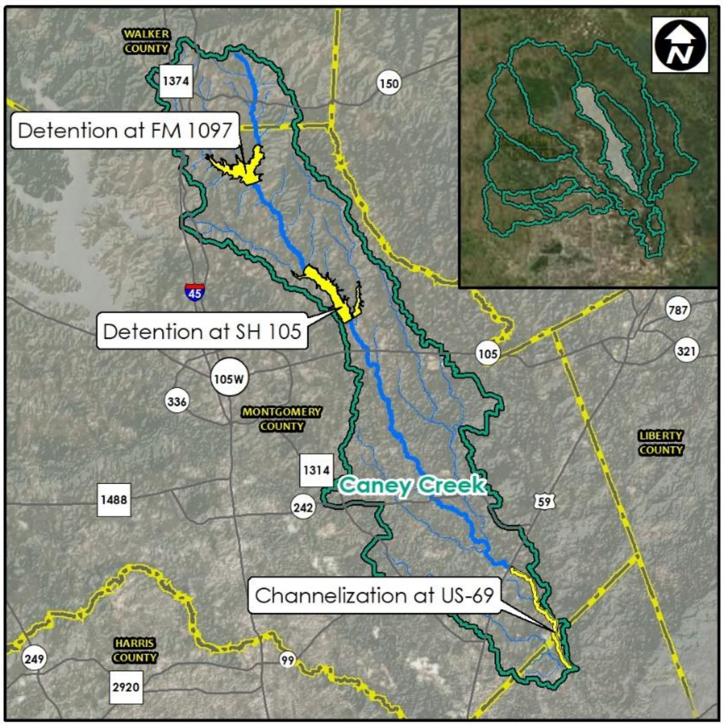

Figure 68. Spring Creek Recommended Alternatives

Each alternative was chosen based on several factors, including but not limited to, its ability to reduce water surface elevations in damage centers, availability of land for construction, and its benefit-cost ratio.

The goal of the recommended alternatives is to reduce flooding in the Caney Creek watershed by combining the benefits of two proposed dams on Caney Creek with one region of channel improvement on the Caney Creek mainstem. While any combination of alternatives will be less efficient in reducing flood risk when compared to an individual alternative, this combination of alternatives performs well and provides significant benefit to the Caney Creek watershed.

5.4.4.2 H&H Considerations

A summary of the proposed dam and channel improvement alternatives is shown in **Table 106** and **Table 107** respectively. The channel improvement option as well as the two dam options were modeled in HEC-RAS. Flow data from the existing conditions HEC-HMS model was combined with the proposed HEC-RAS geometry to arrive at a comprehensive model for the Caney Creek watershed.

Table 106: 1% ACE Summary Dams

Alternative	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
FM 1097 Dam	35,853	13,763	13,892	259.37
SH 105 Dam	31,798	16,015	20,918	206.03

Table 107: Channel Improvement Summary

Alternative	Location	Improvement Length (mi)	Bench Width (ft)	Bench Height (ft)
I-69 Channelization	I-69 to East Fork	7.8	700	25

The combination of detention basins with region of channel improvement provides significant reduction in water surface elevations and flows along Caney Creek, with increased reductions through the regions of channel improvement. The average reduction in water surface elevation along Caney Creek is summarized in **Table 108**.

Table 108: Average Reduction in Water Surface Elevation - Caney Creek

Location	Frequency Event			
	10% ACE	2% ACE	1% ACE	0.2% ACE
FM 1097 – FM 1494	0.89	3.72	4.77	4.89
SH 105 – I-69	0.66	2.24	2.81	3.69
I-69 – East Fork Confluence	6.65	6.95	6.38	5.19

5.4.4.3 Project Benefits

The combination of alternatives reduces the 1% ACE existing conditions water surface elevations to elevations between the existing conditions 4% ACE and 10% ACE between the FM 1097 Dam and SH 105 Dam. Downstream of the SH 105 Dam, the 1% ACE existing conditions water surface elevation is reduced to 2% ACE in regions outside of the proposed channel improvements. Within the extents of the channel improvements the existing 1% ACE water surface elevations are reduced to approximately 10% ACE water surface elevations.

By reducing flows along Caney Creek and increasing channel capacity in one area, the proposed improvements remove 1,166 structures from the 1% ACE floodplain and provide a potential reduction in flooding instances of 2,735. Benefits are realized on the majority of Caney Creek downstream of the FM

1097, and the benefits extend to the confluence with Caney Creek. The net present value of benefits based on a 50-year project life within the watershed is approximately $112.1 M. The distribution of these benefits along Caney Creek and the downstream end of Peach Creek is shown in **Figure 69**. The proposed improvements also provide some benefits along the East Fork and West Fork that are not shown in this figure. The average water surface elevation reduction is approximately 3.8' in the 1% ACE event from Roman Forrest Road to the Caney Creek confluence.

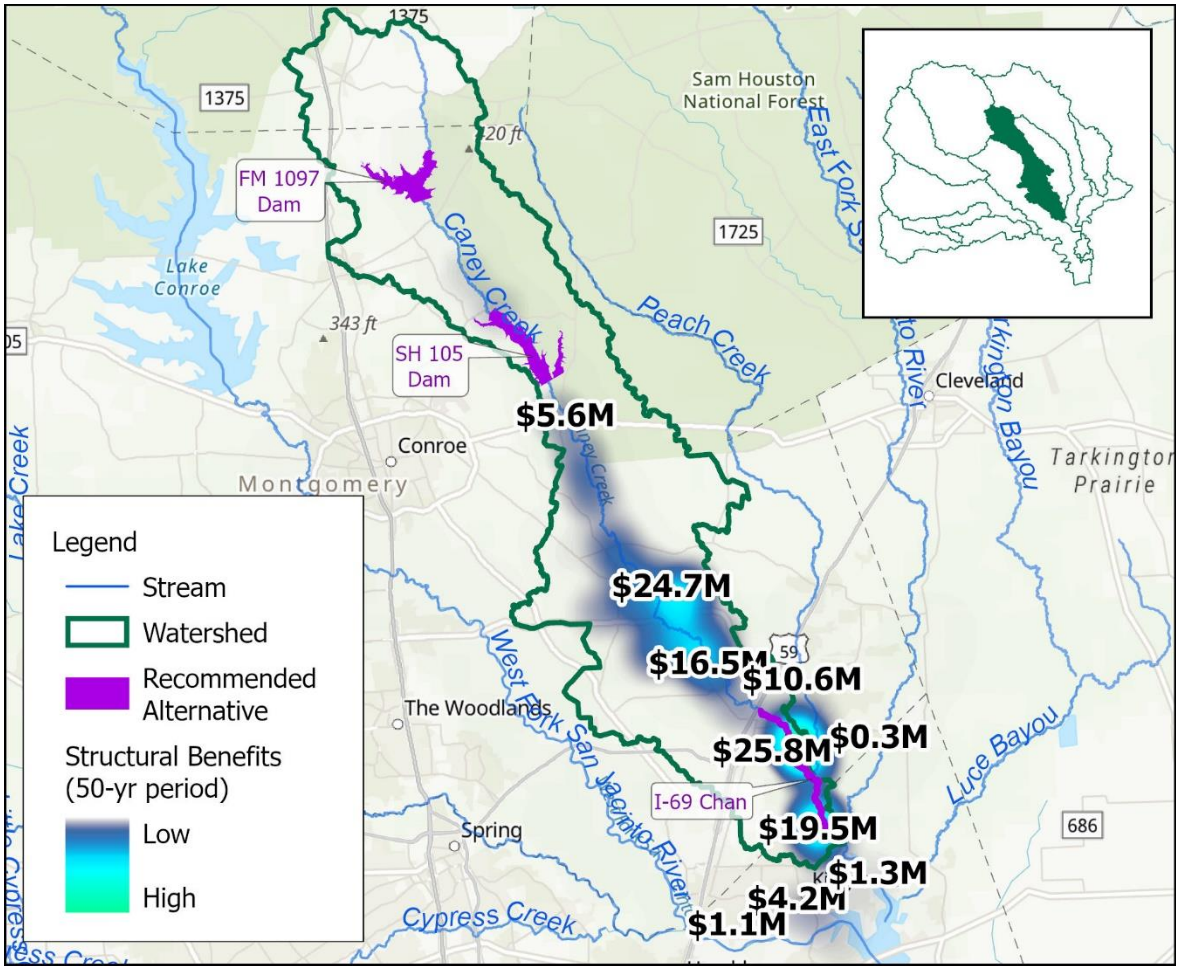

Figure 69. Caney Creek Overall Benefits

5.4.4.4 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 109**. The approximate costs range from $408 M to $469 M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.24 to 0.27.

Table 109: Caney Creek Combined Alternatives Estimated Cost and BCR

Item	FM 1097 Dam	SH 105 Dam	I-69 Channel	Overall
Construction	$65 M	$61 M	$146 M	$272 M
Design	$8 M	$7 M	$18 M	$33 M
Environmental	$8 M	$8 M	$20 M	$36 M
Right-of-Way	$24 – 50 M	$38 – 74 M	$6.0 M	$68 – 130 M
TOTAL COST	**$105 - $131 M**	**$114 M - $149 M**	**$189 M**	**$408 – $469 M**
TOTAL BENEFIT	**$27.7 M**	**$55.2 M**	**$57.4 M**	**$112.1 M**
BCR:	**0.21 – 0.26**	**0.37 – 0.48**	**0.30**	**0.24 – 0.27**
20-Year Escalation	**$159 M - $199 M**	**$173 M - $227 M**	**$287 M**	**$619 M - $713 M**

5.5 East Fork San Jacinto River

Four mitigation alternatives were explored on the East Fork San Jacinto watershed. The alternatives included two inline detention facilities along Winter's Bayou, one facility on the East Fork San Jacinto, and one channelization project on the downstream end of the watershed. The alternatives targeted reducing flooding instances primarily in East Fork San Jacinto with some reductions downstream.

5.5.1 FM 945 Detention

5.5.1.1 Description/Specifications

The FM 945 Detention Basin near MR-945 on the East Fork of the San Jacinto River is one of three detention areas explored in the East Fork watershed to reduce flood risk downstream. The proposed inline detention basin is located on the East Fork of the San Jacinto River, approximately 10 miles upstream of Cleveland, Texas. The basin is located in the upper half of the East Fork watershed and captures flow from a drainage area of approximately 135 square miles. The proposed detention is located in San Jacinto County as shown in **Figure 70.**

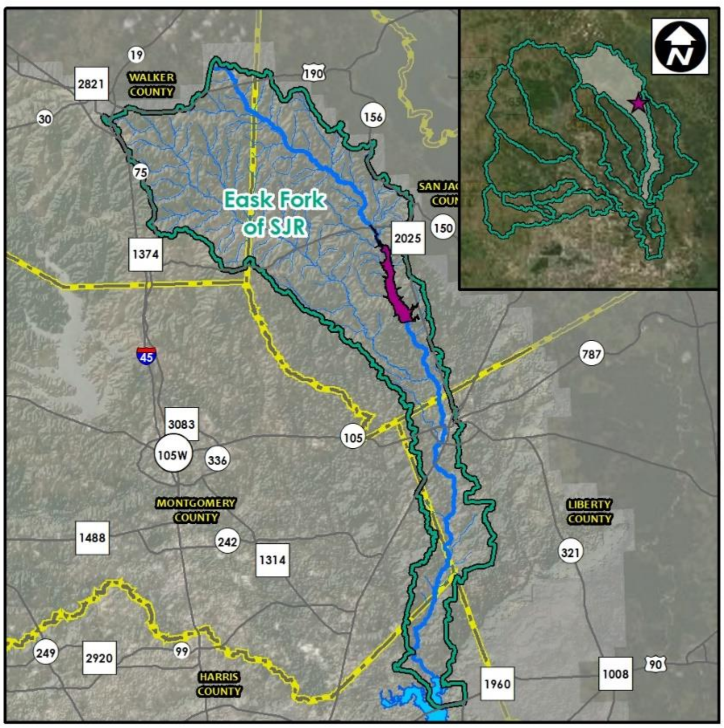

Figure 70: East Fork Detention near FM 945

Several sites within the watershed were initially screened as potential detention locations. The site near FM-945 near the East Fork confluence was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and steep terrain that allows for increased storage volume.

The goal of the detention facility is to reduce flooding in the East Fork watershed by constructing a 1.40-mile-long earthen impoundment that captures runoff from Winters Bayou. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 54-foot high concrete dam with a primary outfall consisting of 4 -10’ x 10’ RCBC and a secondary spillway 600’ in length. The impoundment will require over 1.3 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 3,030 acres below the 1% ACE water surface elevation, which includes Winters Bayou and its tributaries. The basin will provide approximately 28,248 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.5.1.2 H&H Considerations

The FM 945 Detention near FM-945 was modeled as an inline structure in the HEC-RAS model for the San Jacinto River basin. The reservoir was modeled with 4 – 10’ x 10’ low flow culverts. The 600’ spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, while maintaining an acceptable water surface elevation.

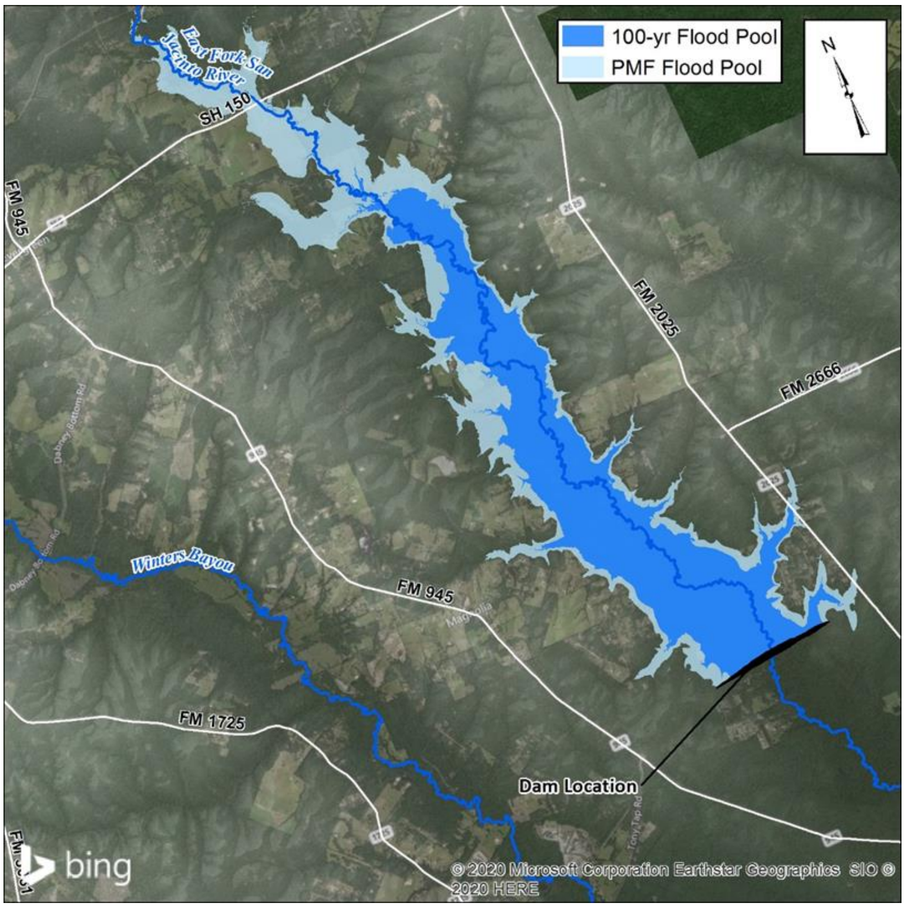

Figure 71: FM 945 Detention Detail

Table 110 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 110: East Fork SJR at FM 945 H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	3,903	3,793	179	170.4’
20% ACE	7,381	6,555	1,625	176.3’
10% ACE	12,069	8,459	6,091	181.7’
4% ACE	20,538	10,142	15,199	187.9’
2% ACE	26,851	11,082	22,189	192.2’
1% ACE	36,301	11,934	28,248	196.5’
0.2% ACE	60,086	36,228	49,739	201.5’

The detention basin will provide a reduction in water surface elevations and flows along the East Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 2.6 feet between FM 945 and the Caney Creek confluence. Downstream of the Caney Creek confluence, the reduction is less than 0.5 feet. The target volume for the East Fork reduces the 1% ACE to the 2% ACE which corresponds to a water surface reduction of approximately 2 feet.

5.5.1.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 36,301 cfs to 11,934 cfs downstream of the dam, which corresponds to approximately the 10% ACE. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 38.7 miles along the East Fork with a maximum water surface reduction of 5.2 feet near the Winters Bayou confluence.

By reducing the flows downstream, the basin removes 570 structures from the 1% ACE floodplain and provides a potential reduction in water surface elevation for 295 structures and a potential reduction in 1,109 flooding instances. Most benefits would be realized between I-69 and FM-1485. The net present value of benefits based on a 50-year project life within the watershed is approximately $51.9M. The distribution of benefits between watersheds and counties is shown below.

Table 111: FM 945 Detention Benefits Summary ($M)

Watershed	Benefits ($M)				
	Harris County	Liberty County	Montgomery County	San Jacinto County	Total
East Fork	7.6	24.9	4.2	1.8	**38.5**
West Fork	13.3	0.0	0.1	0.0	**13.4**
Total	**21.0**	**24.9**	**4.3**	**1.8**	**51.9**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 112**.

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Table 112: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Stanley Rd/Old Chapel Rd	0.00	0.2% ACE	No Change
Dodge-Oakhurst Rd	0.00	0.2% ACE	No Change
US-190	0.00	0.2% ACE	No Change
Guinea Rd	-0.03	50% ACE	No Change
Jenkins Rd	0.01	10% ACE	No Change
FM-945/RR-2	-0.01	20% ACE	No Change
TX-150/FM-1375	0.00	2% ACE	No Change
Cold Springs Oil Field Rd	0.00	4% ACE	No Change
Lower Vann Rd	-8.88	20% ACE	No Change
FM-945	4.95	10% ACE	1% ACE
CR-388/Bridge Rd	2.41	20% ACE	No Change
BNSF Railroad	2.67	4% ACE	2% ACE
TX-105/W Southline St	0.00	1% ACE	No Change
TX-105	0.00	0.2% ACE	No Change
I-69	0.00	1% ACE	No Change
Union Pacific Railroad	1.90	2% ACE	1% ACE
FM-2090	2.27	10% ACE	No Change
FM-1485	2.60	2% ACE	1% ACE

The proposed detention facility also provides regional benefit outside the East Fork watershed. The project shows direct benefit downstream of the East Fork in Lake Houston with reductions of approximately 0.35 feet in the 1% ACE event.

5.5.1.4 Real Estate

214 parcels would need to be acquired for a total of 2,994 acres if the parcels inundated in the 1% ACE are purchased. 328 parcels would need to be acquired for a total of 5,420 acres if the parcels inundated in the PMF elevation are purchased. The majority of the required parcels are currently private property and located within the Sam Houston National Forest.

5.5.1.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.2 miles of roadways are located within the preliminary 1% ACE elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 113**.

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Table 113: East Fork Detention at FM 945 Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	4-inch Gas Pipeline	Jet Oil Producers	1.2 miles	Natural Gas
Utility	5-inch Gas Pipeline	Jet Oil Producers	1.1 miles	Natural Gas
Utility	2-inch Gas Pipeline	Five-Jab	1.7 miles	Multiple lines, Natural Gas
Utility	4-inch Gas Pipeline	Five-Jab	1.2 miles	Multiple lines, Natural Gas
Roadway	SH 105	TxDOT	0.1 miles	

5.5.1.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 11.7 acres of potential wetlands within the footprint of the proposed dam and a potential 1,617 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

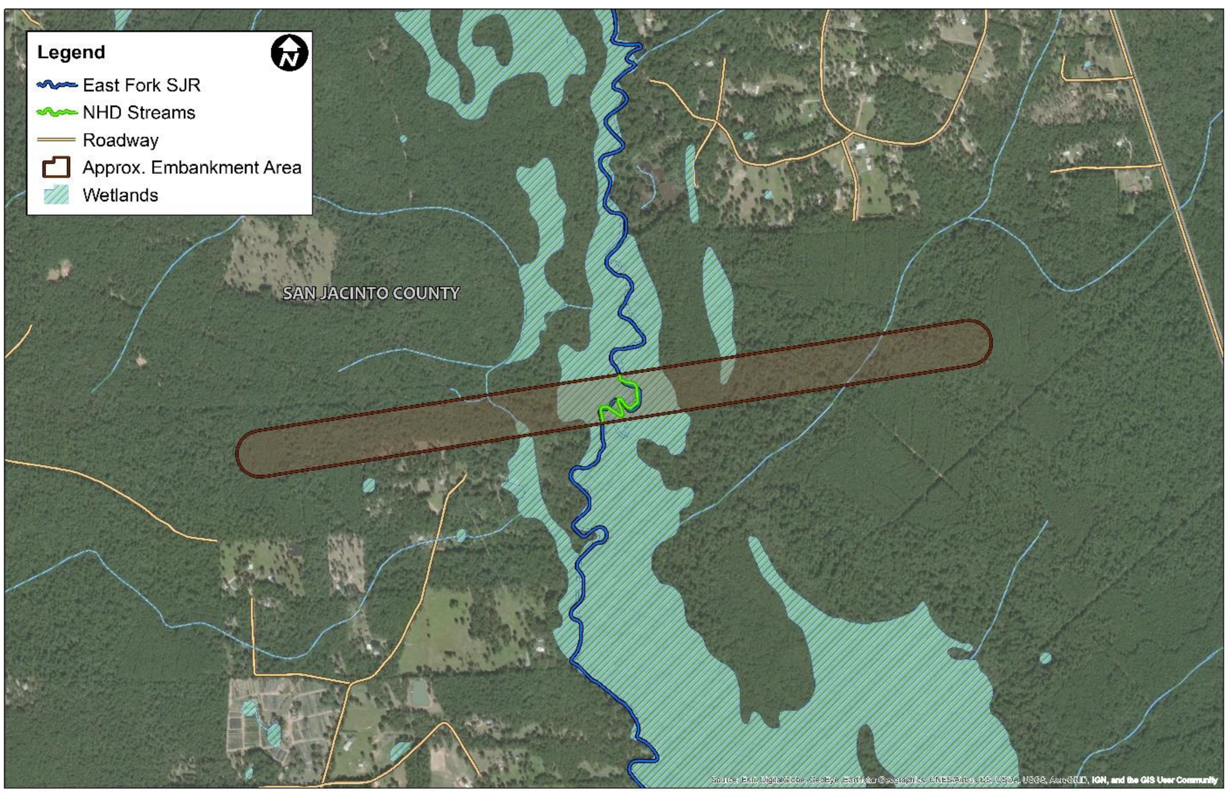


Figure 72: East Fork SJR at FM 945 Dam Embankment Maximum Footprint

5.5.1.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at 1% of the construction cost of the dam, or approximately $779,000. This cost is not included in the overall OPCC.

5.5.1.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 114**. The approximate costs range from $146M to $166M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.31 to 0.36.

Table 114: Estimated Cost and Benefit-Cost Ratio (BCR)—FM 945 Detention on East Fork SJR

Item	Cost
Construction	$73 M
Design	$9 M
Environmental	$11 M
Right-of-Way	$53 M - $73 M
TOTAL	**$146 M - $ 166 M**
BCR:	**0.31 – 0.36**
20-Year Escalation	**$221 M - $251 M**

5.5.1.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- San Jacinto County - The project is located within San Jacinto and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

- TxDOT – The proposed project improves the level of service for two TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.
- US Forest Service – The project is located within the Sam Houston National Forest. The US Forest Service may serve as a project sponsor if the project can be combined with an environmental restoration project in the forest.

Funding Agencies

- BNSF Railroad – The proposed project improves the level of service for a BNSF railroad in the watershed and could be a potential funding partner for any of the aspects of the project.
- UPRR – The proposed project improves the level of service for a UPRR railroad in the watershed and could be a potential funding partner for any of the aspects of the project.
- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.5.2 Winters Bayou Detention

5.5.2.1 Description/Specifications

The Winters Bayou Detention Basin at the Winters Bayou confluence with the East Fork of the San Jacinto River is one of three detention areas explored in the East Fork watershed to reduce flood risk downstream. The proposed inline detention basin is located on Winters Bayou, a tributary to East Fork, approximately 4 upstream of the confluence with East Fork 5 miles north Cleveland, Texas. The basin is located in the upper half of the East Fork watershed in San Jacinto County and captures flow from a drainage area of approximately 171 square miles. The location of the proposed detention is shown in **Figure 73**.

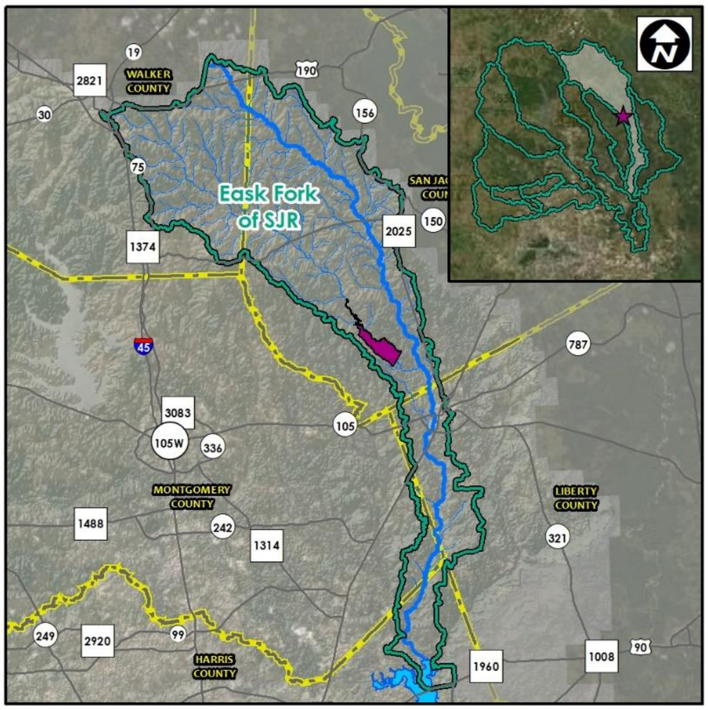


Figure 73: East Fork at Winters Bayou

Several sites within the watershed were initially screened as potential detention locations. The site on Winters Bayou near the East Fork confluence was chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and Winters Bayou's significant influence on flows and water surface elevations within the East Fork.

The goal of the detention facility is to reduce flooding in the East Fork watershed by constructing a 1.60-mile-long earthen impoundment that captures runoff from Winters Bayou. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 48-foot high concrete dam with a primary outfall consisting of 5 -10' x 10' RCBC and a tiered secondary spillway that has two openings approximately 300' in length. The impoundment will require over 1.3 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 2,479 acres below the 1% ACE water surface elevation, which includes Winters Bayou and its tributaries. The basin will provide approximately 45,055 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.5.2.2 H&H Considerations

The Winters Bayou Detention near Cleveland was modeled as a reservoir in the HEC-HMS model for the San Jacinto River basin. The reservoir was modeled with 5 – 10' x 10' low flow culverts. The 300' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, while maintaining an acceptable water surface elevation.

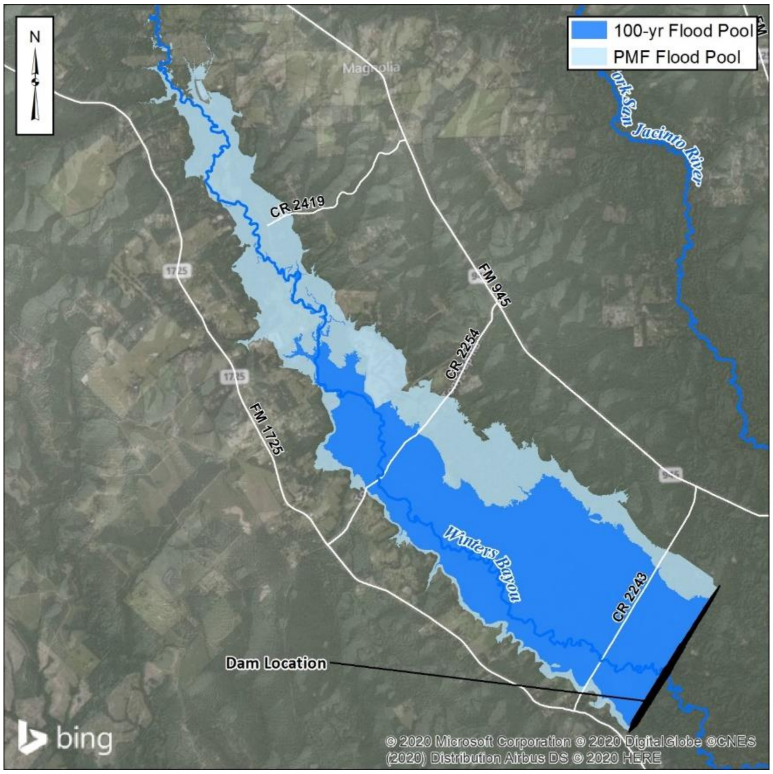


Figure 74: East Fork Winters Bayou Detention Detail

Table 115 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 115. East Fork SJR at Winters Bayou H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	6,375	5,723	1,212	150.9'
20% ACE	10,997	8,166	4,577	156.1'
10% ACE	15,710	10,004	9,931	160.7'
4% ACE	23,505	11,942	20,531	166.6'
2% ACE	30,693	13,169	31,400	170.9'
1% ACE	39,102	14,273	45,055	175.0'
0.2% ACE	63,533	32,111	68,747	180.8'

The detention basin will provide a reduction in water surface elevations and flows along the East Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 2.5 feet between the Winters Bayou and Caney Creek confluences. Downstream of the Caney Creek confluence, the reduction is less than 0.5 feet. The target volume for the East Fork reduces the 1% ACE flow to the 2% ACE which corresponds to a water surface reduction of approximately 2 feet.

5.5.2.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 39,102 cfs to 14,273 cfs downstream of the dam, which corresponds to approximately the 10% ACE. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 31.6 miles along the East Fork with a maximum water surface reduction of 3.1 feet near TX-105.

By reducing the flows downstream, the basin removes 615 structures from the 1% ACE floodplain and provides a potential reduction in 1,334 flooding instances. Most benefits would be realized between I-69 and FM-1485. The net present value of benefits based on a 50-year project life within the watershed is approximately $63.5M. The distribution of benefits between watersheds and counties is shown below.

Table 116: Winters Bayou Detention Benefits Summary ($M)

Watershed	Benefits ($M)				
	Harris County	Liberty County	Montgomery County	San Jacinto County	Total
East Fork	9.7	31.3	5.2	0.2	**46.5**
West Fork	16.9	0.0	0.1	0.0	**17.0**
Total	**26.6**	**31.3**	**5.3**	**0.2**	**63.5**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 117**.

Table 117: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Stanley Rd/Old Chapel Rd	0.00	0.2% ACE	No Change
Dodge-Oakhurst Rd	0.00	0.2% ACE	No Change
US-190	0.00	0.2% ACE	No Change
Guinea Rd	0.07	50% ACE	No Change
Jenkins Rd	0.01	10% ACE	No Change
FM-945/RR-2	-0.01	20% ACE	No Change
TX-150/FM-1375	-0.01	2% ACE	No Change
Cold Springs Oil Field Rd	0.11	4% ACE	No Change
Lower Vann Rd	0.08	20% ACE	No Change
FM-945	0.00	10% ACE	No Change
CR-388/Bridge Rd	2.66	20% ACE	No Change
BNSF Railroad	3.01	4% ACE	2% ACE
TX-105/W Southline St	2.82	1% ACE	No Change
TX-105	2.01	0.2% ACE	No Change
I-69	2.76	1% ACE	No Change
Union Pacific Railroad	2.09	2% ACE	1% ACE
FM-2090	2.53	10% ACE	No Change
FM-1485	2.96	2% ACE	1% ACE

The proposed detention facility also provides regional benefit outside the East Fork watershed. The project shows direct benefit downstream of the East Fork in Lake Houston with reductions of approximately 0.4 feet in the 1% ACE event.

Because only the East Fork mainstem was modeled as part of this study, these benefits do not include the potential benefits to structures or roadways along Winters Bayou or other tributaries.

5.5.2.4 Real Estate

88 parcels would need to be acquired for a total of 2,461 acres if the parcels inundated in the 1% ACE are purchased. 181 parcels would need to be acquired for a total of 4,356 acres if the parcels inundated in the PMF elevation are purchased. The majority of the required parcels are currently private property and located within the Sam Houston National Forest.

5.5.2.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.2 miles of roadways are located within the preliminary 1% ACE elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 118**.

Table 118: East Fork Detention at Winters Bayou Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	11-inch Oil Pipeline	Sunoco	2.9 miles	Crude Oil
Utility	5-inch Gas Pipeline	Hilcorp Energy	2.4 miles	Natural Gas
Utility	30-inch Gas Pipeline	Gulf South	2.7 miles	Natural Gas
Roadway	Tony Tap Road	San Jacinto County	1.1 miles	

5.5.2.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 18.1 acres of potential wetlands within the footprint of the proposed dam and a potential 442 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

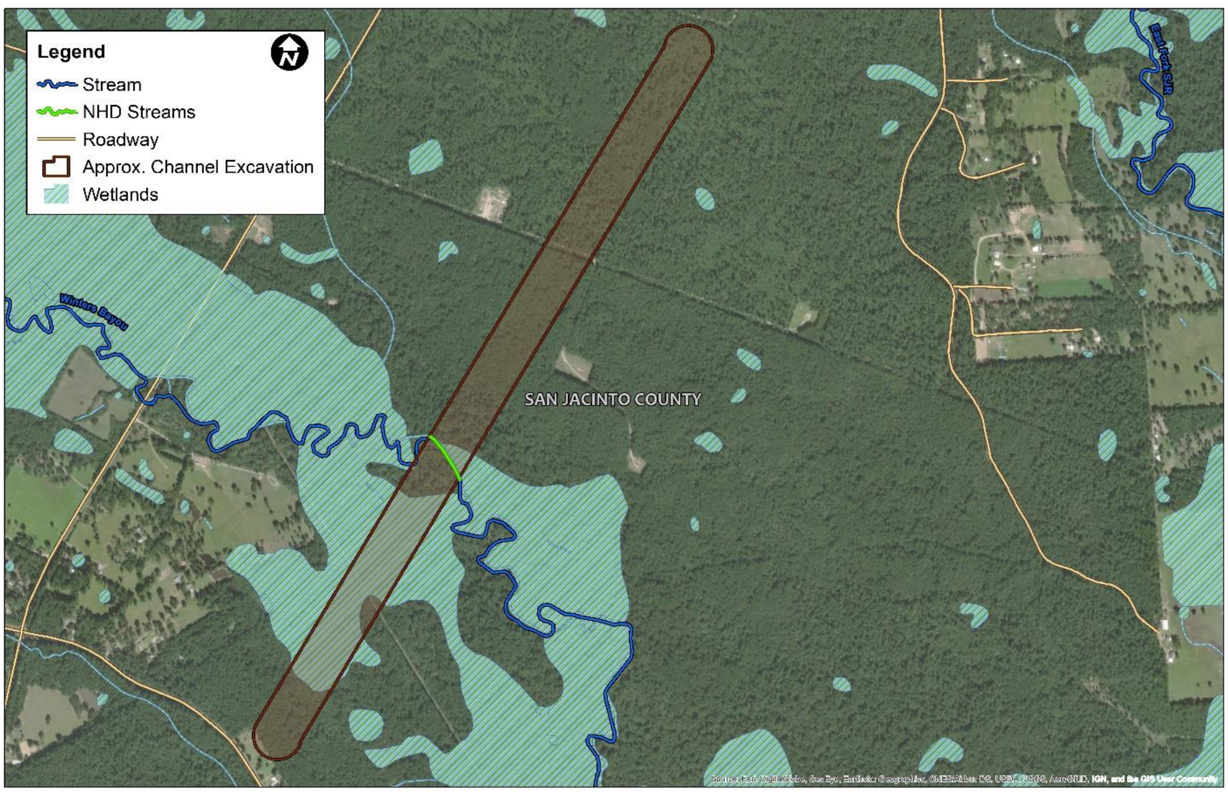


Figure 75: East Fork SJR at Winters Bayou Dam Embankment Maximum Footprint

5.5.2.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at 1% of the construction cost of the dam, or approximately $740,000. This cost is not included in the overall OPCC.

5.5.2.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 119**. The approximate costs range from $134M to $167M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.38 to 0.47.

Table 119: Estimated Cost and Benefit-Cost Ratio (BCR)—Winters Bayou Detention on East Fork SJR

Item	Cost
Construction	$74 M
Design	$9 M
Environmental	$7 M
Right-of-Way	$45 M - $77 M
TOTAL	**$134 M - $ 167 M**
BCR:	**0.38 – 0.47**
20-Year Escalation	**$204 M - $252 M**

5.5.2.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- San Jacinto County – The project is located within San Jacinto County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in East Fork San Jacinto tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

- TxDOT – The proposed project improves the level of service for one TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.
- BNSF Railroad – The proposed project improves the level of service for a BNSF railroad in the watershed and could be a potential funding partner for any of the aspects of the project.
- UPRR – The proposed project improves the level of service for a UPRR railroad in the watershed and could be a potential funding partner for any of the aspects of the project.
- US Forest Service – The project is located within the Sam Houston National Forest. The US Forest Service may serve as a project sponsor if the project can be combined with an environmental restoration project in the forest.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.5.3 Winters Bayou-Nebletts Creek Detention

5.5.3.1 Description/Specifications

The Winters Bayou-Nebletts Creek Detention Basin on Winters Bayou is one of three detention areas explored in the East Fork watershed to reduce flood risk downstream. The proposed inline detention basin is located on Winters Bayou, a tributary to East Fork, approximately 14 upstream of Cleveland, Texas. The basin is located in the upper half of the East Fork watershed and captures flow from a drainage area of approximately 149 square miles. The proposed detention is located in San Jacinto County as shown in **Figure 76**.

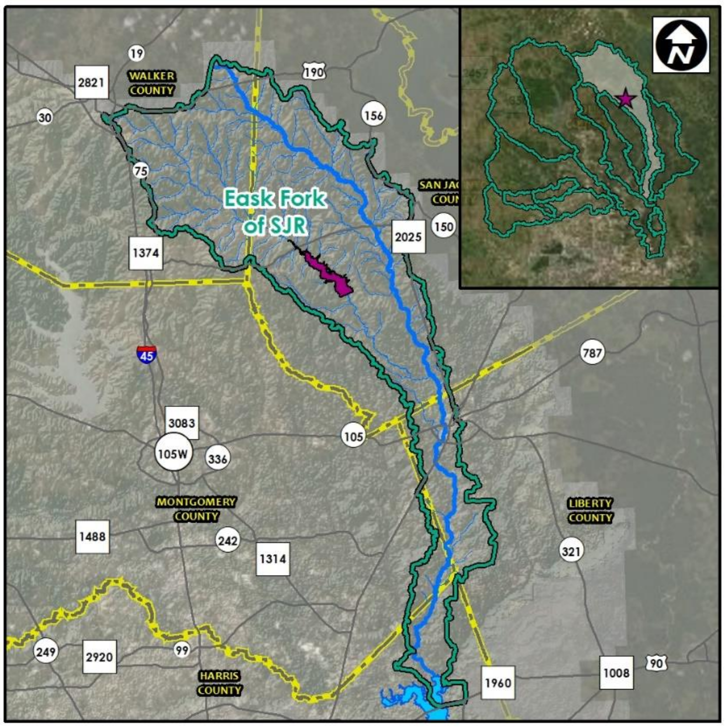


Figure 76: Winters Bayou-Nebletts Creek Detention

Several sites within the watershed were initially screened as potential detention locations. The site on Winters Bayou near Nebletts Creek chosen based on several factors, including its ability to reduce flows in the downstream damage centers, limited development within the footprint, and Winters Bayou's significant influence on flows and water surface elevations within the East Fork.

The goal of the detention facility is to reduce flooding in the East Fork watershed by constructing a 1.3-mile-long earthen impoundment that captures runoff from Winters Bayou. The basin is planned to be inline with all flow passing through the impoundment outfall. The control structure is a 53-foot high concrete dam with a primary outfall consisting of 5 -10' x 10' RCBC and a tiered secondary spillway that has two openings 150' and 200' in length. The impoundment will require over 1.35 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin would encompass an area of 2,271 acres below the 1% ACE water surface elevation, which includes Winters Bayou and its tributaries. The basin will provide approximately 36,370 acre-feet of storage capacity below the 1% ACE water surface elevation.

5.5.3.2 H&H Considerations

The Winters Bayou Detention near Nebletts Creek was modeled as a reservoir in the HEC-HMS model for the San Jacinto River basin. The reservoir was modeled with 5 – 10' x 10' low flow culverts. The 150' spillway was set at an elevation above the 1% ACE water surface elevation in order to contain the full event as well as to safely pass higher flows, including the PMF, while maintaining an acceptable water surface elevation.

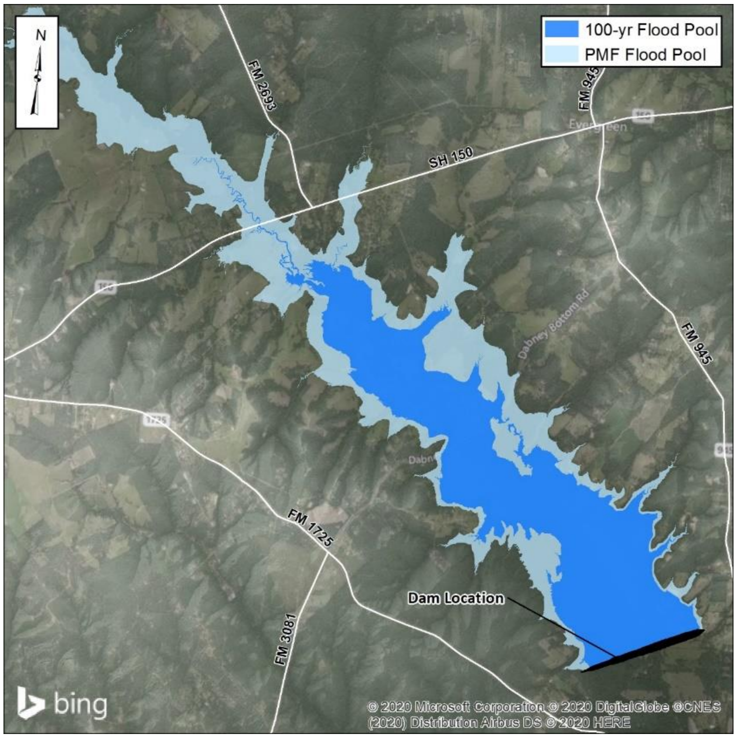


Figure 77: East Fork Winters Bayou–Nebletts Creek Dam Detail

Table 120 summarizes the peak inflows, outflows, estimated volumes and water surface elevations of the detention facility for each design storm event analyzed.

Table 120: East Fork SJR at Winters Bayou-Nebletts Creek H&H Modeling Summary

Storm Event	Inflow (cfs)	Outflow (cfs)	Volume (acre-ft)	WSEL (ft)
50% ACE	6,881	5,548	1,545	193.2'
20% ACE	11,167	7,967	4,444	197.9'
10% ACE	15,344	9,783	8,801	202.4'
4% ACE	21,875	11,736	17,107	208.2'
2% ACE	28,700	12,965	25,624	212.4'
1% ACE	36,653	14,088	36,370	216.6'
0.2% ACE	59,501	28,870	57,153	222.9'

The detention basin will provide a reduction in water surface elevations and flows along the East Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 2.2 feet between RS 209101 and RS 45844. Downstream of RS 45844, the reduction is less than 0.5 feet. The target volume for the East Fork reduces the 1% ACE to the 2% ACE which corresponds to a water surface reduction of approximately 2 feet.

5.5.3.3 Project Benefits

The detention facility reduces the 1% ACE existing conditions flows of 36,653 cfs to 14,088 cfs downstream of the dam, which corresponds to approximately the 10% ACE. The reduction in flow reduces the 1% ACE water surface elevation by at least 0.5-feet for 31.6 miles along the East Fork with a maximum water surface reduction of 2.7 feet near TX-105.

By reducing the flows downstream, the basin removes 544 structures from the 1% ACE floodplain and provides a potential reduction in 1,215 flooding instances. Most benefits would be realized between I-69 and FM-1485. The net present value of benefits based on a 50-year project life within the watershed is approximately $57.3M. The distribution of benefits between watersheds and counties is shown below.

Table 121: Winters Bayou-Nebletts Creek Detention Benefits Summary ($M)

Watershed	Benefits ($M)				
	Harris County	Liberty County	Montgomery County	San Jacinto County	Total
East Fork	8.5	29.4	4.9	0.2	**43.0**
West Fork	14.2	0.0	0.1	0.0	**14.3**
Total	**22.7**	**29.4**	**4.9**	**0.2**	**57.3**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in Table 122**.**

Table 122: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Stanley Rd/Old Chapel Rd	0.00	0.2% ACE	No Change
Dodge-Oakhurst Rd	0.00	0.2% ACE	No Change
US-190	0.00	0.2% ACE	No Change
Guinea Rd	0.07	50% ACE	No Change
Jenkins Rd	0.01	10% ACE	No Change
FM-945/RR-2	-0.01	20% ACE	No Change
TX-150/FM-1375	-0.01	2% ACE	No Change
Cold Springs Oil Field Rd	0.11	4% ACE	No Change
Lower Vann Rd	0.08	20% ACE	No Change
FM-945	0.00	10% ACE	No Change
CR-388/Bridge Rd	2.37	20% ACE	No Change
BNSF Railroad	2.62	4% ACE	2% ACE
TX-105/W Southline St	2.44	1% ACE	No Change
TX-105	1.79	0.2% ACE	No Change
I-69	2.50	1% ACE	No Change
Union Pacific Railroad	1.88	2% ACE	1% ACE
FM-2090	2.24	10% ACE	No Change
FM-1485	2.56	2% ACE	1% ACE

The proposed detention facility also provides regional benefit outside the East watershed. The project shows direct benefit downstream of the East Fork in Lake Houston with reductions of approximately 0.3 feet in the 1% ACE event.

Because only the East Fork mainstem was modeled as part of this study, these benefits do not include the potential benefits to structures or roadways along Winters Bayou or other tributaries.

5.5.3.4 Real Estate

105 parcels would need to be acquired for a total of 2,269 acres if the parcels inundated in the 1% ACE are purchased. 182 parcels would need to be acquired for a total of 4,529 acres if the parcels inundated in the PMF elevation are purchased. The majority of the required parcels are currently private property and located within the Sam Houston National Forest.

5.5.3.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.2 miles of roadways are located within the preliminary 1% ACE elevation of the dam and may need removal, relocation, or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 123**.

Table 123: East Fork Detention at Winter Bayou Nebletts Creek Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Roadway	TX-150	TxDOT	0.4 miles	
Roadway	Dabney Bottom Road	San Jacinto County	1.2 miles	

5.5.3.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 7.5 acres of potential wetlands within the footprint of the proposed dam and a potential 1,385 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

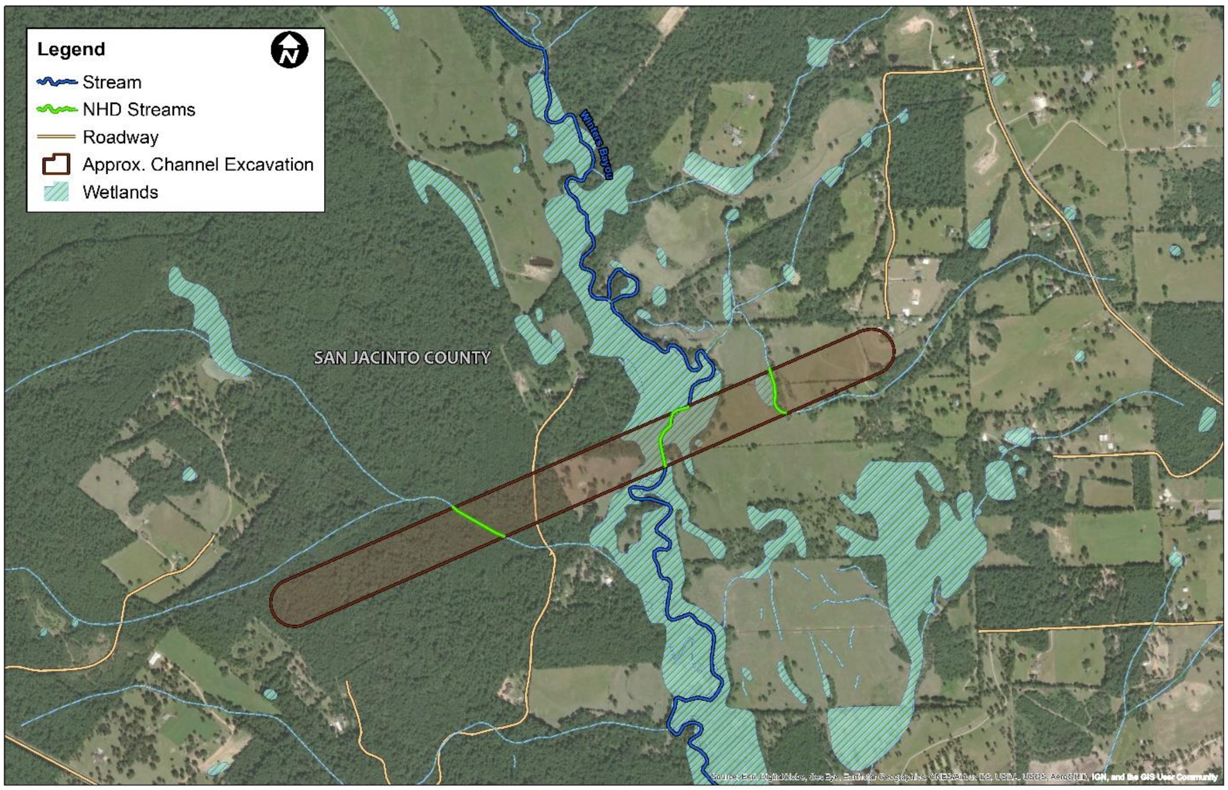


Figure 78. East Fork SJR at Winters Bayou Nebletts Creek Dam Embankment Maximum Footprint

5.5.3.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the dam, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at 1% of the construction cost of the dam, or approximately $650,000. This cost is not included in the overall OPCC.

5.5.3.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 124**. The approximate costs range from $131M to $181M depending on the ROW acquired. The BCR for the project based on the calculated benefits ranges from 0.32 to 0.44.

Table 124: Estimated Cost and Benefit-Cost Ratio (BCR)—Winters Bayou Nebletts Creek Detention on East Fork SJR

Item	Cost
Construction	$62 M
Design	$7 M
Environmental	$9 M
Right-of-Way	$52 M - $102 M
TOTAL	**$131 M - $ 181 M**
BCR:	**0.32 – 0.44**
20-Year Escalation	**$198 M- $274 M**

5.5.3.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- San Jacinto County – The project is located within San Jacinto County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for one TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.
- BNSF Railroad – The proposed project improves the level of service for a BNSF railroad in the watershed and could be a potential funding partner for any of the aspects of the project.
- UPRR – The proposed project improves the level of service for a UPRR railroad in the watershed and could be a potential funding partner for any of the aspects of the project.

- US Forest Service – The project is located within the Sam Houston National Forest. The US Forest Service may serve as a project sponsor if the project can be combined with an environmental restoration project in the forest.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.5.4 FM 1485 Channelization

5.5.4.1 Description/Specifications

The FM 1485 Channel Improvement option is a channel improvement alternative explored in the East Fork watershed to reduce flood risk. The proposed channel improvement is located on East Fork of the San Jacinto River from FM 1485 to just downstream of the Caney Creek confluence. The proposed channel improvements are located within Harris County as shown in **Figure 79**.

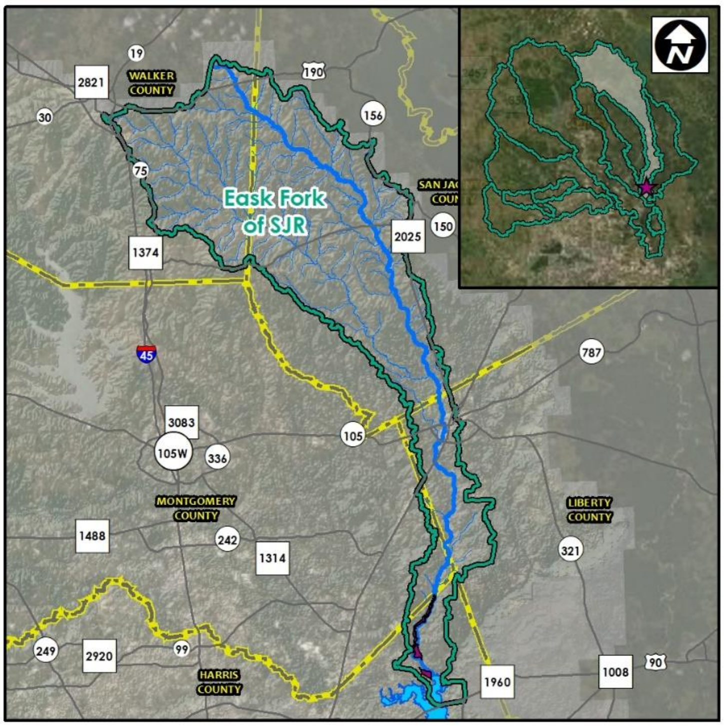


Figure 79: East Fork Benching at FM 1485 to Luce Bayou

Several sites within the watershed were initially screened as potential areas that could benefit from channel improvements. The region from FM 1485 to the Caney Creek confluence was chosen based on several factors, including its ability to reduce water surface elevations in damage centers, and availability of undeveloped land.

The goal of the channel improvement is to reduce flooding in the East Fork watershed by constructing a benched improvement that lies approximately 2 feet above the natural flowline of the East Fork outside of Lake Houston influence, and 0.5 feet above the normal pool elevation within the influence of Lake Houston. The benched improvement will require approximately 12.4 million cubic yards of excavation. The proposed channel improvement will also require 671 acres of additional right-of-way. The channel improvement will reduce the 1% ACE water surface elevation by approximately 2-5 feet through the extents of the improvement.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 15,000 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing the Winters Bayou Dam. Refer to **Appendix H: Implementation** for details.

5.5.4.2 H&H Considerations

The FM 1485 channel improvement from FM-1485 to the Caney Creek confluence was modeled in the HEC-RAS model for the San Jacinto River basin. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

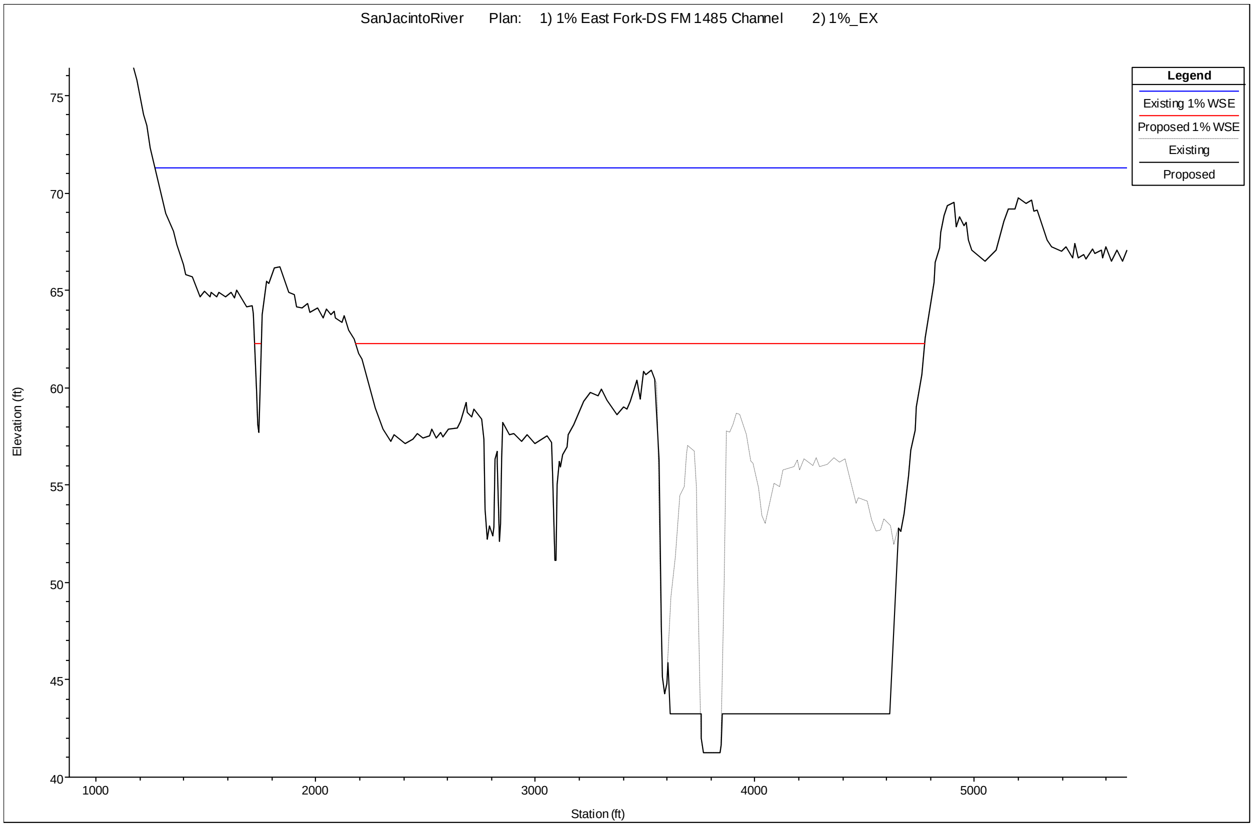


Figure 80. Cross Section Example of Channelization on Peach Creek

Table 125 summarizes the reduction in peak water surface elevations at key locations through the extent of the channel improvements.

Table 125: East Fork SJR H&H Modeling Summary – FM 1485 Channel Improvements

Location	Reduction in Water Surface Elevation (feet)			
	10% ACE	**2% ACE**	**1% ACE**	**0.2% ACE**
FM-1485	3.2	4.6	4.8	5.7
Caney Creek Confluence	1.3	1.7	1.8	2.0

The channel improvement will provide a reduction in water surface elevations along the East Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 4.2 feet from upstream of FM 1485 to the Caney Creek confluence.

5.5.4.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to approximately the existing conditions 10% ACE water surface elevations for a length of approximately 4.3 miles. The increase in channel capacity reduces the 1% ACE water surface elevation by at least 0.5-feet for 10.4 miles along the East Fork with a maximum water surface reduction of 11.6 feet just downstream of the FM-1485.

By increasing the channel capacity, the proposed improvement removes 318 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 727. Most of the benefits would be realized near FM 1485. The net present value of benefits based on a 50-year project life within the watershed is approximately $26.4M. The distribution of benefits between watersheds and counties is shown below.

Table 126: FM 1485 Channelization Benefits Summary ($M)

Watershed	Benefits ($M)			
	Harris County	**Liberty County**	**Montgomery County**	**Total**
East Fork	14.2	0.0	7.5	**21.8**
Caney	4.7	0.0	0.0	**4.6**
Total	**18.9**	**0.0**	**7.5**	**26.4**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in Table 127**.**

Table 127: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Stanley Rd/Old Chapel Rd	0.00	0.2% ACE	No Change
Dodge-Oakhurst Rd	0.00	0.2% ACE	No Change
US-190	0.00	0.2% ACE	No Change
Guinea Rd	0.00	50% ACE	No Change
Jenkins Rd	0.01	10% ACE	No Change
FM-945/RR-2	0.00	20% ACE	No Change
TX-150/FM-1375	0.00	2% ACE	No Change
Cold Springs Oil Field Rd	0.00	4% ACE	No Change
Lower Vann Rd	0.00	20% ACE	No Change
FM-945	0.00	10% ACE	No Change
CR-388/Bridge Rd	-0.04	20% ACE	No Change
BNSF Railroad	-0.07	4% ACE	No Change
TX-105/W Southline St	-0.48	1% ACE	2% ACE
TX-105	0.07	0.2% ACE	No Change
I-69	0.22	1% ACE	No Change
Union Pacific Railroad	0.11	2% ACE	No Change
FM-2090	0.24	10% ACE	No Change
FM-1485	4.81	2% ACE	1% ACE

The proposed channel improvements do not provide regional benefit outside the East Fork San Jacinto watershed.

5.5.4.4 Real Estate

166 parcels would need to be acquired for the total of 671 acres of additional right-of-way is required. The majority of the required area currently lies within the 1% ACE floodplain.

5.5.4.5 Relocations

Pipelines and visible electric lines were identified within the extents of the proposed channel. Most of the utilities are buried but may need relocation depending on location and depth. Additional buried utilities could potentially be within the channel extents; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 128.**

Table 128: East Fork Benching at FM 1485 Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Utility	7-inch Oil Pipeline	Mustang	0.2 miles	Highly Volatile Liquid
Utility	11-inch Oil Pipeline	Mustang	0.2 miles	Highly Volatile Liquid
Utility	13-inch Gas Pipeline	Kinder Morgan Texas	0.3 miles	Natural Gas
Utility	13-inch Oil Pipeline	Enterprise Products Operating	0.1 miles	Highly Volatile Liquid
Utility	20-inch Oil Pipeline	Enterprise Products Operating	0.5 miles	Highly Volatile Liquid

5.5.4.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 286 acres of potential wetlands within the footprint of the proposed channel improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

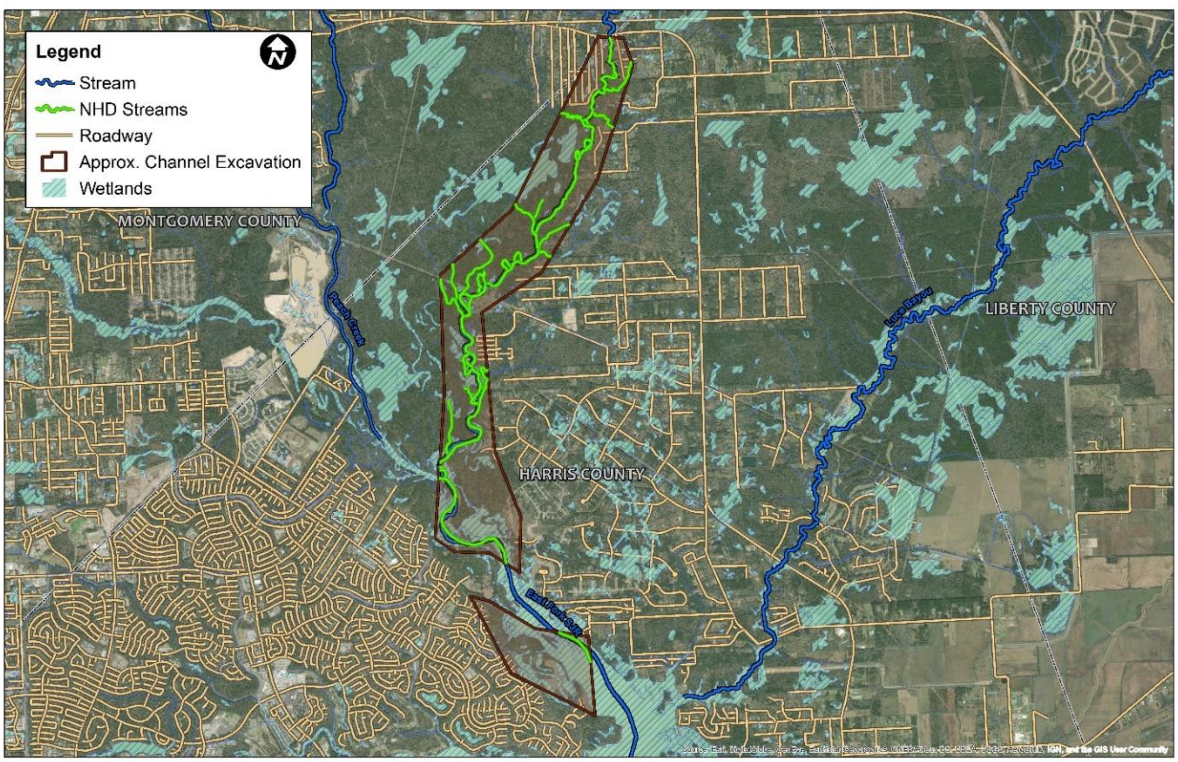


Figure 81: East Fork Winters Bayou–Nebletts Creek Dam Detail

5.5.4.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed channel improvement. Regular mowing of the channel, maintenance of the access road, inspection, maintenance of the outfall structure, and repair will be required throughout the life of the project. Annualized maintenance costs for the channel improvements are estimated at approximately $885,000 based on an assumed annual mowing and maintenance cost of $400 per acre for the benched channel area and $1,200 per acre for the sloped area down to the bench. This cost is not included in the overall OPCC.

5.5.4.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 129**. The approximate cost of the channel improvement is $340M. The BCR for the project based on the calculated benefits is 0.08.

Table 129. Estimated Cost and Benefit-Cost Ratio (BCR)—FM 1485 to Luce Bayou Channelization on East Fork SJR

Item	Cost
Construction	$243 M
Design	$29 M
Environmental	$36 M
Right-of-Way	$32 M
TOTAL	**$340 M**
BCR:	**0.08**
20-Year Escalation	**$515 M**

5.5.4.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in Spring Creek tributary to the San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- TxDOT – The proposed project improves the level of service for one TxDOT operated roadways in the watershed and could be a potential funding partner for any of the aspects of the project.
- City of Houston – The proposed project has a slight reduction in water surface elevations in East Fork of the San Jacinto River within Houston's city limits, just north of Lake Houston. The City

could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.5.5 East Fork Recommendation

The project team recommends construction of the Winters Bayou Dam which provides effectiveness in reducing flood damages through the upper portion of the East Fork San Jacinto River.

5.5.5.1 Description

The project team recommends construction of the Winters Bayou Dam which provides effectiveness in reducing flood damages through the upper portion of the East Fork San Jacinto River. The section that describes the individual alternative in detail is listed below. The location of the proposed dam is shown in **Figure 82**.

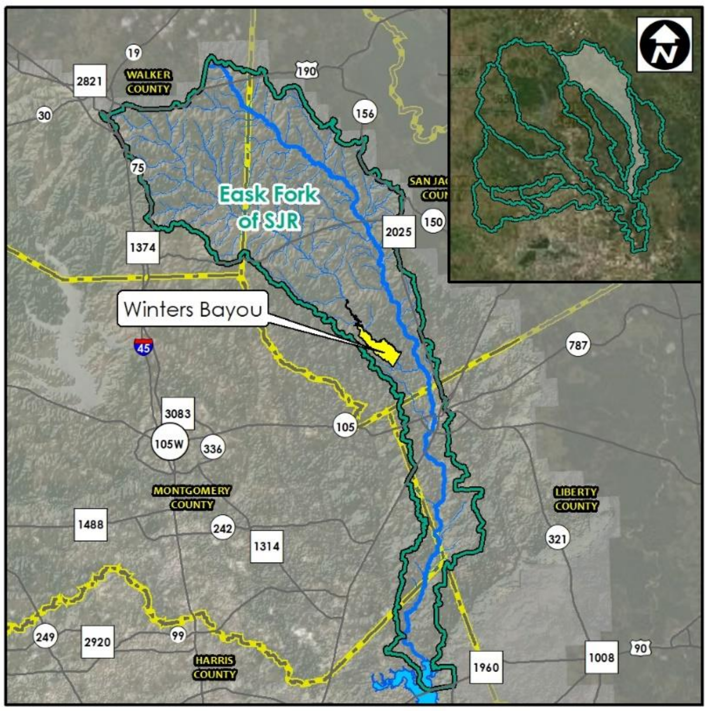


Figure 82: East Fork Recommended Alternatives

5.5.5.2 H&H Considerations

A summary of the proposed dam and channel improvement alternatives is shown in **Table 130**. The dam alternative was modeled in HEC-HMS. Flow data from the proposed HEC-HMS model was combined with the existing HEC-RAS geometry to arrive at a comprehensive model for the Spring Creek watershed.

Table 130: Detention Summary – 1% ACE

Alternative	Peak Inflow (cfs)	Peak Outflow (cfs)	Storage Volume (ac-ft)	Peak WSEL
Winters Bayou Dam	39,102	14,273	45,055	175.0’

The detention basin on Winters Bayou provides significant reduction in water surface elevations and flows on the East Fork. The average water surface elevation reduction through key locations along the East Fork is summarized in **Table 131**.

Table 131: Average Reduction in Water Surface Elevation

Location	Frequency Event			
	10% ACE	2% ACE	1% ACE	0.2% ACE
Winters Bayou – CR 388	0.7’	1.7’	2.1’	2.8’
CR 388 – TX-105	1.0’	2.4’	2.6’	2.9’
TX-105 – FM-1485	1.3’	2.2’	2.6’	3.3’

5.5.5.3 Project Benefits

By reducing flows from Winters Bayou, the proposed improvements remove 615 structures from the 1% ACE floodplain and provide a potential reduction in flooding instances of 1,334. Benefits are realized on the entirety of the East Fork downstream of Winters Bayou. The net present value of benefits based on a 50-year project life within the watershed is approximately $63.5M. The distribution of these benefits along the East Fork and the downstream end of the West Fork is shown in **Figure 83**. The project shows direct benefit downstream of the East Fork in Lake Houston with reductions of approximately 0.4 feet in the 1% ACE event.

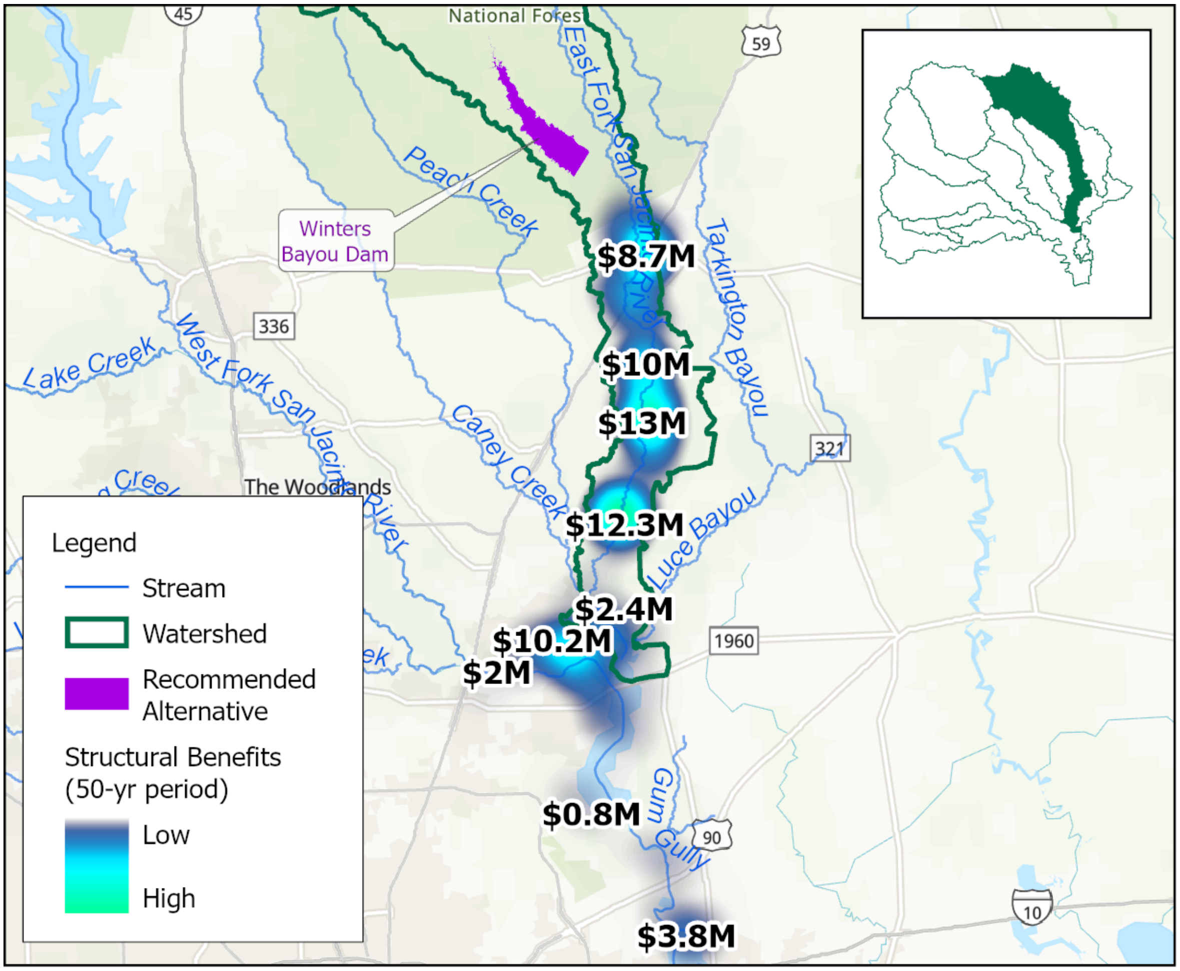


Figure 83: East Fork Benefits – Recommended Alternative

5.5.5.4 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 132**. The approximate costs range from \$134 M to \$167 M depending on the ROW acquired. The structural BCR for the project based on the calculated benefits ranges from 0.38 to 0.47.

Table 132: East Fork Recommended Alternative Estimated Cost and BCR

Item	Winters Bayou Dam
Construction	\$74 M
Design	\$9 M
Environmental	\$7 M
Right-of-Way	\$45 – 77 M
TOTAL COST	**\$134 - \$167 M**
TOTAL BENEFIT	**\$63.5 M**
BCR:	**0.38 – 0.47**
20-Year Escalation	**\$204 M - \$252 M**

5.6 West Fork San Jacinto River

The preliminary volume analysis showed that storage mitigation would not be as effective along the West Fork. However, the West Fork has several damage centers that could benefit from channelization projects. Four channel projects were proposed to target damages near SH 242 and I-69.

5.6.1 River Plantation Channelization

5.6.1.1 Description/Specifications

The Upper West Fork channel improvements is one of two options that were explored in the upper watershed to reduce flood risk in the River Plantation damage center. The proposed improvement is located on West Fork, from I45 to the midpoint between SH 242 and SH 99. The location of the proposed channel improvement is within Montgomery County and is shown in **Figure 84**.

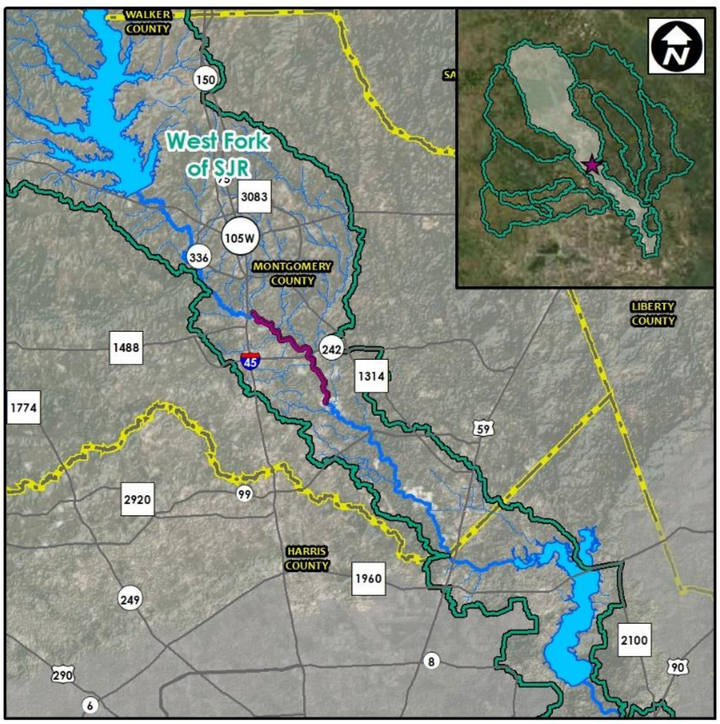


Figure 84: Upper West Fork benching from I-45 past SH 242

Several sites within the watershed were initially screened as potential channel improvement locations. The site from I45 to SH 242 was chosen based on the proximity to the large damage center along the West Fork.

The goal of the channel improvement is to reduce flooding in the West Fork watershed by widening a 9.3-mile-long stretch to increase conveyance capacity of West Fork in order to lower the water surface elevation. The improvements are planned to widen the West Fork with a 500-foot bench located 2-feet above the normal flow elevation. This would require 6.17 million cubic yards of excavation over a surface area of 560 acres.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 13,100 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing one of the recommended detention alternatives on Lake Creek. Refer to **Appendix H: Implementation** for details.

5.6.1.2 H&H Considerations

The Upper West Fork channel improvement near River Plantation was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The channel was widened to 500ft from I45 to the midpoint between SH 242 and SH 99. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

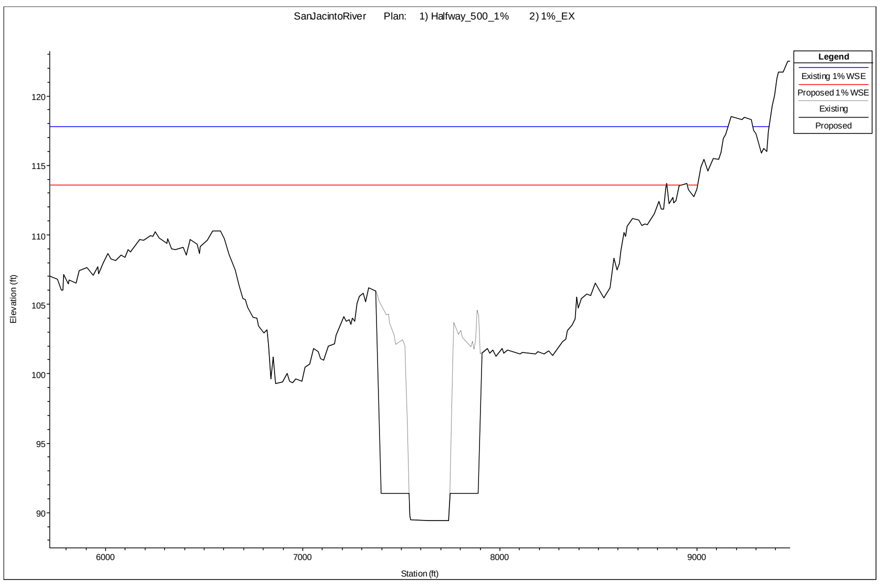


Figure 85: Representative Cross Section of Benching

The channel improvement will provide a reduction in water surface elevations along the West Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.4 feet from I45 to SH-242.

5.6.1.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 2% ACE and 4% ACE water surface elevations for a length of approximately 8.5 miles. The proposed improvements reduce the 1% ACE water surface elevations by at 0.5 feet for 12.6 miles along the West Fork, with a maximum water surface elevation reduction of 4.1 feet near River Plantation.

By reducing the flows downstream, the basin removes 383 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,016. Most of the benefits would be realized in the River Plantation area. The net present value of benefits based on a 50-year project life within the watershed is approximately $44.4M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 133: River Plantation Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	-7.1	51.5	**44.4**

The project does improve the level of service for one roadway. The proposed channel improvements do not show any significant benefit outside of the West Fork watershed.

Table 134: Roadway Benefits

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Highway 105	0.00	1% ACE	No Change
FM 2854	0.00	10% ACE	No Change
Timber Rock RR	0.00	0.2% ACE	No Change
I-45 N	1.38	1% ACE	No Change
I-45 Railroad	1.75	2% ACE	No Change
Lazy River Rd	3.88	1% ACE	0.2% ACE
SH 99	-0.12	1% ACE	No Change
I-69	-0.08	1% ACE	No Change
Southern Pacific RR	-0.07	4% ACE	No Change
West Lake Houston Parkway	-0.07	1% ACE	No Change
FM 1960	-0.07	0.2% ACE	No Change
Union Pacific Railroad	-0.07	1% ACE	No Change
Southern Pacific RR	-0.09	1% ACE	No Change
Beaumont Highway	-0.08	2% ACE	No Change
Hwy 90	-0.12	0.2% ACE	No Change
Union Pacific RR	-0.11	4% ACE	No Change

5.6.1.4 Real Estate

212 parcels would need to be acquired for a total of 367 acres if purchased below the 1% ACE water surface elevation. All parcels required are currently private property.

The proposed channel improvements could potentially impact land protected by the Bayou Land Conservancy (BLC). Coordination with the BLC will be required to finalize the location of the improvements. The specific locations impacted are listed below.

- West Fork San Jacinto Preserve

5.6.1.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.1 miles of bridge are located within the channel widening area and may need relocation or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 135.**

Table 135: West Fork SJR 500' Channelization at I-45 Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Roadway	SH 242	TX DOT	0.1 miles	2-lane highway bridge
Utility	6" Pipeline	Energy Transfer	500 feet	Natural Gas
Utility	30" Pipeline	Gulf South Pipeline	500 feet	Natural Gas
Utility	8" Pipeline	Enterprise Crude	500 feet	Crude Oil
Utility	8" Pipeline	Genesis	500 feet	Crude Oil
Utility	4.5" Pipeline	Exxon Mobil	500 feet	Refined Liquid Product
Utility	3.5" Pipeline	Exxon Mobil	500 feet	Refined Liquid Product

5.6.1.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 228 acres of potential wetlands within the footprint of the proposed improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

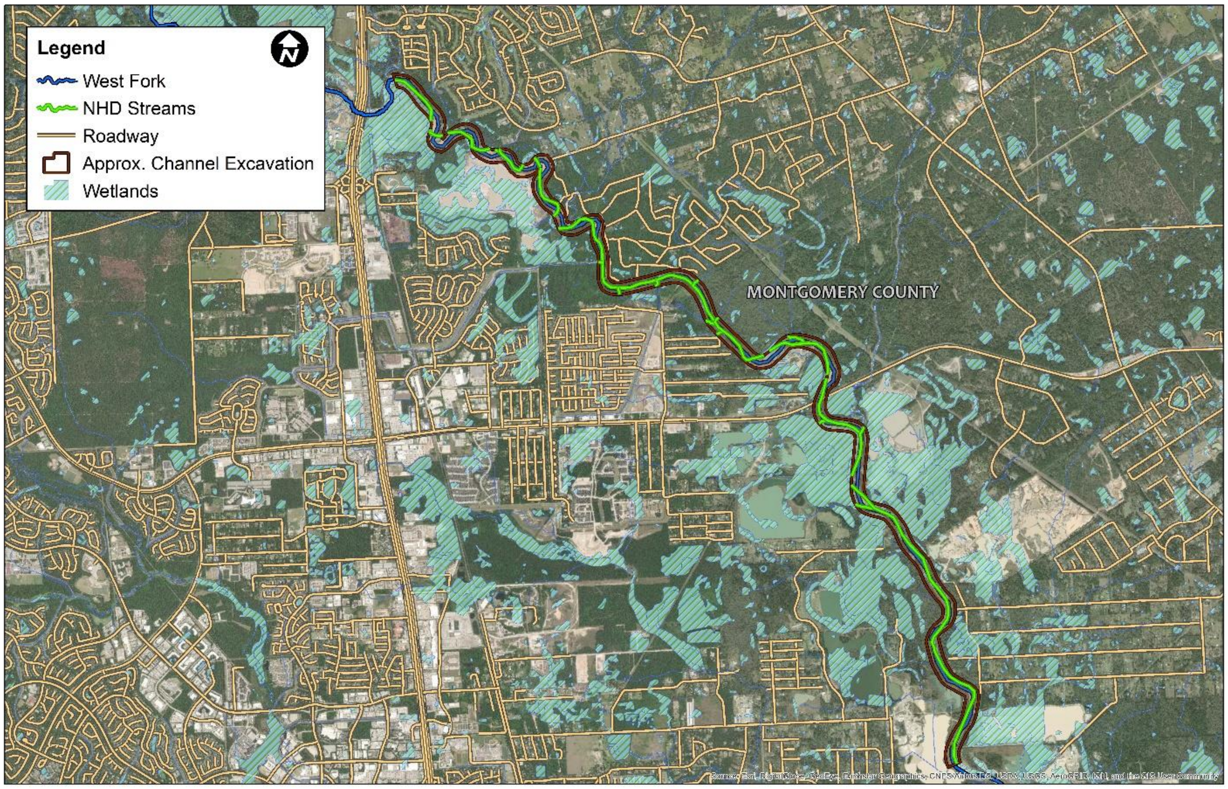


Figure 86: West Fork SJR at I-45 500' Channel Excavation Maximum Footprint

5.6.1.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed channel improvements. Regular mowing of the channel and repair will be required throughout the life of the dam and basin. Annualized maintenance costs for the dam are estimated at $600,000.

5.6.1.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 136**. The approximate cost is estimated at $187M. The BCR for the project based on the calculated benefits is estimated at 0.24.

Table 136. Estimated Cost and Benefit-Cost Ratio (BCR)—500' Channelization on West Fork SJR

Item	Cost
Construction	$126 M
Design	$15 M
Environmental	$32 M
Right-of-Way	$14 M
TOTAL	**$187 M**
BCR:	**0.24**
20-Year Escalation	**$283 M**

5.6.1.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.6.2 Highway 242 Channelization

5.6.2.1 Description/Specifications

The majority of damage centers in the West Fork watershed are located in the southern half of the watershed. The Upper West Fork channel improvements is one of two options that were explored in the upper watershed to reduce flood risk in the River Plantation damage center within Montgomery County. The proposed improvement is located on West Fork, from I45 to SH 242. The location of the proposed channel improvement is shown in **Figure 87**.

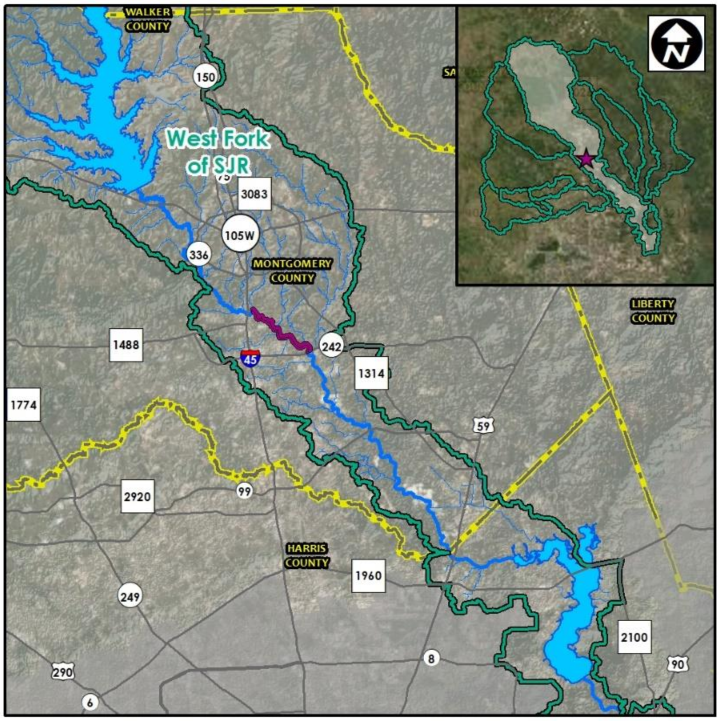


Figure 87: Upper West Fork SJR Benching from I-45 to SH 242

Several sites within the watershed were initially screened as potential channel improvement locations. The site from I45 to SH 242 was chosen due to proximity to the River Plantation damage center.

The goal of the channel improvement is to reduce flooding in the West Fork watershed by widening a 5.7-mile-long stretch to increase conveyance capacity of West Fork in order to lower the water surface elevation. The improvements are planned to widen the West Fork to 750-feet with a 2-foot bench above the stream bed. This would require 5.73 million cubic yards of excavation over a surface area of 520 acres.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 12,400 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing one of the recommended detention alternatives on Lake Creek or Spring Creek. Refer to **Appendix H: Implementation** for details.

5.6.2.2 H&H Considerations

The Upper West Fork channel improvement near River Plantation was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The channel was widened to 750-feet wide from I45 to SH 242. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

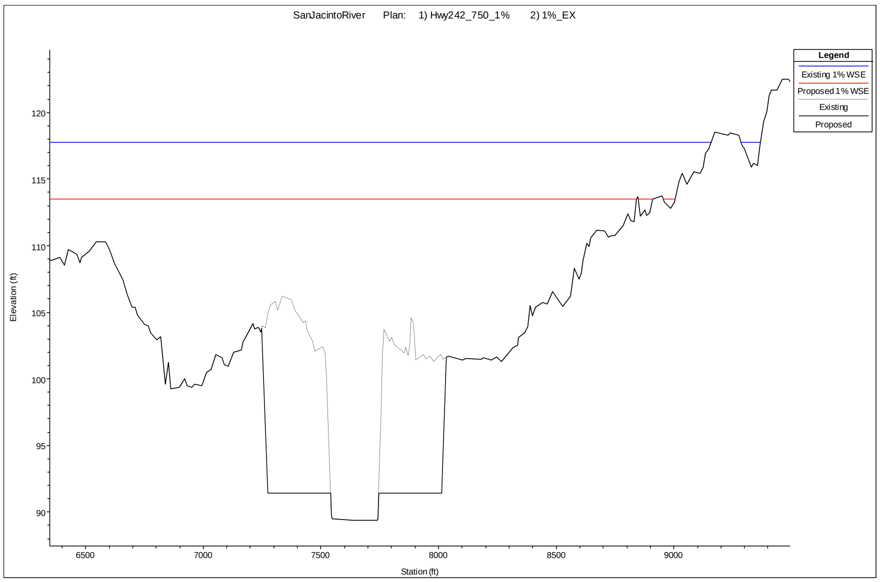


Figure 88: Representative Cross Section of Benching

The channel improvement will provide a reduction in water surface elevations along the West Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.5 feet from I-45 to SH-242.

5.6.2.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 2% ACE and 4% ACE water surface elevations for a length of approximately 4.7 miles. The proposed improvements reduce the 1% ACE water surface elevations by at 0.5 feet for 9.1 miles along the West Fork, with a maximum water surface elevation reduction of 3.3 feet between I-45 and SH-242. The 1% ACE water surface elevation is reduced on average by 3.5 feet over the extent of the improvement.

By reducing the flows downstream, the basin removes 383 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,004. Most of the benefits would be realized in the River Plantation area. The net present value of benefits based on a 50-year project life within the watershed is approximately $45.4M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 137: Highway 242 Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	-5.7	51.1	**45.4**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 138**.

Table 138: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Highway 105	0.00	1% ACE	No Change
FM 2854	0.00	10% ACE	No Change
Timber Rock RR	0.00	0.2% ACE	No Change
I-45 N	2.34	1% ACE	No Change
I-45 Railroad	3.04	2% ACE	1% ACE
Lazy River Rd	-0.06	1% ACE	No Change
99 Grand Parkway	0.07	1% ACE	No Change
I-69	-0.41	1% ACE	No Change
Southern Pacific RR	-0.17	4% ACE	No Change
West Lake Houston Parkway	-0.85	1% ACE	2% ACE
FM 1960	-0.11	0.2% ACE	No Change
Union Pacific Railroad	-0.06	1% ACE	No Change
Southern Pacific RR	-1.59	1% ACE	No Change
Beaumont Highway	0.02	2% ACE	No Change
Hwy 90	0.04	0.2% ACE	No Change
Union Pacific RR	0.28	4% ACE	No Change

The proposed detention facility does not show any significant benefit outside of the West Fork watershed.

5.6.2.4 Real Estate

225 parcels would need to be acquired for a total of 369 acres if purchased below the 1% ACE water surface elevation. All parcels required are currently private property.

The proposed channel improvements could potentially impact land protected by the Bayou Land Conservancy (BLC). Coordination with the BLC will be required to finalize the location of the improvements. The specific locations impacted are listed below.

- West Fork San Jacinto Preserve

5.6.2.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 0.1 miles of bridge are located within the channel widening area and may need relocation or raising. Additional buried utilities could potentially be within the detention footprint; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 139**.

Table 139: West Fork SJR 750' Channelization at I-45 Potential Relocation Summary

Relocation Type	Name	Owner	Length	Notes
Roadway	SH 242	TX DOT	0.1 miles	2-lane highway bridge
Utility	6" Pipeline	Energy Transfer	750 feet	Natural Gas
Utility	30" Pipeline	Gulf South Pipeline	750 feet	Natural Gas
Utility	8" Pipeline	Enterprise Crude	750 feet	Crude Oil
Utility	8" Pipeline	Genesis	750 feet	Crude Oil
Utility	4.5" Pipeline	Exxon Mobil	750 feet	Refined Liquid Product
Utility	3.5" Pipeline	Exxon Mobil	750 feet	Refined Liquid Product

5.6.2.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 152 acres of potential wetlands within the footprint of the proposed improvement. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

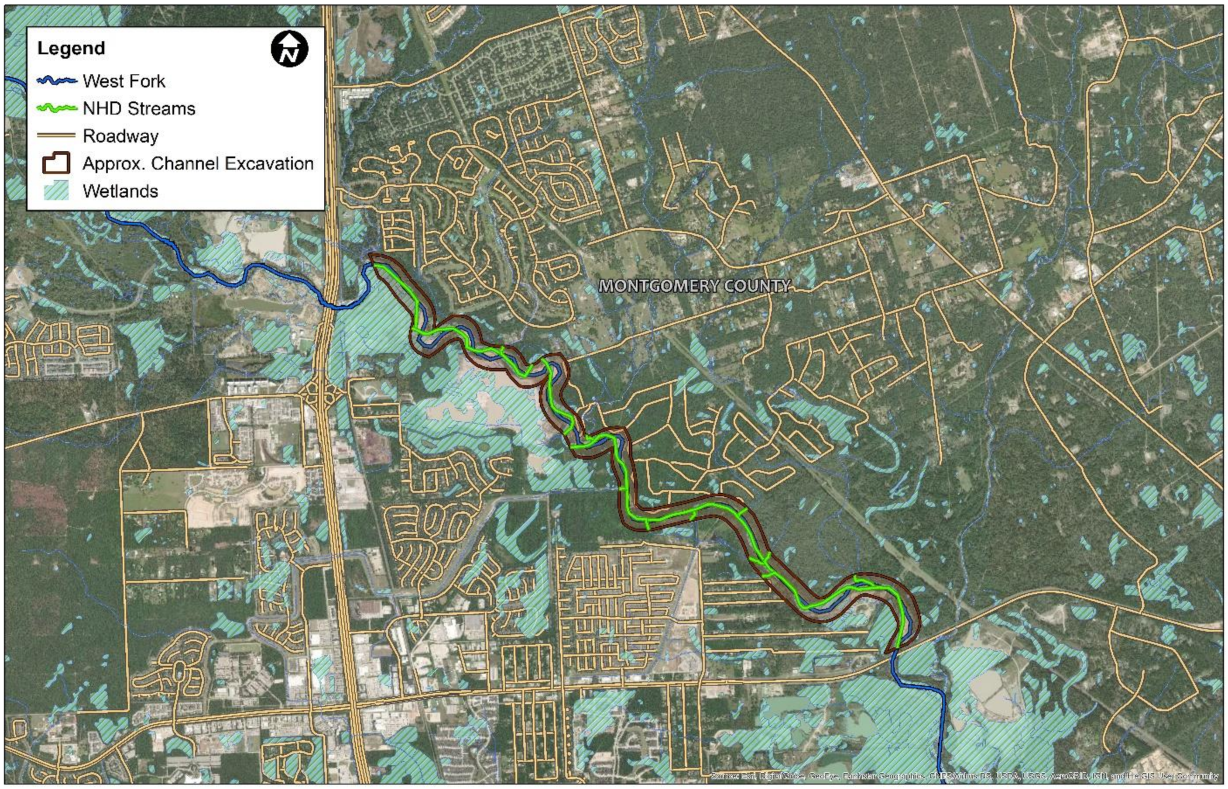


Figure 89: West Fork SJR at I-45 750' Channel Excavation Maximum Footprint

5.6.2.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the channel and repair will be required throughout the life of the channel to maximize channel capacity. Annualized maintenance costs for the dam are estimated at $550,000.

5.6.2.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 140**. The approximate cost is estimated at $157M. The BCR for the project based on the calculated benefits is estimated at 0.23.

Table 140. Estimated Cost and Benefit-Cost Ratio (BCR)—750' Channelization on West Fork SJR

Item	Cost
Construction	$110 M
Design	$13 M
Environmental	$22 M
Right-of-Way	$11 M
TOTAL	**$157 M**
BCR:	**0.29**
20-Year Escalation	**$238 M**

5.6.2.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Montgomery County – The project is located within Montgomery County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.

5.6.3 Kingwood Channelization

5.6.3.1 Description/Specifications

The West Fork channelization is one of the options explored in the middle watershed to reduce flood risk near the Kingwood area. The proposed channelization is located on the main stem of West Fork, between I-69 and West Lake Houston Parkway. The channelization is at the approximate middle portion of the West Fork watershed. The location of the propose channelization shown in **Figure 90**.

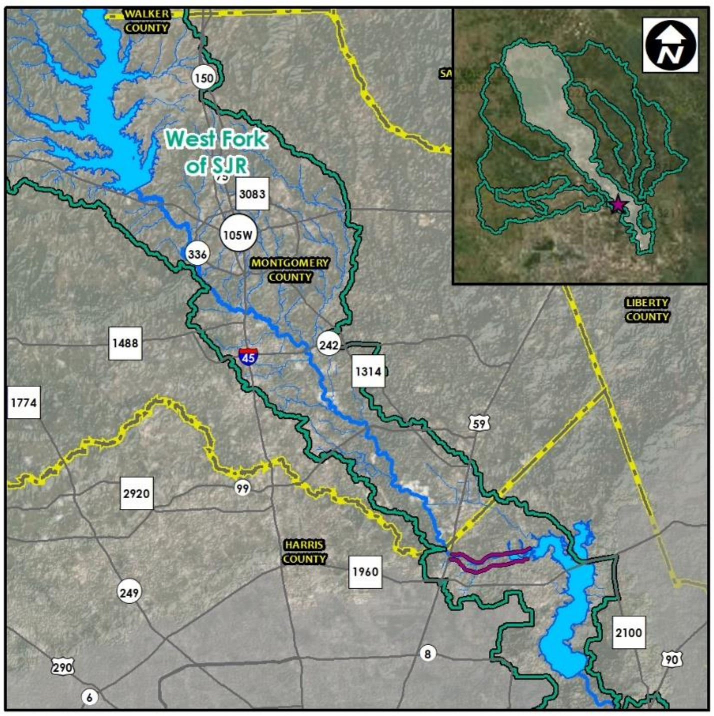


Figure 90: West Fork SJR Channelization Downstream of I-69

Several sites within the watershed were initially screened as potential channel improvement locations. The site from I-69 to West Lake Houston Parkway was chosen based on several factors, including its ability to reduce water surface elevations on the Kingwood area.

The goal of the channelization is to reduce flooding in the West Fork watershed by widening a 5-mile-long stretch to increase conveyance capacity of West Fork in order to lower the water surface elevation. The improvements are planned to widen West Fork to 3,000 feet starting 4 feet above the stream bed. It will require over 31 million cubic yards of excavation over a surface area of 1,700 acres.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 1,365 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing one of the recommended detention alternatives on Lake Creek or Spring Creek. Refer to **Appendix H** for details.

5.6.3.2 H&H Considerations

The West Fork channelization downstream of I-69 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The existing cross sections were improved with the channel modification option. The existing cross sections were improved with the channel modification option. The cross sections located between I-69 and West Lake Houston Parkway were modified by making the channel wider at a set elevation of 4 feet higher than the natural stream bed. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

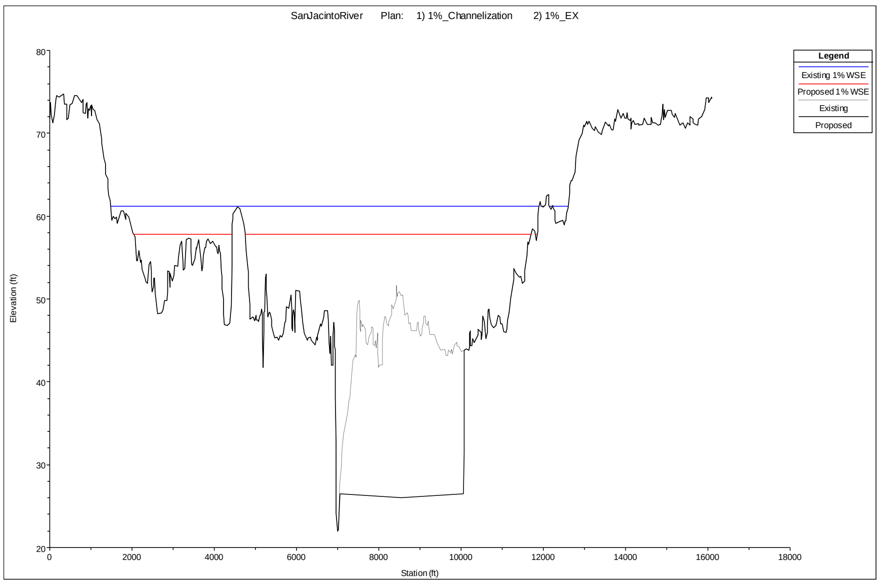


Figure 91. Cross Section Example of Channelization on West Fork

The channel improvement will provide a reduction in water surface elevations along the West Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 5.1 feet from the Spring Creek confluence to West Lake Houston Parkway.

5.6.3.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 2% ACE and 4% ACE water surface elevations for a length of approximately 6.5 miles. The proposed improvements reduce the 1% ACE water surface elevations by at 0.5 feet for 9.9 miles along the West Fork, with a maximum water surface elevation reduction of 8.1 feet just downstream of I-69. The 1% ACE water surface elevation is reduced on average by 4.0 feet over the extent of the improvement.

By reducing the flows downstream, the basin removes 895 structures from the 1% ACE floodplain and provides a potential reduction in flooding instances of 1,140. Most of the benefits would be realized in Kingwood, Atascocita, and Humble. The net present value of benefits based on a 50-year project life within the watershed is approximately $72.7M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 141: Kingwood Channelization Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	68.0	4.7	**72.7**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 142**.

Table 142: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Highway 105	0.00	1% ACE	No Change
FM 2854	0.00	10% ACE	No Change
Timber Rock RR	0.00	0.2% ACE	No Change
I-45 N	0.00	1% ACE	No Change
I-45 Railroad	0.00	2% ACE	No Change
Lazy River Rd	0.00	1% ACE	No Change
99 Grand Parkway	0.01	1% ACE	No Change
I-69	8.09	1% ACE	0.2% ACE
Southern Pacific RR	7.09	4% ACE	1% ACE
West Lake Houston Parkway	-0.17	1% ACE	1% ACE
FM 1960	-0.10	0.2% ACE	No Change
Union Pacific Railroad	-0.09	1% ACE	No Change
Southern Pacific RR	-0.11	1% ACE	No Change
Beaumont Highway	-0.10	2% ACE	No Change
Hwy 90	-0.14	0.2% ACE	No Change
Union Pacific RR	-0.13	4% ACE	No Change

The proposed channel improvement does not show any direct benefit at the Lake Houston dam.

5.6.3.4 Real Estate

737 parcels would need to be acquired for a total of 1,868 acres if purchased below the 1% ACE water surface elevation. All parcels required are currently private property.

5.6.3.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 5.1 miles of roadways are located within the preliminary channelization area and may need removal, relocation, or raising. Additional buried utilities could potentially be within the channel improvement; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 143**.

Table 143: West Fork SJR Channelization at I-69 Potential Relocation Summary

Relocation Type	Name	Owner	Length (miles)	Notes
Roadway	1st St	Harris County	0.33	1-lane asphalt road
Roadway	Aqua Vista Dr	Harris County	0.0002	1-lane asphalt road
Roadway	Belleau Wood	Harris County	0.52	1-lane asphalt road
Roadway	Lakelane Dr	Harris County	0.25	1-lane asphalt road
Roadway	Lakelane West Dr	Harris County	0.31	1-lane asphalt road
Roadway	Mirabeau Dr	Harris County	0.15	1-lane asphalt road
Roadway	Moonshine Hill Rd	Harris County	0.39	1-lane asphalt road
Roadway	N Houston Ave	Harris County	0.36	1-lane asphalt road
Roadway	Old River Rd	Harris County	0.31	1-lane asphalt road
Roadway	Rivercrest Dr	Harris County	0.29	1-lane asphalt road
Roadway	Silverline	Harris County	0.31	1-lane asphalt road
Roadway	Songbird Ln	Harris County	0.28	1-lane asphalt road
Roadway	Southshore Dr	Harris County	0.59	1-lane asphalt road
Roadway	Thelma Dr	Harris County	0.42	1-lane asphalt road
Roadway	Upper Lake Dr	Harris County	0.38	1-lane asphalt road
Roadway	White Deer Ln	Harris County	0.21	1-lane asphalt road
Utility	4.5-inch Crude Oil Pipeline	Shell Pipeline Company Lp	0.93	
Utility	2.88-inch Condensate Pipeline	Chevron U. S. A. Inc.	0.19	
Utility	2.88-inch Condensate Pipeline	Chevron U. S. A. Inc.	0.14	

5.6.3.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 948 acres of potential wetlands within the footprint of the proposed channelization and a potential 61,950 linear feet of NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

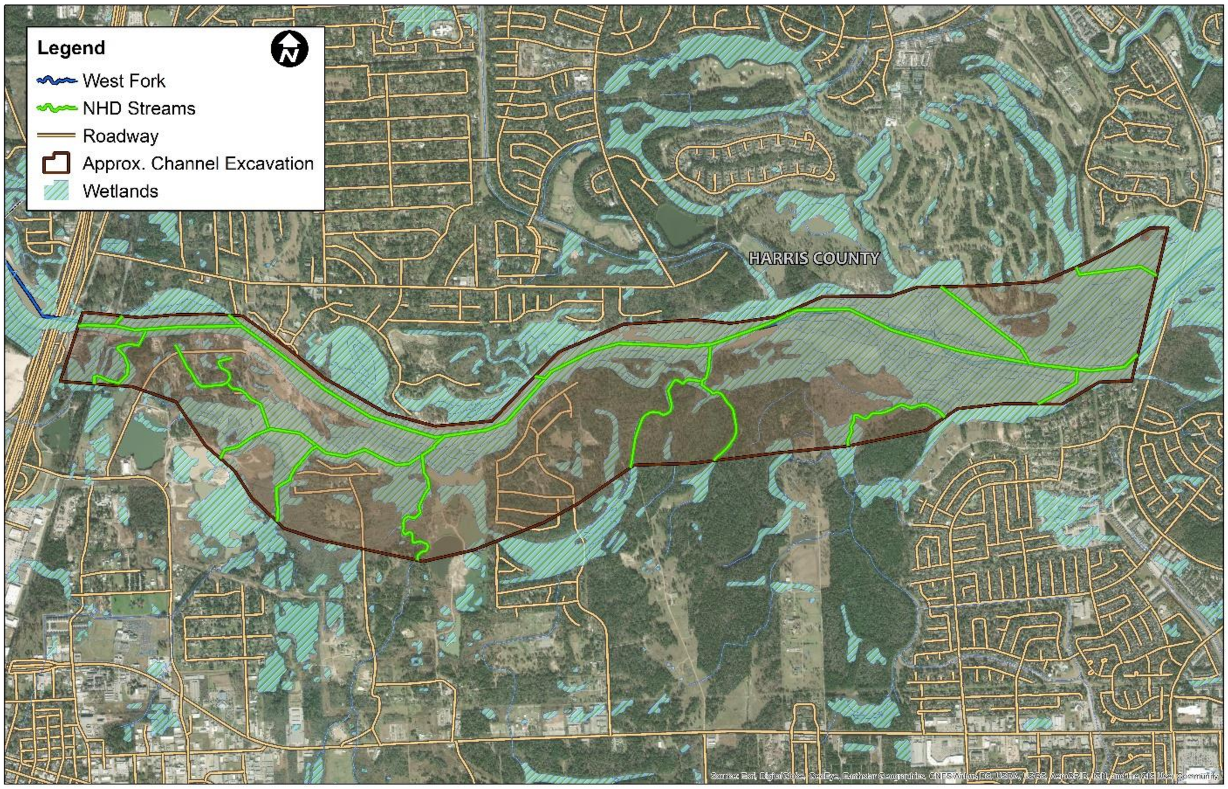


Figure 92: West Fork SJR at I-69 Channel Excavation Maximum Footprint

5.6.3.7 Operation and Maintenance

Regular operation and maintenance are required for the proposed detention basin. Regular mowing of the channel and repair will be required throughout the life of the channel to maximize channel capacity. This stretch of the West Fork is also subject to sedimentation from upstream rivers. Regular dredging may be needed to keep the channel free of sedimentation since the proposed channel is below the normal WSEL of Lake Houston. Annualized maintenance costs for the channel are estimated at $2,600,000.

5.6.3.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 144**. The approximate cost is $976M. The BCR for the project based on the calculated benefit is 0.07.

Table 144. Estimated Cost and Benefit-Cost Ratio (BCR)—Channelization at I-69 on West Fork SJR

Item	Cost
Construction	$534 M
Design	$64 M
Environmental	$354 M
Right-of-Way	$23 M
TOTAL	**$976 M**
BCR:	**0.07**
20-Year Escalation	**$1.5 B**

5.6.3.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Harris County – The project is located within Harris County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- City of Houston – The project is located within the City of Houston and would provide direct benefits to the residents. The City could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Montgomery County – While the project is not located within Montgomery County, there are benefits near the county line along Spring Creek and the West Fork. The County could serve as a project sponsor and potential funding partner.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.
- USACE – The US Army Corps of Engineers funds flood risk management civil works projects through congressional authorization and generally requires a benefit-cost ratio of greater than 1.0.

5.6.4 Kingwood Benching

5.6.4.1 Description/Specifications

The majority of damage centers in the West Fork watershed are located in the middle of the watershed. The West Fork benching is one of the options explored in the middle watershed to reduce flood risk downstream. The proposed benching is located on the main stem of West Fork, between I-69 and West Lake Houston Parkway. The benching is at the approximate middle portion of the West Fork watershed. The location of the propose detention shown in **Figure 93**.

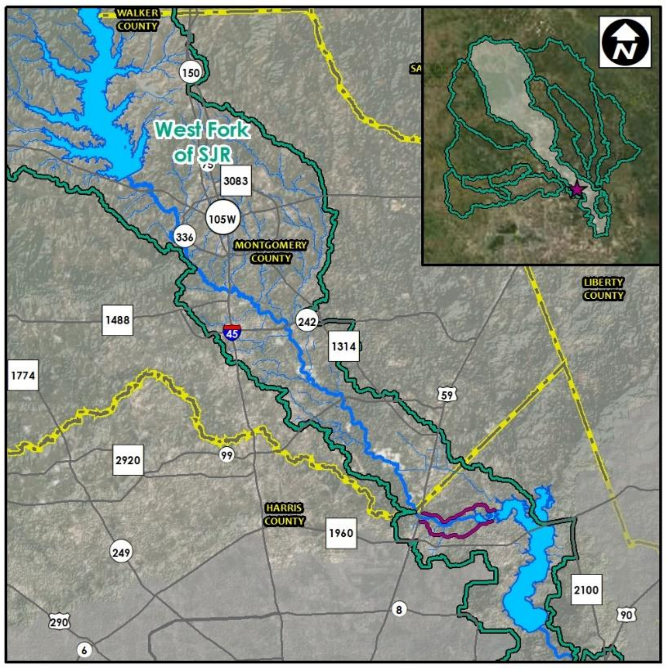


Figure 93: West Fork SJR Benching Downstream of I-69

Several sites within the watershed were initially screened as potential channel improvement locations. The site from I-69 to West Lake Houston Parkway was chosen based on several factors, including its ability to reduce water surface elevations on the Kingwood area.

The goal of the channel improvement is to reduce flooding in the West Fork watershed by widening a 5-mile-long stretch to increase conveyance capacity of West Fork in order to lower the water surface elevation. The improvements are planned to widen West Fork to 3,500 feet starting at the elevation of 42 feet. It will require over 30.5 million cubic yards of excavation over a surface area of 3,527 acres.

Channelization alternatives are likely to result in adverse downstream impacts if implemented individually. This is because channelization reduces floodplain storage along the reach and increases peak flow rates downstream. Therefore, compensatory storage must first be constructed upstream of each channelization alternative to avoid adverse downstream impacts. This channel alternative will require a minimum of approximately 923 ac-ft of detention volume upstream in order to mitigate increases to the 1% ACE flow rate downstream. This detention must be provided by first constructing one of the recommended detention alternatives on Lake Creek or Spring Creek. Refer to **Appendix H** for details.

5.6.4.2 H&H Considerations

The West Fork benching downstream of I-69 was modeled using the existing cross sections in the combined HEC-RAS model for the San Jacinto River basin. The existing cross sections were improved with the channel modification option. The existing cross sections were improved with the channel modification option. The cross sections located between I-69 and West Lake Houston Parkway were modified by making the channel wider at a set elevation of 42 feet. A typical comparison of the existing and proposed channel cross section is shown below. The existing water surface elevation at this example cross section is shown in blue, and the proposed condition water surface elevation is shown in red.

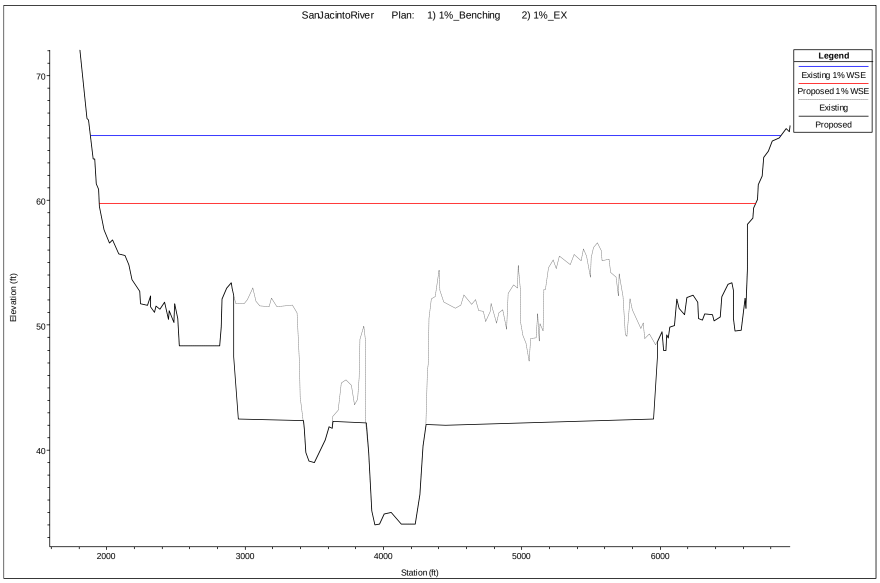


Figure 94: Cross Section Example of Benching on West Fork

The channel improvement will provide a reduction in water surface elevations along the West Fork for each of the design storm events. The 1% ACE water surface elevation is reduced on average by 3.7 feet from the Spring Creek confluence to West Lake Houston Parkway.

5.6.4.3 Project Benefits

The channel improvements reduce the 1% ACE existing conditions water surface elevations to the elevations between the existing conditions 2% ACE and 4% ACE water surface elevations for a length of approximately 4.1 miles. The proposed improvements reduce the 1% ACE water surface elevations by at 0.5 feet for 9.2 miles along the West Fork, with a maximum water surface elevation reduction of 5.5 feet just downstream of the Southern Pacific Railroad. The 1% ACE water surface elevation is reduced on average by 4.0 feet over the extent of the improvement.

By reducing the flows downstream, the basin removes 743 structures from the 1% ACE floodplain and provides a reduction in flooding instances of 963. Most of the benefits would be realized in Kingwood, Atascocita, and Humble. The net present value of benefits based on a 50-year project life within the watershed is approximately $60.5M. The project provides benefit to low-moderate income areas. The distribution of benefits between watersheds and counties is shown below.

Table 145: Kingwood Benching Benefits Summary ($M)

Watershed	Benefits ($M)		
	Harris County	Montgomery County	Total
West Fork	57.4	3.1	**60.5**

The project would also provide an increase in the level of service (LOS) of crossing roadways and railroads downstream of the dam. The roadways and improved LOS are summarized in **Table 146**.

Table 146: Improved Roadway Level of Service

Roadway	Reduction in 1% ACE WSE (ft)	Existing LOS	Proposed LOS
Highway 105	0.00	1% ACE	No Change
FM 2854	0.00	10% ACE	No Change
Timber Rock RR	0.00	0.2% ACE	No Change
I-45 N	0.00	1% ACE	No Change
I-45 Railroad	0.00	2% ACE	No Change
Lazy River Rd	0.00	1% ACE	No Change
99 Grand Parkway	0.00	1% ACE	No Change
I-59	4.20	1% ACE	0.2% ACE
Southern Pacific RR	3.75	4% ACE	2% ACE
West Lake Houston Parkway	-0.23	1% ACE	No Change
FM 1960	-0.07	0.2% ACE	No Change
Union Pacific Railroad	-0.06	1% ACE	No Change
Southern Pacific RR	-0.08	1% ACE	No Change
Beaumont Highway	-0.07	2% ACE	No Change
Hwy 90	-0.10	0.2% ACE	No Change
Union Pacific RR	-0.09	4% ACE	No Change

The proposed channel improvement does not show any direct benefit at the Lake Houston Dam.

5.6.4.4 Real Estate

1,301 parcels would need to be acquired for a total of 4,340 acres if purchased below the 1% ACE water surface elevation. All parcels required are currently private property.

5.6.4.5 Relocations

Pipelines and visible electric lines were identified within the footprint of the proposed pond. Most of the utilities are buried but may need relocation depending on location and depth. Approximately 9.9 miles of roadways are located within the preliminary benching area and may need removal, relocation, or raising. Additional buried utilities could potentially be within the channel improvement; however, subsurface utility investigation will need to be completed during the feasibility and preliminary engineering stages in order to make that determination. The list of known utilities and roadways are summarized in **Table 147**.

Table 147: West Fork SJR Benching at I-69 Potential Relocation Summary

Relocation Type	Name	Owner	Length (miles)	Notes
Roadway	1st St	Harris County	0.33	1-lane asphalt road
Roadway	Aqua Vista Dr	Harris County	0.35	1-lane asphalt road
Roadway	Belle Way Dr	Harris County	0.02	1-lane asphalt road
Roadway	Belleau Wood	Harris County	0.95	1-lane asphalt road
Roadway	Blair Ln	Harris County	0.16	1-lane asphalt road
Roadway	Blue Lake Dr	Harris County	0.15	1-lane asphalt road
Roadway	Coldwater Ln	Harris County	0.07	1-lane asphalt road
Roadway	Deer Run Dr	Harris County	0.11	1-lane asphalt road
Roadway	Forest Cove Dr	Harris County	0.29	1-lane asphalt road
Roadway	Hamblen Rd	Harris County	0.55	1-lane asphalt road
Roadway	Kelsey	Harris County	0.02	1-lane asphalt road
Roadway	Kelso	Harris County	0.09	1-lane asphalt road
Roadway	Lakelane Dr	Harris County	0.46	1-lane asphalt road
Roadway	Lakelane West Dr	Harris County	0.60	1-lane asphalt road
Roadway	Lakepoint Dr	Harris County	0.21	1-lane asphalt road
Roadway	Lakeshore Dr	Harris County	0.16	1-lane asphalt road
Roadway	Marina Dr	Harris County	0.28	1-lane asphalt road
Roadway	Mirabeau Dr	Harris County	0.15	1-lane asphalt road
Roadway	Moonshine Hill Rd	Harris County	0.54	1-lane asphalt road
Roadway	N Houston Ave	Harris County	0.36	1-lane asphalt road
Roadway	Old River Rd	Harris County	0.36	1-lane asphalt road
Roadway	River Bnd	Harris County	0.32	1-lane asphalt road
Roadway	Rivercrest Dr	Harris County	0.29	1-lane asphalt road
Roadway	Riviera Ln	Harris County	0.41	1-lane asphalt road
Roadway	Ross Rd	Harris County	0.08	1-lane asphalt road
Roadway	Silverline	Harris County	0.31	1-lane asphalt road
Roadway	Songbird Ln	Harris County	0.28	1-lane asphalt road
Roadway	Southshore Dr	Harris County	0.59	1-lane asphalt road
Roadway	Thelma Dr	Harris County	0.42	1-lane asphalt road
Roadway	Timberline	Harris County	0.23	1-lane asphalt road
Roadway	Timberline Pass	Harris County	0.09	1-lane asphalt road
Roadway	Upper Lake Dr	Harris County	0.38	1-lane asphalt road
Roadway	White Deer Ln	Harris County	0.21	1-lane asphalt road
Roadway	Woodland Hills Dr	Harris County	0.09	1-lane asphalt road
Utility	4.5-inch Crude Oil Pipeline	Shell Pipeline Company Lp	1.65	
Utility	4.5-inch Crude Oil Pipeline	Shell Pipeline Company Lp	0.63	
Utility	2.88-inch Condensate Pipeline	Chevron U. S. A. Inc.	0.88	
Utility	2.88-inch Condensate Pipeline	Chevron U. S. A. Inc.	0.80	

5.6.4.6 Environmental Mitigation

The desktop environmental analysis using NWI data shows 1,416 acres of potential wetlands within the footprint of the proposed benching. By benching the existing channel rather than full channelization, the project avoids any conflict with NHD streams. Both the affected wetlands and streams would have to be mitigated within the watershed by purchasing credits from agencies in the region or mitigating within the watershed. The extent, type and quality of impacted wetlands and streams will need to be determined as part of the feasibility and preliminary engineering.

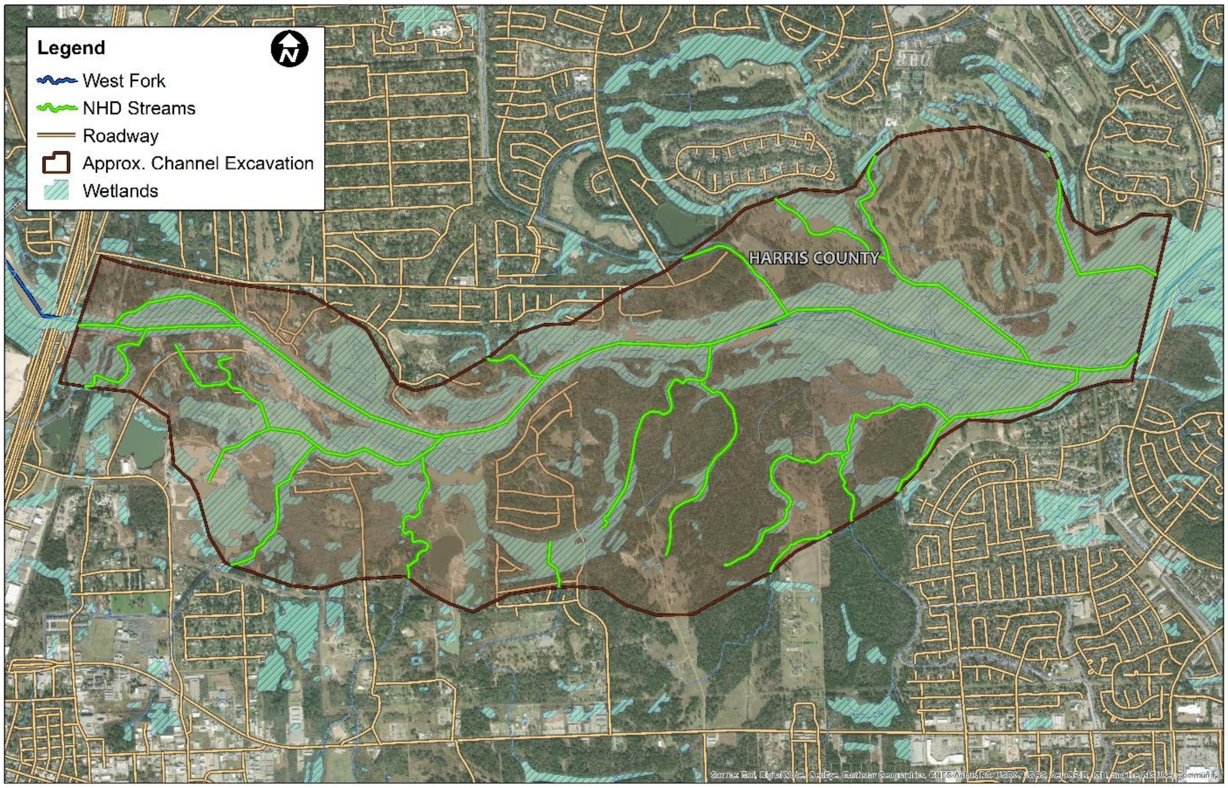


Figure 95: West Fork SJR at I-69 Benching Excavation Maximum Footprint

5.6.4.7 Operation and Maintenance

Regular operation and maintenance is required for the proposed detention basin. Regular mowing of the channel, repair will be required throughout the life of the channel. Annualized maintenance costs for the dam are estimated at $2,600,000.

5.6.4.8 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 148**. The approximate cost is $837M. The BCR for the project based on the calculated benefits is 0.07.

Table 148: West Fork Benching at Kingwood Estimated Cost and Benefit-Cost Ratio (BCR)

Item	Cost
Construction	$537 M
Design	$64 M
Environmental	$180 M
Right-of-Way	$56 M
TOTAL	**$837 M**
BCR:	**0.07**
20-Year Escalation	**$1.3 B**

5.6.4.9 Potential Partners

Potential partners are agencies or communities that could provide assistance in the implementation of the project. Once the project is completed, an agency will need to be determined to own and maintain the detention basin. Potential agencies partners include:

Sponsor Agencies

- Harris County – The project is located within Harris County and would provide direct benefits to the residents. The County could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- SJRA – The proposed project is within the jurisdiction of the SJRA. The SJRA could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- HCFCD – The proposed project has a slight reduction in water surface elevations in the East Fork San Jacinto River within Harris County. The district could assist in funding, maintenance, and right-of-way acquisition to purchase, construct, and maintain the detention facility.
- City of Houston - The project is located within the City of Houston and would provide direct benefits to the residents. The City could serve as a project sponsor to work with other agencies to pursue funding sources for acquiring land, construction, and maintenance of the facility.
- Montgomery County – While the project is not located within Montgomery County, there are benefits near the county line along Spring Creek and the West Fork. The County could serve as a project sponsor and potential funding partner.

Funding Agencies

- TWDB – The TWDB has low interest loans and grants available for planning, designing, and constructing flood mitigation projects throughout Texas. The TWDB could assist the local jurisdictions in funding the project.
- GLO – The General Land Office provides a funding mechanism for local jurisdictions to plan, design, and construct flood mitigation projects. Some of the watershed has Low to Moderate Income (LMI) areas which may help the project qualify for funding.
- USACE – The US Army Corps of Engineers funds flood risk management civil works projects through congressional authorization and generally requires a benefit-cost ratio of greater than 1.0.

5.6.5 West Fork Recommendation

5.6.5.1 Description/Specifications

Of the four alternatives for the West Fork San Jacinto River watershed analyzed in this study, the following combination channel improvement options are recommended for the West Fork. The section that describes each individual alternative in detail is also listed.

- River Plantation Channel – Section 5.6.1
- Kingwood Benching – Section 5.6.4

The location of the proposed extents of the channel improvements is shown in **Figure 96**.

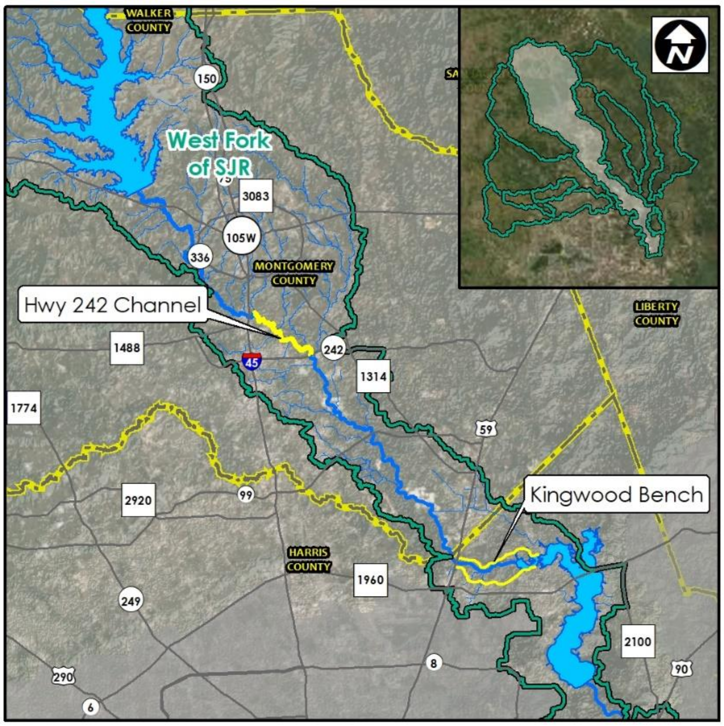


Figure 96: West Fork Recommended Alternatives

Each alternative was chosen based on several factors, including but not limited to, its ability to reduce water surface elevations in damage centers, availability of land for construction, and its benefit-cost ratio.

The goal of the recommended alternatives is to reduce flooding in the West Fork watershed by combining the benefits of two regions of channel improvement on the West Fork. While any combination of alternatives will be less efficient in reducing flood risk when compared to an individual alternative, this combination of alternatives performs well and provides significant benefit to the West Fork watershed.

5.6.5.2 H&H Considerations

A summary of the proposed channel improvement alternatives is shown in **Table 149**. The two channel improvement options were modeled in HEC-RAS. Flow data from the existing conditions HEC-HMS model was combined with the proposed HEC-RAS geometry to arrive at a comprehensive model for the West Fork watershed.

Table 149: Channel Improvement Summary

Alternative	Location	Improvement Length (mi)	Bench Width (ft)	Bench Height (ft)
River Plantation Channelization	IH-45 to DS SH 242	5.7	750	17
Kingwood Benching	I-69 to West Lake Houston Parkway	5	3,500	9

The combination channel improvements provide significant reduction in water surface elevations along the West Fork, generally localized to the extents of the channel improvements. The average reduction in water surface elevation along the West Fork is summarized in **Table 150**.

Table 150: Average Reduction in Water Surface Elevation – West Fork

Location	Frequency Event			
	10% ACE	2% ACE	1% ACE	0.2% ACE
I-45 to Lazy River Road	3.9	3.4	3.2	3.1
I-69 to West Lake Houston Parkway	2.3	2.8	2.8	3.1

5.6.5.3 Project Benefits

The combination of alternatives reduces the 1% ACE existing conditions water surface elevations to elevations between the existing conditions 2% ACE and 4% ACE within the extents of the channel improvements.

By increasing channel capacity in several areas, the proposed improvements remove 1,126 structures from the 1% ACE floodplain and provide a potential reduction in flooding instances of 2,011. Significant benefits are realized in the identified damages centers along the West Fork. These benefits are generally limited to the area of the proposed improvements. The net present value of benefits based on a 50-year project life within the watershed is approximately $107.7 M. The distribution of these benefits along West Fork is shown in **Figure 97**. The proposed improvements do not provide regional benefit outside the West Fork watershed.

The negative benefit values shown in the figure represent adverse downstream impact that would occur if the channel improvements were constructed without first constructing one of the detention projects along Lake Creek or Spring Creek. These detention projects must be constructed first to offset these potential downstream impacts, as discussed in **Sections 5.6.1**, **5.6.4**, and **Appendix H**.

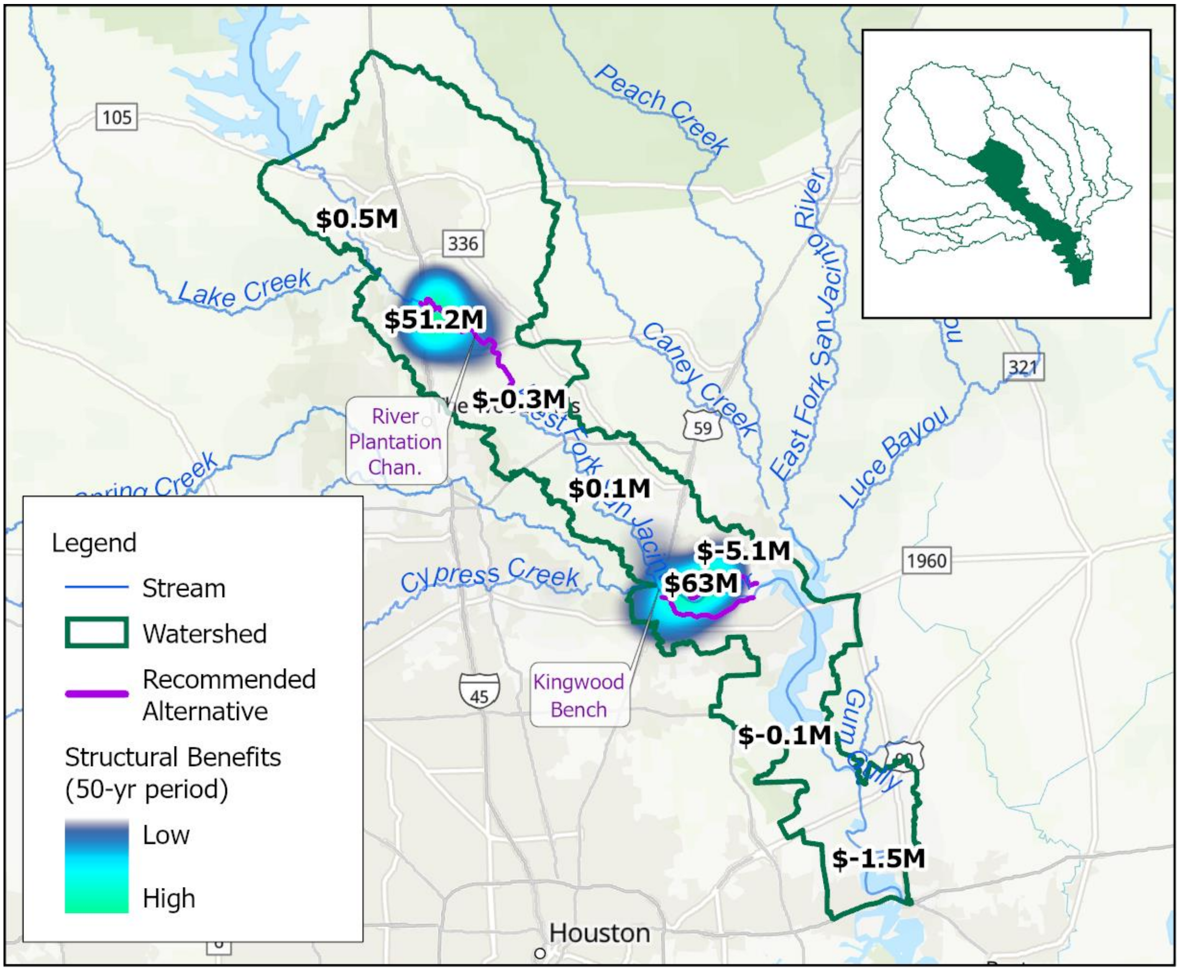


Figure 97: West Fork Overall Benefits

5.6.5.4 Estimated Costs and Benefit-Cost Ratio (BCR)

The preliminary cost estimates including design, construction, environmental mitigation, right-of-way and a 20-year escalation are summarized in **Table 151**. The approximate costs are $974 M. The structural BCR for the project based on the calculated benefits is 0.11.

Table 151: West Fork Combined Alternatives Estimated Cost and BCR

Item	Highway 242 Channelization	Kingwood Benching	Overall
Construction	$110 M	$537 M	$647 M
Design	$13 M	$64 M	$77 M
Environmental	$22 M	$180 M	$202 M
Right-of-Way	$11 M	$56 M	$67 M
TOTAL COST	**$157 M**	**$837 M**	**$994 M**
TOTAL BENEFIT	**$45.4 M**	**$60.5 M**	**$107.7 M**
BCR:	**0.29**	**0.07**	**0.11**
20-Year Escalation	**$238 M**	**$1.2 B**	**$1.4 B**

5.7 Overview of Alternatives

5.7.1 Summary of Alternatives Considered

The benefit, cost range, and benefit-cost ratio range of each alternative considered in the previous sections are summarized in the table below. The recommended alternatives are highlighted in blue. In this table, the benefits shown for each individual alternative includes all benefits from the project in the San Jacinto watershed. For example, the Spring Creek detention alternatives also benefit structures on Willow Creek, and the East Fork detention alternatives also benefit structures on the West Fork. The alternatives are shown in the figure below.

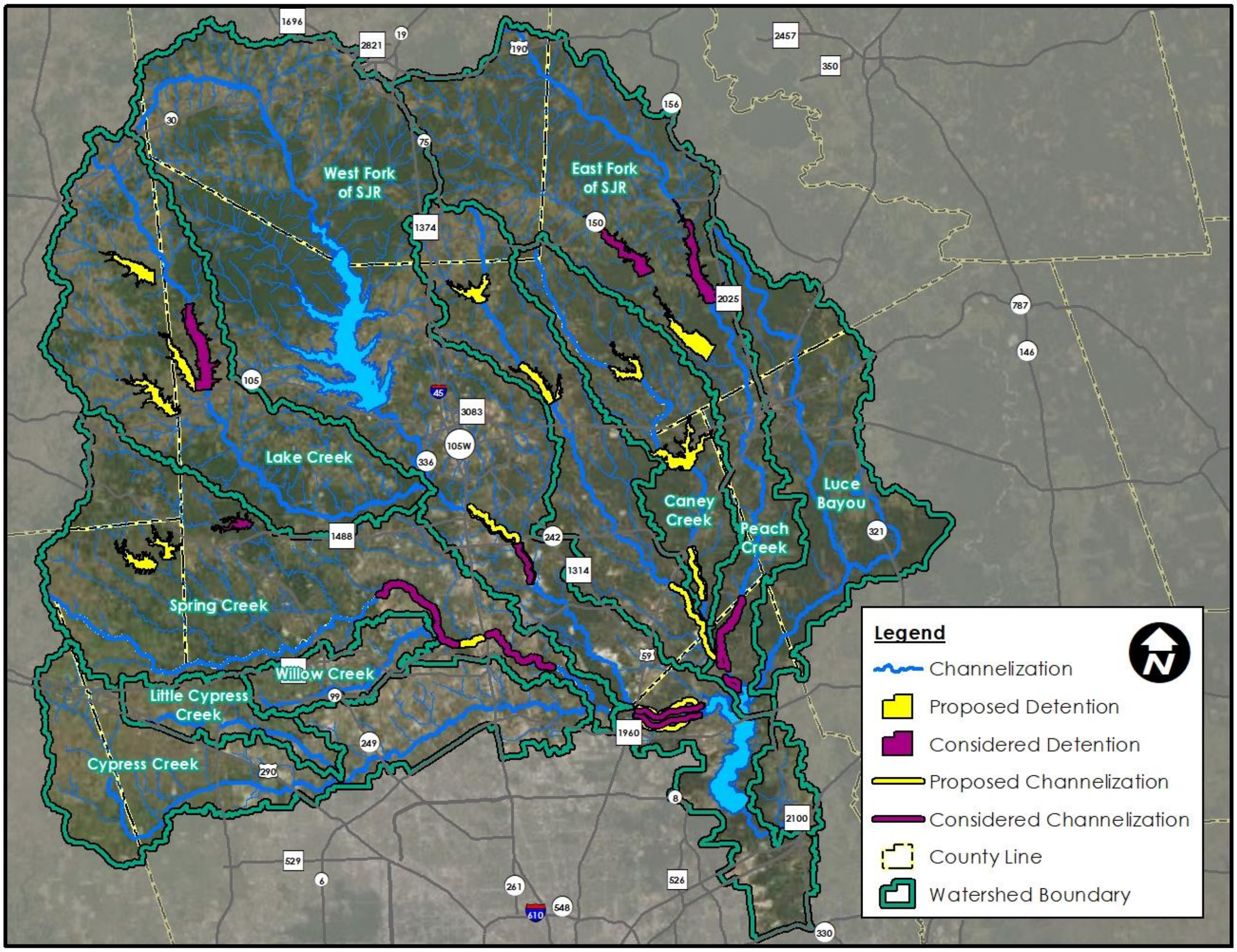


Figure 98: San Jacinto Regional Watershed Master Drainage Plan – Alternatives Considered

Note that the recommended channelization projects cannot be constructed without first constructing one of the recommended detention options upstream. This is reflected in the recommended implementation ranking discussed in **Appendix H**. The benefits of each individual channelization option listed in the table below are standalone net benefits reflecting channelization only.

Table 152: Summary of Alternatives Considered

Stream	Alternative	Damages ($M)	Benefit ($M)	Cost Range ($M)	Benefit-Cost Ratio Range
All	**Existing Conditions**	**1,979.2**		**-**	**-**
	Recommended Alts.	**1,247.9**	**731.3**	**2,913–3,288**	**0.22–0.25**
Spring Creek	**Walnut Creek Det.**	**1,878.0**	**101.2**	**97–132**	**0.77–1.04**
	Mill Creek Det.	1,914.1	65.1	99–131	0.50–0.66
	Birch Creek Det.	**1,913.2**	**66.0**	**80–120**	**0.55–0.83**
	Woodlands Chan. (500’)	1,931.1	48.1	149	0.32
	Woodlands Chan. (200’)	**1,944.5**	**34.7**	**56**	**0.62**
	I-45 Chan.	**1,879.8**	**99.4**	**85**	**1.17**
	Gosling Chan.	1,916.0	63.2	132	0.48
Lake Creek	**Caney Creek Det.**	**1,937.1**	**42.1**	**98–163**	**0.26–0.43**
	Little Caney Crk. Det.	**1,944.2**	**35.0**	**98–128**	**0.27–0.36**
	Garrett's Crk Det.	**1,939.4**	**39.8**	**107–131**	**0.31–0.37**
	Mainstem Det.	1,878.8	100.4	187–267	0.38–0.54
Peach Creek	**Det. at Walker**	**1,922.9**	**56.3**	**201–218**	**0.26–0.28**
	Det. at SH 105	**1,897.7**	**81.5**	**356–433**	**0.19–0.23**
	Chan. at I-69	**1,905.6**	**73.6**	**159**	**0.46**
Caney Creek	**Det. at FM 1097**	**1,951.5**	**27.7**	**105–131**	**0.21–0.26**
	Det. at SH 105	**1,924.0**	**55.2**	**114–149**	**0.37–0.48**
	Chan. at I-69	**1,921.8**	**57.4**	**189**	**0.30**
East Fork SJR	FM 945 Dam	1,927.3	51.9	146–166	0.31–0.36
	Winters Bayou Dam	**1,915.7**	**63.5**	**134–167**	**0.38–0.47**
	Winters-Nebletts Dam	1,921.9	57.3	131–181	0.32–0.44
	FM 1485 Chan.	1,952.8	26.4	340	0.08
West Fork SJR	**River Plantation Chan.**	**1,934.8**	**44.4**	**187**	**0.24**
	Highway 242 Chan.	1,933.8	45.4	157	0.29
	Kingwood Chan.	1,906.5	72.7	976	0.07
	Kingwood Bench	**1,918.7**	**60.5**	**837**	**0.07**

Table 153 summarizes the number of structures flooded in each frequency event, the number of instances of structural flooding over a 50-year period, the reduction in instances, and the total number of individual structures benefited. This data is provided for existing conditions, for the combined recommended alternatives scenario, and for each individual alternative. The recommended alternatives are again highlighted in blue.

Table 153: Alternative Summary – Structures Benefited

Stream	Alternative	Estimated Structures Flooded in Each Annual Chance Event					Estimated Instances of Structural Flooding (50-yr Period)	
		0.2%	1%	2%	4%	10%	Total	Reduction
All	**Existing Conditions**	41,153	16,235	8,559	4,430	1,557	37,044	-
	Recommended Alts.	28,211	9,137	5,068	2,607	953	22,580	14,464
Spring Creek	**Walnut Creek Det.**	**39,808**	**14,985**	**8,134**	**4,250**	**1,510**	**35,391**	**1,653**
	Mill Creek Det.	40,010	15,318	8,321	4,341	1,545	36,029	1,015
	Birch Creek Det.	**40,270**	**15,393**	**8,302**	**4,312**	**1,525**	**35,960**	**1,084**
	Woodlands Chan. (500')	40,546	16,030	8,447	4,381	1,524	36,268	776
	Woodlands Chan. (200')	**41,136**	**16,102**	**8,447**	**4,379**	**1,534**	**36,567**	**477**
	I-45 Chan.	**37,420**	**15,078**	**8,286**	**4,376**	**1,544**	**35,305**	**1,739**
	Gosling Chan.	40,542	15,655	8,394	4,344	1,517	36,053	991
Lake Creek	**Caney Creek Det.**	**40,755**	**15,895**	**8,373**	**4,333**	**1,531**	**36,358**	**686**
	Little Caney Crk. Det.	**40,836**	**15,974**	**8,405**	**4,355**	**1,533**	**36,480**	**564**
	Garrett's Creek Det.	**40,642**	**15,883**	**8,355**	**4,329**	**1,521**	**36,360**	**684**
	Mainstem Det.	39,869	15,280	8,142	4,211	1,493	35,350	1,694
Peach Creek	**Det. at Walker**	**41,026**	**15,997**	**8,324**	**4,291**	**1,453**	**35,971**	**1,073**
	Det. at SH 105	**40,983**	**15,895**	**8,142**	**4,168**	**1,408**	**35,276**	**1,768**
	Chan. at I-69	**40,874**	**15,817**	**8,146**	**4,111**	**1,378**	**35,164**	**1,880**
Caney Creek	**Det. at FM 1097**	**40,703**	**15,943**	**8,303**	**4,299**	**1,536**	**36,261**	**783**
	Det. at SH 105	**40,405**	**15,550**	**8,063**	**4,156**	**1,505**	**35,448**	**1,596**
	Chan. at I-69	**40,914**	**15,705**	**8,158**	**4,260**	**1,509**	**35,922**	**1,122**
East Fork	Det. at FM 945	40,799	15,659	8,271	4,270	1,502	35,935	1,109
	Winters Bayou Dam	**40,559**	**15,611**	**8,204**	**4,227**	**1,496**	**35,710**	**1,334**
	Winters-Nebletts Dam	40,670	15,686	8,259	4,239	1,497	35,829	1,215
	FM 1485 Chan.	40,821	15,941	8,391	4,331	1,533	36,317	727
West Fork	**River Plantation Chan.**	**40,389**	**15,858**	**8,359**	**4,234**	**1,531**	**36,028**	**1,016**
	Highway 242 Chan.	40,247	15,857	8,357	4,258	1,529	36,040	1,004
	Kingwood Chan.	40,852	15,302	8,194	4,301	1,522	35,904	1,140
	Kingwood Bench	**40,905**	**15,406**	**8,197**	**4,312**	**1,520**	**36,081**	**963**

5.7.2 Combined Benefit of Recommended Alternatives

The recommended projects were combined into an overall San Jacinto River Master Plan model to determine the total watershed benefit of the master plan implementation. The table below documents the combined structural benefit of implementing all recommended alternatives in the watershed. In this table, the benefits reported are only the benefits located along that particular stream. For example, the individual alternatives table indicates that the individual East Fork Winters Bayou Dam would yield $63.5M in structural benefit, but the combined alternatives table below shows $50.1M in benefits on the East Fork alone. This is because the $63.5M in structural benefit provided by the East Fork Winters Bayou Dam also includes some structural benefit along the West Fork.

In addition, the table below shows that the combined alternatives yield a total structural benefit of $731.3M, which is lower than the sum of the structural benefits of each individual project. As each project is constructed, the incremental benefit of each new project is slightly decreased compared to its individual benefit. This is because, as flood depths continue to decrease at any given structure, the incremental benefit to that structure also decreases. The first few inches of flood reduction yield more benefit than the last few inches.

The combined benefit of these alternatives include in residual benefits to other streams without proposed alternatives, such as Willow Creek, Cypress Creek, Little Cypress Creek, and Luce and Tarkington Bayou. The benefits here accrue because of decreases in tailwater (the water surface elevation at the downstream end of the reach) that propagate upstream.

The figure below maps the distribution of the recommended alternatives' benefits across the watershed.

Table 154: Watershed Benefits for Recommended Alternatives

Stream	Existing Structural Damages (50-yr Period) ($M)	Recommended Alternatives Structural Damages (50-yr Period) ($M)	Structural Benefit (50-yr Period) ($M)	Cost Range ($M)
Spring Creek	339.3	117.3	222.0	314–389
Willow Creek	119.1	101.4	17.7	–
Cypress Creek	373.1	372.0	1.1	–
Little Cypress Creek	196.6	196.6	0.0	–
East Fork SJR	128.2	78.1	50.1	134–167
West Fork SJR	396.7	197.2	199.5	966
Lake Creek	16.5	4.5	12.0	303–422
Peach Creek	163.5	32.9	130.6	718–812
Caney Creek	140.9	43.4	97.5	478–533
Luce Bayou	20.0	19.2	0.8	–
Tarkington Bayou	75.1	75.0	0.1	–
Jackson Bayou	3.9	3.9	0.0	–
Gum Gully	6.3	6.3	0.0	–
Total	**1,979.2**	**1,247.9**	**731.3**	**2,913–3,288**

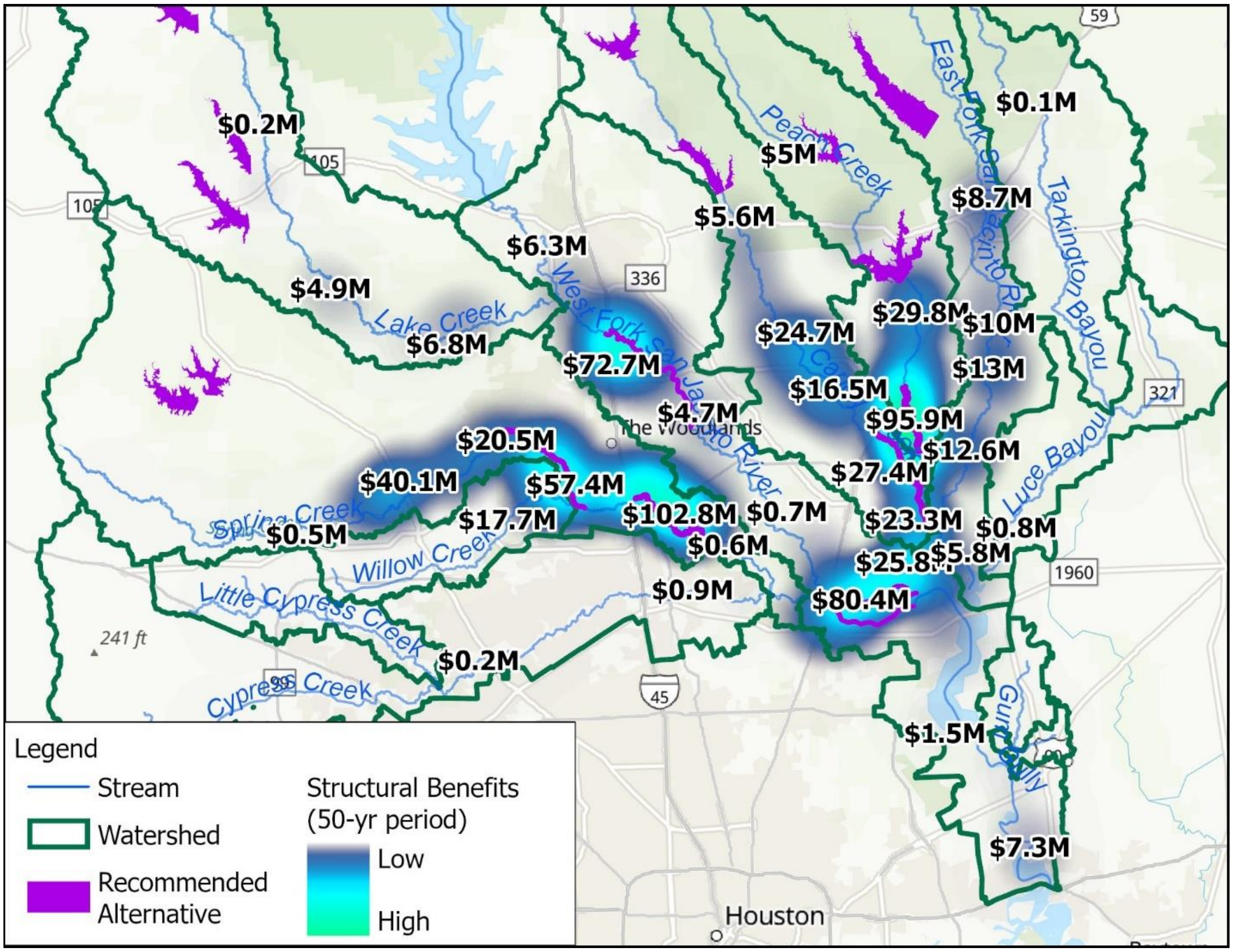


Figure 99. Combined Alternatives Benefits (50-Year Period)

5.7.3 Upper San Jacinto River Benefits

The recommended alternatives provide sizeable detention basins in five separate watersheds aimed at lowering flows downstream. These are prevalent in the upper portions of the watersheds where higher relative benefits may be achieved with lower storage volumes. In addition, there are also channel improvement areas in most of the watersheds that address specific damage areas. Based on the combined recommended alternatives modeling, there are significant expected WSEL reductions at various points throughout the San Jacinto Basin. Along the West Fork, WSEL reductions range from 1.7' at SH-99 to 6' and 5' at IH-45 and I-69, respectively as shown in **Table 155**. These are significant reductions that will reduce flood risk to a high percentage of structures. Along the East Fork, reductions range from nearly 10' at the Peach/Caney confluence to nearly 3' at the East Fork/Caney confluence. However, as previously discussed, the reductions within the Lake Houston zone of influence are somewhat limited since the improvements do not appreciably change the elevations in Lake Houston.

Table 155: Water Surface Elevation Reductions for Recommended Alternatives

Location	1% ACE WSEL Reductions (ft) – Combined Recommendations
Caney Creek at Peach Creek Confluence	-9.7
East Fork at Caney Creek Confluence	-2.8
West Fork at Lake Creek Confluence	-2.4
West Fork at I-45	-5.9
West Fork at SH-99	-1.7
West Fork at Spring Creek Confluence	-4.8
West Fork at I-69	-5.1
West Fork at Lake Houston Pkwy*	-0.8
West Fork at East Fork Confluence*	-0.8
Lake Houston Dam*	-0.6

* WSEL at these locations is primarily influenced by Lake Houston Dam

The recommended alternatives provide significant benefits to the remainder of the watershed upstream of Lake Houston, including a 40% reduction in expected instances of flooding over a 50-year period throughout the entire watershed. More specific information includes:

- A 42% reduction in structures at risk of flooding during the 4% ACE storm
- A 41% reduction in structures at risk of flooding during the 2% ACE storm
- A 44% reduction in structures at risk of flooding during the 1% ACE storm
- A 33% reduction in structures at risk of flooding during the 0.2% ACE storm

The data provided above shows a high degree of improved protection up to the 1% ACE storm. The reduction in flood risk during the 0.2% ACE storm is less than the reduction during other storms. For context, the Atlas 14 0.2% ACE storm exceeds Hurricane Harvey levels by a noticeable margin. Given that, decision makers and the public should consider if that level of protection is reasonable.

5.7.4 Lake Houston Flood Reduction

This study does not include the evaluation of specific strategies aimed at lowering Lake Houston flood levels. As such, the modeling does not include any scenarios that analyze gate configuration, spillway options, or lowering of the normal pool elevation. Those strategies may be considered as part of separate study efforts. At a conceptual level, the storage needed in the upper basin to achieve target WSEL reductions in Lake Houston that would achieve flood reduction benefits in Kingwood (along the West Fork downstream of W. Lake Houston Pkwy and the East Fork downstream of the Caney Creek confluence). This storage does not consider the storage recommended for the master plan.

Three target volumes were considered and their resultant WSEL reductions. The evaluation was framed in terms of reducing the existing conditions 1% ACE WSEL to a lower existing conditions elevation, such as the 10% ACE, 4% ACE or 2% ACE. **Table 156** below provides the necessary storage volumes for each target reduction, as well as the approximate WSEL reduction at key locations along the lower reaches of the West Fork and the East Fork. As a point of reference, the Addicks Reservoir provides approximately 200,000 ac-ft of storage.

Table 156: Storage Volumes Needed Near Lake Houston

1% ACE Volume Needed to Achieve Lower WSEL (acre-feet)		
Target WSE	**West Fork (I-69)** [1]	**East Fork (Conf. w/ Caney)** [2]
10% ACE	520,000	270,000
4% ACE	280,000	150,000
2% ACE	90,000	60,000
Reductions in 1% ACE WSEL (ft)		
Target WSE	**West Fork (I-69)** [1]	**East Fork (Conf. w/ Caney)** [2]
10% ACE	9.0	6.5
4% ACE	5.5	4.5
2% ACE	2.5	2.2

The results in **Table 156** indicate that in order to achieve a WSEL reduction in Lake Houston equivalent to the existing conditions 10% ACE WSEL, approximately 520,000 ac-ft are needed in the West Fork Basin and 270,000 ac-ft in the East Fork Basin.

Buyouts of flood prone properties are another option for reducing flood risk in the Lake Houston area. This is discussed at a conceptual level in Section 6.2. This study did not complete a detailed investigation of this option or the implications of those buyouts from a benefit standpoint.

The projects as proposed in the report for the areas upstream of Lake Houston provide flood reduction benefits in the lower reaches of the West Fork and the East Fork. However, the projects do not completely reduce flood risk at Lake Houston due to the backwater effects of the dam. Modifications to the control structure may be necessary to reduce flood risk associated with Lake Houston. At the time of this report, the Coastal Water Authority was engaged in a study to evaluating improvements to the Lake Houston dam spillway.

6.0 Additional Regional Flood Reduction Measures

While the Primary Mitigation task primarily focuses on structural flood reduction projects, drainage policy has a significant role to play in mitigating current flood damages and avoiding future damages as the San Jacinto River Basin continues to develop. These policy considerations were not evaluated using detailed analysis and the recommendations are general in nature. Ultimately, it is up to individual jurisdictions to determine what policies should be applied to development and capital improvements, such that they avoid increasing flood risk in their jurisdictions as well as in neighboring jurisdictions. The modeling prepared as part of this study could be leveraged to perform more in-depth investigations of the implications of policy changes.

6.1 Floodplain Preservation

The hydrologic and unsteady hydraulic modeling prepared for the San Jacinto study was based on the most current rainfall and topographic information and accounts for conveyance as well as floodplain storage. As development occurs in the basin, there is the potential for fill in the floodplain to result in a loss of floodplain storage. This storage loss could have an impact on discharge rates and flood elevations. Even a small, seemingly negligible increase in developed area could result in significant cumulative changes to storage throughout the watershed.

The San Jacinto study did not evaluate fill scenarios and their resultant impacts because there are an infinite number of potential fill placement combinations. However, the study team has extensive experience with hydraulic modeling and are well versed on the impacts of floodplain storage loss on downstream hydrology. Many jurisdictions within the San Jacinto basin, including HCFCD, Harris County, and the City of Houston, have floodplain fill mitigation and No Adverse Impact policies in place. These policies help ensure that fill placement in the floodplain is not detrimental to other properties within the watershed.

The most effective way to avoid riverine flood damages is to avoid developing in floodplains. As such, implementing a policy of floodplain preservation would protect people and property by 1) avoiding development within the floodplain that increases the public's chance of flood risk and 2) preventing adverse impacts downstream caused by changes to floodplain storage. In addition, avoiding the streams and wetland areas often located in floodplains would protect valuable aquatic resources, improve biodiversity in the region, provide buffer for extreme climate patterns that the region has experienced and is likely to experience in the future, and contribute to the region's overall resiliency.

It cannot be overlooked that most of the property in these floodplains is privately owned and preventing the property owners from developing could result in legal challenges. As such, a floodplain preservation policy through acquisition is recommended where feasible. The Bayou Land Conservancy is another possibly option for landowners interested in granting conservation easements along bayous or streams. As a reference, the market value of the property located within the 1% ACE floodplain as defined in this study is approximately $3 billion based on county appraisal district data obtained from Harris County, Montgomery County, and TNRIS for areas outside Harris and Montgomery counties.

The study team recognizes that a floodplain preservation policy may be infeasible due to property acquisition costs or in areas that are already developed and have a limited amount of area to preserve. At a minimum, floodplain storage should be protected through policies such as the one that HCFCD has for floodplain fill mitigation. Current HCFCD and City of Houston criteria requires that all fill placed below the 0.2% ACE FEMA effective flood elevation be mitigated at a 1:1 ratio. In addition, fill placement should be modeled to ensure that there are no WSEL rises or increases in discharge rates as far downstream as possible. The San Jacinto study H&H models can evaluate changes all the way to IH-10, but smaller tributary models may only be able to be traced to their confluence with the receiving stream.

As maps are updated to reflect Atlas 14, Volume 11 rainfall depths, the mitigation required could potentially revert back to the 1% ACE flood elevations. The jurisdiction considering the policy will need to weigh the desired level of protection against the potential economic implications of more demanding mitigation requirements. Whatever the specific requirements, a policy that ensures that floodplain storage is maintained will help prevent additional flood damages as development occurs in the San Jacinto River basin.

6.2 Buyouts

The flood mitigation projects proposed in this memo are targeted toward reducing the number of structures at risk of flooding under large, infrequent storms (between the 10% ACE and 0.2% ACE events). For structures at risk of flooding under smaller, more frequent storms (between the 50% ACE and 20% ACE events), mitigating flood risk with detention or channelization projects is very costly. For these frequently flooded structures, acquiring the property and removing it from the floodplain and from potential flood risk is often the most cost-effective approach.

The scope of this project does not include identification of specific buyout projects. However, the tables below provide a count of structures flooded during the 20% ACE event under existing conditions in each watershed and county. These structures may be considered good candidates for buyouts due to the frequency of flooding. The decision to pursue buyouts for any of these structures will depend on several factors. First, this regional study assumes a 1-foot finished floor elevation (FFE) above existing grade at the centroid of each structure with some limited adjustments based on Google Street View imagery for the 50% ACE and 20% ACE structures. The 20% ACE structures identified in the tables below represent an estimate. Individual FFE surveys and updates to the BCA damage calculations should be conducted before pursuing buyouts. Second, care should be taken to avoid buying out a patchwork of individual structures in a neighborhood. Buying out a set of contiguous properties can remain cost-beneficial, help preserve the character of the neighborhood, and provide an opportunity for a community green space.

The benefit of acquiring a property and removing it from the floodplain is equal to the sum of the net present value of expected flooding damages over a 50-year period per FEMA standards. For this study, the presumed cost of acquiring and removing a structure is 2.5 times the property's market value. This cost does not include potential long-term maintenance costs. The market values are tax year 2019 values downloaded from Harris County Appraisal District, Montgomery County Appraisal District, and TNRIS. The benefit-cost ratio is therefore the existing damages divided by 2.5 times the property market value.

An estimate of reduced tax revenue is also provided for comparison purposes; this calculation is based on a 2% property tax assessed each year for 50 years and converted to net present value at a discount rate of 7%. This discount rate matches the rate used for FEMA benefit-cost calculations as required by the Office of Management and Budget.

Table 157. Buyout Candidates by Stream—Structures Flooding in 20% ACE Storm

Watershed	Structure Count	Existing Damages (NPV, 50-yr Period) ($M)	2019 Market Value ($M)	Buyout Cost (2.5× Mkt. Value) ($M)	Benefit-Cost Ratio	Reduced Tax Revenue (NPV, 50-yr Period)
Spring Creek	50	46.7	4.4	11.0	4.3	1.2
Willow Creek	60	29.9	9.6	24.5	1.2	2.7
Cypress Creek	62	69.9	16.8	42.1	1.7	4.6
Little Cypress Creek	41	31.0	6.1	15.4	2.0	1.7
East Fork SJR	61	36.5	5.5	13.8	2.6	1.5
West Fork SJR	54	40.3	6.4	16.0	2.5	1.8
Lake Creek	8	4.7	1.0	2.5	1.9	0.3
Peach Creek	108	59.5	8.7	21.7	2.7	2.4
Caney Creek	76	41.8	4.4	11.1	3.8	1.2
Luce Bayou	11	4.8	1.1	2.7	1.8	0.3
Tarkington Bayou	88	57.1	7.3	18.9	3.0	2.0
Jackson Bayou	1	1.5	0.2	0.5	2.9	0.1
Gum Gully	2	1.6	1.0	2.4	0.6	0.3
Totals	**622**	**$425.2**	**$73.1**	**$182.8**	**2.3**	**$20.2**

Table 158. Buyout Candidates by County—Structures Flooding in 20% ACE Storm

County	Structure Count	Existing Damages (NPV, 50-yr Period) ($M)	2019 Market Value ($M)	Buyout Cost (2.5× Mkt. Value) ($M)	Benefit-Cost Ratio	Reduced Tax Revenue (NPV, 50-yr Period)
Harris County	274	211.1	45.7	114.3	1.8	12.6
Liberty County	77	48.5	7.9	19.7	2.5	2.2
Montgomery County	208	124.5	15.1	37.8	3.3	4.2
San Jacinto County	63	41.1	4.4	11.0	3.7	1.2
Totals	**622**	**$425.2**	**$73.1**	**$182.8**	**2.3**	**$20.2**

6.3 Detention Policy

Many jurisdictions within the San Jacinto basin have detention policies in place to help offset increased runoff rates from development. As part of the H&H model development, the study team developed hydrology for both the existing and future development conditions. Both models included the assumption of detention within the hydrologic parameter calculations. A more detailed discussion of the future conditions methodology and findings is available in the *Future Flood Risk Assessment* in **Appendix E**.

This detention policy discussion should distinguish the local impacts of detention from the regional impacts. This study focuses on developing a long-term strategy for flood mitigation on a regional/basin level. The “regional detention basins” evaluated and recommended as part of the alternatives analysis are intended to address existing flooding and the associated damages, whereas detention policy is focused on mitigating increases due to future development. Detention has been demonstrated to be a valuable tool in the flood mitigation toolbox, both at a local and regional level.

With respect to the modeling completed with this study, Halff investigate the regional impact of detention policy by comparing the results of our existing conditions modeling to the future conditions modeling. The future conditions modeling utilized data from multiple sources to estimate population growth in the San Jacinto River basin. The data sources include:

- Texas Water Development Board (TWDB) population growth projections developed for the State Water Plan
- Harris Galveston Subsidence District (HGSD), Ft. Bend Subsidence District (FBSD), and Lone Star Groundwater Conservation District (LSGCD) population growth data from the Regional Groundwater Update Project (RGUP)

This data was used to identify the areas and rates of growth that are projected within the basin out to 2070. As discussed in the aforementioned memo, the study team leveraged this information to estimate changes in development and, subsequently, impervious cover, which has a direct impact on discharge rates and runoff volume. These projections determined that future development will largely remain concentrated around the existing "urban core" meaning that development will most likely occur around Conroe, the Woodlands, and in the Tomball area. The outlying areas are not predicted to see as much growth over the same 50-year horizon.

Given the growth assumptions used for the analysis, the 2070 modeling indicated that detention maintains existing conditions flow rates at a regional level. However, since detention does not offset impervious cover, development in the watershed will cause an increase in total runoff volume. Future conditions models show an increase in volume of about 1-2% compared to existing conditions and a small change in discharge rates. However, if development occurred in a pattern different than that of the data provided, the impact could be more pronounced. For example, full development could result in an increase in volume of greater than 5% across the basin and improving conveyance capacity in the outer part of the basin could speed up runoff resulting in higher discharge rates downstream.

As discussed above, the limited regional impact of detention policy does not diminish its substantial positive local impact. Allowing local development to go undetained could potentially result in additional sheet flow, overburdened storm sewer systems, higher water surface elevations in smaller streams that could exacerbate existing flood problems or create new ones, increased streambank erosion due to increased velocities, and increased runoff due to higher saturation within open channels and floodplains.

As the study area continues to develop, counties and municipalities are recommended to enforce detention policies that limit post-development runoff rates to pre-development runoff rates to protect downstream properties. Enforcing these local detention policies provides a significant local benefit to neighboring properties that could otherwise be harmed by more frequent flooding. However, the regional benefit miles downstream of these local detention facilities may be somewhat limited, as documented in the *Future Flood Risk Planning Assessment* in **Appendix E**. Downstream impact analyses should still be performed from the proposed development downstream to the next major confluence to confirm no adverse impacts to downstream peak flows.

Requiring local developments to substantially over-detain runoff below pre-development conditions or retain it onsite could theoretically provide more of a regional benefit. This would most likely require paying developers to provide additional detention capacity beyond the capacity required using current regulations. Administering this would require significant planning and coordination of hydrograph timing between hundreds or thousands of individual detention facilities. The facilities would be constructed over several decades as development occurs. It would be impractical to centrally coordinate and model these facilities to ensure meaningful reductions in flood risk throughout the watershed.

The study team recommends that local jurisdictions consider adopting and implementing the following:

- Local policies that require detention for new development and for capital improvements projects that increase conveyance.
- Requiring drainage analyses for development and capital improvement projects that demonstrate no adverse impact. These analyses should be performed for multiple storm events ranging from frequent (e.g. 50% ACE) to infrequent (1% ACE or lower) to ensure sufficient detention is provided. Analyses should be extended downstream to the next major stream confluence.
- Using common criteria when analyzing detention and floodplain analysis being mindful that runoff does not consider political boundaries.
- Consider public-private partnerships to construct regional detention facilities to accommodate new developments, as demonstrated by HCFCD’s Little Cypress Creek Frontier Program.

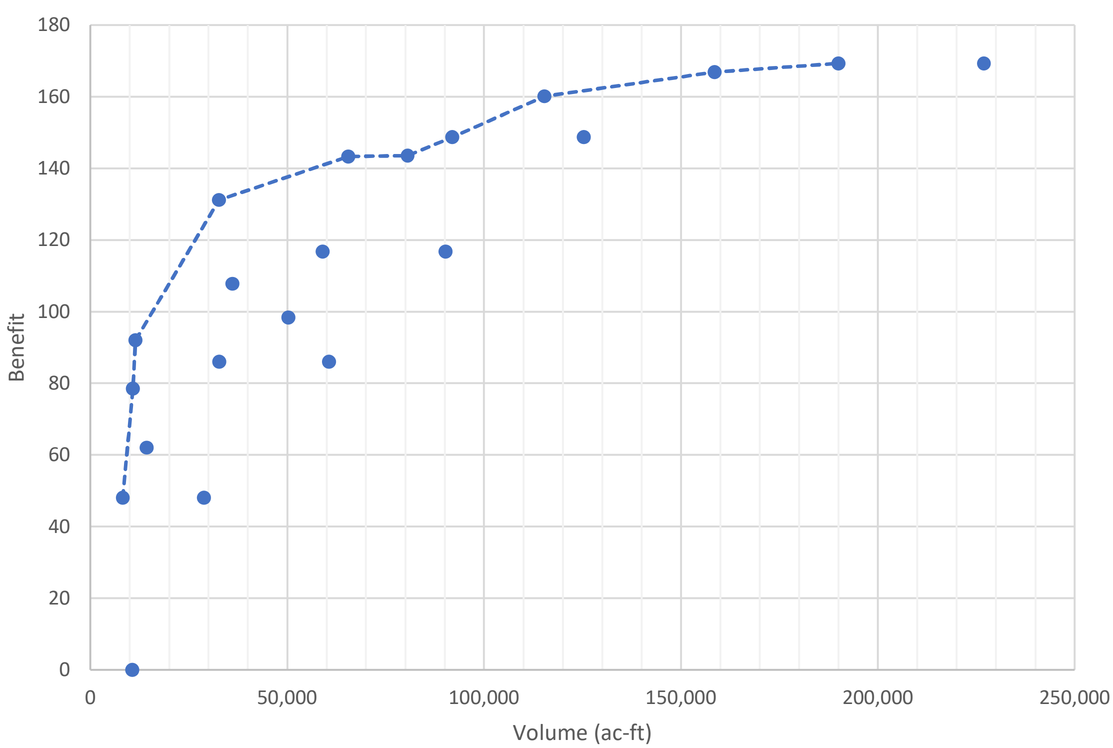
Appendix G.1

Damage Center Identification

Damage center: **DC_GLC_001** *Station range:* 62467 to 41880 *Mile range:* 11.8 to 7.9

Existing conditions	103	71	41	19	12	0	0	**169**	**Flood instances (50-yr)**

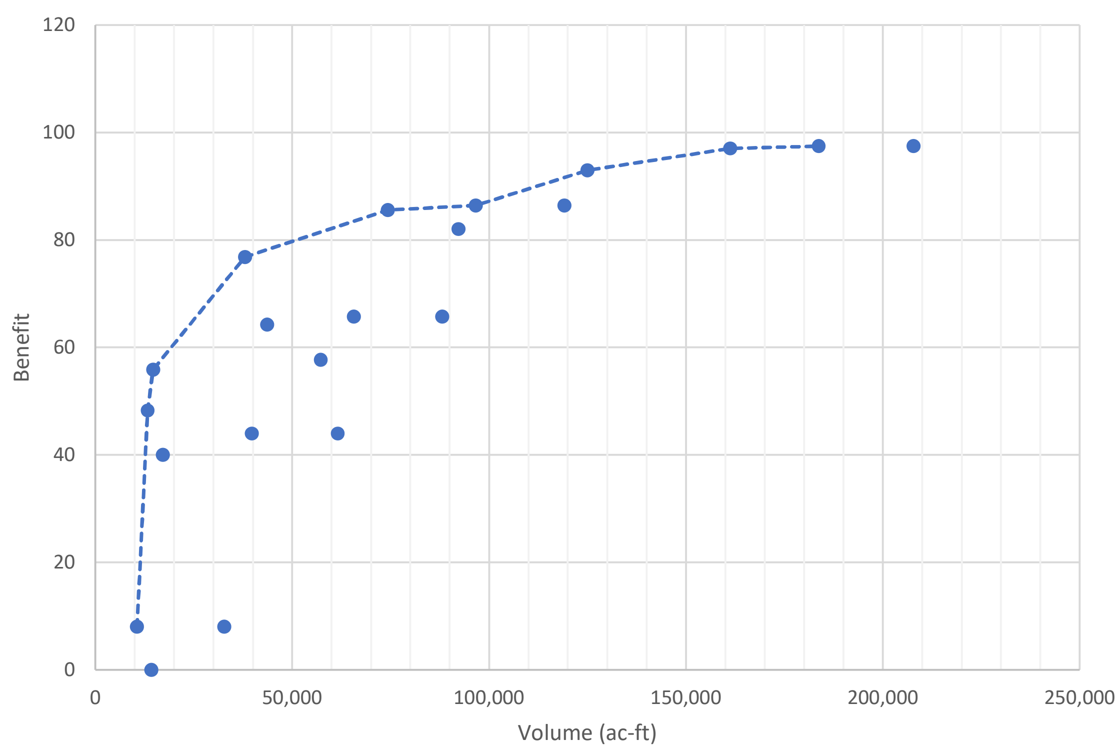
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**50,289**	71	41	19	12	0	0	0	**98**	2	50,289	98
500yr	50yr	**80,569**	41	19	12	0	0	0	0	**144**	2	30,280	45
500yr	25yr	**115,295**	19	12	0	0	0	0	0	**160**	1	34,726	17
500yr	10yr	**158,547**	12	0	0	0	0	0	0	**167**	1	43,253	7
500yr	5yr	**189,973**	0	0	0	0	0	0	0	**169**	1	31,426	2
500yr	2yr	**226,936**	0	0	0	0	0	0	0	**169**	1	36,963	0
100yr	50yr	**11,441**	103	41	19	12	0	0	0	**92**	8	11,441	92
100yr	25yr	**32,684**	103	19	12	0	0	0	0	**131**	4	21,243	39
100yr	10yr	**65,537**	103	12	0	0	0	0	0	**143**	2	32,852	12
100yr	5yr	**91,931**	103	0	0	0	0	0	0	**149**	2	26,394	5
100yr	2yr	**125,341**	103	0	0	0	0	0	0	**149**	1	33,410	0
50yr	25yr	**10,827**	103	71	19	12	0	0	0	**79**	7	10,827	79
50yr	10yr	**36,082**	103	71	12	0	0	0	0	**108**	3	25,255	29
50yr	5yr	**59,047**	103	71	0	0	0	0	0	**117**	2	22,965	9
50yr	2yr	**90,236**	103	71	0	0	0	0	0	**117**	1	31,189	0
25yr	10yr	**14,323**	103	71	41	12	0	0	0	**62**	4	14,323	62
25yr	5yr	**32,731**	103	71	41	0	0	0	0	**86**	3	18,408	24
25yr	2yr	**60,588**	103	71	41	0	0	0	0	**86**	1	27,857	0
10yr	5yr	**8,234**	103	71	41	19	0	0	0	**48**	6	8,234	48
10yr	2yr	**28,852**	103	71	41	19	0	0	0	**48**	2	20,618	0
5yr	2yr	**10,655**	103	71	41	19	12	0	0	**0**	0	10,655	0



Damage center: **DC_GLC_002** *Station range:* 144682 to 130119 *Mile range:* 27.4 to 24.6

	Existing conditions		55	46	29	18	2	0	0	**97 Flood instances (50-yr)**

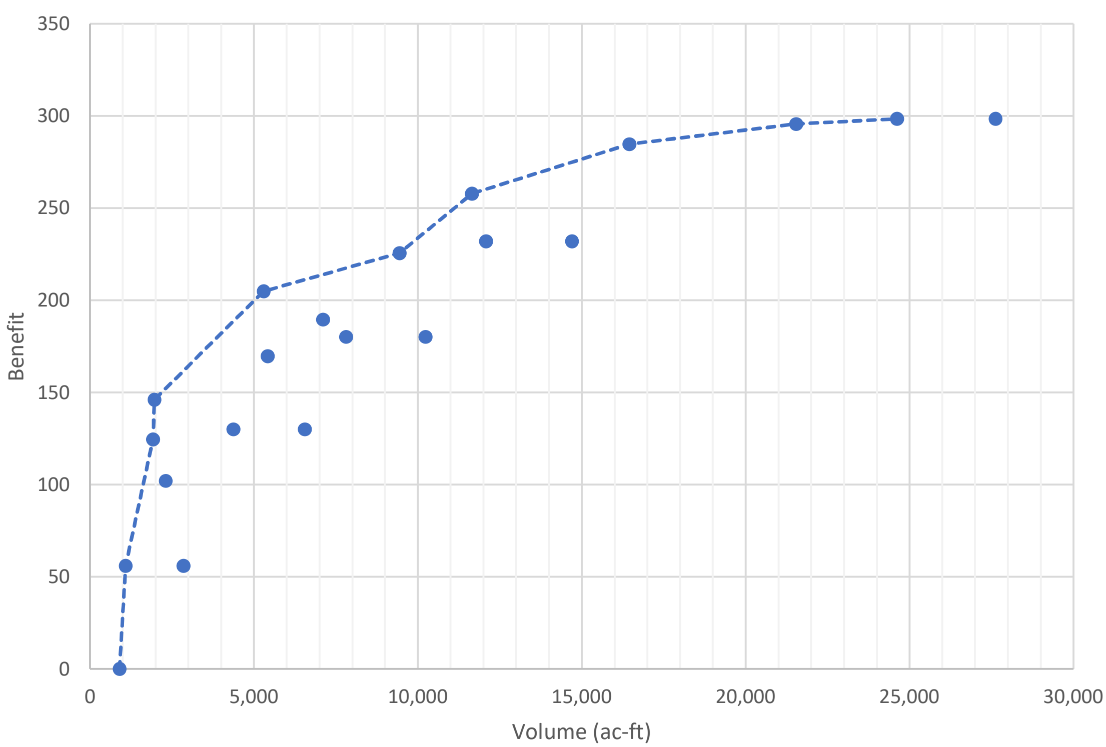
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**57,243**	46	29	18	2	0	0	0	**58**	1	57,243	58
500yr	50yr	**92,173**	29	18	2	0	0	0	0	**82**	1	34,931	24
500yr	25yr	**124,983**	18	2	0	0	0	0	0	**93**	1	32,809	11
500yr	10yr	**161,226**	2	0	0	0	0	0	0	**97**	1	36,243	4
500yr	5yr	**183,689**	0	0	0	0	0	0	0	**97**	1	22,463	0
500yr	2yr	**207,757**	0	0	0	0	0	0	0	**97**	0	24,068	0
100yr	50yr	**14,660**	55	29	18	2	0	0	0	**56**	4	14,660	56
100yr	25yr	**38,002**	55	18	2	0	0	0	0	**77**	2	23,341	21
100yr	10yr	**74,266**	55	2	0	0	0	0	0	**86**	1	36,264	9
100yr	5yr	**96,546**	55	0	0	0	0	0	0	**86**	1	22,280	1
100yr	2yr	**119,089**	55	0	0	0	0	0	0	**86**	1	22,543	0
50yr	25yr	**13,262**	55	46	18	2	0	0	0	**48**	4	13,262	48
50yr	10yr	**43,627**	55	46	2	0	0	0	0	**64**	1	30,365	16
50yr	5yr	**65,652**	55	46	0	0	0	0	0	**66**	1	22,025	2
50yr	2yr	**88,054**	55	46	0	0	0	0	0	**66**	1	22,402	0
25yr	10yr	**17,112**	55	46	29	2	0	0	0	**40**	2	17,112	40
25yr	5yr	**39,722**	55	46	29	0	0	0	0	**44**	1	22,610	4
25yr	2yr	**61,564**	55	46	29	0	0	0	0	**44**	1	21,842	0
10yr	5yr	**10,595**	55	46	29	18	0	0	0	**8**	1	10,595	8
10yr	2yr	**32,709**	55	46	29	18	0	0	0	**8**	0	22,114	0
5yr	2yr	**14,217**	55	46	29	18	2	0	0	**0**	0	14,217	0



Damage center: **DC_M100_001** *Station range:* 42695.9 to 23156.8 *Mile range:* 8.1 to 4.4

Existing conditions	332	115	67	37	14	0	0	**298**	**Flood instances (50-yr)**

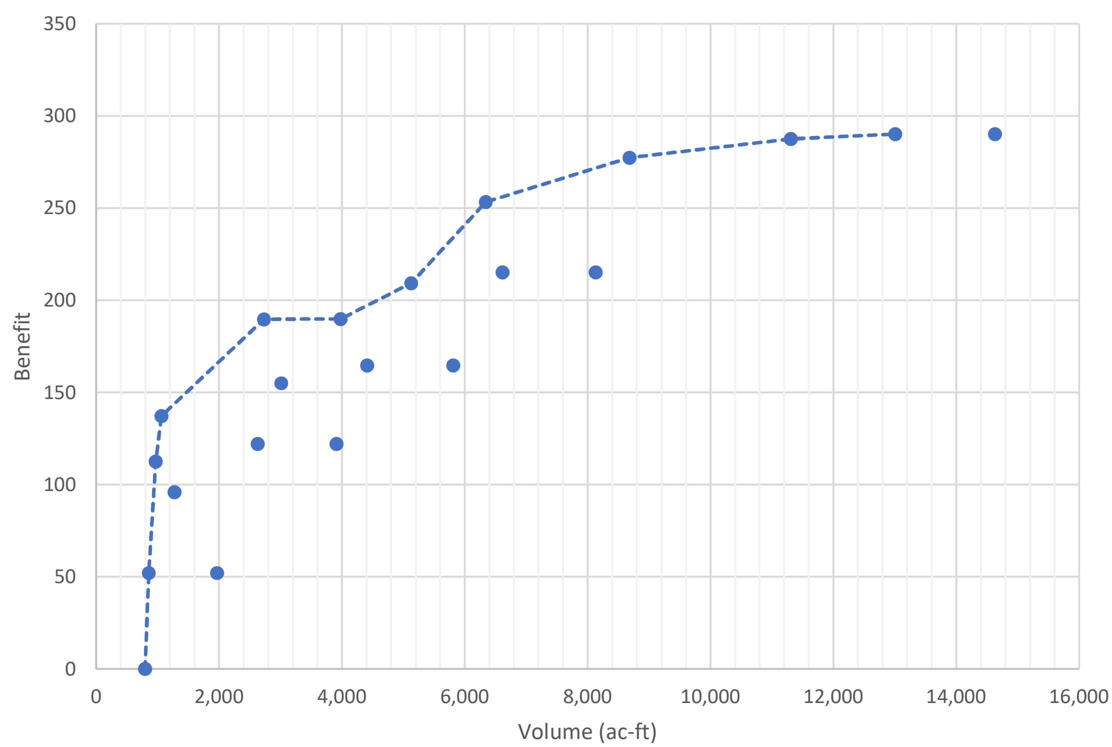
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**7,107**	115	67	37	14	0	0	0	**190**	27	7,107	190
500yr	50yr	**11,649**	67	37	14	0	0	0	0	**258**	22	4,542	68
500yr	25yr	**16,451**	37	14	0	0	0	0	0	**285**	17	4,802	27
500yr	10yr	**21,536**	14	0	0	0	0	0	0	**296**	14	5,085	11
500yr	5yr	**24,613**	0	0	0	0	0	0	0	**298**	12	3,077	3
500yr	2yr	**27,627**	0	0	0	0	0	0	0	**298**	11	3,014	0
100yr	50yr	**1,966**	332	67	37	14	0	0	0	**146**	74	1,966	146
100yr	25yr	**5,297**	332	37	14	0	0	0	0	**205**	39	3,331	59
100yr	10yr	**9,447**	332	14	0	0	0	0	0	**226**	24	4,151	21
100yr	5yr	**12,083**	332	0	0	0	0	0	0	**232**	19	2,636	6
100yr	2yr	**14,701**	332	0	0	0	0	0	0	**232**	16	2,617	0
50yr	25yr	**1,915**	332	115	37	14	0	0	0	**125**	65	1,915	125
50yr	10yr	**5,418**	332	115	14	0	0	0	0	**170**	31	3,503	45
50yr	5yr	**7,812**	332	115	0	0	0	0	0	**180**	23	2,393	11
50yr	2yr	**10,237**	332	115	0	0	0	0	0	**180**	18	2,426	0
25yr	10yr	**2,303**	332	115	67	14	0	0	0	**102**	44	2,303	102
25yr	5yr	**4,370**	332	115	67	0	0	0	0	**130**	30	2,068	28
25yr	2yr	**6,556**	332	115	67	0	0	0	0	**130**	20	2,186	0
10yr	5yr	**1,086**	332	115	67	37	0	0	0	**56**	52	1,086	56
10yr	2yr	**2,854**	332	115	67	37	0	0	0	**56**	20	1,767	0
5yr	2yr	**898**	332	115	67	37	14	0	0	**0**	0	898	0



Damage center: **DC_M100_002** *Station range:* 79204.5 to 53485.6 *Mile range:* 15 to 10.1

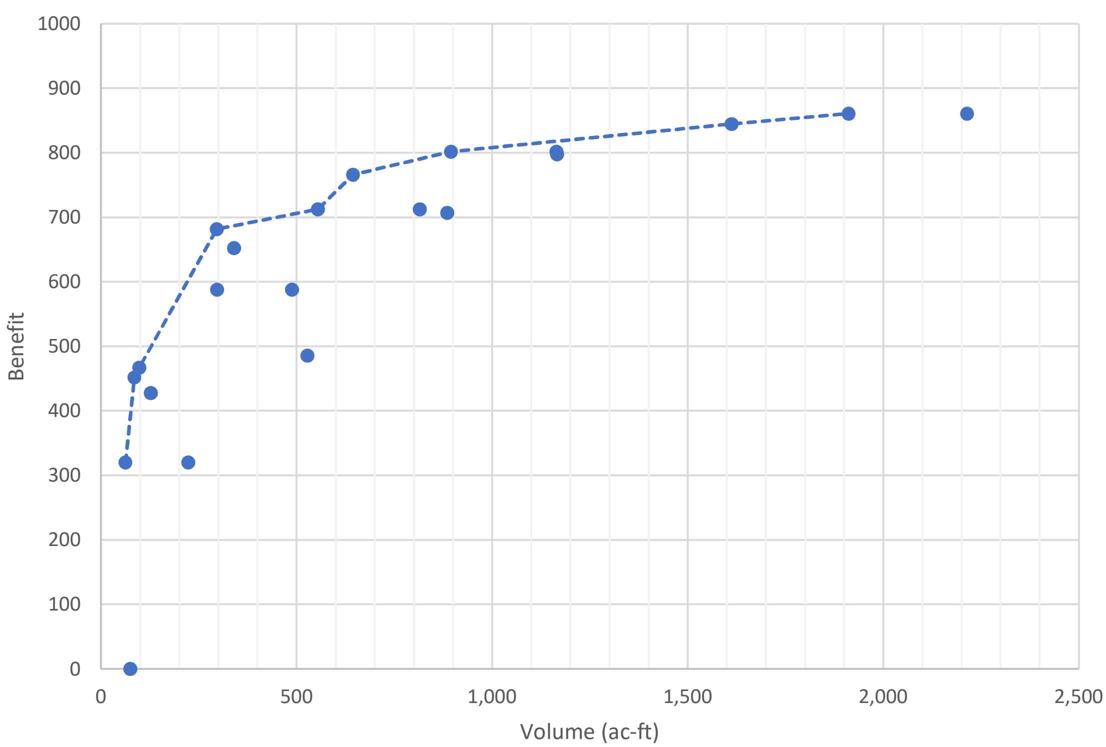
	Existing conditions	375	112	57	35	13	0	0	**290**	**Flood instances (50-yr)**

Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**3,979**	112	57	35	13	0	0	0	**190**	48	3,979	190
500yr	50yr	**6,339**	57	35	13	0	0	0	0	**253**	40	2,361	63
500yr	25yr	**8,680**	35	13	0	0	0	0	0	**277**	32	2,341	24
500yr	10yr	**11,305**	13	0	0	0	0	0	0	**288**	25	2,625	10
500yr	5yr	**13,010**	0	0	0	0	0	0	0	**290**	22	1,705	3
500yr	2yr	**14,632**	0	0	0	0	0	0	0	**290**	20	1,623	0
100yr	50yr	**1,061**	375	57	35	13	0	0	0	**137**	129	1,061	137
100yr	25yr	**2,732**	375	35	13	0	0	0	0	**190**	69	1,671	52
100yr	10yr	**5,127**	375	13	0	0	0	0	0	**209**	41	2,395	20
100yr	5yr	**6,614**	375	0	0	0	0	0	0	**215**	33	1,487	6
100yr	2yr	**8,132**	375	0	0	0	0	0	0	**215**	26	1,518	0
50yr	25yr	**968**	375	112	35	13	0	0	0	**113**	116	968	113
50yr	10yr	**3,011**	375	112	13	0	0	0	0	**155**	51	2,044	43
50yr	5yr	**4,412**	375	112	0	0	0	0	0	**165**	37	1,401	10
50yr	2yr	**5,813**	375	112	0	0	0	0	0	**165**	28	1,401	0
25yr	10yr	**1,274**	375	112	57	13	0	0	0	**96**	75	1,274	96
25yr	5yr	**2,628**	375	112	57	0	0	0	0	**122**	46	1,353	26
25yr	2yr	**3,914**	375	112	57	0	0	0	0	**122**	31	1,286	0
10yr	5yr	**856**	375	112	57	35	0	0	0	**52**	61	856	52
10yr	2yr	**1,965**	375	112	57	35	0	0	0	**52**	26	1,109	0
5yr	2yr	**794**	375	112	57	35	13	0	0	**0**	0	794	0



Damage center: **DC_M100_003** *Station range:* 101840 to 82544.2 *Mile range:* 19.3 to 15.6

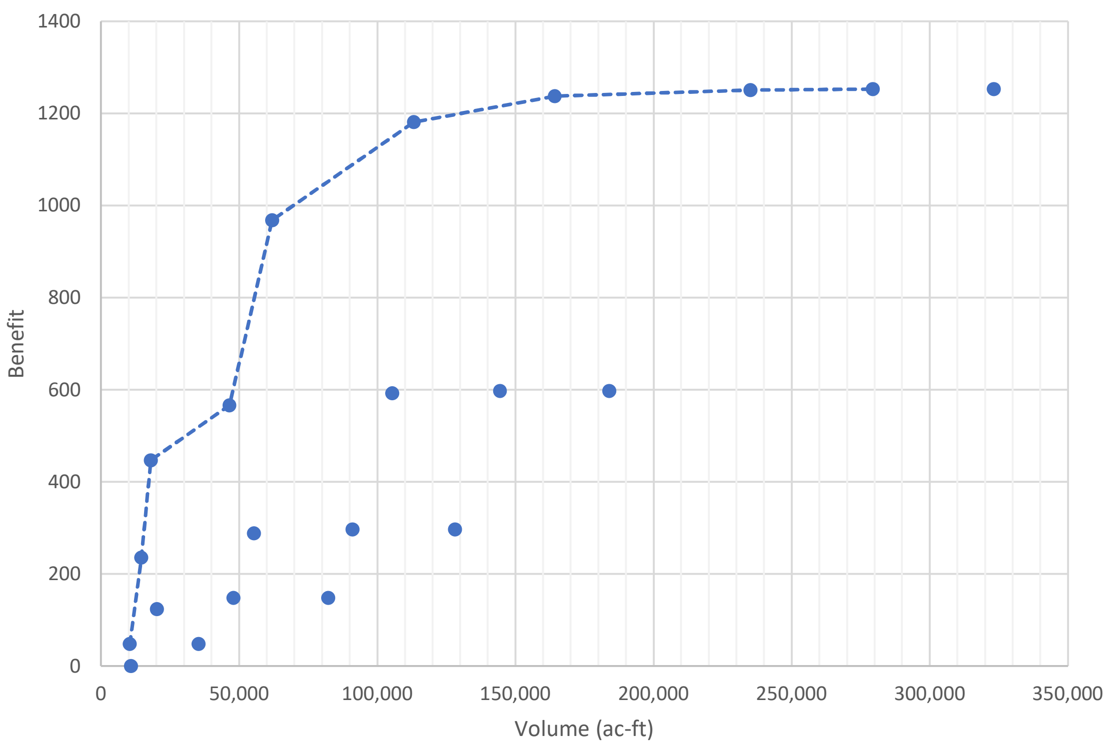
										Benefit			
	Existing conditions		294	199	166	134	80	0	0	**861 Flood instances (50-yr)**			
Start	Target		Cumulative number of flooded structures										
Flow	Flow	**Vol, ac-ft**	500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**528**	199	166	134	80	0	0	0	**486**	920	528	486
500yr	50yr	**885**	166	134	80	0	0	0	0	**707**	799	357	222
500yr	25yr	**1,166**	134	80	0	0	0	0	0	**798**	685	280	91
500yr	10yr	**1,613**	80	0	0	0	0	0	0	**845**	524	447	47
500yr	5yr	**1,911**	0	0	0	0	0	0	0	**861**	450	299	16
500yr	2yr	**2,214**	0	0	0	0	0	0	0	**861**	389	303	0
100yr	50yr	**98**	294	166	134	80	0	0	0	**467**	4784	98	467
100yr	25yr	**296**	294	134	80	0	0	0	0	**682**	2306	198	215
100yr	10yr	**645**	294	80	0	0	0	0	0	**766**	1188	349	84
100yr	5yr	**895**	294	0	0	0	0	0	0	**802**	896	250	36
100yr	2yr	**1,165**	294	0	0	0	0	0	0	**802**	689	270	0
50yr	25yr	**85**	294	199	134	80	0	0	0	**452**	5320	85	452
50yr	10yr	**340**	294	199	80	0	0	0	0	**653**	1920	255	201
50yr	5yr	**555**	294	199	0	0	0	0	0	**713**	1285	215	60
50yr	2yr	**815**	294	199	0	0	0	0	0	**713**	874	261	0
25yr	10yr	**127**	294	199	166	80	0	0	0	**428**	3371	127	428
25yr	5yr	**297**	294	199	166	0	0	0	0	**588**	1981	170	160
25yr	2yr	**488**	294	199	166	0	0	0	0	**588**	1204	191	0
10yr	5yr	**63**	294	199	166	134	0	0	0	**320**	5112	63	320
10yr	2yr	**223**	294	199	166	134	0	0	0	**320**	1434	160	0
5yr	2yr	**75**	294	199	166	134	80	0	0	**0**	0	75	0



Damage center: **DC_J100_001** *Station range:* 86681.8 to 69232.2 *Mile range:* 16.4 to 13.1

Existing conditions	3275	668	199	50	12	0	0	**1253**	**Flood instances (50-yr)**

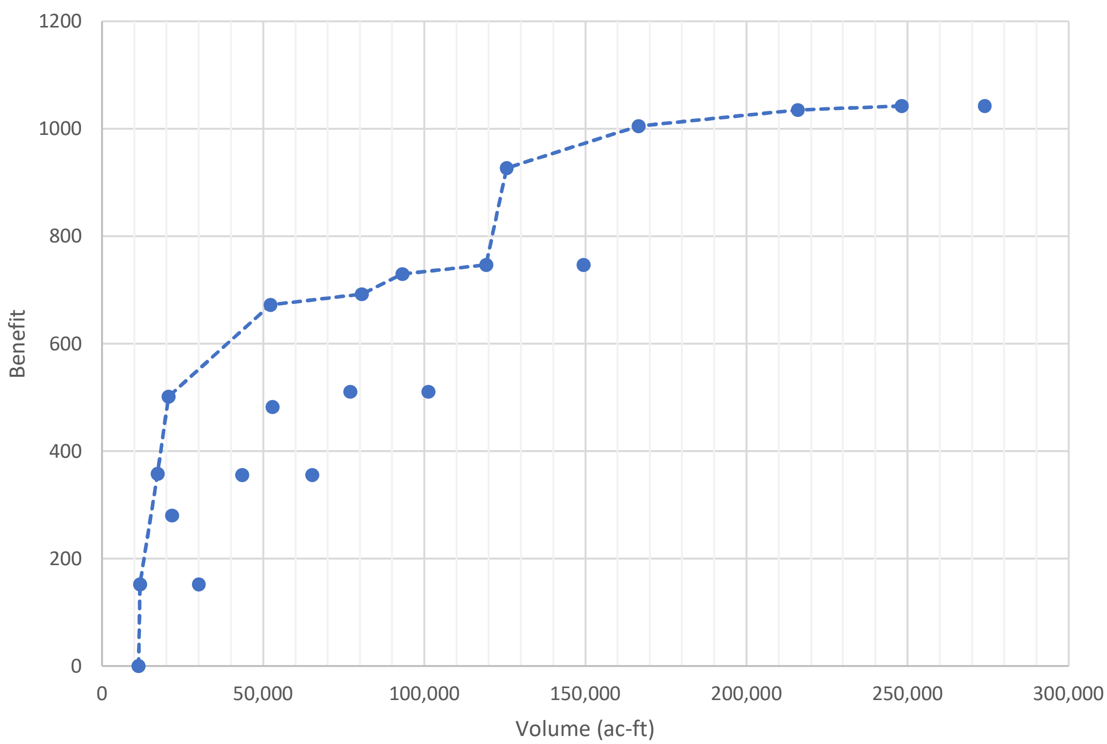
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**61,913**	668	199	50	12	0	0	0	**968**	16	61,913	968
500yr	50yr	**113,299**	199	50	12	0	0	0	0	**1182**	10	51,386	213
500yr	25yr	**164,268**	50	12	0	0	0	0	0	**1237**	8	50,969	56
500yr	10yr	**235,070**	12	0	0	0	0	0	0	**1250**	5	70,802	13
500yr	5yr	**279,437**	0	0	0	0	0	0	0	**1253**	4	44,367	2
500yr	2yr	**323,259**	0	0	0	0	0	0	0	**1253**	4	43,822	0
100yr	50yr	**18,018**	3275	199	50	12	0	0	0	**447**	25	18,018	447
100yr	25yr	**46,541**	3275	50	12	0	0	0	0	**566**	12	28,522	120
100yr	10yr	**105,496**	3275	12	0	0	0	0	0	**592**	6	58,955	26
100yr	5yr	**144,465**	3275	0	0	0	0	0	0	**598**	4	38,969	5
100yr	2yr	**184,012**	3275	0	0	0	0	0	0	**598**	3	39,546	0
50yr	25yr	**14,639**	3275	668	50	12	0	0	0	**236**	16	14,639	236
50yr	10yr	**55,360**	3275	668	12	0	0	0	0	**288**	5	40,721	53
50yr	5yr	**91,099**	3275	668	0	0	0	0	0	**297**	3	35,739	9
50yr	2yr	**128,168**	3275	668	0	0	0	0	0	**297**	2	37,070	0
25yr	10yr	**20,274**	3275	668	199	12	0	0	0	**124**	6	20,274	124
25yr	5yr	**47,938**	3275	668	199	0	0	0	0	**148**	3	27,664	24
25yr	2yr	**82,250**	3275	668	199	0	0	0	0	**148**	2	34,312	0
10yr	5yr	**10,398**	3275	668	199	50	0	0	0	**48**	5	10,398	48
10yr	2yr	**35,381**	3275	668	199	50	0	0	0	**48**	1	24,984	0
5yr	2yr	**10,827**	3275	668	199	50	12	0	0	**0**	0	10,827	0



Damage center: **DC_J100_002** *Station range:* 136198 to 107035 *Mile range:* 25.8 to 20.3

Existing conditions	1478	525	206	102	38	0	0	**1042 Flood instances (50-yr)**

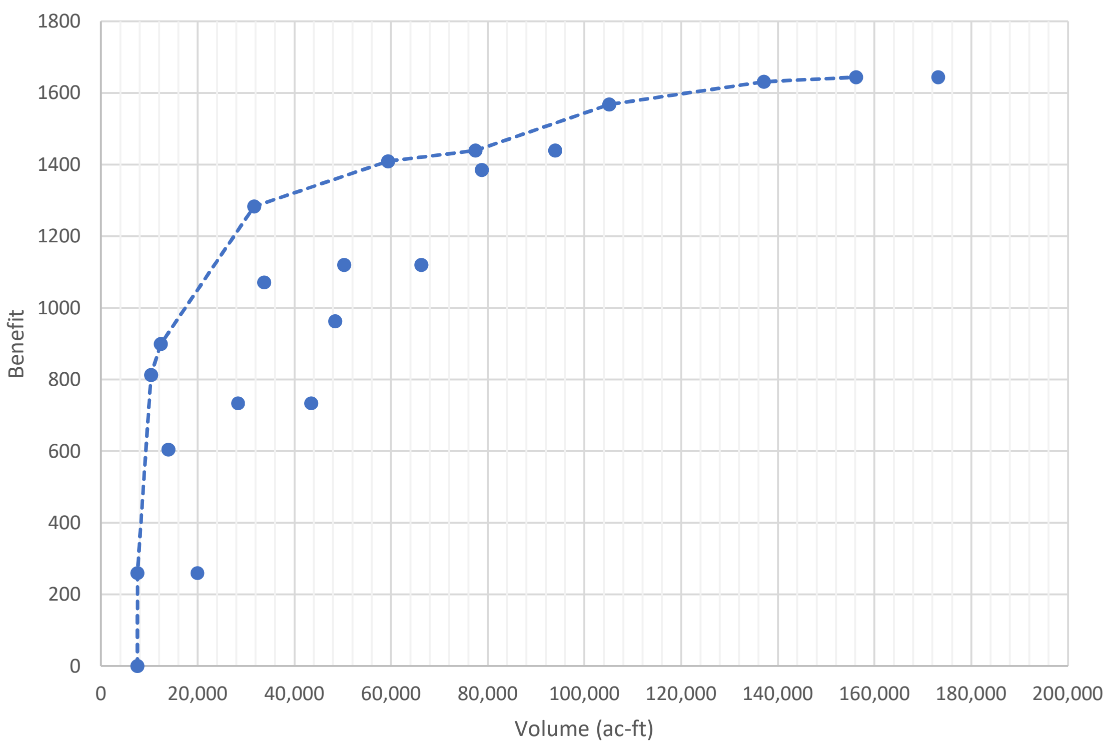
Start	Target		Cumulative number of flooded structures										
Flow	Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**80,577**	525	206	102	38	0	0	0	**692**	9	80,577	692
500yr	50yr	**125,545**	206	102	38	0	0	0	0	**927**	7	44,968	235
500yr	25yr	**166,508**	102	38	0	0	0	0	0	**1005**	6	40,963	78
500yr	10yr	**215,926**	38	0	0	0	0	0	0	**1035**	5	49,418	30
500yr	5yr	**248,159**	0	0	0	0	0	0	0	**1042**	4	32,234	8
500yr	2yr	**273,914**	0	0	0	0	0	0	0	**1042**	4	25,755	0
100yr	50yr	**20,606**	1478	206	102	38	0	0	0	**502**	24	20,606	502
100yr	25yr	**52,195**	1478	102	38	0	0	0	0	**672**	13	31,588	171
100yr	10yr	**93,178**	1478	38	0	0	0	0	0	**730**	8	40,983	57
100yr	5yr	**119,211**	1478	0	0	0	0	0	0	**747**	6	26,033	17
100yr	2yr	**149,399**	1478	0	0	0	0	0	0	**747**	5	30,188	0
50yr	25yr	**17,194**	1478	525	102	38	0	0	0	**358**	21	17,194	358
50yr	10yr	**52,838**	1478	525	38	0	0	0	0	**482**	9	35,644	124
50yr	5yr	**76,981**	1478	525	0	0	0	0	0	**511**	7	24,143	29
50yr	2yr	**101,258**	1478	525	0	0	0	0	0	**511**	5	24,278	0
25yr	10yr	**21,654**	1478	525	206	38	0	0	0	**280**	13	21,654	280
25yr	5yr	**43,433**	1478	525	206	0	0	0	0	**356**	8	21,779	76
25yr	2yr	**65,193**	1478	525	206	0	0	0	0	**356**	5	21,760	0
10yr	5yr	**11,731**	1478	525	206	102	0	0	0	**152**	13	11,731	152
10yr	2yr	**30,013**	1478	525	206	102	0	0	0	**152**	5	18,282	0
5yr	2yr	**11,314**	1478	525	206	102	38	0	0	**0**	0	11,314	0



Damage center: **DC_J100_003** *Station range:* 213919 to 162164 *Mile range:* 40.5 to 30.7

Existing conditions	1026	708	515	237	65	0	0	**1644**	**Flood instances (50-yr)**

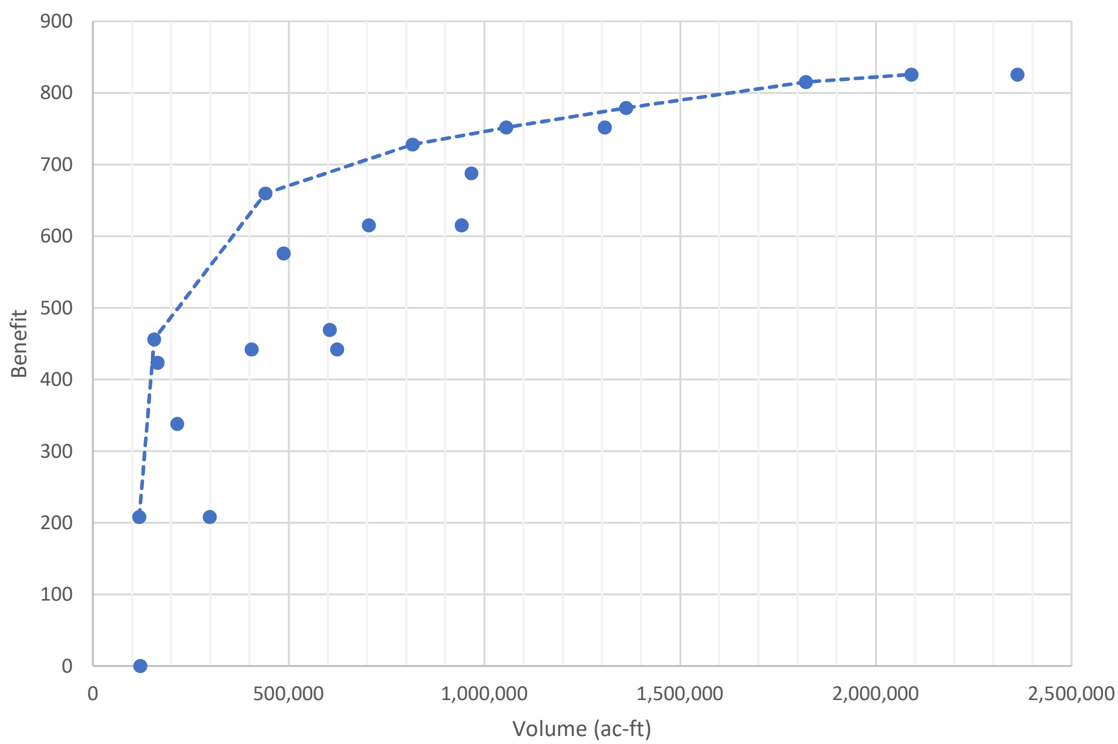
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**48,445**	708	515	237	65	0	0	0	**963**	20	48,445	963
500yr	50yr	**78,776**	515	237	65	0	0	0	0	**1386**	18	30,331	423
500yr	25yr	**105,080**	237	65	0	0	0	0	0	**1567**	15	26,304	182
500yr	10yr	**137,082**	65	0	0	0	0	0	0	**1631**	12	32,002	64
500yr	5yr	**156,188**	0	0	0	0	0	0	0	**1644**	11	19,106	13
500yr	2yr	**173,164**	0	0	0	0	0	0	0	**1644**	9	16,976	0
100yr	50yr	**12,383**	1026	515	237	65	0	0	0	**899**	73	12,383	899
100yr	25yr	**31,690**	1026	237	65	0	0	0	0	**1283**	41	19,307	384
100yr	10yr	**59,385**	1026	65	0	0	0	0	0	**1410**	24	27,695	126
100yr	5yr	**77,438**	1026	0	0	0	0	0	0	**1439**	19	18,053	29
100yr	2yr	**93,945**	1026	0	0	0	0	0	0	**1439**	15	16,506	0
50yr	25yr	**10,320**	1026	708	237	65	0	0	0	**813**	79	10,320	813
50yr	10yr	**33,785**	1026	708	65	0	0	0	0	**1072**	32	23,465	259
50yr	5yr	**50,292**	1026	708	0	0	0	0	0	**1120**	22	16,507	49
50yr	2yr	**66,218**	1026	708	0	0	0	0	0	**1120**	17	15,926	0
25yr	10yr	**13,904**	1026	708	515	65	0	0	0	**604**	43	13,904	604
25yr	5yr	**28,362**	1026	708	515	0	0	0	0	**734**	26	14,458	130
25yr	2yr	**43,469**	1026	708	515	0	0	0	0	**734**	17	15,107	0
10yr	5yr	**7,561**	1026	708	515	237	0	0	0	**260**	34	7,561	260
10yr	2yr	**19,917**	1026	708	515	237	0	0	0	**260**	13	12,356	0
5yr	2yr	**7,515**	1026	708	515	237	65	0	0	**0**	0	7,515	0



Damage center: **DC_G103_001** *Station range:* 56253 to 1326 *Mile range:* 10.7 to 0.3

Existing conditions	371	303	231	117	52	0	0	**826**	**Flood instances (50-yr)**

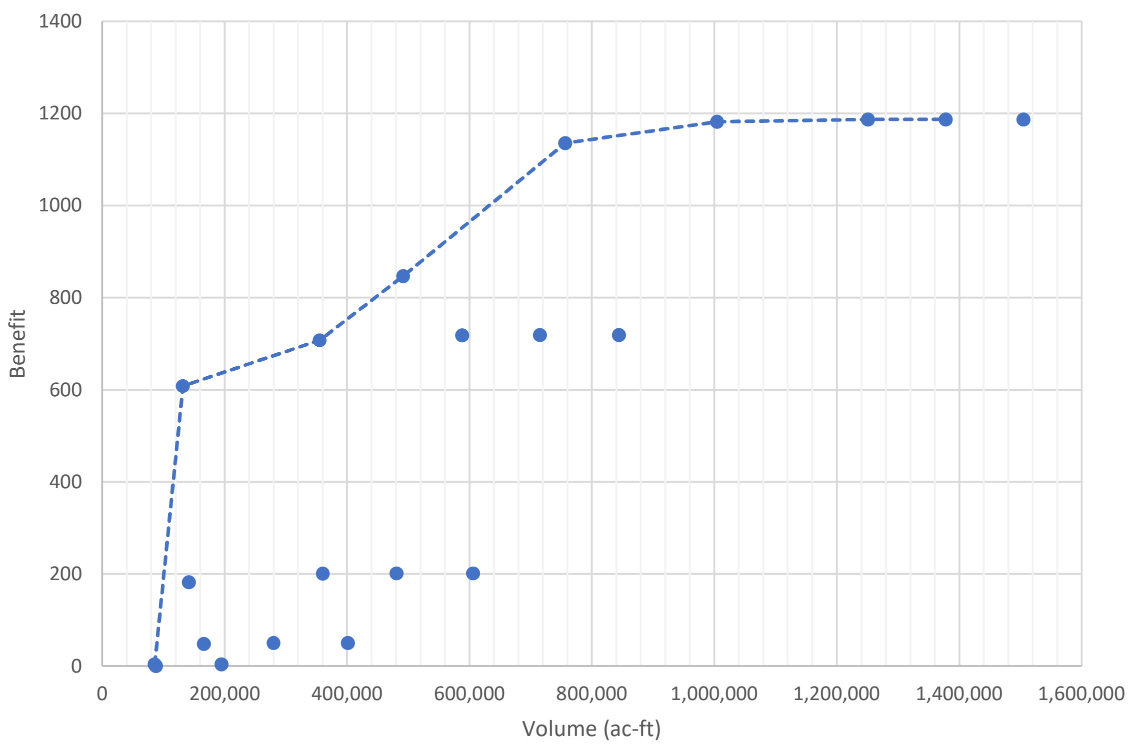
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**604,395**	303	231	117	52	0	0	0	**470**	1	604,395	470
500yr	50yr	**966,619**	231	117	52	0	0	0	0	**688**	1	362,224	218
500yr	25yr	**1,361,969**	117	52	0	0	0	0	0	**779**	1	395,350	91
500yr	10yr	**1,820,920**	52	0	0	0	0	0	0	**815**	0	458,951	36
500yr	5yr	**2,091,023**	0	0	0	0	0	0	0	**826**	0	270,103	10
500yr	2yr	**2,361,766**	0	0	0	0	0	0	0	**826**	0	270,743	0
100yr	50yr	**156,085**	371	231	117	52	0	0	0	**456**	3	156,085	456
100yr	25yr	**440,643**	371	117	52	0	0	0	0	**660**	1	284,558	204
100yr	10yr	**816,308**	371	52	0	0	0	0	0	**728**	1	375,665	68
100yr	5yr	**1,055,928**	371	0	0	0	0	0	0	**752**	1	239,620	23
100yr	2yr	**1,307,477**	371	0	0	0	0	0	0	**752**	1	251,549	0
50yr	25yr	**165,486**	371	303	117	52	0	0	0	**424**	3	165,486	424
50yr	10yr	**486,470**	371	303	52	0	0	0	0	**576**	1	320,984	153
50yr	5yr	**704,696**	371	303	0	0	0	0	0	**615**	1	218,225	39
50yr	2yr	**941,679**	371	303	0	0	0	0	0	**615**	1	236,983	0
25yr	10yr	**215,131**	371	303	231	52	0	0	0	**338**	2	215,131	338
25yr	5yr	**405,216**	371	303	231	0	0	0	0	**442**	1	190,086	104
25yr	2yr	**623,796**	371	303	231	0	0	0	0	**442**	1	218,580	0
10yr	5yr	**118,373**	371	303	231	117	0	0	0	**208**	2	118,373	208
10yr	2yr	**298,731**	371	303	231	117	0	0	0	**208**	1	180,358	0
5yr	2yr	**120,907**	371	303	231	117	52	0	0	**0**	0	120,907	0



Damage center: **DC_G103_002** *Station range:* 158811 to 129790 *Mile range:* 30.1 to 24.6

Existing conditions	2343	1149	202	23	1	0	0	**1187 Flood instances (50-yr)**

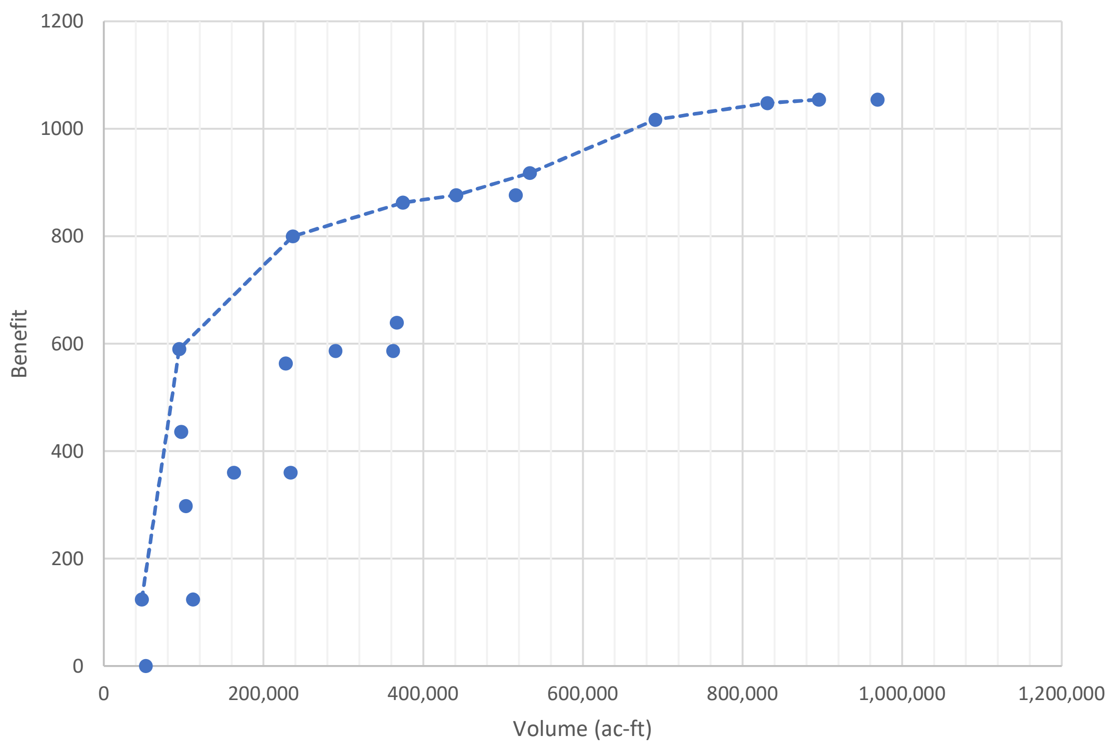
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**491,438**	1149	202	23	1	0	0	0	**847**	2	491,438	847
500yr	50yr	**756,559**	202	23	1	0	0	0	0	**1136**	2	265,122	288
500yr	25yr	**1,004,370**	23	1	0	0	0	0	0	**1182**	1	247,811	46
500yr	10yr	**1,250,905**	1	0	0	0	0	0	0	**1187**	1	246,535	5
500yr	5yr	**1,378,229**	0	0	0	0	0	0	0	**1187**	1	127,324	0
500yr	2yr	**1,505,082**	0	0	0	0	0	0	0	**1187**	1	126,853	0
100yr	50yr	**131,594**	2343	202	23	1	0	0	0	**608**	5	131,594	608
100yr	25yr	**355,397**	2343	23	1	0	0	0	0	**707**	2	223,803	99
100yr	10yr	**588,024**	2343	1	0	0	0	0	0	**718**	1	232,627	11
100yr	5yr	**715,048**	2343	0	0	0	0	0	0	**719**	1	127,024	0
100yr	2yr	**843,996**	2343	0	0	0	0	0	0	**719**	1	128,949	0
50yr	25yr	**141,415**	2343	1149	23	1	0	0	0	**182**	1	141,415	182
50yr	10yr	**360,520**	2343	1149	1	0	0	0	0	**201**	1	219,105	19
50yr	5yr	**480,665**	2343	1149	0	0	0	0	0	**202**	0	120,145	1
50yr	2yr	**606,110**	2343	1149	0	0	0	0	0	**202**	0	125,445	0
25yr	10yr	**165,875**	2343	1149	202	1	0	0	0	**48**	0	165,875	48
25yr	5yr	**279,850**	2343	1149	202	0	0	0	0	**50**	0	113,976	2
25yr	2yr	**401,393**	2343	1149	202	0	0	0	0	**50**	0	121,543	0
10yr	5yr	**85,741**	2343	1149	202	23	0	0	0	**4**	0	85,741	4
10yr	2yr	**194,991**	2343	1149	202	23	0	0	0	**4**	0	109,250	0
5yr	2yr	**87,774**	2343	1149	202	23	1	0	0	**0**	0	87,774	0



Damage center: **DC_G103_003** *Station range:* 179158 to 158811 *Mile range:* 33.9 to 30.1

Existing conditions	890	644	302	118	31	0	0	**1054 Flood instances (50-yr)**

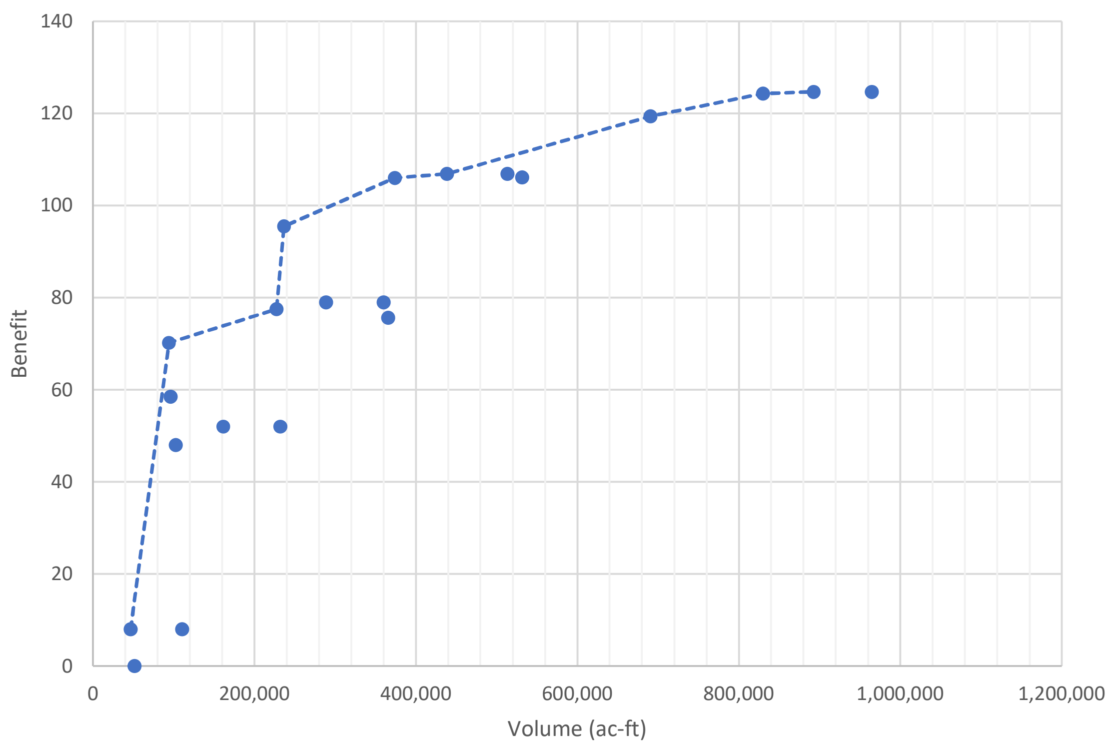
Start	Target		Cumulative number of flooded structures										
Flow	Flow	**Vol, ac-ft**	500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**366,764**	644	302	118	31	0	0	0	**639**	2	366,764	639
500yr	50yr	**533,683**	302	118	31	0	0	0	0	**918**	2	166,919	278
500yr	25yr	**690,685**	118	31	0	0	0	0	0	**1017**	1	157,002	99
500yr	10yr	**830,933**	31	0	0	0	0	0	0	**1048**	1	140,248	31
500yr	5yr	**895,607**	0	0	0	0	0	0	0	**1054**	1	64,674	6
500yr	2yr	**969,361**	0	0	0	0	0	0	0	**1054**	1	73,754	0
100yr	50yr	**94,444**	890	302	118	31	0	0	0	**590**	6	94,444	590
100yr	25yr	**236,787**	890	118	31	0	0	0	0	**800**	3	142,343	210
100yr	10yr	**374,476**	890	31	0	0	0	0	0	**862**	2	137,689	62
100yr	5yr	**441,158**	890	0	0	0	0	0	0	**876**	2	66,682	14
100yr	2yr	**515,819**	890	0	0	0	0	0	0	**876**	2	74,661	0
50yr	25yr	**96,866**	890	644	118	31	0	0	0	**436**	5	96,866	436
50yr	10yr	**227,579**	890	644	31	0	0	0	0	**563**	2	130,713	127
50yr	5yr	**290,181**	890	644	0	0	0	0	0	**587**	2	62,601	23
50yr	2yr	**362,387**	890	644	0	0	0	0	0	**587**	2	72,207	0
25yr	10yr	**102,453**	890	644	302	31	0	0	0	**298**	3	102,453	298
25yr	5yr	**162,964**	890	644	302	0	0	0	0	**360**	2	60,511	62
25yr	2yr	**233,855**	890	644	302	0	0	0	0	**360**	2	70,891	0
10yr	5yr	**47,358**	890	644	302	118	0	0	0	**124**	3	47,358	124
10yr	2yr	**111,687**	890	644	302	118	0	0	0	**124**	1	64,329	0
5yr	2yr	**52,581**	890	644	302	118	31	0	0	**0**	0	52,581	0



Damage center: **DC_G103_004** *Station range:* 191722 to 186806 *Mile range:* 36.3 to 35.4

	Existing conditions		89	62	36	22	2	0	0	**125**	**Flood instances (50-yr)**		

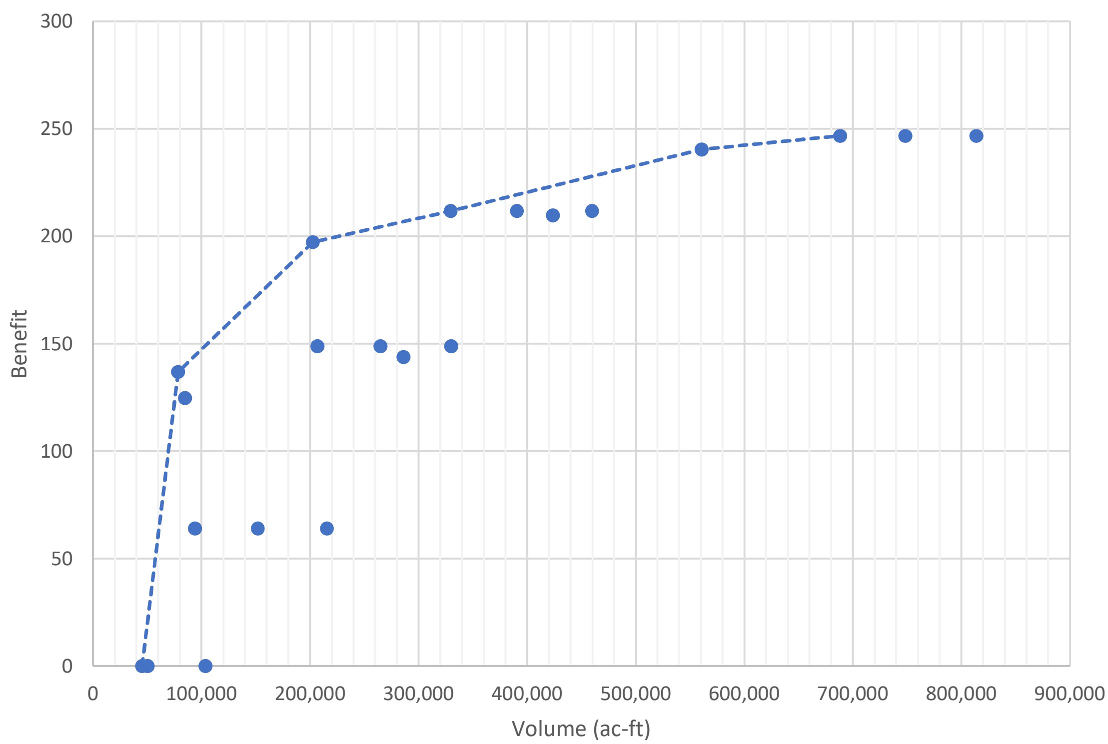
Start	Target		Cumulative number of flooded structures										
Flow	Flow	**Vol, ac-ft**	500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**365,673**	62	36	22	2	0	0	0	**76**	0	365,673	76
500yr	50yr	**531,527**	36	22	2	0	0	0	0	**106**	0	165,854	31
500yr	25yr	**690,534**	22	2	0	0	0	0	0	**119**	0	159,008	13
500yr	10yr	**829,962**	2	0	0	0	0	0	0	**124**	0	139,427	5
500yr	5yr	**892,602**	0	0	0	0	0	0	0	**125**	0	62,640	0
500yr	2yr	**964,667**	0	0	0	0	0	0	0	**125**	0	72,066	0
100yr	50yr	**93,913**	89	36	22	2	0	0	0	**70**	1	93,913	70
100yr	25yr	**236,704**	89	22	2	0	0	0	0	**96**	0	142,791	25
100yr	10yr	**374,067**	89	2	0	0	0	0	0	**106**	0	137,363	11
100yr	5yr	**438,352**	89	0	0	0	0	0	0	**107**	0	64,285	1
100yr	2yr	**513,468**	89	0	0	0	0	0	0	**107**	0	75,116	0
50yr	25yr	**96,172**	89	62	22	2	0	0	0	**59**	1	96,172	59
50yr	10yr	**227,445**	89	62	2	0	0	0	0	**78**	0	131,274	19
50yr	5yr	**288,723**	89	62	0	0	0	0	0	**79**	0	61,278	2
50yr	2yr	**360,093**	89	62	0	0	0	0	0	**79**	0	71,370	0
25yr	10yr	**102,711**	89	62	36	2	0	0	0	**48**	0	102,711	48
25yr	5yr	**161,439**	89	62	36	0	0	0	0	**52**	0	58,728	4
25yr	2yr	**231,893**	89	62	36	0	0	0	0	**52**	0	70,454	0
10yr	5yr	**46,643**	89	62	36	22	0	0	0	**8**	0	46,643	8
10yr	2yr	**110,309**	89	62	36	22	0	0	0	**8**	0	63,666	0
5yr	2yr	**51,510**	89	62	36	22	2	0	0	**0**	0	51,510	0



Damage center: **DC_G103_005** *Station range:* 267595 to 256696 *Mile range:* 50.7 to 48.6

Existing conditions	175	140	113	32	0	0	0	**247**	**Flood instances (50-yr)**

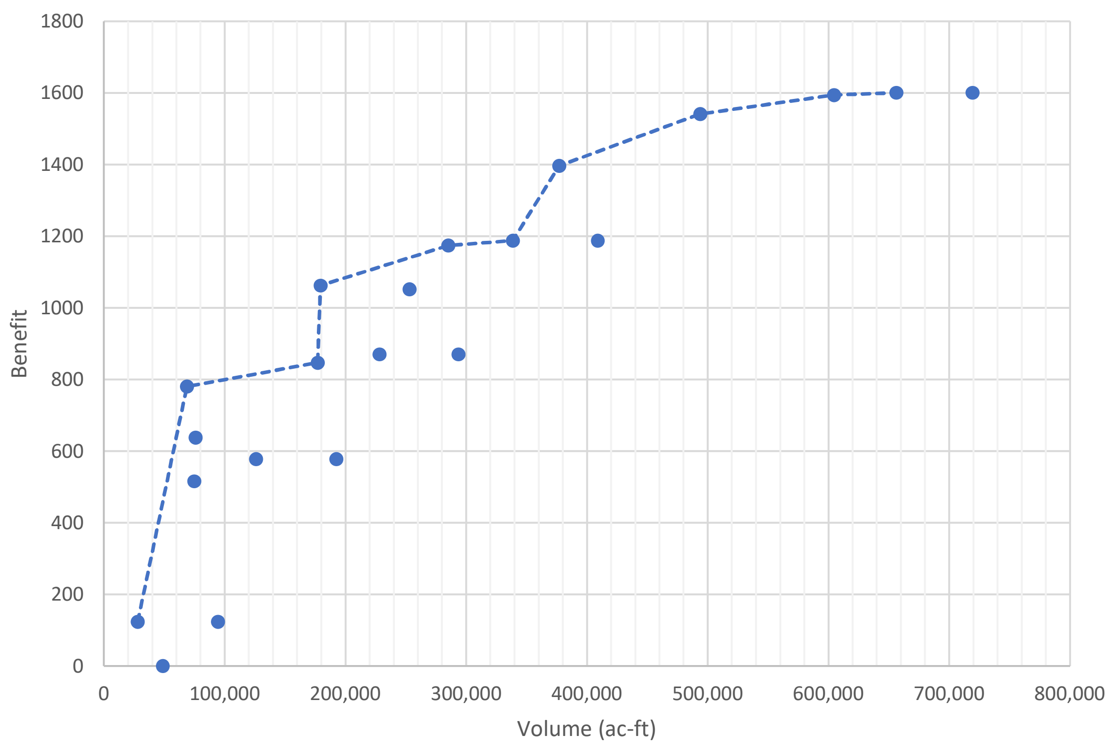
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**286,172**	140	113	32	0	0	0	0	**144**	1	286,172	144
500yr	50yr	**423,648**	113	32	0	0	0	0	0	**210**	0	137,476	66
500yr	25yr	**560,762**	32	0	0	0	0	0	0	**240**	0	137,115	31
500yr	10yr	**688,534**	0	0	0	0	0	0	0	**247**	0	127,771	6
500yr	5yr	**748,420**	0	0	0	0	0	0	0	**247**	0	59,886	0
500yr	2yr	**813,781**	0	0	0	0	0	0	0	**247**	0	65,361	0
100yr	50yr	**78,449**	175	113	32	0	0	0	0	**137**	2	78,449	137
100yr	25yr	**202,522**	175	32	0	0	0	0	0	**197**	1	124,074	60
100yr	10yr	**329,671**	175	0	0	0	0	0	0	**212**	1	127,149	14
100yr	5yr	**390,659**	175	0	0	0	0	0	0	**212**	1	60,987	0
100yr	2yr	**459,791**	175	0	0	0	0	0	0	**212**	0	69,132	0
50yr	25yr	**84,780**	175	140	32	0	0	0	0	**125**	1	84,780	125
50yr	10yr	**206,806**	175	140	0	0	0	0	0	**149**	1	122,026	24
50yr	5yr	**264,916**	175	140	0	0	0	0	0	**149**	1	58,110	0
50yr	2yr	**330,142**	175	140	0	0	0	0	0	**149**	0	65,226	0
25yr	10yr	**94,057**	175	140	113	0	0	0	0	**64**	1	94,057	64
25yr	5yr	**151,928**	175	140	113	0	0	0	0	**64**	0	57,871	0
25yr	2yr	**215,654**	175	140	113	0	0	0	0	**64**	0	63,726	0
10yr	5yr	**45,236**	175	140	113	32	0	0	0	**0**	0	45,236	0
10yr	2yr	**103,600**	175	140	113	32	0	0	0	**0**	0	58,365	0
5yr	2yr	**50,363**	175	140	113	32	0	0	0	**0**	0	50,363	0



Damage center: **DC_G103_006** *Station range:* 311663 to 278339 *Mile range:* 59 to 52.7

	500yr	100yr	50yr	25yr	10yr	5yr	2yr		
Existing conditions	2063	705	390	227	31	0	0	**1600**	**Flood instances (50-yr)**

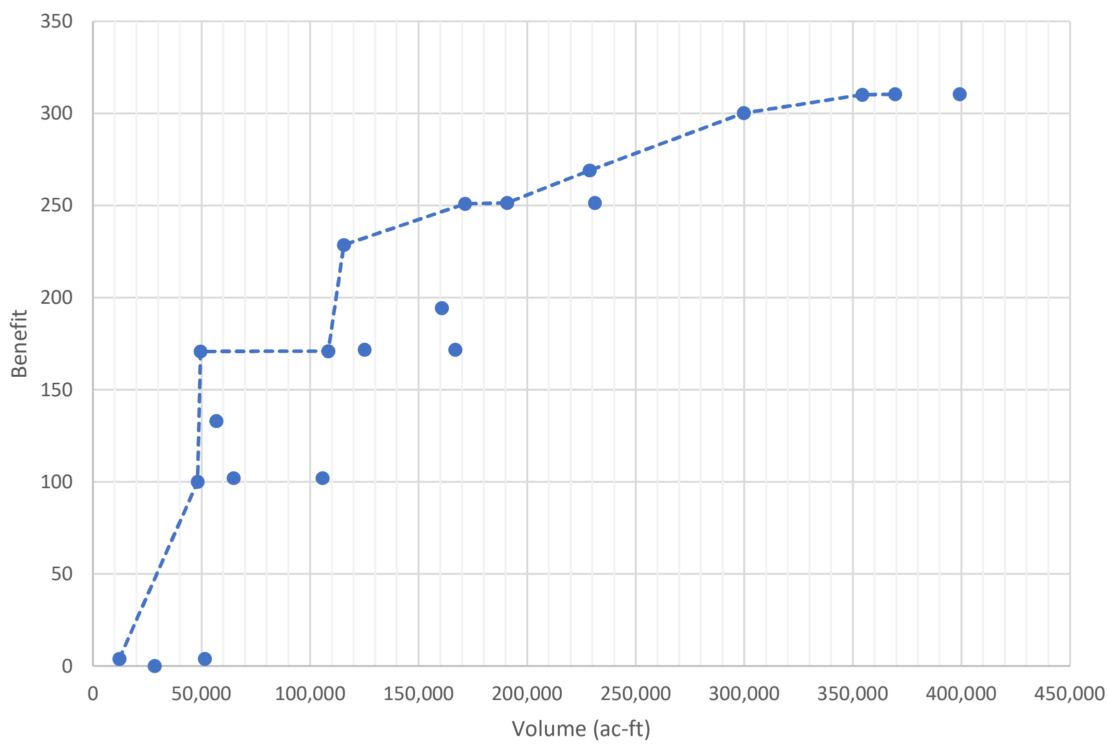
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**252,890**	705	390	227	31	0	0	0	**1052**	4	252,890	1052
500yr	50yr	**376,935**	390	227	31	0	0	0	0	**1397**	4	124,045	345
500yr	25yr	**493,773**	227	31	0	0	0	0	0	**1541**	3	116,838	144
500yr	10yr	**604,624**	31	0	0	0	0	0	0	**1594**	3	110,851	53
500yr	5yr	**656,072**	0	0	0	0	0	0	0	**1600**	2	51,448	6
500yr	2yr	**719,208**	0	0	0	0	0	0	0	**1600**	2	63,136	0
100yr	50yr	**68,756**	2063	390	227	31	0	0	0	**780**	11	68,756	780
100yr	25yr	**179,220**	2063	227	31	0	0	0	0	**1062**	6	110,464	282
100yr	10yr	**285,082**	2063	31	0	0	0	0	0	**1174**	4	105,862	111
100yr	5yr	**338,636**	2063	0	0	0	0	0	0	**1188**	4	53,554	14
100yr	2yr	**408,948**	2063	0	0	0	0	0	0	**1188**	3	70,312	0
50yr	25yr	**75,766**	2063	705	227	31	0	0	0	**638**	8	75,766	638
50yr	10yr	**176,867**	2063	705	31	0	0	0	0	**847**	5	101,101	209
50yr	5yr	**228,216**	2063	705	0	0	0	0	0	**871**	4	51,350	23
50yr	2yr	**293,585**	2063	705	0	0	0	0	0	**871**	3	65,369	0
25yr	10yr	**74,605**	2063	705	390	31	0	0	0	**516**	7	74,605	516
25yr	5yr	**125,983**	2063	705	390	0	0	0	0	**578**	5	51,378	62
25yr	2yr	**192,448**	2063	705	390	0	0	0	0	**578**	3	66,465	0
10yr	5yr	**27,962**	2063	705	390	227	0	0	0	**124**	4	27,962	124
10yr	2yr	**94,430**	2063	705	390	227	0	0	0	**124**	1	66,468	0
5yr	2yr	**48,697**	2063	705	390	227	31	0	0	**0**	0	48,697	0



Damage center: **DC_G103_007** *Station range:* 379849 to 341230 *Mile range:* 71.9 to 64.6

Existing conditions	295	177	93	49	1	0	0	**310**	**Flood instances (50-yr)**

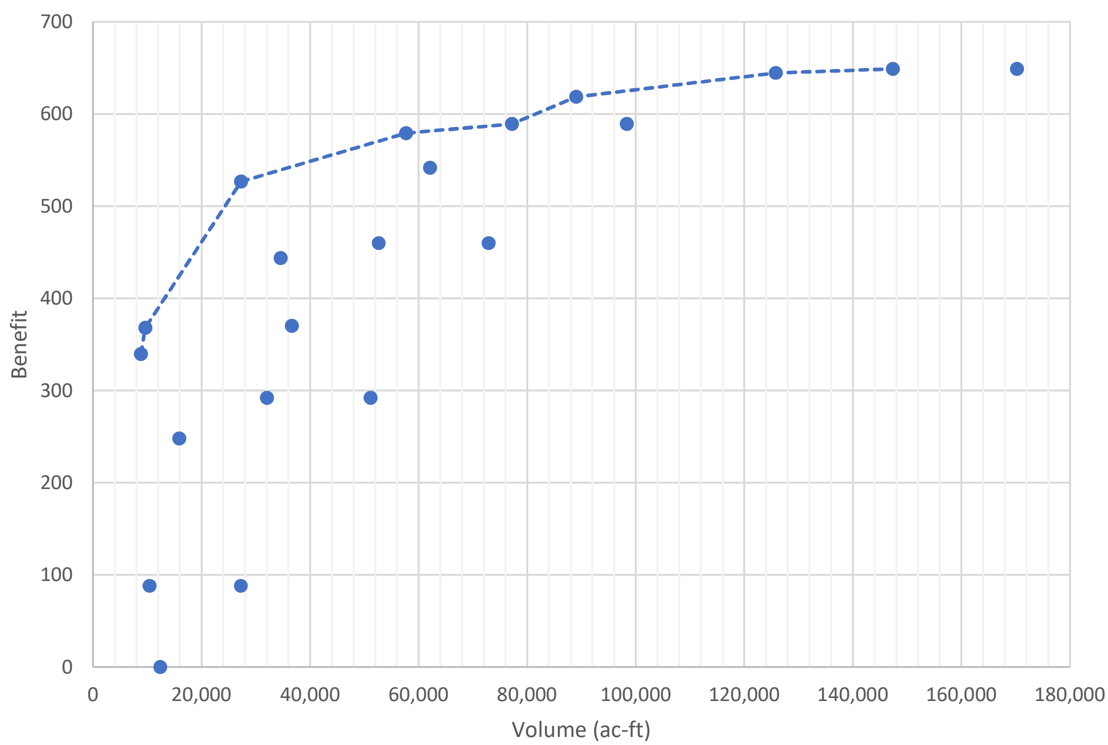
Start Flow	Target Flow	**Vol, ac-ft**	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**160,624**	177	93	49	1	0	0	0	**194**	1	160,624	194
500yr	50yr	**228,748**	93	49	1	0	0	0	0	**269**	1	68,124	75
500yr	25yr	**299,665**	49	1	0	0	0	0	0	**300**	1	70,917	31
500yr	10yr	**354,380**	1	0	0	0	0	0	0	**310**	1	54,714	10
500yr	5yr	**369,499**	0	0	0	0	0	0	0	**310**	1	15,119	0
500yr	2yr	**399,130**	0	0	0	0	0	0	0	**310**	1	29,632	0
100yr	50yr	**49,558**	295	93	49	1	0	0	0	**171**	3	49,558	171
100yr	25yr	**115,571**	295	49	1	0	0	0	0	**229**	2	66,013	58
100yr	10yr	**171,350**	295	1	0	0	0	0	0	**251**	1	55,780	22
100yr	5yr	**190,676**	295	0	0	0	0	0	0	**251**	1	19,326	0
100yr	2yr	**231,170**	295	0	0	0	0	0	0	**251**	1	40,494	0
50yr	25yr	**56,845**	295	177	49	1	0	0	0	**133**	2	56,845	133
50yr	10yr	**108,343**	295	177	1	0	0	0	0	**171**	2	51,499	38
50yr	5yr	**125,129**	295	177	0	0	0	0	0	**172**	1	16,785	1
50yr	2yr	**166,880**	295	177	0	0	0	0	0	**172**	1	41,751	0
25yr	10yr	**48,172**	295	177	93	1	0	0	0	**100**	2	48,172	100
25yr	5yr	**64,756**	295	177	93	0	0	0	0	**102**	2	16,584	2
25yr	2yr	**105,774**	295	177	93	0	0	0	0	**102**	1	41,018	0
10yr	5yr	**12,130**	295	177	93	49	0	0	0	**4**	0	12,130	4
10yr	2yr	**51,435**	295	177	93	49	0	0	0	**4**	0	39,305	0
5yr	2yr	**28,459**	295	177	93	49	1	0	0	**0**	0	28,459	0



Damage center: **DC_G1038003_001** *Station range:* 36738 to 18008 *Mile range:* 7 to 3.4

	Existing conditions	299	287	224	102	22	0	0	**649 Flood instances (50-yr)**

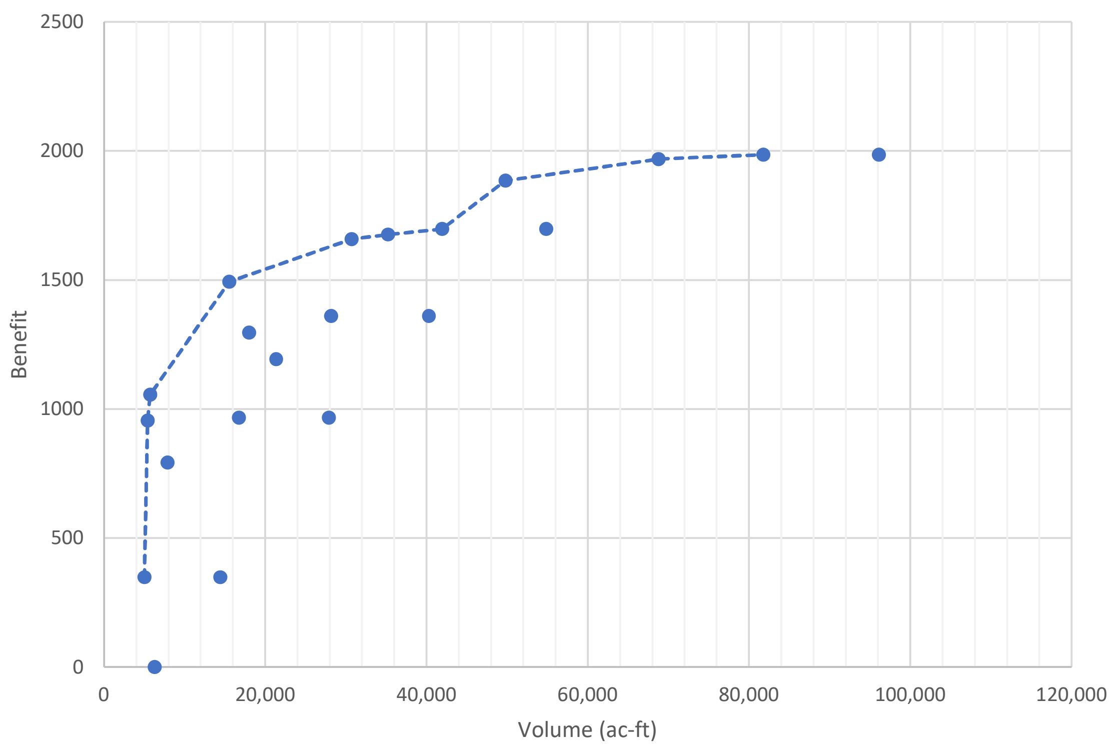
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**36,598**	287	224	102	22	0	0	0	**370**	10	36,598	370
500yr	50yr	**62,099**	224	102	22	0	0	0	0	**542**	9	25,501	172
500yr	25yr	**89,027**	102	22	0	0	0	0	0	**619**	7	26,928	77
500yr	10yr	**125,749**	22	0	0	0	0	0	0	**645**	5	36,723	26
500yr	5yr	**147,380**	0	0	0	0	0	0	0	**649**	4	21,631	4
500yr	2yr	**170,220**	0	0	0	0	0	0	0	**649**	4	22,840	0
100yr	50yr	**9,630**	299	224	102	22	0	0	0	**368**	38	9,630	368
100yr	25yr	**27,255**	299	102	22	0	0	0	0	**527**	19	17,626	159
100yr	10yr	**57,667**	299	22	0	0	0	0	0	**579**	10	30,412	53
100yr	5yr	**77,168**	299	0	0	0	0	0	0	**589**	8	19,502	10
100yr	2yr	**98,348**	299	0	0	0	0	0	0	**589**	6	21,179	0
50yr	25yr	**8,828**	299	287	102	22	0	0	0	**340**	38	8,828	340
50yr	10yr	**34,546**	299	287	22	0	0	0	0	**444**	13	25,718	104
50yr	5yr	**52,644**	299	287	0	0	0	0	0	**460**	9	18,098	17
50yr	2yr	**72,910**	299	287	0	0	0	0	0	**460**	6	20,265	0
25yr	10yr	**15,878**	299	287	224	22	0	0	0	**248**	16	15,878	248
25yr	5yr	**32,036**	299	287	224	0	0	0	0	**292**	9	16,158	44
25yr	2yr	**51,173**	299	287	224	0	0	0	0	**292**	6	19,137	0
10yr	5yr	**10,389**	299	287	224	102	0	0	0	**88**	8	10,389	88
10yr	2yr	**27,204**	299	287	224	102	0	0	0	**88**	3	16,815	0
5yr	2yr	**12,377**	299	287	224	102	22	0	0	**0**	0	12,377	0



Damage center: **DC_G1038003_002** *Station range:* 118670 to 48236 *Mile range:* 22.5 to 9.1

	Existing conditions		1439	749	526	309	87	0	0	**1985 Flood instances (50-yr)**			

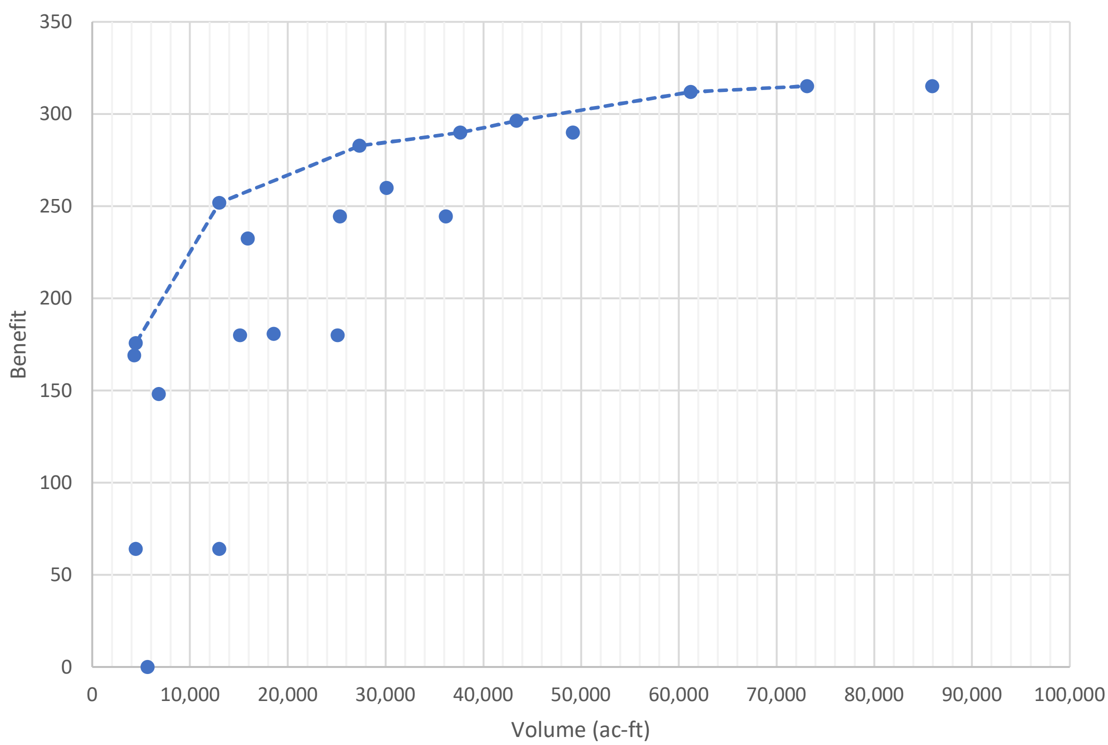
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**21,340**	749	526	309	87	0	0	0	**1193**	56	21,340	1193
500yr	50yr	**35,217**	526	309	87	0	0	0	0	**1676**	48	13,877	483
500yr	25yr	**49,805**	309	87	0	0	0	0	0	**1884**	38	14,587	209
500yr	10yr	**68,781**	87	0	0	0	0	0	0	**1968**	29	18,976	84
500yr	5yr	**81,777**	0	0	0	0	0	0	0	**1985**	24	12,997	17
500yr	2yr	**96,106**	0	0	0	0	0	0	0	**1985**	21	14,329	0
100yr	50yr	**5,725**	1439	526	309	87	0	0	0	**1055**	184	5,725	1055
100yr	25yr	**15,504**	1439	309	87	0	0	0	0	**1493**	96	9,779	438
100yr	10yr	**30,693**	1439	87	0	0	0	0	0	**1658**	54	15,189	165
100yr	5yr	**41,919**	1439	0	0	0	0	0	0	**1698**	40	11,226	39
100yr	2yr	**54,837**	1439	0	0	0	0	0	0	**1698**	31	12,918	0
50yr	25yr	**5,418**	1439	749	309	87	0	0	0	**955**	176	5,418	955
50yr	10yr	**17,973**	1439	749	87	0	0	0	0	**1295**	72	12,555	341
50yr	5yr	**28,158**	1439	749	0	0	0	0	0	**1361**	48	10,185	65
50yr	2yr	**40,283**	1439	749	0	0	0	0	0	**1361**	34	12,125	0
25yr	10yr	**7,885**	1439	749	526	87	0	0	0	**792**	100	7,885	792
25yr	5yr	**16,746**	1439	749	526	0	0	0	0	**966**	58	8,861	174
25yr	2yr	**27,899**	1439	749	526	0	0	0	0	**966**	35	11,153	0
10yr	5yr	**5,002**	1439	749	526	309	0	0	0	**348**	70	5,002	348
10yr	2yr	**14,421**	1439	749	526	309	0	0	0	**348**	24	9,419	0
5yr	2yr	**6,279**	1439	749	526	309	87	0	0	**0**	0	6,279	0



Damage center: **DC_G1038003_003** *Station range:* 158747 to 129425 *Mile range:* 30.1 to 24.5

Existing conditions	126	101	86	58	16	0	0	**315**	**Flood instances (50-yr)**

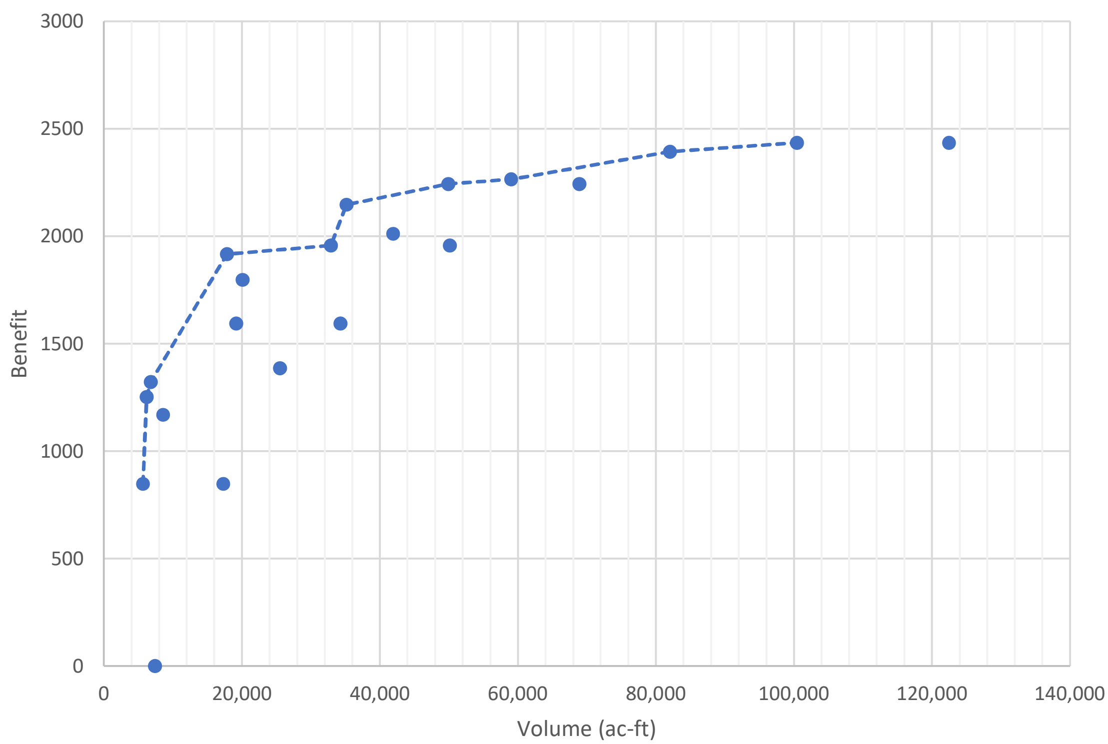
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**18,559**	101	86	58	16	0	0	0	**181**	10	18,559	181
500yr	50yr	**30,115**	86	58	16	0	0	0	0	**260**	9	11,556	79
500yr	25yr	**43,409**	58	16	0	0	0	0	0	**296**	7	13,294	37
500yr	10yr	**61,218**	16	0	0	0	0	0	0	**312**	5	17,809	16
500yr	5yr	**73,124**	0	0	0	0	0	0	0	**315**	4	11,906	3
500yr	2yr	**85,941**	0	0	0	0	0	0	0	**315**	4	12,817	0
100yr	50yr	**4,435**	126	86	58	16	0	0	0	**176**	40	4,435	176
100yr	25yr	**12,986**	126	58	16	0	0	0	0	**252**	19	8,551	76
100yr	10yr	**27,334**	126	16	0	0	0	0	0	**283**	10	14,349	31
100yr	5yr	**37,664**	126	0	0	0	0	0	0	**290**	8	10,329	7
100yr	2yr	**49,166**	126	0	0	0	0	0	0	**290**	6	11,503	0
50yr	25yr	**4,293**	126	101	58	16	0	0	0	**169**	39	4,293	169
50yr	10yr	**15,920**	126	101	16	0	0	0	0	**233**	15	11,627	64
50yr	5yr	**25,348**	126	101	0	0	0	0	0	**245**	10	9,428	12
50yr	2yr	**36,174**	126	101	0	0	0	0	0	**245**	7	10,826	0
25yr	10yr	**6,796**	126	101	86	16	0	0	0	**148**	22	6,796	148
25yr	5yr	**15,104**	126	101	86	0	0	0	0	**180**	12	8,308	32
25yr	2yr	**25,098**	126	101	86	0	0	0	0	**180**	7	9,995	0
10yr	5yr	**4,459**	126	101	86	58	0	0	0	**64**	14	4,459	64
10yr	2yr	**13,003**	126	101	86	58	0	0	0	**64**	5	8,545	0
5yr	2yr	**5,648**	126	101	86	58	16	0	0	**0**	0	5,648	0



Damage center: **DC_GPC_001** *Station range:* 38659 to 11231 *Mile range:* 7.3 to 2.1

Existing conditions	961	637	483	373	212	0	0	**2435**	**Flood instances (50-yr)**	

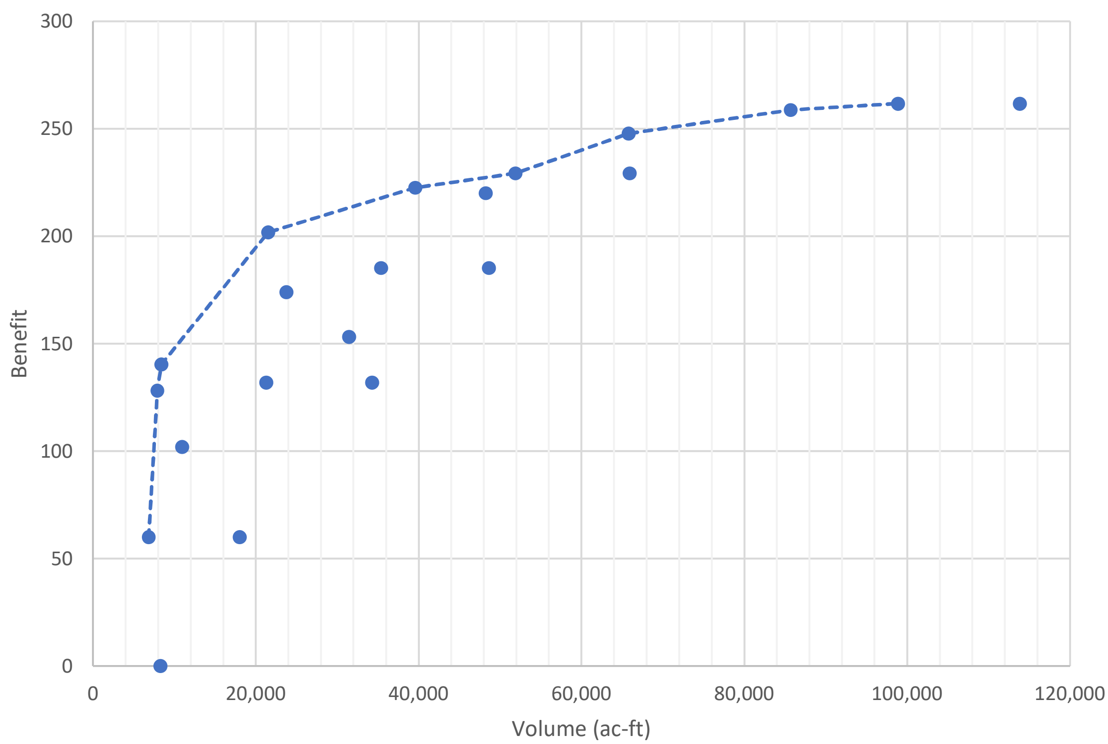
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**25,526**	637	483	373	212	0	0	0	**1387**	54	25,526	1387
500yr	50yr	**41,882**	483	373	212	0	0	0	0	**2012**	48	16,356	625
500yr	25yr	**58,989**	373	212	0	0	0	0	0	**2265**	38	17,107	253
500yr	10yr	**82,037**	212	0	0	0	0	0	0	**2393**	29	23,048	128
500yr	5yr	**100,437**	0	0	0	0	0	0	0	**2435**	24	18,400	42
500yr	2yr	**122,467**	0	0	0	0	0	0	0	**2435**	20	22,030	0
100yr	50yr	**6,757**	961	483	373	212	0	0	0	**1322**	196	6,757	1322
100yr	25yr	**17,846**	961	373	212	0	0	0	0	**1916**	107	11,089	594
100yr	10yr	**35,157**	961	212	0	0	0	0	0	**2148**	61	17,311	231
100yr	5yr	**49,908**	961	0	0	0	0	0	0	**2243**	45	14,751	95
100yr	2yr	**68,902**	961	0	0	0	0	0	0	**2243**	33	18,994	0
50yr	25yr	**6,175**	961	637	373	212	0	0	0	**1253**	203	6,175	1253
50yr	10yr	**20,095**	961	637	212	0	0	0	0	**1797**	89	13,920	545
50yr	5yr	**32,906**	961	637	0	0	0	0	0	**1956**	59	12,811	159
50yr	2yr	**50,131**	961	637	0	0	0	0	0	**1956**	39	17,225	0
25yr	10yr	**8,588**	961	637	483	212	0	0	0	**1170**	136	8,588	1170
25yr	5yr	**19,146**	961	637	483	0	0	0	0	**1594**	83	10,558	424
25yr	2yr	**34,254**	961	637	483	0	0	0	0	**1594**	47	15,108	0
10yr	5yr	**5,645**	961	637	483	373	0	0	0	**848**	150	5,645	848
10yr	2yr	**17,281**	961	637	483	373	0	0	0	**848**	49	11,636	0
5yr	2yr	**7,405**	961	637	483	373	212	0	0	**0**	0	7,405	0



Damage center: **DC_GPC_002** *Station range:* 55641 to 45107 *Mile range:* 10.5 to 8.5

Existing conditions	162	98	71	36	15	0	0	**262**	**Flood instances (50-yr)**

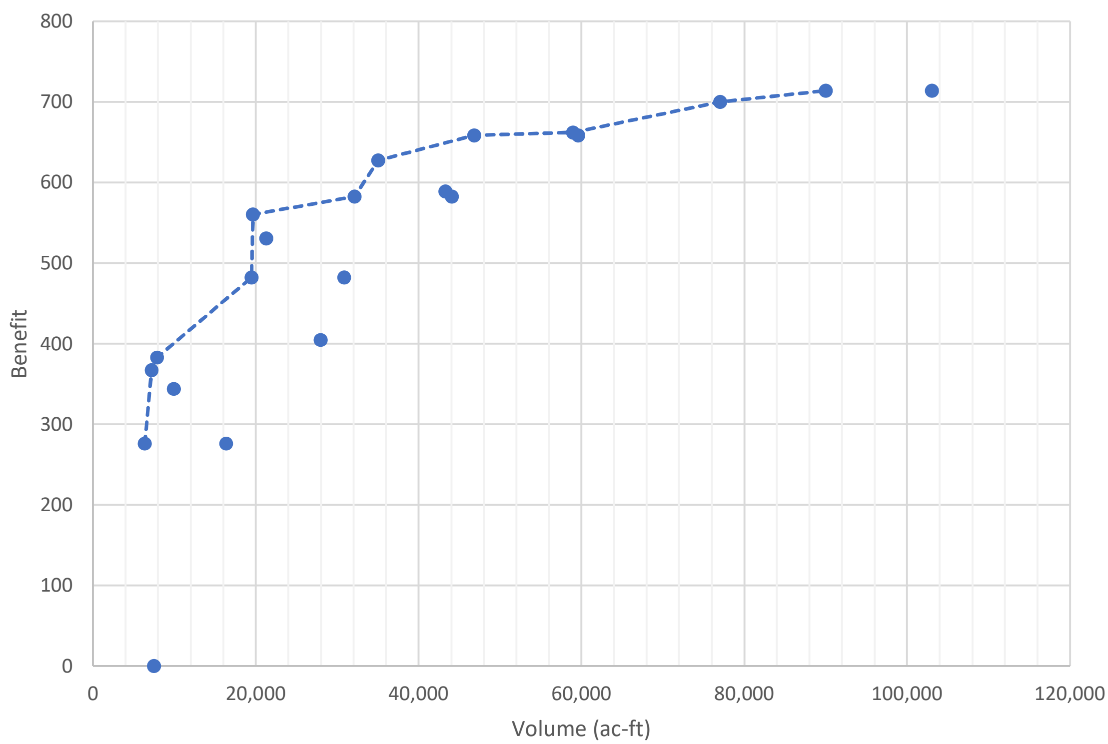
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**31,449**	98	71	36	15	0	0	0	**153**	5	31,449	153
500yr	50yr	**48,267**	71	36	15	0	0	0	0	**220**	5	16,818	67
500yr	25yr	**65,788**	36	15	0	0	0	0	0	**248**	4	17,520	28
500yr	10yr	**85,694**	15	0	0	0	0	0	0	**259**	3	19,907	11
500yr	5yr	**98,888**	0	0	0	0	0	0	0	**262**	3	13,194	3
500yr	2yr	**113,857**	0	0	0	0	0	0	0	**262**	2	14,968	0
100yr	50yr	**8,393**	162	71	36	15	0	0	0	**140**	17	8,393	140
100yr	25yr	**21,530**	162	36	15	0	0	0	0	**202**	9	13,137	62
100yr	10yr	**39,604**	162	15	0	0	0	0	0	**223**	6	18,074	21
100yr	5yr	**51,900**	162	0	0	0	0	0	0	**229**	4	12,296	7
100yr	2yr	**65,930**	162	0	0	0	0	0	0	**229**	3	14,030	0
50yr	25yr	**7,890**	162	98	36	15	0	0	0	**128**	16	7,890	128
50yr	10yr	**23,761**	162	98	15	0	0	0	0	**174**	7	15,871	46
50yr	5yr	**35,375**	162	98	0	0	0	0	0	**185**	5	11,615	11
50yr	2yr	**48,635**	162	98	0	0	0	0	0	**185**	4	13,259	0
25yr	10yr	**10,956**	162	98	71	15	0	0	0	**102**	9	10,956	102
25yr	5yr	**21,268**	162	98	71	0	0	0	0	**132**	6	10,312	30
25yr	2yr	**34,297**	162	98	71	0	0	0	0	**132**	4	13,030	0
10yr	5yr	**6,839**	162	98	71	36	0	0	0	**60**	9	6,839	60
10yr	2yr	**18,024**	162	98	71	36	0	0	0	**60**	3	11,186	0
5yr	2yr	**8,281**	162	98	71	36	15	0	0	**0**	0	8,281	0



Damage center: **DC_GPC_003** *Station range:* 80171 to 56232 *Mile range:* 15.2 to 10.7

Existing conditions	277	169	134	103	69	0	0	**714**	**Flood instances (50-yr)**

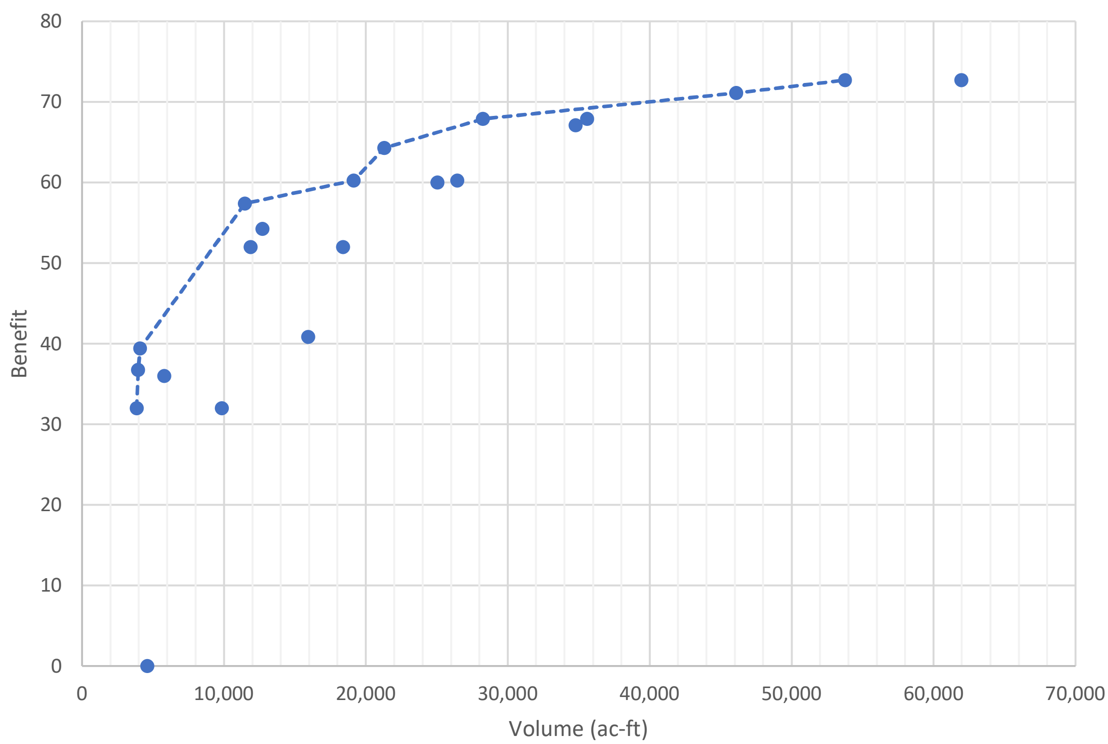
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**27,974**	169	134	103	69	0	0	0	**405**	14	27,974	405
500yr	50yr	**43,321**	134	103	69	0	0	0	0	**589**	14	15,347	184
500yr	25yr	**58,970**	103	69	0	0	0	0	0	**662**	11	15,649	73
500yr	10yr	**77,034**	69	0	0	0	0	0	0	**700**	9	18,063	38
500yr	5yr	**90,011**	0	0	0	0	0	0	0	**714**	8	12,977	14
500yr	2yr	**103,076**	0	0	0	0	0	0	0	**714**	7	13,065	0
100yr	50yr	**7,892**	277	134	103	69	0	0	0	**383**	49	7,892	383
100yr	25yr	**19,664**	277	103	69	0	0	0	0	**560**	29	11,772	177
100yr	10yr	**35,035**	277	69	0	0	0	0	0	**628**	18	15,371	67
100yr	5yr	**46,846**	277	0	0	0	0	0	0	**659**	14	11,811	31
100yr	2yr	**59,609**	277	0	0	0	0	0	0	**659**	11	12,763	0
50yr	25yr	**7,193**	277	169	103	69	0	0	0	**367**	51	7,193	367
50yr	10yr	**21,297**	277	169	69	0	0	0	0	**531**	25	14,104	164
50yr	5yr	**32,144**	277	169	0	0	0	0	0	**583**	18	10,847	52
50yr	2yr	**44,085**	277	169	0	0	0	0	0	**583**	13	11,941	0
25yr	10yr	**9,926**	277	169	134	69	0	0	0	**344**	35	9,926	344
25yr	5yr	**19,488**	277	169	134	0	0	0	0	**482**	25	9,562	138
25yr	2yr	**30,851**	277	169	134	0	0	0	0	**482**	16	11,363	0
10yr	5yr	**6,349**	277	169	134	103	0	0	0	**276**	43	6,349	276
10yr	2yr	**16,373**	277	169	134	103	0	0	0	**276**	17	10,024	0
5yr	2yr	**7,487**	277	169	134	103	69	0	0	**0**	0	7,487	0



Damage center: **DC_GPC_004** *Station range:* 123295 to 113293 *Mile range:* 23.4 to 21.5

Existing conditions	24	17	11	10	8	0	0	**73**	**Flood instances (50-yr)**

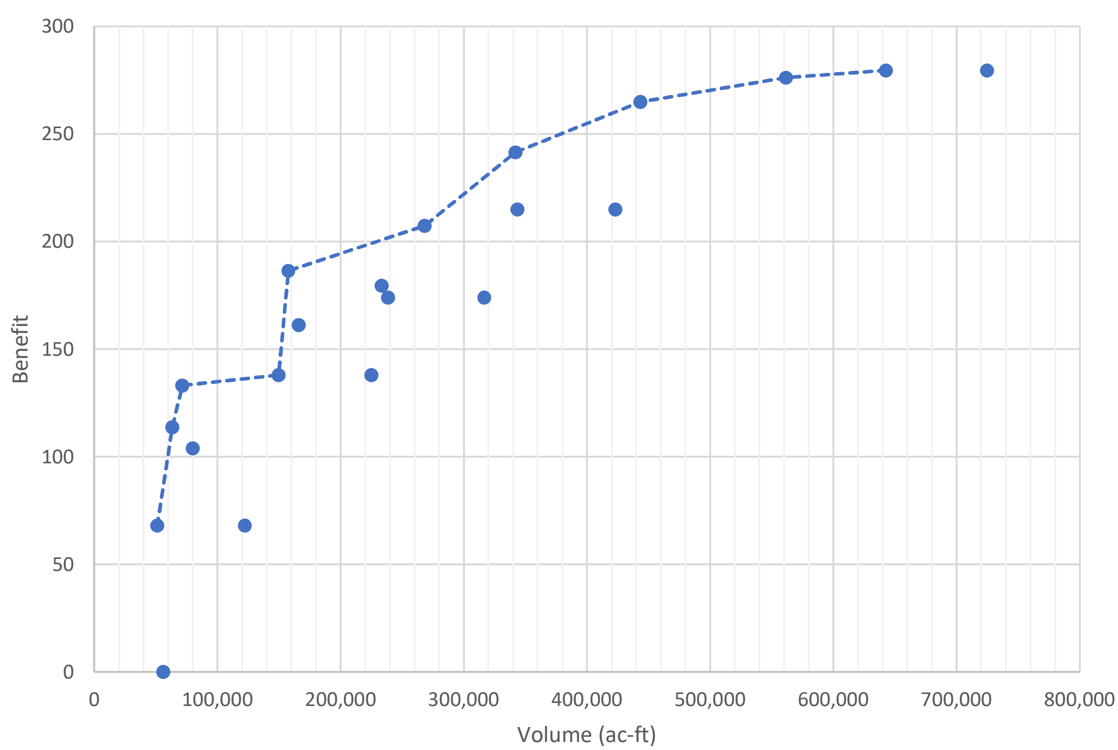
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**15,940**	17	11	10	8	0	0	0	**41**	3	15,940	41
500yr	50yr	**25,059**	11	10	8	0	0	0	0	**60**	2	9,119	19
500yr	25yr	**34,798**	10	8	0	0	0	0	0	**67**	2	9,739	7
500yr	10yr	**46,101**	8	0	0	0	0	0	0	**71**	2	11,303	4
500yr	5yr	**53,775**	0	0	0	0	0	0	0	**73**	1	7,674	2
500yr	2yr	**61,966**	0	0	0	0	0	0	0	**73**	1	8,191	0
100yr	50yr	**4,096**	24	11	10	8	0	0	0	**39**	10	4,096	39
100yr	25yr	**11,485**	24	10	8	0	0	0	0	**57**	5	7,389	18
100yr	10yr	**21,301**	24	8	0	0	0	0	0	**64**	3	9,816	7
100yr	5yr	**28,263**	24	0	0	0	0	0	0	**68**	2	6,962	4
100yr	2yr	**35,603**	24	0	0	0	0	0	0	**68**	2	7,340	0
50yr	25yr	**3,955**	24	17	10	8	0	0	0	**37**	9	3,955	37
50yr	10yr	**12,709**	24	17	8	0	0	0	0	**54**	4	8,754	18
50yr	5yr	**19,153**	24	17	0	0	0	0	0	**60**	3	6,444	6
50yr	2yr	**26,455**	24	17	0	0	0	0	0	**60**	2	7,302	0
25yr	10yr	**5,810**	24	17	11	8	0	0	0	**36**	6	5,810	36
25yr	5yr	**11,897**	24	17	11	0	0	0	0	**52**	4	6,087	16
25yr	2yr	**18,399**	24	17	11	0	0	0	0	**52**	3	6,502	0
10yr	5yr	**3,845**	24	17	11	10	0	0	0	**32**	8	3,845	32
10yr	2yr	**9,863**	24	17	11	10	0	0	0	**32**	3	6,018	0
5yr	2yr	**4,605**	24	17	11	10	8	0	0	**0**	0	4,605	0



Damage center: **DC_GEF_001** *Station range:* 22852 to 8985 *Mile range:* 4.3 to 1.7

Existing conditions	323	91	48	35	17	0	0	**280 Flood instances (50-yr)**

Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**233,447**	91	48	35	17	0	0	0	**180**	1	233,447	180
500yr	50yr	**341,880**	48	35	17	0	0	0	0	**241**	1	108,433	62
500yr	25yr	**443,480**	35	17	0	0	0	0	0	**265**	1	101,600	23
500yr	10yr	**561,438**	17	0	0	0	0	0	0	**276**	0	117,958	11
500yr	5yr	**642,717**	0	0	0	0	0	0	0	**280**	0	81,279	3
500yr	2yr	**724,730**	0	0	0	0	0	0	0	**280**	0	82,013	0
100yr	50yr	**71,441**	323	48	35	17	0	0	0	**133**	2	71,441	133
100yr	25yr	**157,607**	323	35	17	0	0	0	0	**186**	1	86,167	53
100yr	10yr	**268,158**	323	17	0	0	0	0	0	**207**	1	110,551	21
100yr	5yr	**343,532**	323	0	0	0	0	0	0	**215**	1	75,374	8
100yr	2yr	**423,013**	323	0	0	0	0	0	0	**215**	1	79,481	0
50yr	25yr	**63,411**	323	91	35	17	0	0	0	**114**	2	63,411	114
50yr	10yr	**166,099**	323	91	17	0	0	0	0	**161**	1	102,688	48
50yr	5yr	**238,651**	323	91	0	0	0	0	0	**174**	1	72,552	13
50yr	2yr	**316,658**	323	91	0	0	0	0	0	**174**	1	78,007	0
25yr	10yr	**80,035**	323	91	48	17	0	0	0	**104**	1	80,035	104
25yr	5yr	**149,750**	323	91	48	0	0	0	0	**138**	1	69,715	34
25yr	2yr	**224,988**	323	91	48	0	0	0	0	**138**	1	75,238	0
10yr	5yr	**51,179**	323	91	48	35	0	0	0	**68**	1	51,179	68
10yr	2yr	**122,205**	323	91	48	35	0	0	0	**68**	1	71,026	0
5yr	2yr	**56,190**	323	91	48	35	17	0	0	**0**	0	56,190	0

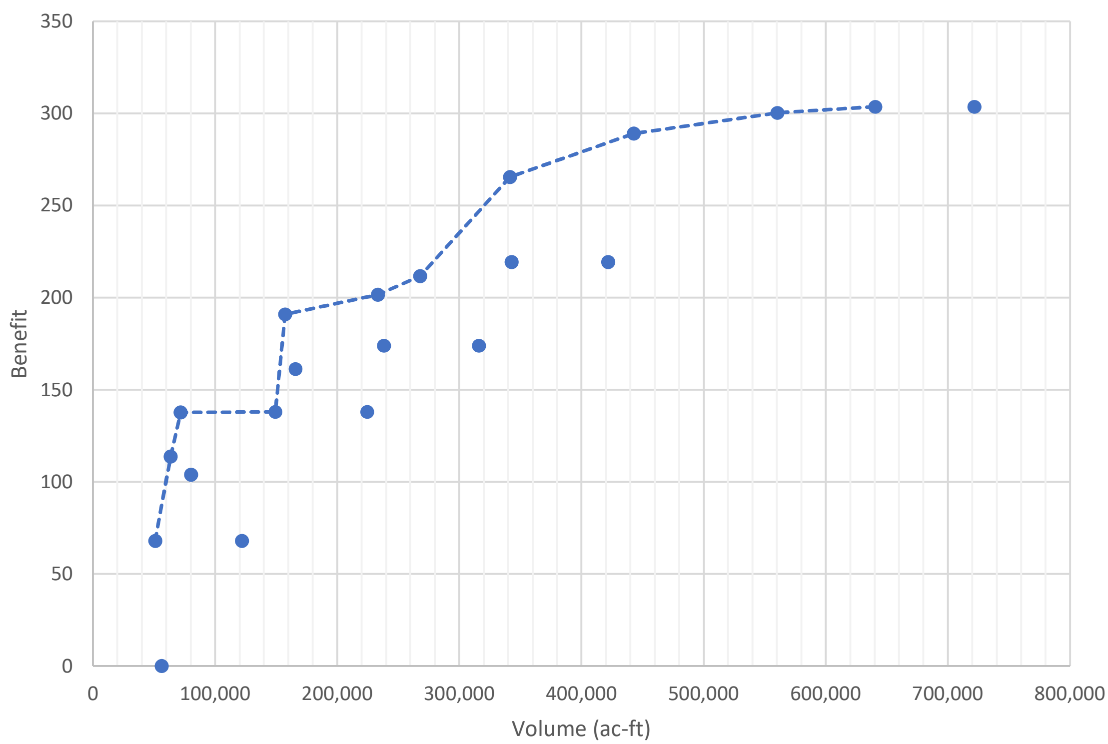


SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Damage center: **DC_GEF_002** *Station range:* 30042 to 8985 *Mile range:* 5.7 to 1.7

Existing conditions	421	101	48	35	17	0	0	**304**	**Flood instances (50-yr)**			

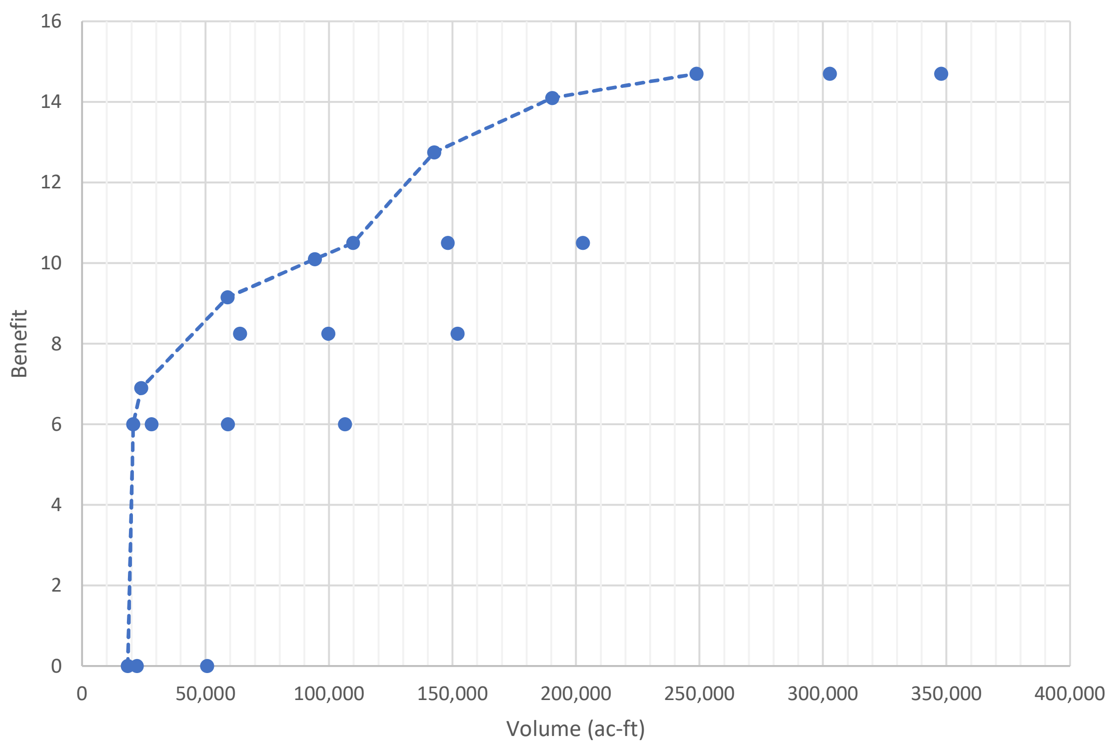
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**233,187**	101	48	35	17	0	0	0	**202**	1	233,187	202
500yr	50yr	**341,520**	48	35	17	0	0	0	0	**266**	1	108,333	64
500yr	25yr	**442,879**	35	17	0	0	0	0	0	**289**	1	101,360	23
500yr	10yr	**560,390**	17	0	0	0	0	0	0	**300**	1	117,510	11
500yr	5yr	**640,511**	0	0	0	0	0	0	0	**304**	0	80,121	3
500yr	2yr	**721,679**	0	0	0	0	0	0	0	**304**	0	81,167	0
100yr	50yr	**71,684**	421	48	35	17	0	0	0	**138**	2	71,684	138
100yr	25yr	**157,309**	421	35	17	0	0	0	0	**191**	1	85,624	53
100yr	10yr	**267,789**	421	17	0	0	0	0	0	**212**	1	110,480	21
100yr	5yr	**342,830**	421	0	0	0	0	0	0	**219**	1	75,041	8
100yr	2yr	**421,945**	421	0	0	0	0	0	0	**219**	1	79,115	0
50yr	25yr	**63,609**	421	101	35	17	0	0	0	**114**	2	63,609	114
50yr	10yr	**165,831**	421	101	17	0	0	0	0	**161**	1	102,223	48
50yr	5yr	**238,165**	421	101	0	0	0	0	0	**174**	1	72,334	13
50yr	2yr	**315,907**	421	101	0	0	0	0	0	**174**	1	77,741	0
25yr	10yr	**80,216**	421	101	48	17	0	0	0	**104**	1	80,216	104
25yr	5yr	**149,385**	421	101	48	0	0	0	0	**138**	1	69,169	34
25yr	2yr	**224,464**	421	101	48	0	0	0	0	**138**	1	75,078	0
10yr	5yr	**50,946**	421	101	48	35	0	0	0	**68**	1	50,946	68
10yr	2yr	**121,886**	421	101	48	35	0	0	0	**68**	1	70,940	0
5yr	2yr	**56,218**	421	101	48	35	17	0	0	**0**	0	56,218	0



Damage center: **DC_GEF_003** *Station range:* 45844 to 38240 *Mile range:* 8.7 to 7.2

Existing conditions	21	5	3	3	0	0	0	**15**	**Flood instances (50-yr)**

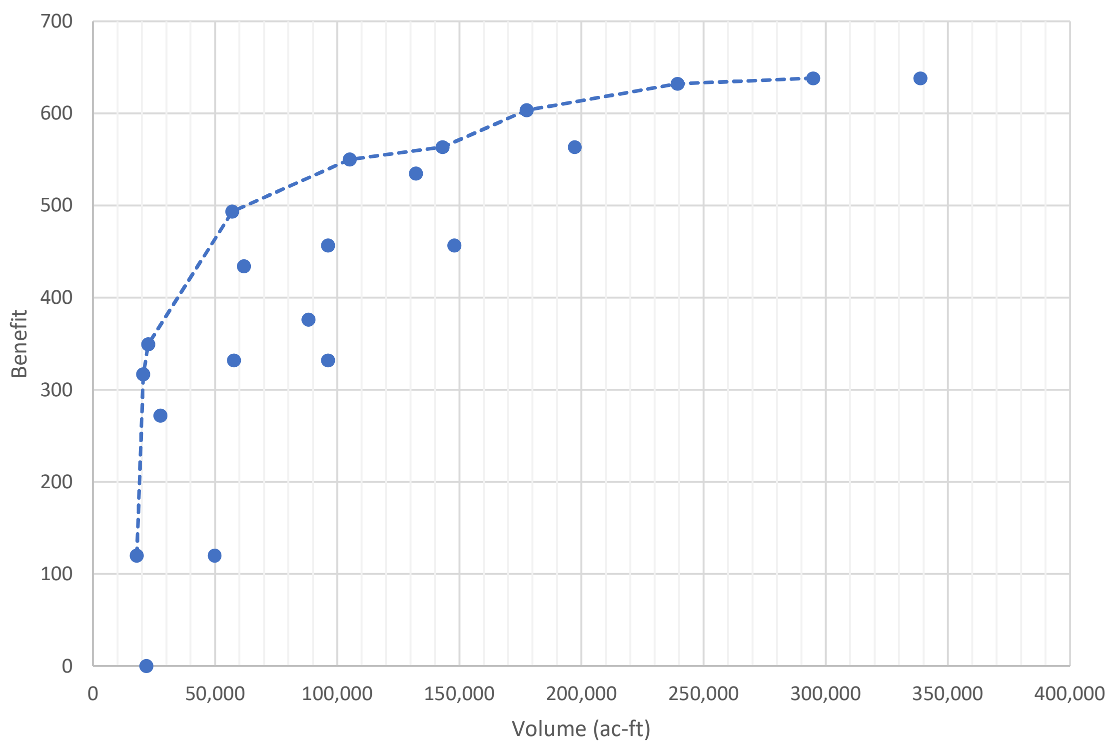
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**94,288**	5	3	3	0	0	0	0	**10**	0	94,288	10
500yr	50yr	**142,590**	3	3	0	0	0	0	0	**13**	0	48,302	3
500yr	25yr	**190,470**	3	0	0	0	0	0	0	**14**	0	47,880	1
500yr	10yr	**248,791**	0	0	0	0	0	0	0	**15**	0	58,320	1
500yr	5yr	**302,775**	0	0	0	0	0	0	0	**15**	0	53,984	0
500yr	2yr	**347,934**	0	0	0	0	0	0	0	**15**	0	45,159	0
100yr	50yr	**23,994**	21	3	3	0	0	0	0	**7**	0	23,994	7
100yr	25yr	**58,920**	21	3	0	0	0	0	0	**9**	0	34,926	2
100yr	10yr	**109,800**	21	0	0	0	0	0	0	**11**	0	50,880	1
100yr	5yr	**148,156**	21	0	0	0	0	0	0	**11**	0	38,356	0
100yr	2yr	**202,809**	21	0	0	0	0	0	0	**11**	0	54,653	0
50yr	25yr	**20,695**	21	5	3	0	0	0	0	**6**	0	20,695	6
50yr	10yr	**64,000**	21	5	0	0	0	0	0	**8**	0	43,305	2
50yr	5yr	**99,684**	21	5	0	0	0	0	0	**8**	0	35,684	0
50yr	2yr	**152,057**	21	5	0	0	0	0	0	**8**	0	52,373	0
25yr	10yr	**28,153**	21	5	3	0	0	0	0	**6**	0	28,153	6
25yr	5yr	**59,098**	21	5	3	0	0	0	0	**6**	0	30,945	0
25yr	2yr	**106,528**	21	5	3	0	0	0	0	**6**	0	47,430	0
10yr	5yr	**18,509**	21	5	3	3	0	0	0	**0**	0	18,509	0
10yr	2yr	**50,698**	21	5	3	3	0	0	0	**0**	0	32,190	0
5yr	2yr	**22,269**	21	5	3	3	0	0	0	**0**	0	22,269	0



Damage center: **DC_GEF_004** *Station range:* 70458 to 55269 *Mile range:* 13.3 to 10.5

Existing conditions	373	238	166	106	30	0	0	**638**	**Flood instances (50-yr)**

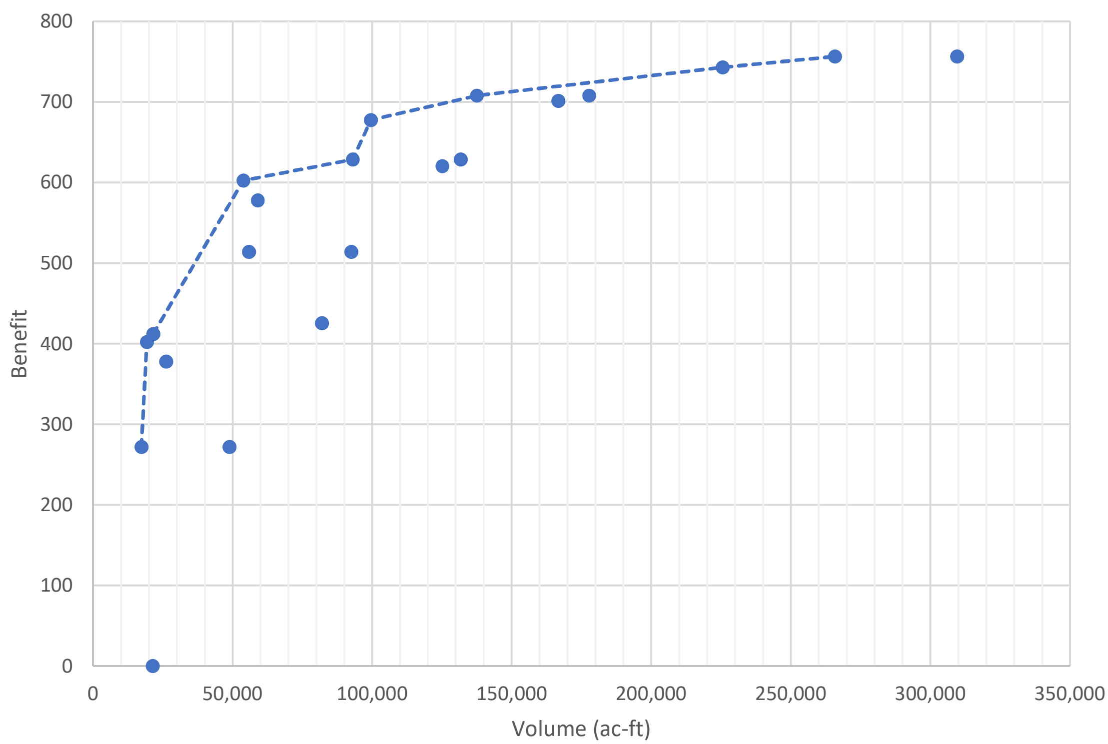
Start Flow	Target Flow	**Vol, ac-ft**	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**88,288**	238	166	106	30	0	0	0	**376**	4	88,288	376
500yr	50yr	**132,207**	166	106	30	0	0	0	0	**535**	4	43,919	158
500yr	25yr	**177,651**	106	30	0	0	0	0	0	**604**	3	45,444	69
500yr	10yr	**239,347**	30	0	0	0	0	0	0	**632**	3	61,695	29
500yr	5yr	**294,928**	0	0	0	0	0	0	0	**638**	2	55,581	6
500yr	2yr	**338,840**	0	0	0	0	0	0	0	**638**	2	43,912	0
100yr	50yr	**22,653**	373	166	106	30	0	0	0	**349**	15	22,653	349
100yr	25yr	**57,020**	373	106	30	0	0	0	0	**493**	9	34,367	144
100yr	10yr	**105,149**	373	30	0	0	0	0	0	**550**	5	48,129	57
100yr	5yr	**143,242**	373	0	0	0	0	0	0	**564**	4	38,093	14
100yr	2yr	**197,313**	373	0	0	0	0	0	0	**564**	3	54,071	0
50yr	25yr	**20,560**	373	238	106	30	0	0	0	**317**	15	20,560	317
50yr	10yr	**61,876**	373	238	30	0	0	0	0	**434**	7	41,316	117
50yr	5yr	**96,304**	373	238	0	0	0	0	0	**457**	5	34,428	23
50yr	2yr	**148,029**	373	238	0	0	0	0	0	**457**	3	51,726	0
25yr	10yr	**27,684**	373	238	166	30	0	0	0	**272**	10	27,684	272
25yr	5yr	**57,771**	373	238	166	0	0	0	0	**332**	6	30,087	60
25yr	2yr	**96,306**	373	238	166	0	0	0	0	**332**	3	38,535	0
10yr	5yr	**17,945**	373	238	166	106	0	0	0	**120**	7	17,945	120
10yr	2yr	**49,895**	373	238	166	106	0	0	0	**120**	2	31,950	0
5yr	2yr	**21,889**	373	238	166	106	30	0	0	**0**	0	21,889	0



Damage center: **DC_GEF_005** *Station range:* 109934 to 94148 *Mile range:* 20.8 to 17.8

Existing conditions	242	176	153	121	68	0	0	**756**	**Flood instances (50-yr)**

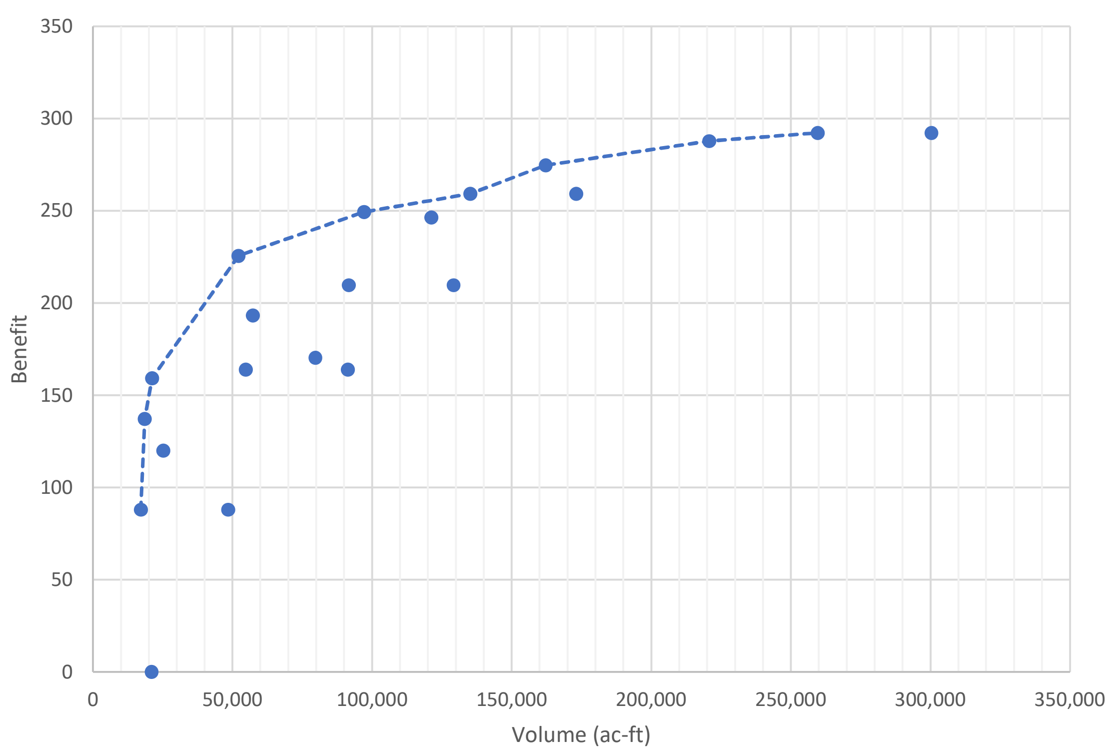
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**82,046**	176	153	121	68	0	0	0	**426**	5	82,046	426
500yr	50yr	**125,161**	153	121	68	0	0	0	0	**620**	5	43,115	195
500yr	25yr	**166,680**	121	68	0	0	0	0	0	**702**	4	41,519	81
500yr	10yr	**225,569**	68	0	0	0	0	0	0	**743**	3	58,889	41
500yr	5yr	**265,806**	0	0	0	0	0	0	0	**756**	3	40,237	14
500yr	2yr	**309,533**	0	0	0	0	0	0	0	**756**	2	43,727	0
100yr	50yr	**21,595**	242	153	121	68	0	0	0	**412**	19	21,595	412
100yr	25yr	**53,811**	242	121	68	0	0	0	0	**603**	11	32,216	190
100yr	10yr	**99,536**	242	68	0	0	0	0	0	**677**	7	45,725	75
100yr	5yr	**137,528**	242	0	0	0	0	0	0	**708**	5	37,992	31
100yr	2yr	**177,752**	242	0	0	0	0	0	0	**708**	4	40,224	0
50yr	25yr	**19,301**	242	176	121	68	0	0	0	**402**	21	19,301	402
50yr	10yr	**59,032**	242	176	68	0	0	0	0	**578**	10	39,731	176
50yr	5yr	**93,041**	242	176	0	0	0	0	0	**629**	7	34,009	51
50yr	2yr	**131,703**	242	176	0	0	0	0	0	**629**	5	38,662	0
25yr	10yr	**26,184**	242	176	153	68	0	0	0	**378**	14	26,184	378
25yr	5yr	**55,793**	242	176	153	0	0	0	0	**514**	9	29,609	136
25yr	2yr	**92,567**	242	176	153	0	0	0	0	**514**	6	36,774	0
10yr	5yr	**17,334**	242	176	153	121	0	0	0	**272**	16	17,334	272
10yr	2yr	**48,930**	242	176	153	121	0	0	0	**272**	6	31,595	0
5yr	2yr	**21,320**	242	176	153	121	68	0	0	**0**	0	21,320	0



Damage center: **DC_GEF_006** *Station range:* 127270 to 118355 *Mile range:* 24.1 to 22.4

Existing conditions	165	110	61	38	22	0	0	**292**	**Flood instances (50-yr)**

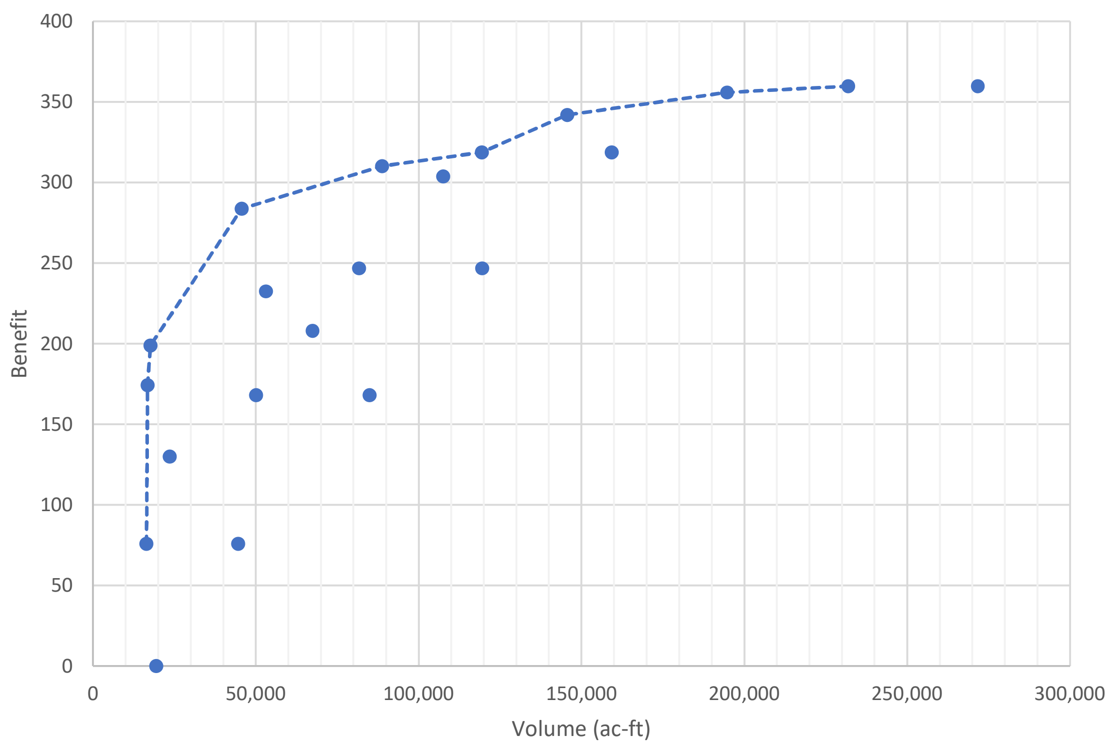
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**79,660**	110	61	38	22	0	0	0	**170**	2	79,660	170
500yr	50yr	**121,237**	61	38	22	0	0	0	0	**246**	2	41,577	76
500yr	25yr	**162,161**	38	22	0	0	0	0	0	**275**	2	40,924	28
500yr	10yr	**220,767**	22	0	0	0	0	0	0	**288**	1	58,606	13
500yr	5yr	**259,608**	0	0	0	0	0	0	0	**292**	1	38,840	4
500yr	2yr	**300,402**	0	0	0	0	0	0	0	**292**	1	40,795	0
100yr	50yr	**21,146**	165	61	38	22	0	0	0	**159**	8	21,146	159
100yr	25yr	**52,154**	165	38	22	0	0	0	0	**226**	4	31,008	66
100yr	10yr	**97,129**	165	22	0	0	0	0	0	**249**	3	44,975	24
100yr	5yr	**135,164**	165	0	0	0	0	0	0	**259**	2	38,035	10
100yr	2yr	**173,045**	165	0	0	0	0	0	0	**259**	1	37,880	0
50yr	25yr	**18,519**	165	110	38	22	0	0	0	**137**	7	18,519	137
50yr	10yr	**57,323**	165	110	22	0	0	0	0	**193**	3	38,803	56
50yr	5yr	**91,587**	165	110	0	0	0	0	0	**210**	2	34,264	17
50yr	2yr	**129,180**	165	110	0	0	0	0	0	**210**	2	37,593	0
25yr	10yr	**25,165**	165	110	61	22	0	0	0	**120**	5	25,165	120
25yr	5yr	**54,677**	165	110	61	0	0	0	0	**164**	3	29,512	44
25yr	2yr	**91,301**	165	110	61	0	0	0	0	**164**	2	36,624	0
10yr	5yr	**17,123**	165	110	61	38	0	0	0	**88**	5	17,123	88
10yr	2yr	**48,360**	165	110	61	38	0	0	0	**88**	2	31,237	0
5yr	2yr	**20,932**	165	110	61	38	22	0	0	**0**	0	20,932	0



Damage center: **DC_GEF_007** *Station range:* 193433 to 170435 *Mile range:* 36.6 to 32.3

Existing conditions	205	160	105	46	19	0	0	**360 Flood instances (50-yr)**		

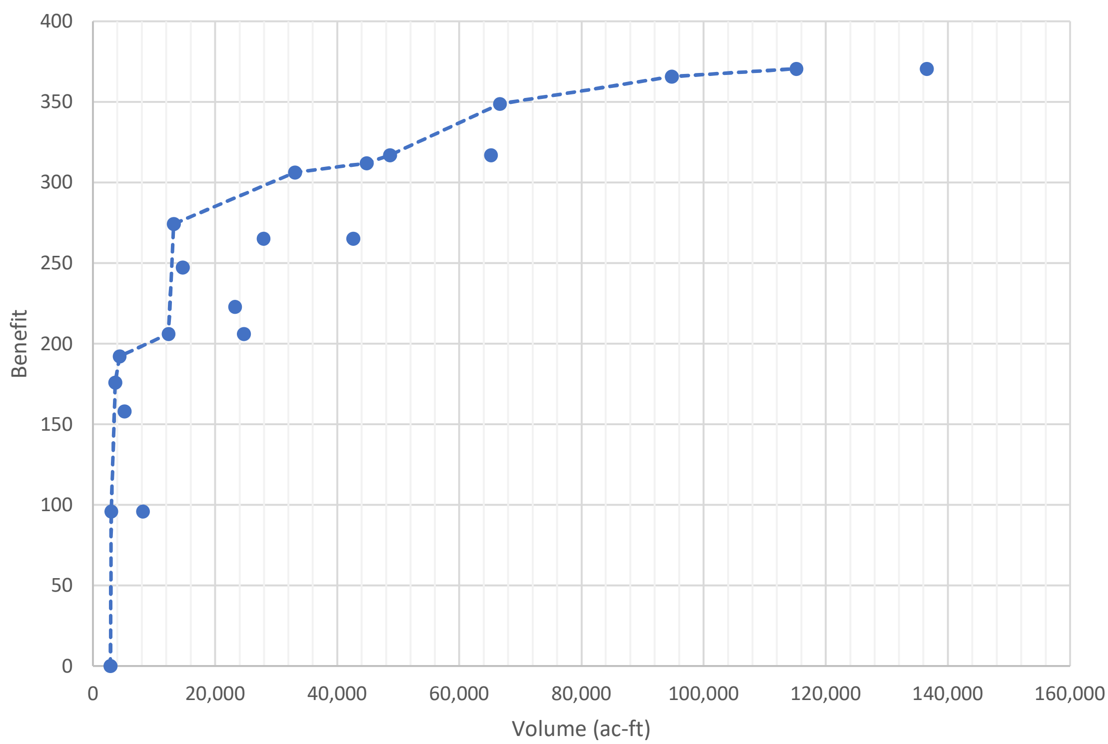
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**67,368**	160	105	46	19	0	0	0	**208**	3	67,368	208
500yr	50yr	**107,515**	105	46	19	0	0	0	0	**304**	3	40,147	96
500yr	25yr	**145,630**	46	19	0	0	0	0	0	**342**	2	38,115	38
500yr	10yr	**194,681**	19	0	0	0	0	0	0	**356**	2	49,051	14
500yr	5yr	**231,888**	0	0	0	0	0	0	0	**360**	2	37,207	4
500yr	2yr	**271,721**	0	0	0	0	0	0	0	**360**	1	39,834	0
100yr	50yr	**17,682**	205	105	46	19	0	0	0	**199**	11	17,682	199
100yr	25yr	**45,685**	205	46	19	0	0	0	0	**284**	6	28,003	85
100yr	10yr	**88,805**	205	19	0	0	0	0	0	**310**	3	43,120	26
100yr	5yr	**119,432**	205	0	0	0	0	0	0	**319**	3	30,627	9
100yr	2yr	**159,261**	205	0	0	0	0	0	0	**319**	2	39,829	0
50yr	25yr	**16,790**	205	160	46	19	0	0	0	**174**	10	16,790	174
50yr	10yr	**53,061**	205	160	19	0	0	0	0	**233**	4	36,270	58
50yr	5yr	**81,729**	205	160	0	0	0	0	0	**247**	3	28,669	14
50yr	2yr	**119,492**	205	160	0	0	0	0	0	**247**	2	37,763	0
25yr	10yr	**23,568**	205	160	105	19	0	0	0	**130**	6	23,568	130
25yr	5yr	**50,042**	205	160	105	0	0	0	0	**168**	3	26,474	38
25yr	2yr	**84,876**	205	160	105	0	0	0	0	**168**	2	34,834	0
10yr	5yr	**16,433**	205	160	105	46	0	0	0	**76**	5	16,433	76
10yr	2yr	**44,628**	205	160	105	46	0	0	0	**76**	2	28,194	0
5yr	2yr	**19,397**	205	160	105	46	19	0	0	**0**	0	19,397	0



Damage center: **DC_K100_001** *Station range:* 24423 to 16487 *Mile range:* 4.6 to 3.1

Existing conditions	268	115	79	55	24	0	0	**371**	**Flood instances (50-yr)**

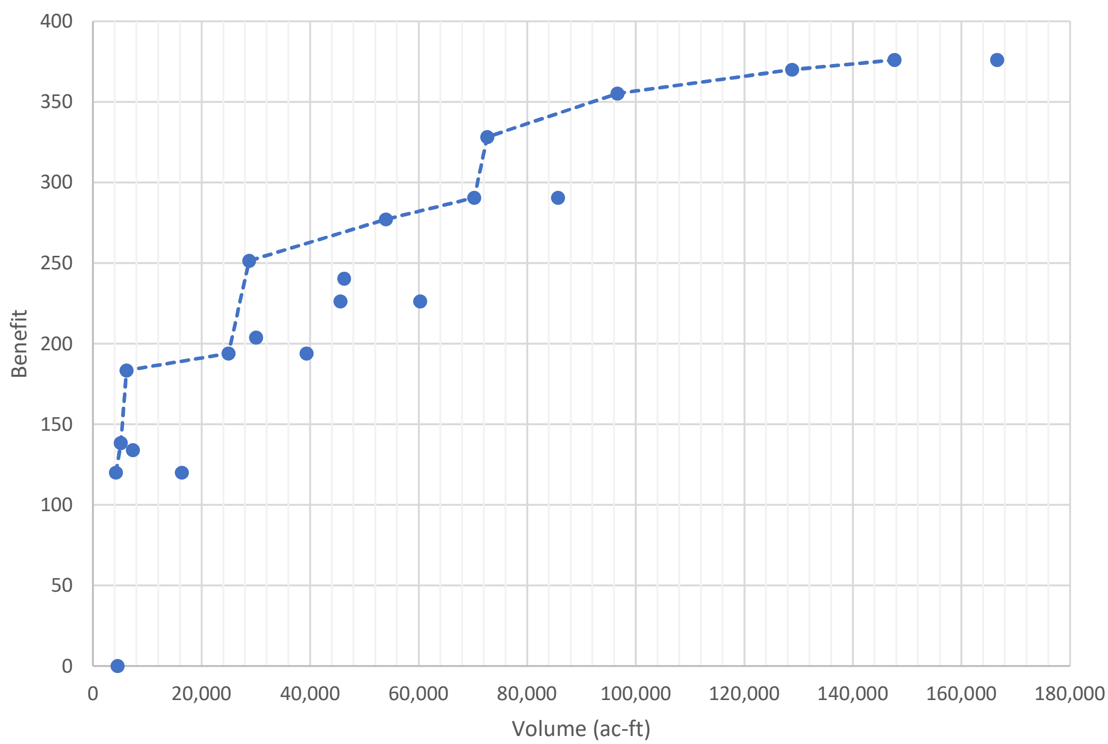
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**23,239**	115	79	55	24	0	0	0	**223**	10	23,239	223
500yr	50yr	**44,784**	79	55	24	0	0	0	0	**312**	7	21,545	89
500yr	25yr	**66,656**	55	24	0	0	0	0	0	**349**	5	21,872	37
500yr	10yr	**94,776**	24	0	0	0	0	0	0	**366**	4	28,120	17
500yr	5yr	**115,205**	0	0	0	0	0	0	0	**371**	3	20,429	5
500yr	2yr	**136,549**	0	0	0	0	0	0	0	**371**	3	21,344	0
100yr	50yr	**4,376**	268	79	55	24	0	0	0	**192**	44	4,376	192
100yr	25yr	**13,217**	268	55	24	0	0	0	0	**274**	21	8,841	82
100yr	10yr	**33,073**	268	24	0	0	0	0	0	**306**	9	19,856	32
100yr	5yr	**48,616**	268	0	0	0	0	0	0	**317**	7	15,543	11
100yr	2yr	**65,167**	268	0	0	0	0	0	0	**317**	5	16,551	0
50yr	25yr	**3,662**	268	115	55	24	0	0	0	**176**	48	3,662	176
50yr	10yr	**14,670**	268	115	24	0	0	0	0	**247**	17	11,008	71
50yr	5yr	**27,943**	268	115	0	0	0	0	0	**265**	9	13,272	18
50yr	2yr	**42,624**	268	115	0	0	0	0	0	**265**	6	14,681	0
25yr	10yr	**5,144**	268	115	79	24	0	0	0	**158**	31	5,144	158
25yr	5yr	**12,363**	268	115	79	0	0	0	0	**206**	17	7,219	48
25yr	2yr	**24,727**	268	115	79	0	0	0	0	**206**	8	12,364	0
10yr	5yr	**3,002**	268	115	79	55	0	0	0	**96**	32	3,002	96
10yr	2yr	**8,156**	268	115	79	55	0	0	0	**96**	12	5,154	0
5yr	2yr	**2,851**	268	115	79	55	24	0	0	**0**	0	2,851	0



Damage center: **DC_K100_002** *Station range:* 34622 to 28610.9 *Mile range:* 6.6 to 5.4

Existing conditions	427	143	43	37	30	0	0	**376 Flood instances (50-yr)**

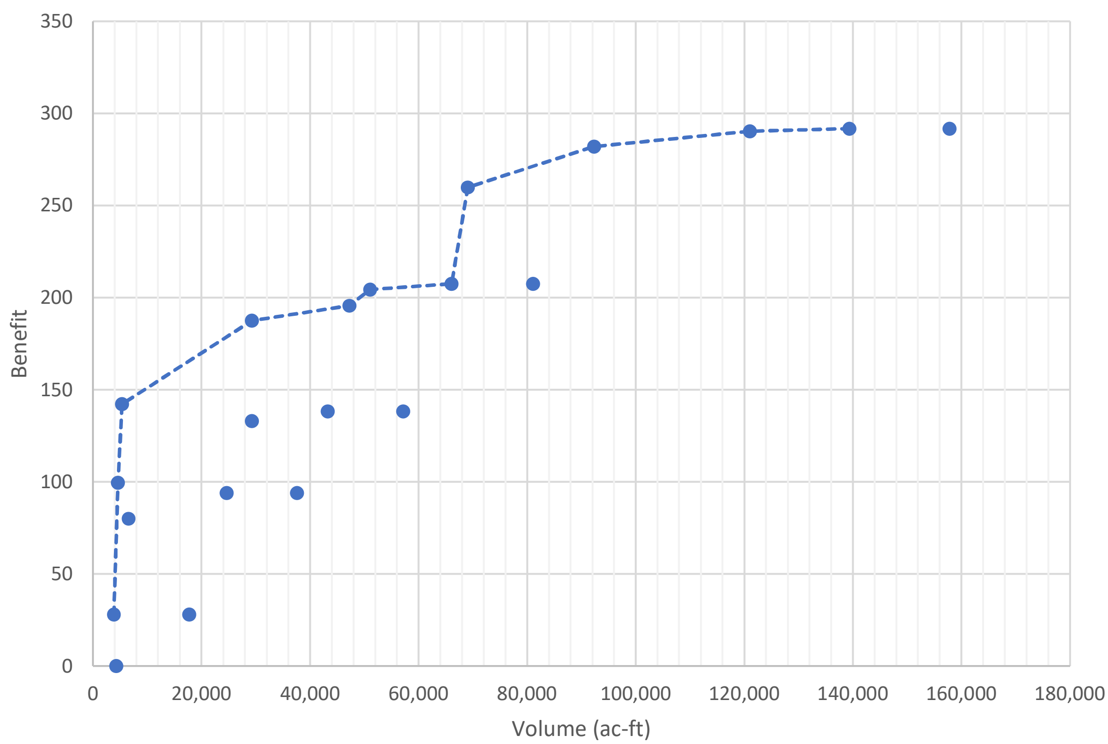
Start	Target		Cumulative number of flooded structures										
Flow	Flow	**Vol, ac-ft**	500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**46,285**	143	43	37	30	0	0	0	**240**	5	46,285	240
500yr	50yr	**72,657**	43	37	30	0	0	0	0	**328**	5	26,373	88
500yr	25yr	**96,635**	37	30	0	0	0	0	0	**355**	4	23,977	27
500yr	10yr	**128,798**	30	0	0	0	0	0	0	**370**	3	32,163	15
500yr	5yr	**147,691**	0	0	0	0	0	0	0	**376**	3	18,893	6
500yr	2yr	**166,595**	0	0	0	0	0	0	0	**376**	2	18,903	0
100yr	50yr	**6,172**	427	43	37	30	0	0	0	**184**	30	6,172	184
100yr	25yr	**28,787**	427	37	30	0	0	0	0	**251**	9	22,616	68
100yr	10yr	**53,945**	427	30	0	0	0	0	0	**277**	5	25,158	26
100yr	5yr	**70,278**	427	0	0	0	0	0	0	**291**	4	16,332	14
100yr	2yr	**85,694**	427	0	0	0	0	0	0	**291**	3	15,417	0
50yr	25yr	**5,127**	427	143	37	30	0	0	0	**139**	27	5,127	139
50yr	10yr	**30,051**	427	143	30	0	0	0	0	**204**	7	24,924	65
50yr	5yr	**45,594**	427	143	0	0	0	0	0	**226**	5	15,543	23
50yr	2yr	**60,260**	427	143	0	0	0	0	0	**226**	4	14,666	0
25yr	10yr	**7,337**	427	143	43	30	0	0	0	**134**	18	7,337	134
25yr	5yr	**24,973**	427	143	43	0	0	0	0	**194**	8	17,636	60
25yr	2yr	**39,308**	427	143	43	0	0	0	0	**194**	5	14,335	0
10yr	5yr	**4,243**	427	143	43	37	0	0	0	**120**	28	4,243	120
10yr	2yr	**16,363**	427	143	43	37	0	0	0	**120**	7	12,119	0
5yr	2yr	**4,555**	427	143	43	37	30	0	0	**0**	0	4,555	0



Damage center: **DC_K100_003** *Station range:* 49972 to 41696 *Mile range:* 9.5 to 7.9

Existing conditions	421	154	59	33	7	0	0	**292**	**Flood instances (50-yr)**

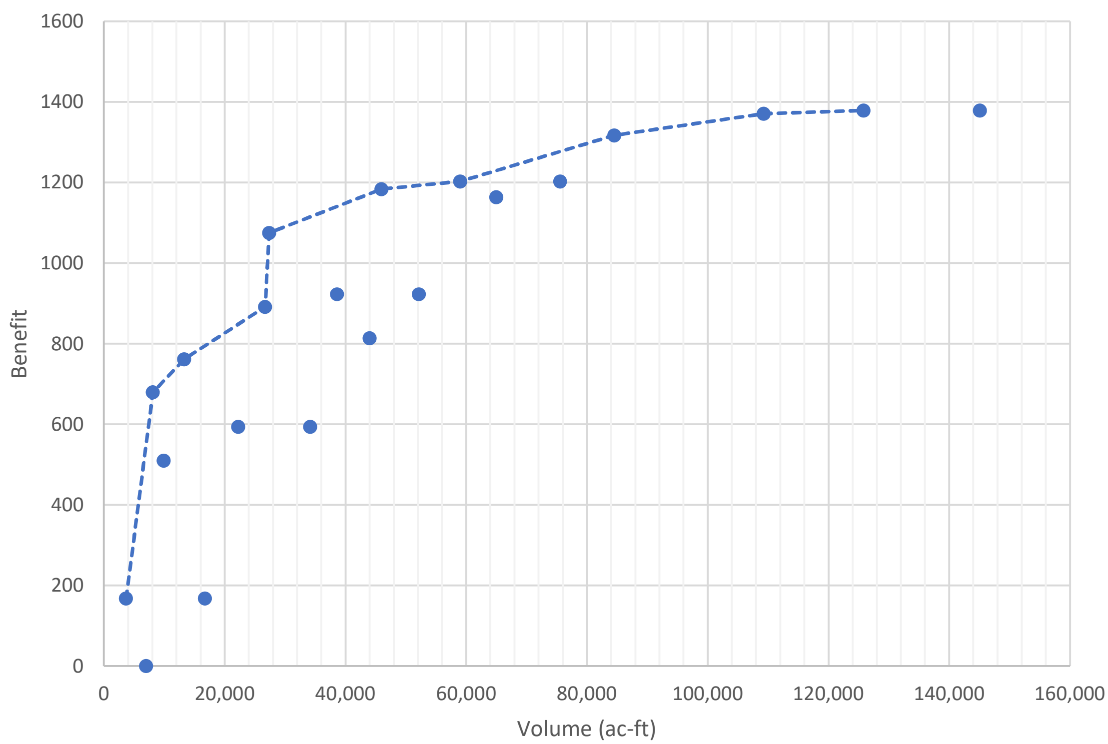
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**47,229**	154	59	33	7	0	0	0	**196**	4	47,229	196
500yr	50yr	**69,057**	59	33	7	0	0	0	0	**260**	4	21,827	64
500yr	25yr	**92,332**	33	7	0	0	0	0	0	**282**	3	23,276	22
500yr	10yr	**121,041**	7	0	0	0	0	0	0	**290**	2	28,709	8
500yr	5yr	**139,397**	0	0	0	0	0	0	0	**292**	2	18,355	1
500yr	2yr	**157,854**	0	0	0	0	0	0	0	**292**	2	18,457	0
100yr	50yr	**5,324**	421	59	33	7	0	0	0	**142**	27	5,324	142
100yr	25yr	**29,267**	421	33	7	0	0	0	0	**187**	6	23,943	45
100yr	10yr	**51,041**	421	7	0	0	0	0	0	**204**	4	21,774	17
100yr	5yr	**66,062**	421	0	0	0	0	0	0	**208**	3	15,020	3
100yr	2yr	**81,078**	421	0	0	0	0	0	0	**208**	3	15,017	0
50yr	25yr	**4,606**	421	154	33	7	0	0	0	**100**	22	4,606	100
50yr	10yr	**29,287**	421	154	7	0	0	0	0	**133**	5	24,681	34
50yr	5yr	**43,290**	421	154	0	0	0	0	0	**138**	3	14,004	5
50yr	2yr	**57,148**	421	154	0	0	0	0	0	**138**	2	13,857	0
25yr	10yr	**6,566**	421	154	59	7	0	0	0	**80**	12	6,566	80
25yr	5yr	**24,666**	421	154	59	0	0	0	0	**94**	4	18,100	14
25yr	2yr	**37,576**	421	154	59	0	0	0	0	**94**	3	12,910	0
10yr	5yr	**3,841**	421	154	59	33	0	0	0	**28**	7	3,841	28
10yr	2yr	**17,742**	421	154	59	33	0	0	0	**28**	2	13,901	0
5yr	2yr	**4,311**	421	154	59	33	7	0	0	**0**	0	4,311	0



Damage center: **DC_K100_004** *Station range:* 75290 to 58980 *Mile range:* 14.3 to 11.2

Existing conditions	881	621	439	213	42	0	0	**1379**	**Flood instances (50-yr)**

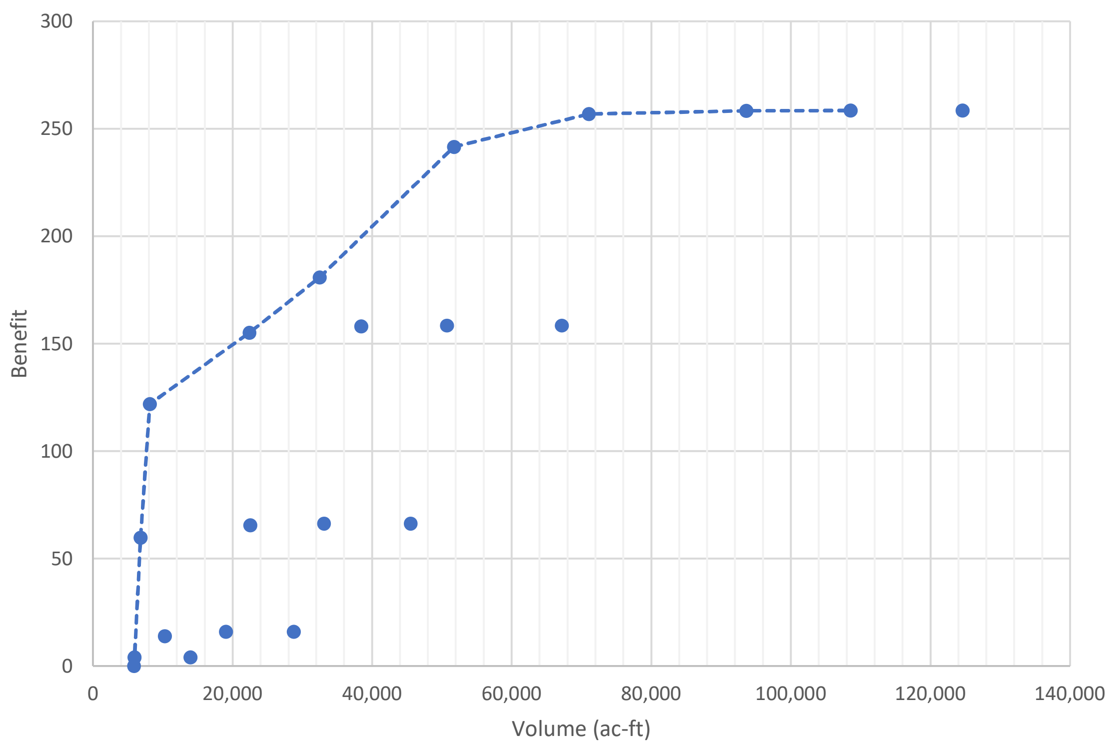
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**44,002**	621	439	213	42	0	0	0	**813**	18	44,002	813
500yr	50yr	**64,981**	439	213	42	0	0	0	0	**1164**	18	20,979	350
500yr	25yr	**84,556**	213	42	0	0	0	0	0	**1317**	16	19,576	154
500yr	10yr	**109,283**	42	0	0	0	0	0	0	**1371**	13	24,726	53
500yr	5yr	**125,836**	0	0	0	0	0	0	0	**1379**	11	16,553	8
500yr	2yr	**145,109**	0	0	0	0	0	0	0	**1379**	10	19,273	0
100yr	50yr	**13,309**	881	439	213	42	0	0	0	**761**	57	13,309	761
100yr	25yr	**27,374**	881	213	42	0	0	0	0	**1075**	39	14,065	314
100yr	10yr	**45,978**	881	42	0	0	0	0	0	**1184**	26	18,603	108
100yr	5yr	**59,006**	881	0	0	0	0	0	0	**1203**	20	13,028	19
100yr	2yr	**75,579**	881	0	0	0	0	0	0	**1203**	16	16,573	0
50yr	25yr	**8,088**	881	621	213	42	0	0	0	**680**	84	8,088	680
50yr	10yr	**26,707**	881	621	42	0	0	0	0	**892**	33	18,619	212
50yr	5yr	**38,622**	881	621	0	0	0	0	0	**923**	24	11,915	32
50yr	2yr	**52,167**	881	621	0	0	0	0	0	**923**	18	13,545	0
25yr	10yr	**9,917**	881	621	439	42	0	0	0	**510**	51	9,917	510
25yr	5yr	**22,269**	881	621	439	0	0	0	0	**594**	27	12,352	84
25yr	2yr	**34,181**	881	621	439	0	0	0	0	**594**	17	11,912	0
10yr	5yr	**3,683**	881	621	439	213	0	0	0	**168**	46	3,683	168
10yr	2yr	**16,722**	881	621	439	213	0	0	0	**168**	10	13,039	0
5yr	2yr	**7,002**	881	621	439	213	42	0	0	**0**	0	7,002	0



Damage center: **DC_K100_005** *Station range:* 101787 to 91723 *Mile range:* 19.3 to 17.4

Existing conditions	500	205	67	6	1	0	0	**259**	**Flood instances (50-yr)**

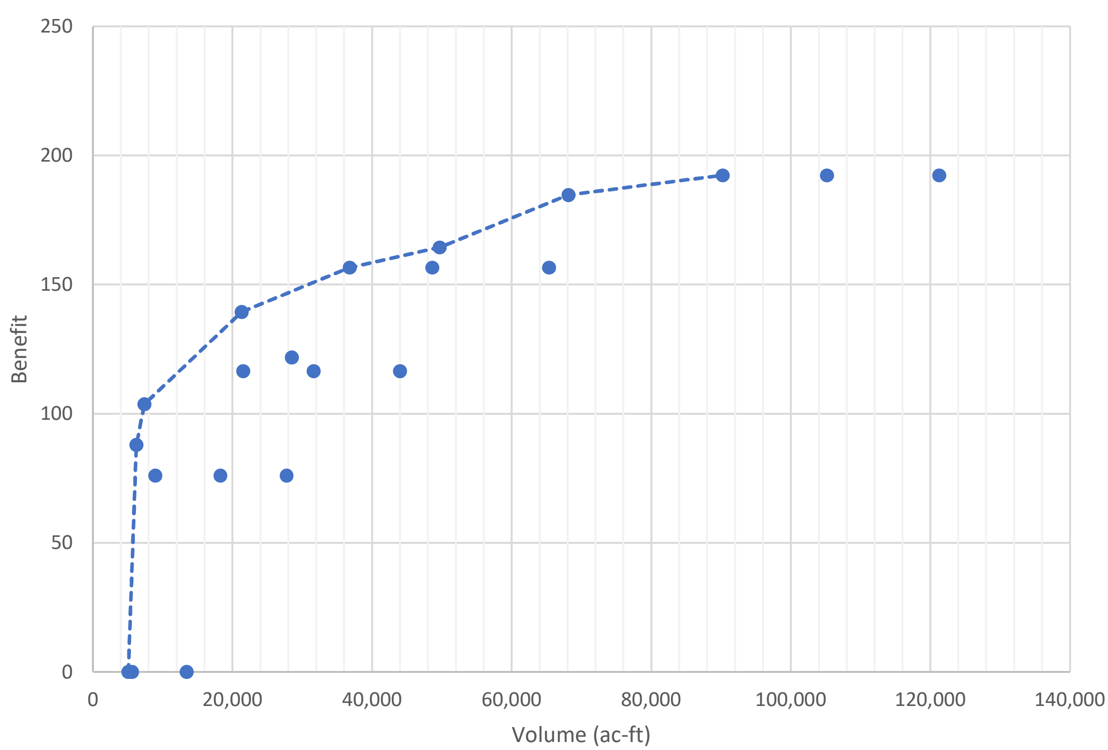
Start Flow	Target Flow	**Vol, ac-ft**	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**32,489**	205	67	6	1	0	0	0	**181**	6	32,489	181
500yr	50yr	**51,720**	67	6	1	0	0	0	0	**242**	5	19,231	61
500yr	25yr	**71,043**	6	1	0	0	0	0	0	**257**	4	19,323	15
500yr	10yr	**93,594**	1	0	0	0	0	0	0	**258**	3	22,551	1
500yr	5yr	**108,560**	0	0	0	0	0	0	0	**259**	2	14,966	0
500yr	2yr	**124,580**	0	0	0	0	0	0	0	**259**	2	16,019	0
100yr	50yr	**8,118**	500	67	6	1	0	0	0	**122**	15	8,118	122
100yr	25yr	**22,405**	500	6	1	0	0	0	0	**155**	7	14,287	33
100yr	10yr	**38,426**	500	1	0	0	0	0	0	**158**	4	16,021	3
100yr	5yr	**50,695**	500	0	0	0	0	0	0	**159**	3	12,268	0
100yr	2yr	**67,167**	500	0	0	0	0	0	0	**159**	2	16,473	0
50yr	25yr	**6,837**	500	205	6	1	0	0	0	**60**	9	6,837	60
50yr	10yr	**22,535**	500	205	1	0	0	0	0	**66**	3	15,698	6
50yr	5yr	**33,097**	500	205	0	0	0	0	0	**66**	2	10,562	1
50yr	2yr	**45,508**	500	205	0	0	0	0	0	**66**	1	12,411	0
25yr	10yr	**10,284**	500	205	67	1	0	0	0	**14**	1	10,284	14
25yr	5yr	**19,013**	500	205	67	0	0	0	0	**16**	1	8,729	2
25yr	2yr	**28,758**	500	205	67	0	0	0	0	**16**	1	9,745	0
10yr	5yr	**5,946**	500	205	67	6	0	0	0	**4**	1	5,946	4
10yr	2yr	**13,954**	500	205	67	6	0	0	0	**4**	0	8,008	0
5yr	2yr	**5,858**	500	205	67	6	1	0	0	**0**	0	5,858	0



Damage center: **DC_K100_006** *Station range:* 111804 to 107974 *Mile range:* 21.2 to 20.4

Existing conditions	179	89	54	38	0	0	0	**192**	**Flood instances (50-yr)**

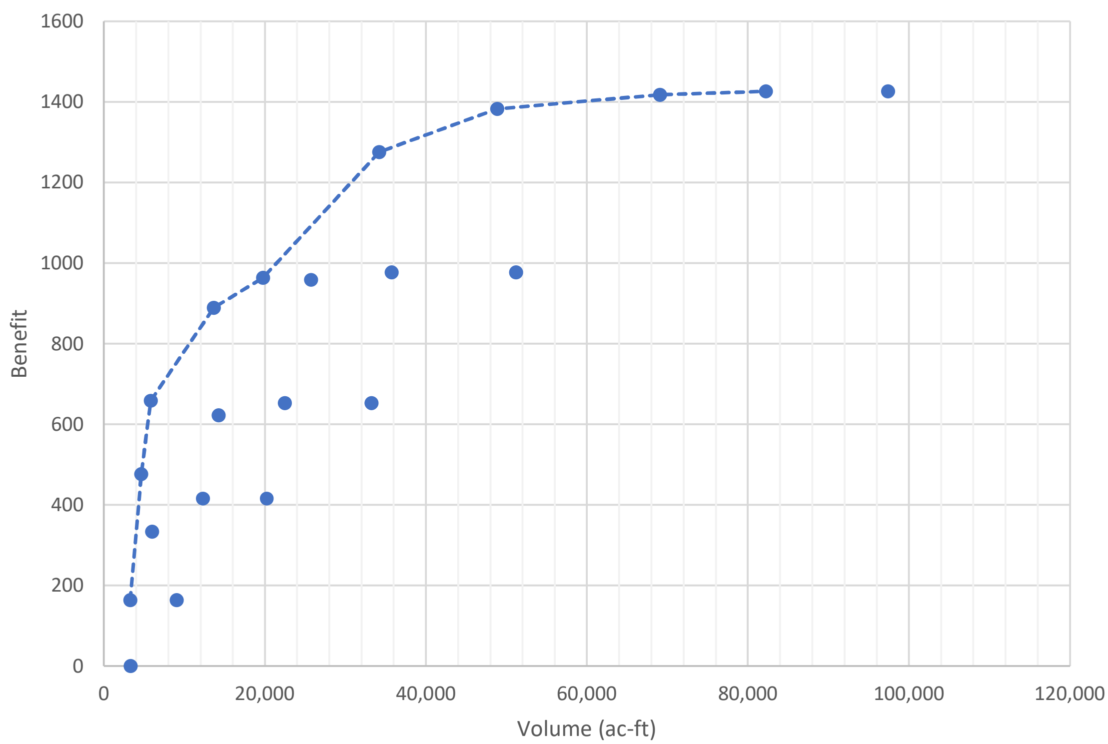
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**28,476**	89	54	38	0	0	0	0	**122**	4	28,476	122
500yr	50yr	**49,677**	54	38	0	0	0	0	0	**164**	3	21,201	43
500yr	25yr	**68,109**	38	0	0	0	0	0	0	**185**	3	18,432	20
500yr	10yr	**90,245**	0	0	0	0	0	0	0	**192**	2	22,136	8
500yr	5yr	**105,179**	0	0	0	0	0	0	0	**192**	2	14,934	0
500yr	2yr	**121,260**	0	0	0	0	0	0	0	**192**	2	16,081	0
100yr	50yr	**7,353**	179	54	38	0	0	0	0	**104**	14	7,353	104
100yr	25yr	**21,314**	179	38	0	0	0	0	0	**139**	7	13,961	36
100yr	10yr	**36,777**	179	0	0	0	0	0	0	**157**	4	15,463	17
100yr	5yr	**48,621**	179	0	0	0	0	0	0	**157**	3	11,845	0
100yr	2yr	**65,344**	179	0	0	0	0	0	0	**157**	2	16,722	0
50yr	25yr	**6,224**	179	89	38	0	0	0	0	**88**	14	6,224	88
50yr	10yr	**21,501**	179	89	0	0	0	0	0	**117**	5	15,277	29
50yr	5yr	**31,605**	179	89	0	0	0	0	0	**117**	4	10,104	0
50yr	2yr	**44,003**	179	89	0	0	0	0	0	**117**	3	12,398	0
25yr	10yr	**8,940**	179	89	54	0	0	0	0	**76**	9	8,940	76
25yr	5yr	**18,273**	179	89	54	0	0	0	0	**76**	4	9,334	0
25yr	2yr	**27,738**	179	89	54	0	0	0	0	**76**	3	9,465	0
10yr	5yr	**5,061**	179	89	54	38	0	0	0	**0**	0	5,061	0
10yr	2yr	**13,409**	179	89	54	38	0	0	0	**0**	0	8,348	0
5yr	2yr	**5,589**	179	89	54	38	0	0	0	**0**	0	5,589	0



Damage center: **DC_K100_007** *Station range:* 139166 to 120252 *Mile range:* 26.4 to 22.8

Existing conditions	2246	720	316	126	41	0	0	**1426**	**Flood instances (50-yr)**	

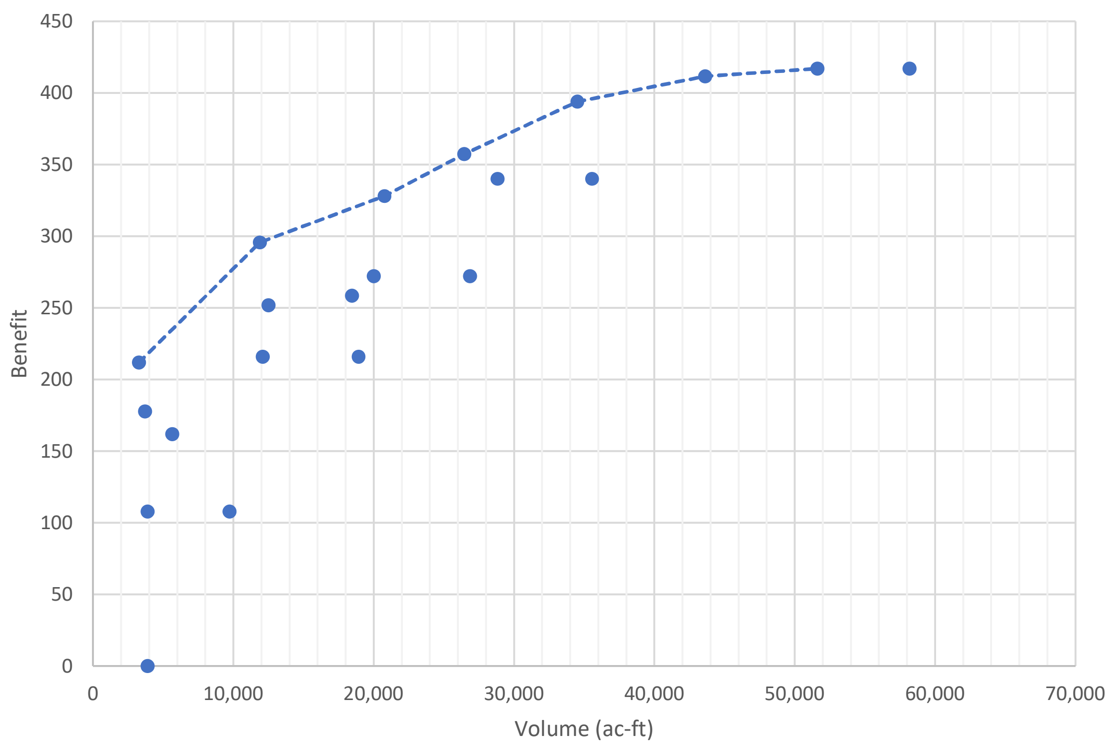
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**19,747**	720	316	126	41	0	0	0	**964**	49	19,747	964
500yr	50yr	**34,199**	316	126	41	0	0	0	0	**1276**	37	14,452	312
500yr	25yr	**48,866**	126	41	0	0	0	0	0	**1383**	28	14,667	107
500yr	10yr	**69,060**	41	0	0	0	0	0	0	**1418**	21	20,194	35
500yr	5yr	**82,245**	0	0	0	0	0	0	0	**1426**	17	13,186	8
500yr	2yr	**97,397**	0	0	0	0	0	0	0	**1426**	15	15,151	0
100yr	50yr	**5,835**	2246	316	126	41	0	0	0	**658**	113	5,835	658
100yr	25yr	**13,641**	2246	126	41	0	0	0	0	**890**	65	7,806	231
100yr	10yr	**25,734**	2246	41	0	0	0	0	0	**959**	37	12,094	69
100yr	5yr	**35,739**	2246	0	0	0	0	0	0	**977**	27	10,005	18
100yr	2yr	**51,208**	2246	0	0	0	0	0	0	**977**	19	15,469	0
50yr	25yr	**4,645**	2246	720	126	41	0	0	0	**477**	103	4,645	477
50yr	10yr	**14,262**	2246	720	41	0	0	0	0	**622**	44	9,617	146
50yr	5yr	**22,477**	2246	720	0	0	0	0	0	**653**	29	8,215	31
50yr	2yr	**33,241**	2246	720	0	0	0	0	0	**653**	20	10,763	0
25yr	10yr	**5,984**	2246	720	316	41	0	0	0	**334**	56	5,984	334
25yr	5yr	**12,293**	2246	720	316	0	0	0	0	**416**	34	6,308	82
25yr	2yr	**20,224**	2246	720	316	0	0	0	0	**416**	21	7,931	0
10yr	5yr	**3,269**	2246	720	316	126	0	0	0	**164**	50	3,269	164
10yr	2yr	**9,037**	2246	720	316	126	0	0	0	**164**	18	5,768	0
5yr	2yr	**3,322**	2246	720	316	126	41	0	0	**0**	0	3,322	0



Damage center: **DC_K100_008** *Station range:* 158469 to 144516 *Mile range:* 30 to 27.4

	Existing conditions	384	151	75	54	27	0	0	**417**	**Flood instances (50-yr)**

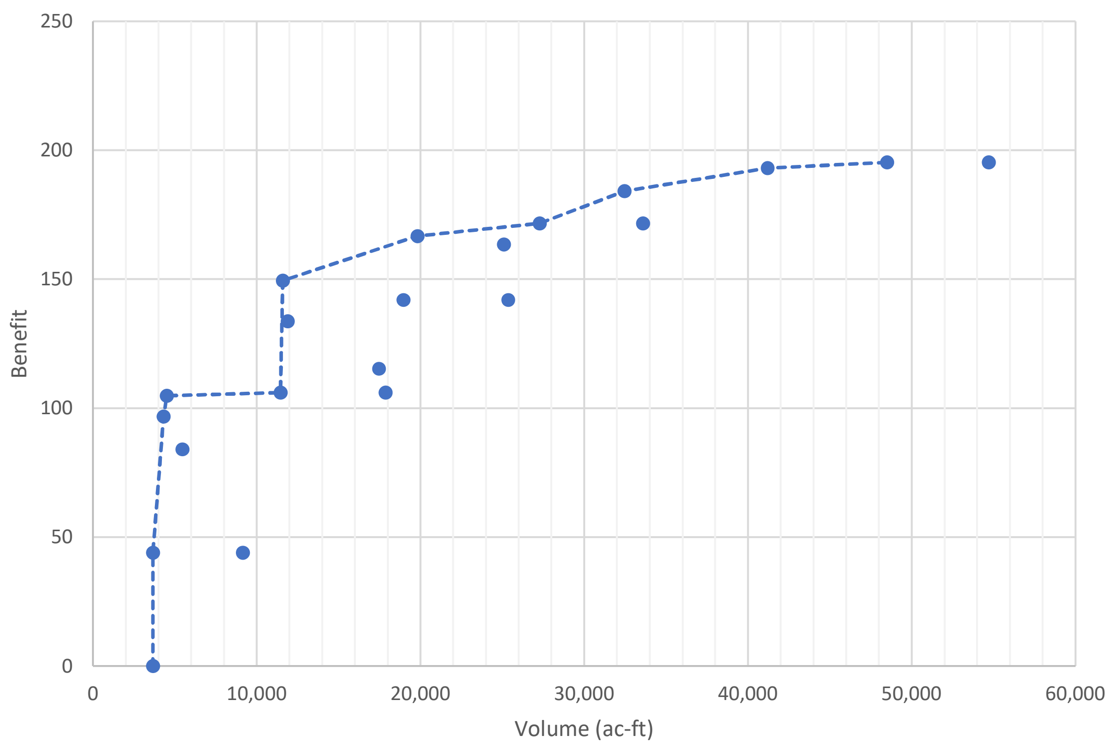
Start Flow	Target Flow	**Vol, ac-ft**	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**18,463**	151	75	54	27	0	0	0	**259**	14	18,463	259
500yr	50yr	**26,464**	75	54	27	0	0	0	0	**357**	14	8,001	99
500yr	25yr	**34,513**	54	27	0	0	0	0	0	**394**	11	8,050	37
500yr	10yr	**43,626**	27	0	0	0	0	0	0	**412**	9	9,113	18
500yr	5yr	**51,625**	0	0	0	0	0	0	0	**417**	8	7,999	5
500yr	2yr	**58,192**	0	0	0	0	0	0	0	**417**	7	6,567	0
100yr	50yr	**3,274**	384	75	54	27	0	0	0	**212**	65	3,274	212
100yr	25yr	**11,888**	384	54	27	0	0	0	0	**296**	25	8,614	84
100yr	10yr	**20,771**	384	27	0	0	0	0	0	**328**	16	8,883	32
100yr	5yr	**28,832**	384	0	0	0	0	0	0	**340**	12	8,061	12
100yr	2yr	**35,561**	384	0	0	0	0	0	0	**340**	10	6,729	0
50yr	25yr	**3,705**	384	151	54	27	0	0	0	**178**	48	3,705	178
50yr	10yr	**12,500**	384	151	27	0	0	0	0	**252**	20	8,796	74
50yr	5yr	**20,009**	384	151	0	0	0	0	0	**272**	14	7,509	20
50yr	2yr	**26,878**	384	151	0	0	0	0	0	**272**	10	6,869	0
25yr	10yr	**5,660**	384	151	75	27	0	0	0	**162**	29	5,660	162
25yr	5yr	**12,094**	384	151	75	0	0	0	0	**216**	18	6,434	54
25yr	2yr	**18,932**	384	151	75	0	0	0	0	**216**	11	6,838	0
10yr	5yr	**3,897**	384	151	75	54	0	0	0	**108**	28	3,897	108
10yr	2yr	**9,744**	384	151	75	54	0	0	0	**108**	11	5,847	0
5yr	2yr	**3,895**	384	151	75	54	27	0	0	**0**	0	3,895	0



Damage center: **DC_K100_009** *Station range:* 170004 to 162447 *Mile range:* 32.2 to 30.8

Existing conditions	118	66	48	31	11	0	0	**195**	**Flood instances (50-yr)**

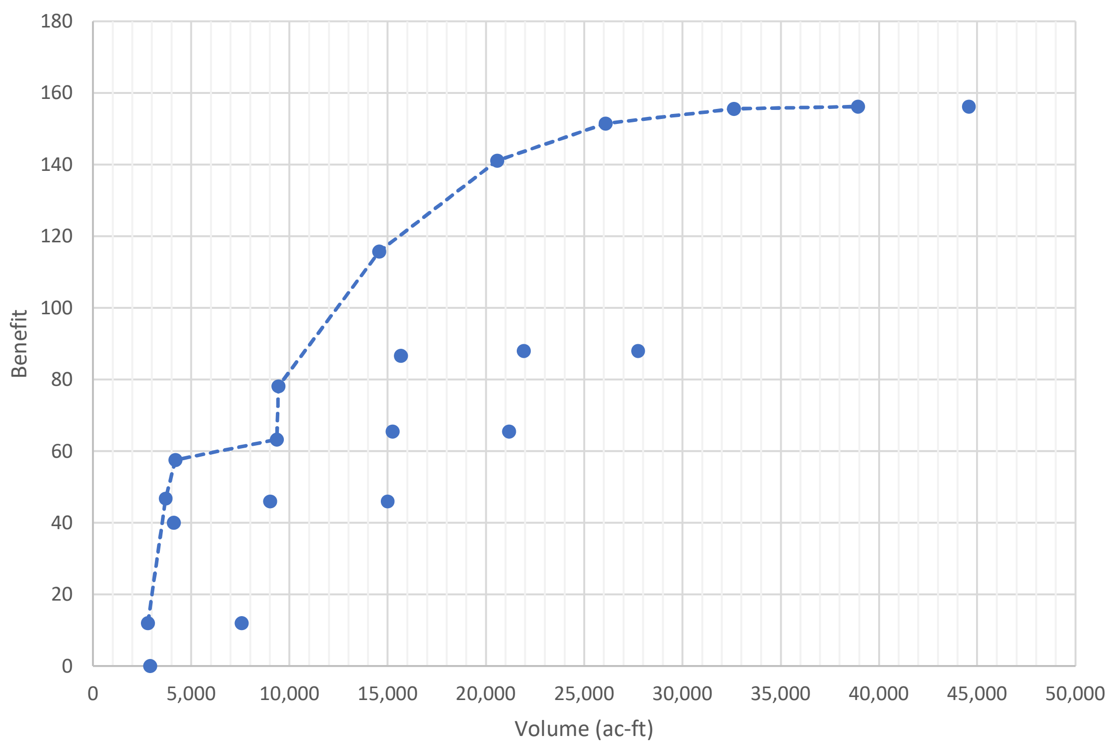
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**17,461**	66	48	31	11	0	0	0	**115**	7	17,461	115
500yr	50yr	**25,098**	48	31	11	0	0	0	0	**164**	7	7,637	48
500yr	25yr	**32,455**	31	11	0	0	0	0	0	**184**	6	7,357	21
500yr	10yr	**41,190**	11	0	0	0	0	0	0	**193**	5	8,734	9
500yr	5yr	**48,493**	0	0	0	0	0	0	0	**195**	4	7,303	2
500yr	2yr	**54,695**	0	0	0	0	0	0	0	**195**	4	6,203	0
100yr	50yr	**4,506**	118	48	31	11	0	0	0	**105**	23	4,506	105
100yr	25yr	**11,581**	118	31	11	0	0	0	0	**150**	13	7,075	45
100yr	10yr	**19,808**	118	11	0	0	0	0	0	**167**	8	8,227	17
100yr	5yr	**27,271**	118	0	0	0	0	0	0	**172**	6	7,463	5
100yr	2yr	**33,577**	118	0	0	0	0	0	0	**172**	5	6,306	0
50yr	25yr	**4,315**	118	66	31	11	0	0	0	**97**	22	4,315	97
50yr	10yr	**11,885**	118	66	11	0	0	0	0	**134**	11	7,570	37
50yr	5yr	**18,950**	118	66	0	0	0	0	0	**142**	7	7,065	8
50yr	2yr	**25,358**	118	66	0	0	0	0	0	**142**	6	6,407	0
25yr	10yr	**5,457**	118	66	48	11	0	0	0	**84**	15	5,457	84
25yr	5yr	**11,451**	118	66	48	0	0	0	0	**106**	9	5,994	22
25yr	2yr	**17,858**	118	66	48	0	0	0	0	**106**	6	6,408	0
10yr	5yr	**3,665**	118	66	48	31	0	0	0	**44**	12	3,665	44
10yr	2yr	**9,140**	118	66	48	31	0	0	0	**44**	5	5,475	0
5yr	2yr	**3,652**	118	66	48	31	11	0	0	**0**	0	3,652	0



Damage center: **DC_K100_010** *Station range:* 180551 to 174645 *Mile range:* 34.2 to 33.1

Existing conditions	341	50	26	17	3	0	0	**156 Flood instances (50-yr)**

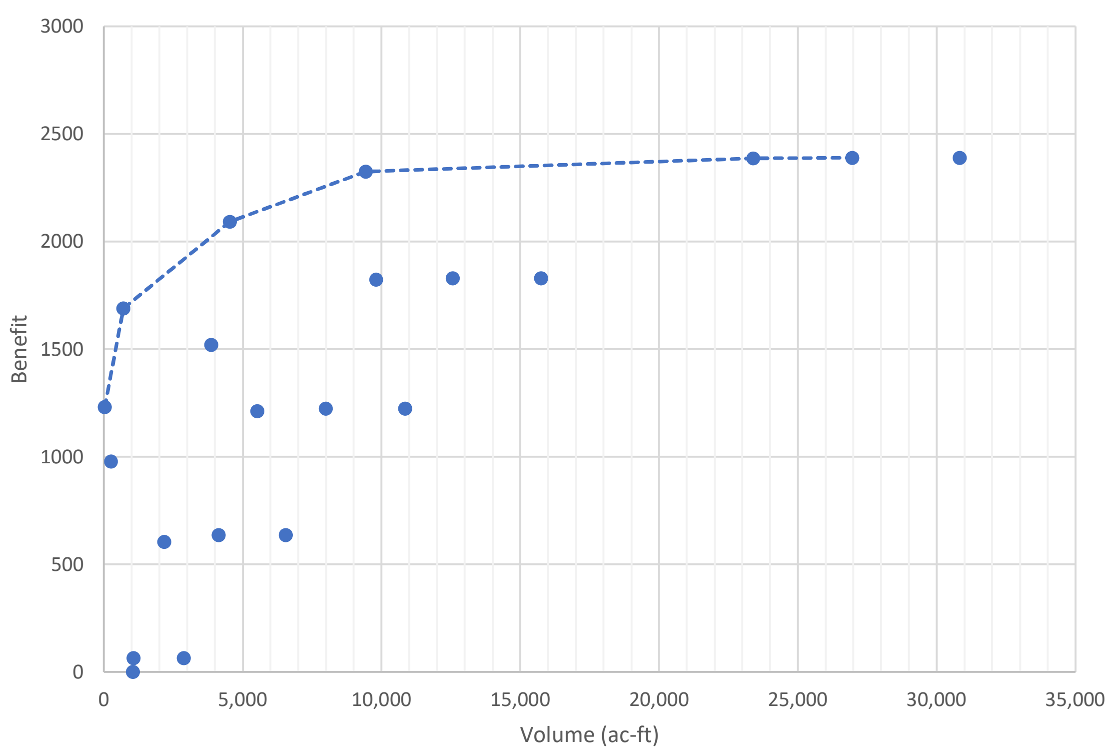
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**14,570**	50	26	17	3	0	0	0	**116**	8	14,570	116
500yr	50yr	**20,573**	26	17	3	0	0	0	0	**141**	7	6,003	25
500yr	25yr	**26,090**	17	3	0	0	0	0	0	**151**	6	5,517	10
500yr	10yr	**32,616**	3	0	0	0	0	0	0	**156**	5	6,526	4
500yr	5yr	**38,935**	0	0	0	0	0	0	0	**156**	4	6,319	1
500yr	2yr	**44,570**	0	0	0	0	0	0	0	**156**	4	5,635	0
100yr	50yr	**4,192**	341	26	17	3	0	0	0	**58**	14	4,192	58
100yr	25yr	**9,437**	341	17	3	0	0	0	0	**78**	8	5,245	21
100yr	10yr	**15,669**	341	3	0	0	0	0	0	**87**	6	6,232	9
100yr	5yr	**21,927**	341	0	0	0	0	0	0	**88**	4	6,257	1
100yr	2yr	**27,738**	341	0	0	0	0	0	0	**88**	3	5,811	0
50yr	25yr	**3,694**	341	50	17	3	0	0	0	**47**	13	3,694	47
50yr	10yr	**9,347**	341	50	3	0	0	0	0	**63**	7	5,653	17
50yr	5yr	**15,240**	341	50	0	0	0	0	0	**66**	4	5,893	2
50yr	2yr	**21,172**	341	50	0	0	0	0	0	**66**	3	5,932	0
25yr	10yr	**4,113**	341	50	26	3	0	0	0	**40**	10	4,113	40
25yr	5yr	**9,015**	341	50	26	0	0	0	0	**46**	5	4,902	6
25yr	2yr	**14,996**	341	50	26	0	0	0	0	**46**	3	5,981	0
10yr	5yr	**2,793**	341	50	26	17	0	0	0	**12**	4	2,793	12
10yr	2yr	**7,571**	341	50	26	17	0	0	0	**12**	2	4,778	0
5yr	2yr	**2,912**	341	50	26	17	3	0	0	**0**	0	2,912	0



Damage center: **DC_L100_001** *Station range:* 30322.9 to 3777.8 *Mile range:* 5.7 to 0.7

Existing conditions	2798	1346	784	286	16	0	0	**2389**	**Flood instances (50-yr)**	

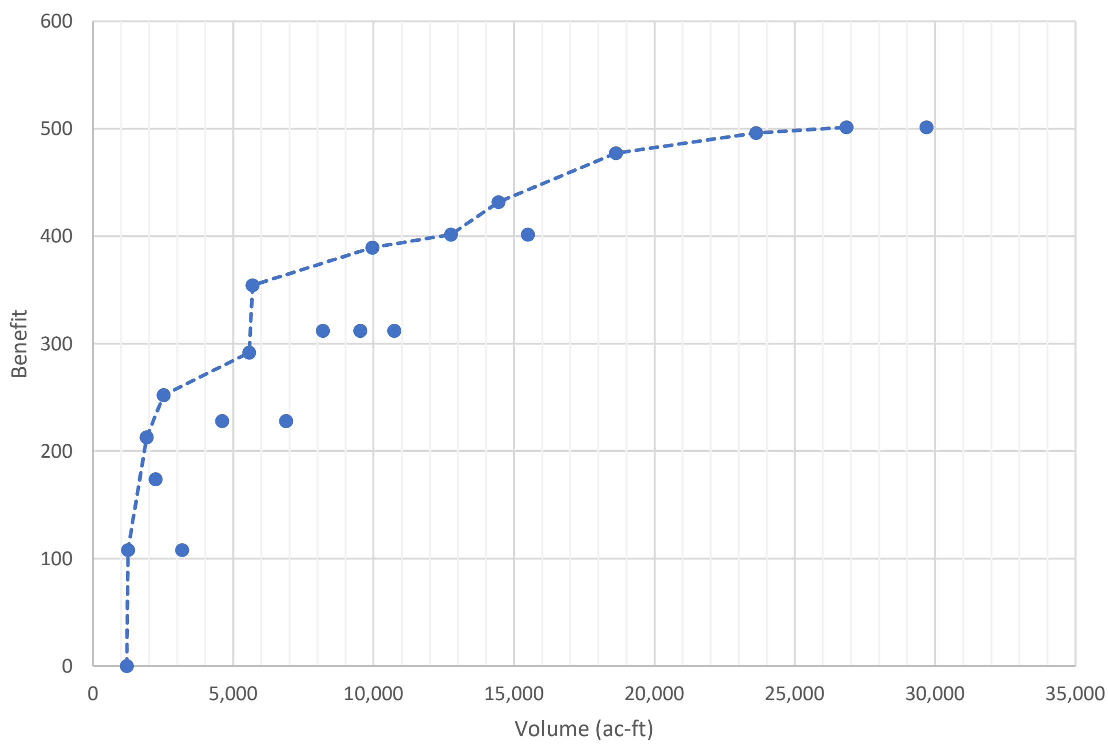
Start	Target		Cumulative number of flooded structures										
Flow	Flow	**Vol, ac-ft**	500yr	100yr	50yr	25yr	10yr	5yr	2yr	**Benefit**	B/V	Incr. V	Incr. B
500yr	100yr	**3,860**	1346	784	286	16	0	0	0	**1521**	394	3,860	1521
500yr	50yr	**4,535**	784	286	16	0	0	0	0	**2092**	461	675	571
500yr	25yr	**9,433**	286	16	0	0	0	0	0	**2325**	246	4,899	233
500yr	10yr	**23,389**	16	0	0	0	0	0	0	**2386**	102	13,956	61
500yr	5yr	**26,963**	0	0	0	0	0	0	0	**2389**	89	3,574	3
500yr	2yr	**30,830**	0	0	0	0	0	0	0	**2389**	77	3,867	0
100yr	50yr	**29**	2798	784	286	16	0	0	0	**1230**	41903	29	1230
100yr	25yr	**697**	2798	286	16	0	0	0	0	**1689**	2422	668	459
100yr	10yr	**9,804**	2798	16	0	0	0	0	0	**1823**	186	9,106	134
100yr	5yr	**12,567**	2798	0	0	0	0	0	0	**1830**	146	2,764	7
100yr	2yr	**15,743**	2798	0	0	0	0	0	0	**1830**	116	3,175	0
50yr	25yr	**257**	2798	1346	286	16	0	0	0	**978**	3810	257	978
50yr	10yr	**5,519**	2798	1346	16	0	0	0	0	**1212**	220	5,263	235
50yr	5yr	**7,994**	2798	1346	0	0	0	0	0	**1224**	153	2,474	12
50yr	2yr	**10,856**	2798	1346	0	0	0	0	0	**1224**	113	2,863	0
25yr	10yr	**2,166**	2798	1346	784	16	0	0	0	**604**	279	2,166	604
25yr	5yr	**4,128**	2798	1346	784	0	0	0	0	**636**	154	1,961	32
25yr	2yr	**6,547**	2798	1346	784	0	0	0	0	**636**	97	2,420	0
10yr	5yr	**1,061**	2798	1346	784	286	0	0	0	**64**	60	1,061	64
10yr	2yr	**2,877**	2798	1346	784	286	0	0	0	**64**	22	1,816	0
5yr	2yr	**1,038**	2798	1346	784	286	16	0	0	**0**	0	1,038	0



Damage center: **DC_L100_002** *Station range:* 48304.3 to 30322.9 *Mile range:* 9.1 to 5.7

Existing conditions	499	199	112	60	27	0	0	**501**	**Flood instances (50-yr)**

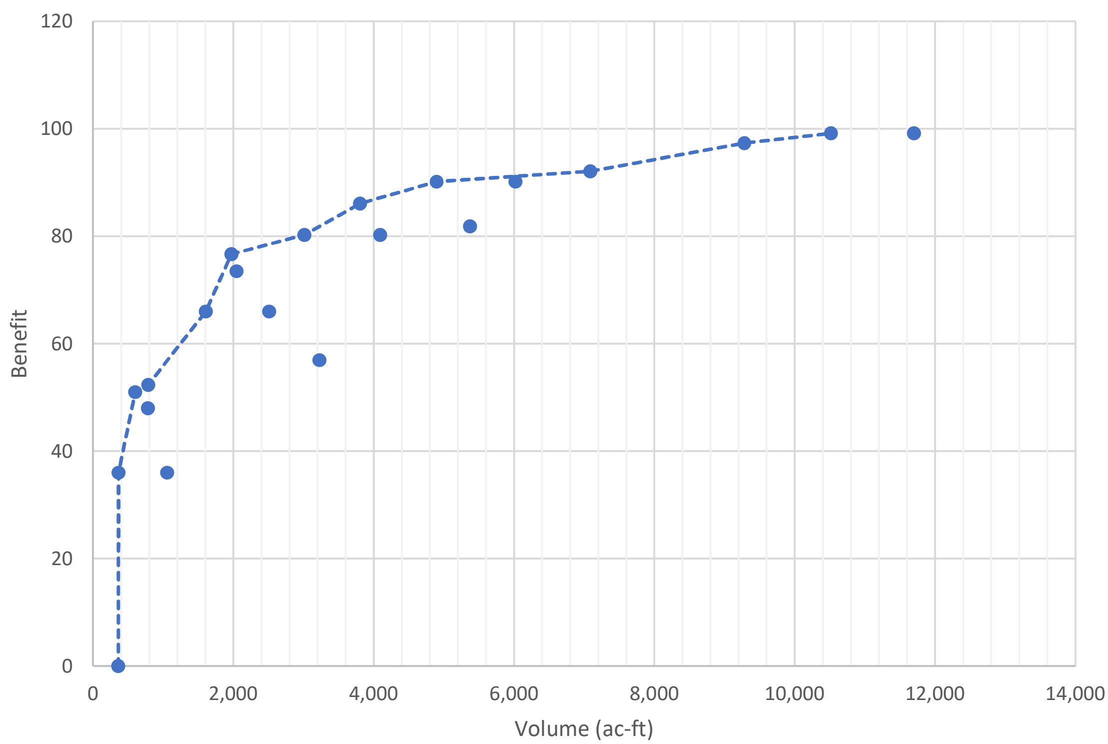
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**9,527**	199	112	60	27	0	0	0	**312**	33	9,527	312
500yr	50yr	**14,448**	112	60	27	0	0	0	0	**432**	30	4,922	120
500yr	25yr	**18,633**	60	27	0	0	0	0	0	**477**	26	4,184	46
500yr	10yr	**23,625**	27	0	0	0	0	0	0	**496**	21	4,992	19
500yr	5yr	**26,844**	0	0	0	0	0	0	0	**501**	19	3,219	5
500yr	2yr	**29,696**	0	0	0	0	0	0	0	**501**	17	2,851	0
100yr	50yr	**2,518**	499	112	60	27	0	0	0	**252**	100	2,518	252
100yr	25yr	**5,688**	499	60	27	0	0	0	0	**354**	62	3,169	102
100yr	10yr	**9,954**	499	27	0	0	0	0	0	**389**	39	4,266	35
100yr	5yr	**12,755**	499	0	0	0	0	0	0	**402**	31	2,801	12
100yr	2yr	**15,487**	499	0	0	0	0	0	0	**402**	26	2,732	0
50yr	25yr	**1,912**	499	199	60	27	0	0	0	**213**	111	1,912	213
50yr	10yr	**5,569**	499	199	27	0	0	0	0	**292**	52	3,657	79
50yr	5yr	**8,191**	499	199	0	0	0	0	0	**312**	38	2,622	20
50yr	2yr	**10,732**	499	199	0	0	0	0	0	**312**	29	2,541	0
25yr	10yr	**2,233**	499	199	112	27	0	0	0	**174**	78	2,233	174
25yr	5yr	**4,597**	499	199	112	0	0	0	0	**228**	50	2,364	54
25yr	2yr	**6,876**	499	199	112	0	0	0	0	**228**	33	2,279	0
10yr	5yr	**1,243**	499	199	112	60	0	0	0	**108**	87	1,243	108
10yr	2yr	**3,178**	499	199	112	60	0	0	0	**108**	34	1,935	0
5yr	2yr	**1,204**	499	199	112	60	27	0	0	**0**	0	1,204	0



Damage center: **DC_L100_003** *Station range:* 84132 to 75631.5 *Mile range:* 15.9 to 14.3

	Existing conditions	45	22	19	15	9	0	0	**99**	**Flood instances (50-yr)**

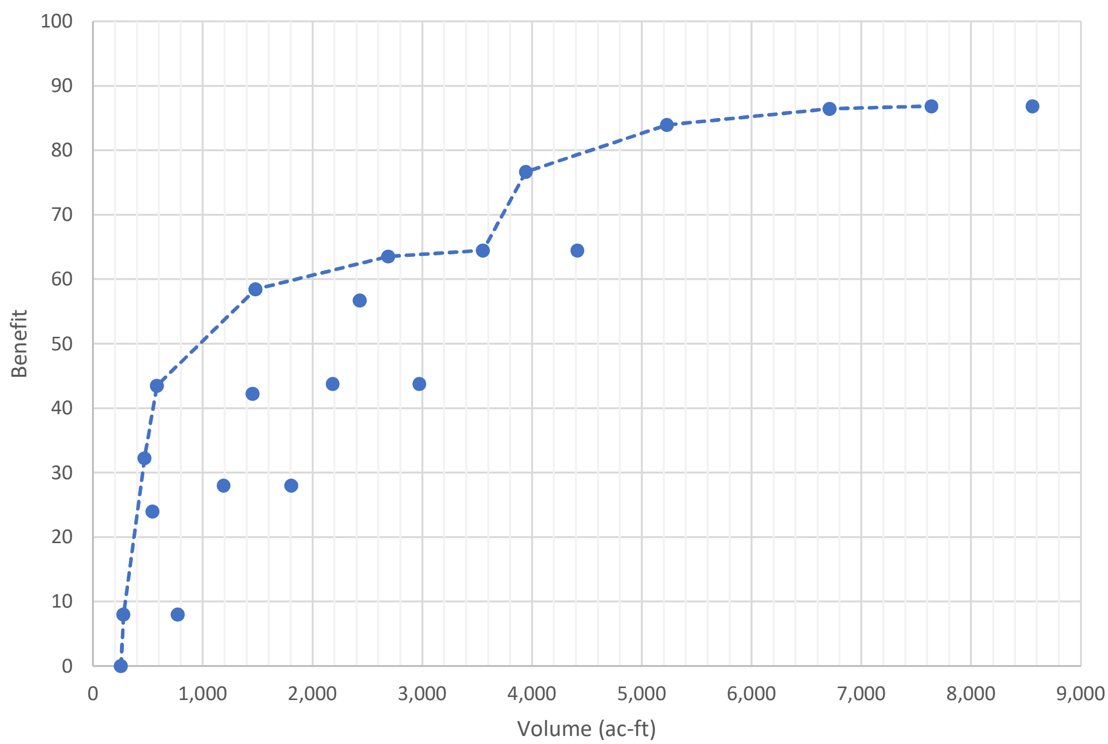
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**3,230**	22	19	15	9	0	0	0	**57**	18	3,230	57
500yr	50yr	**5,371**	19	15	9	0	0	0	0	**82**	15	2,142	25
500yr	25yr	**7,088**	15	9	0	0	0	0	0	**92**	13	1,717	10
500yr	10yr	**9,284**	9	0	0	0	0	0	0	**97**	10	2,196	5
500yr	5yr	**10,519**	0	0	0	0	0	0	0	**99**	9	1,236	2
500yr	2yr	**11,697**	0	0	0	0	0	0	0	**99**	8	1,178	0
100yr	50yr	**785**	45	19	15	9	0	0	0	**52**	67	785	52
100yr	25yr	**1,974**	45	15	9	0	0	0	0	**77**	39	1,189	24
100yr	10yr	**3,804**	45	9	0	0	0	0	0	**86**	23	1,830	9
100yr	5yr	**4,897**	45	0	0	0	0	0	0	**90**	18	1,092	4
100yr	2yr	**6,020**	45	0	0	0	0	0	0	**90**	15	1,124	0
50yr	25yr	**603**	45	22	15	9	0	0	0	**51**	85	603	51
50yr	10yr	**2,044**	45	22	9	0	0	0	0	**74**	36	1,441	23
50yr	5yr	**3,013**	45	22	0	0	0	0	0	**80**	27	969	7
50yr	2yr	**4,095**	45	22	0	0	0	0	0	**80**	20	1,082	0
25yr	10yr	**784**	45	22	19	9	0	0	0	**48**	61	784	48
25yr	5yr	**1,607**	45	22	19	0	0	0	0	**66**	41	823	18
25yr	2yr	**2,511**	45	22	19	0	0	0	0	**66**	26	904	0
10yr	5yr	**366**	45	22	19	15	0	0	0	**36**	98	366	36
10yr	2yr	**1,056**	45	22	19	15	0	0	0	**36**	34	690	0
5yr	2yr	**361**	45	22	19	15	9	0	0	**0**	0	361	0



Damage center: **DC_L100_004** *Station range:* 99719.3 to 90841.5 *Mile range:* 18.9 to 17.2

	Existing conditions		112	46	21	10	2	0	0	**87**	**Flood instances (50-yr)**	

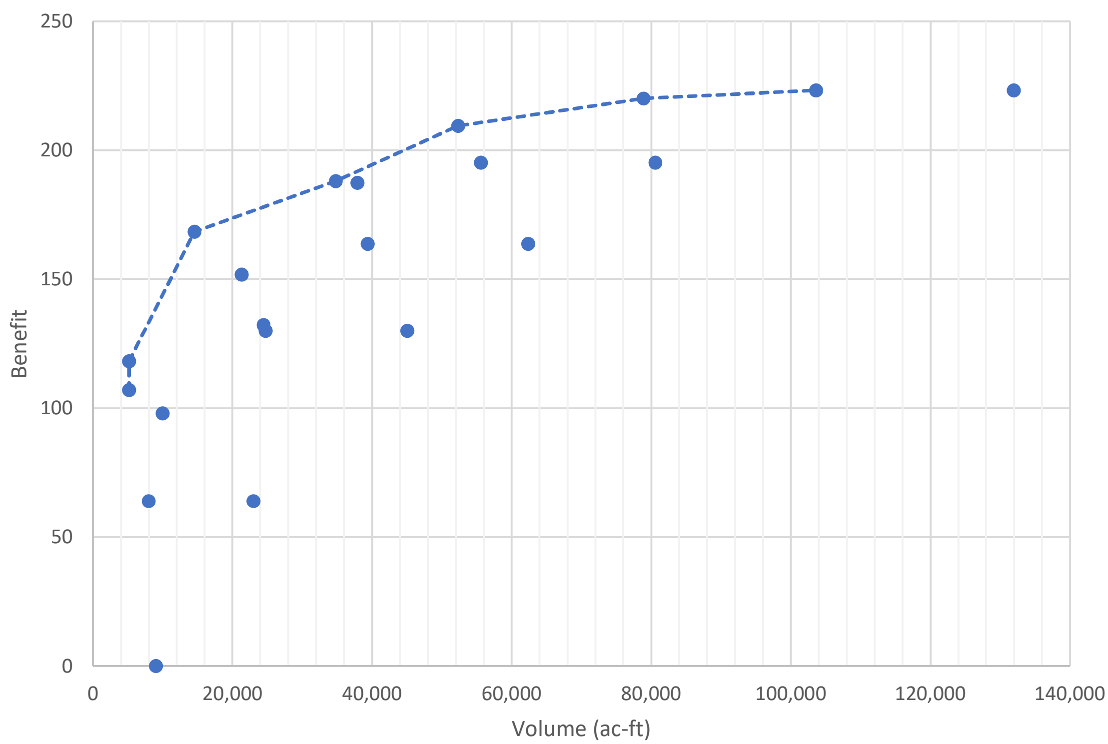
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**2,431**	46	21	10	2	0	0	0	**57**	23	2,431	57
500yr	50yr	**3,945**	21	10	2	0	0	0	0	**77**	19	1,514	20
500yr	25yr	**5,230**	10	2	0	0	0	0	0	**84**	16	1,285	7
500yr	10yr	**6,710**	2	0	0	0	0	0	0	**86**	13	1,480	3
500yr	5yr	**7,639**	0	0	0	0	0	0	0	**87**	11	929	0
500yr	2yr	**8,559**	0	0	0	0	0	0	0	**87**	10	920	0
100yr	50yr	**583**	112	21	10	2	0	0	0	**44**	75	583	44
100yr	25yr	**1,482**	112	10	2	0	0	0	0	**58**	39	899	15
100yr	10yr	**2,690**	112	2	0	0	0	0	0	**64**	24	1,208	5
100yr	5yr	**3,554**	112	0	0	0	0	0	0	**64**	18	865	1
100yr	2yr	**4,414**	112	0	0	0	0	0	0	**64**	15	860	0
50yr	25yr	**470**	112	46	10	2	0	0	0	**32**	69	470	32
50yr	10yr	**1,454**	112	46	2	0	0	0	0	**42**	29	984	10
50yr	5yr	**2,186**	112	46	0	0	0	0	0	**44**	20	732	2
50yr	2yr	**2,975**	112	46	0	0	0	0	0	**44**	15	789	0
25yr	10yr	**544**	112	46	21	2	0	0	0	**24**	44	544	24
25yr	5yr	**1,191**	112	46	21	0	0	0	0	**28**	24	647	4
25yr	2yr	**1,807**	112	46	21	0	0	0	0	**28**	15	616	0
10yr	5yr	**279**	112	46	21	10	0	0	0	**8**	29	279	8
10yr	2yr	**775**	112	46	21	10	0	0	0	**8**	10	496	0
5yr	2yr	**255**	112	46	21	10	2	0	0	**0**	0	255	0



Damage center: **DC_S100_001** *Station range:* 31579 to 4727 *Mile range:* 6 to 0.9

Existing conditions	140	70	45	33	16	0	0	**223**	**Flood instances (50-yr)**	

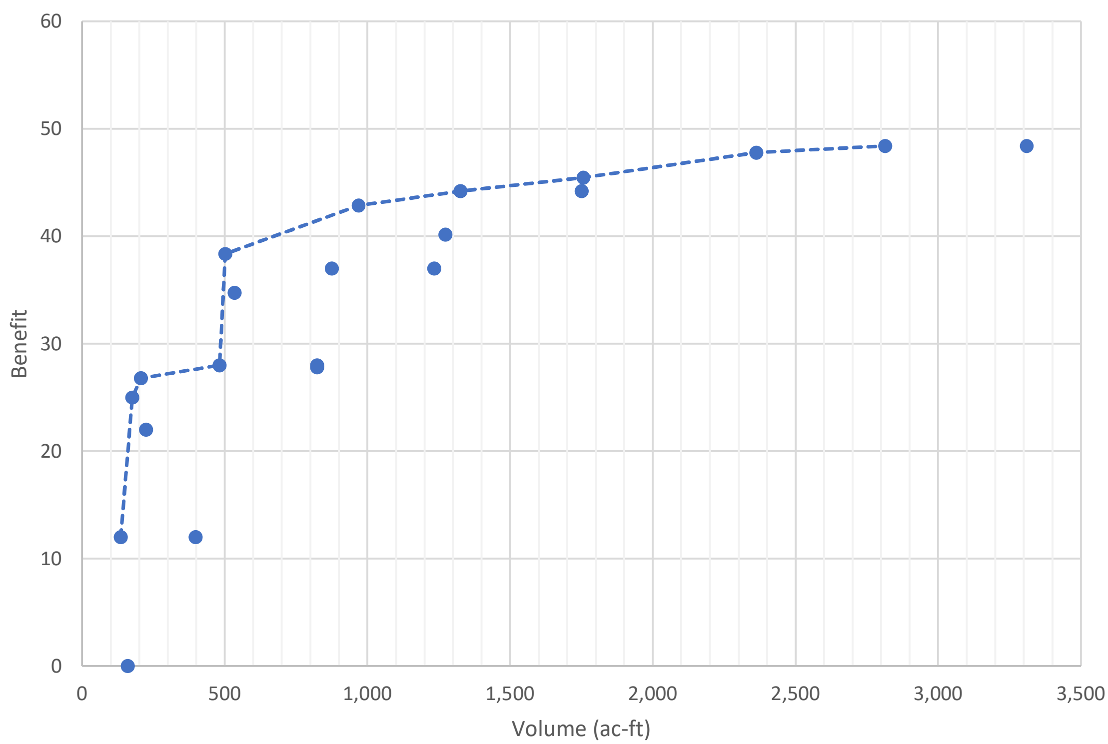
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**24,423**	70	45	33	16	0	0	0	**132**	5	24,423	132
500yr	50yr	**37,872**	45	33	16	0	0	0	0	**187**	5	13,449	55
500yr	25yr	**52,319**	33	16	0	0	0	0	0	**209**	4	14,447	22
500yr	10yr	**78,898**	16	0	0	0	0	0	0	**220**	3	26,578	11
500yr	5yr	**103,614**	0	0	0	0	0	0	0	**223**	2	24,717	3
500yr	2yr	**131,927**	0	0	0	0	0	0	0	**223**	2	28,312	0
100yr	50yr	**5,167**	140	45	33	16	0	0	0	**118**	23	5,167	118
100yr	25yr	**14,537**	140	33	16	0	0	0	0	**168**	12	9,370	50
100yr	10yr	**34,785**	140	16	0	0	0	0	0	**188**	5	20,247	20
100yr	5yr	**55,595**	140	0	0	0	0	0	0	**195**	4	20,811	7
100yr	2yr	**80,564**	140	0	0	0	0	0	0	**195**	2	24,969	0
50yr	25yr	**5,160**	140	70	33	16	0	0	0	**107**	21	5,160	107
50yr	10yr	**21,288**	140	70	16	0	0	0	0	**152**	7	16,128	45
50yr	5yr	**39,362**	140	70	0	0	0	0	0	**164**	4	18,073	12
50yr	2yr	**62,346**	140	70	0	0	0	0	0	**164**	3	22,984	0
25yr	10yr	**9,971**	140	70	45	16	0	0	0	**98**	10	9,971	98
25yr	5yr	**24,737**	140	70	45	0	0	0	0	**130**	5	14,766	32
25yr	2yr	**45,010**	140	70	45	0	0	0	0	**130**	3	20,274	0
10yr	5yr	**7,960**	140	70	45	33	0	0	0	**64**	8	7,960	64
10yr	2yr	**23,012**	140	70	45	33	0	0	0	**64**	3	15,052	0
5yr	2yr	**9,013**	140	70	45	33	16	0	0	**0**	0	9,013	0



Damage center: **DC_S100_002** *Station range:* 158863 to 152713 *Mile range:* 30.1 to 28.9

Existing conditions	21	16	12	8	3	0	0	**48**	**Flood instances (50-yr)**

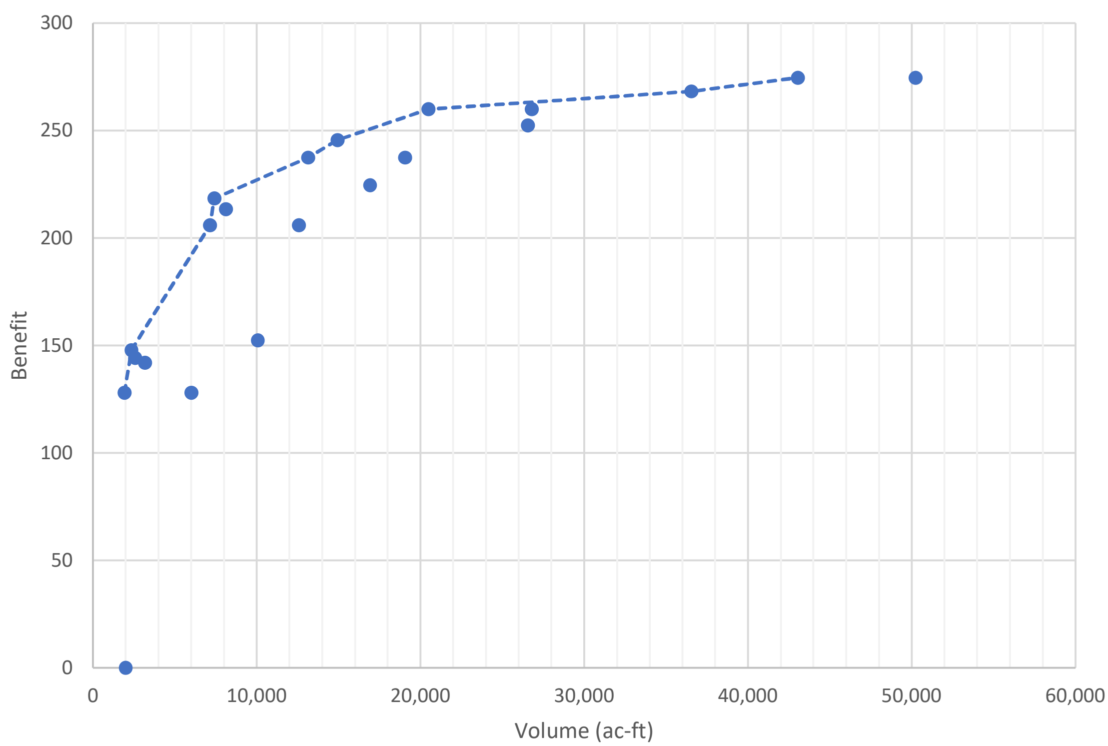
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**823**	16	12	8	3	0	0	0	**28**	34	823	28
500yr	50yr	**1,273**	12	8	3	0	0	0	0	**40**	32	450	12
500yr	25yr	**1,757**	8	3	0	0	0	0	0	**45**	26	483	5
500yr	10yr	**2,363**	3	0	0	0	0	0	0	**48**	20	606	2
500yr	5yr	**2,814**	0	0	0	0	0	0	0	**48**	17	451	1
500yr	2yr	**3,310**	0	0	0	0	0	0	0	**48**	15	496	0
100yr	50yr	**207**	21	12	8	3	0	0	0	**27**	130	207	27
100yr	25yr	**502**	21	8	3	0	0	0	0	**38**	76	295	12
100yr	10yr	**969**	21	3	0	0	0	0	0	**43**	44	467	5
100yr	5yr	**1,326**	21	0	0	0	0	0	0	**44**	33	357	1
100yr	2yr	**1,750**	21	0	0	0	0	0	0	**44**	25	424	0
50yr	25yr	**176**	21	16	8	3	0	0	0	**25**	142	176	25
50yr	10yr	**534**	21	16	3	0	0	0	0	**35**	65	357	10
50yr	5yr	**875**	21	16	0	0	0	0	0	**37**	42	342	2
50yr	2yr	**1,234**	21	16	0	0	0	0	0	**37**	30	359	0
25yr	10yr	**225**	21	16	12	3	0	0	0	**22**	98	225	22
25yr	5yr	**482**	21	16	12	0	0	0	0	**28**	58	257	6
25yr	2yr	**824**	21	16	12	0	0	0	0	**28**	34	342	0
10yr	5yr	**135**	21	16	12	8	0	0	0	**12**	89	135	12
10yr	2yr	**398**	21	16	12	8	0	0	0	**12**	30	263	0
5yr	2yr	**160**	21	16	12	8	3	0	0	**0**	0	160	0



Damage center: **DC_STB_001** *Station range:* 104391 to 92871 *Mile range:* 19.8 to 17.6

Existing conditions	73	50	42	39	32	0	0	**275**	**Flood instances (50-yr)**

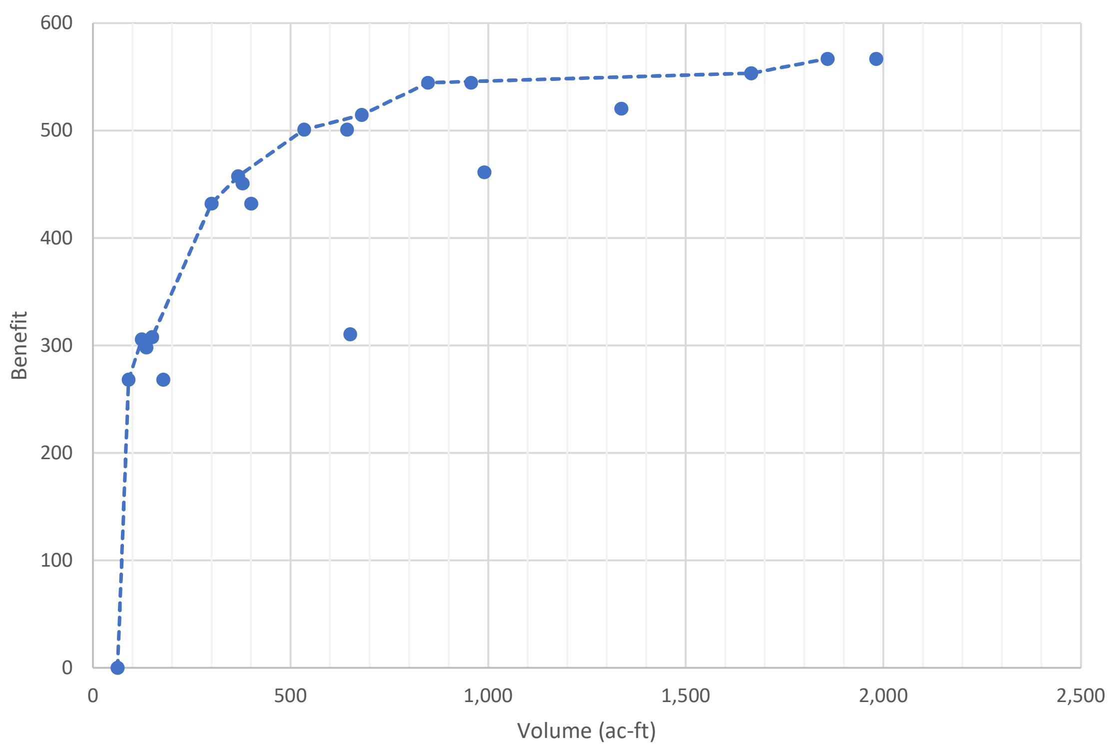
Start Flow	Target Flow	Vol, ac-ft	500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
			Cumulative number of flooded structures										
500yr	100yr	**10,061**	50	42	39	32	0	0	0	**152**	15	10,061	152
500yr	50yr	**16,919**	42	39	32	0	0	0	0	**225**	13	6,858	72
500yr	25yr	**26,553**	39	32	0	0	0	0	0	**252**	10	9,634	28
500yr	10yr	**36,534**	32	0	0	0	0	0	0	**268**	7	9,981	16
500yr	5yr	**43,052**	0	0	0	0	0	0	0	**275**	6	6,518	6
500yr	2yr	**50,241**	0	0	0	0	0	0	0	**275**	5	7,189	0
100yr	50yr	**2,345**	73	42	39	32	0	0	0	**148**	63	2,345	148
100yr	25yr	**7,406**	73	39	32	0	0	0	0	**218**	29	5,061	71
100yr	10yr	**14,924**	73	32	0	0	0	0	0	**246**	16	7,518	27
100yr	5yr	**20,480**	73	0	0	0	0	0	0	**260**	13	5,556	14
100yr	2yr	**26,805**	73	0	0	0	0	0	0	**260**	10	6,325	0
50yr	25yr	**2,568**	73	50	39	32	0	0	0	**144**	56	2,568	144
50yr	10yr	**8,115**	73	50	32	0	0	0	0	**214**	26	5,547	69
50yr	5yr	**13,142**	73	50	0	0	0	0	0	**238**	18	5,027	24
50yr	2yr	**19,057**	73	50	0	0	0	0	0	**238**	12	5,915	0
25yr	10yr	**3,167**	73	50	42	32	0	0	0	**142**	45	3,167	142
25yr	5yr	**7,140**	73	50	42	0	0	0	0	**206**	29	3,973	64
25yr	2yr	**12,574**	73	50	42	0	0	0	0	**206**	16	5,434	0
10yr	5yr	**1,924**	73	50	42	39	0	0	0	**128**	67	1,924	128
10yr	2yr	**5,994**	73	50	42	39	0	0	0	**128**	21	4,071	0
5yr	2yr	**1,990**	73	50	42	39	32	0	0	**0**	0	1,990	0



Damage center: **DC_STB_002** *Station range:* 179366 to 167484 *Mile range:* 34 to 31.7

Existing conditions	111	97	92	82	67	0	0	**567**	**Flood instances (50-yr)**

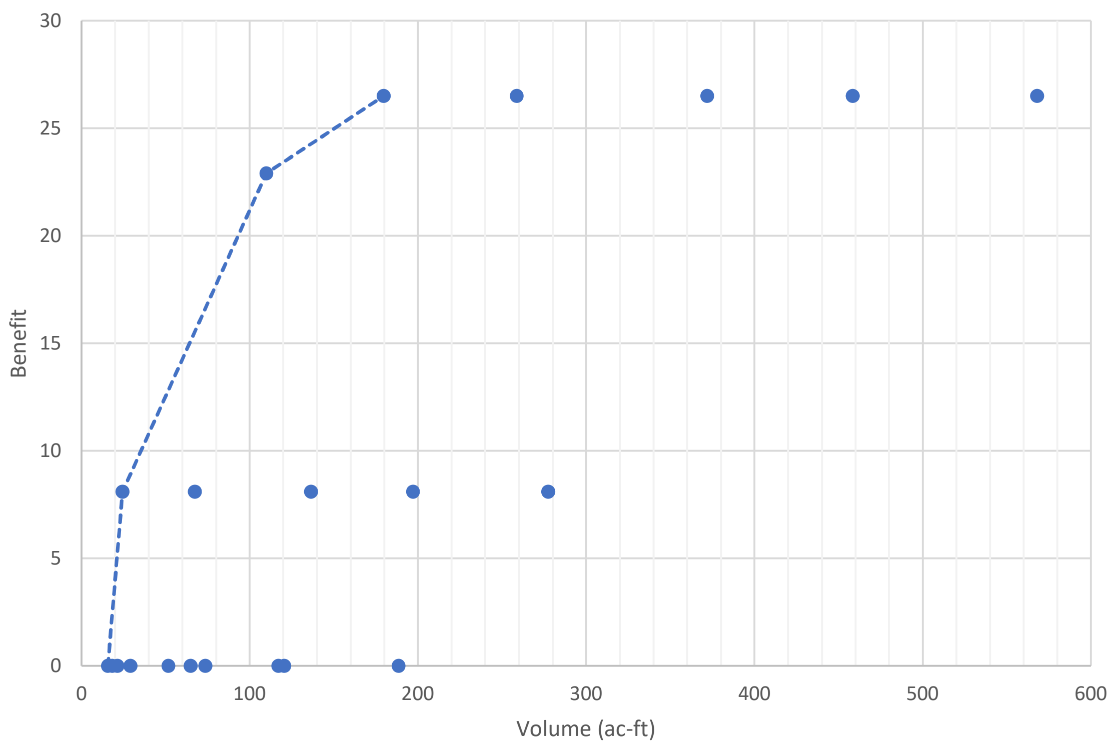
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**651**	97	92	82	67	0	0	0	**311**	477	651	311
500yr	50yr	**991**	92	82	67	0	0	0	0	**461**	466	339	151
500yr	25yr	**1,337**	82	67	0	0	0	0	0	**520**	389	346	59
500yr	10yr	**1,666**	67	0	0	0	0	0	0	**553**	332	329	33
500yr	5yr	**1,858**	0	0	0	0	0	0	0	**567**	305	193	13
500yr	2yr	**1,982**	0	0	0	0	0	0	0	**567**	286	124	0
100yr	50yr	**150**	111	92	82	67	0	0	0	**308**	2052	150	308
100yr	25yr	**368**	111	82	67	0	0	0	0	**458**	1244	218	150
100yr	10yr	**680**	111	67	0	0	0	0	0	**515**	756	312	57
100yr	5yr	**847**	111	0	0	0	0	0	0	**545**	643	167	30
100yr	2yr	**957**	111	0	0	0	0	0	0	**545**	569	110	0
50yr	25yr	**123**	111	97	82	67	0	0	0	**306**	2475	123	306
50yr	10yr	**379**	111	97	67	0	0	0	0	**451**	1190	255	145
50yr	5yr	**534**	111	97	0	0	0	0	0	**501**	938	155	50
50yr	2yr	**643**	111	97	0	0	0	0	0	**501**	779	109	0
25yr	10yr	**135**	111	97	92	67	0	0	0	**298**	2208	135	298
25yr	5yr	**300**	111	97	92	0	0	0	0	**432**	1440	165	134
25yr	2yr	**401**	111	97	92	0	0	0	0	**432**	1078	101	0
10yr	5yr	**90**	111	97	92	82	0	0	0	**268**	2977	90	268
10yr	2yr	**178**	111	97	92	82	0	0	0	**268**	1502	88	0
5yr	2yr	**62**	111	97	92	82	67	0	0	**0**	0	62	0



Damage center: **DC_R100_001** *Station range:* 25734.9 to 22863.2 *Mile range:* 4.9 to 4.3

Existing conditions	92	18	0	0	0	0	0	**27**	**Flood instances (50-yr)**

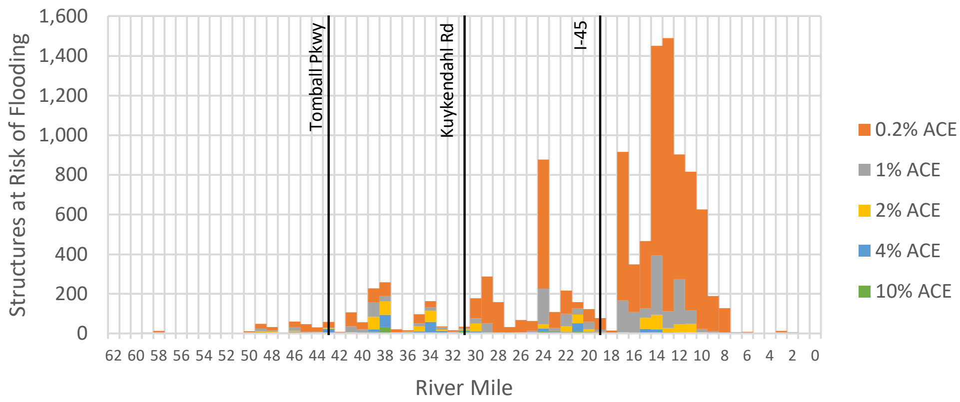
Start Flow	Target Flow	Vol, ac-ft	Cumulative number of flooded structures 500yr	100yr	50yr	25yr	10yr	5yr	2yr	Benefit	B/V	Incr. V	Incr. B
500yr	100yr	**110**	18	0	0	0	0	0	0	**23**	208	110	23
500yr	50yr	**180**	0	0	0	0	0	0	0	**27**	148	70	4
500yr	25yr	**259**	0	0	0	0	0	0	0	**27**	102	79	0
500yr	10yr	**372**	0	0	0	0	0	0	0	**27**	71	113	0
500yr	5yr	**458**	0	0	0	0	0	0	0	**27**	58	87	0
500yr	2yr	**568**	0	0	0	0	0	0	0	**27**	47	110	0
100yr	50yr	**24**	92	0	0	0	0	0	0	**8**	332	24	8
100yr	25yr	**67**	92	0	0	0	0	0	0	**8**	120	43	0
100yr	10yr	**136**	92	0	0	0	0	0	0	**8**	59	69	0
100yr	5yr	**197**	92	0	0	0	0	0	0	**8**	41	60	0
100yr	2yr	**277**	92	0	0	0	0	0	0	**8**	29	80	0
50yr	25yr	**21**	92	18	0	0	0	0	0	**0**	0	21	0
50yr	10yr	**73**	92	18	0	0	0	0	0	**0**	0	52	0
50yr	5yr	**120**	92	18	0	0	0	0	0	**0**	0	47	0
50yr	2yr	**188**	92	18	0	0	0	0	0	**0**	0	68	0
25yr	10yr	**29**	92	18	0	0	0	0	0	**0**	0	29	0
25yr	5yr	**65**	92	18	0	0	0	0	0	**0**	0	36	0
25yr	2yr	**117**	92	18	0	0	0	0	0	**0**	0	52	0
10yr	5yr	**16**	92	18	0	0	0	0	0	**0**	0	16	0
10yr	2yr	**52**	92	18	0	0	0	0	0	**0**	0	36	0
5yr	2yr	**18**	92	18	0	0	0	0	0	**0**	0	18	0



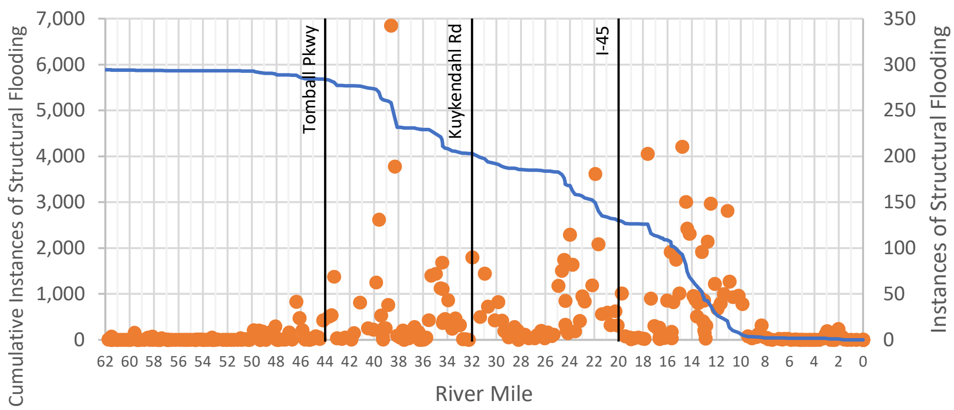
Appendix G.2

Existing Conditions Flooding

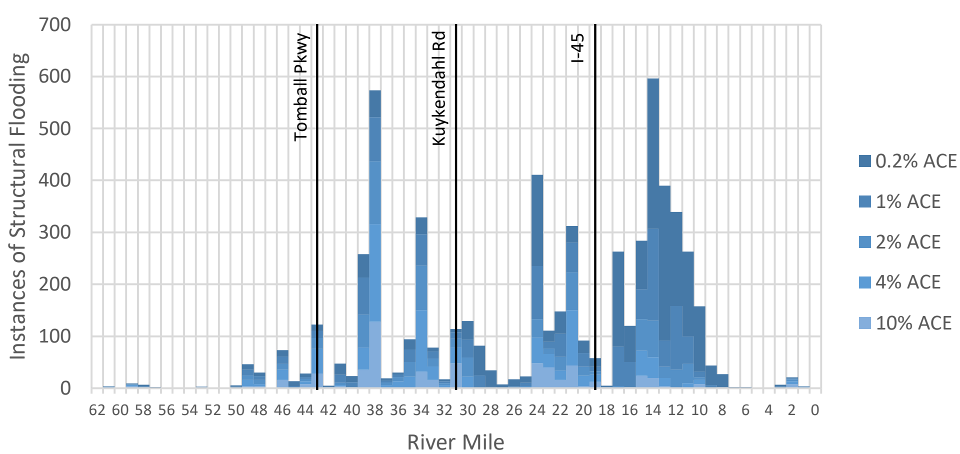
Spring Creek – Structures at Risk of Flooding

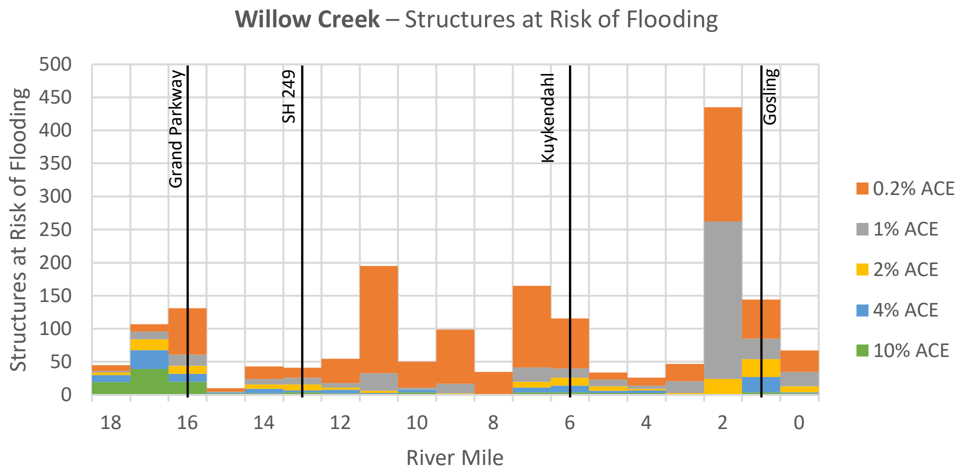


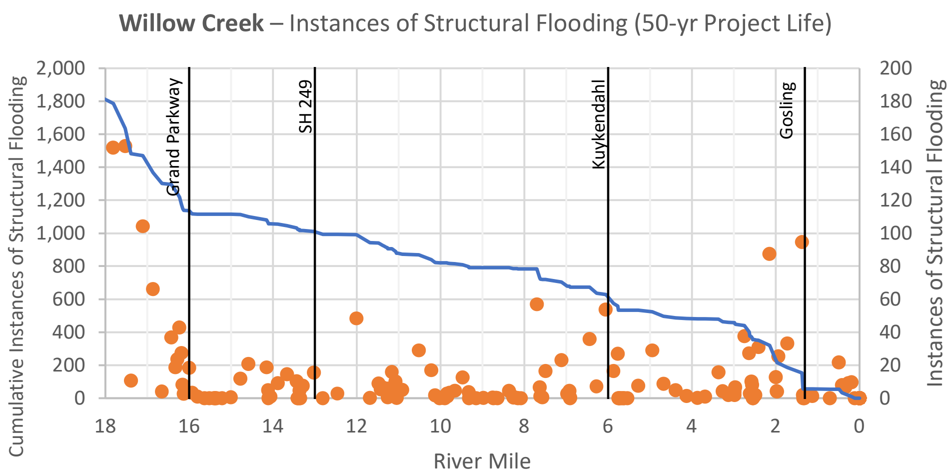
Spring Creek – Instances of Structural Flooding (50-yr Project Life)

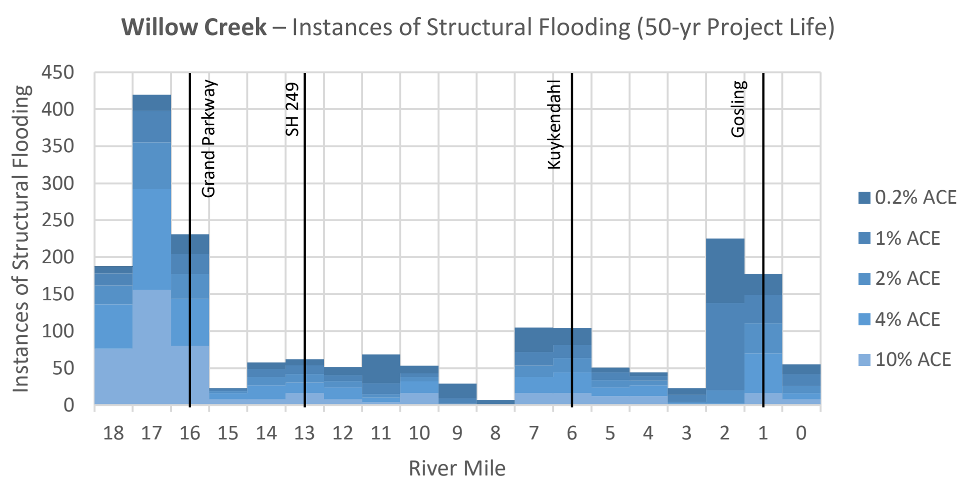


Spring Creek – Instances of Structural Flooding (50-yr Project Life)

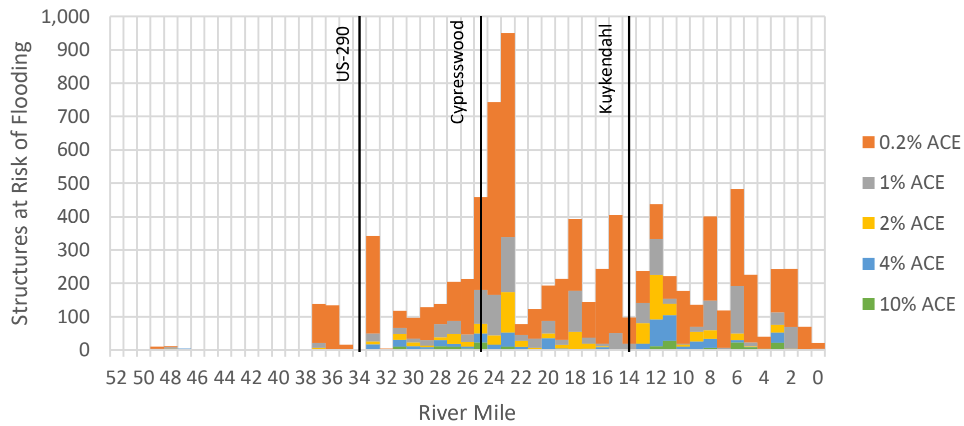



Willow Creek – Structures at Risk of Flooding
Structures at Risk of Flooding
River Mile
Grand Parkway
SH 249
Kuykendahl
Gosling
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE
500
450
400
350
300
250
200
150
100
50
0
18
16
14
12
10
8
6
4
2
0

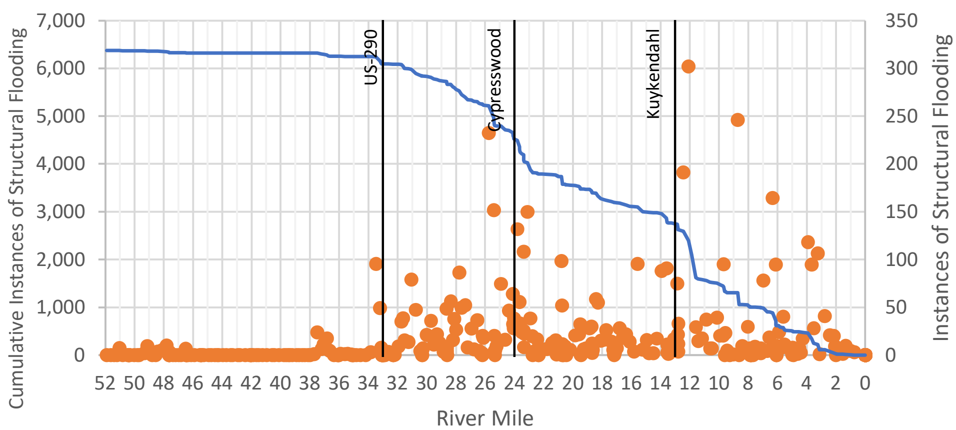

Willow Creek – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
Instances of Structural Flooding
River Mile
Grand Parkway
SH 249
Kuykendahl
Gosling
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
200
180
160
140
120
100
80
60
40
20
0
18
16
14
12
10
8
6
4
2
0


Willow Creek – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
Grand Parkway
SH 249
Kuykendahl
Gosling
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE
450
400
350
300
250
200
150
100
50
0
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

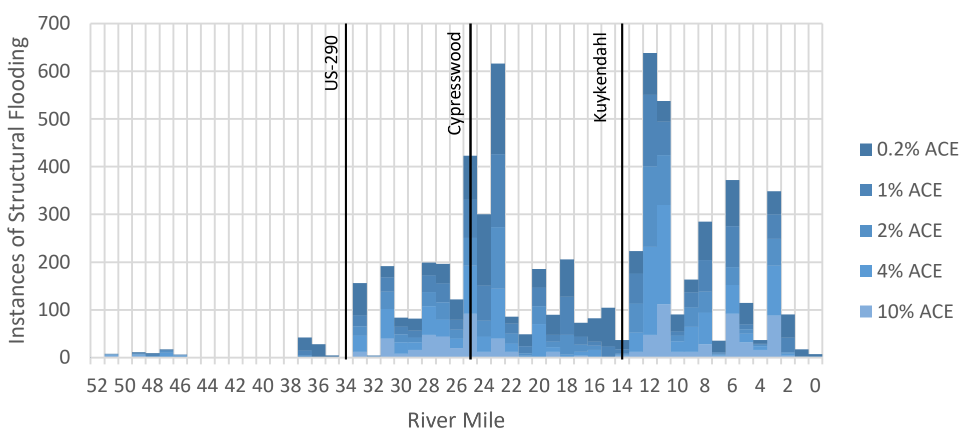
Cypress Creek – Structures at Risk of Flooding

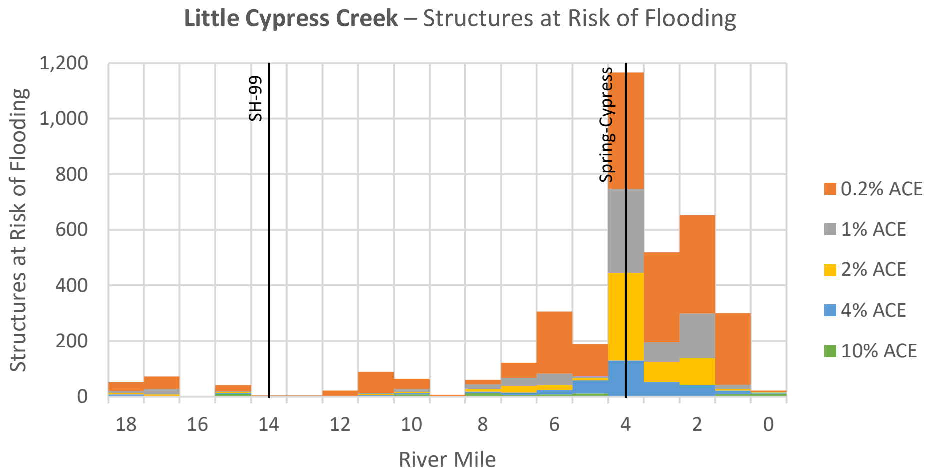


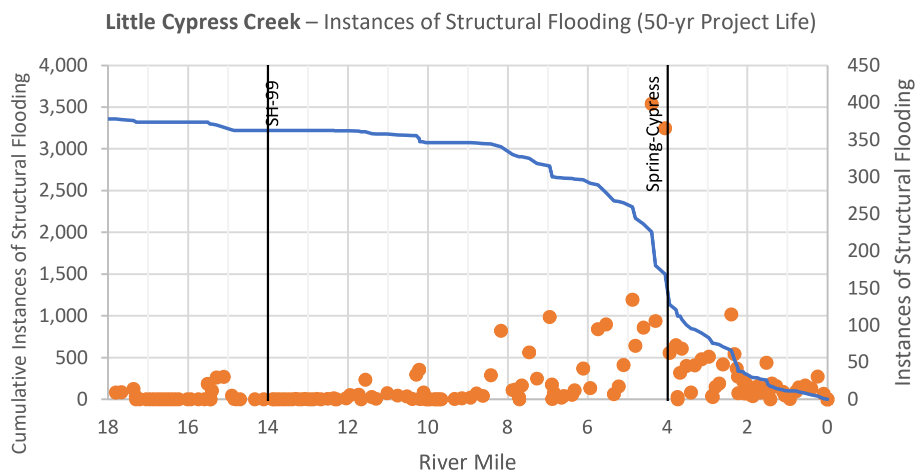
Cypress Creek – Instances of Structural Flooding (50-yr Project Life)

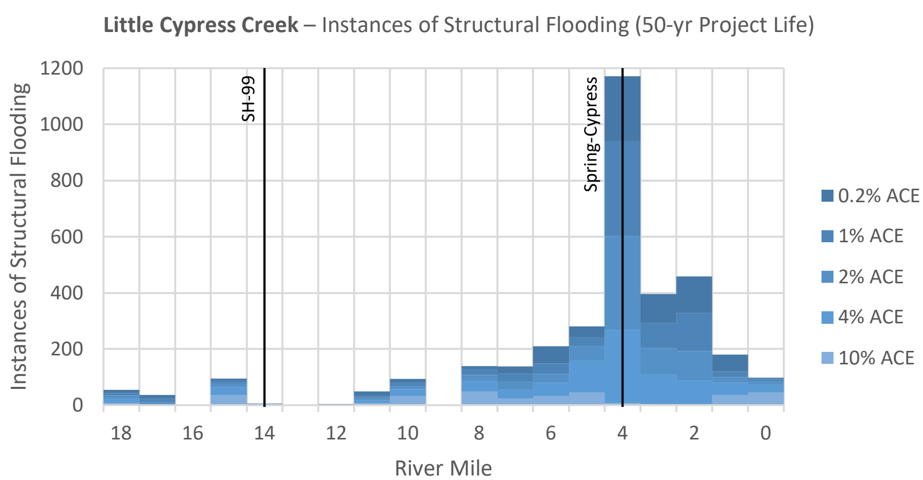


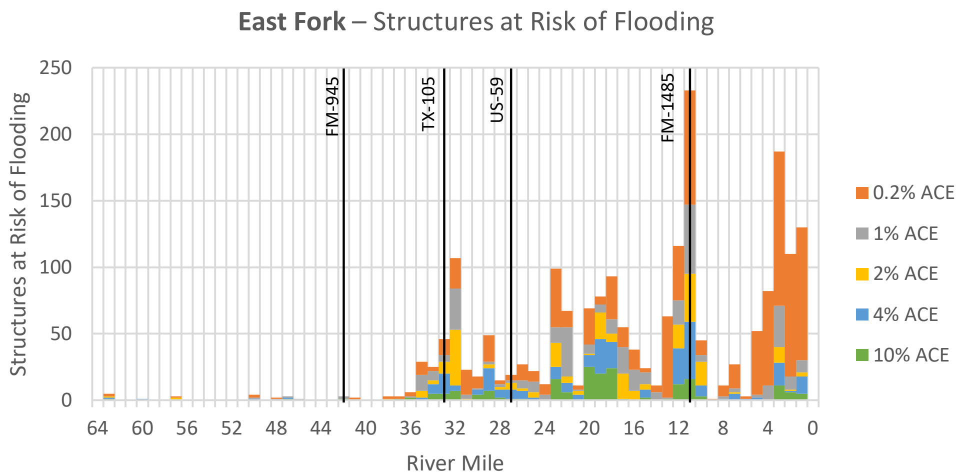
Cypress Creek – Instances of Structural Flooding (50-yr Project Life)

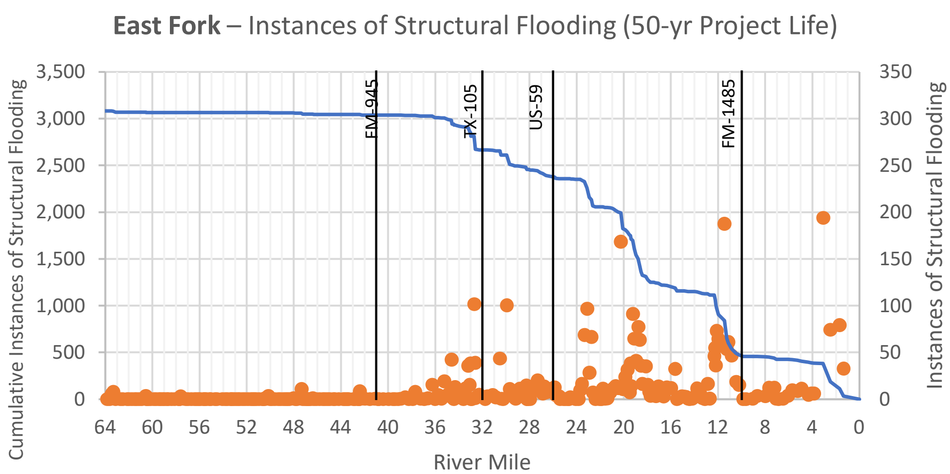


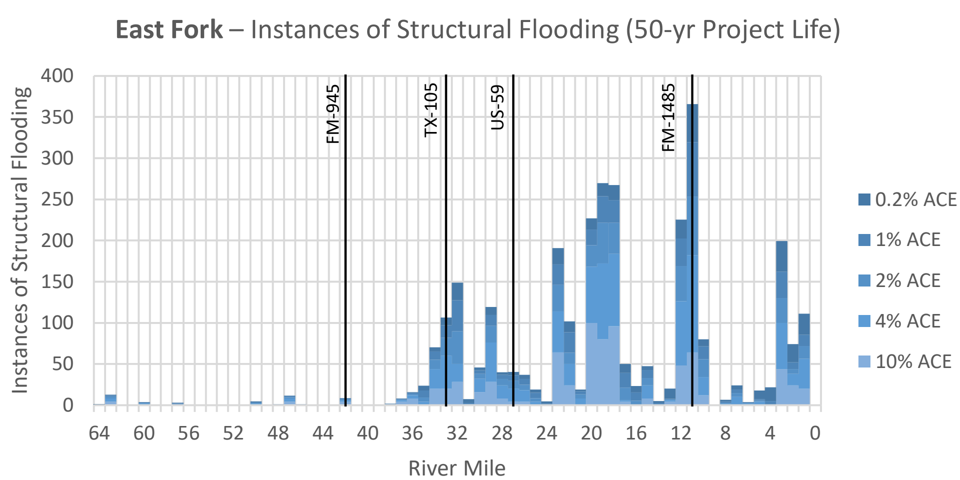

Little Cypress Creek – Structures at Risk of Flooding
Structures at Risk of Flooding
1,200
1,000
800
600
400
200
0
SH-99
Spring-Cypress
18
16
14
12
10
8
6
4
2
0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


Little Cypress Creek – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Instances of Structural Flooding
450
400
350
300
250
200
150
100
50
0
SH-99
Spring-Cypress
18
16
14
12
10
8
6
4
2
0
River Mile

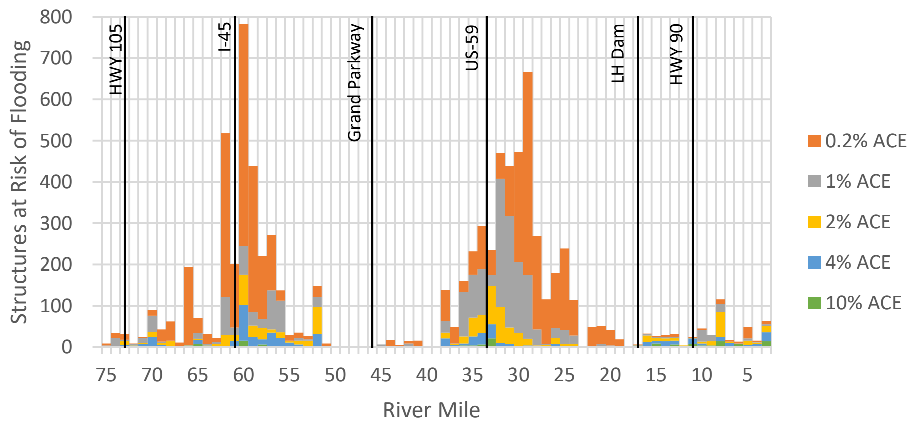

Little Cypress Creek – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
1200
1000
800
600
400
200
0
SH-99
Spring-Cypress
18
16
14
12
10
8
6
4
2
0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


East Fork – Structures at Risk of Flooding
Structures at Risk of Flooding
River Mile
FM-945
TX-105
US-59
FM-1485
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

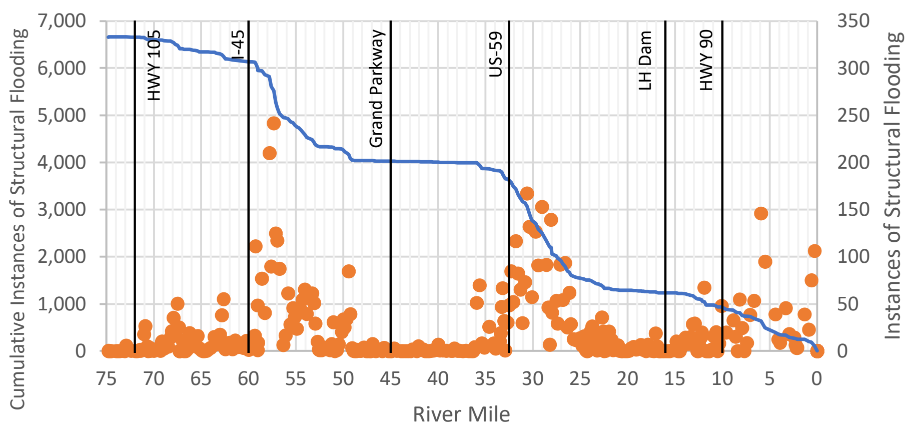

East Fork – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
Instances of Structural Flooding
River Mile
FM-945
TX-105
US-59
FM-1485


East Fork – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
FM-945
TX-105
US-59
FM-1485
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

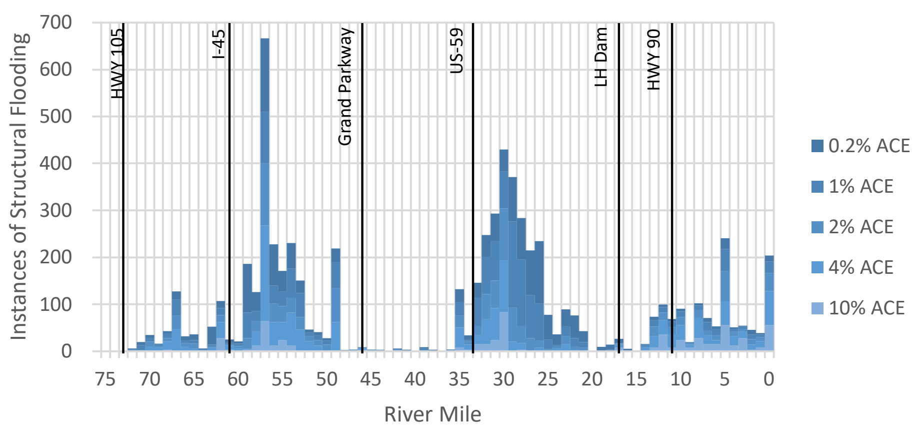
West Fork – Structures at Risk of Flooding

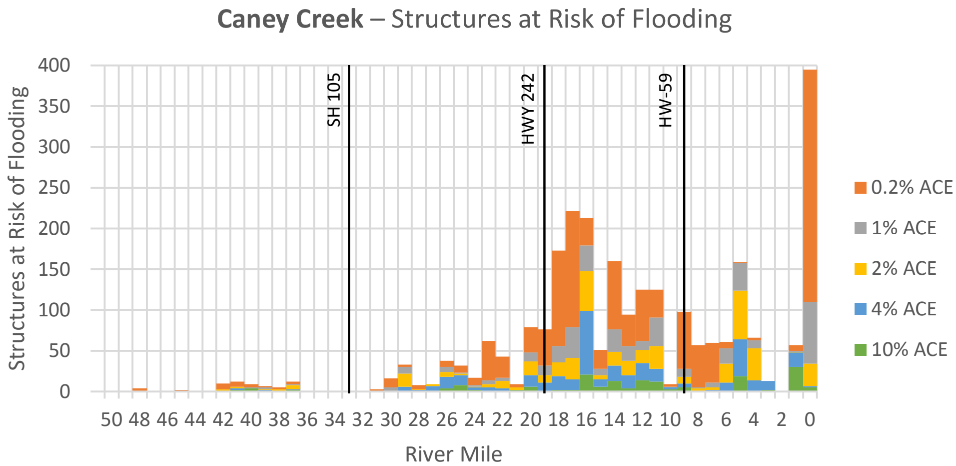


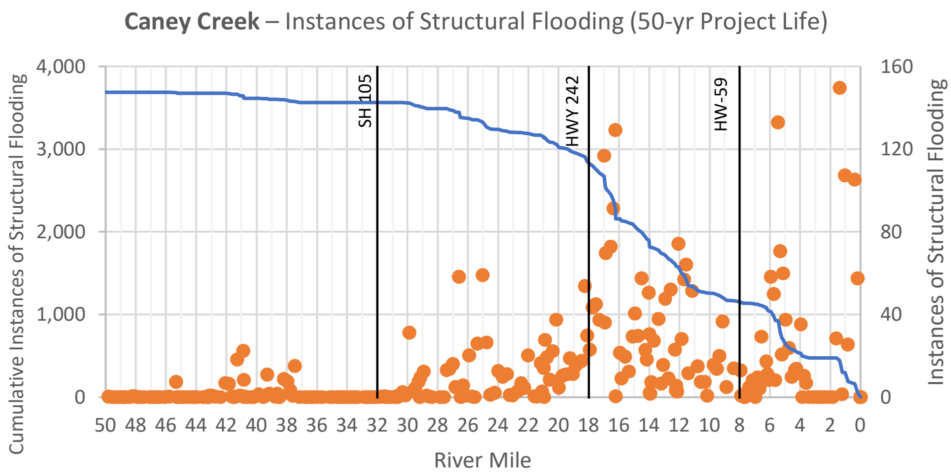
West Fork – Instances of Structural Flooding (50-yr Project Life)

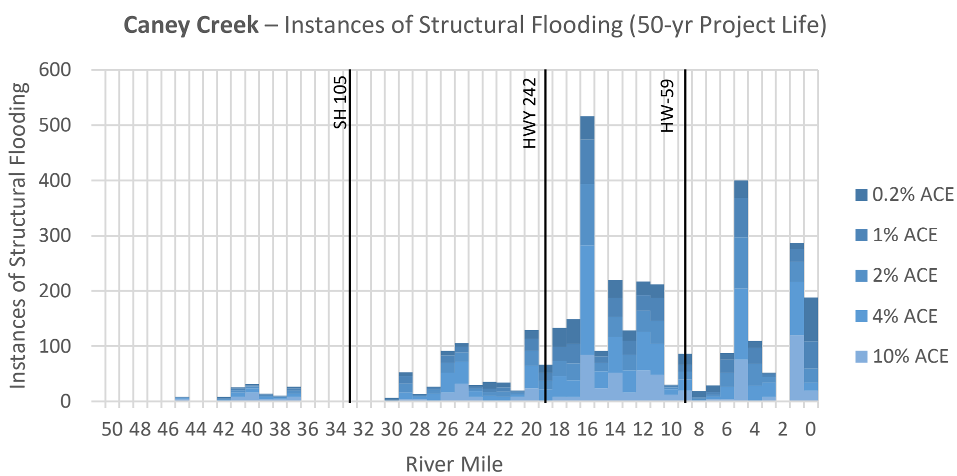


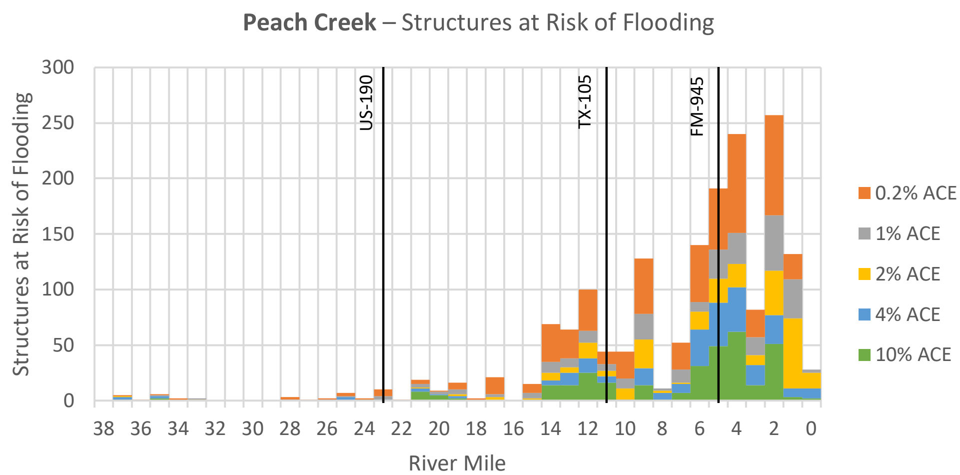
West Fork – Instances of Structural Flooding (50-yr Project Life)

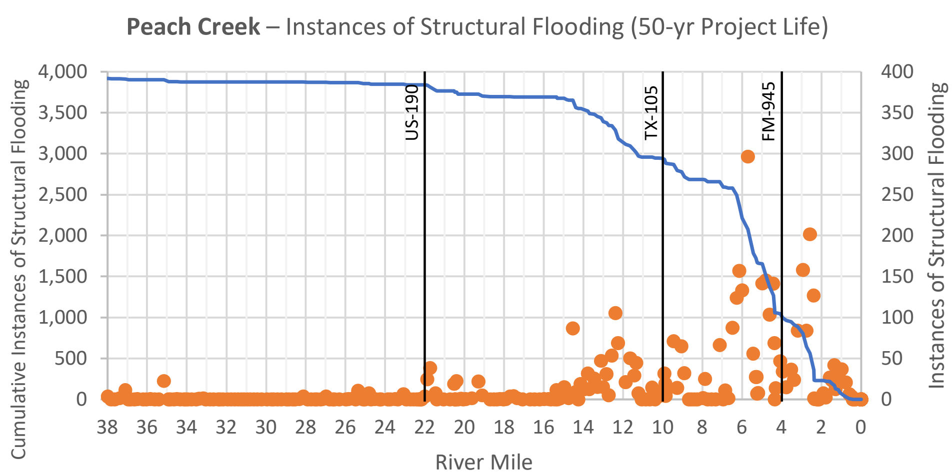


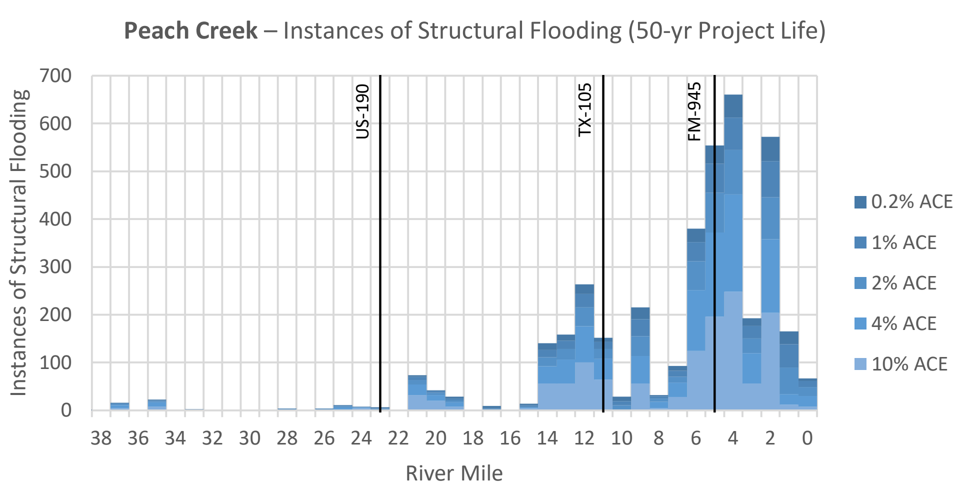

Caney Creek – Structures at Risk of Flooding
Structures at Risk of Flooding
400
350
300
250
200
150
100
50
0
SH 105
HWY 242
HW-59
50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


Caney Creek – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
4,000
3,000
2,000
1,000
0
Instances of Structural Flooding
160
120
80
40
0
SH 105
HWY 242
HW-59
50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile

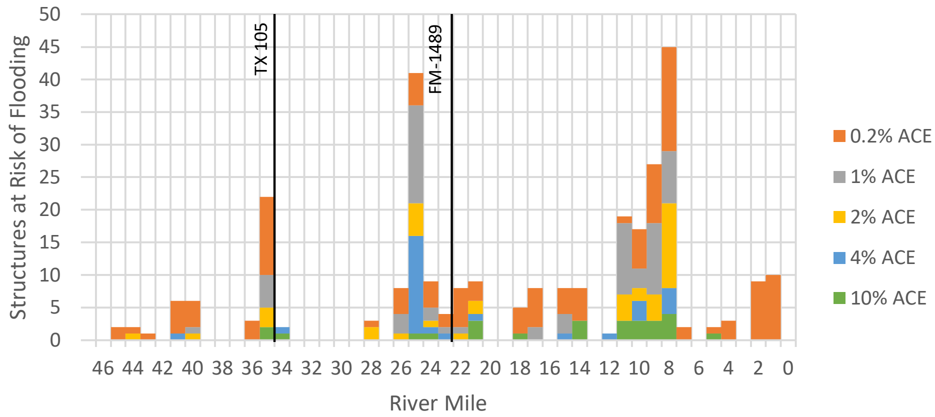

Caney Creek – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
600
500
400
300
200
100
0
SH 105
HWY 242
HW-59
50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


Peach Creek – Structures at Risk of Flooding
Structures at Risk of Flooding
River Mile
US-190
TX-105
FM-945
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

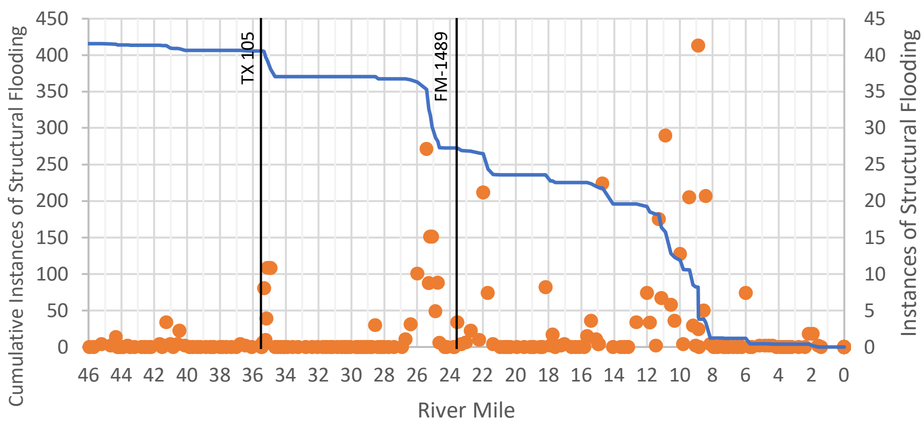

Peach Creek – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
Instances of Structural Flooding
River Mile
US-190
TX-105
FM-945


Peach Creek – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
US-190
TX-105
FM-945
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

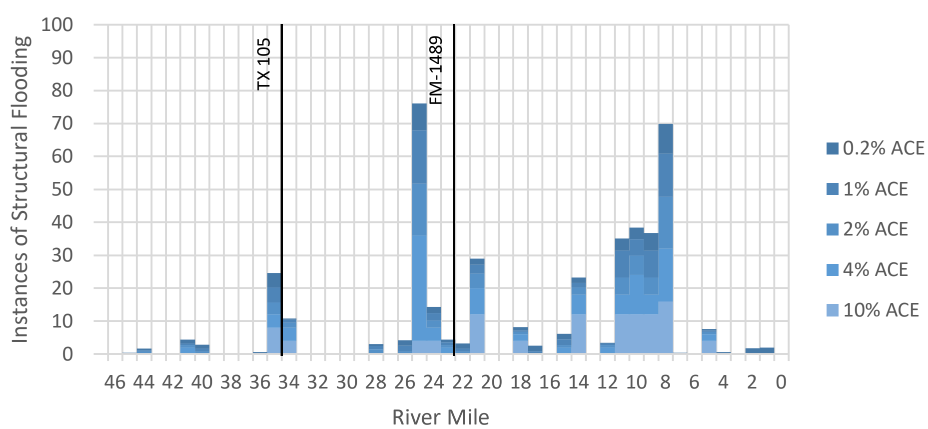
Lake Creek – Structures at Risk of Flooding



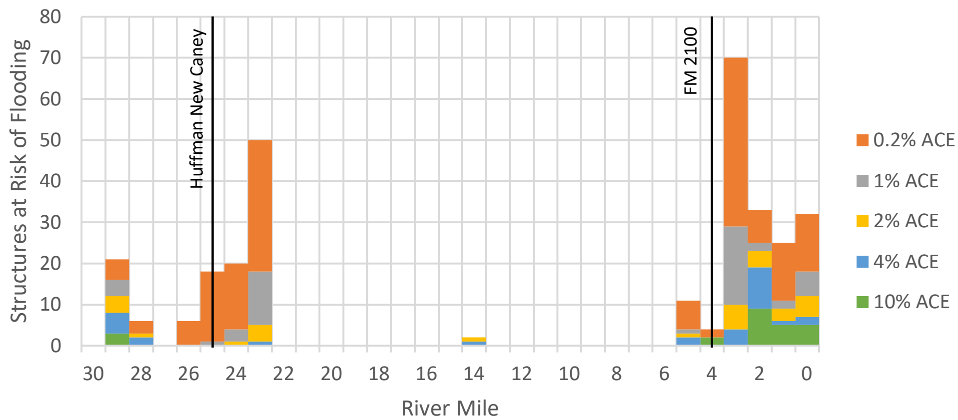
Lake Creek – Instances of Structural Flooding (50-yr Project Life)



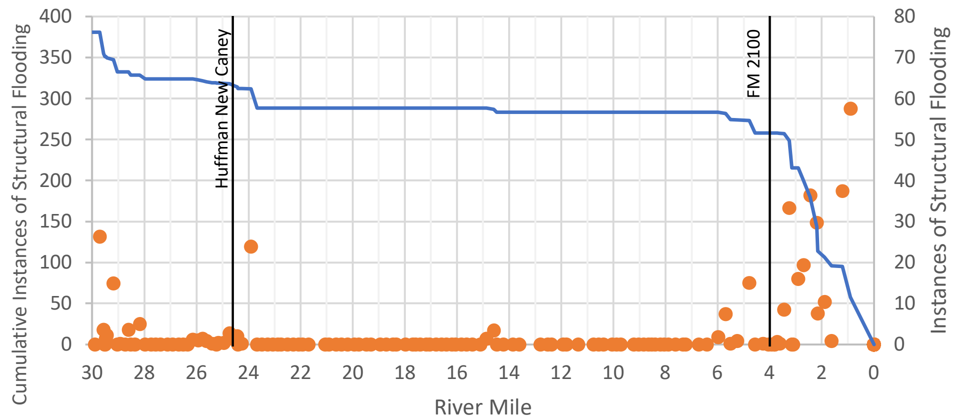
Lake Creek – Instances of Structural Flooding (50-yr Project Life)



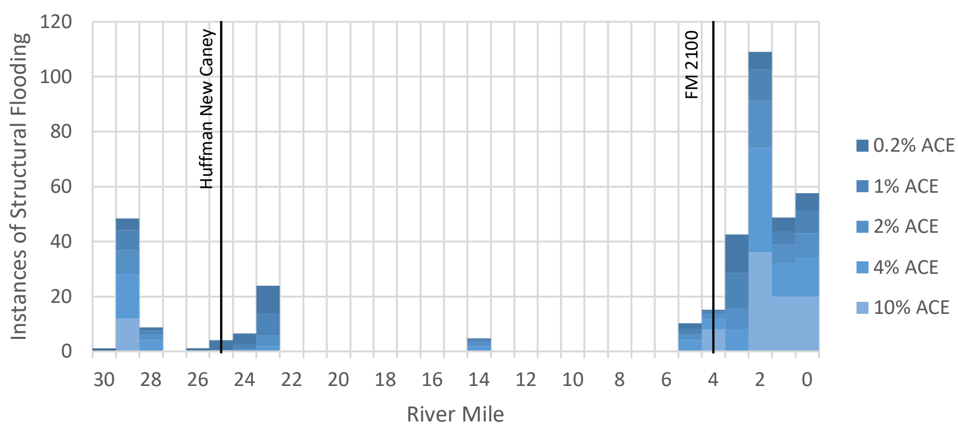
Luce Bayou – Structures at Risk of Flooding

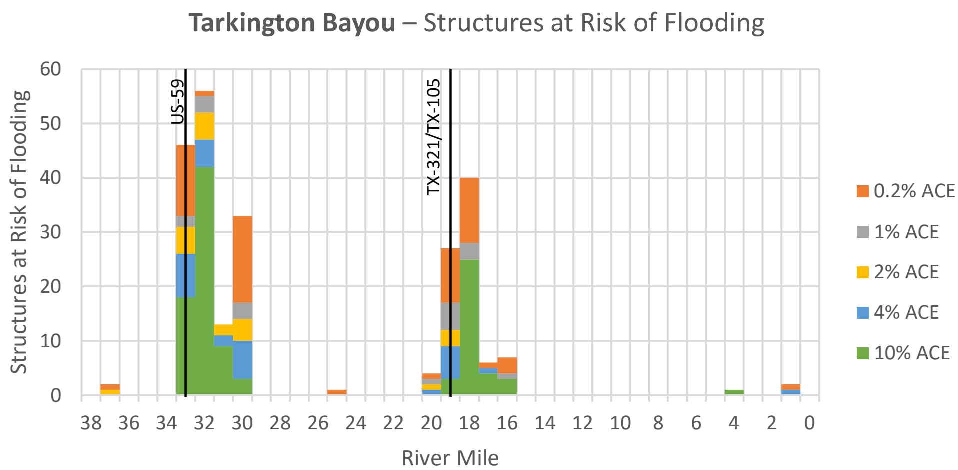


Luce Bayou – Instances of Structural Flooding (50-yr Project Life)

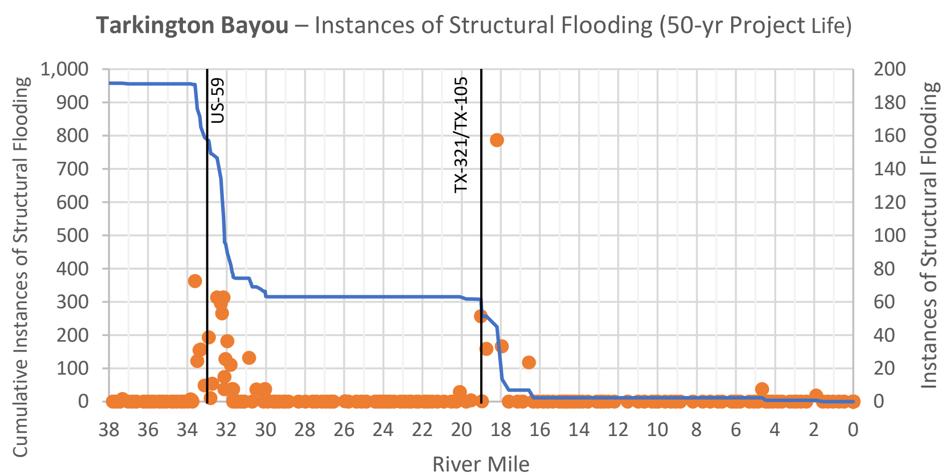


Luce Bayou – Instances of Structural Flooding (50-yr Project Life)

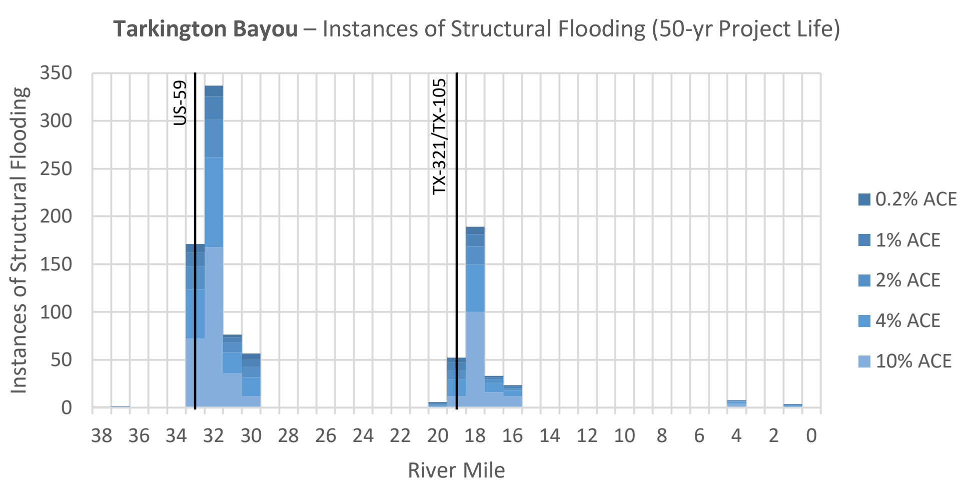




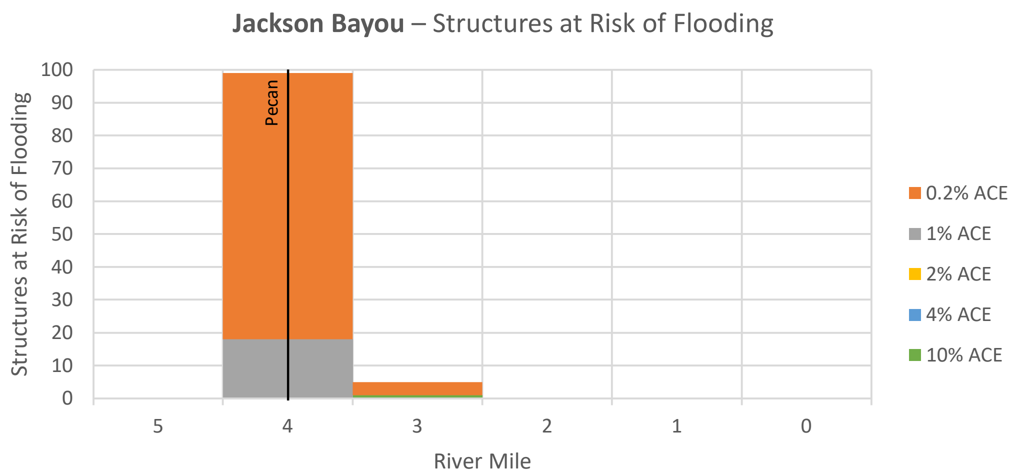
Tarkington Bayou – Structures at Risk of Flooding
Structures at Risk of Flooding
River Mile
US-59
TX-321/TX-105
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

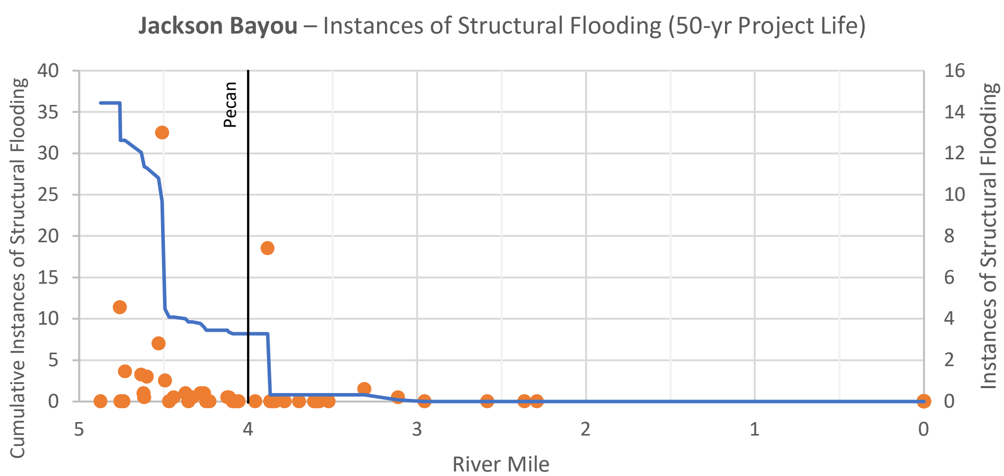


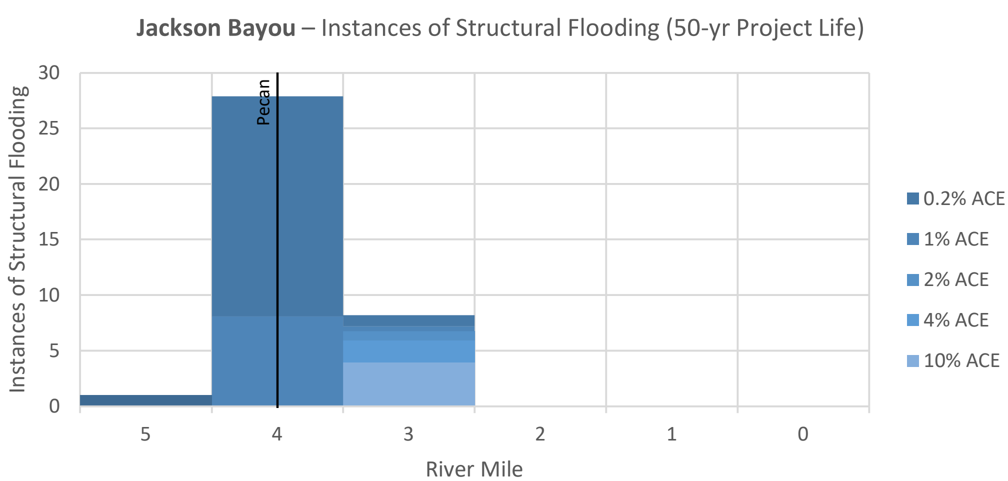
Tarkington Bayou – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
Instances of Structural Flooding
River Mile
US-59
TX-321/TX-105

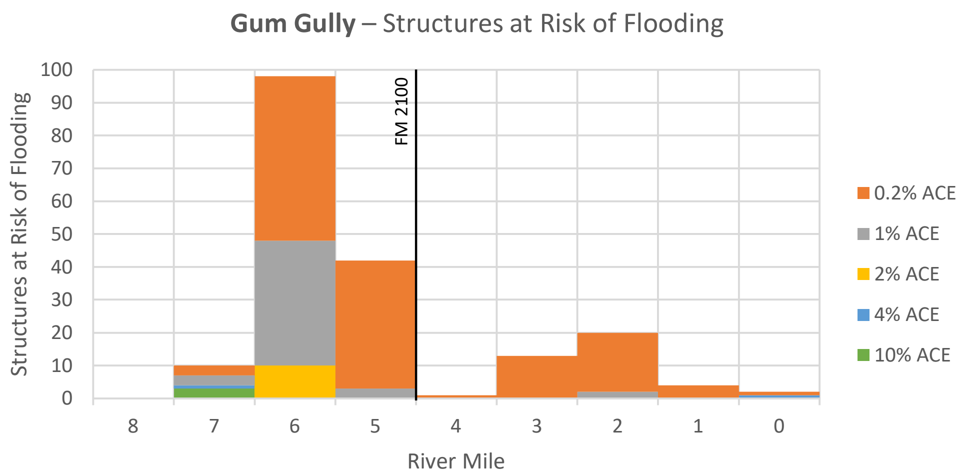


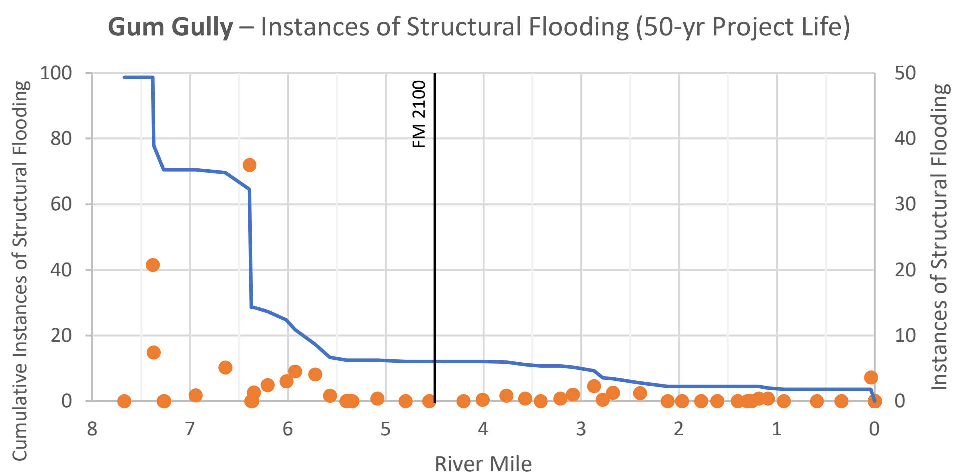
Tarkington Bayou – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
US-59
TX-321/TX-105
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

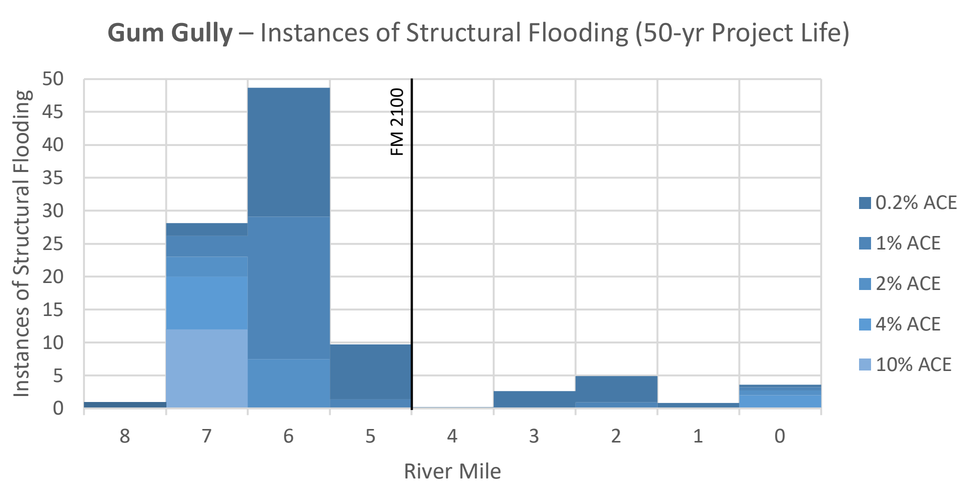

Jackson Bayou – Structures at Risk of Flooding
Structures at Risk of Flooding
100
90
80
70
60
50
40
30
20
10
0
Pecan
5
4
3
2
1
0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


Jackson Bayou – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
40
35
30
25
20
15
10
5
0
Pecan
16
14
12
10
8
6
4
2
0
Instances of Structural Flooding
5
4
3
2
1
0
River Mile


Jackson Bayou – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
30
25
20
15
10
5
0
Pecan
5
4
3
2
1
0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


Gum Gully – Structures at Risk of Flooding
Structures at Risk of Flooding
100
90
80
70
60
50
40
30
20
10
0
FM 2100
8
7
6
5
4
3
2
1
0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE


Gum Gully – Instances of Structural Flooding (50-yr Project Life)
Cumulative Instances of Structural Flooding
100
80
60
40
20
0
FM 2100
8
7
6
5
4
3
2
1
0
River Mile
50
40
30
20
10
0
Instances of Structural Flooding


Gum Gully – Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
50
45
40
35
30
25
20
15
10
5
0
FM 2100
8
7
6
5
4
3
2
1
0
River Mile
0.2% ACE
1% ACE
2% ACE
4% ACE
10% ACE

Appendix G.3

Cost Estimates

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – Walnut Creek Detention**
DATE	August 30, 2020
ESTIMATED BY	Josh Mata
QC CHECKED BY	Dustin Mortensen

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 1,345,000	$ 1,345,000
2	Temporary Erosion and Sediment Control	1	LS	$ 510,000	$ 510,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 770,000	$ 770,000
5	Clearing and Grubbing	25	AC	$ 10,000	$ 250,000
6	Oil/Gas Utility Conflicts/Relocation	1	EA	$ 1,000,000	$ 1,000,000
DAM CONSTRUCTION					
7	Excavation	150,000	CY	$ 10	$ 1,500,000
8	Embankment (Compacted Fill)	670,000	CY	$ 15	$ 10,050,000
9	Embankment Internal Drainage	63,000	CY	$ 70	$ 4,410,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	18,000	CY	$ 205	$ 3,690,000
12	Principal Spillway Outlet (10' x 10')	1,140	LF	$ 1,500	$ 1,710,000
13	Erosion Control (Rock Riprap)	890	CY	$ 175	$ 155,750
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	100,000	SY	$ 5	$ 500,000
16	Seeding	108	AC	$ 4,000	$ 432,400
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	7,000	CY	$ 90	$ 630,000
		SUBTOTAL			$ 28,228,150
		CONTINGENCY		30%	$ 8,468,500
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 36,696,700**

Engineering/Survey			12%	$ 4,403,700
Environmental Permitting—Wetlands Mitigation	6.0	AC	$ 125,000	$ 750,000
Environmental Permitting—Stream Mitigation	840	LF	$ 3,750	$ 3,150,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	30	EA	Varies	$ 49,195,250
Land Acquisition (Within PMF Flood Pool)	37	EA	Varies	$ 84,165,250
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 97,195,700**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 132,165,700**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 50,153,000
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 68,197,500
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 147,348,700**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 200,363,200**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – Mill Creek Detention**
DATE	August 30, 2020
ESTIMATED BY	Josh Mata
QC CHECKED BY	Dustin Mortensen

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 1,087,000	$ 1,087,000
2	Temporary Erosion and Sediment Control	1	LS	$ 420,000	$ 420,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 620,000	$ 620,000
5	Clearing and Grubbing	20	AC	$ 10,000	$ 200,000
6	Oil/Gas Utility Conflicts/Relocation	1	EA	$ 1,000,000	$ 1,000,000
DAM CONSTRUCTION					
7	Excavation	110,000	CY	$ 10	$ 1,100,000
8	Embankment (Compacted Fill)	420,000	CY	$ 15	$ 6,300,000
9	Embankment Internal Drainage	44,000	CY	$ 70	$ 3,080,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	19,000	CY	$ 205	$ 3,895,000
12	Principal Spillway Outlet (10' x 10')	1,820	LF	$ 1,500	$ 2,730,000
13	Erosion Control (Rock Riprap)	890	CY	$ 175	$ 155,750
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	78,000	SY	$ 5	$ 390,000
16	Seeding	72	AC	$ 4,000	$ 288,400
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	3,000	CY	$ 90	$ 270,000
		SUBTOTAL			$ 22,811,150
		CONTINGENCY		30%	$ 6,843,400
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 29,654,600**

Engineering/Survey			12%	$ 3,558,600
Environmental Permitting—Wetlands Mitigation	0.0	AC	$ 125,000	$ -
Environmental Permitting—Stream Mitigation	1,370	LF	$ 3,750	$ 5,137,500
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	129	EA	Varies	$ 57,542,000
Land Acquisition (Within PMF Flood Pool)	234	EA	Varies	$ 89,491,250
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 98,892,700**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 130,842,000**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 51,028,600
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 67,514,500
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 149,921,300**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 198,356,500**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – Birch Creek Detention**
DATE	August 30, 2020
ESTIMATED BY	Josh Mata
QC CHECKED BY	Dustin Mortensen

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 840,000	$ 840,000
2	Temporary Erosion and Sediment Control	1	LS	$ 320,000	$ 320,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 480,000	$ 480,000
5	Clearing and Grubbing	20	AC	$ 10,000	$ 200,000
6	Oil/Gas Utility Conflicts/Relocation	0	EA	$ 1,000,000	$ -
DAM CONSTRUCTION					
7	Excavation	90,000	CY	$ 10	$ 900,000
8	Embankment (Compacted Fill)	460,000	CY	$ 15	$ 6,900,000
9	Embankment Internal Drainage	34,000	CY	$ 70	$ 2,380,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	11,000	CY	$ 205	$ 2,255,000
12	Principal Spillway Outlet (10' x 10')	690	LF	$ 1,500	$ 1,035,000
13	Erosion Control (Rock Riprap)	450	CY	$ 175	$ 78,750
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	78,000	SY	$ 5	$ 390,000
16	Seeding	77	AC	$ 4,000	$ 308,400
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	3,000	CY	$ 90	$ 270,000
		SUBTOTAL			$ 17,632,150
		CONTINGENCY		30%	$ 5,289,700
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 22,921,900**

Engineering/Survey			12%	$ 2,750,700
Environmental Permitting—Wetlands Mitigation	2.1	AC	$ 125,000	$ 262,500
Environmental Permitting—Stream Mitigation	760	LF	$ 3,750	$ 2,850,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	15	EA	Varies	$ 47,758,250
Land Acquisition (Within PMF Flood Pool)	71	EA	Varies	$ 87,758,000
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 79,543,400**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 119,543,100**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 41,044,400
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 61,684,200
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 120,587,800**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 181,227,300**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – Woodlands Channelization (500')**
DATE	August 30, 2020
ESTIMATED BY	Andrew Swynenberg
QC CHECKED BY	Garrett Johnston

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 4,538,000	$ 4,538,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,730,000	$ 1,730,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 2,590,000	$ 2,590,000
5	Clearing and Grubbing	595	AC	$ 10,000	$ 5,950,000
6	Oil/Gas Utility Conflicts/Relocation	8	EA	$ 1,000,000	$ 8,000,000
CHANNEL CONSTRUCTION					
7	Excavation	6,030,000	CY	$ 10	$ 60,300,000
8	Fill	0	CY	$ 15	$ -
9	Topsoil	960,000	SY	$ 5	$ 4,800,000
10	Seeding	594	AC	$ 4,000	$ 2,376,000
11	Site Restoration	1	LS	$ 75,000	$ 75,000
12	Access Roadway (Flex Base)	2,600	CY	$ 90	$ 234,000
13	Erosion Control (Rock Riprap)			5%	$ 4,537,000
14					
15					
16					
17					
18					
		SUBTOTAL			$ 95,280,000
		CONTINGENCY		30%	$ 28,584,000
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 123,864,000**

Engineering/Survey			12%	$ 14,863,700
Environmental Permitting—Wetlands Mitigation	52.8	AC	$ 125,000	$ 6,600,000
Land Acquisition	119	EA	Varies	$ 4,014,250
PROJECT TOTAL (2020 DOLLARS)				**$ 149,342,000**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 77,060,500
PROJECT TOTAL (2040 DOLLARS)		**$ 226,402,500**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – Woodlands Channelization (200')**
DATE	August 30, 2020
ESTIMATED BY	Andrew Swynenberg
QC CHECKED BY	Garrett Johnston

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 1,729,000	$ 1,729,000
2	Temporary Erosion and Sediment Control	1	LS	$ 660,000	$ 660,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 990,000	$ 990,000
5	Clearing and Grubbing	178	AC	$ 10,000	$ 1,780,000
6	Oil/Gas Utility Conflicts/Relocation	8	EA	$ 1,000,000	$ 8,000,000
CHANNEL CONSTRUCTION					
7	Excavation	1,880,000	CY	$ 10	$ 18,800,000
8	Fill	0	CY	$ 15	$ -
9	Topsoil	290,000	SY	$ 5	$ 1,450,000
10	Seeding	176	AC	$ 4,000	$ 704,000
11	Site Restoration	1	LS	$ 75,000	$ 75,000
12	Access Roadway (Flex Base)	2,600	CY	$ 90	$ 234,000
13	Erosion Control (Rock Riprap)			5%	$ 1,729,000
14					
15					
16					
17					
18					
		SUBTOTAL			$ 36,301,000
		CONTINGENCY		30%	$ 10,890,300
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 47,191,300**
Engineering/Survey				12%	$ 5,663,000
Environmental Permitting—Wetlands Mitigation		11.0	AC	$ 125,000	$ 1,375,000
Land Acquisition		113	EA	Varies	$ 2,146,250
PROJECT TOTAL (2020 DOLLARS)					**$ 56,375,600**
20-Year Cost Escalation Factor (2.1%/Year)				51.6%	$ 29,089,800
PROJECT TOTAL (2040 DOLLARS)					**$ 85,465,400**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – I-45 Channelization**
DATE	August 30, 2020
ESTIMATED BY	Andrew Swynenberg
QC CHECKED BY	Garrett Johnston

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 2,525,000	$ 2,525,000
2	Temporary Erosion and Sediment Control	1	LS	$ 960,000	$ 960,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,440,000	$ 1,440,000
5	Clearing and Grubbing	208	AC	$ 10,000	$ 2,080,000
6	Oil/Gas Utility Conflicts/Relocation	4	EA	$ 1,000,000	$ 4,000,000
CHANNEL CONSTRUCTION					
7	Excavation	3,650,000	CY	$ 10	$ 36,500,000
8	Fill	0	CY	$ 15	$ -
9	Topsoil	340,000	SY	$ 5	$ 1,700,000
10	Seeding	206	AC	$ 4,000	$ 824,000
11	Site Restoration	1	LS	$ 75,000	$ 75,000
12	Access Roadway (Flex Base)	2,600	CY	$ 90	$ 234,000
13	Erosion Control (Rock Riprap)			5%	$ 2,524,000
14					
15					
16					
17					
18					
		SUBTOTAL			$ 53,012,000
		CONTINGENCY		30%	$ 15,903,600
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 68,915,600**

Engineering/Survey			12%	$ 8,269,900
Environmental Permitting—Wetlands Mitigation	35.2	AC	$ 125,000	$ 4,400,000
Land Acquisition	137	EA	Varies	$ 3,629,250
PROJECT TOTAL (2020 DOLLARS)				**$ 85,214,800**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 43,970,800
PROJECT TOTAL (2040 DOLLARS)		**$ 129,185,600**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Spring Creek – Gosling Channelization**
DATE	August 30, 2020
ESTIMATED BY	Andrew Swynenberg
QC CHECKED BY	Garrett Johnston

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 3,771,000	$ 3,771,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,440,000	$ 1,440,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 2,160,000	$ 2,160,000
5	Clearing and Grubbing	371	AC	$ 10,000	$ 3,710,000
6	Oil/Gas Utility Conflicts/Relocation	5	EA	$ 1,000,000	$ 5,000,000
CHANNEL CONSTRUCTION					
7	Excavation	5,440,000	CY	$ 10	$ 54,400,000
8	Fill	0	CY	$ 15	$ -
9	Topsoil	600,000	SY	$ 5	$ 3,000,000
10	Seeding	370	AC	$ 4,000	$ 1,480,000
11	Site Restoration	1	LS	$ 75,000	$ 75,000
12	Access Roadway (Flex Base)	2,600	CY	$ 90	$ 234,000
13	Erosion Control (Rock Riprap)			5%	$ 3,771,000
14					
15					
16					
17					
18					
		SUBTOTAL			$ 79,191,000
		CONTINGENCY		30%	$ 23,757,300
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 102,948,300**

Engineering/Survey			12%	$ 12,353,800
Environmental Permitting—Wetlands Mitigation	42.9	AC	$ 125,000	$ 5,362,500
Land Acquisition	160	EA	Varies	$ 11,528,250
PROJECT TOTAL (2020 DOLLARS)				**$ 132,192,900**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 68,211,500
PROJECT TOTAL (2040 DOLLARS)		**$ 200,404,400**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Lake Creek – Caney Creek Detention**
DATE	August 30, 2020
ESTIMATED BY	Spencer Taylor
QC CHECKED BY	Andrew Moore

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 1,245,000	$ 1,245,000
2	Temporary Erosion and Sediment Control	1	LS	$ 480,000	$ 480,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 710,000	$ 710,000
5	Clearing and Grubbing	26	AC	$ 10,000	$ 260,000
6	Oil/Gas Utility Conflicts/Relocation	0	EA	$ 1,000,000	$ -
DAM CONSTRUCTION					
7	Excavation	95,000	CY	$ 10	$ 950,000
8	Embankment (Compacted Fill)	824,000	CY	$ 15	$ 12,360,000
9	Embankment Internal Drainage	46,300	CY	$ 70	$ 3,241,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	16,700	CY	$ 205	$ 3,423,500
12	Principal Spillway Outlet (5' x 5')	1,420	LF	$ 750	$ 1,065,000
13	Erosion Control (Rock Riprap)	720	CY	$ 175	$ 126,000
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	125,000	SY	$ 5	$ 625,000
16	Seeding	26	AC	$ 4,000	$ 104,000
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	2,900	CY	$ 90	$ 261,000
		SUBTOTAL			$ 26,125,500
		CONTINGENCY		30%	$ 7,837,700
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 33,963,200**

Engineering/Survey			12%	$ 4,075,600
Environmental Permitting—Wetlands Mitigation	10.0	AC	$ 125,000	$ 1,250,000
Environmental Permitting—Stream Mitigation	650	LF	$ 3,750	$ 2,437,500
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)		EA	Varies	$ 53,726,305
Land Acquisition (Within PMF Flood Pool)		EA	Varies	$ 118,465,740
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 98,452,600**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 163,192,000**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 50,801,500
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 84,207,100
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 149,254,100**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 247,399,100**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Lake Creek – Little Caney Creek Detention**
DATE	August 30, 2020
ESTIMATED BY	Spencer Taylor
QC CHECKED BY	Andrew Moore

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 1,814,000	$ 1,814,000
2	Temporary Erosion and Sediment Control	1	LS	$ 690,000	$ 690,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,040,000	$ 1,040,000
5	Clearing and Grubbing	33	AC	$ 10,000	$ 330,000
6	Oil/Gas Utility Conflicts/Relocation	4	EA	$ 1,000,000	$ 4,000,000
DAM CONSTRUCTION					
7	Excavation	105,000	CY	$ 10	$ 1,050,000
8	Embankment (Compacted Fill)	1,240,000	CY	$ 15	$ 18,600,000
9	Embankment Internal Drainage	50,000	CY	$ 70	$ 3,500,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	16,800	CY	$ 205	$ 3,444,000
12	Principal Spillway Outlet (5' x 5')	1,400	LF	$ 750	$ 1,050,000
13	Erosion Control (Rock Riprap)	650	CY	$ 175	$ 113,750
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	159,800	SY	$ 5	$ 799,000
16	Seeding	33	AC	$ 4,000	$ 132,000
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	2,650	CY	$ 90	$ 238,500
		SUBTOTAL			$ 38,076,250
		CONTINGENCY		30%	$ 11,422,900
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 49,499,200**

Engineering/Survey			12%	$ 5,940,000
Environmental Permitting—Wetlands Mitigation	21.0	AC	$ 125,000	$ 2,625,000
Environmental Permitting—Stream Mitigation	1,105	LF	$ 3,750	$ 4,143,750
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)		EA	Varies	$ 33,111,403
Land Acquisition (Within PMF Flood Pool)		EA	Varies	$ 63,287,748
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 98,319,400**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 128,495,700**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 50,732,800
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 66,303,800
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 149,052,200**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 194,799,500**

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NOTES:

1. OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2. Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3. Assumed suitable borrow available onsite.
4. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5. Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Lake Creek – Garrett's Creek Detention**
DATE	August 30, 2020
ESTIMATED BY	Spencer Taylor
QC CHECKED BY	Andrew Moore

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 1,877,000	$ 1,877,000
2	Temporary Erosion and Sediment Control	1	LS	$ 720,000	$ 720,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,070,000	$ 1,070,000
5	Clearing and Grubbing	34	AC	$ 10,000	$ 340,000
6	Oil/Gas Utility Conflicts/Relocation	8	EA	$ 1,000,000	$ 8,000,000
DAM CONSTRUCTION					
7	Excavation	142,300	CY	$ 10	$ 1,423,000
8	Embankment (Compacted Fill)	1,025,000	CY	$ 15	$ 15,375,000
9	Embankment Internal Drainage	66,700	CY	$ 70	$ 4,669,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	11,110	CY	$ 205	$ 2,277,550
12	Principal Spillway Outlet (5' x 5')	1,370	LF	$ 750	$ 1,027,500
13	Erosion Control (Rock Riprap)	600	CY	$ 175	$ 105,000
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	164,600	SY	$ 5	$ 823,000
16	Seeding	34	AC	$ 4,000	$ 136,000
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	3,170	CY	$ 90	$ 285,300
		SUBTOTAL			$ 39,403,350
		CONTINGENCY		30%	$ 11,821,100
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 51,224,500**

Engineering/Survey			12%	$ 6,147,000
Environmental Permitting—Wetlands Mitigation	35.0	AC	$ 125,000	$ 4,375,000
Environmental Permitting—Stream Mitigation	2,590	LF	$ 3,750	$ 9,712,500
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)		EA	Varies	$ 32,165,135
Land Acquisition (Within PMF Flood Pool)		EA	Varies	$ 56,169,570
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 106,624,100**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 130,628,600**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 55,018,000
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 67,404,400
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 161,642,100**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 198,033,000**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Lake Creek – Mainstem Detention**
DATE	August 30, 2020
ESTIMATED BY	Spencer Taylor
QC CHECKED BY	Andrew Moore

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 3,456,000	$ 3,456,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,320,000	$ 1,320,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,980,000	$ 1,980,000
5	Clearing and Grubbing	69	AC	$ 10,000	$ 690,000
6	Oil/Gas Utility Conflicts/Relocation	6	EA	$ 1,000,000	$ 6,000,000
DAM CONSTRUCTION					
7	Excavation	94,900	CY	$ 10	$ 949,000
8	Embankment (Compacted Fill)	2,994,000	CY	$ 15	$ 44,910,000
9	Embankment Internal Drainage	56,000	CY	$ 70	$ 3,920,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	11,750	CY	$ 205	$ 2,408,750
12	Principal Spillway Outlet (10' x 10')	2,240	LF	$ 1,500	$ 3,360,000
13	Erosion Control (Rock Riprap)	950	CY	$ 175	$ 166,250
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	334,000	SY	$ 5	$ 1,670,000
16	Seeding	69	AC	$ 4,000	$ 276,000
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	2,130	CY	$ 90	$ 191,700
		SUBTOTAL			$ 72,572,700
		CONTINGENCY		30%	$ 21,771,900
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 94,344,600**

Engineering/Survey			12%	$ 11,321,400
Environmental Permitting—Wetlands Mitigation	10.0	AC	$ 125,000	$ 1,250,000
Environmental Permitting—Stream Mitigation	810	LF	$ 3,750	$ 3,037,500
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)		EA	Varies	$ 74,204,538
Land Acquisition (Within PMF Flood Pool)		EA	Varies	$ 154,101,593
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 187,158,000**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 267,055,100**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 96,573,500
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 137,800,400
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 283,731,500**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 404,855,500**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Peach Creek – SH 105 Detention**
DATE	August 30, 2020
ESTIMATED BY	Elmer Hinojosa
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 7,821,000	$ 7,821,000
2	Temporary Erosion and Sediment Control	1	LS	$ 2,980,000	$ 2,980,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 4,470,000	$ 4,470,000
5	Clearing and Grubbing	245	AC	$ 10,000	$ 2,450,000
6	Oil/Gas Utility Conflicts/Relocation	3	EA	$ 1,000,000	$ 3,000,000
DAM CONSTRUCTION					
7	Excavation	590,000	CY	$ 10	$ 5,900,000
8	Embankment (Compacted Fill)	6,400,000	CY	$ 15	$ 96,000,000
9	Embankment Internal Drainage	254,000	CY	$ 70	$ 17,780,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	38,000	CY	$ 205	$ 7,790,000
12	Principal Spillway Outlet (12' x 12')	2,120	LF	$ 1,500	$ 3,180,000
13	Erosion Control (Rock Riprap)	2,230	CY	$ 175	$ 390,250
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	1,170,000	SY	$ 5	$ 5,850,000
16	Seeding	1,045	AC	$ 4,000	$ 4,180,000
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	13,000	CY	$ 90	$ 1,170,000
		SUBTOTAL			$ 164,236,250
		CONTINGENCY		30%	$ 49,270,900
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 213,507,200**

Engineering/Survey			12%	$ 25,620,900
Environmental Permitting—Wetlands Mitigation	6.9	AC	$ 125,000	$ 862,500
Environmental Permitting—Stream Mitigation	900	LF	$ 3,750	$ 3,375,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	273	EA	Varies	$ 109,572,698
Land Acquisition (Within PMF Flood Pool)	505	EA	Varies	$ 187,098,153

PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool	**$ 355,938,300**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool	**$ 433,463,800**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 183,664,200
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 223,667,300
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 539,602,500**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 657,131,100**

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NOTES:

1. OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2. Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3. Assumed suitable borrow available onsite.
4. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5. Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Peach Creek – Walker Detention**
DATE	August 30, 2020
ESTIMATED BY	Elmer Hinojosa
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 5,851,000	$ 5,851,000
2	Temporary Erosion and Sediment Control	1	LS	$ 2,230,000	$ 2,230,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 3,340,000	$ 3,340,000
5	Clearing and Grubbing	190	AC	$ 10,000	$ 1,900,000
6	Oil/Gas Utility Conflicts/Relocation	1	EA	$ 1,000,000	$ 1,000,000
DAM CONSTRUCTION					
7	Excavation	410,000	CY	$ 10	$ 4,100,000
8	Embankment (Compacted Fill)	4,710,000	CY	$ 15	$ 70,650,000
9	Embankment Internal Drainage	192,000	CY	$ 70	$ 13,440,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	40,000	CY	$ 205	$ 8,200,000
12	Principal Spillway Outlet (12' x 12')	1,400	LF	$ 1,500	$ 2,100,000
13	Erosion Control (Rock Riprap)	2,230	CY	$ 175	$ 390,250
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	897,000	SY	$ 5	$ 4,485,000
16	Seeding	774	AC	$ 4,000	$ 3,095,600
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	9,000	CY	$ 90	$ 810,000
		SUBTOTAL			$ 122,866,850
		CONTINGENCY		30%	$ 36,860,100
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 159,727,000**

Engineering/Survey			12%	$ 19,167,300
Environmental Permitting—Wetlands Mitigation	9.0	AC	$ 125,000	$ 1,125,000
Environmental Permitting—Stream Mitigation	1,370	LF	$ 3,750	$ 5,137,500
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	42	EA	Varies	$ 13,104,469
Land Acquisition (Within PMF Flood Pool)	60	EA	Varies	$ 30,095,070

PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool	**$ 201,261,300**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool	**$ 218,251,900**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 103,850,800
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 112,618,000
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 305,112,100**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 330,869,900**

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NOTES:

1. OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2. Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3. Assumed suitable borrow available onsite.
4. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5. Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Peach Creek – I-69 Channelization**
DATE	August 30, 2020
ESTIMATED BY	Elmer Hinojosa
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 4,725,000	$ 4,725,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,800,000	$ 1,800,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 2,700,000	$ 2,700,000
5	Clearing and Grubbing	417	AC	$ 10,000	$ 4,170,000
6	Oil/Gas Utility Conflicts/Relocation	3	EA	$ 1,000,000	$ 3,000,000
CHANNEL CONSTRUCTION					
7	Excavation	7,005,000	CY	$ 10	$ 70,050,000
8	Topsoil	670,000	SY	$ 5	$ 3,350,000
9	Seeding	1000	AC	$ 4,000	$ 4,000,000
10	Site Restoration	1	LS	$ 75,000	$ 75,000
11	Access Roadway (Flex Base)	5,200	CY	$ 90	$ 468,019
12	Erosion Control (Rock Riprap)			5%	$ 4,724,000
13					
14					
15					
16					
17					
18					
		SUBTOTAL			$ 99,212,019
		CONTINGENCY		30%	$ 29,763,700
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 128,975,700**

Engineering/Survey			12%	$ 15,477,100
Environmental Permitting—Wetlands Mitigation	28	AC	$ 125,000	$ 3,550,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition	1	EA	Varies	$ 7,855,986
PROJECT TOTAL (2020 DOLLARS)				**$ 158,858,800**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 81,971,100
PROJECT TOTAL (2040 DOLLARS)		**$ 240,829,900**

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NOTES:

1. OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2. Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3. Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4. Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6. An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Caney Creek – FM 1097 Detention**
DATE	August 30, 2020
ESTIMATED BY	K. Homburg
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 2,382,000	$ 2,382,000
2	Temporary Erosion and Sediment Control	1	LS	$ 910,000	$ 910,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,360,000	$ 1,360,000
5	Clearing and Grubbing	45	AC	$ 10,000	$ 450,000
6	Oil/Gas Utility Conflicts/Relocation	0	EA	$ 1,000,000	$ -
DAM CONSTRUCTION					
7	Excavation	150,000	CY	$ 10	$ 1,500,000
8	Embankment (Compacted Fill)	1,490,000	CY	$ 15	$ 22,350,000
9	Embankment Internal Drainage	72,000	CY	$ 70	$ 5,040,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	41,000	CY	$ 205	$ 8,405,000
12	Principal Spillway Outlet (10' x 10')	2,390	LF	$ 1,500	$ 3,585,000
13	Erosion Control (Rock Riprap)	2,230	CY	$ 175	$ 390,250
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	199,000	SY	$ 5	$ 995,000
16	Seeding	230	AC	$ 4,000	$ 919,200
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	5,000	CY	$ 90	$ 450,000
		SUBTOTAL			$ 50,011,450
		CONTINGENCY		30%	$ 15,003,500
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 65,015,000**

Engineering/Survey			12%	$ 7,801,800
Environmental Permitting—Wetlands Mitigation	1.2	AC	$ 125,000	$ 153,192
Environmental Permitting—Stream Mitigation	1,300	LF	$ 3,750	$ 4,875,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	95	EA	Varies	$ 23,868,210
Land Acquisition (Within PMF Flood Pool)	182	EA	Varies	$ 50,452,322
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 104,713,200**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 131,297,300**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 54,032,000
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 67,749,400
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 158,745,200**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 199,046,700**

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NOTES:

1 OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Caney Creek – SH 105 Detention**
DATE	August 30, 2020
ESTIMATED BY	K. Homburg
QC CHECKED BY	K. McLaren

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 2,238,000	$ 2,238,000
2	Temporary Erosion and Sediment Control	1	LS	$ 850,000	$ 850,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,280,000	$ 1,280,000
5	Clearing and Grubbing	40	AC	$ 10,000	$ 400,000
6	Oil/Gas Utility Conflicts/Relocation	2	EA	$ 1,000,000	$ 2,000,000
DAM CONSTRUCTION					
7	Excavation	130,000	CY	$ 10	$ 1,300,000
8	Embankment (Compacted Fill)	1,230,000	CY	$ 15	$ 18,450,000
9	Embankment Internal Drainage	60,000	CY	$ 70	$ 4,200,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	38,000	CY	$ 205	$ 7,790,000
12	Principal Spillway Outlet (10' x 10')	3,320	LF	$ 1,500	$ 4,980,000
13	Erosion Control (Rock Riprap)	1,780	CY	$ 175	$ 311,500
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	173,000	SY	$ 5	$ 865,000
16	Seeding	193	AC	$ 4,000	$ 770,000
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	3,000	CY	$ 90	$ 270,000
		SUBTOTAL			$ 46,979,500
		CONTINGENCY		30%	$ 14,093,900
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 61,073,400**

Engineering/Survey			12%	$ 7,328,900
Environmental Permitting—Wetlands Mitigation	4.4	AC	$ 125,000	$ 546,250
Environmental Permitting—Stream Mitigation	1,060	LF	$ 3,750	$ 3,975,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	227	EA	Varies	$ 38,136,517
Land Acquisition (Within PMF Flood Pool)	346	EA	Varies	$ 73,565,709
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 114,060,100**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 149,489,300**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 58,855,000
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 77,136,500
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 172,915,100**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 226,625,800**

The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

NOTES:

1. OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2. Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3. Assumed suitable borrow available onsite.
4. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5. Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**Caney Creek – I-69 Channelization**
DATE	August 30, 2020
ESTIMATED BY	K. Homburg
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 5,351,000	$ 5,351,000
2	Temporary Erosion and Sediment Control	1	LS	$ 2,040,000	$ 2,040,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 3,060,000	$ 3,060,000
5	Clearing and Grubbing	631	AC	$ 10,000	$ 6,310,000
6	Oil/Gas Utility Conflicts/Relocation	10	EA	$ 1,000,000	$ 10,000,000
CHANNEL CONSTRUCTION					
7	Excavation	7,240,000	CY	$ 10	$ 72,400,000
8	Fill	0	CY	$ 15	$ -
9	Topsoil	1,020,000	SY	$ 5	$ 5,100,000
10	Seeding	630	AC	$ 4,000	$ 2,520,000
11	Site Restoration	1	LS	$ 75,000	$ 75,000
12	Access Roadway (Flex Base)	60	CY	$ 90	$ 5,436
13	Erosion Control (Rock Riprap)			5%	$ 5,351,000
14					
15					
16					
17					
18					
		SUBTOTAL			$ 112,362,436
		CONTINGENCY		30%	$ 33,708,800
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 146,071,200**

Engineering/Survey			12%	$ 17,528,600
Environmental Permitting—Wetlands Mitigation	133	AC	$ 125,000	$ 16,586,873
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition	1	EA	Varies	$ 6,265,878
PROJECT TOTAL (2020 DOLLARS)				**$ 189,452,600**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 97,757,500
PROJECT TOTAL (2040 DOLLARS)		**$ 287,210,100**

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NOTES:

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2 Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**East Fork – FM 945 Detention**
DATE	August 30, 2020
ESTIMATED BY	Josh Mata
QC CHECKED BY	Dustin Mortensen

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 2,684,000	$ 2,684,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,020,000	$ 1,020,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,530,000	$ 1,530,000
5	Clearing and Grubbing	40	AC	$ 10,000	$ 400,000
6	Oil/Gas Utility Conflicts/Relocation	6	EA	$ 1,000,000	$ 6,000,000
DAM CONSTRUCTION					
7	Excavation	180,000	CY	$ 10	$ 1,800,000
8	Embankment (Compacted Fill)	1,320,000	CY	$ 15	$ 19,800,000
9	Embankment Internal Drainage	87,000	CY	$ 70	$ 6,090,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	51,000	CY	$ 205	$ 10,455,000
12	Principal Spillway Outlet (10' x 10')	1,740	LF	$ 1,500	$ 2,610,000
13	Erosion Control (Rock Riprap)	2,670	CY	$ 175	$ 467,250
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	190,000	SY	$ 5	$ 950,000
16	Seeding	204	AC	$ 4,000	$ 814,800
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	5,000	CY	$ 90	$ 450,000
		SUBTOTAL			$ 56,346,050
		CONTINGENCY		30%	$ 16,903,900
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 73,250,000**

Engineering/Survey			12%	$ 8,790,000
Environmental Permitting—Wetlands Mitigation	11.7	AC	$ 125,000	$ 1,462,500
Environmental Permitting—Stream Mitigation	1,620	LF	$ 3,750	$ 6,075,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	214	EA	Varies	$ 53,245,000
Land Acquisition (Within PMF Flood Pool)	328	EA	Varies	$ 73,080,500
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 145,822,500**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 165,658,000**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 75,244,400
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 85,479,500
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 221,066,900**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 251,137,500**

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NOTES:

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2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**East Fork – Winters Bayou Detention**
DATE	August 30, 2020
ESTIMATED BY	Josh Mata
QC CHECKED BY	Dustin Mortensen

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 2,710,000	$ 2,710,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,030,000	$ 1,030,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,550,000	$ 1,550,000
5	Clearing and Grubbing	45	AC	$ 10,000	$ 450,000
6	Oil/Gas Utility Conflicts/Relocation	6	EA	$ 1,000,000	$ 6,000,000
DAM CONSTRUCTION					
7	Excavation	210,000	CY	$ 10	$ 2,100,000
8	Embankment (Compacted Fill)	1,300,000	CY	$ 15	$ 19,500,000
9	Embankment Internal Drainage	91,000	CY	$ 70	$ 6,370,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	49,000	CY	$ 205	$ 10,045,000
12	Principal Spillway Outlet (10' x 10')	1,960	LF	$ 1,500	$ 2,940,000
13	Erosion Control (Rock Riprap)	2,670	CY	$ 175	$ 467,250
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	218,000	SY	$ 5	$ 1,090,000
16	Seeding	206	AC	$ 4,000	$ 824,800
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	6,000	CY	$ 90	$ 540,000
		SUBTOTAL			$ 56,892,050
		CONTINGENCY		30%	$ 17,067,700
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 73,959,750**

Engineering/Survey			12%	$ 8,875,200
Environmental Permitting—Wetlands Mitigation	18.1	AC	$ 125,000	$ 2,262,500
Environmental Permitting—Stream Mitigation	450	LF	$ 3,750	$ 1,687,500
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)	88	EA	Varies	$ 44,566,250
Land Acquisition (Within PMF Flood Pool)	181	EA	Varies	$ 76,801,000
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool				**$ 134,351,200**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool				**$ 166,586,000**

20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)	51.6%	$ 69,325,200
20-Year Cost Escalation Factor (2.1%/Year) (PMF)	51.6%	$ 85,958,400
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool		**$ 203,676,400**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool		**$ 252,544,400**

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NOTES:

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2. Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3. Assumed suitable borrow available onsite.
4. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5. Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**East Fork – Winters/Nebletts Detention**
DATE	August 30, 2020
ESTIMATED BY	Josh Mata
QC CHECKED BY	Dustin Mortensen

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 2,281,000	$ 2,281,000
2	Temporary Erosion and Sediment Control	1	LS	$ 870,000	$ 870,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 1,300,000	$ 1,300,000
5	Clearing and Grubbing	45	AC	$ 10,000	$ 450,000
6	Oil/Gas Utility Conflicts/Relocation	0	EA	$ 1,000,000	$ -
DAM CONSTRUCTION					
7	Excavation	200,000	CY	$ 10	$ 2,000,000
8	Embankment (Compacted Fill)	1,360,000	CY	$ 15	$ 20,400,000
9	Embankment Internal Drainage	97,000	CY	$ 70	$ 6,790,000
10	Miscellaneous Internal Drainage	1	LS	$ 500,000	$ 500,000
11	Spillway (Roller Compacted Concrete)	33,000	CY	$ 205	$ 6,765,000
12	Principal Spillway Outlet (10' x 10')	2,140	LF	$ 1,500	$ 3,210,000
13	Erosion Control (Rock Riprap)	1,560	CY	$ 175	$ 273,000
14	Instrumentation	1	LS	$ 550,000	$ 550,000
15	Topsoil	196,000	SY	$ 5	$ 980,000
16	Seeding	214	AC	$ 4,000	$ 854,400
17	Site Restoration	1	LS	$ 75,000	$ 75,000
18	Access Roadway (Flex Base)	5,000	CY	$ 90	$ 450,000
		SUBTOTAL			$ 47,898,400
		CONTINGENCY		30%	$ 14,369,600
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 62,268,000**
Engineering/Survey				12%	$ 7,472,200
Environmental Permitting—Wetlands Mitigation		7.5	AC	$ 125,000	$ 937,500
Environmental Permitting—Stream Mitigation		1,390	LF	$ 3,750	$ 5,212,500
Environmental Impact Statement		1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition (Within 1% ACE Flood Pool)		105	EA	Varies	$ 52,003,250
Land Acquisition (Within PMF Flood Pool)		182	EA	Varies	$ 101,844,250
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool					**$ 130,893,500**
PROJECT TOTAL (2020 DOLLARS) – Land Acquisition Within PMF Flood Pool					**$ 180,734,500**
20-Year Cost Escalation Factor (2.1%/Year) (1% ACE)				51.6%	$ 67,541,000
20-Year Cost Escalation Factor (2.1%/Year) (PMF)				51.6%	$ 93,259,000
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within 1% ACE Flood Pool					**$ 198,434,500**
PROJECT TOTAL (2040 DOLLARS) – Land Acquisition Within PMF Flood Pool					**$ 273,993,500**

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NOTES:

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2 Land acquisition cost assumes full acquisition of upstream properties below the top of dam at 2.5× market value (2019 tax year).
3 Assumed suitable borrow available onsite.
4 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
5 Relocation cost for oil/gas utilities is planning-level only. Relocation costs for roadway or water/wastewater/telecom utilities are not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**East Fork – FM 1485 Channelization**
DATE	August 30, 2020
ESTIMATED BY	Andrew Swynenberg
QC CHECKED BY	Garrett Johnston

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 8,885,000	$ 8,885,000
2	Temporary Erosion and Sediment Control	1	LS	$ 3,390,000	$ 3,390,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 5,080,000	$ 5,080,000
5	Clearing and Grubbing	1285	AC	$ 10,000	$ 12,850,000
6	Oil/Gas Utility Conflicts/Relocation	8	EA	$ 1,000,000	$ 8,000,000
CHANNEL CONSTRUCTION					
7	Excavation	12,350,000	CY	$ 10	$ 123,500,000
8	Fill	0	CY	$ 15	$ -
9	Topsoil	2,080,000	SY	$ 5	$ 10,400,000
10	Seeding	1284	AC	$ 4,000	$ 5,136,000
11	Site Restoration	1	LS	$ 75,000	$ 75,000
12	Access Roadway (Flex Base)	2,600	CY	$ 90	$ 234,000
13	Erosion Control (Rock Riprap)			5%	$ 8,885,000
14					
15					
16					
17					
18					
		SUBTOTAL			$ 186,585,000
		CONTINGENCY		30%	$ 55,975,500
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 242,560,500**

Engineering/Survey			12%	$ 29,107,300
Environmental Permitting—Wetlands Mitigation	286.0	AC	$ 125,000	$ 35,750,000
Land Acquisition	166	EA	Varies	$ 32,171,000
PROJECT TOTAL (2020 DOLLARS)				**$ 339,588,800**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 175,227,800
PROJECT TOTAL (2040 DOLLARS)		**$ 514,816,600**

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NOTES:

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2. Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3. Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4. Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6. An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**West Fork – River Plantation Channelization**
DATE	August 30, 2020
ESTIMATED BY	Spencer Taylor
QC CHECKED BY	Andrew Moore

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 4,613,000	$ 4,613,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,760,000	$ 1,760,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 2,640,000	$ 2,640,000
5	Clearing and Grubbing	400	AC	$ 10,000	$ 4,000,000
6	Oil/Gas Utility Conflicts/Relocation	6	EA	$ 1,000,000	$ 6,000,000
CHANNEL CONSTRUCTION					
7	Excavation	6,173,000	CY	$ 10	$ 61,730,000
8	Topsoil	1,936,000	SY	$ 5	$ 9,680,000
9	Seeding	400	AC	$ 4,000	$ 1,600,000
10	Site Restoration	1	LS	$ 75,000	$ 75,000
11	Erosion Control (Rock Riprap)			5%	$ 4,612,000
12					
13					
14					
15					
16					
17					
18					
		SUBTOTAL			$ 96,860,000
		CONTINGENCY		30%	$ 29,058,000
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 125,918,000**

Engineering/Survey			12%	$ 15,110,200
Environmental Permitting—Wetlands Mitigation	228.0	AC	$ 125,000	$ 28,500,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition		EA	Varies	$ 14,425,000
PROJECT TOTAL (2020 DOLLARS)				**$ 186,953,200**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 96,467,900
PROJECT TOTAL (2040 DOLLARS)		**$ 283,421,100**

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NOTES:

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2 Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**West Fork – Highway 242 Channelization**
DATE	August 30, 2020
ESTIMATED BY	Spencer Taylor
QC CHECKED BY	Andrew Moore

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 4,047,000	$ 4,047,000
2	Temporary Erosion and Sediment Control	1	LS	$ 1,540,000	$ 1,540,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 2,310,000	$ 2,310,000
5	Clearing and Grubbing	250	AC	$ 10,000	$ 2,500,000
6	Oil/Gas Utility Conflicts/Relocation	6	EA	$ 1,000,000	$ 6,000,000
CHANNEL CONSTRUCTION					
7	Excavation	5,726,000	CY	$ 10	$ 57,260,000
8	Topsoil	1,210,000	SY	$ 5	$ 6,050,000
9	Seeding	250	AC	$ 4,000	$ 1,000,000
10	Site Restoration	1	LS	$ 75,000	$ 75,000
11	Erosion Control (Rock Riprap)			5%	$ 4,047,000
12					
13					
14					
15					
16					
17					
18					
		SUBTOTAL			$ 84,979,000
		CONTINGENCY		30%	$ 25,493,700
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 110,472,700**

Engineering/Survey			12%	$ 13,256,800
Environmental Permitting—Wetlands Mitigation	152.0	AC	$ 125,000	$ 19,000,000
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition		EA	Varies	$ 11,075,000
PROJECT TOTAL (2020 DOLLARS)				**$ 156,804,500**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 80,911,100
PROJECT TOTAL (2040 DOLLARS)		**$ 237,715,600**

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NOTES:

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3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**West Fork – Kingwood Channelization**
DATE	August 30, 2020
ESTIMATED BY	Elmer Hinojosa
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 19,567,000	$ 19,567,000
2	Temporary Erosion and Sediment Control	1	LS	$ 7,460,000	$ 7,460,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 11,180,000	$ 11,180,000
5	Clearing and Grubbing	1,797	AC	$ 5,000	$ 8,985,000
6	Oil/Gas Utility Conflicts/Relocation	3	EA	$ 1,000,000	$ 3,000,000
CHANNEL CONSTRUCTION					
7	Excavation	31,000,000	CY	$ 10	$ 310,000,000
8	Topsoil	4,330,000	SY	$ 5	$ 21,650,000
9	Seeding	2000	AC	$ 4,000	$ 8,000,000
10	Site Restoration	1	LS	$ 75,000	$ 75,000
11	Access Roadway (Flex Base)	13,962	CY	$ 90	$ 1,256,600
12	Erosion Control (Rock Riprap)			5%	$ 19,566,000
13					
14					
15					
16					
17					
18					
		SUBTOTAL			$ 410,889,600
		CONTINGENCY		30%	$ 123,266,900
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 534,156,500**
Engineering/Survey				12%	$ 64,098,800
Environmental Permitting—Wetlands Mitigation		948	AC	$ 125,000	$ 118,482,686
Environmental Permitting—Stream Mitigation		61,950	LF	$ 3,750	$ 232,312,275
Environmental Impact Statement		1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition		737	EA	Varies	$ 23,541,770
PROJECT TOTAL (2020 DOLLARS)					**$ 975,592,000**
20-Year Cost Escalation Factor (2.1%/Year)				51.6%	$ 503,405,500
PROJECT TOTAL (2040 DOLLARS)					**$ 1,478,997,500**

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3 Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4 Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5 Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6 An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE	**West Fork – Kingwood Benching**
DATE	August 30, 2020
ESTIMATED BY	Elmer Hinojosa
QC CHECKED BY	

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
GENERAL ITEMS					
1	Mobilization & Demobilization	1	LS	$ 19,671,000	$ 19,671,000
2	Temporary Erosion and Sediment Control	1	LS	$ 7,500,000	$ 7,500,000
3	Site Preparation and Site Maintenance	1	LS	$ 150,000	$ 150,000
4	Care of Water	1	LS	$ 11,240,000	$ 11,240,000
5	Clearing and Grubbing	3,550	AC	$ 5,000	$ 17,750,000
6	Oil/Gas Utility Conflicts/Relocation	4	EA	$ 1,000,000	$ 4,000,000
CHANNEL CONSTRUCTION					
7	Excavation	30,510,000	CY	$ 10	$ 305,100,000
8	Topsoil	1,897,000	SY	$ 5	$ 9,485,000
9	Seeding	4,000	AC	$ 4,000	$ 16,000,000
10	Site Restoration	1	LS	$ 75,000	$ 75,000
11	Access Roadway (Flex Base)	27,050	CY	$ 90	$ 2,434,500
12	Erosion Control (Rock Riprap)			5%	$ 19,670,000
13					
14					
15					
16					
17					
18					
		SUBTOTAL			$ 413,075,500
		CONTINGENCY		30%	$ 123,922,700
CONSTRUCTION TOTAL (2020 DOLLARS)					**$ 536,998,200**

Engineering/Survey			12%	$ 64,439,800
Environmental Permitting—Wetlands Mitigation	1,416	AC	$ 125,000	$ 177,015,177
Environmental Impact Statement	1	EA	$ 3,000,000	$ 3,000,000
Land Acquisition	1	EA	Varies	$ 55,880,731
PROJECT TOTAL (2020 DOLLARS)				**$ 837,333,900**

20-Year Cost Escalation Factor (2.1%/Year)	51.6%	$ 432,064,300
PROJECT TOTAL (2040 DOLLARS)		**$ 1,269,398,200**

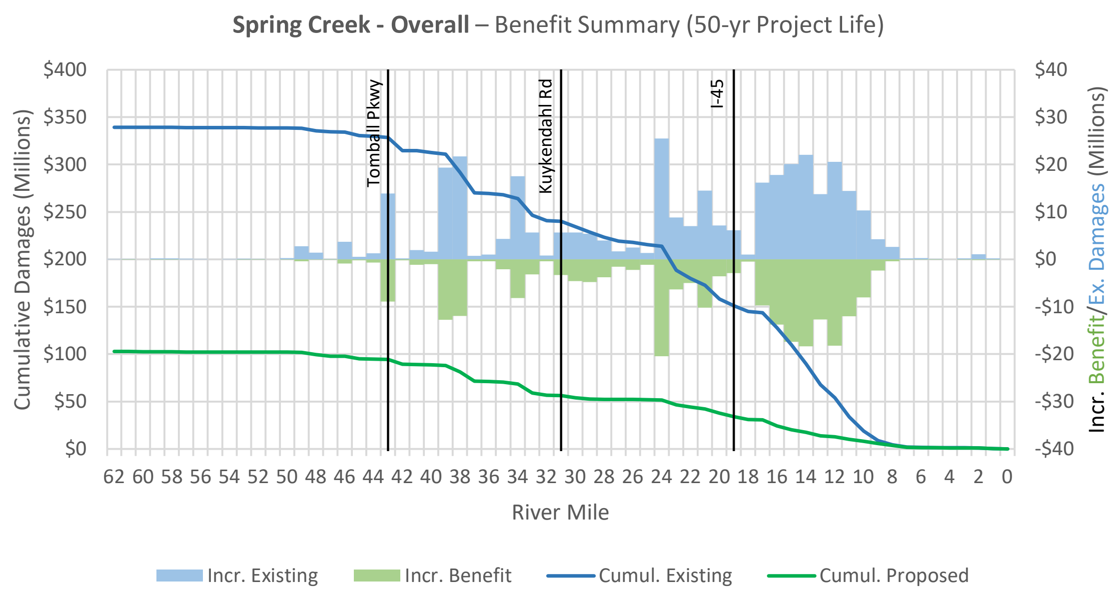
The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

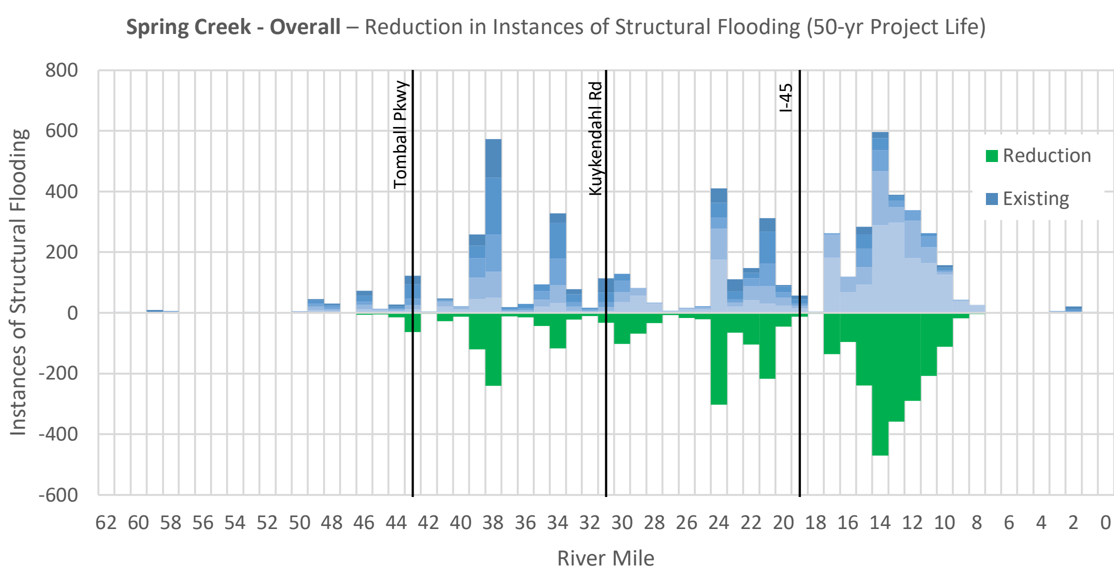
NOTES:

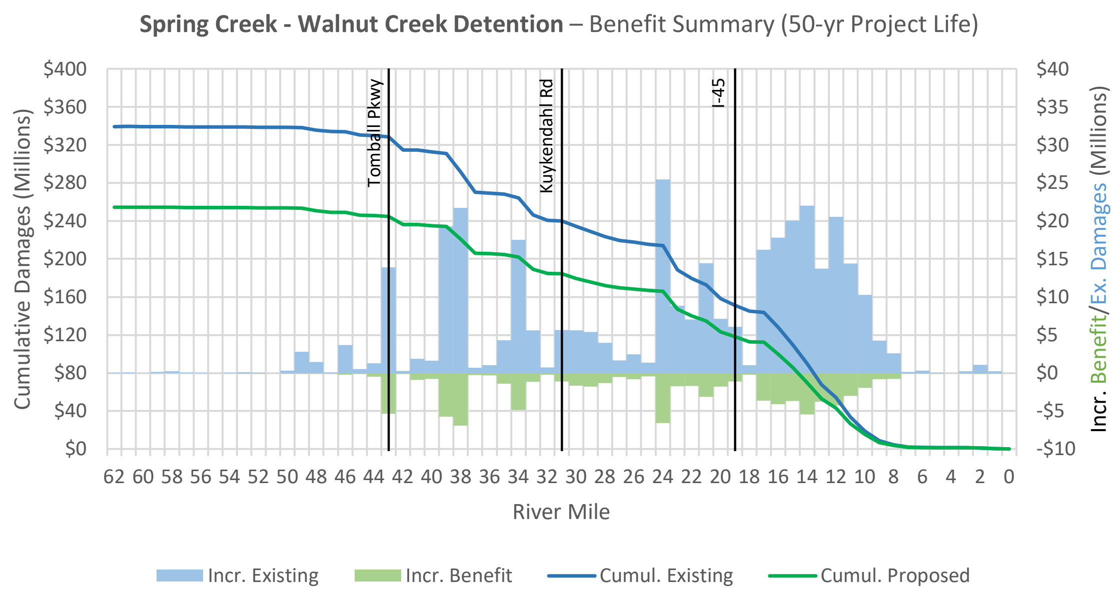
1. OPCC classified as an AACE Class 5 Estimate (Screening/Feasibility) with an accuracy range of -50% to +100%.
2. Land acquisition cost assumes acquisition of property needed to construct the channel plus 20% at 2.5× market value (2019 tax year).
3. Excavation unit cost assumes disposal through an interested buyer. Landfill disposal may increase excavation costs to $20–35/cy.
4. Assumed excavation above the ordinary high-water mark. Environmental permitting only needed for wetlands mitigation.
5. Assumed no USACE individual permit will be required and no impacts to threatened/endangered species, cultural resources, or hazardous materials.
6. An upstream detention project must be constructed first to mitigate downstream flow increases. This cost is not included.

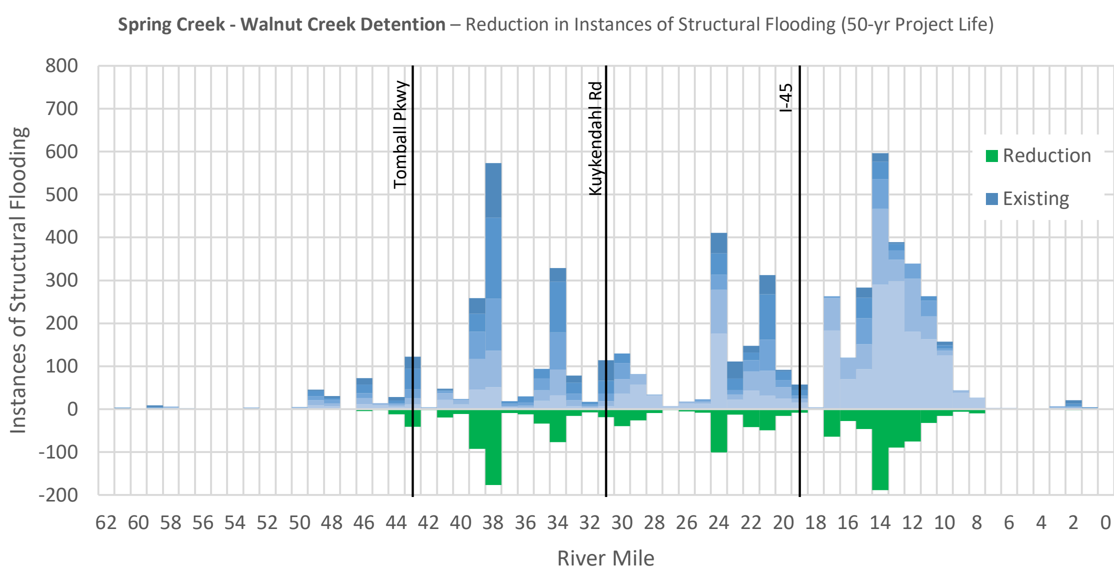
Appendix G.4

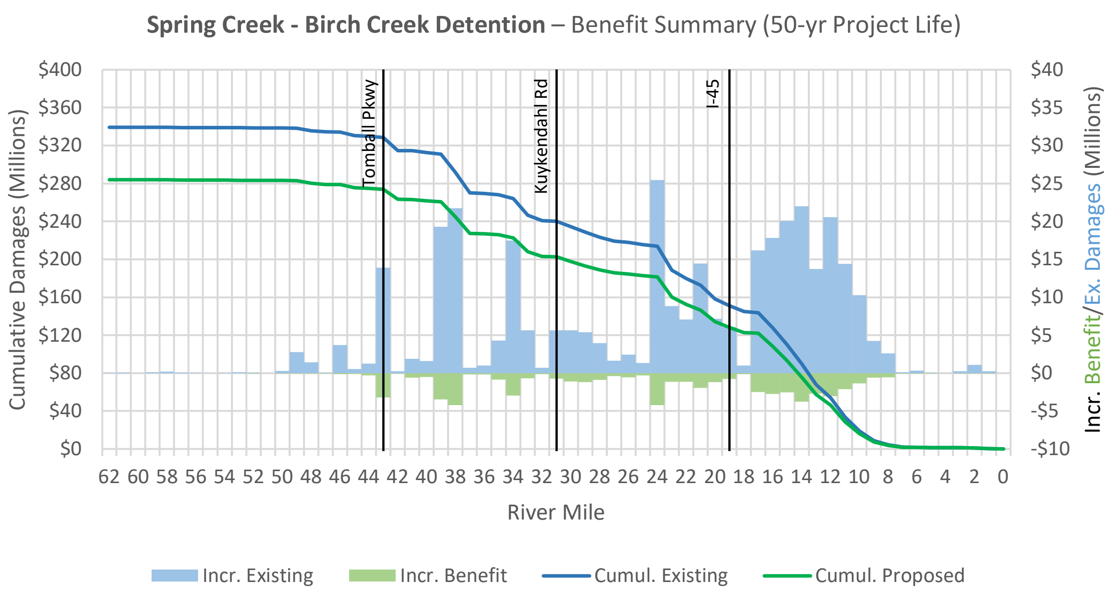
Alternative Damage Reduction Charts


Spring Creek - Overall – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
River Mile
Tomball Pkwy
Kuykendahl Rd
I-45
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

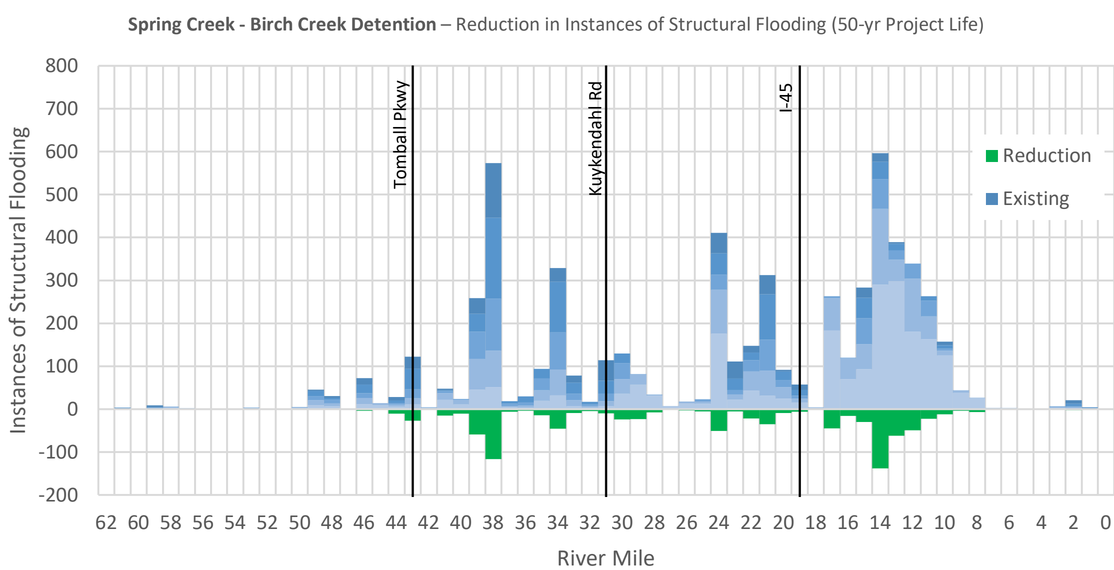

Spring Creek - Overall – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
Tomball Pkwy
Kuykendahl Rd
I-45
Reduction
Existing


Spring Creek - Walnut Creek Detention – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
River Mile
Tomball Pkwy
Kuykendahl Rd
I-45
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

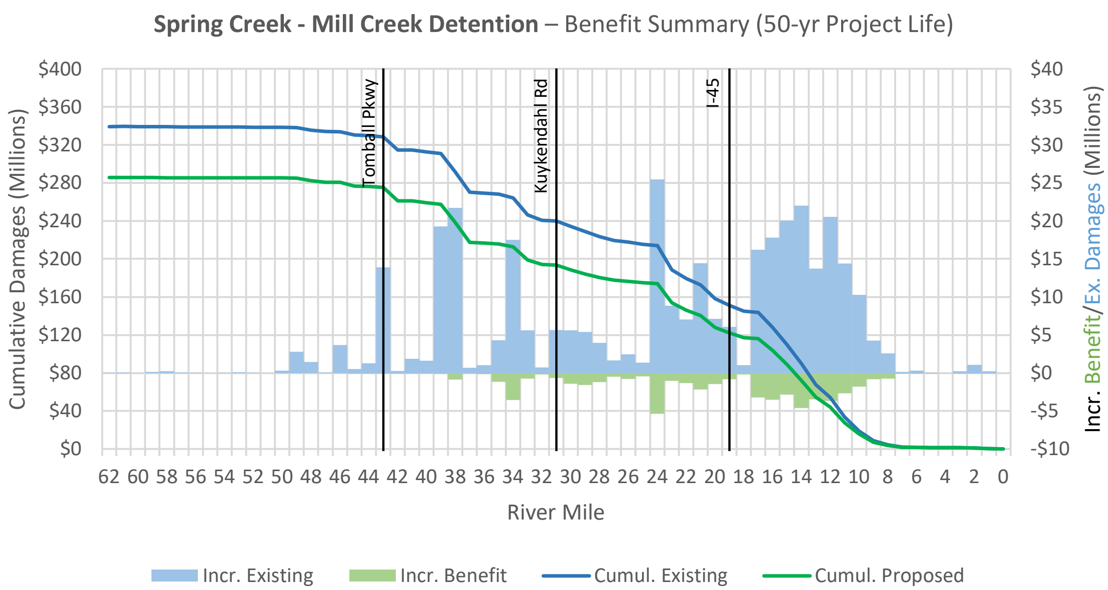

Spring Creek - Walnut Creek Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
Tomball Pkwy
Kuykendahl Rd
I-45
Reduction
Existing

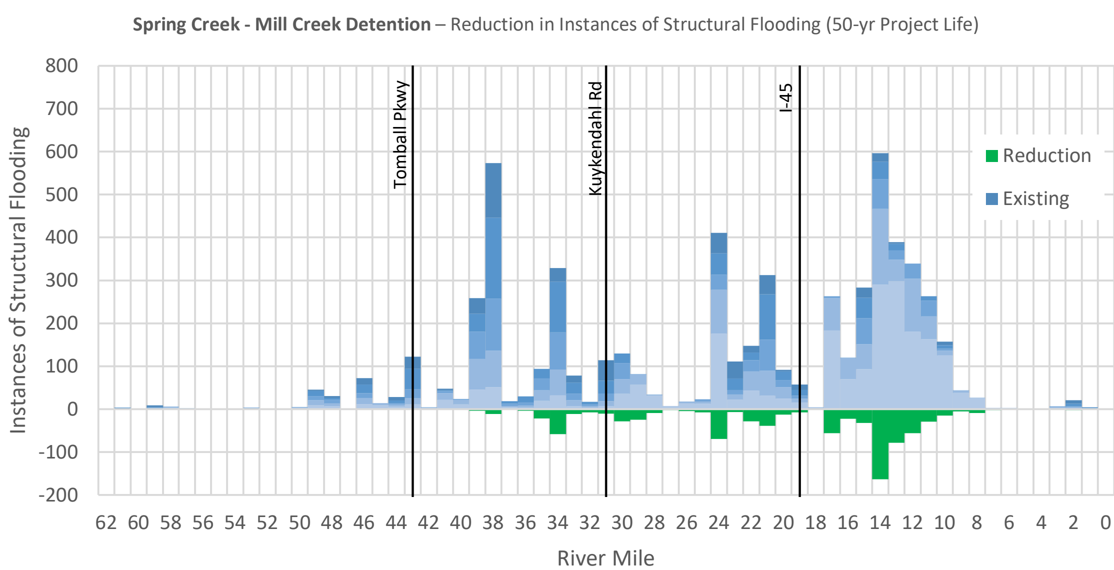


Spring Creek - Birch Creek Detention – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
$400
$360
$320
$280
$240
$200
$160
$120
$80
$40
$0
$40
$35
$30
$25
$20
$15
$10
$5
$0
-$5
-$10
Tomball Pkwy
Kuykendahl Rd
I-45
62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

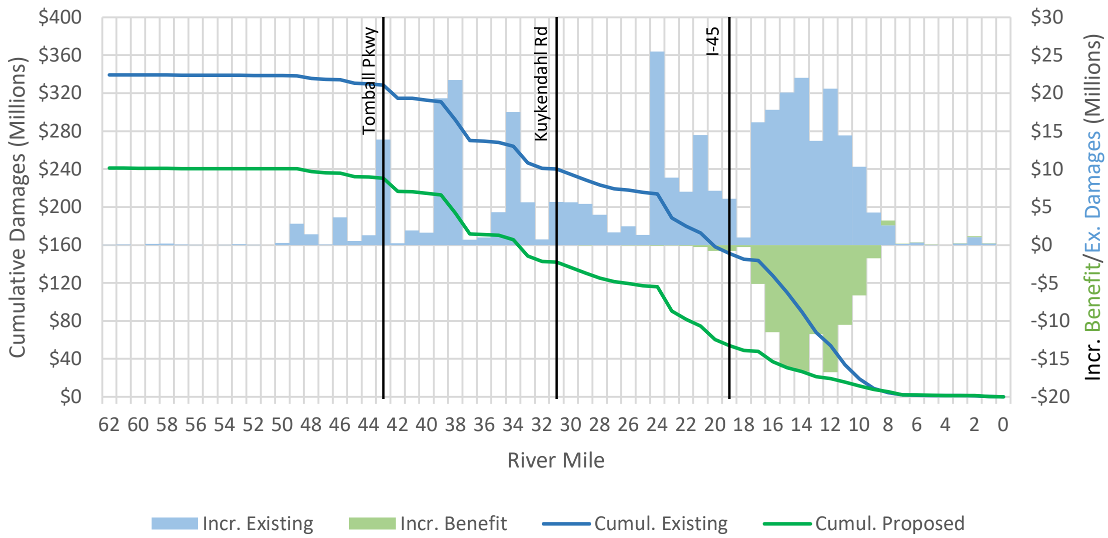


Spring Creek - Birch Creek Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
800
700
600
500
400
300
200
100
0
-100
-200
Tomball Pkwy
Kuykendahl Rd
I-45
Reduction
Existing
62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile

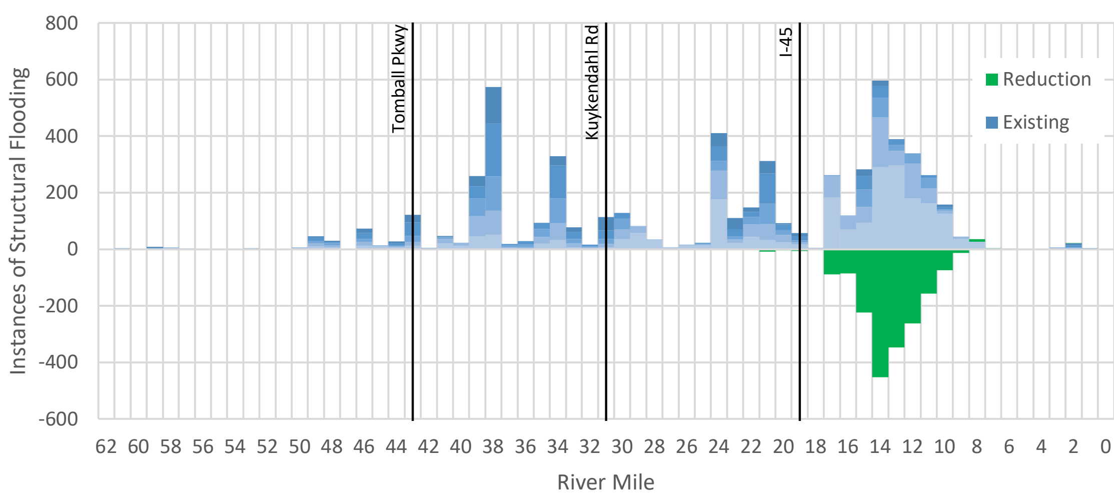

Spring Creek - Mill Creek Detention – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
$400
$360
$320
$280
$240
$200
$160
$120
$80
$40
$0
$40
$35
$30
$25
$20
$15
$10
$5
$0
-$5
-$10
Incr. Benefit/Ex. Damages (Millions)
Tomball Pkwy
Kuykendahl Rd
I-45
62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed


Spring Creek - Mill Creek Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
800
700
600
500
400
300
200
100
0
-100
-200
Tomball Pkwy
Kuykendahl Rd
I-45
Reduction
Existing
62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile

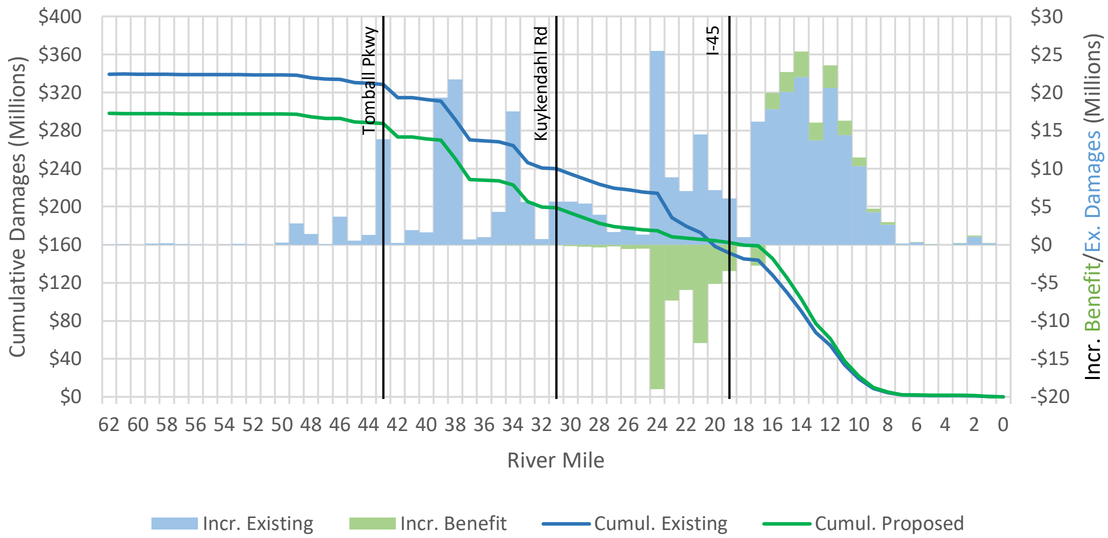
Spring Creek - I-45 Channelization – Benefit Summary (50-yr Project Life)



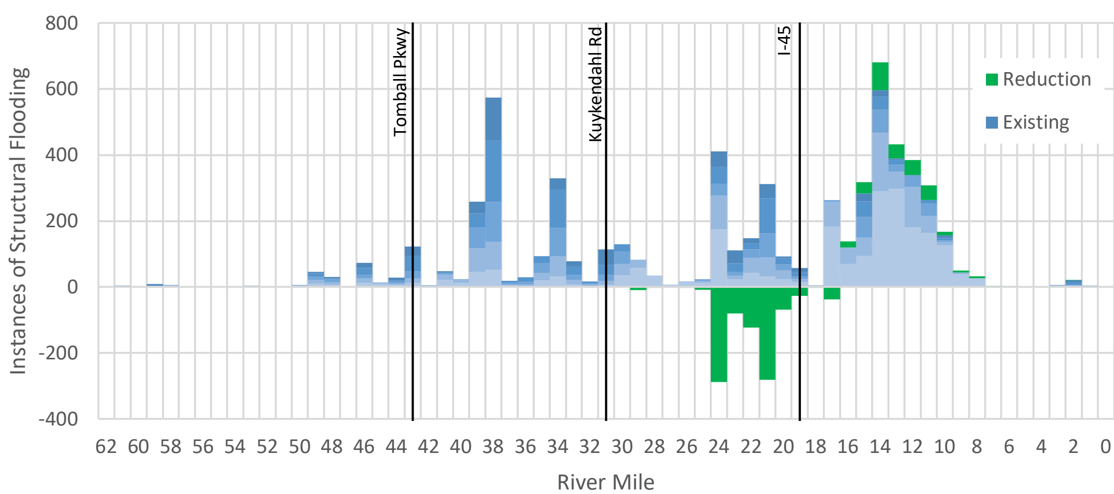
Spring Creek - I-45 Channelization – Reduction in Instances of Structural Flooding (50-yr Project Life)



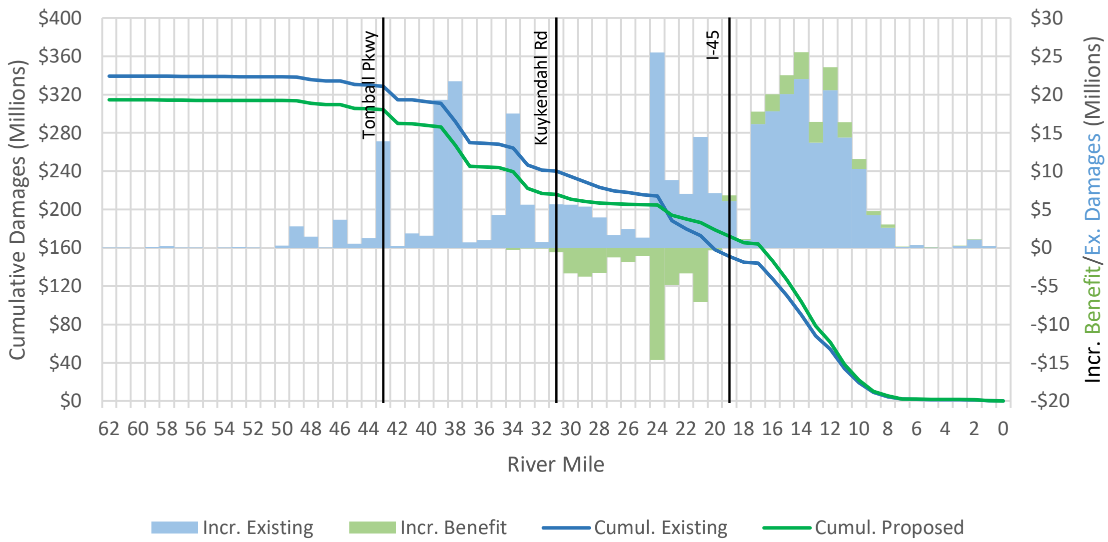
Spring Creek - Gosling Channelization – Benefit Summary (50-yr Project Life)



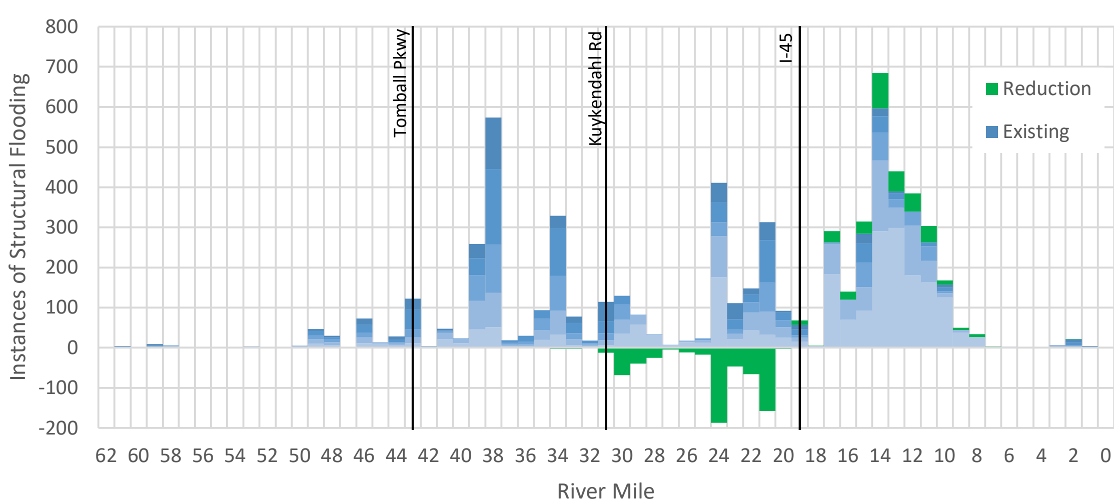
Spring Creek - Gosling Channelization – Reduction in Instances of Structural Flooding (50-yr Project Life)



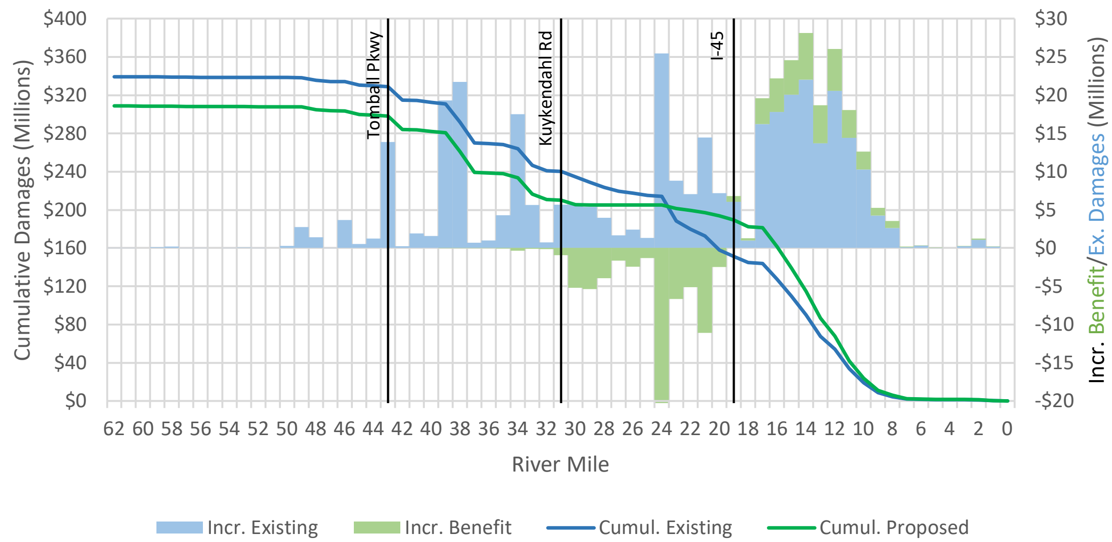
Spring Creek - Woodlands Channelization (200') – Benefit Summary (50-yr Project Life)



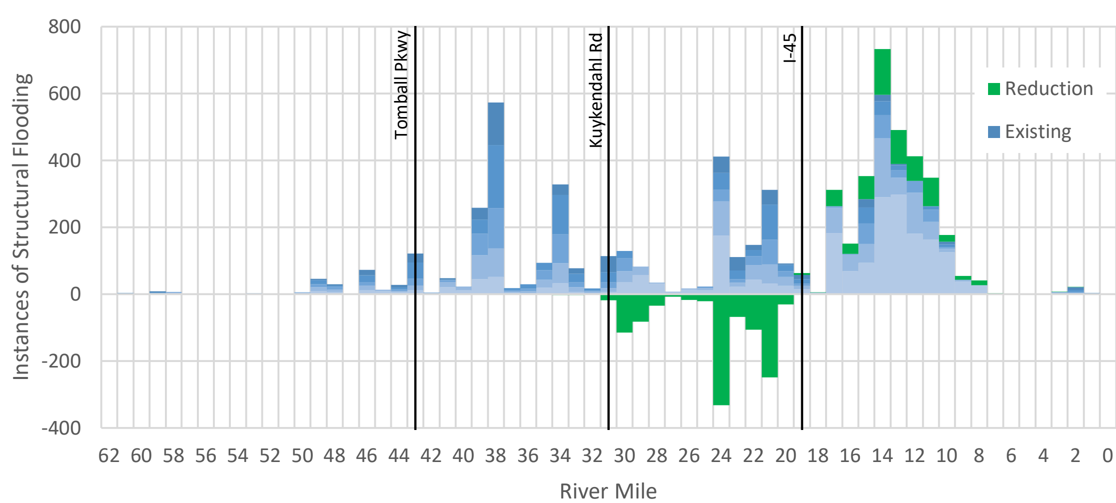
Spring Creek - Woodlands Channelization (200') – Reduction in Instances of Structural Flooding (50-yr Project Life)

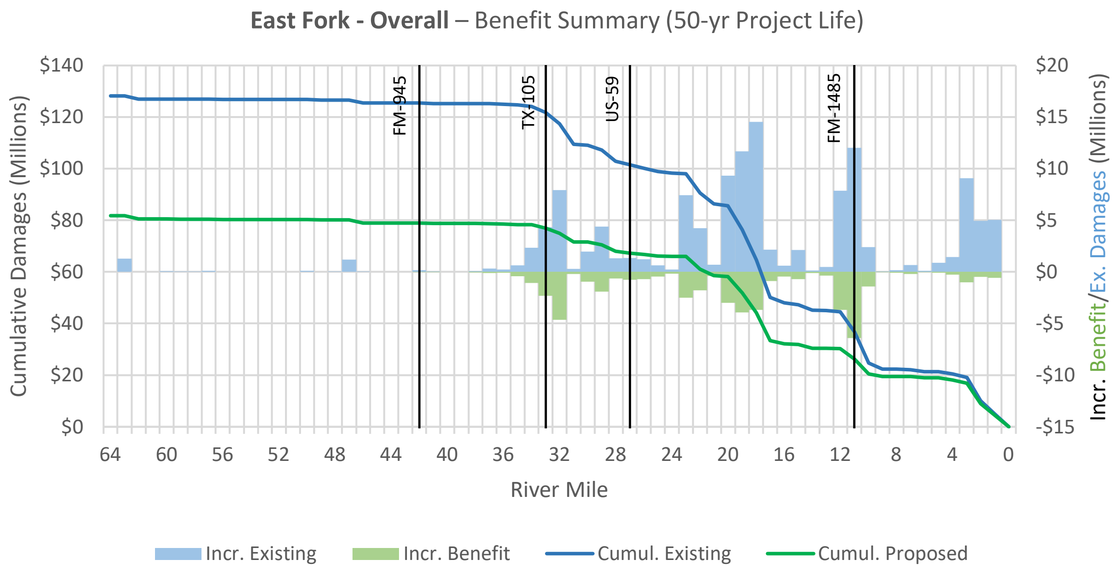


Spring Creek - Woodlands Channelization (500') – Benefit Summary (50-yr Project Life)

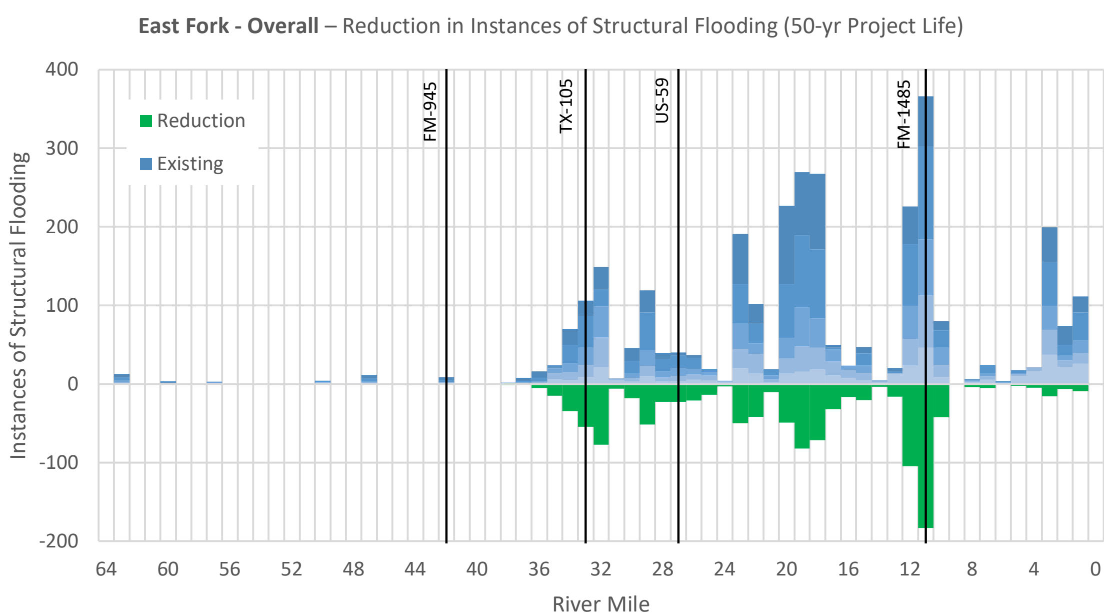


Spring Creek - Woodlands Channelization (500') – Reduction in Instances of Structural Flooding (50-yr Project Life)



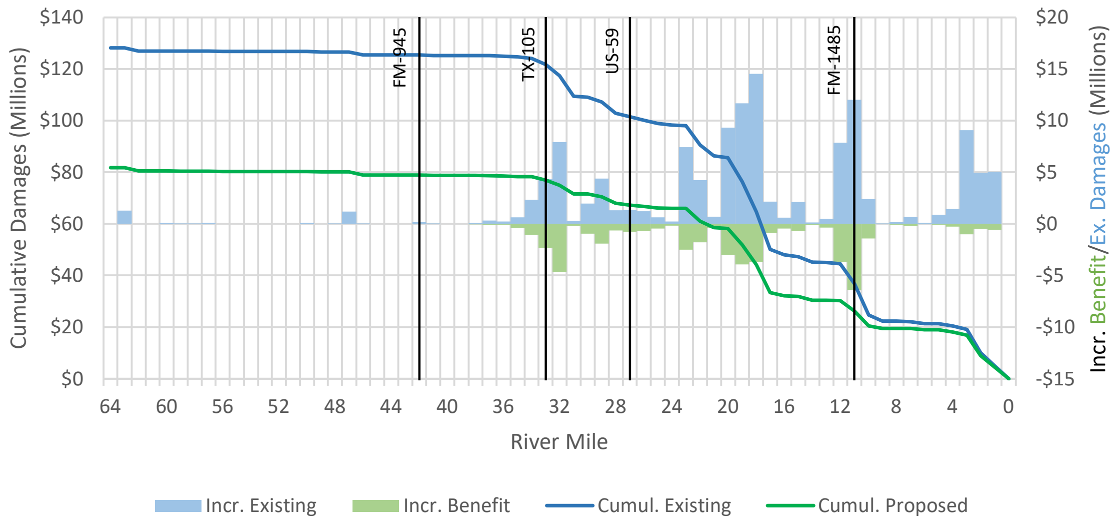


East Fork - Overall – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
$140
$120
$100
$80
$60
$40
$20
$0
$20
$15
$10
$5
$0
-$5
-$10
-$15
FM-945
TX-105
US-59
FM-1485
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

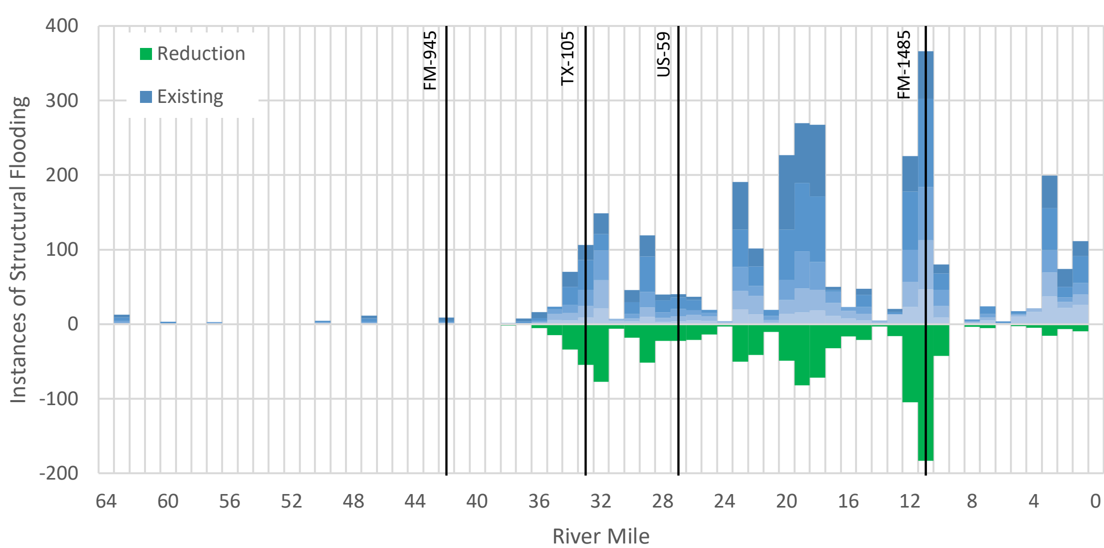


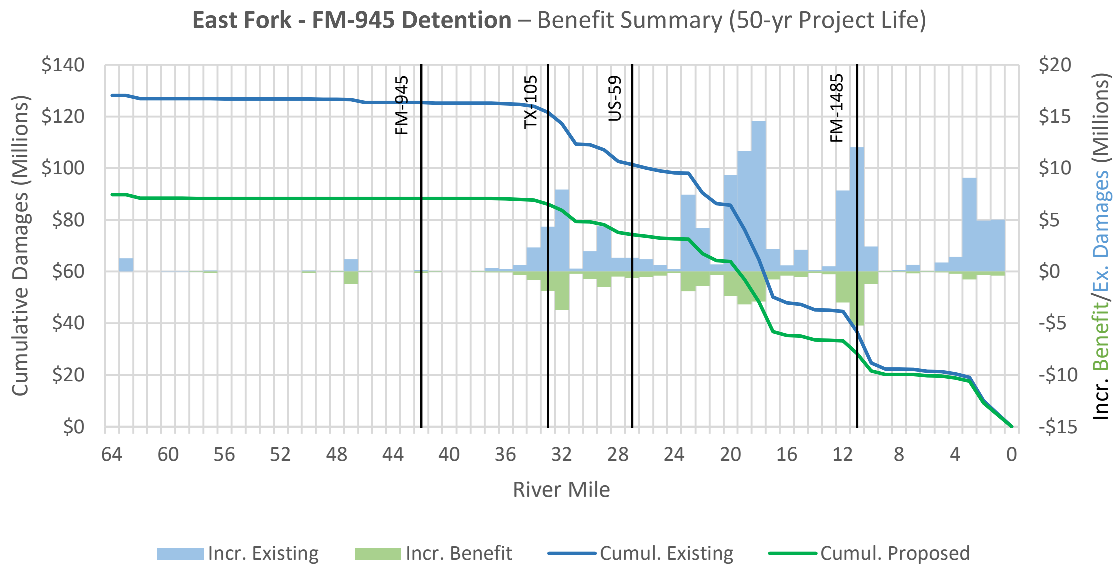
East Fork - Overall – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
400
300
200
100
0
-100
-200
Reduction
Existing
FM-945
TX-105
US-59
FM-1485
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
River Mile

East Fork - Winters Bayou Detention – Benefit Summary (50-yr Project Life)

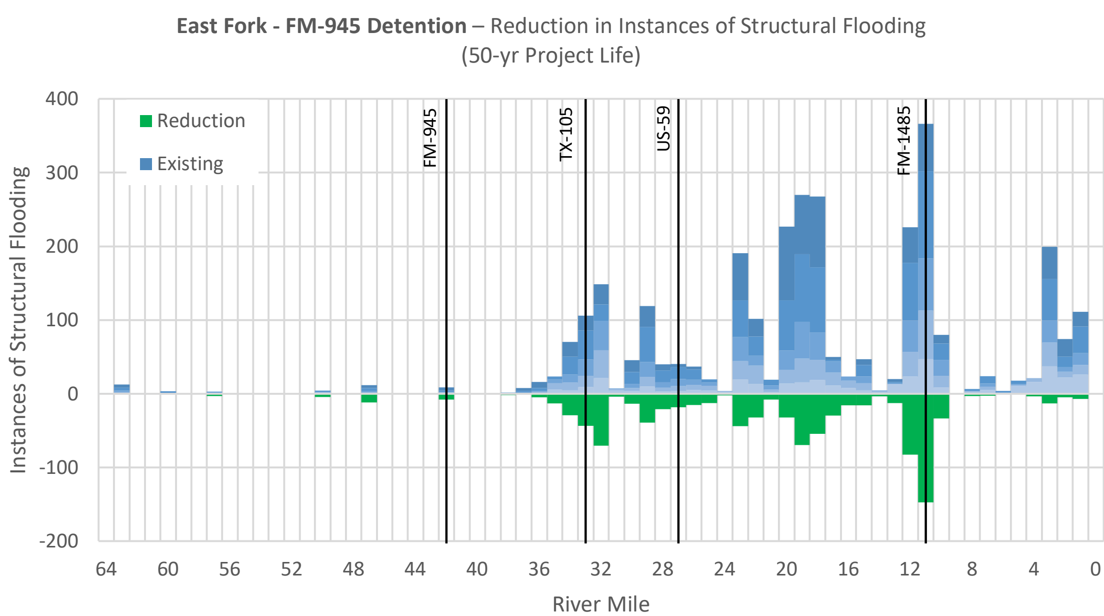


East Fork - Winters Bayou Detention – Reduction in Instances of Structural Flooding
(50-yr Project Life)

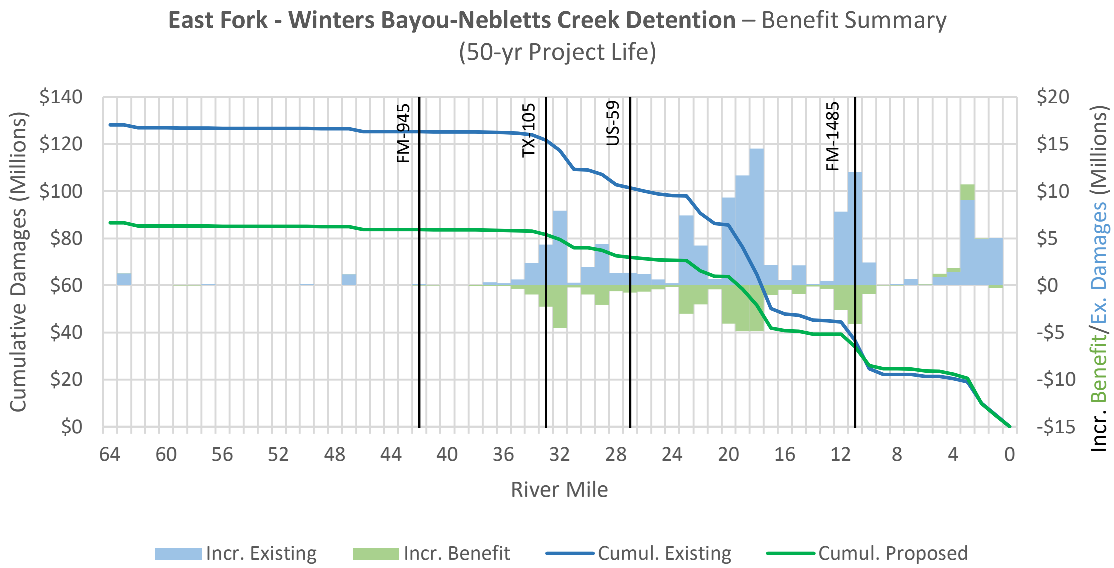


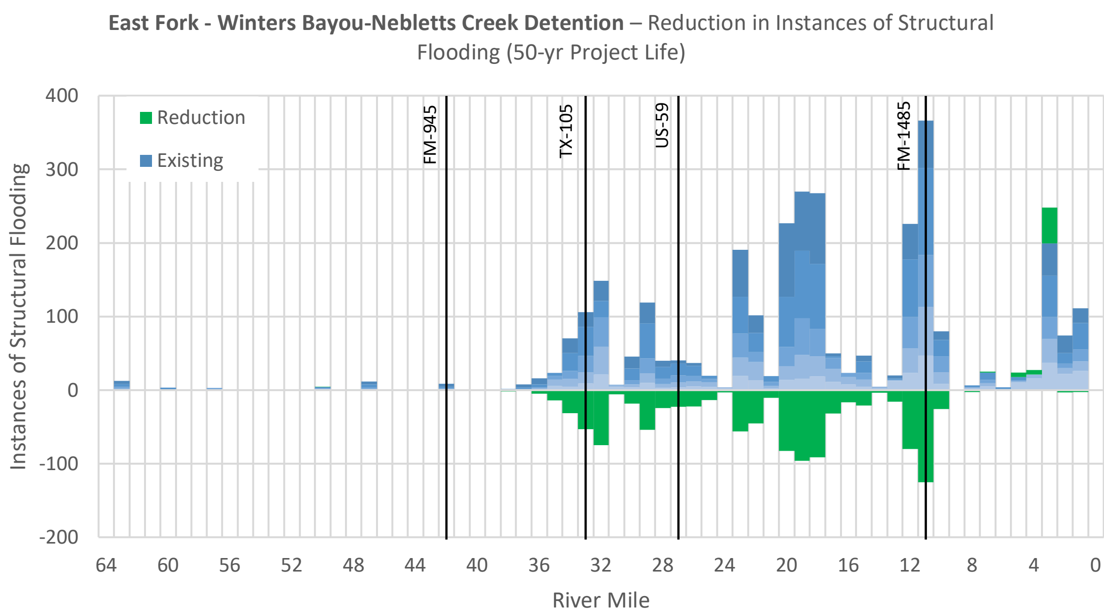


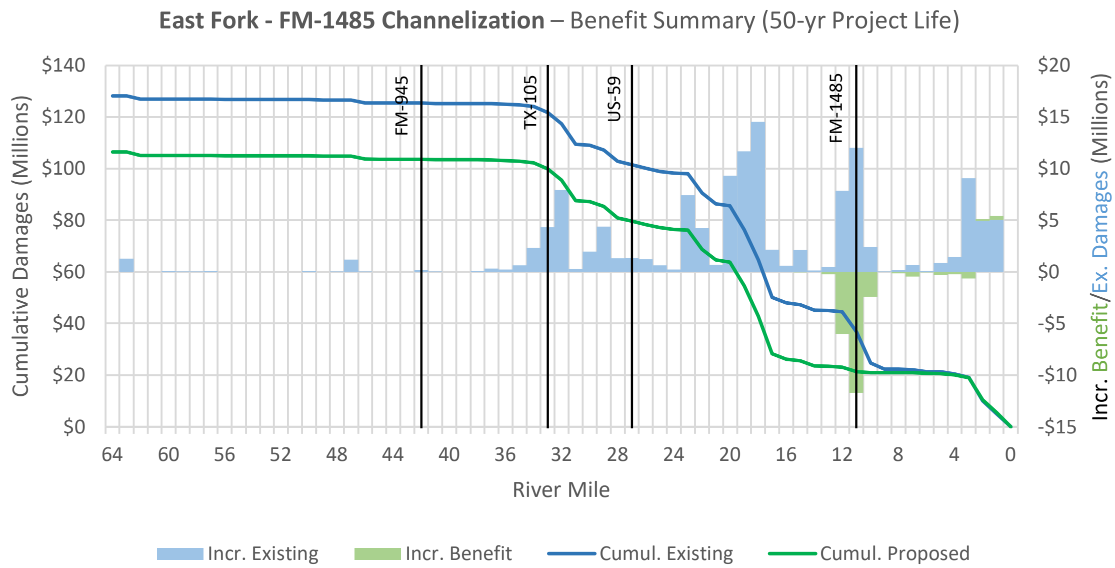
East Fork - FM-945 Detention – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
River Mile
FM-945
TX-105
US-59
FM-1485
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

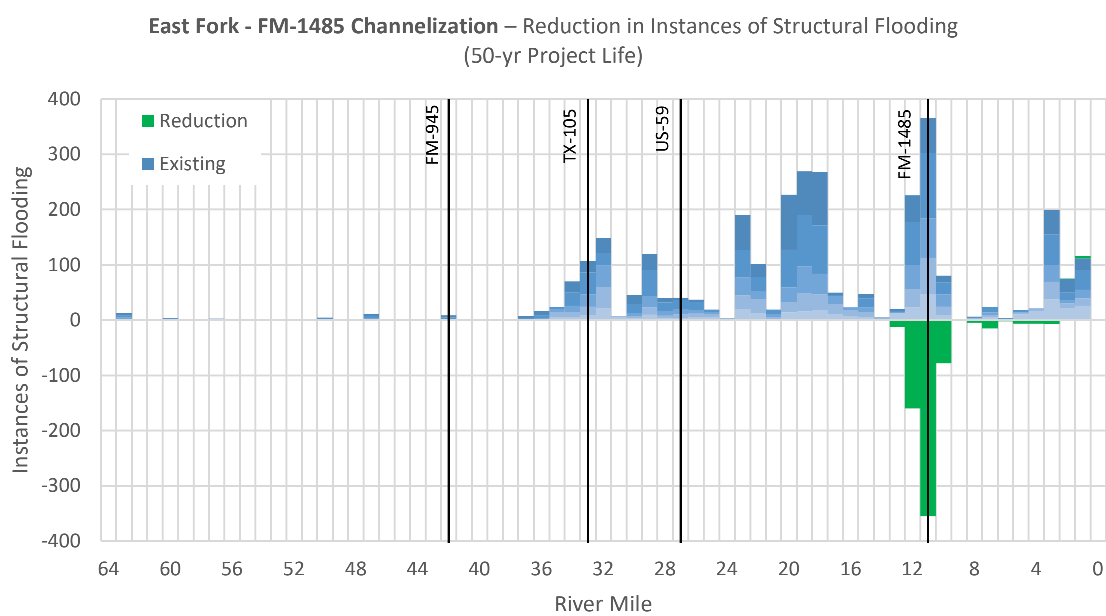


East Fork - FM-945 Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
Reduction
Existing
FM-945
TX-105
US-59
FM-1485

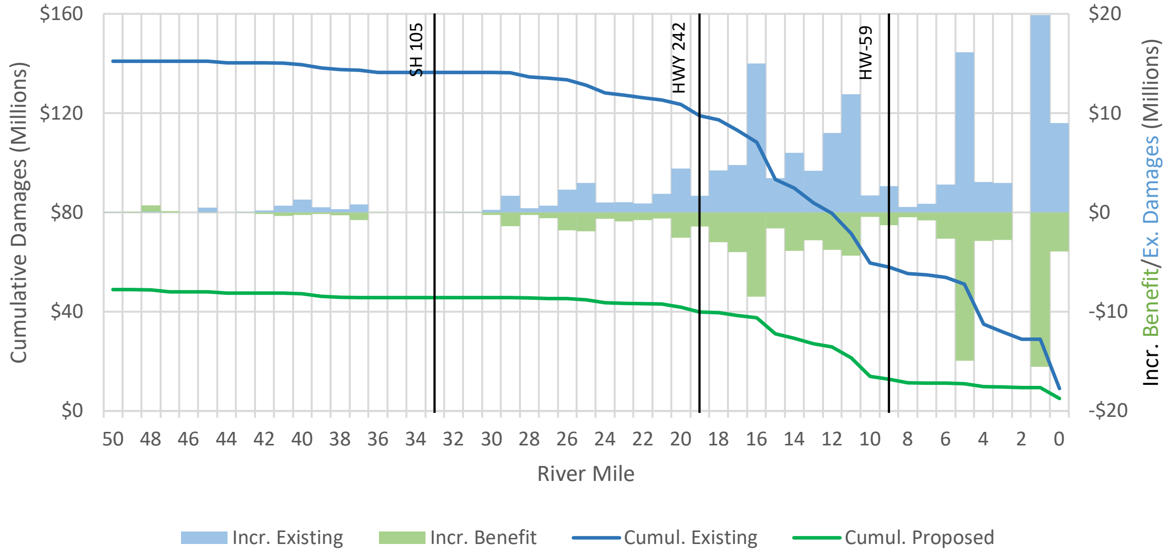

East Fork - Winters Bayou-Nebletts Creek Detention – Benefit Summary
(50-yr Project Life)
$140
$120
$100
$80
$60
$40
$20
$0
Cumulative Damages (Millions)
$20
$15
$10
$5
$0
-$5
-$10
-$15
Incr. Benefit/Ex. Damages (Millions)
FM-945
TX-105
US-59
FM-1485
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed


East Fork - Winters Bayou-Nebletts Creek Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
400
300
200
100
0
-100
-200
Instances of Structural Flooding
Reduction
Existing
FM-945
TX-105
US-59
FM-1485
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
River Mile

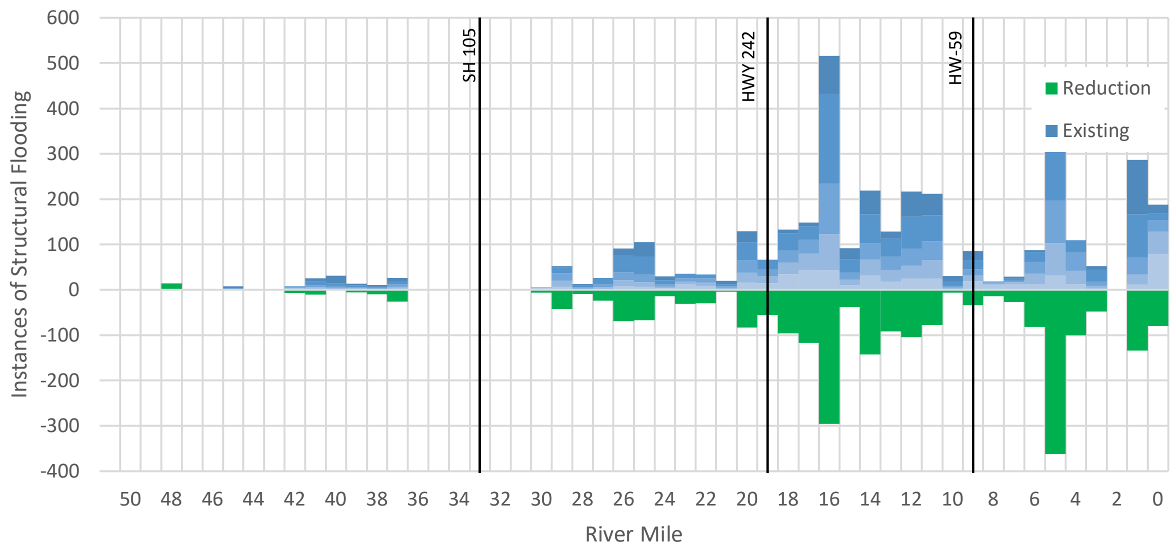

East Fork - FM-1485 Channelization – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
River Mile
FM-945
TX-105
US-59
FM-1485
$140
$120
$100
$80
$60
$40
$20
$0
$20
$15
$10
$5
$0
-$5
-$10
-$15
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

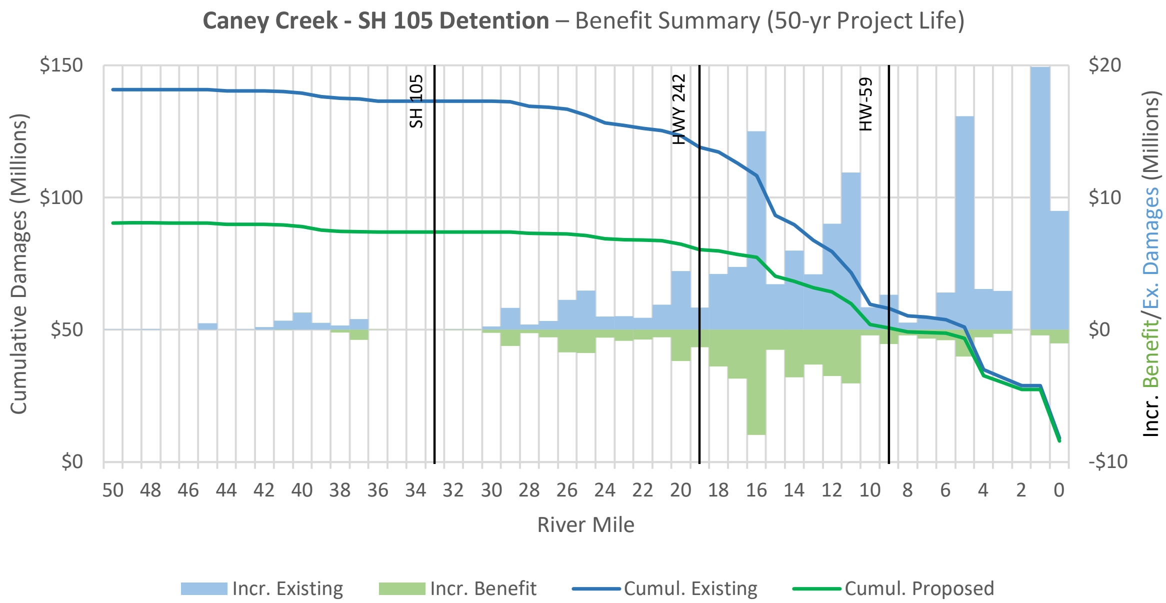

East Fork - FM-1485 Channelization – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
Reduction
Existing
FM-945
TX-105
US-59
FM-1485
400
300
200
100
0
-100
-200
-300
-400
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0

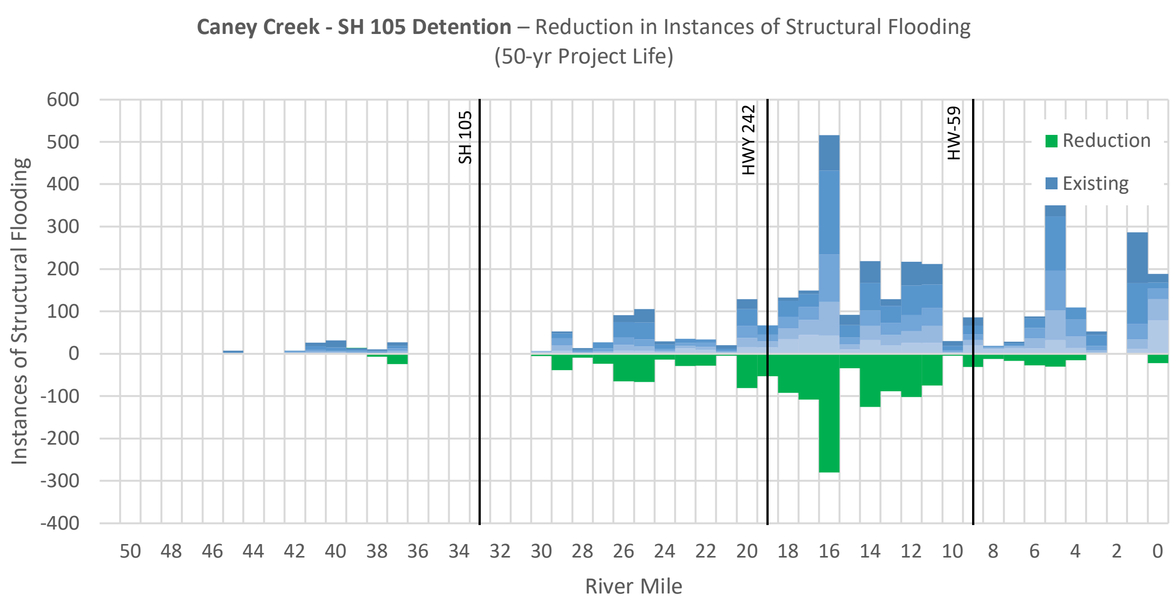
Caney Creek - Overall – Benefit Summary (50-yr Project Life)



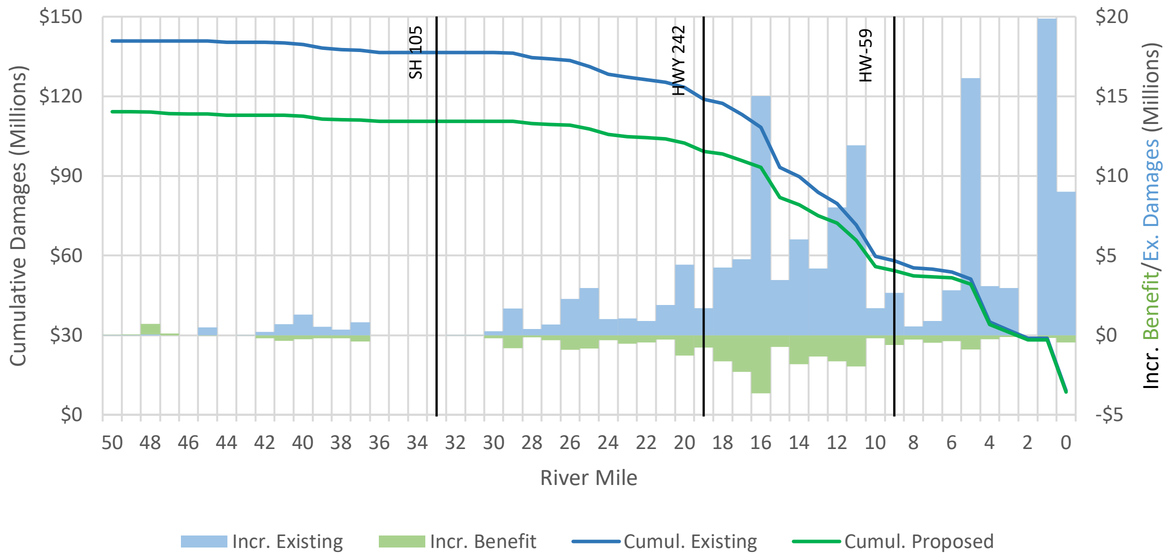
Caney Creek - Overall – Reduction in Instances of Structural Flooding (50-yr Project Life)



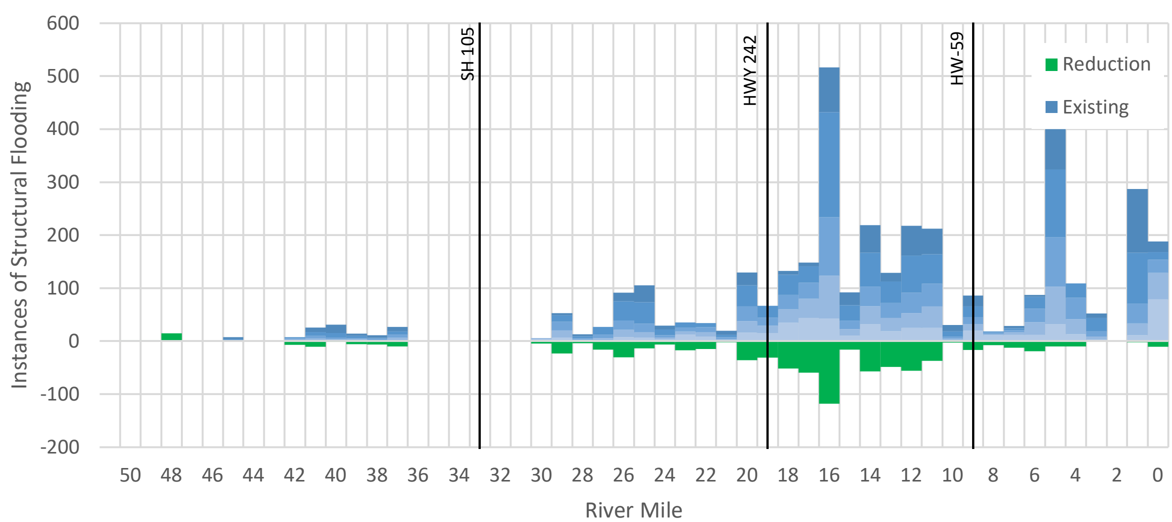

Caney Creek - SH 105 Detention – Benefit Summary (50-yr Project Life)
$150
$100
$50
$0
Cumulative Damages (Millions)
$20
$10
$0
-$10
Incr. Benefit/Ex. Damages (Millions)
SH 105
HWY 242
HW-59
50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed


Caney Creek - SH 105 Detention – Reduction in Instances of Structural Flooding
(50-yr Project Life)
600
500
400
300
200
100
0
-100
-200
-300
-400
Instances of Structural Flooding
SH 105
HWY 242
HW-59
Reduction
Existing
50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile

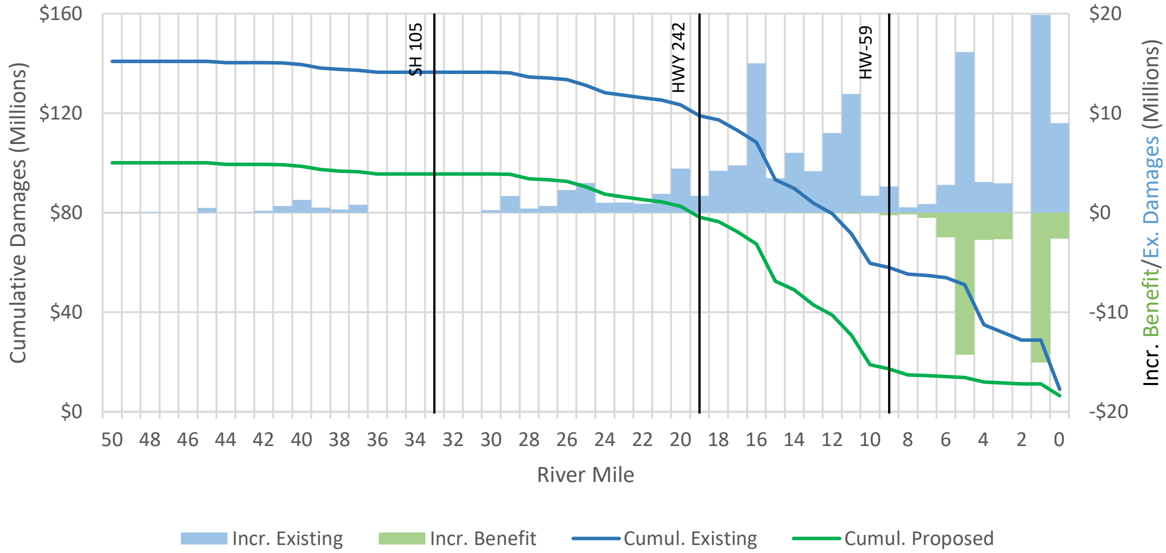
Caney Creek - FM 1097 Detention – Benefit Summary (50-yr Project Life)



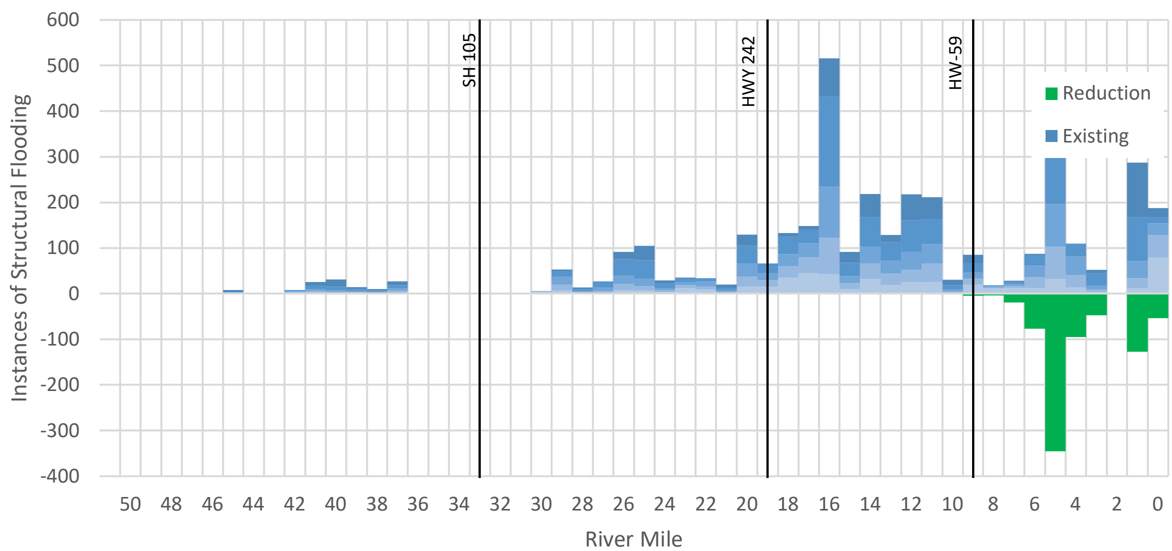
Caney Creek - FM 1097 Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)



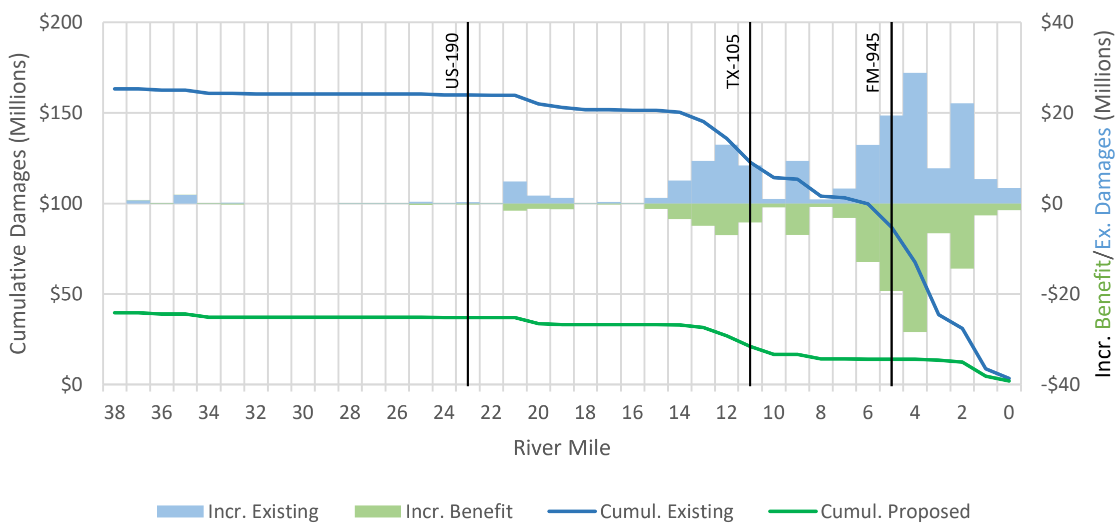
Caney Creek - I-69 Channelization – Benefit Summary (50-yr Project Life)



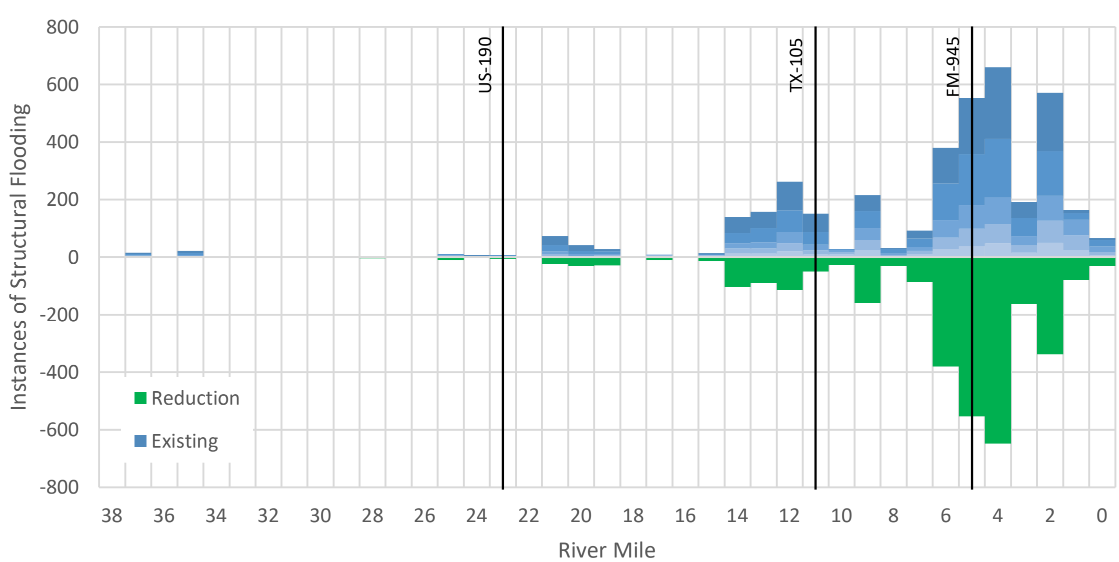
Caney Creek - I-69 Channelization – Reduction in Instances of Structural Flooding (50-yr Project Life)

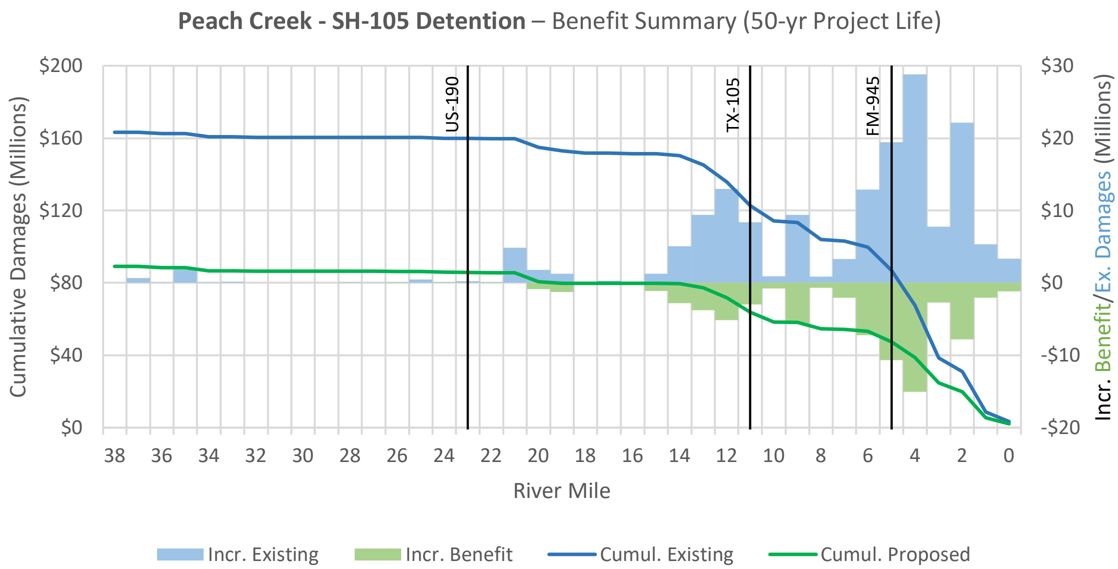


Peach Creek - Overall – Benefit Summary (50-yr Project Life)

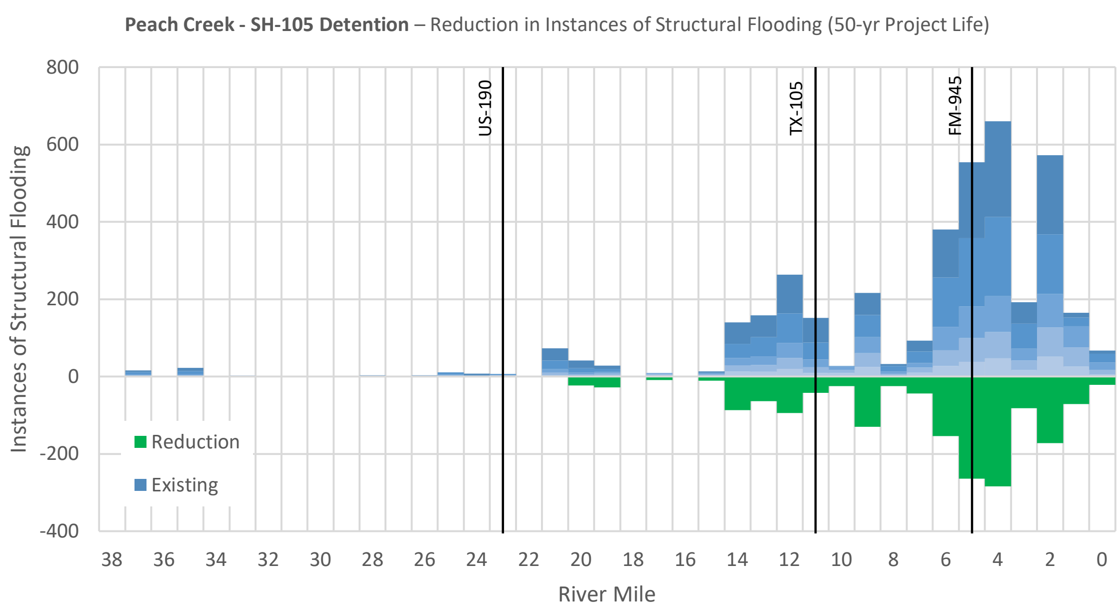


Peach Creek - Overall – Reduction in Instances of Structural Flooding (50-yr Project Life)

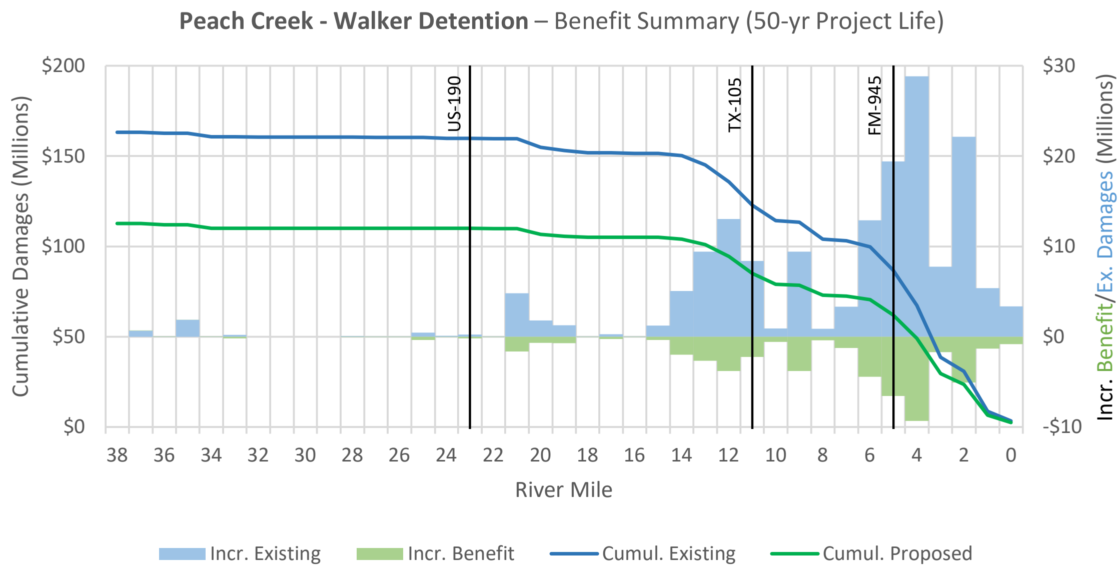




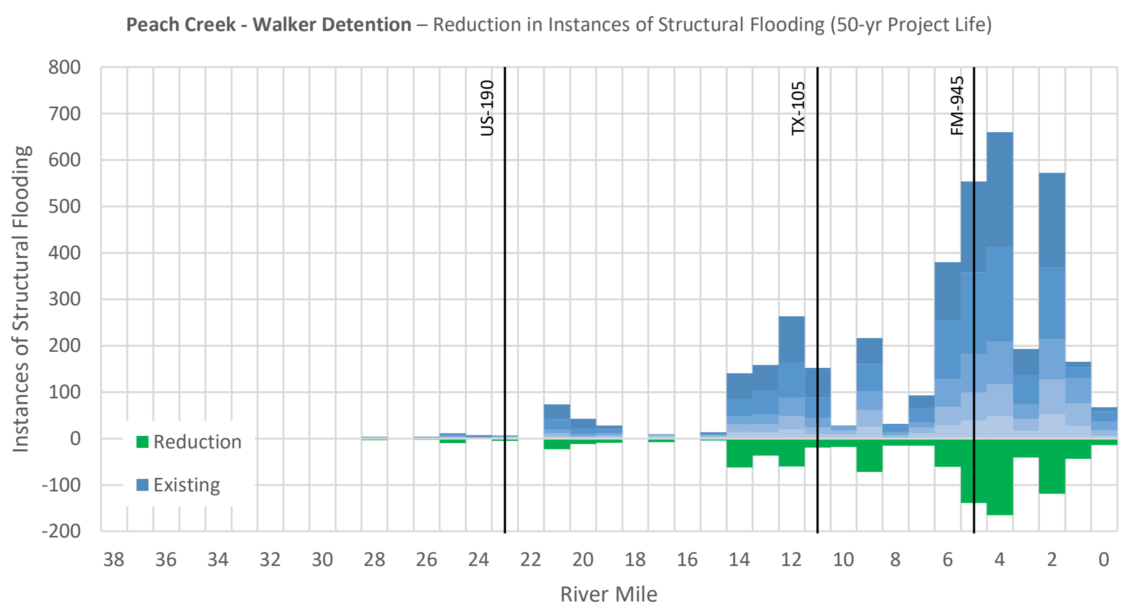
Peach Creek - SH-105 Detention – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
$200
$160
$120
$80
$40
$0
$30
$20
$10
$0
-$10
-$20
US-190
TX-105
FM-945
38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed



Peach Creek - SH-105 Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
800
600
400
200
0
-200
-400
US-190
TX-105
FM-945
Reduction
Existing
38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile

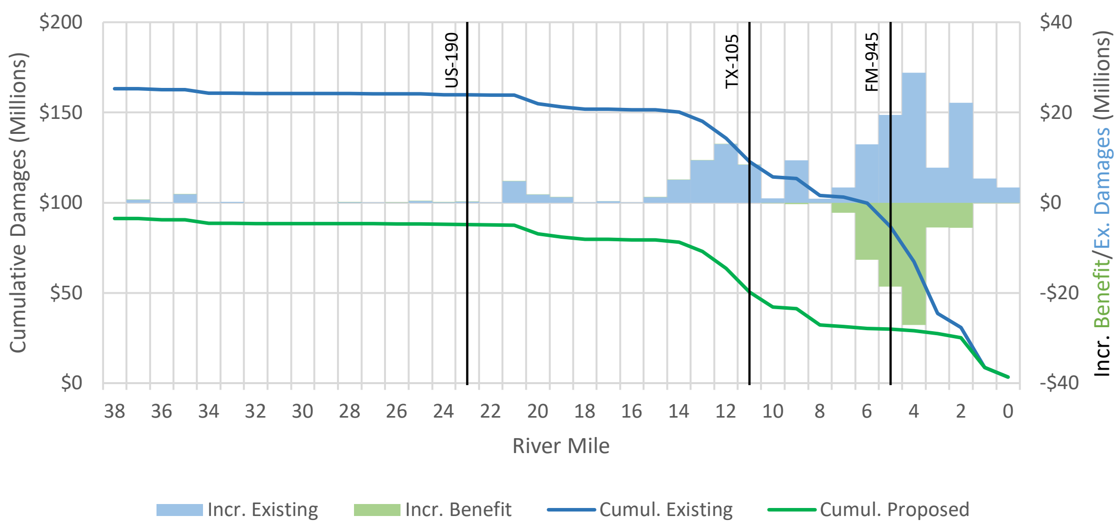


Peach Creek - Walker Detention – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
$200
$150
$100
$50
$0
$30
$20
$10
$0
-$10
Incr. Benefit/Ex. Damages (Millions)
US-190
TX-105
FM-945
38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed

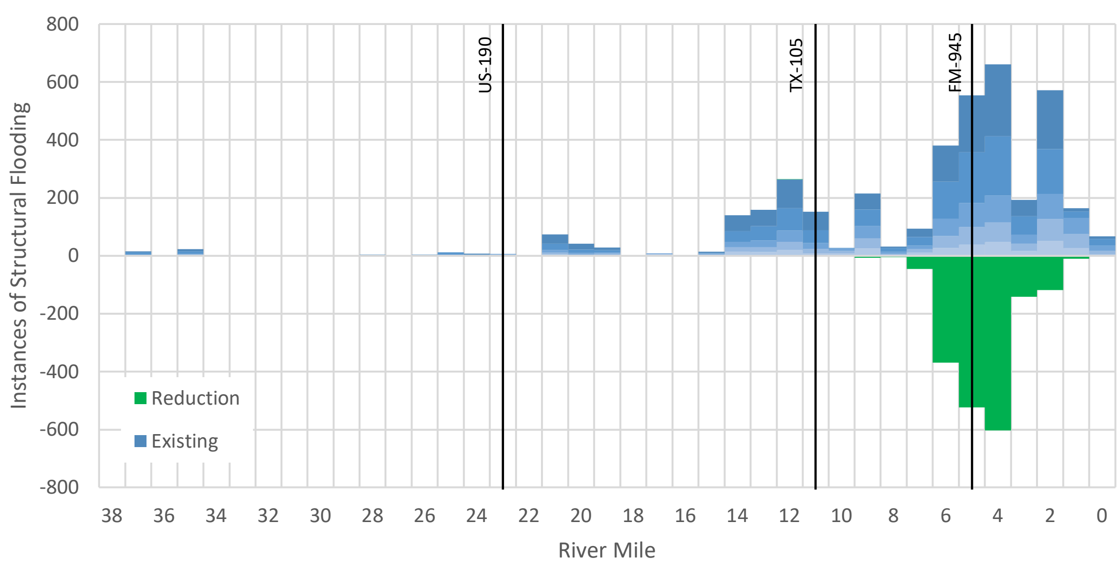


Peach Creek - Walker Detention – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
800
700
600
500
400
300
200
100
0
-100
-200
US-190
TX-105
FM-945
Reduction
Existing
38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
River Mile

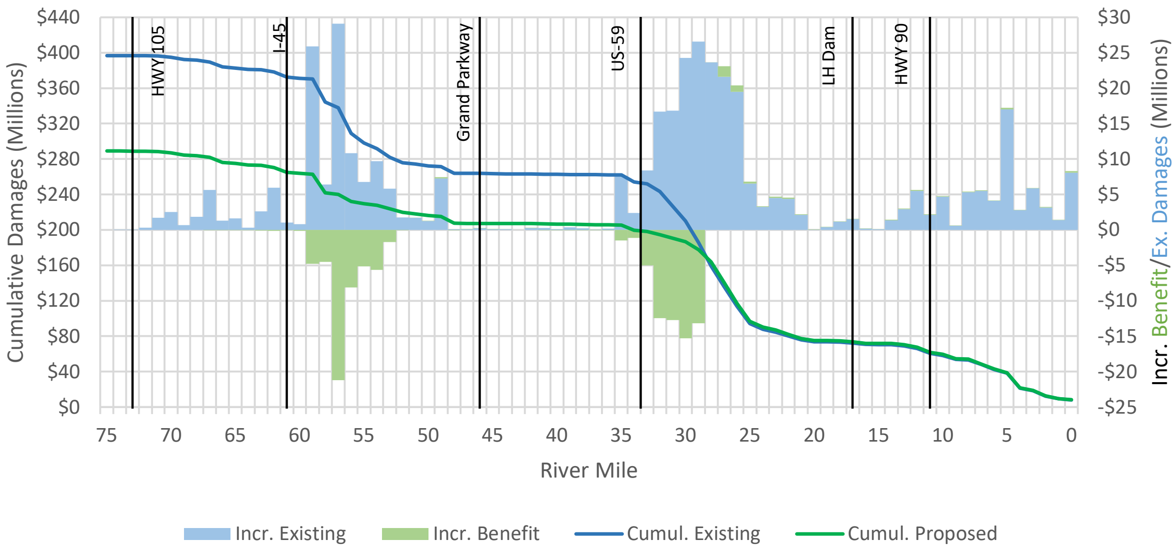
Peach Creek - I-69 Channelization – Benefit Summary (50-yr Project Life)



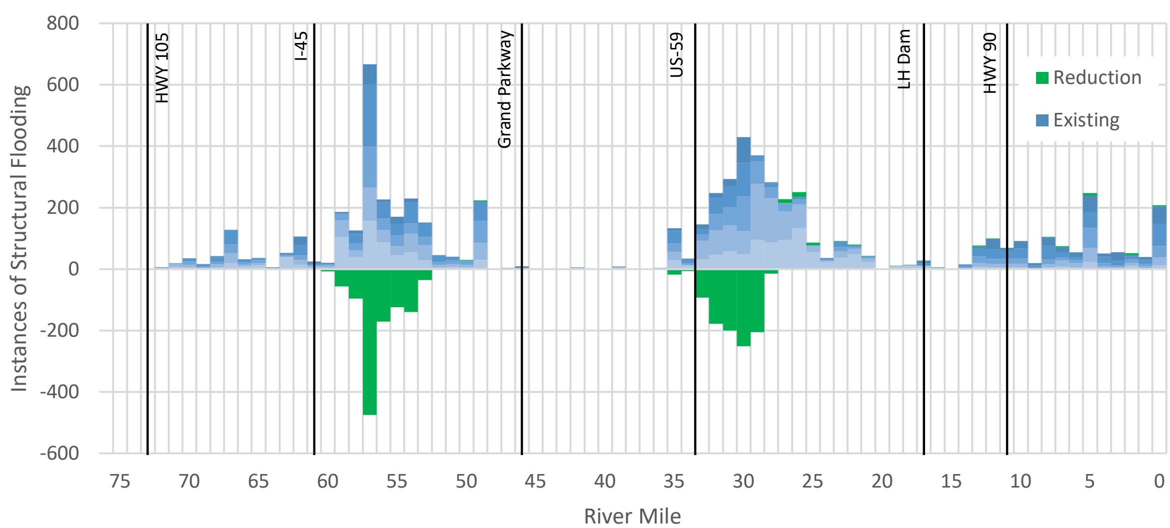
Peach Creek - I-69 Channelization – Reduction in Instances of Structural Flooding (50-yr Project Life)

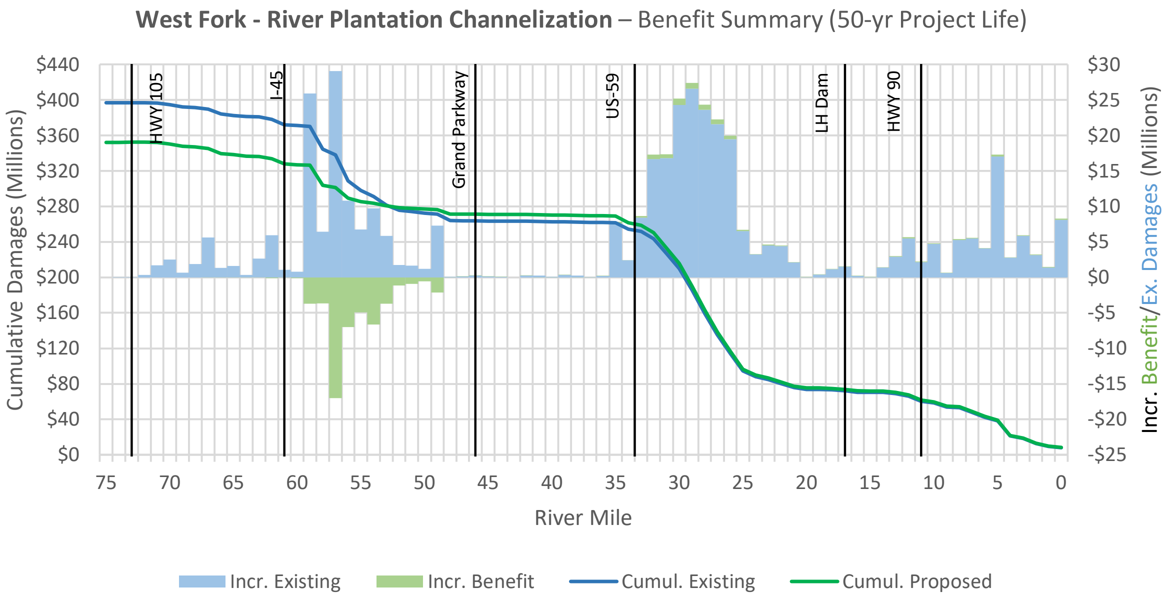


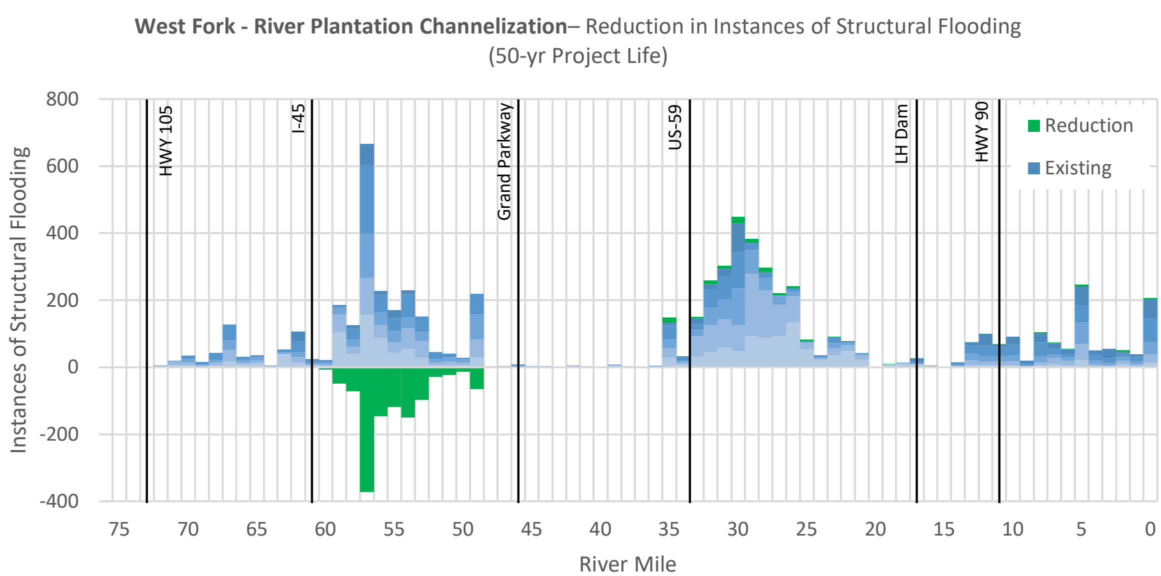
West Fork - Overall – Benefit Summary (50-yr Project Life)

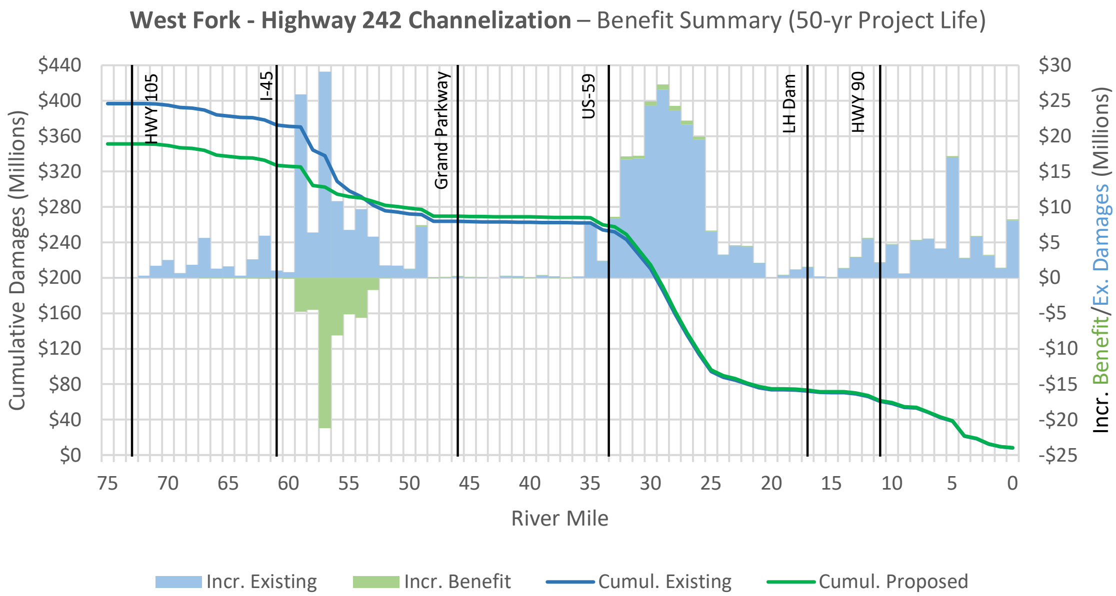


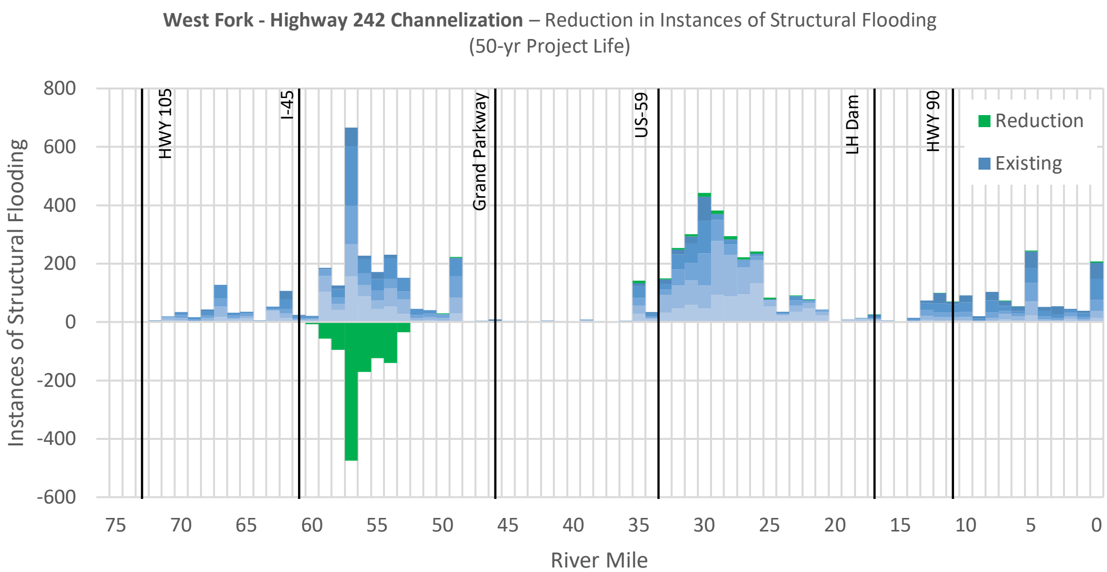
West Fork - Overall – Reduction in Instances of Structural Flooding (50-yr Project Life)



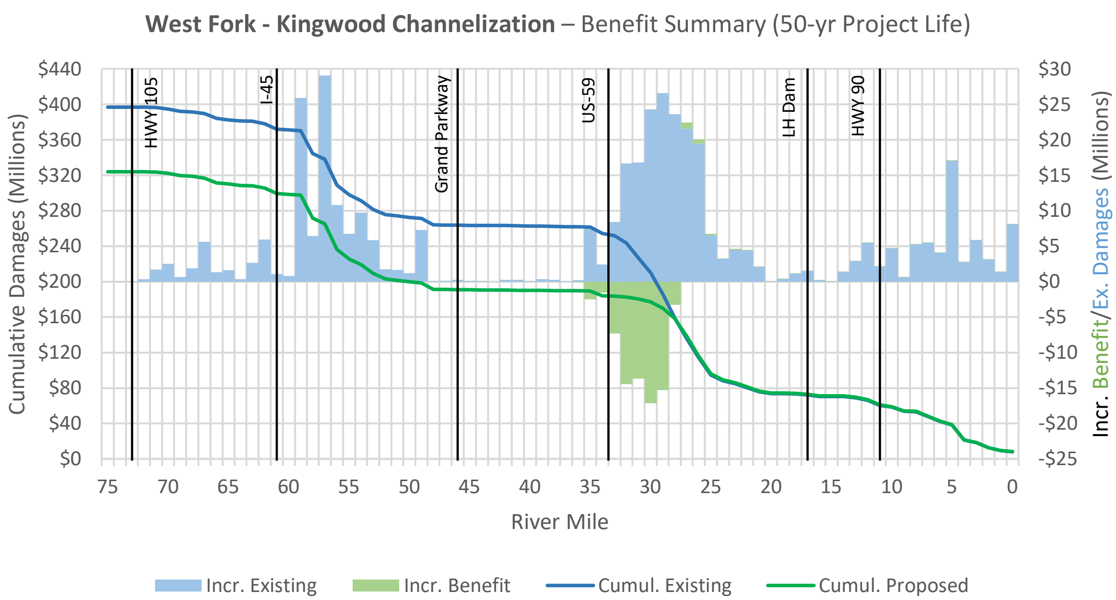

West Fork - River Plantation Channelization – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
River Mile
HWY 105
I-45
Grand Parkway
US-59
LH Dam
HWY 90
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed


West Fork - River Plantation Channelization– Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
HWY 105
I-45
Grand Parkway
US-59
LH Dam
HWY 90
Reduction
Existing

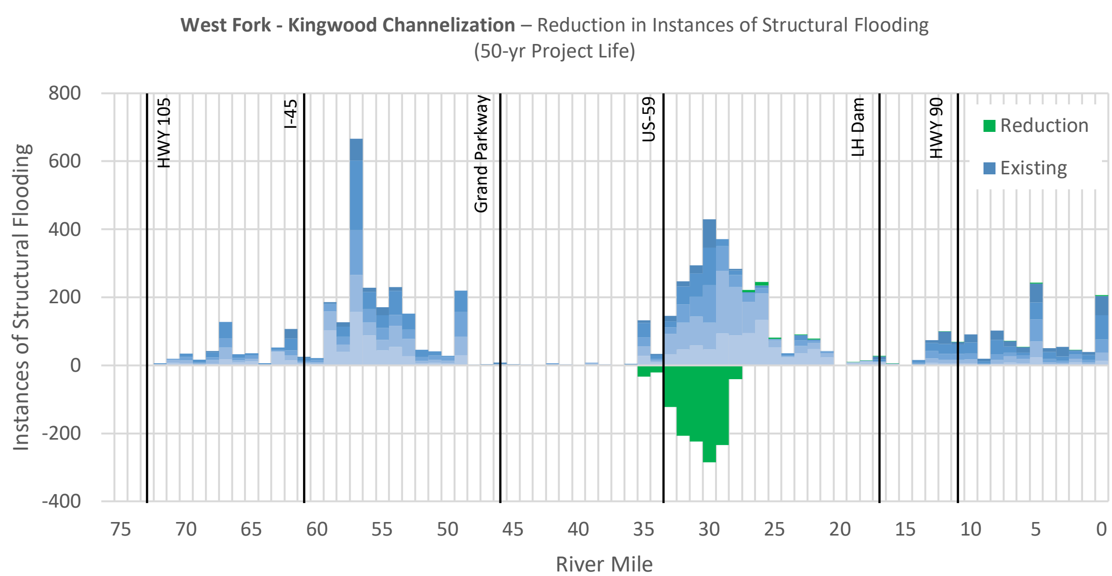




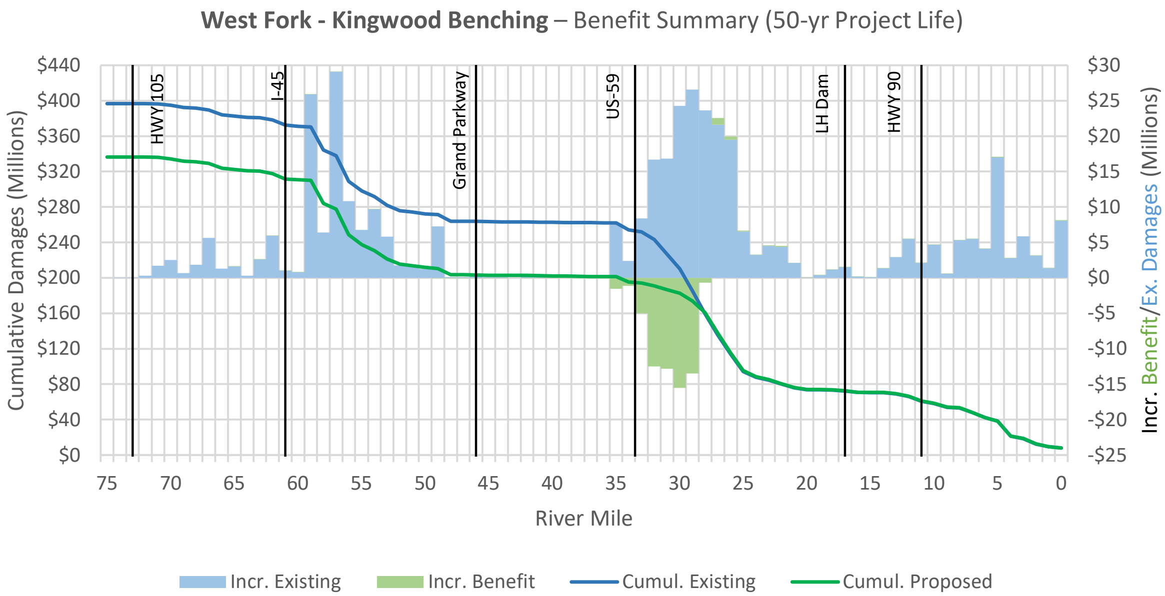
SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN



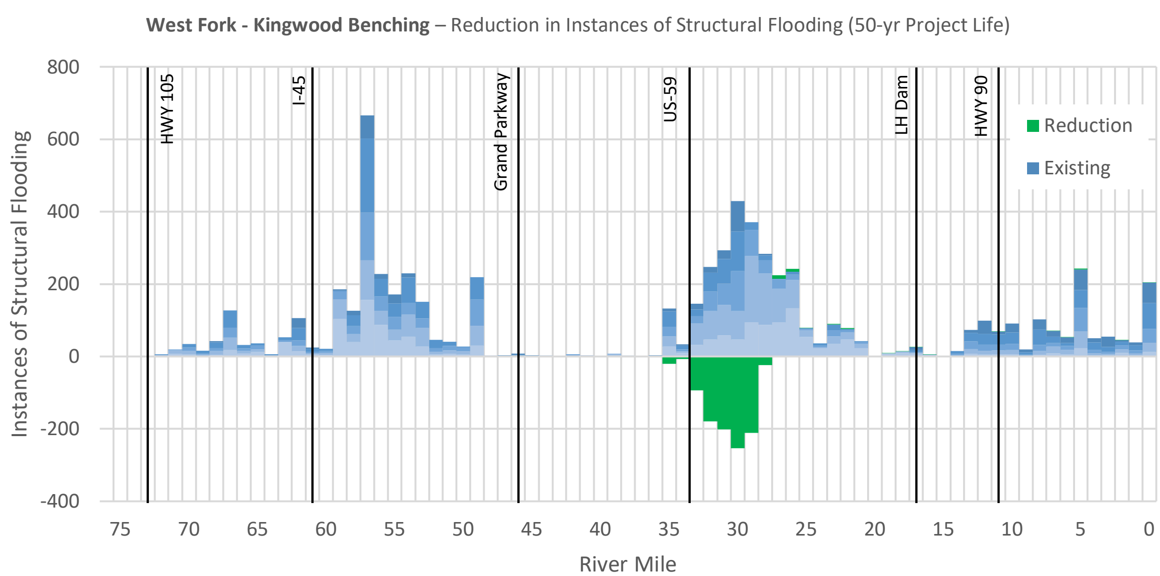
West Fork - Kingwood Channelization – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
HWY 105
I-45
Grand Parkway
US-59
LH Dam
HWY 90
$440
$400
$360
$320
$280
$240
$200
$160
$120
$80
$40
$0
$30
$25
$20
$15
$10
$5
$0
-$5
-$10
-$15
-$20
-$25
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
River Mile
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed



West Fork - Kingwood Channelization – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
HWY 105
I-45
Grand Parkway
US-59
LH Dam
HWY 90
Reduction
Existing
800
600
400
200
0
-200
-400
75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
River Mile



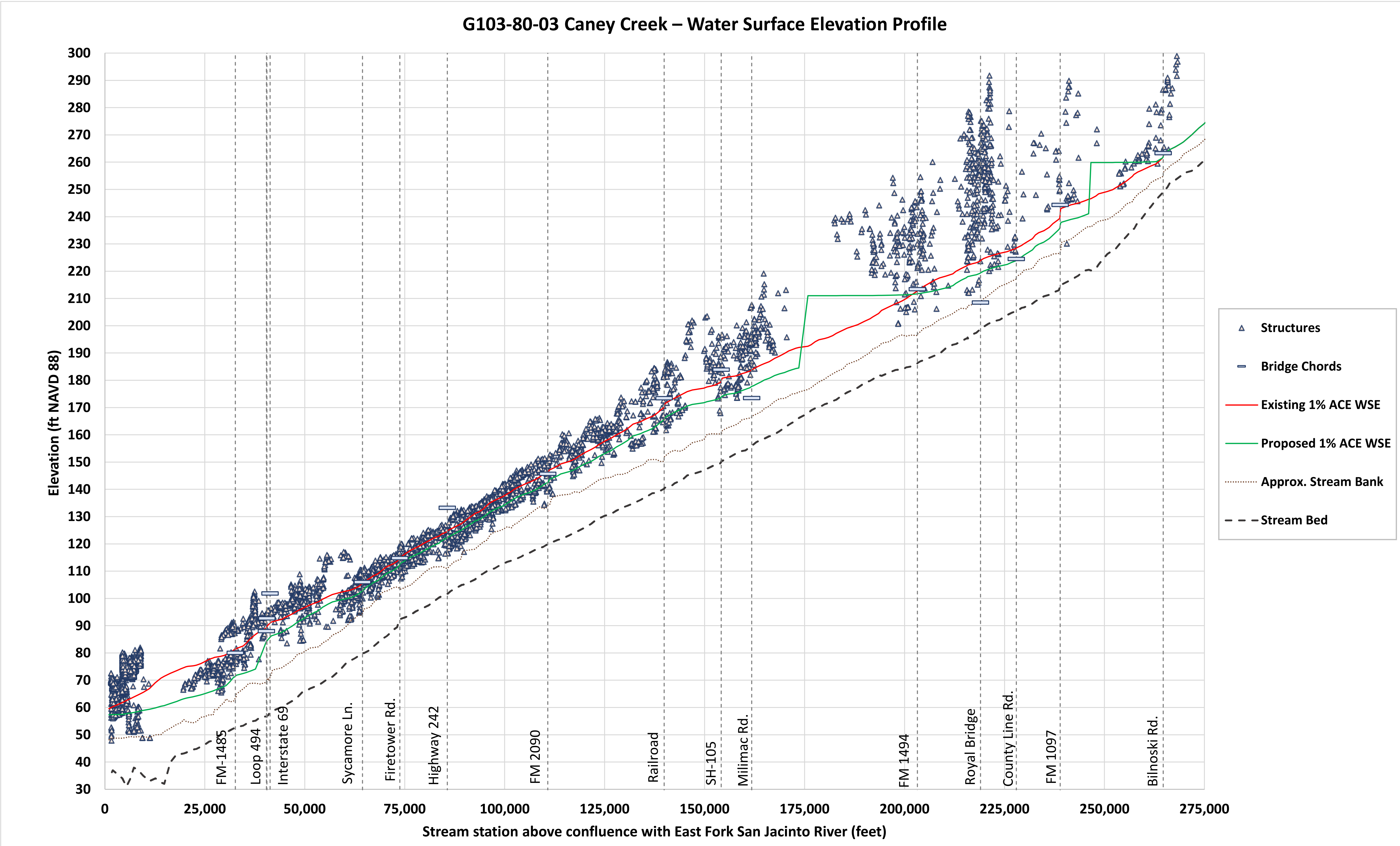
West Fork - Kingwood Benching – Benefit Summary (50-yr Project Life)
Cumulative Damages (Millions)
Incr. Benefit/Ex. Damages (Millions)
River Mile
HWY 105
I-45
Grand Parkway
US-59
LH Dam
HWY 90
Incr. Existing
Incr. Benefit
Cumul. Existing
Cumul. Proposed



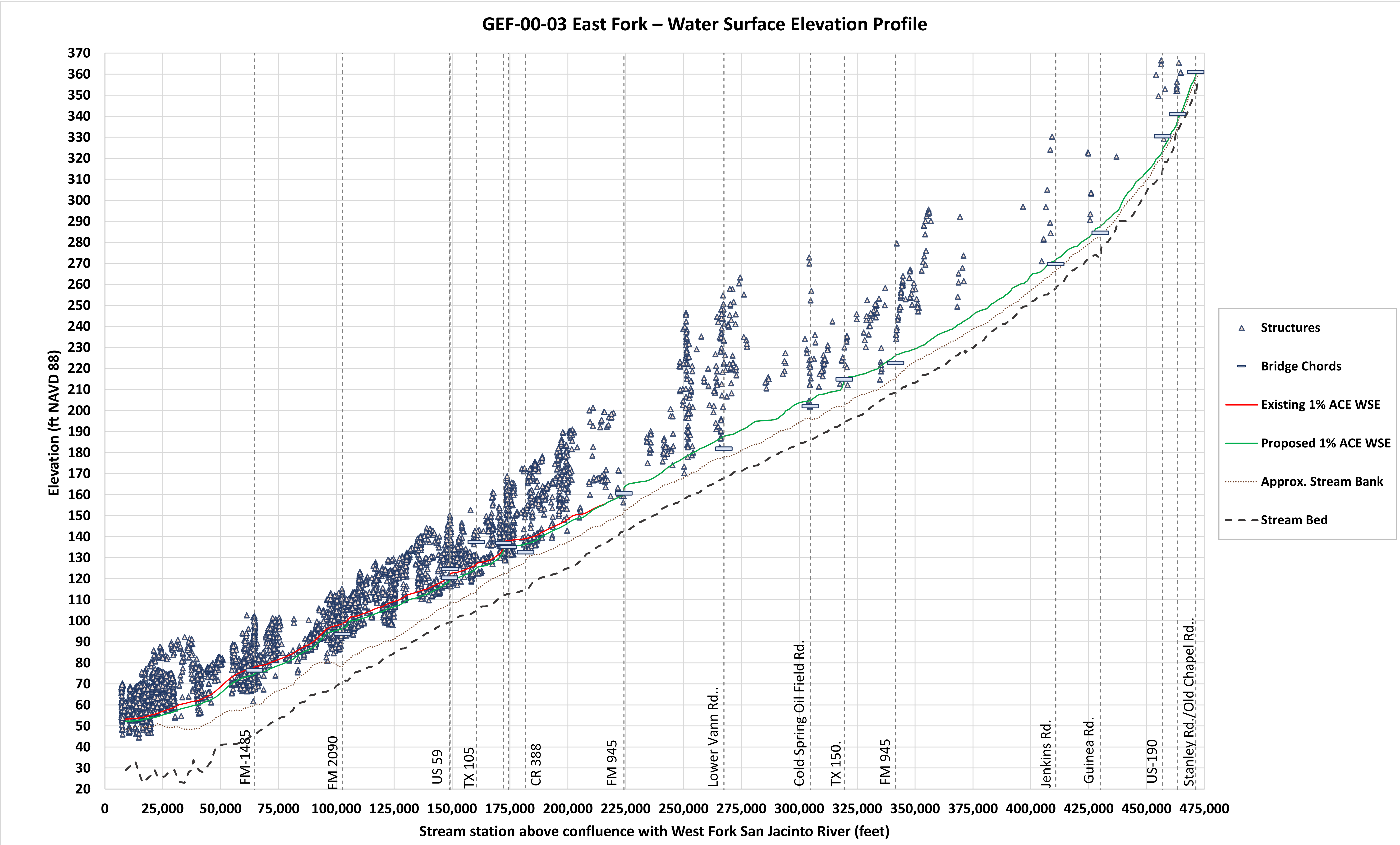
West Fork - Kingwood Benching – Reduction in Instances of Structural Flooding (50-yr Project Life)
Instances of Structural Flooding
River Mile
HWY 105
I-45
Grand Parkway
US-59
LH Dam
HWY 90
Reduction
Existing

Appendix G.5

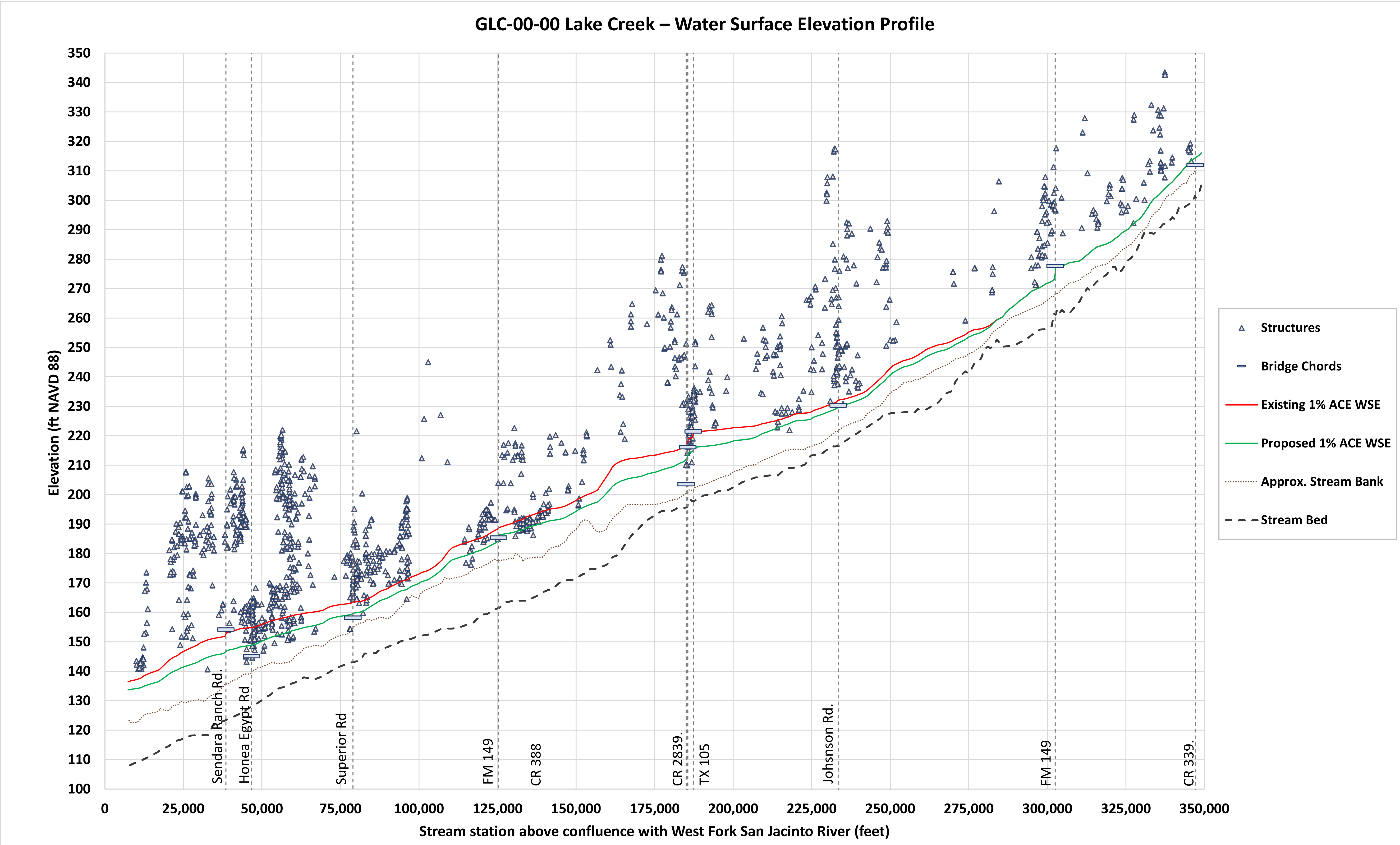
San Jacinto River Plan 1% ACE WSEL Profiles



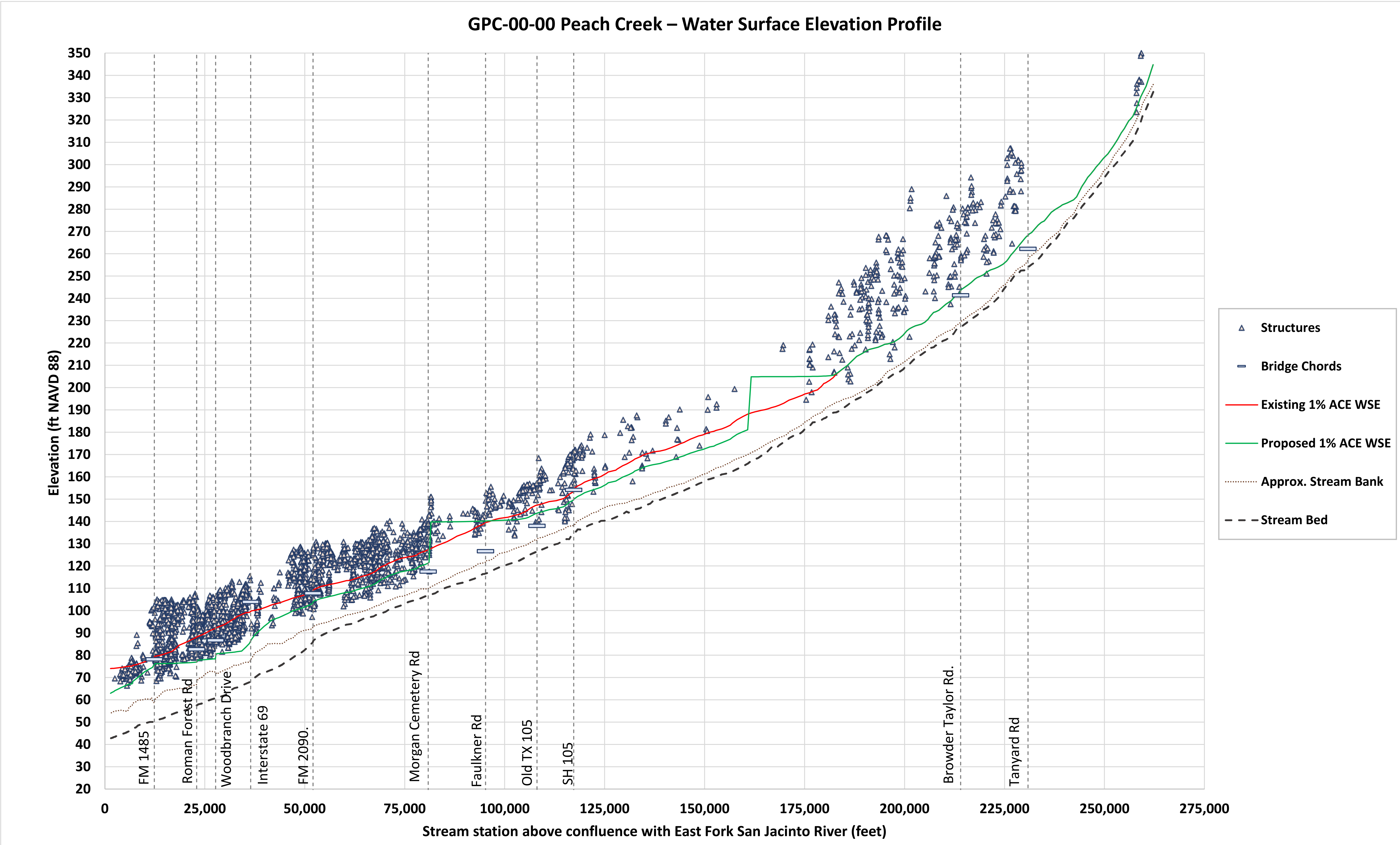
G103-80-03 Caney Creek – Water Surface Elevation Profile
Elevation (ft NAVD 88)
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000
275,000
Stream station above confluence with East Fork San Jacinto River (feet)
FM-1485
Loop 494
Interstate 69
Sycamore Ln.
Firetower Rd.
Highway 242
FM 2090
Railroad
SH-105
Milimac Rd.
FM 1494
Royal Bridge
County Line Rd.
FM 1097
Bilnoski Rd.
Structures
Bridge Chords
Existing 1% ACE WSE
Proposed 1% ACE WSE
Approx. Stream Bank
Stream Bed



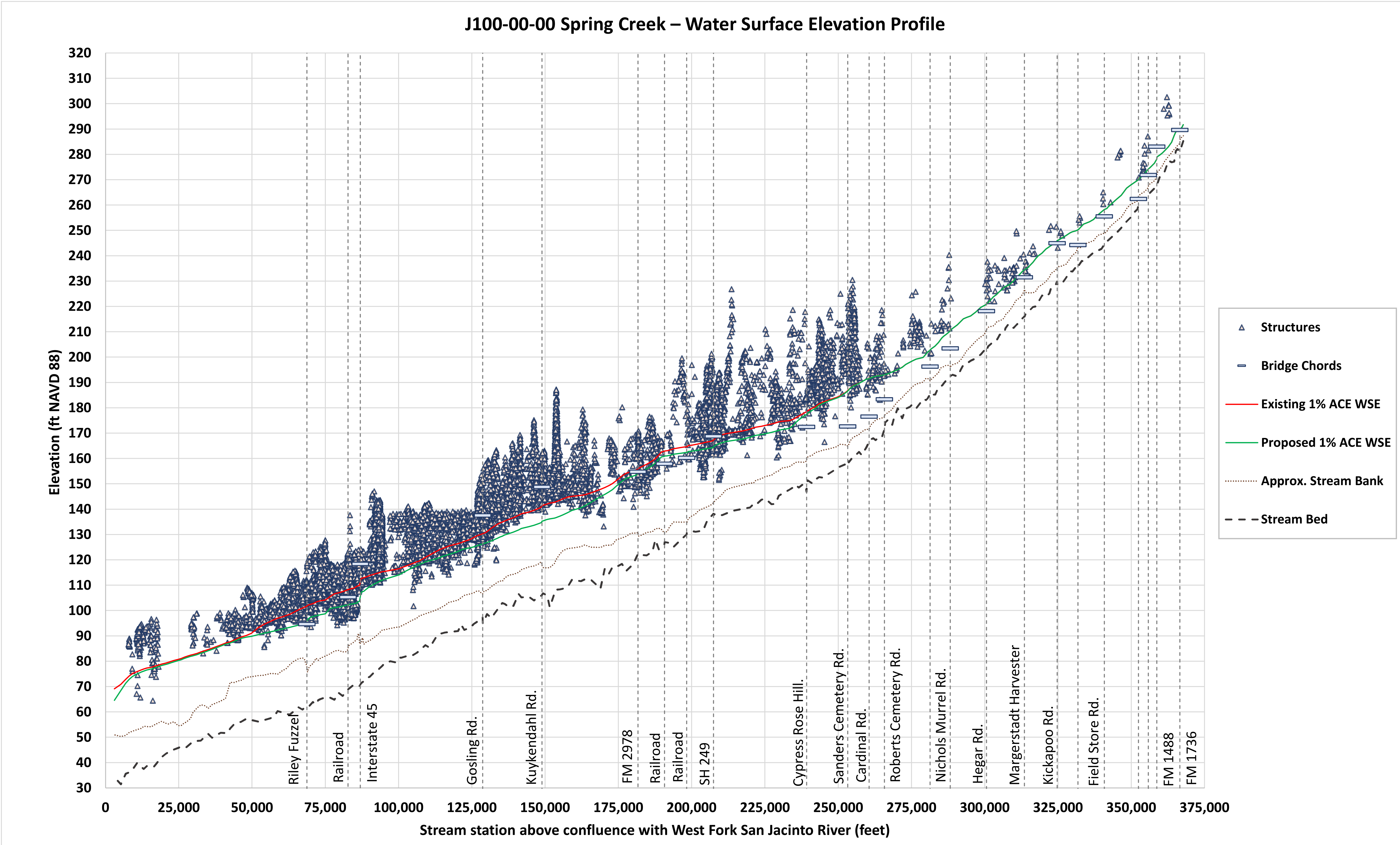
GEF-00-03 East Fork – Water Surface Elevation Profile
Elevation (ft NAVD 88)
Stream station above confluence with West Fork San Jacinto River (feet)
370
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000
275,000
300,000
325,000
350,000
375,000
400,000
425,000
450,000
475,000
FM-1485
FM 2090
US 59
TX 105
CR 388
FM 945
Lower Vann Rd.
Cold Spring Oil Field Rd.
TX 150.
FM 945
Jenkins Rd.
Guinea Rd.
US-190
Stanley Rd./Old Chapel Rd.
Structures
Bridge Chords
Existing 1% ACE WSE
Proposed 1% ACE WSE
Approx. Stream Bank
Stream Bed



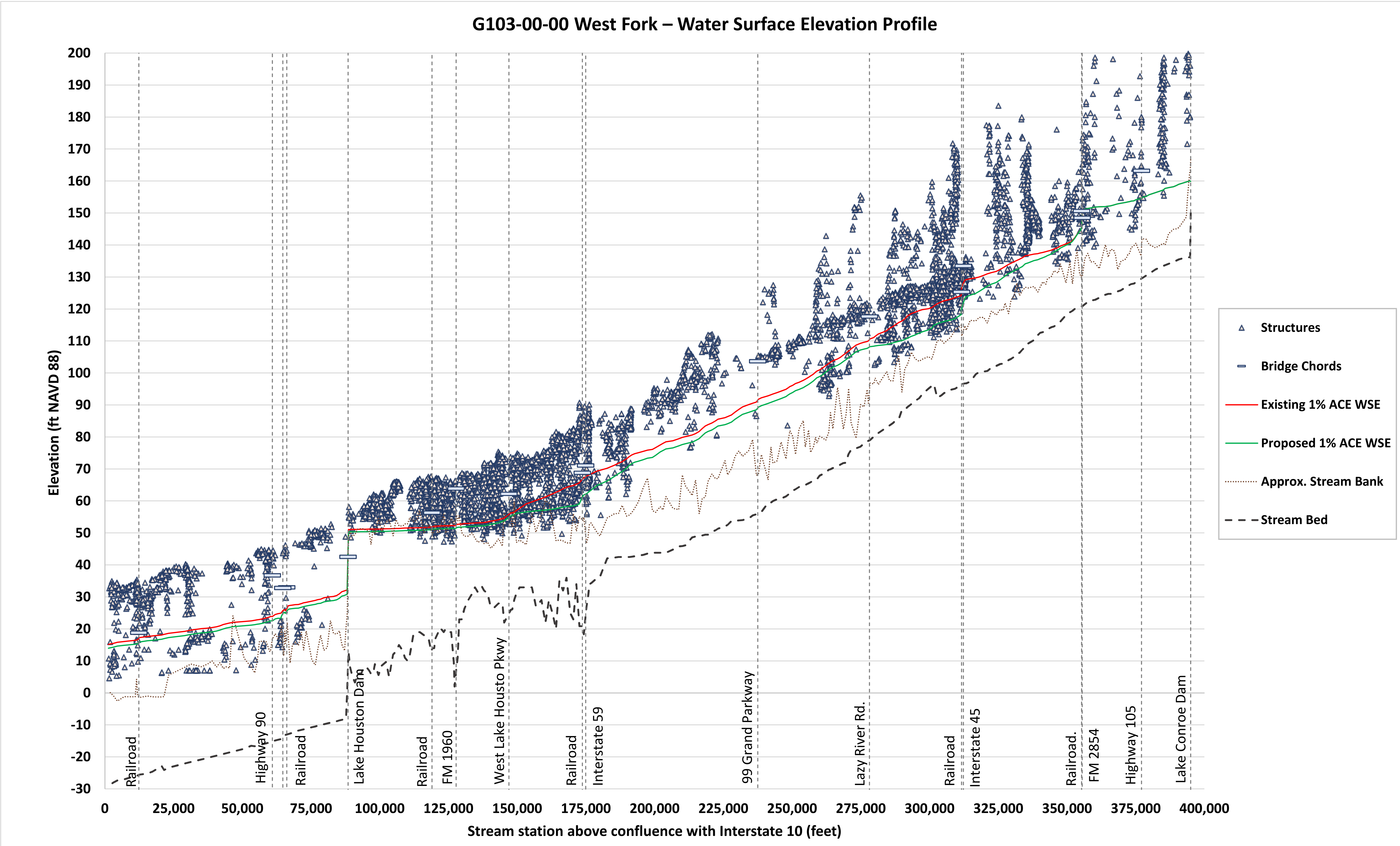
GLC-00-00 Lake Creek – Water Surface Elevation Profile
Elevation (ft NAVD 88)
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000
275,000
300,000
325,000
350,000
Stream station above confluence with West Fork San Jacinto River (feet)
Sendara Ranch Rd.
Honea Egypt Rd
Superior Rd
FM 149
CR 388
CR 2839.
TX 105
Johnsnon Rd.
FM 149
CR 339.
Structures
Bridge Chords
Existing 1% ACE WSE
Proposed 1% ACE WSE
Approx. Stream Bank
Stream Bed



GPC-00-00 Peach Creek – Water Surface Elevation Profile
Elevation (ft NAVD 88)
Stream station above confluence with East Fork San Jacinto River (feet)
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000
275,000
FM 1485
Roman Forest Rd
Woodbranch Drive
Interstate 69
FM 2090.
Morgan Cemetery Rd
Faulkner Rd
Old TX 105
SH 105
Browder Taylor Rd.
Tanyard Rd
Structures
Bridge Chords
Existing 1% ACE WSE
Proposed 1% ACE WSE
Approx. Stream Bank
Stream Bed



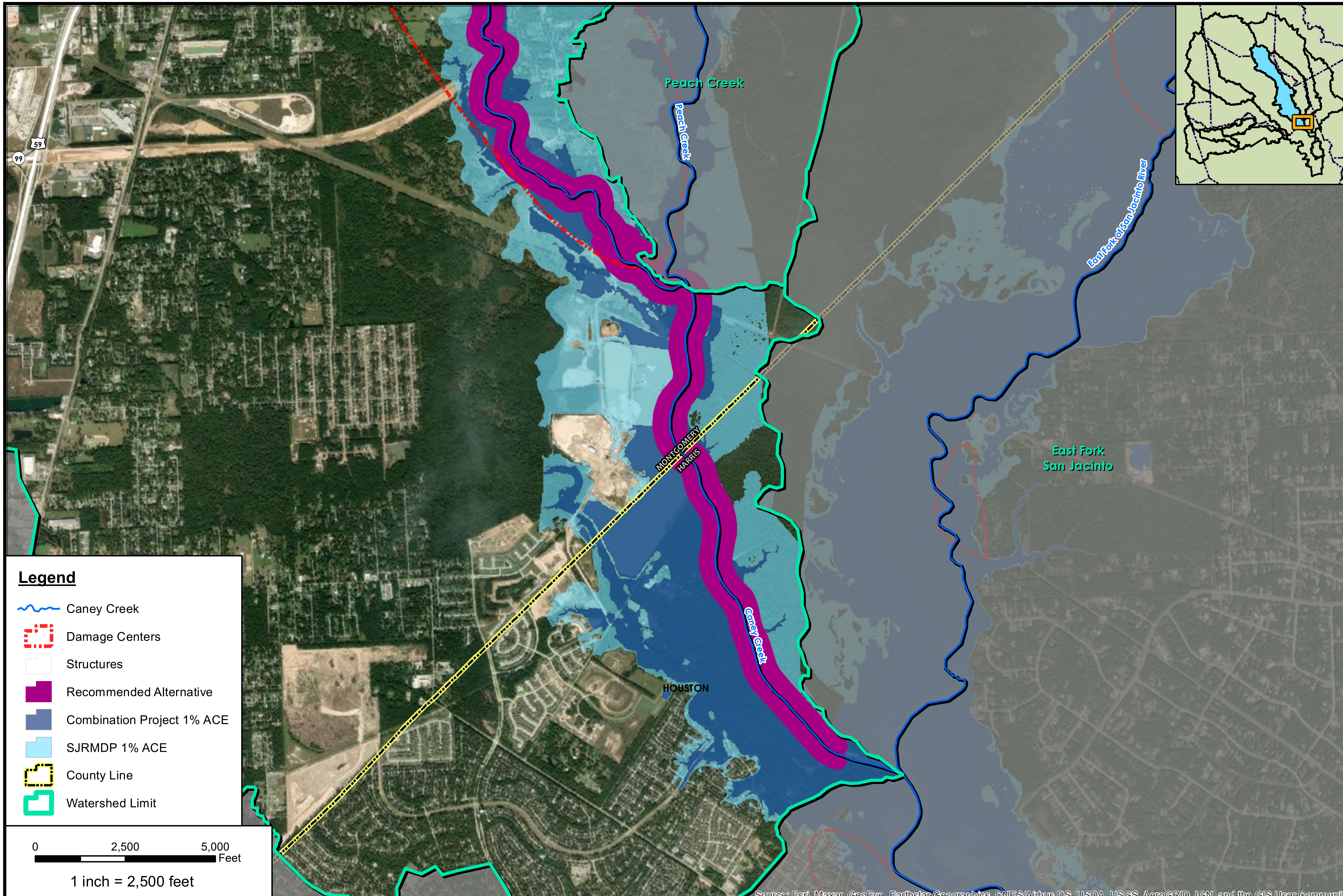
J100-00-00 Spring Creek – Water Surface Elevation Profile
Elevation (ft NAVD 88)
Stream station above confluence with West Fork San Jacinto River (feet)
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
0
25,000
50,000
75,000
100,000
125,000
150,000
175,000
200,000
225,000
250,000
275,000
300,000
325,000
350,000
375,000
Riley Fuzzel
Railroad
Interstate 45
Gosling Rd.
Kuykendahl Rd.
FM 2978
Railroad
Railroad
SH 249
Cypress Rose Hill.
Sanders Cemetery Rd.
Cardinal Rd.
Roberts Cemetery Rd.
Nichols Murrel Rd.
Hegar Rd.
Margerstadt Harvester
Kickapoo Rd.
Field Store Rd.
FM 1488
FM 1736
Structures
Bridge Chords
Existing 1% ACE WSE
Proposed 1% ACE WSE
Approx. Stream Bank
Stream Bed



G103-00-00 West Fork – Water Surface Elevation Profile
Elevation (ft NAVD 88)
Stream station above confluence with Interstate 10 (feet)
Structures
Bridge Chords
Existing 1% ACE WSE
Proposed 1% ACE WSE
Approx. Stream Bank
Stream Bed
Railroad
Highway 90
Railroad
Lake Houston Dam
Railroad
FM 1960
West Lake Housto Pkwy
Railroad
Interstate 59
99 Grand Parkway
Lazy River Rd.
Railroad
Interstate 45
Railroad.
FM 2854
Highway 105
Lake Conroe Dam

Appendix G.6

San Jacinto River Plan 1% ACE Inundation Limits



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

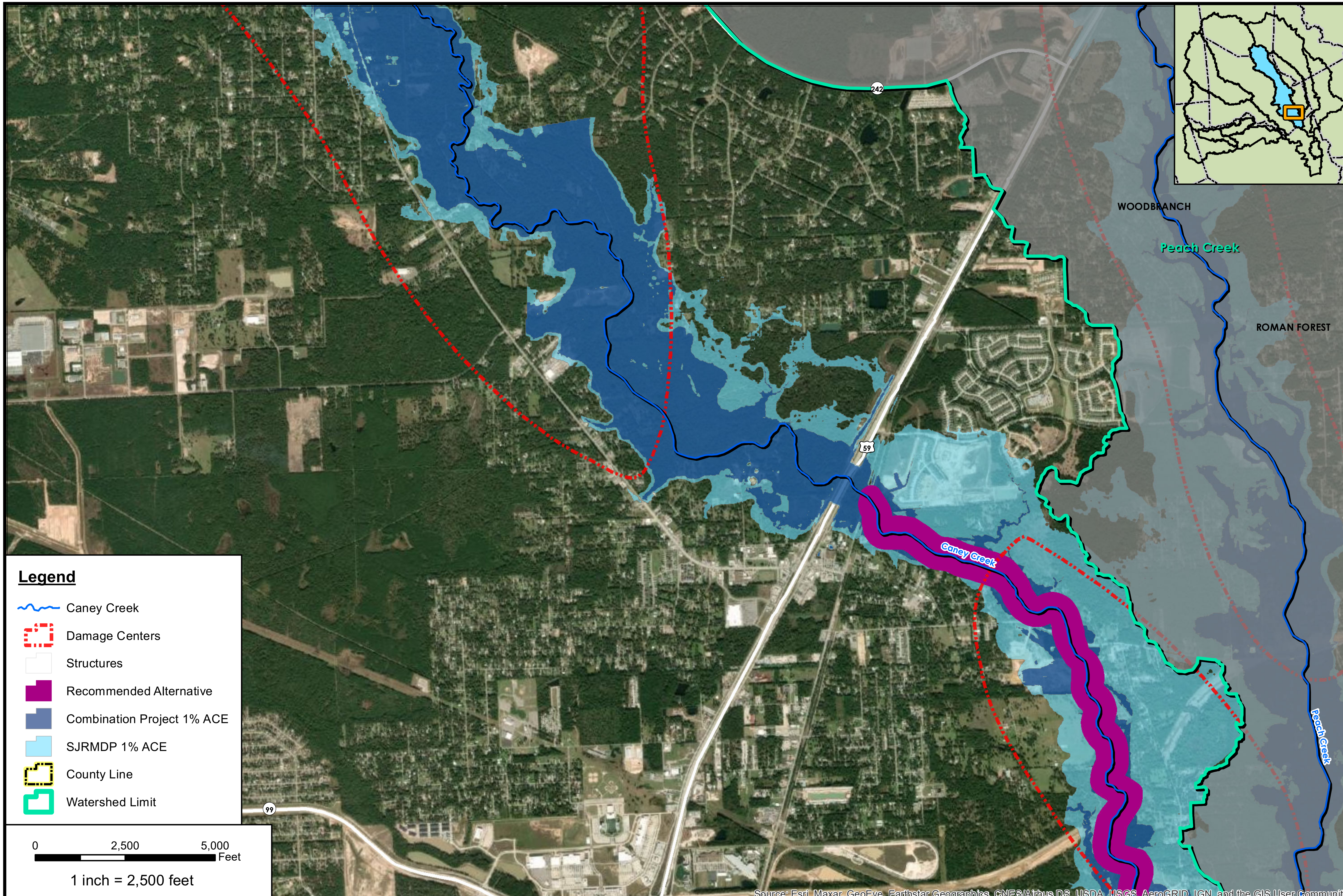
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map A



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N
W E
S

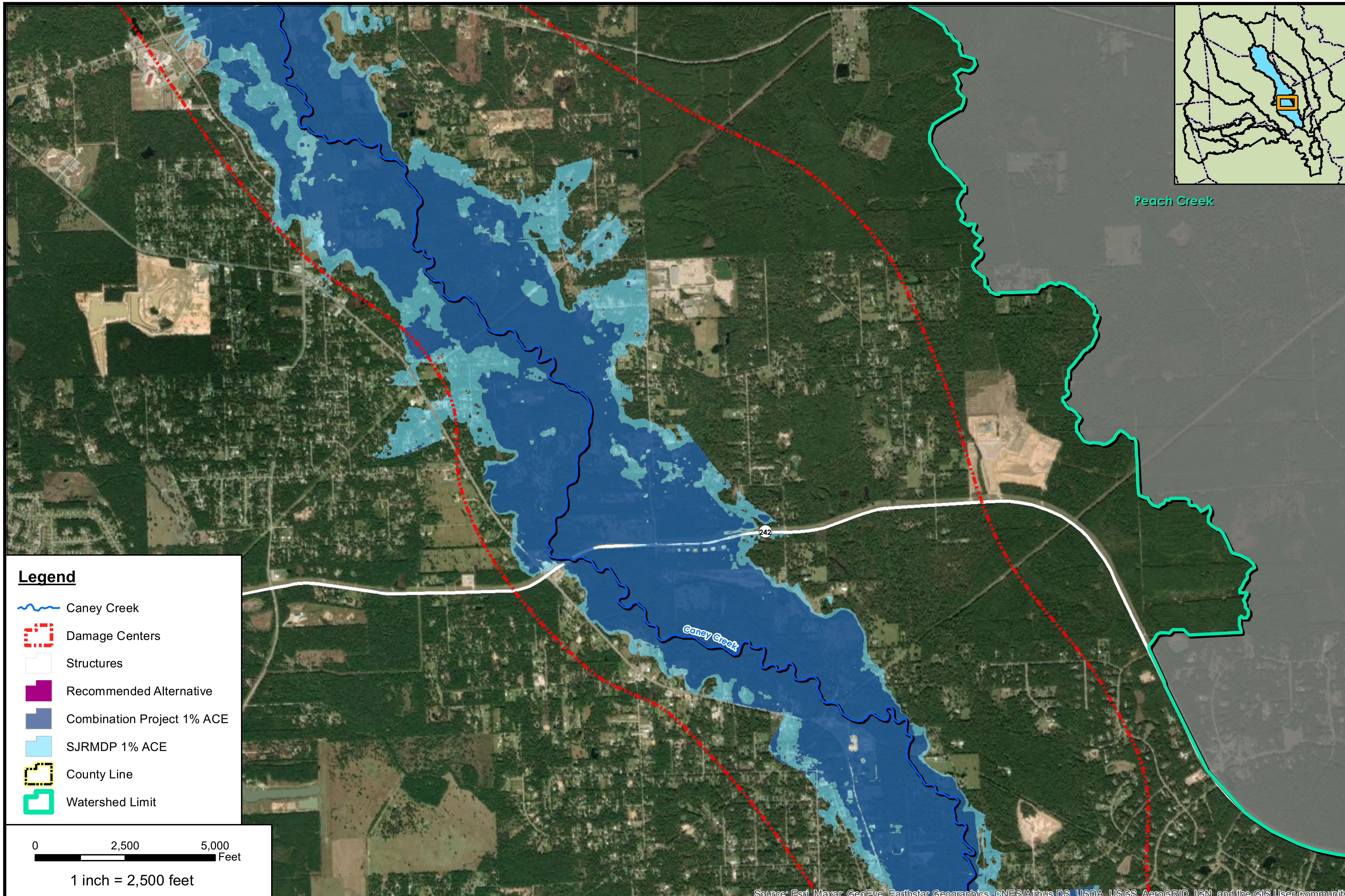
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map B



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NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

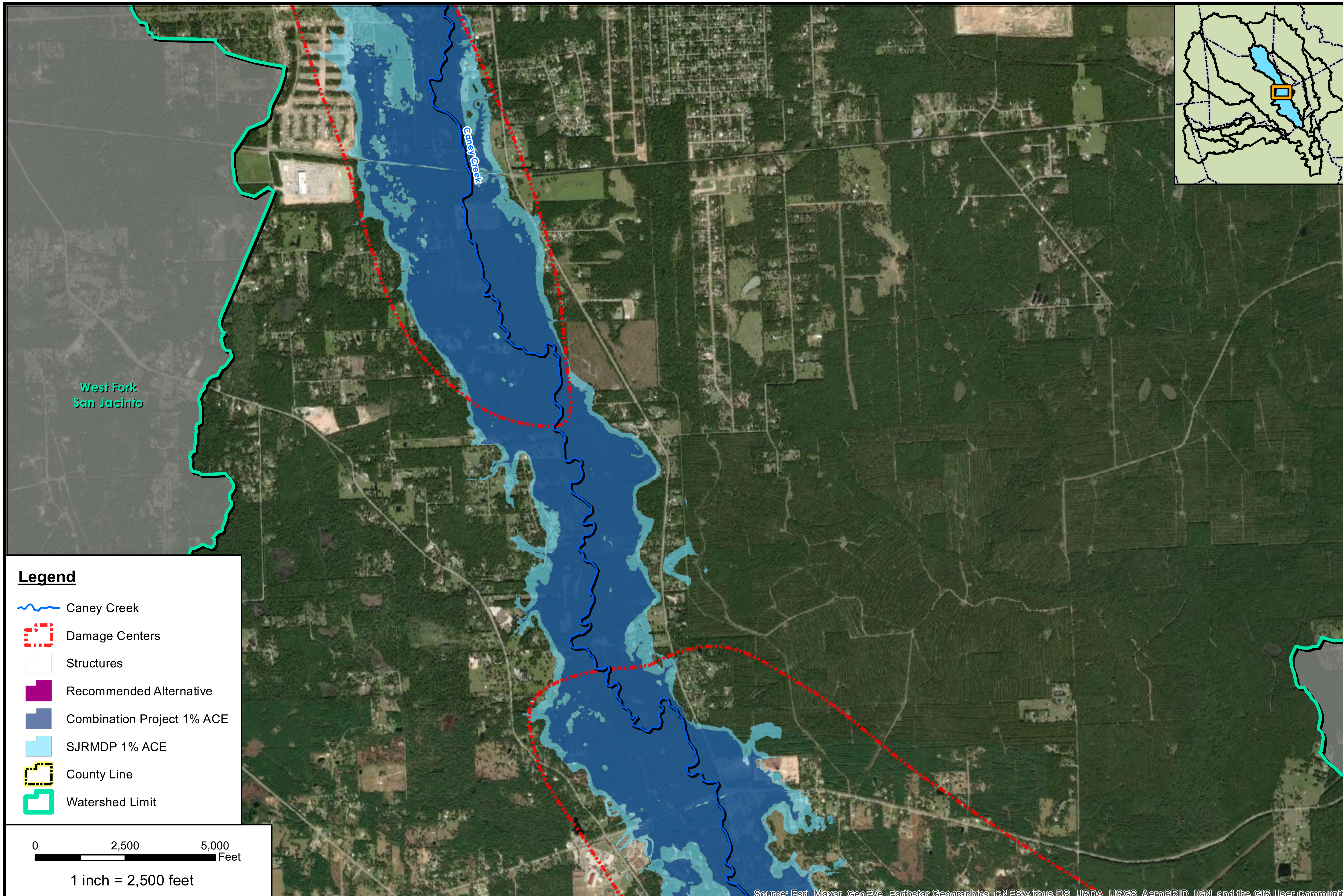
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map C



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HARRIS COUNTY FLOOD CONTROL DISTRICT

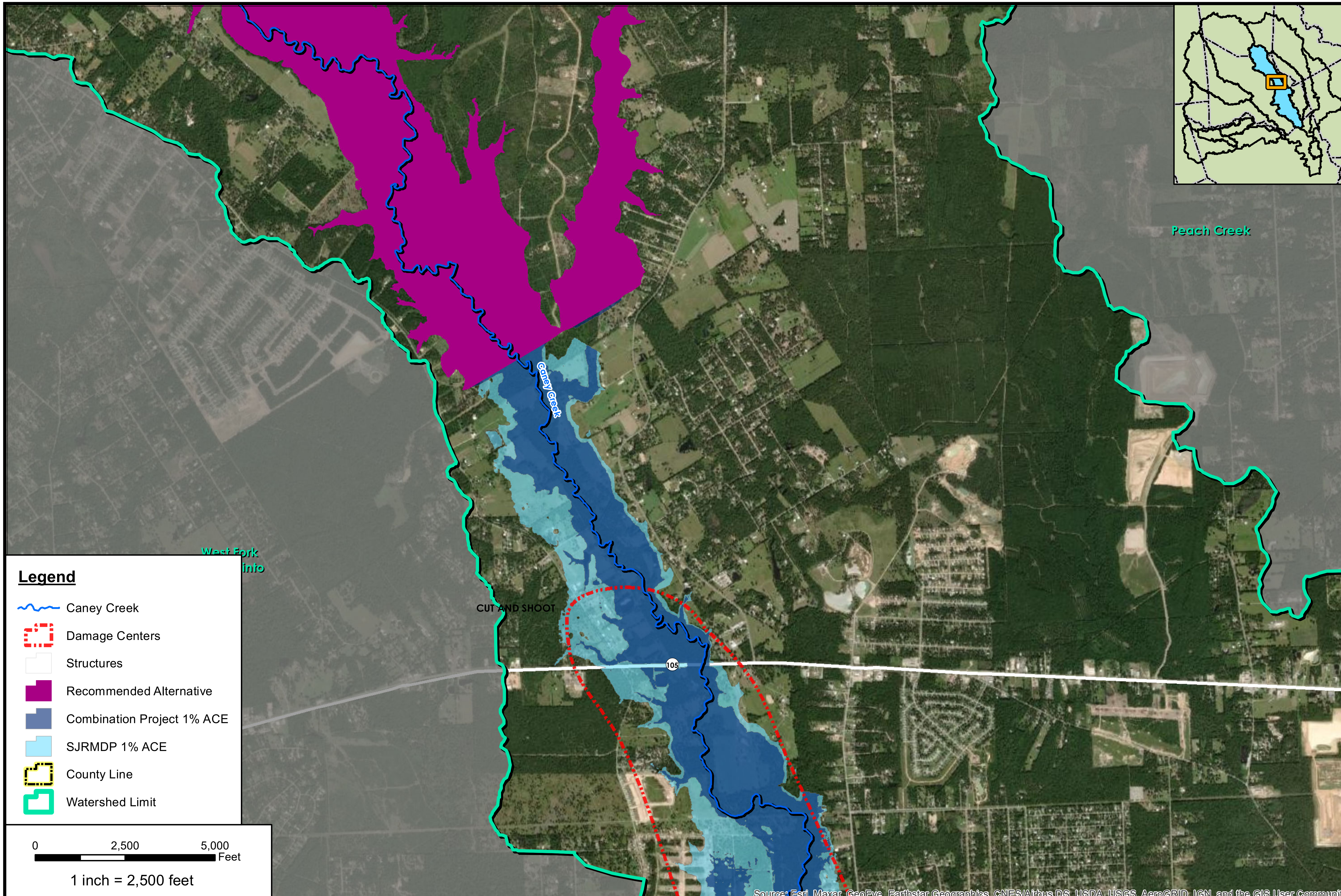
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map D



PROJECT AVO
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DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

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W E
S

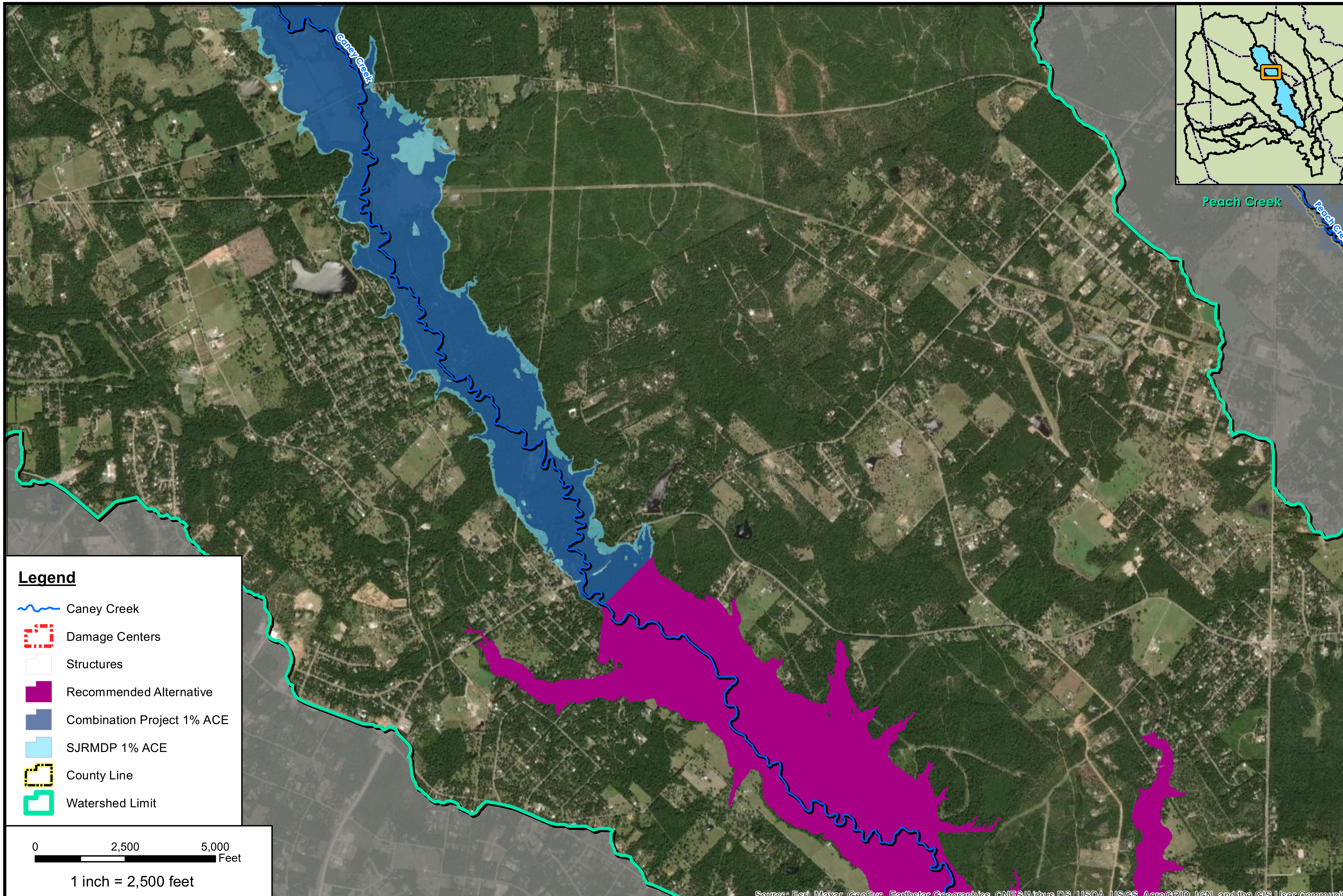
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit
G-1

Map E



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

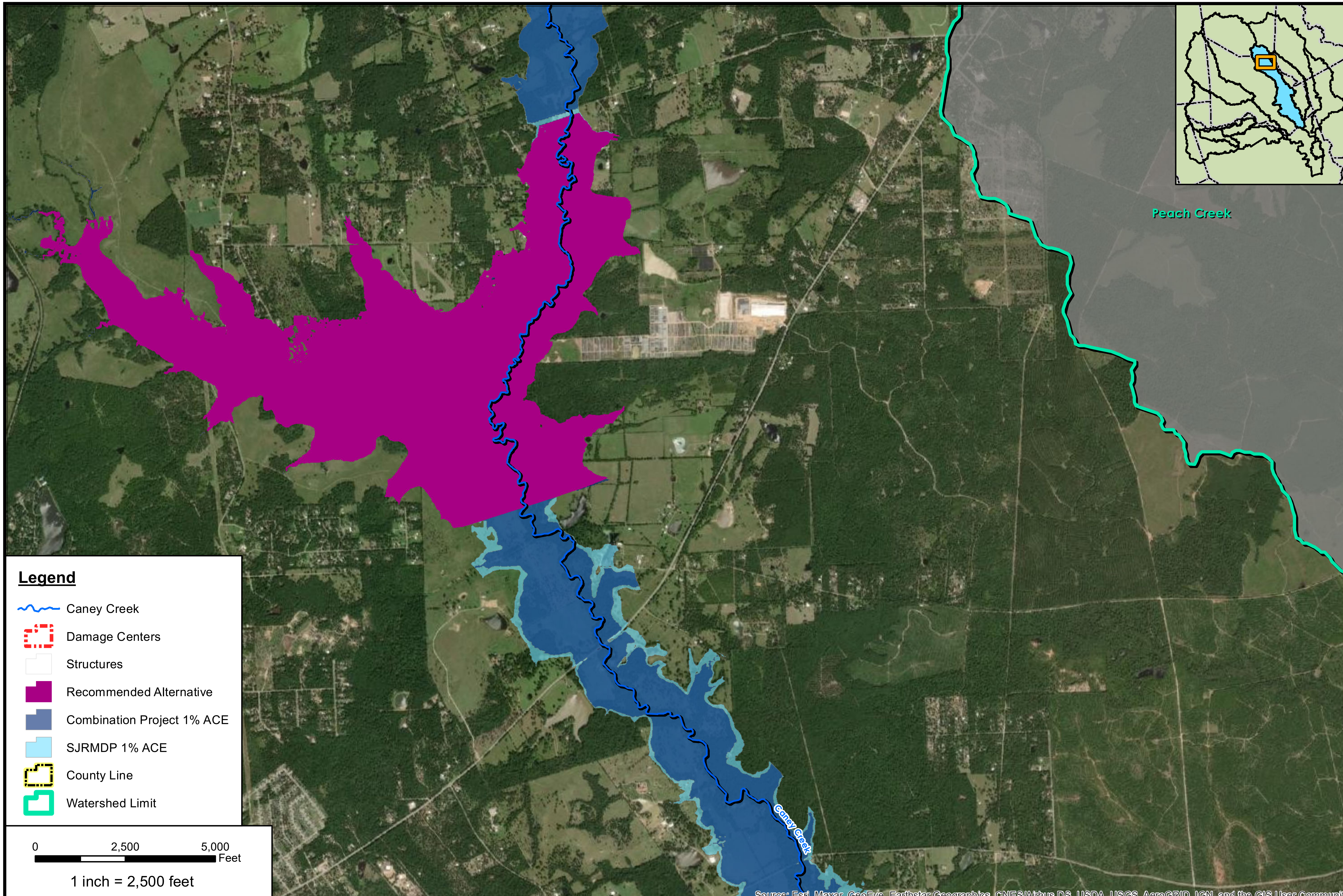
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map F



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33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

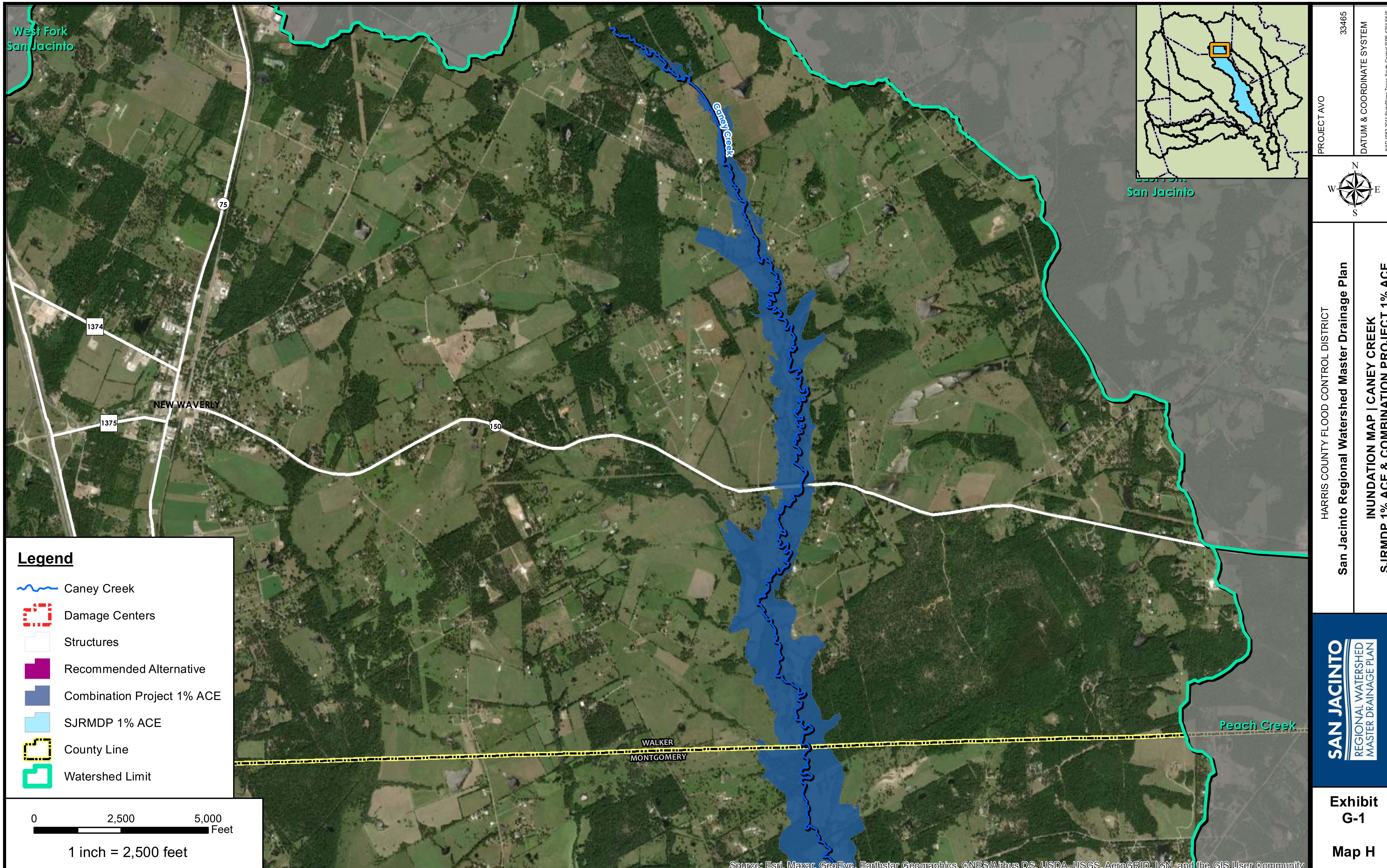
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map G



West Fork
San Jacinto
Caney Creek
75
1374
1375
NEW WAVERLY
150
East Fork
San Jacinto
Peach Creek
WALKER
MONTGOMERY
Legend
Caney Creek
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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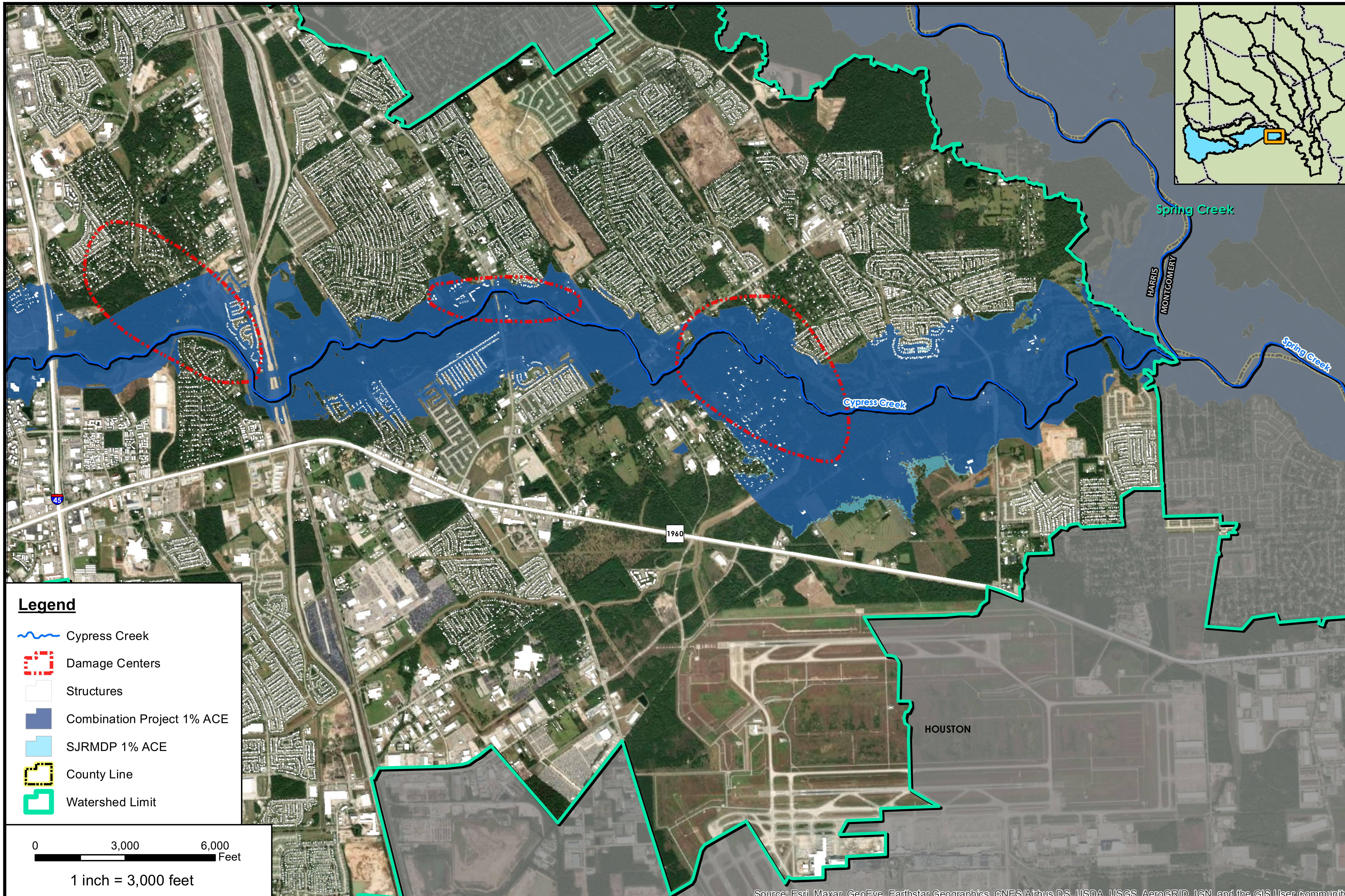
E
S
W
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | CANEY CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map H



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

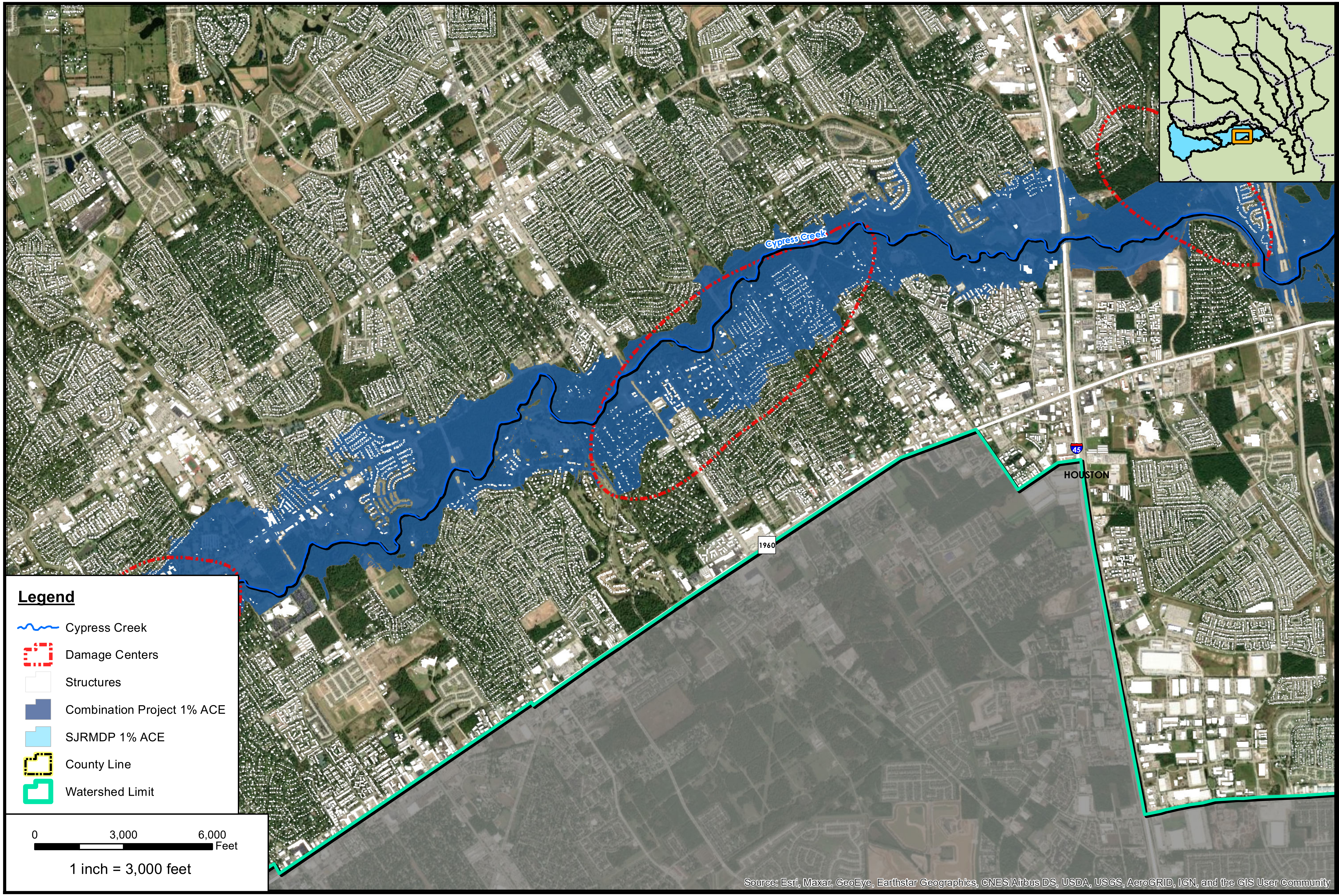
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

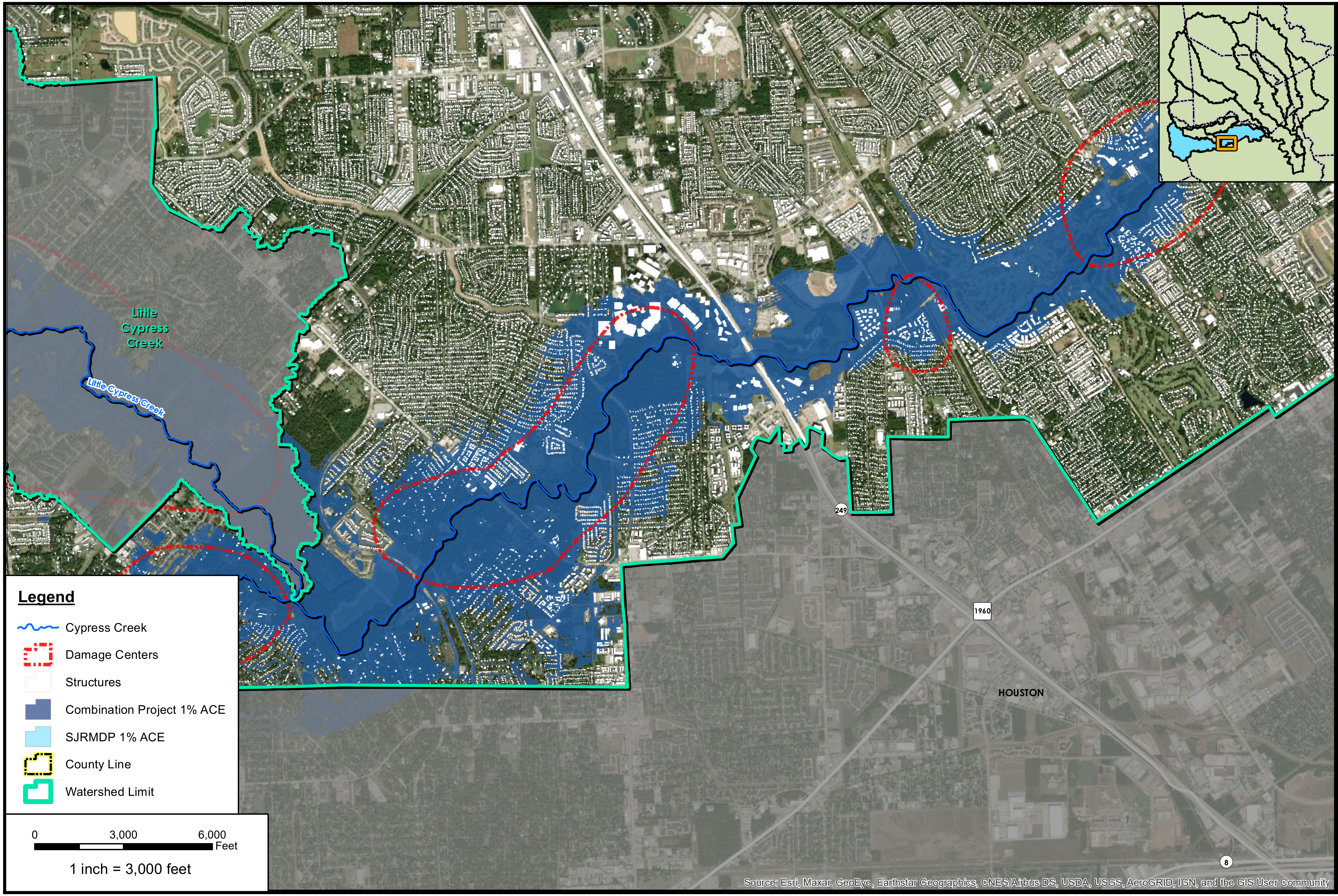
INUNDATION MAP | CYPRESS CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map B



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

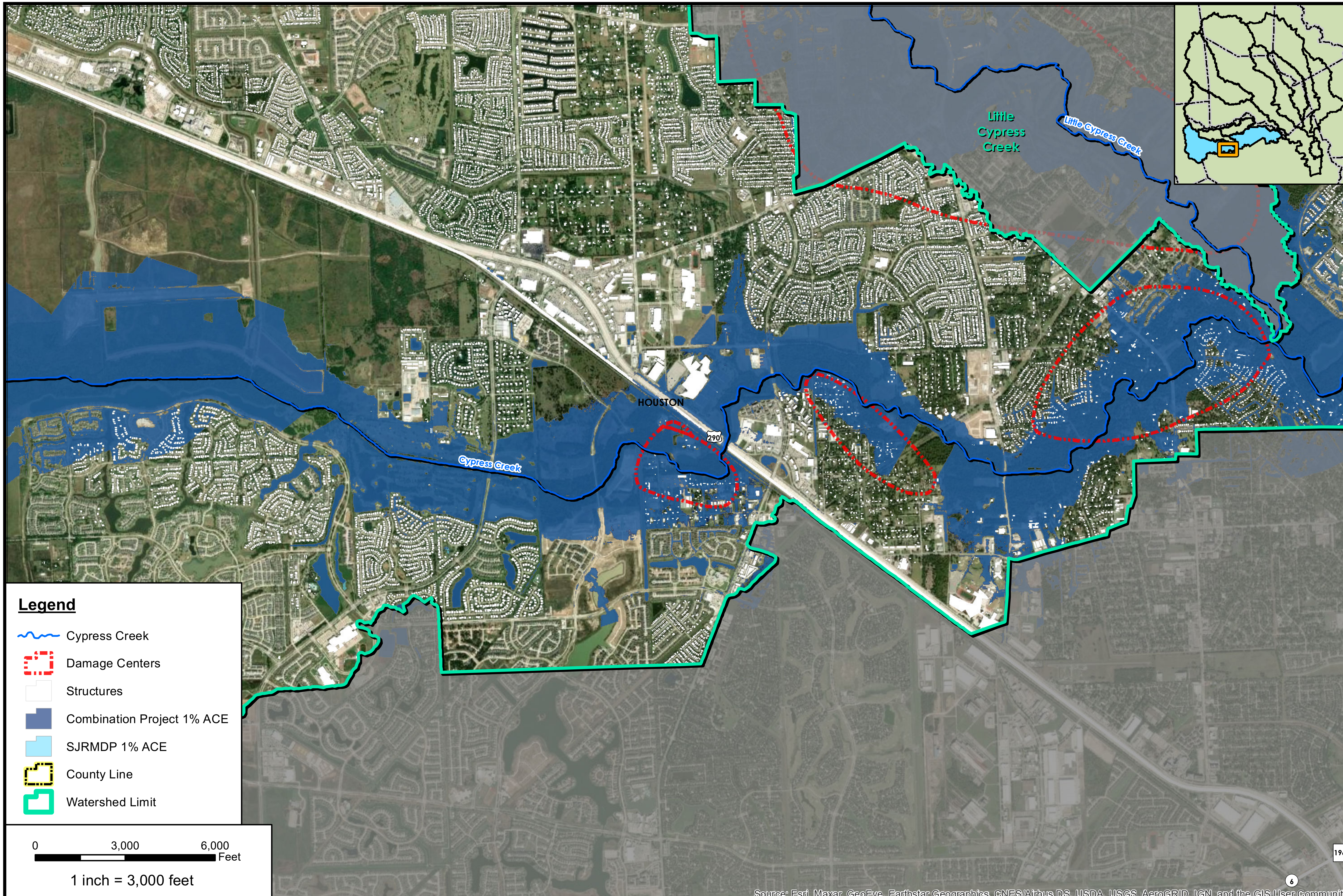
INUNDATION MAP | CYPRESS CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map C



PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

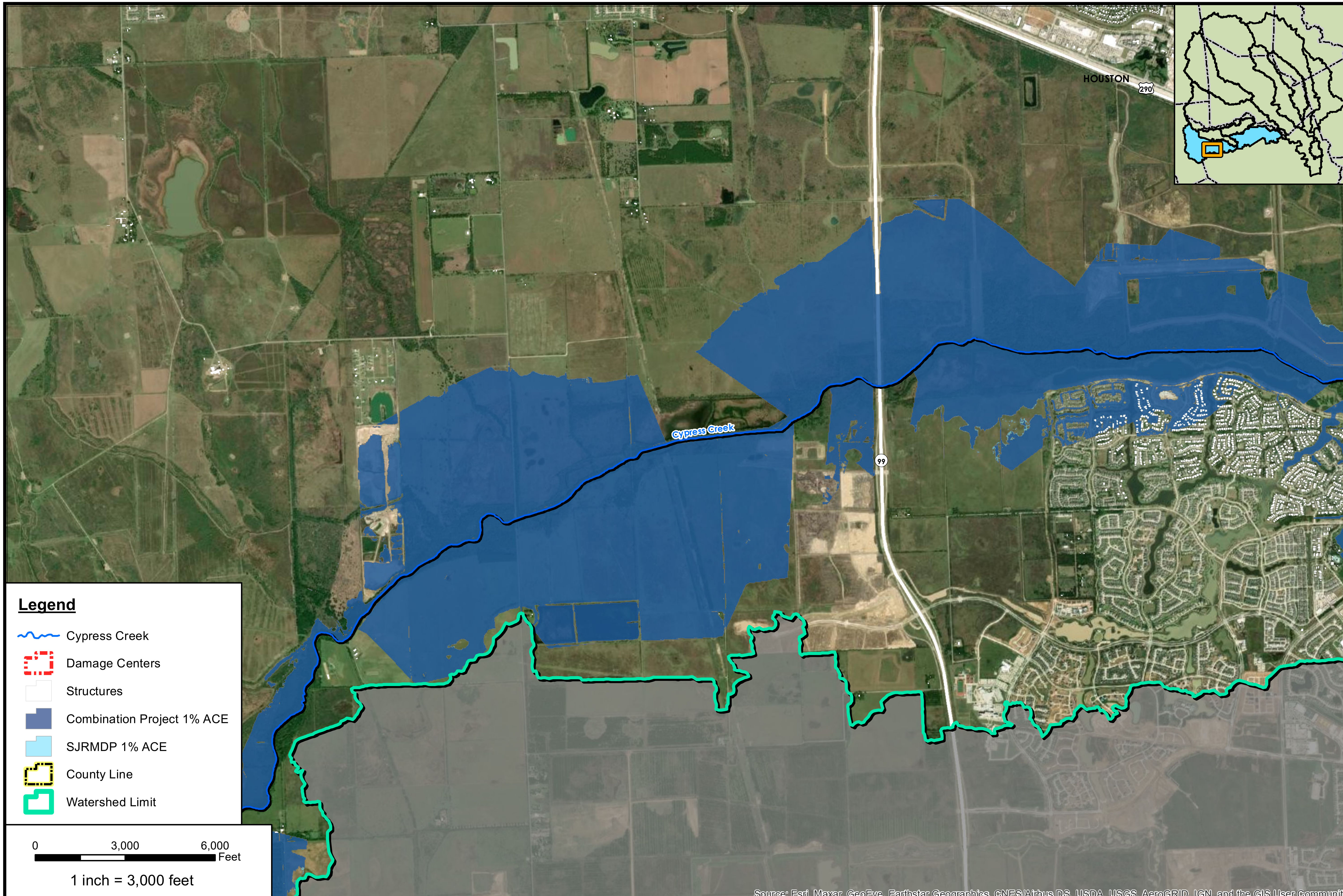
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map D



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

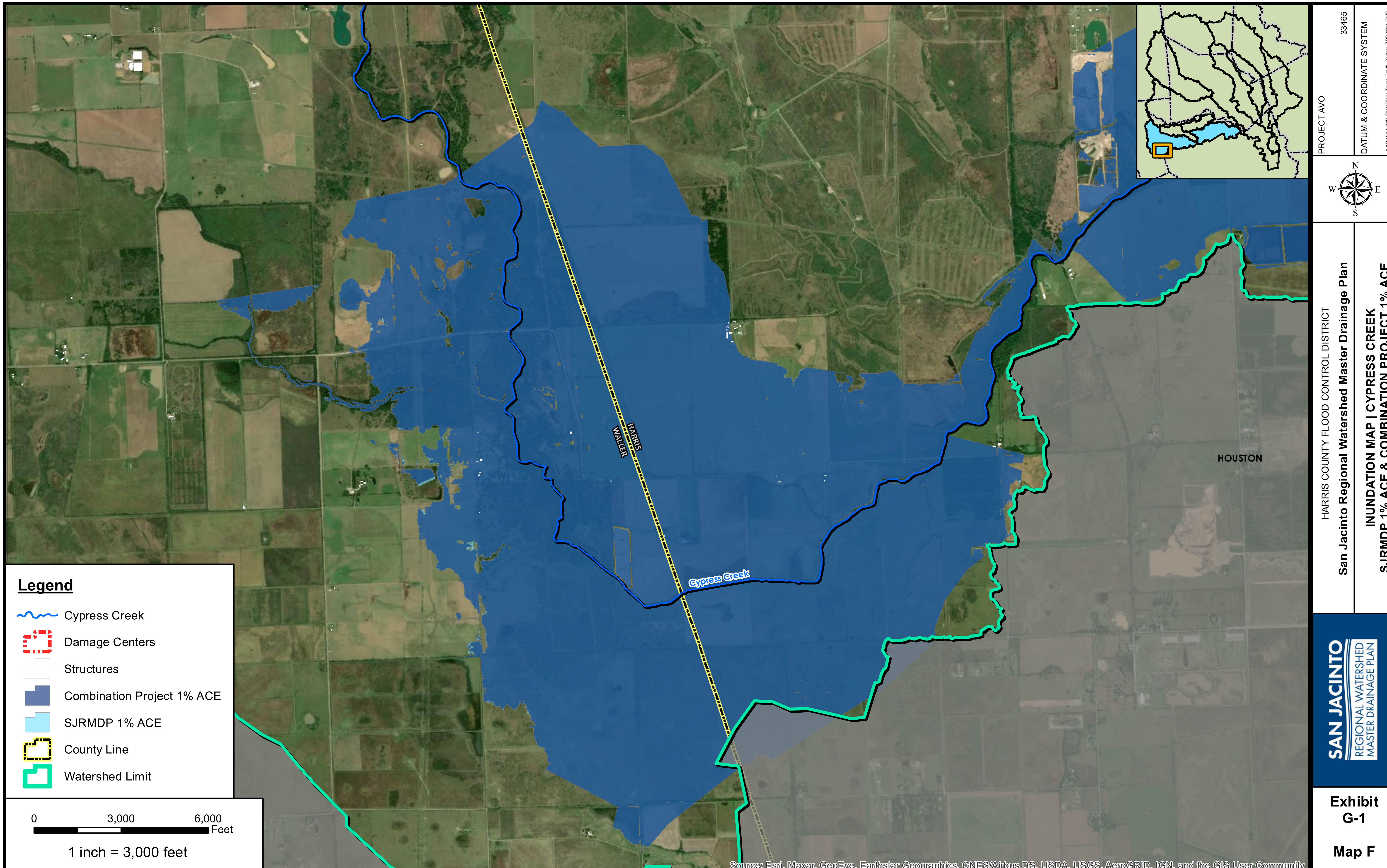
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map E



HARRIS
WALLER
Cypress Creek
HOUSTON
Legend
Cypress Creek
Damage Centers
Structures
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
3,000
6,000
Feet
1 inch = 3,000 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS
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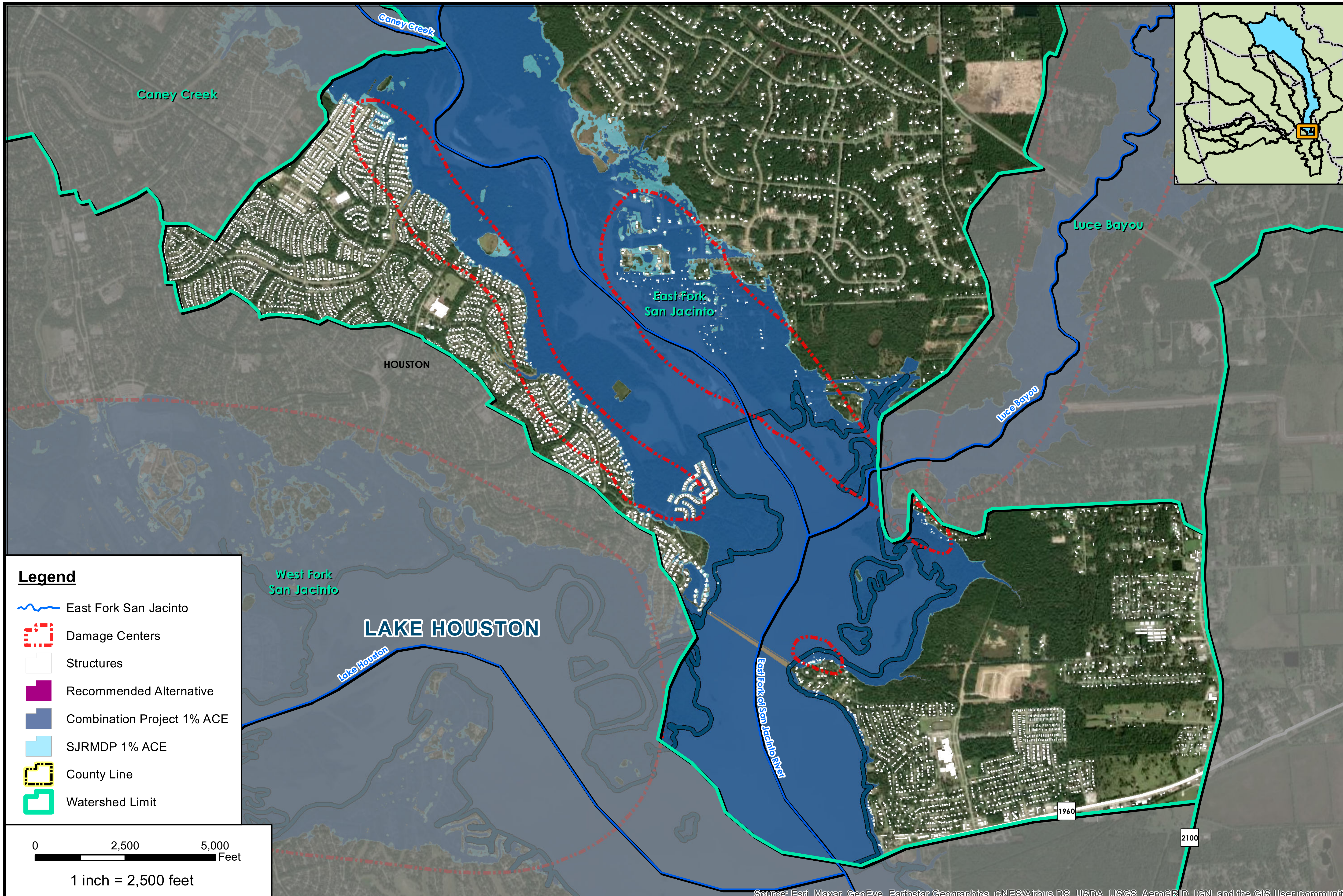
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map F



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

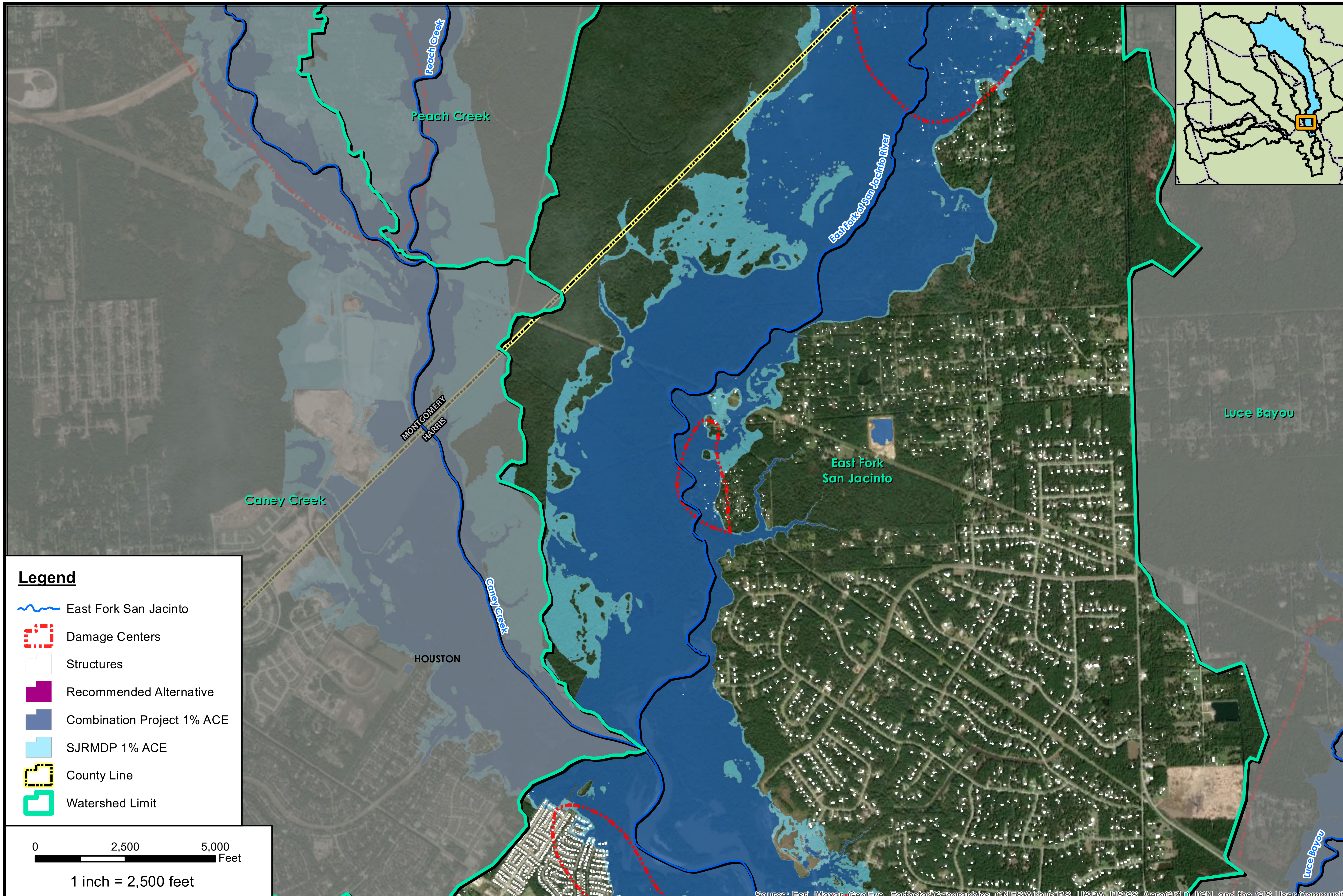
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

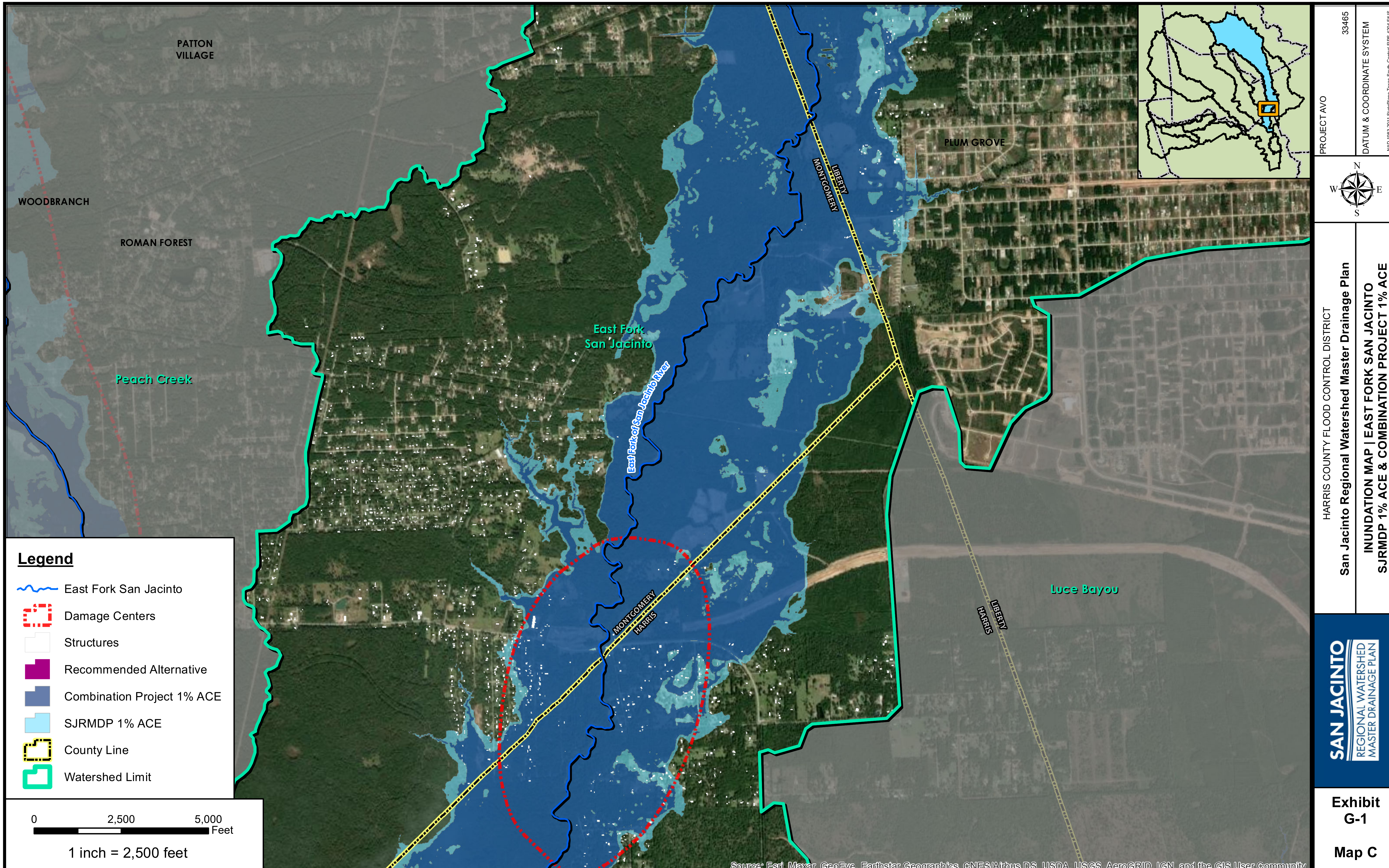
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit G-1

Map B



PATTON VILLAGE
WOODBRANCH
ROMAN FOREST
Peach Creek
East Fork San Jacinto
East Fork of San Jacinto River
PLUM GROVE
LIBERTY
MONTGOMERY
HARRIS
Luce Bayou
Legend
East Fork San Jacinto
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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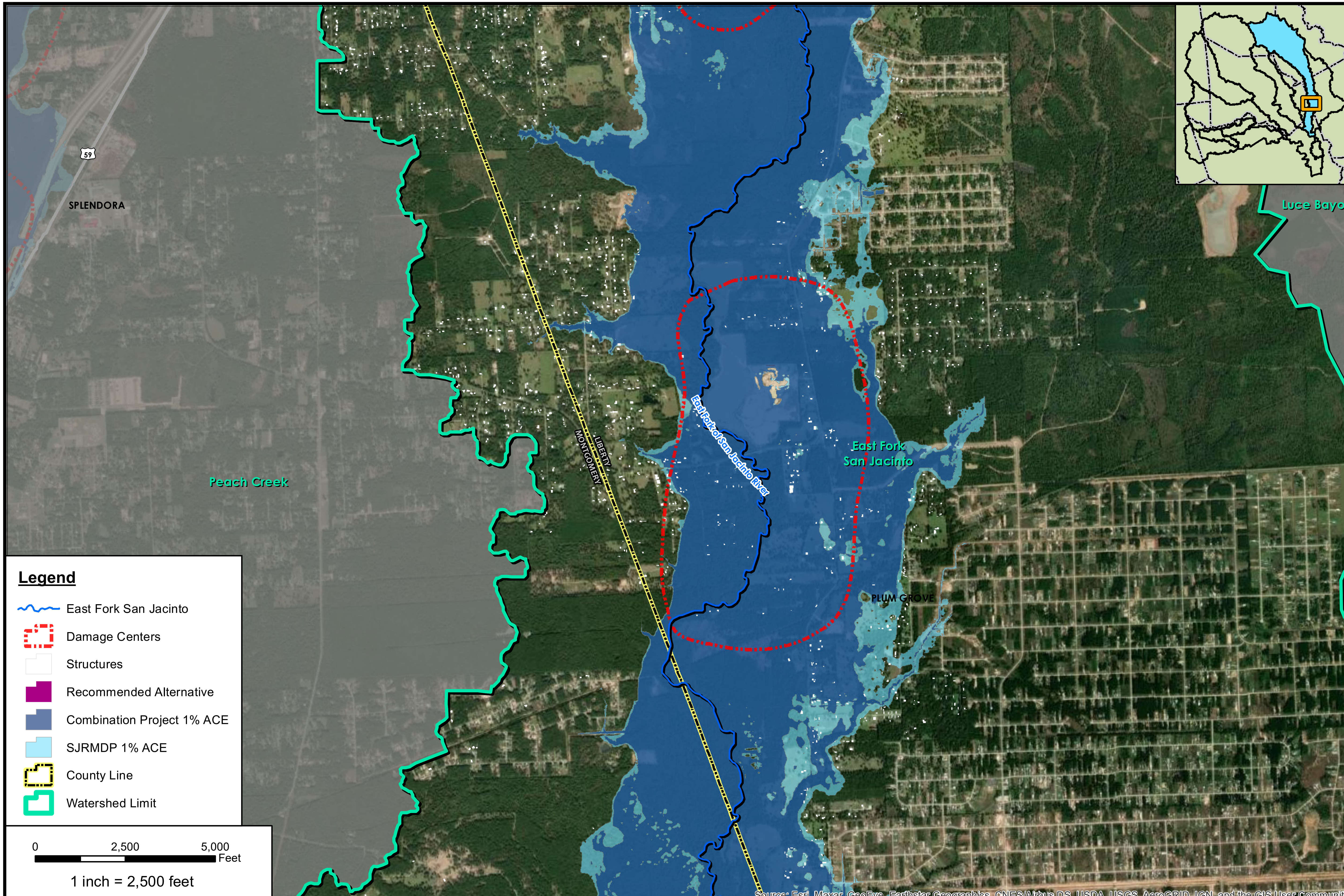
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit G-1
Map C



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

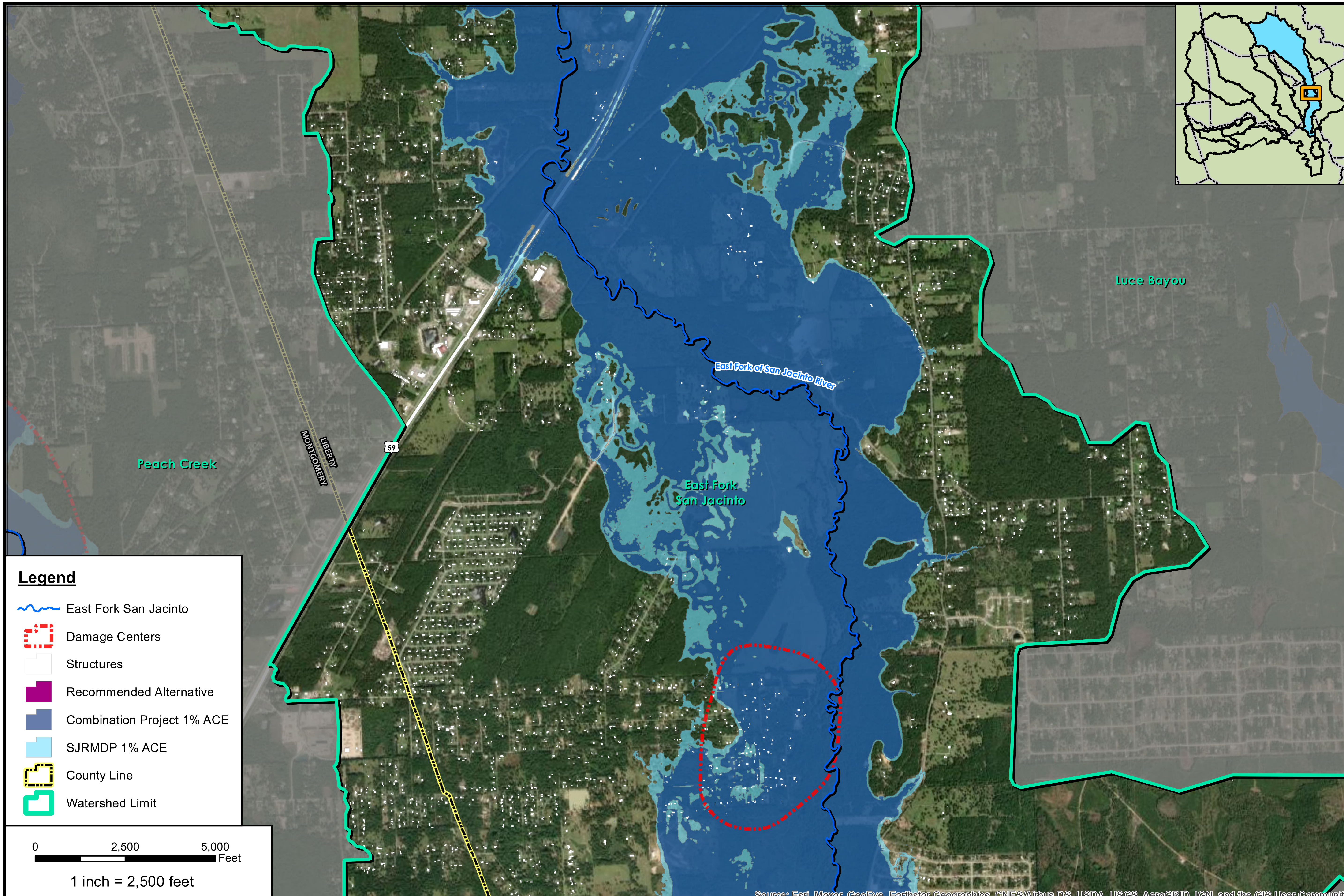
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map D



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

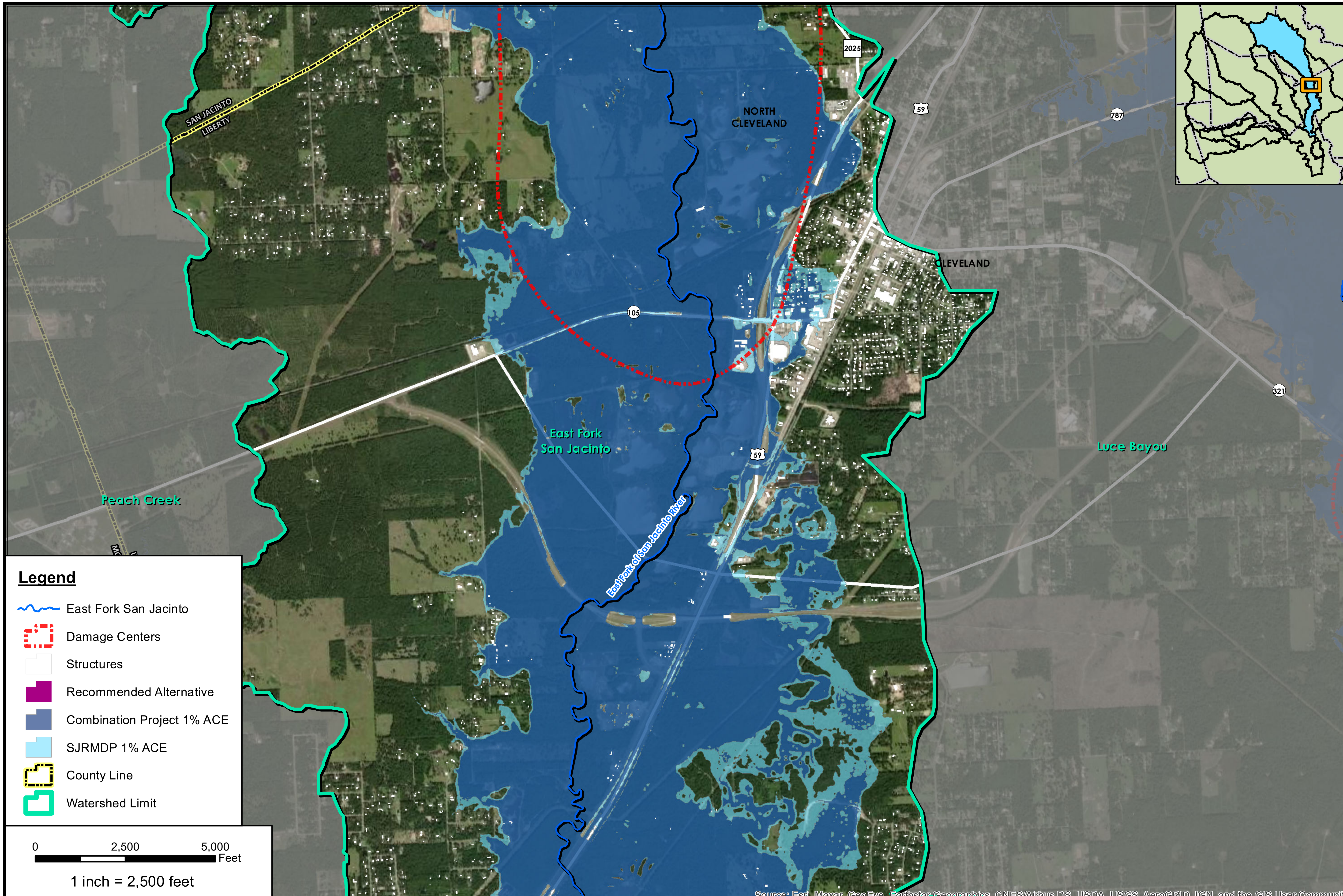
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map E



PROJECT AVO

33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

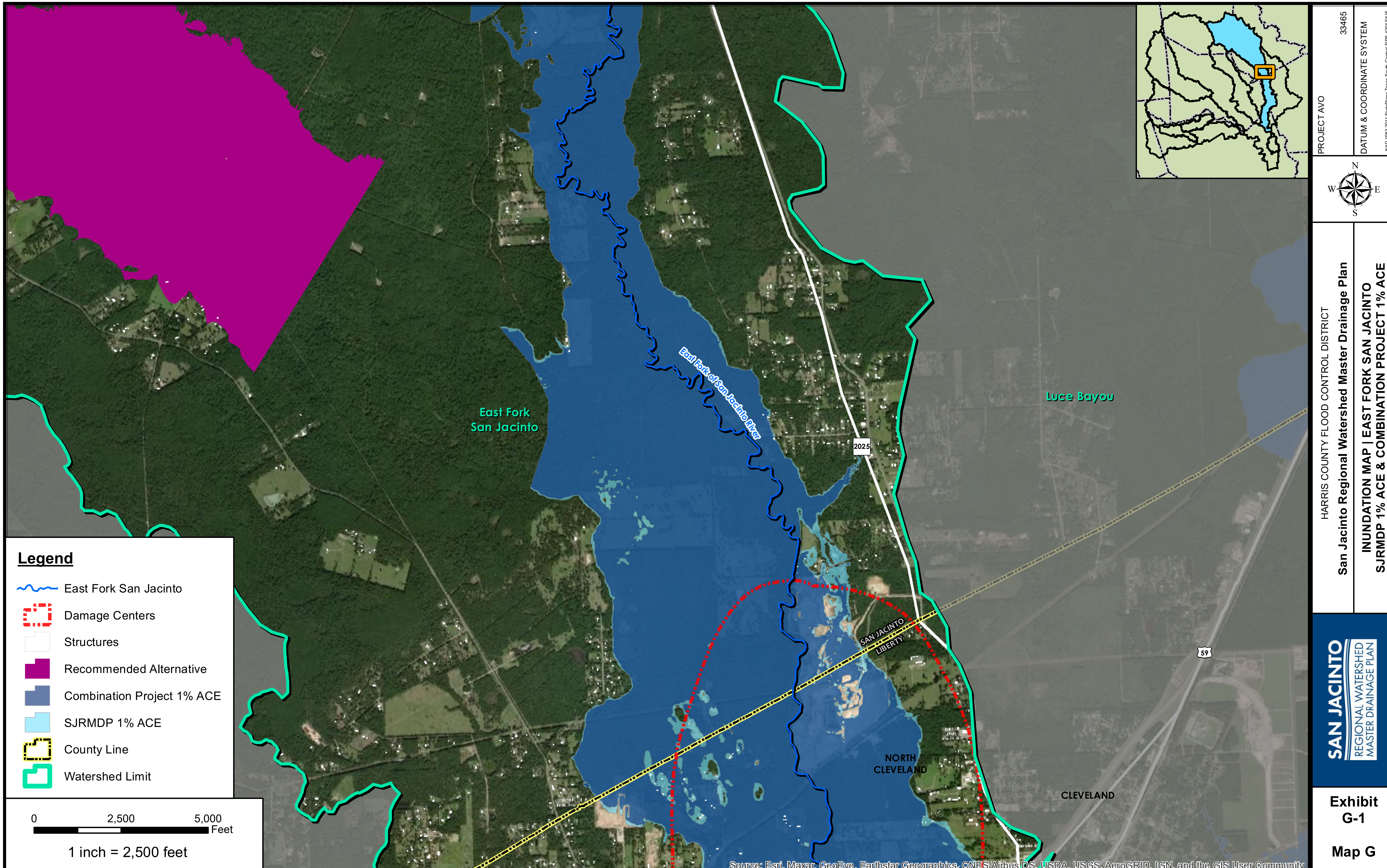
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map F


East Fork of San Jacinto River
East Fork
San Jacinto
Luce Bayou
2025
59
SAN JACINTO
LIBERTY
NORTH
CLEVELAND
CLEVELAND
Legend
East Fork San Jacinto
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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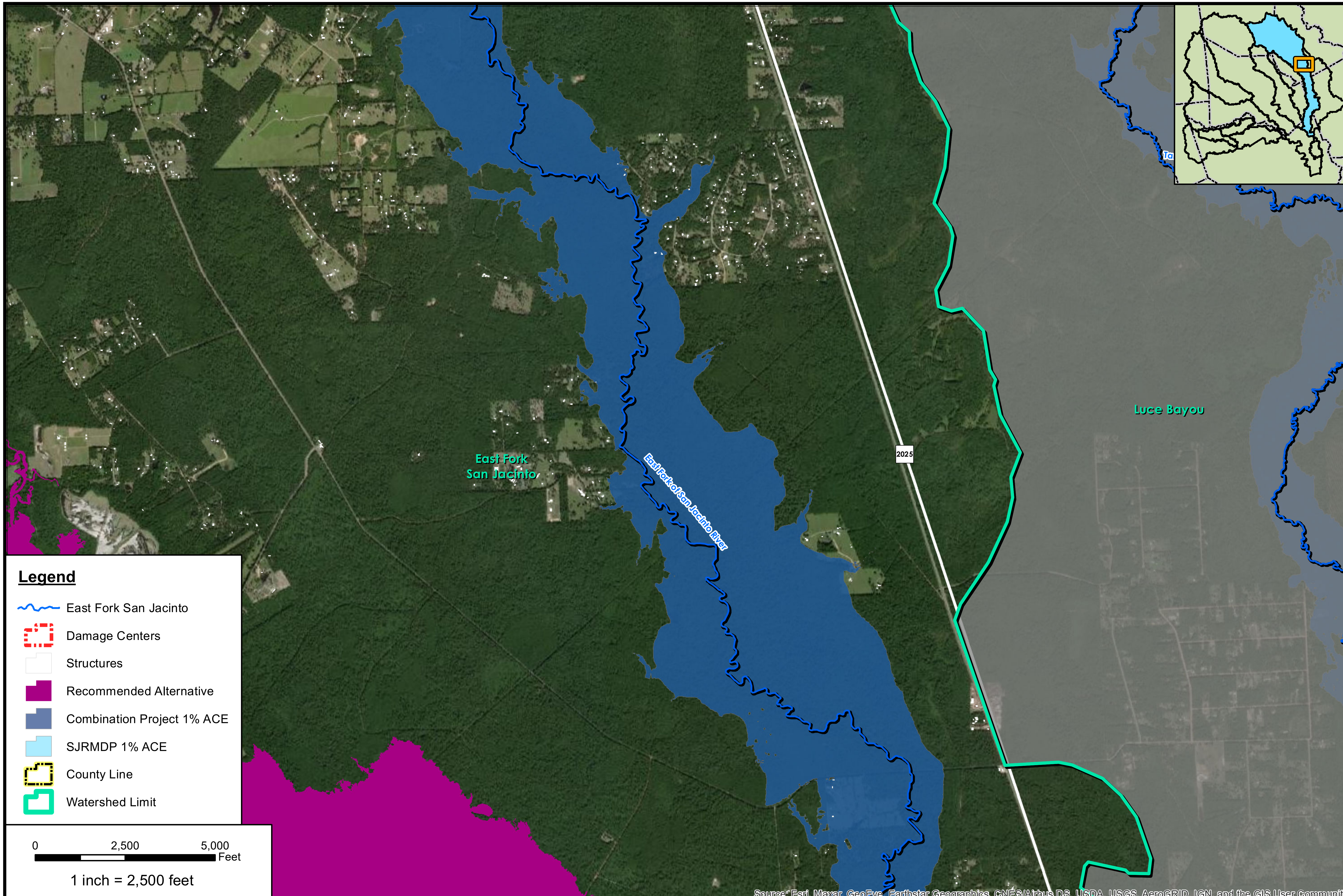
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Feet
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map G



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

N E S W

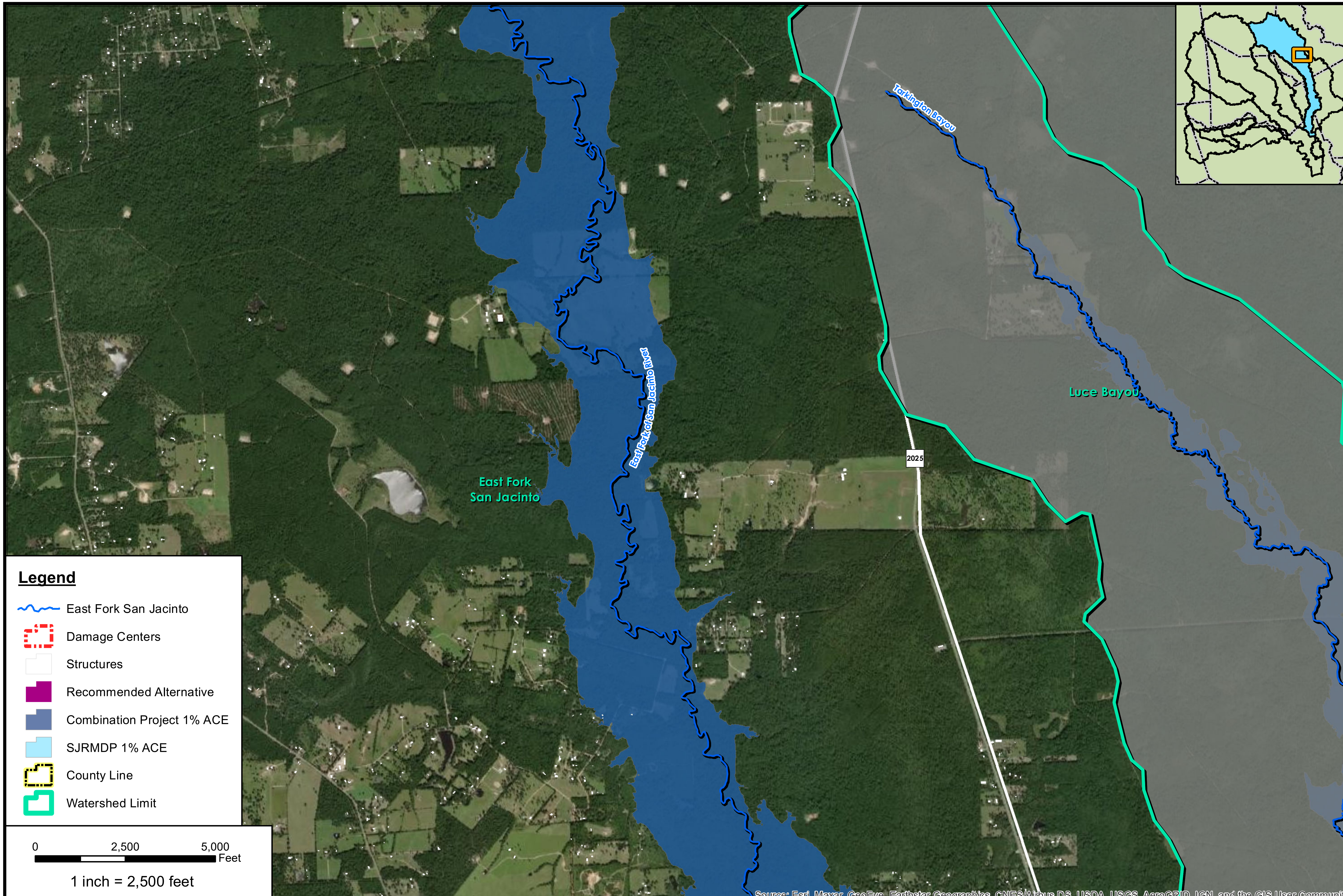
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map H



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

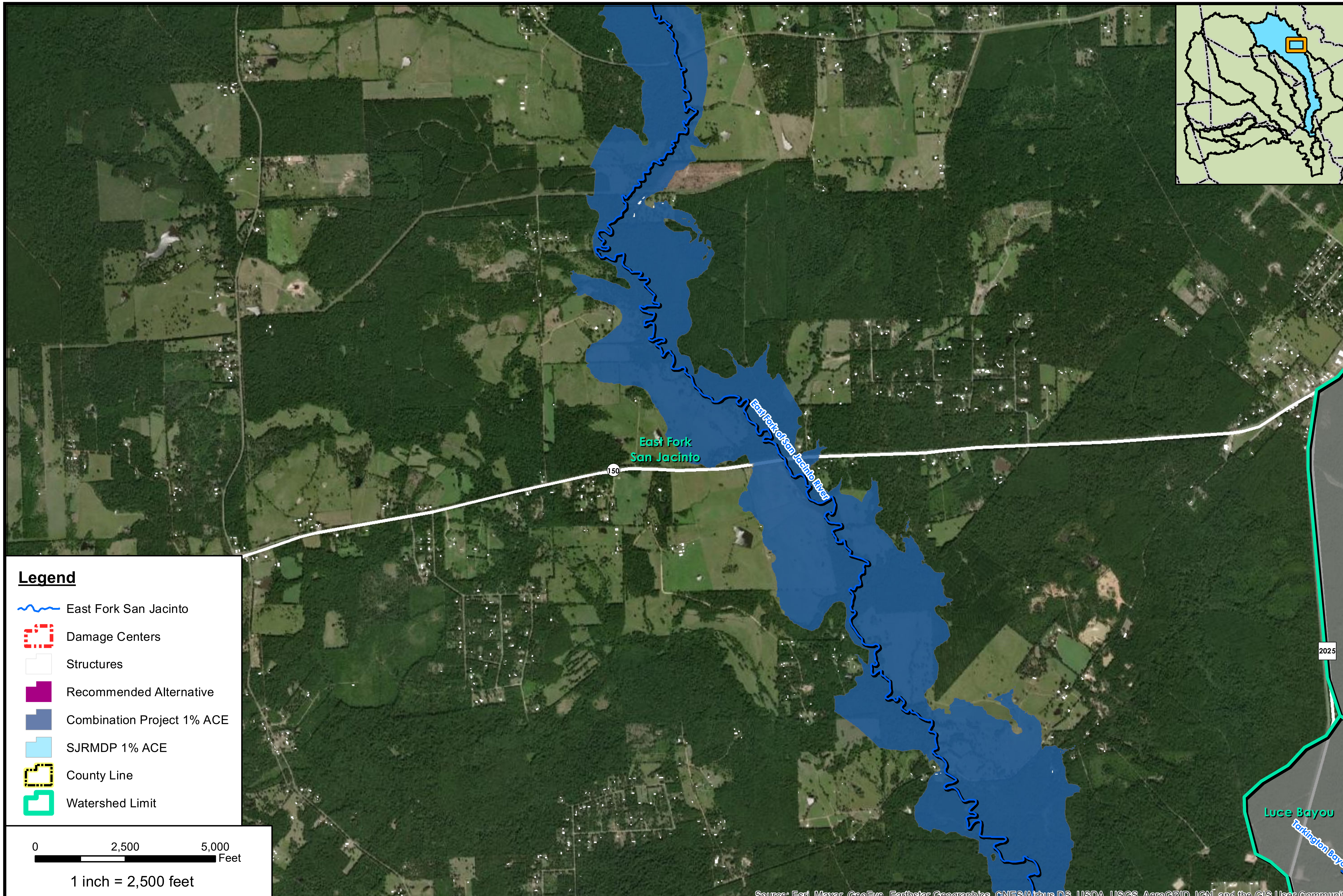
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit
G-1

Map I



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

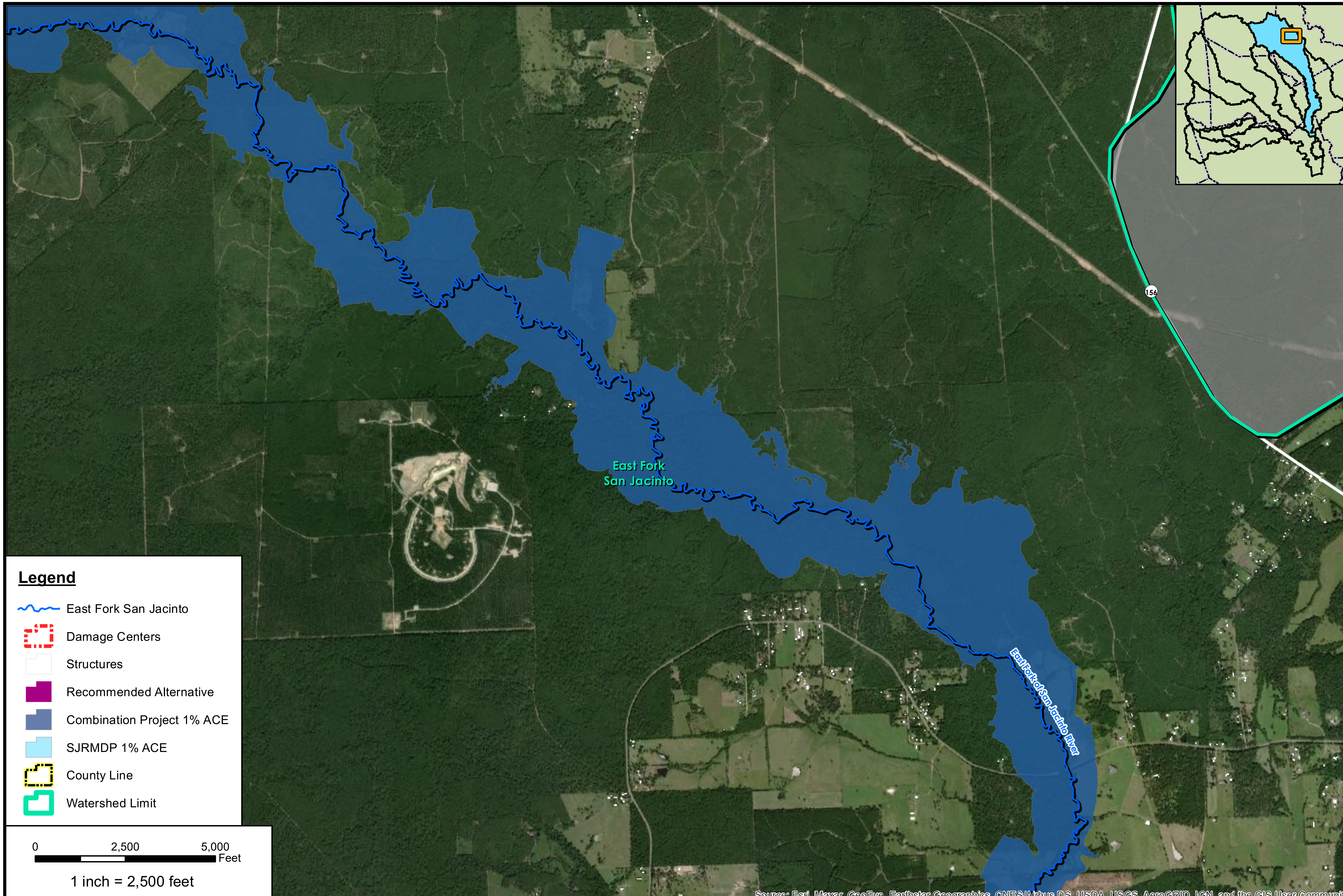
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map J



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

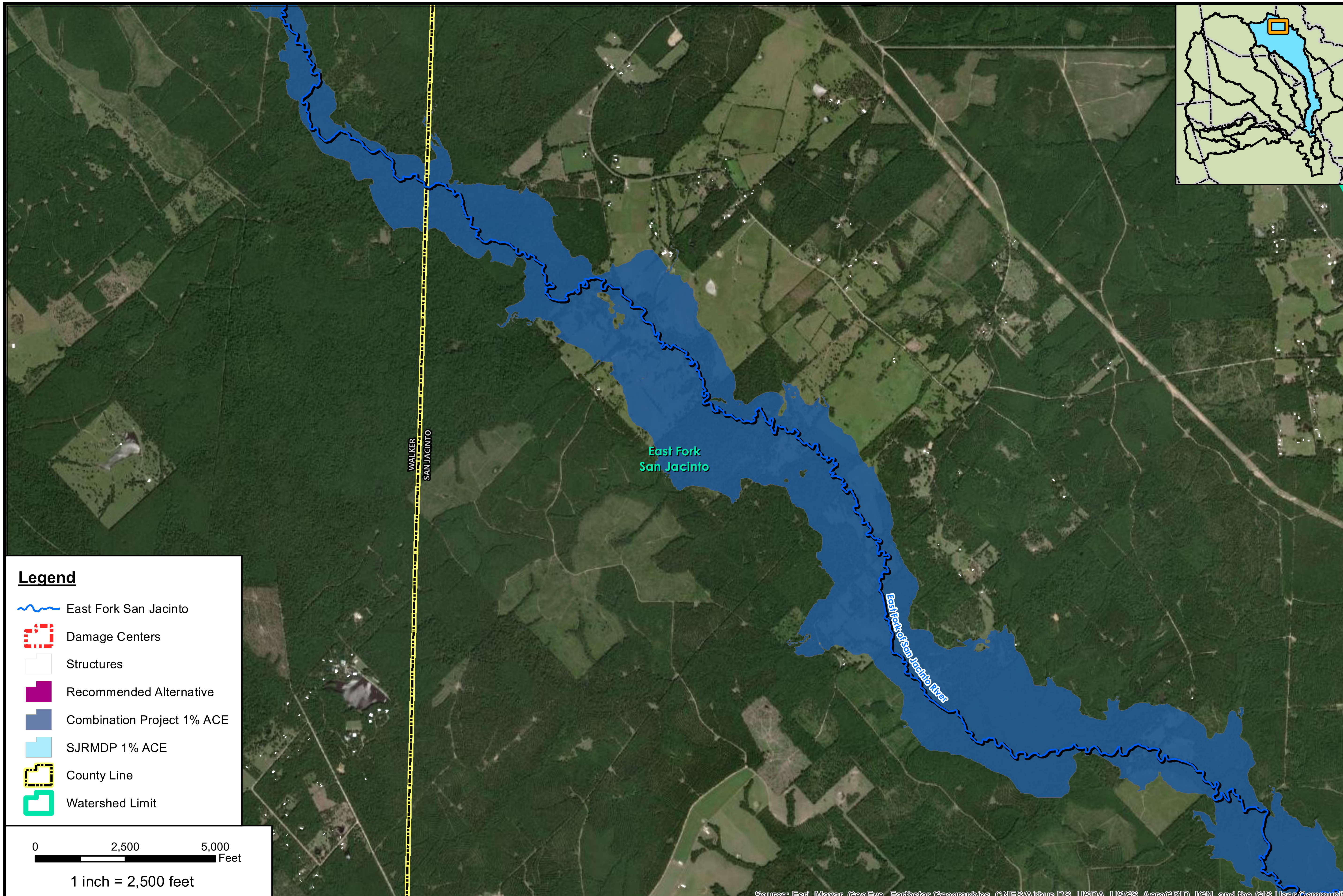
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map K



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

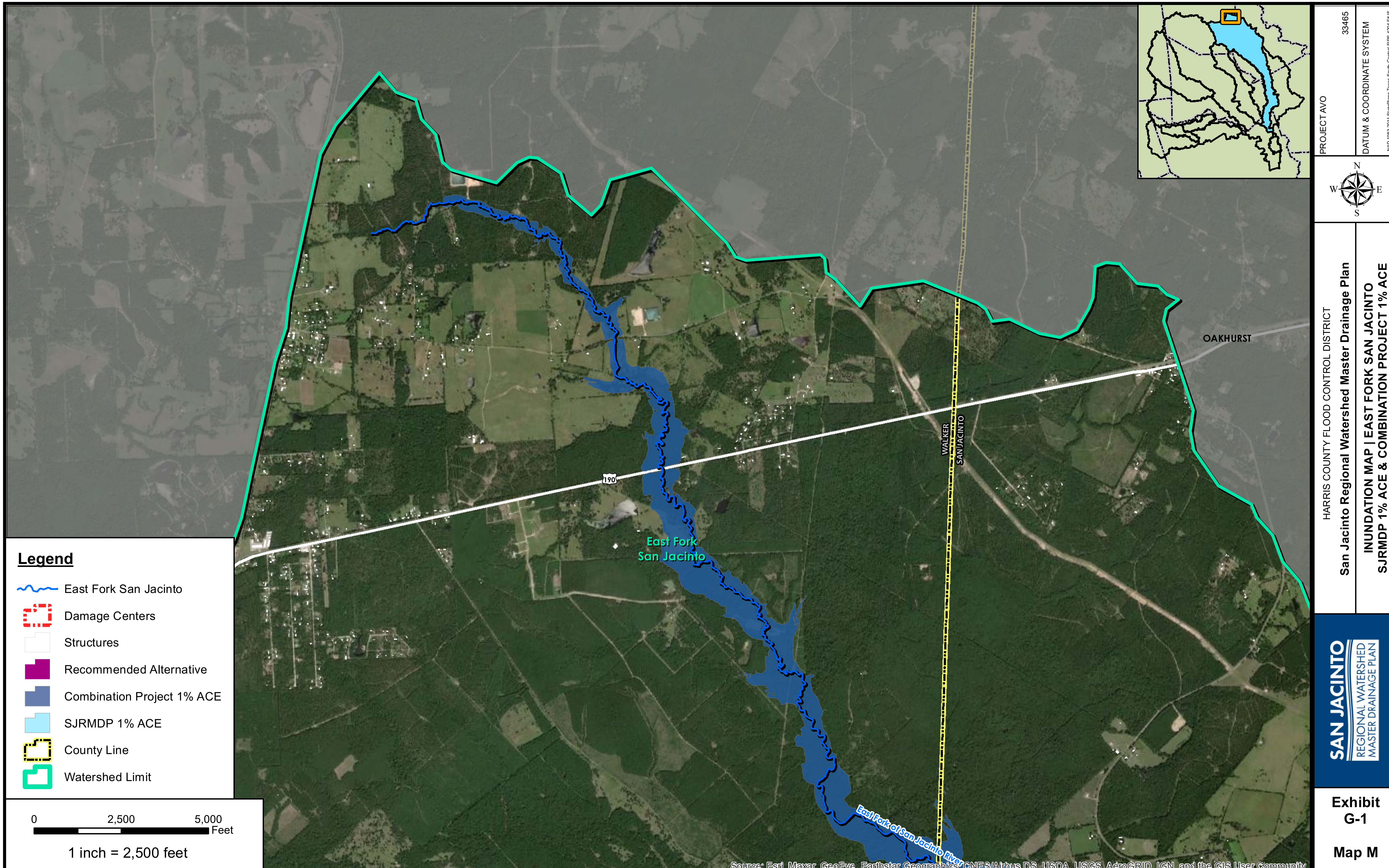
INUNDATION MAP | EAST FORK SAN JACINTO

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map L



OAKHURST
190
WALKER
SAN JACINTO
East Fork San Jacinto
East Fork of San Jacinto River
Legend
East Fork San Jacinto
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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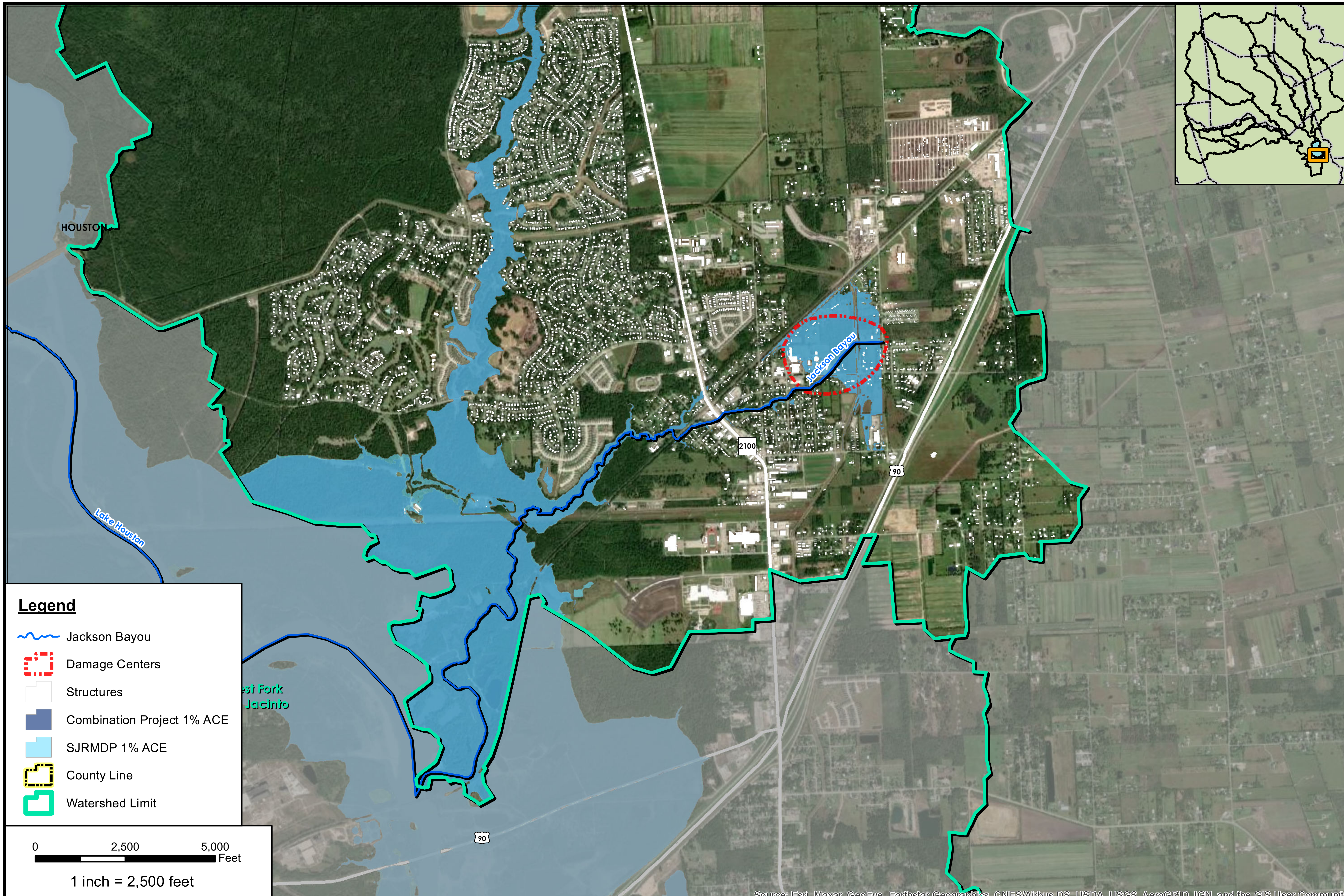
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | EAST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit G-1
Map M



PROJECT AVO 33465

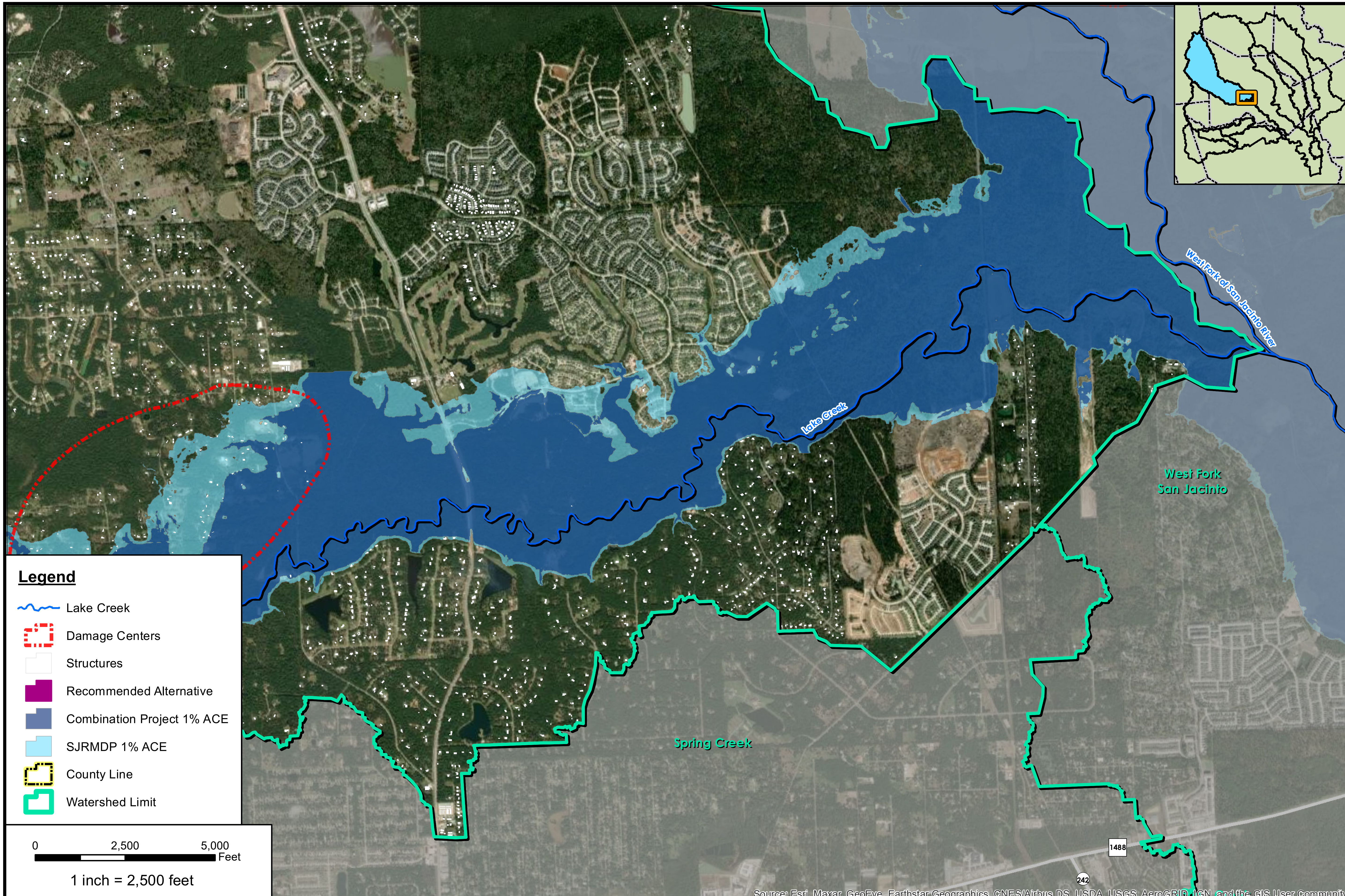
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | JACKSON BAYOU
SJRMDP 1% & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit 11



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

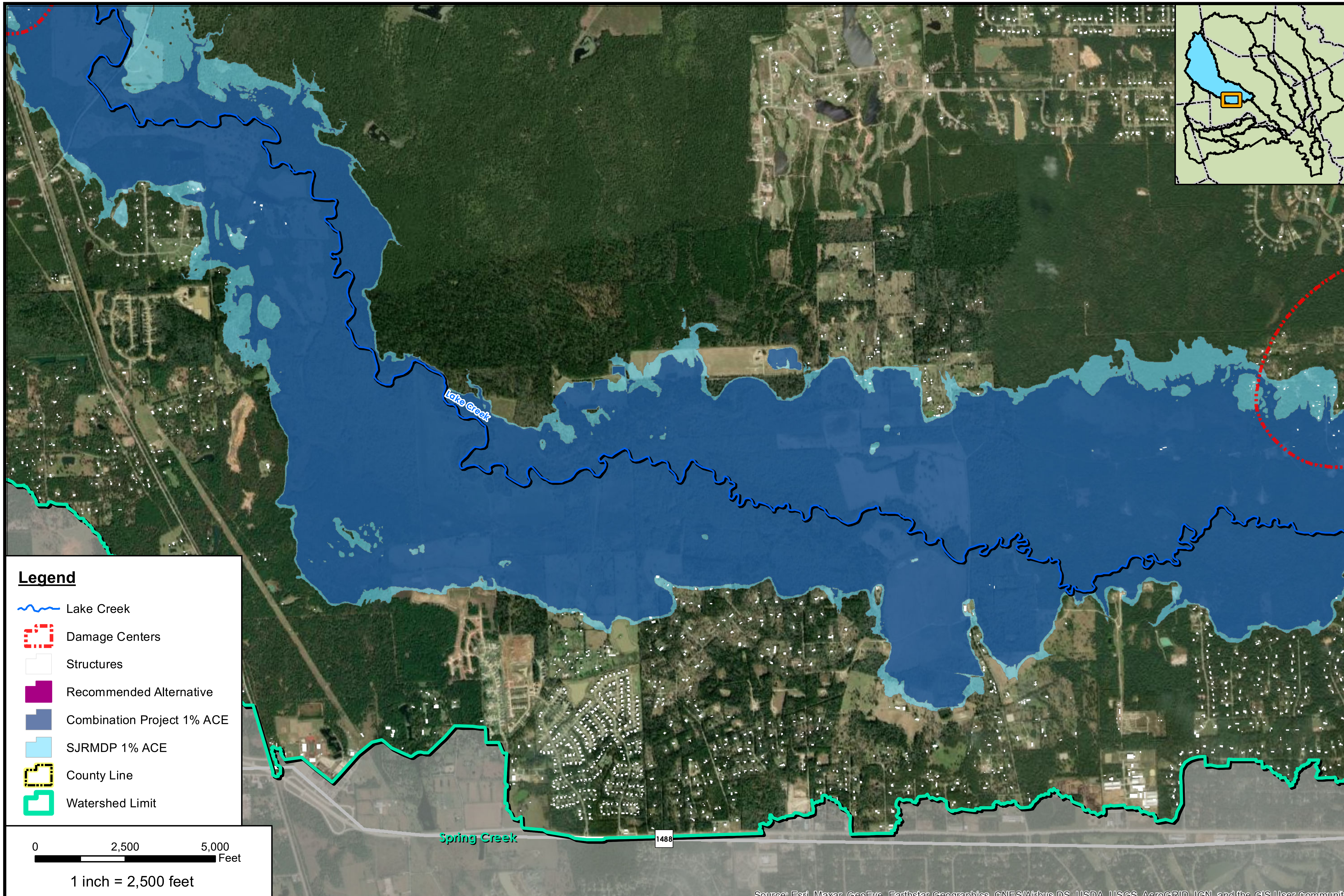
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

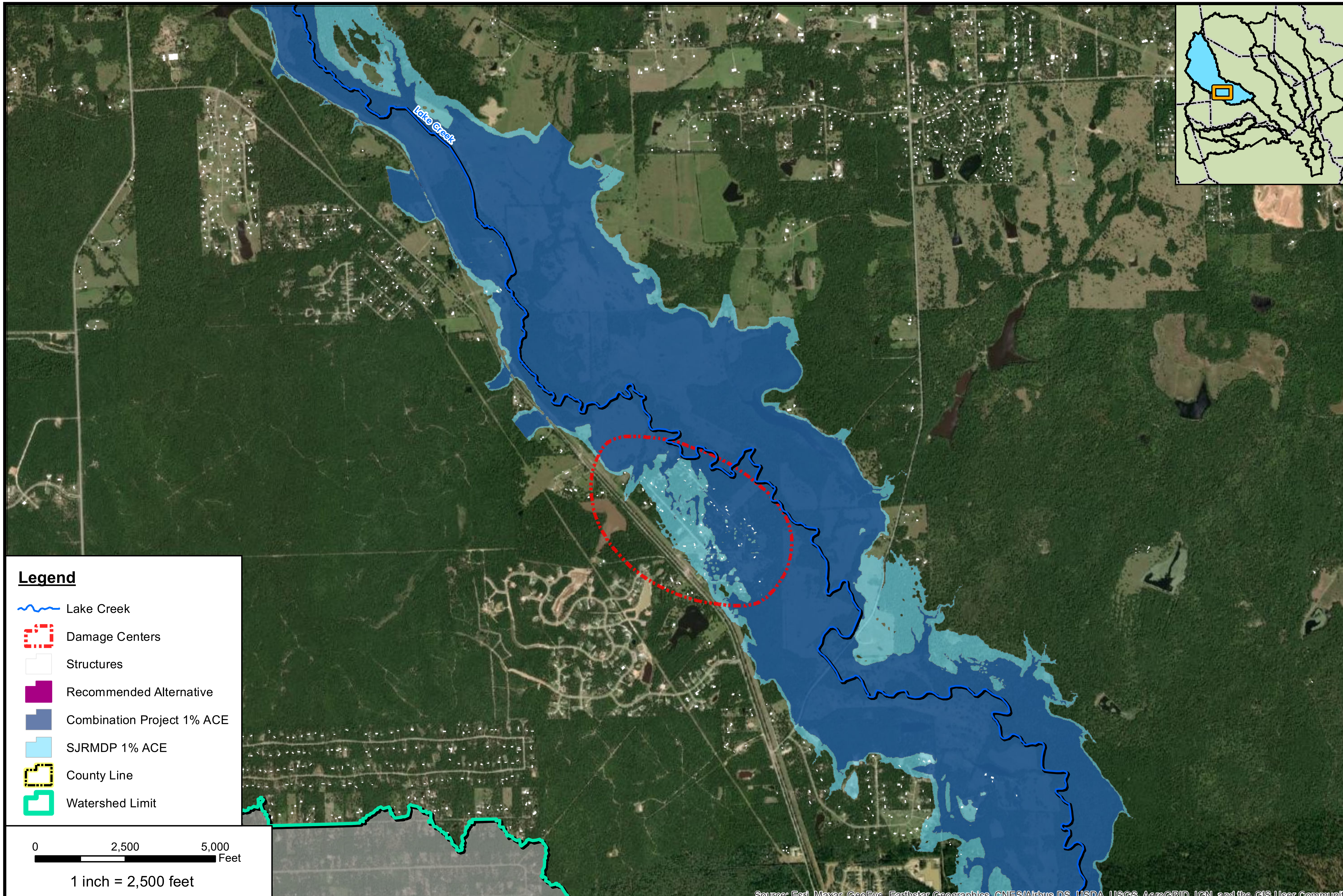
INUNDATION MAP | LAKE CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map B



PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ftus

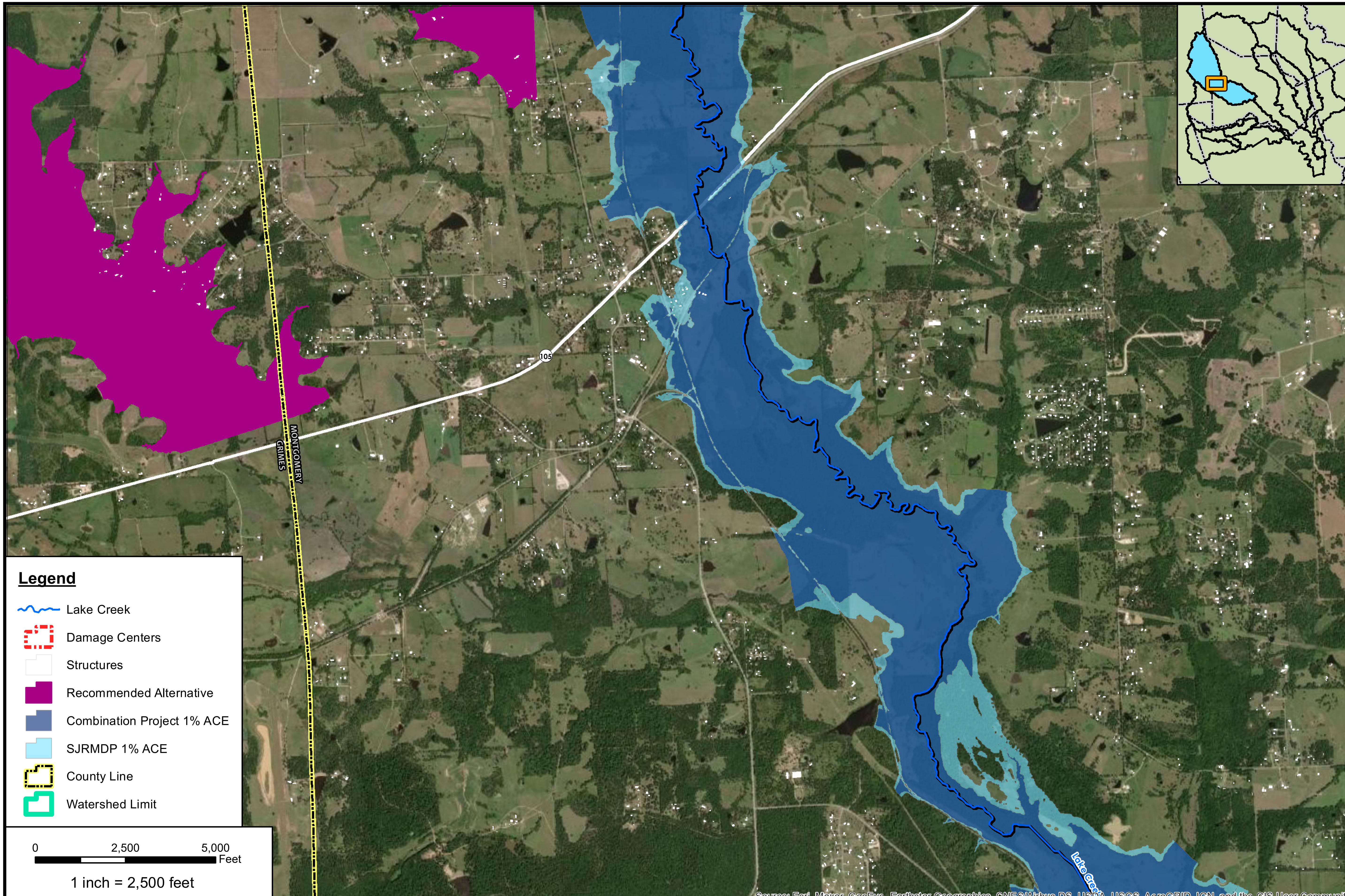
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map C



Legend

- Lake Creek
- Damage Centers
- Structures
- Recommended Alternative
- Combination Project 1% ACE
- SJRMDP 1% ACE
- County Line
- Watershed Limit

0 2,500 5,000 Feet

1 inch = 2,500 feet

PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

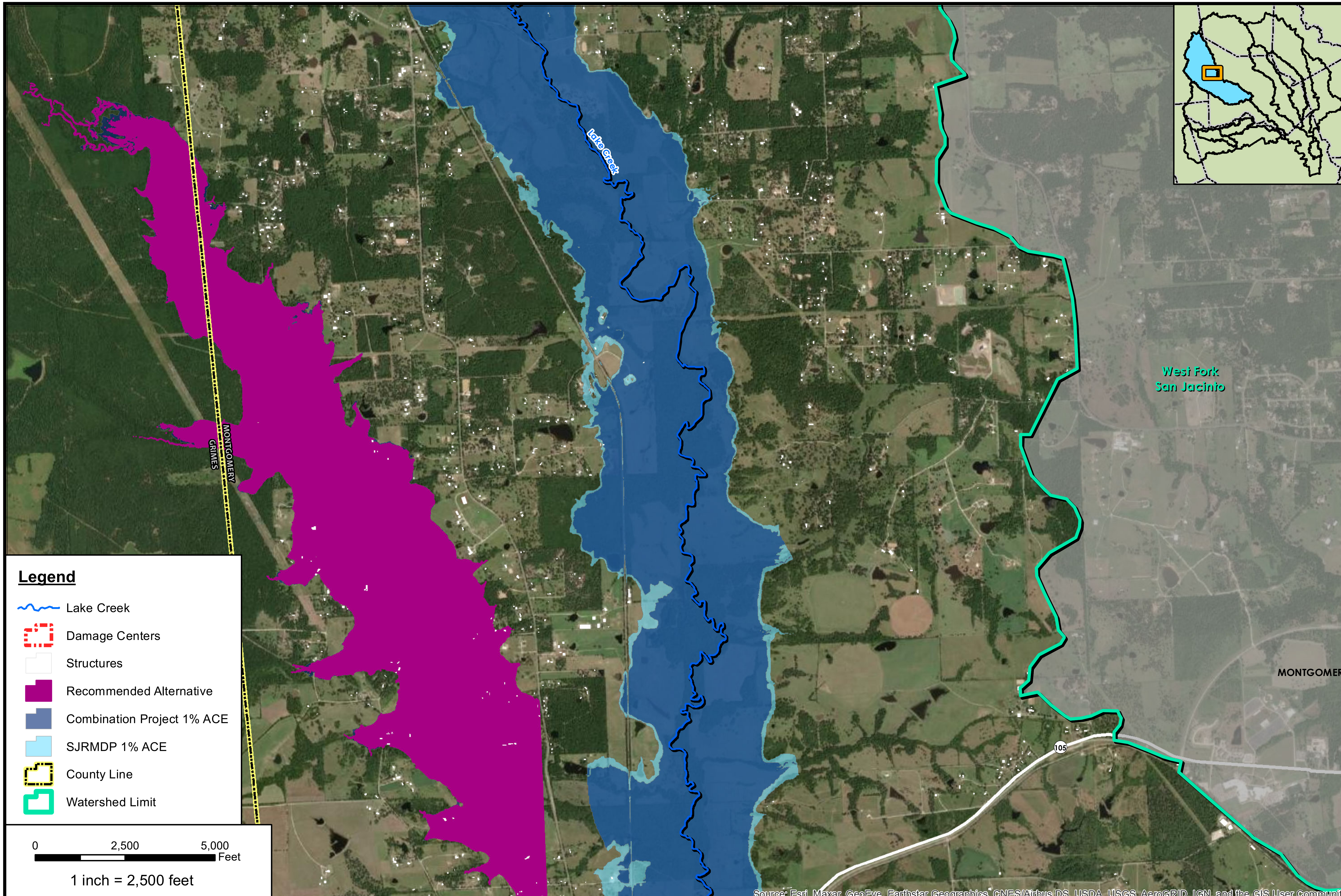
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map D



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

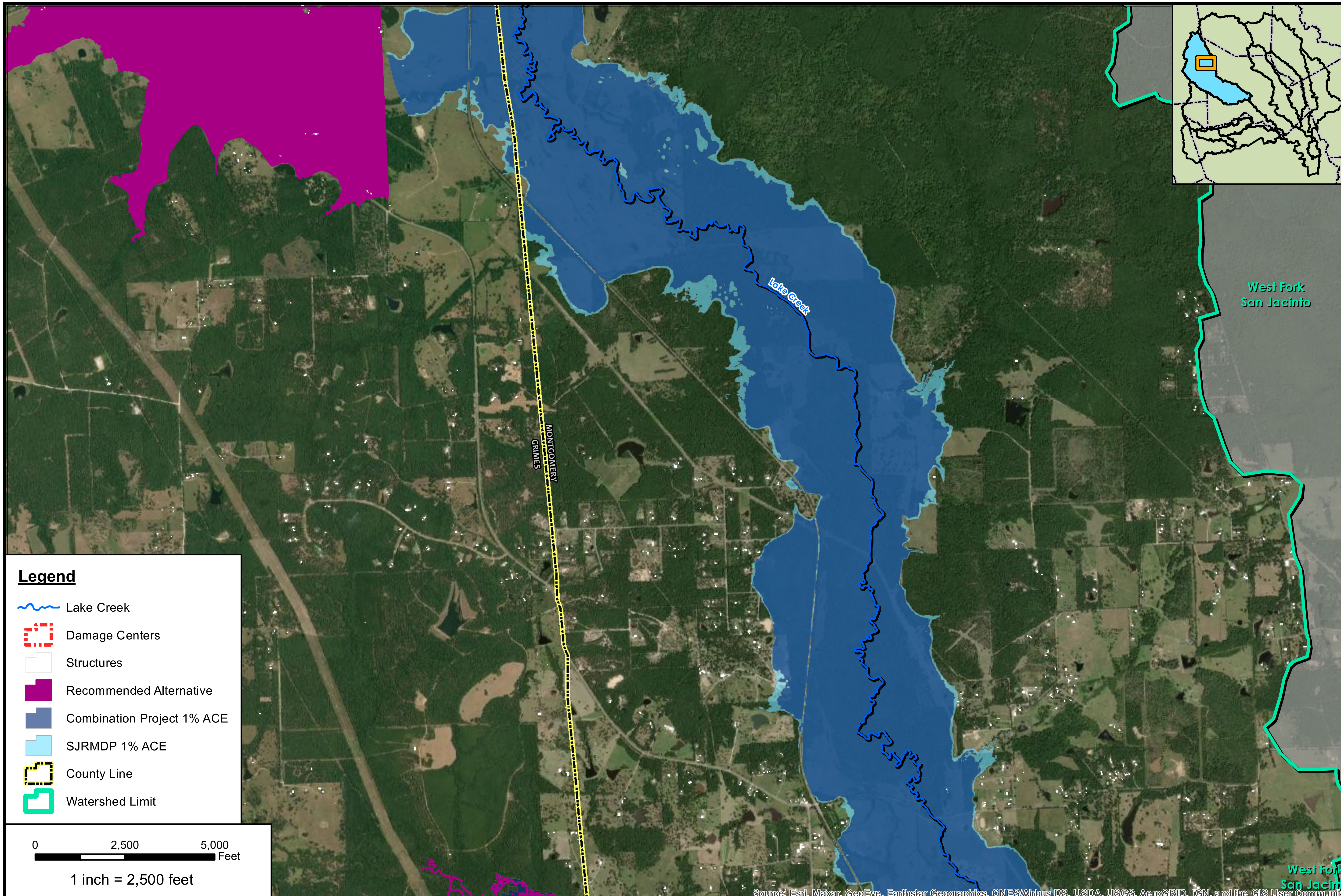
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map E



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

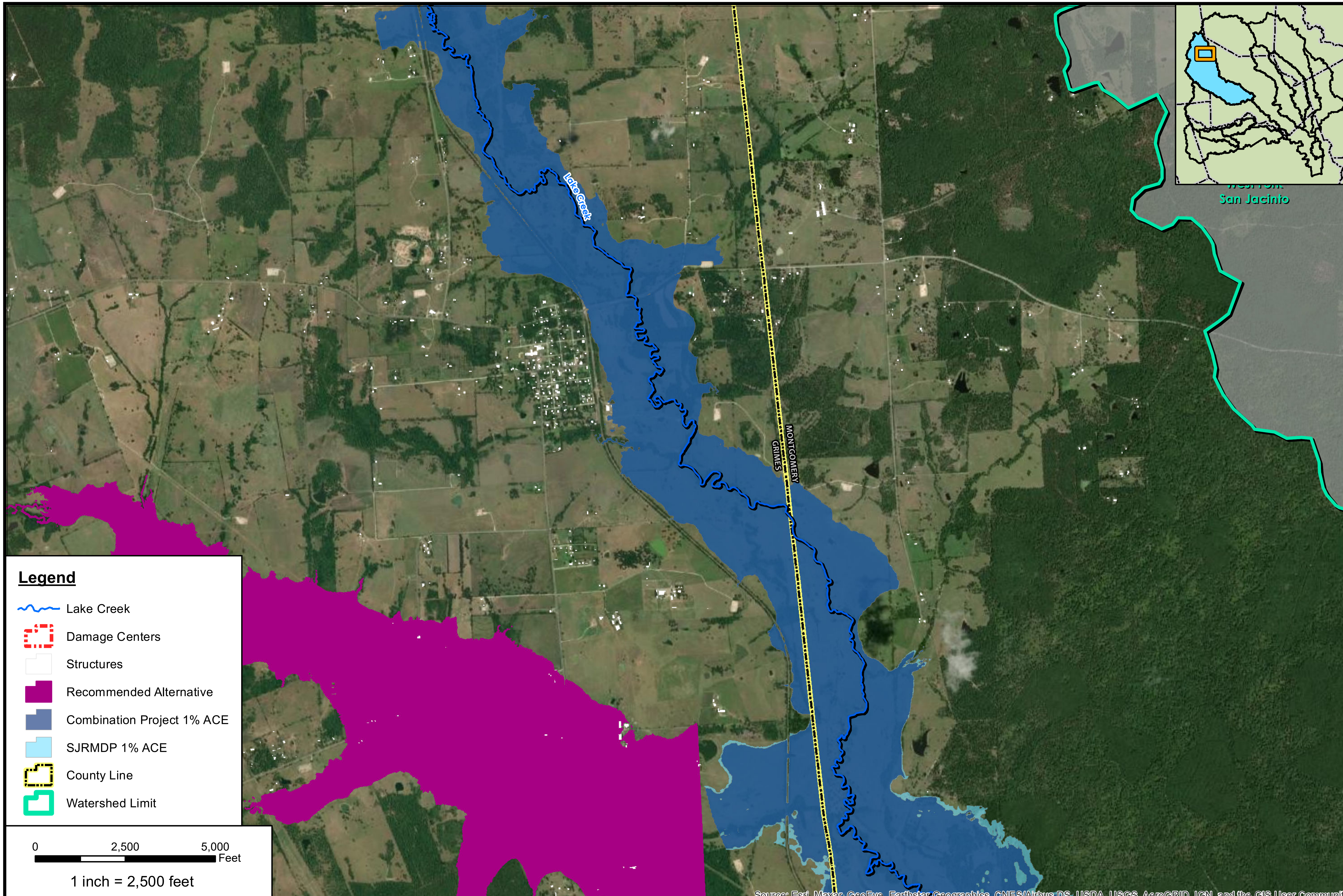
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map F



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

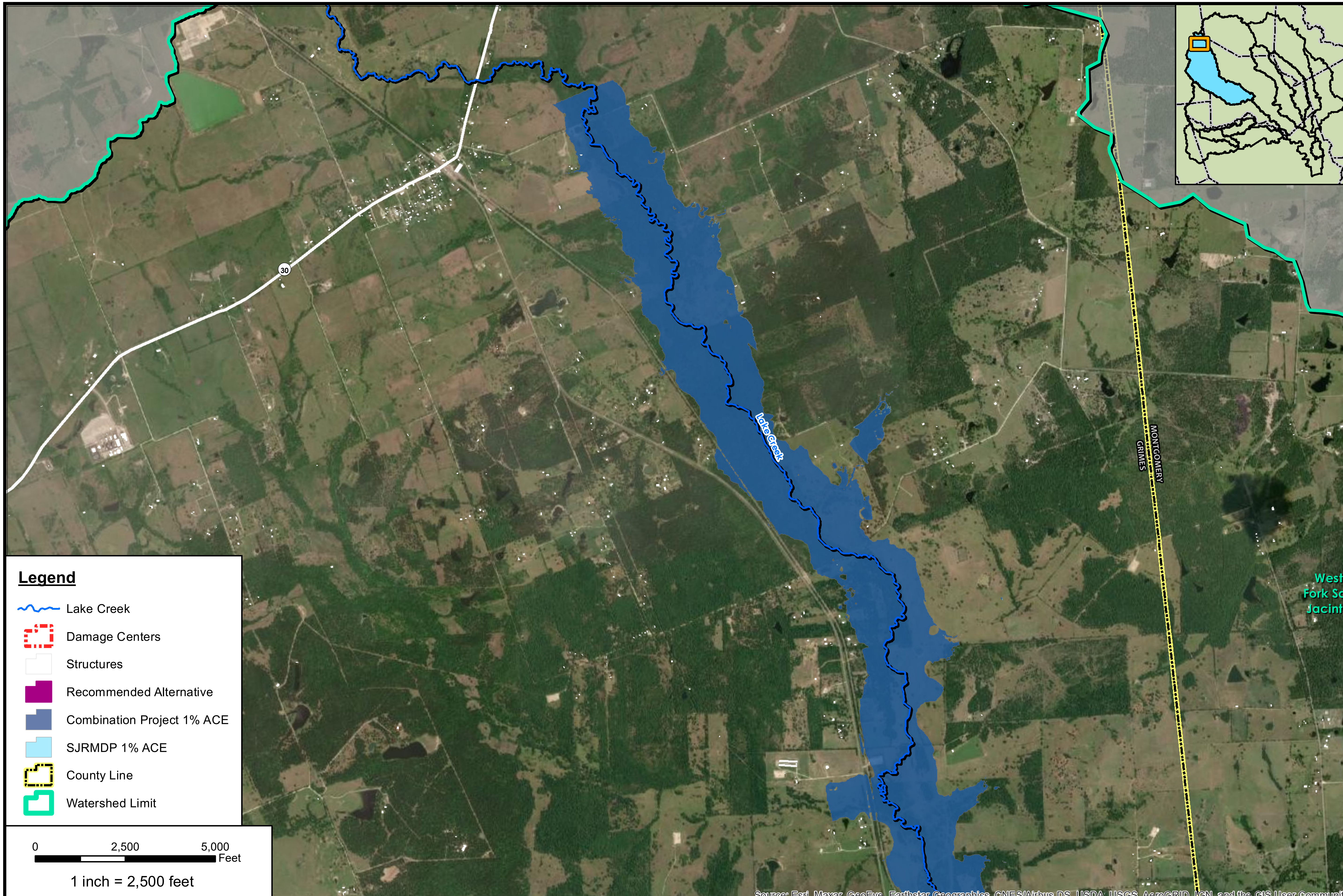
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map G



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

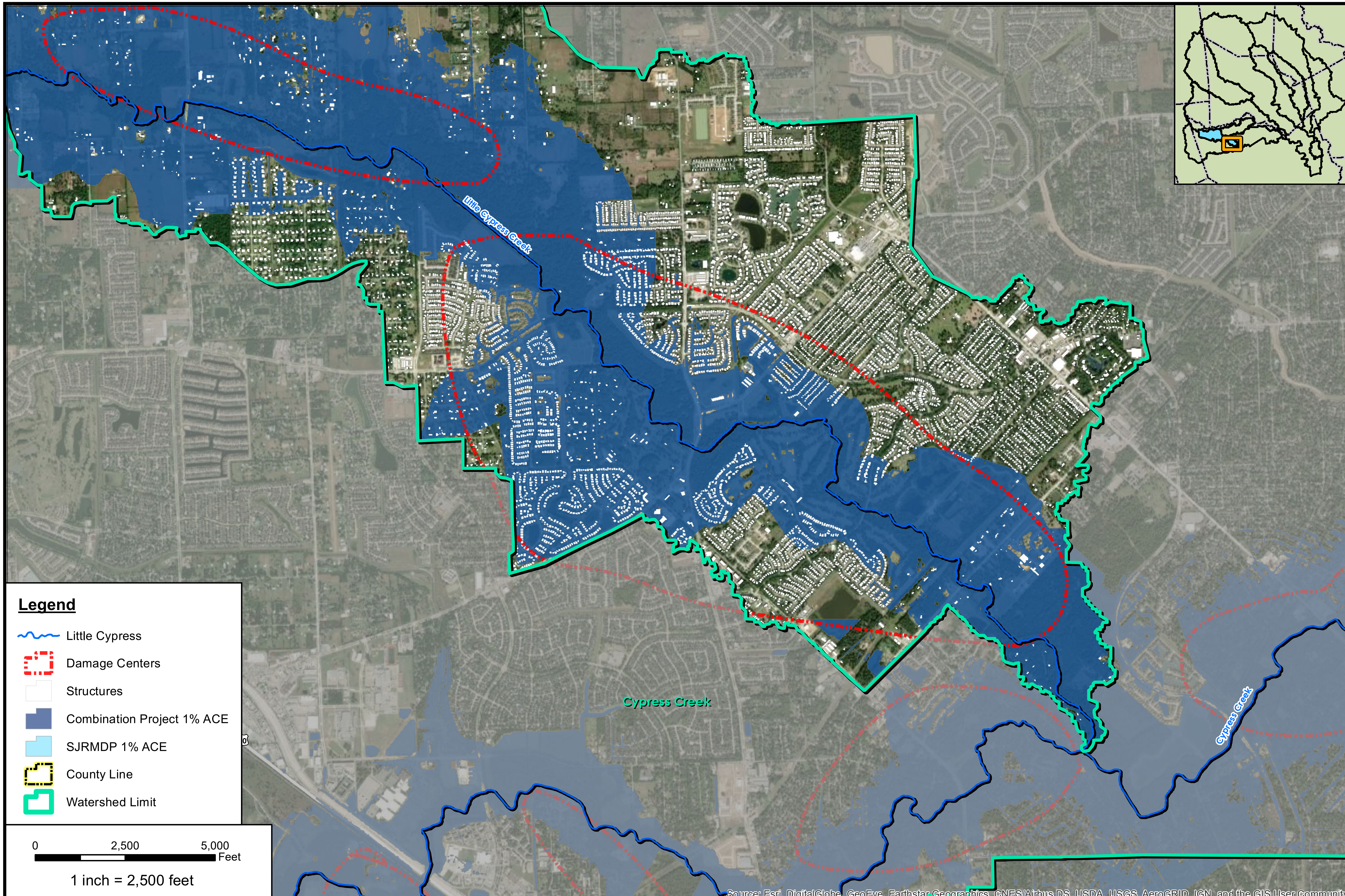
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map H



HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LITTLE CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

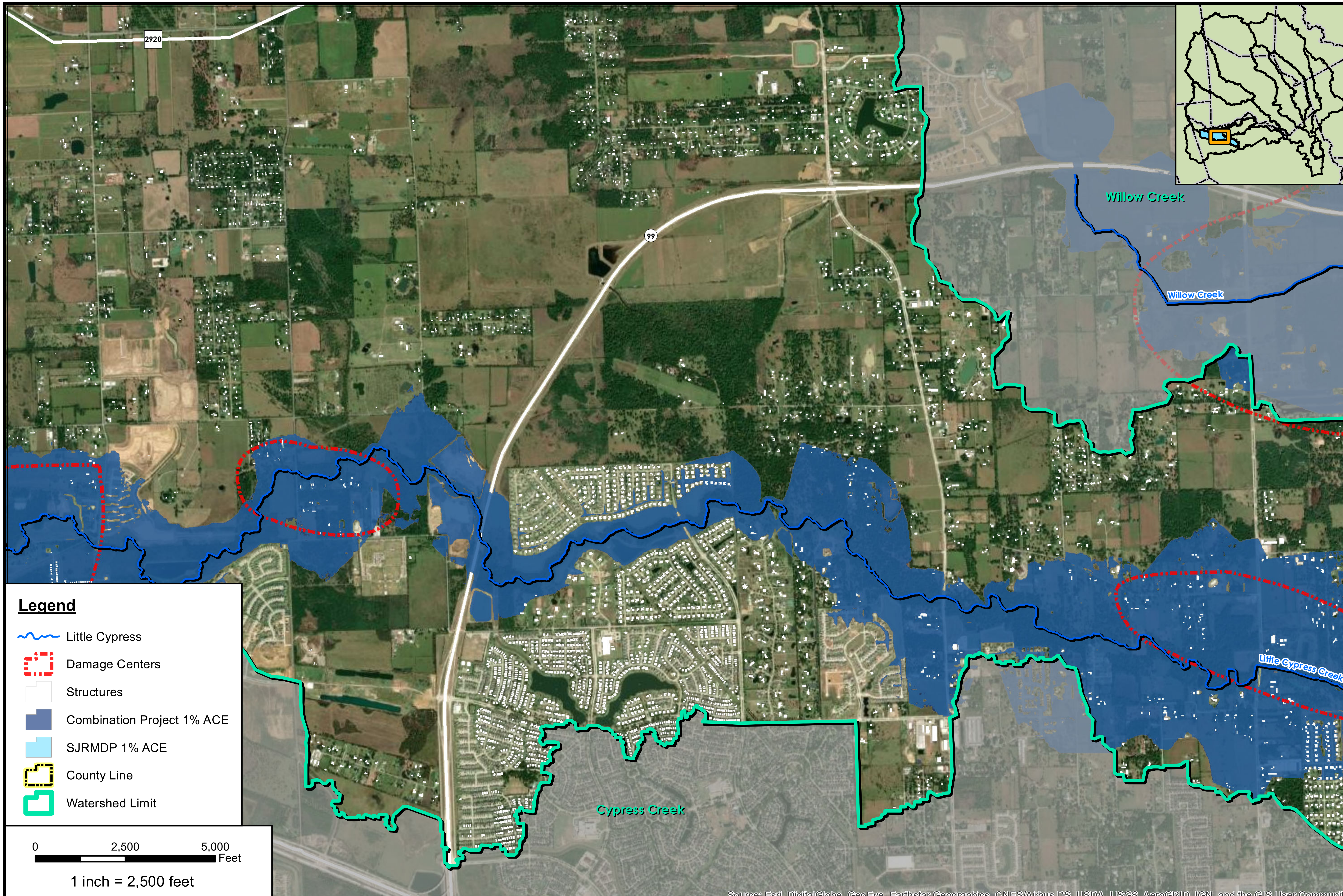
PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

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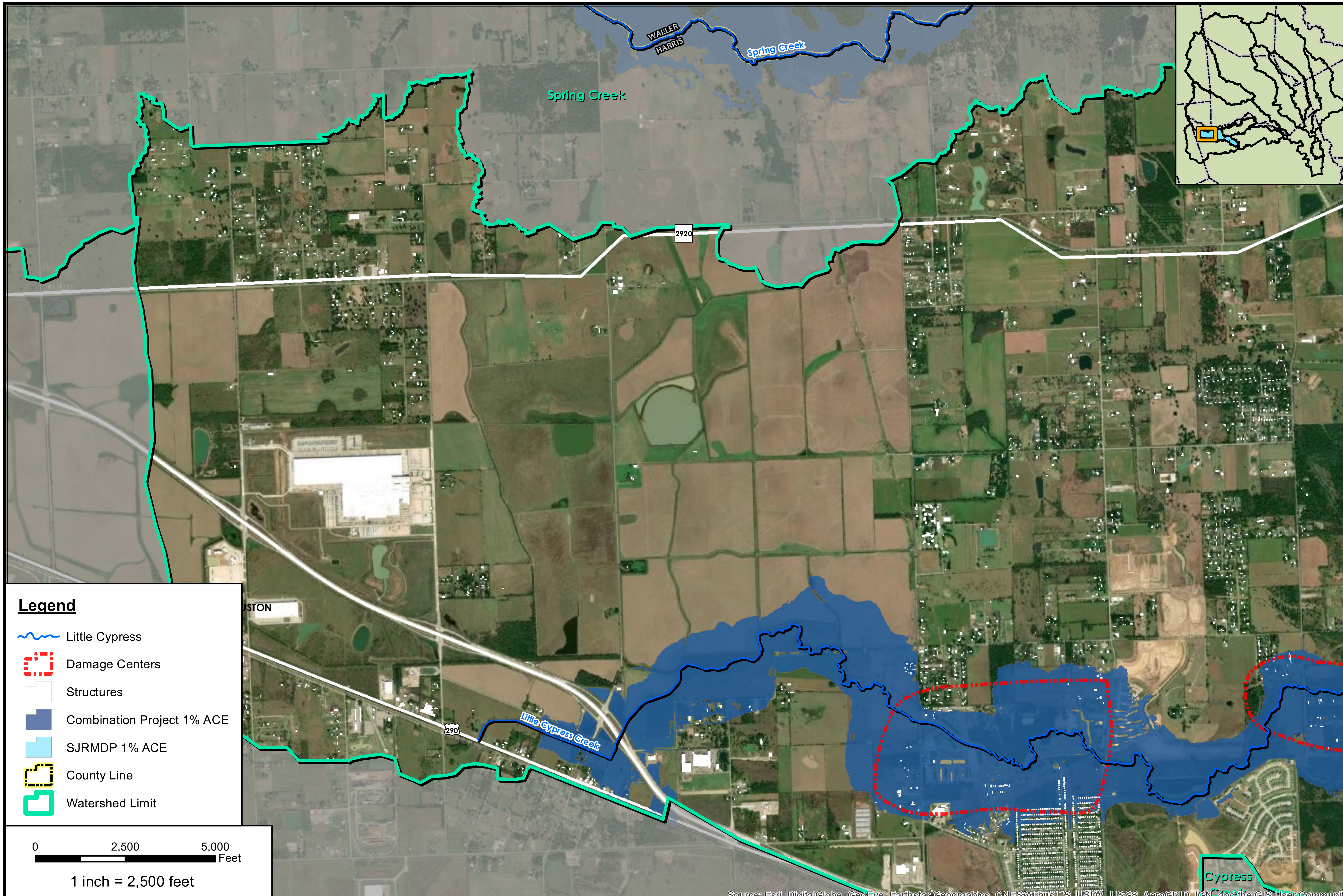
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LITTLE CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map B



PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

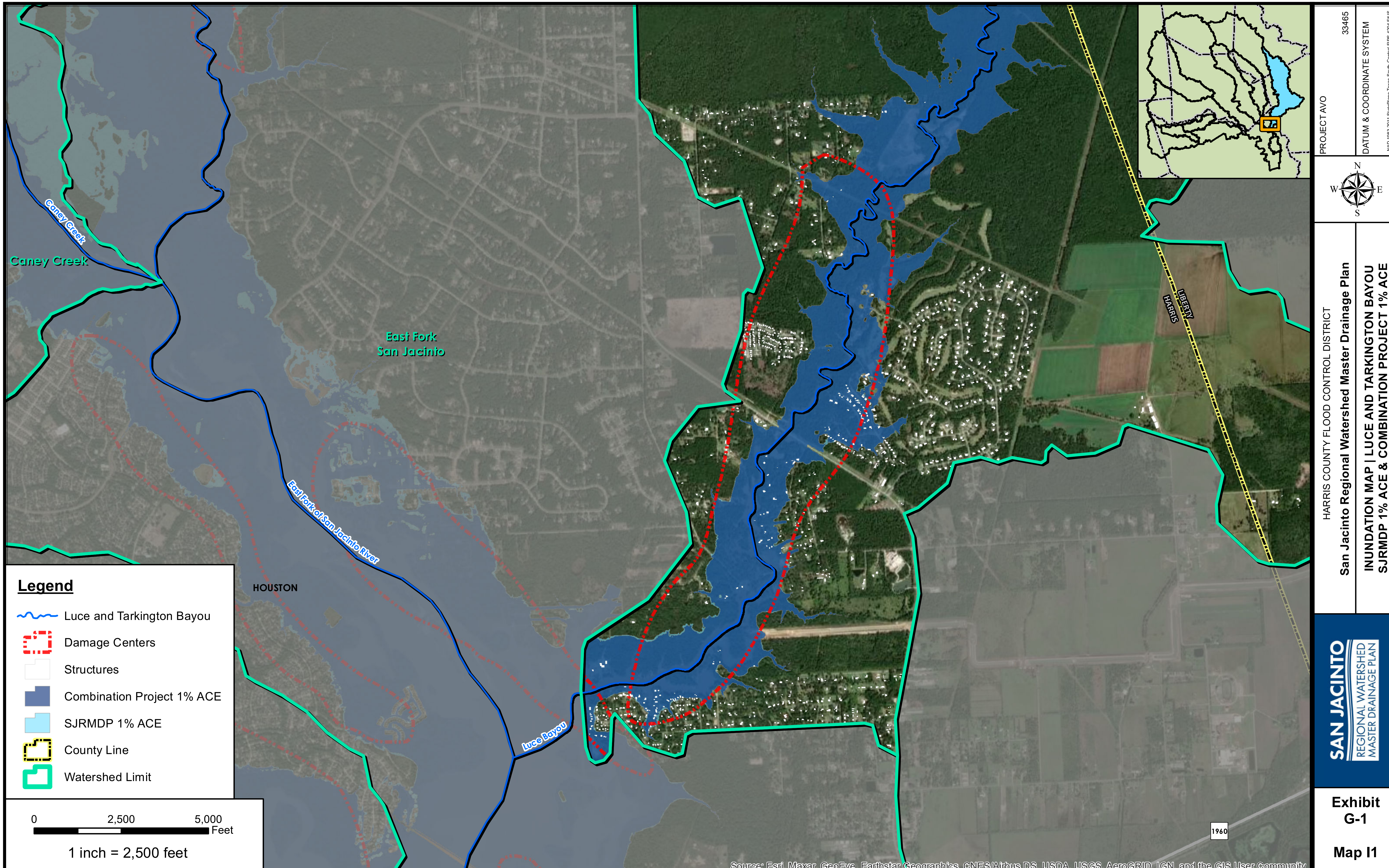
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LITTLE CYPRESS CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map C


Caney Creek
Caney Creek
East Fork
San Jacinto
East Fork of San Jacinto River
HOUSTON
Luce Bayou
LIBERTY
HARRIS
1960
Legend
Luce and Tarkington Bayou
Damage Centers
Structures
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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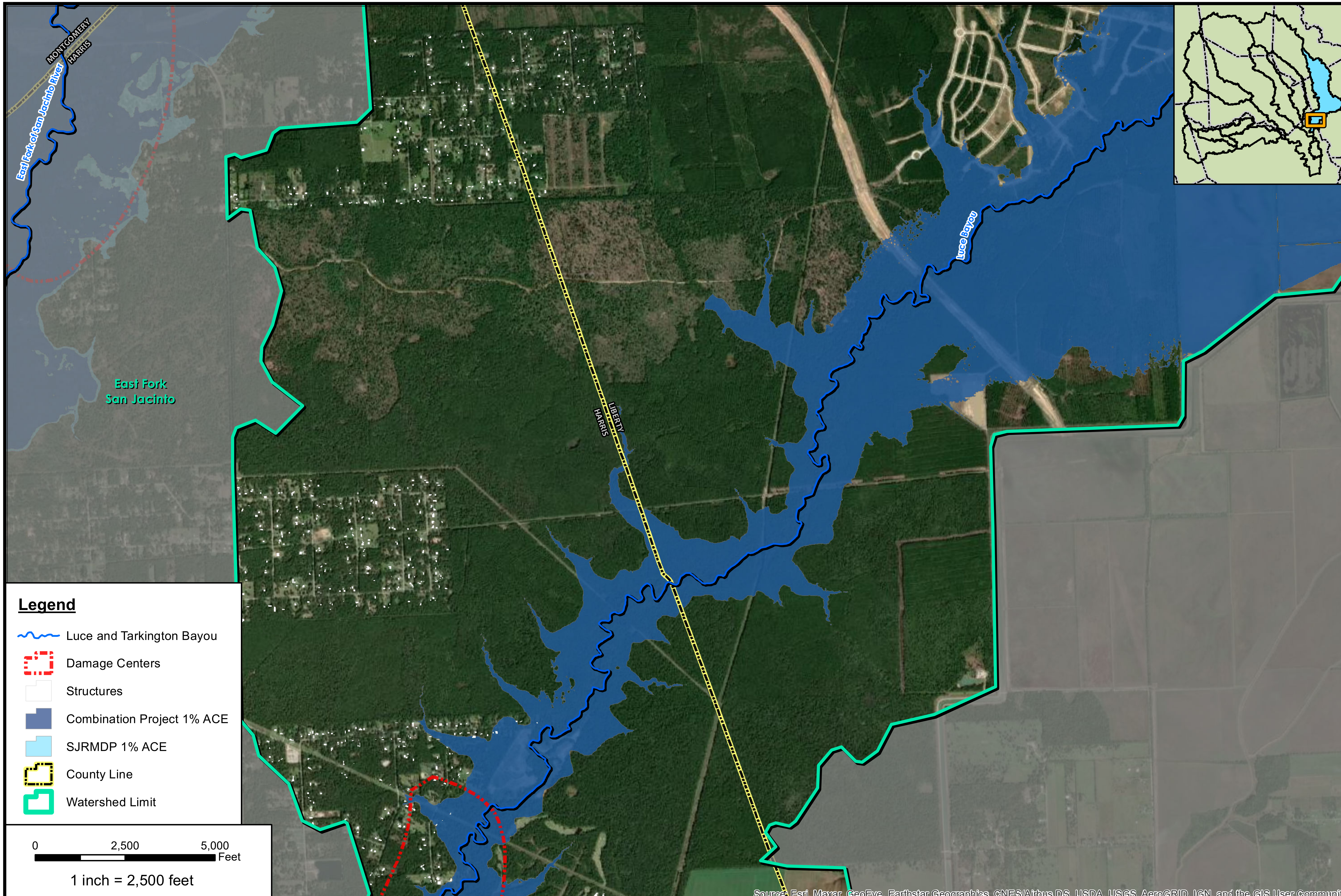
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map I1



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

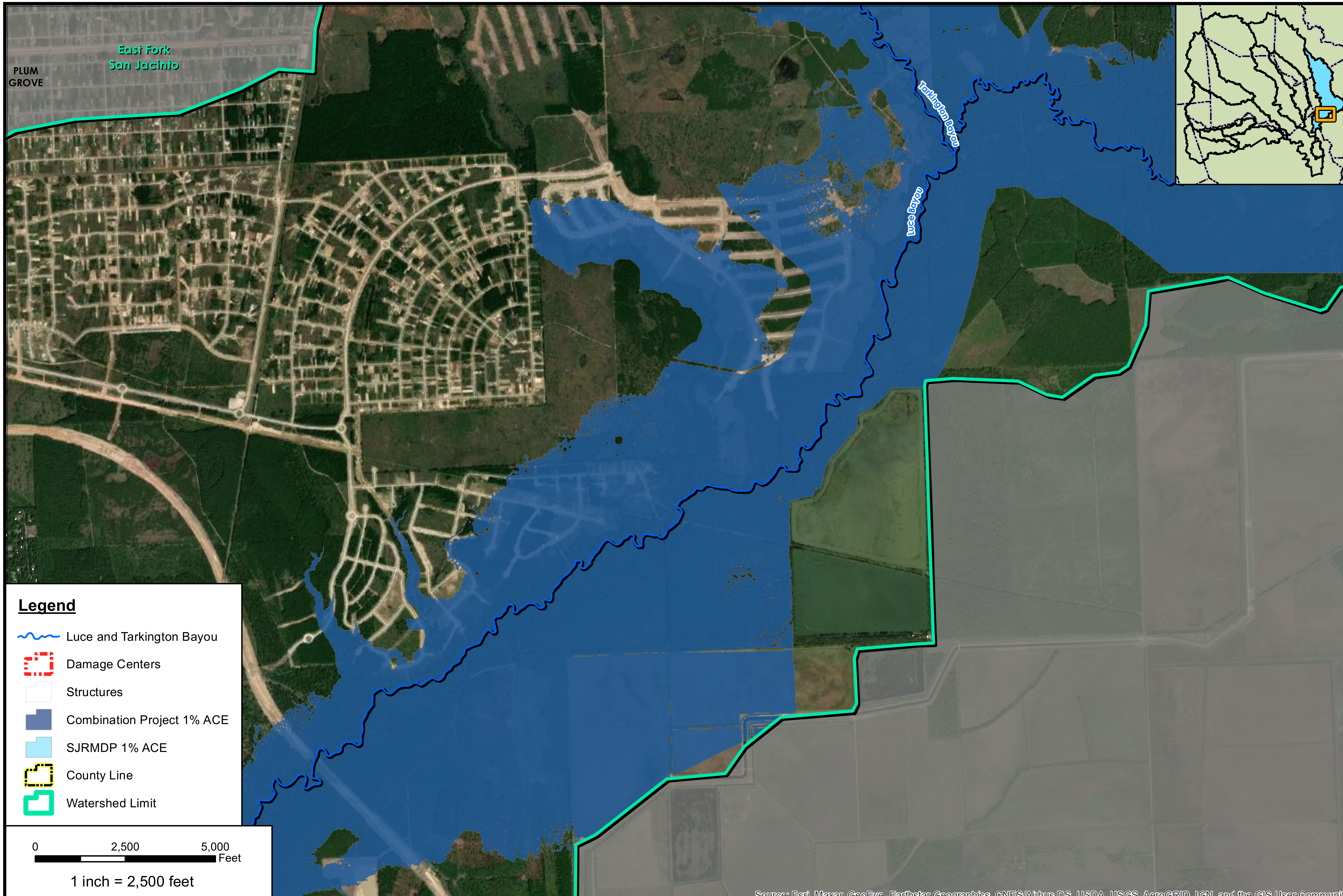
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I2



PROJECT AVO

33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

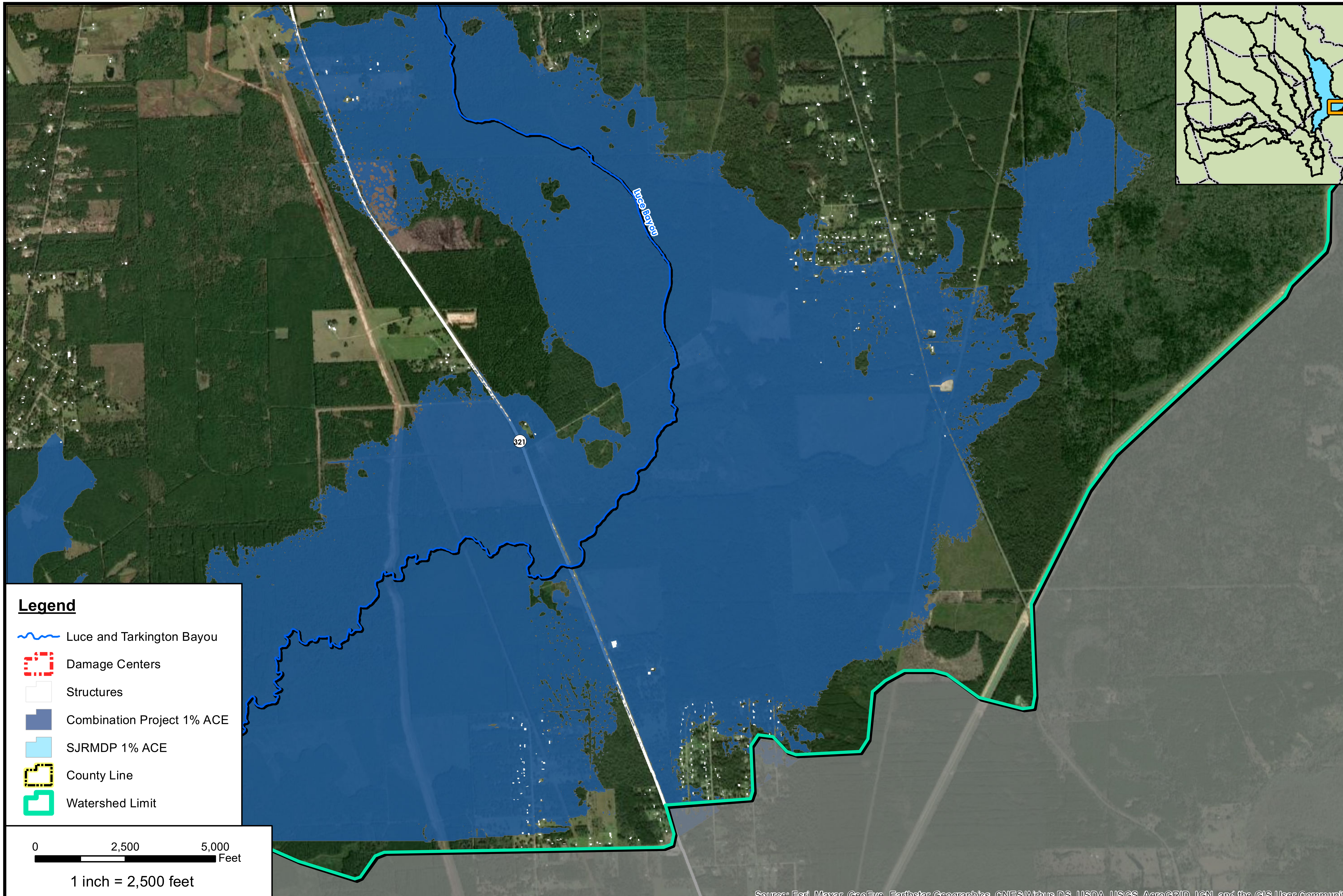
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map I4



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

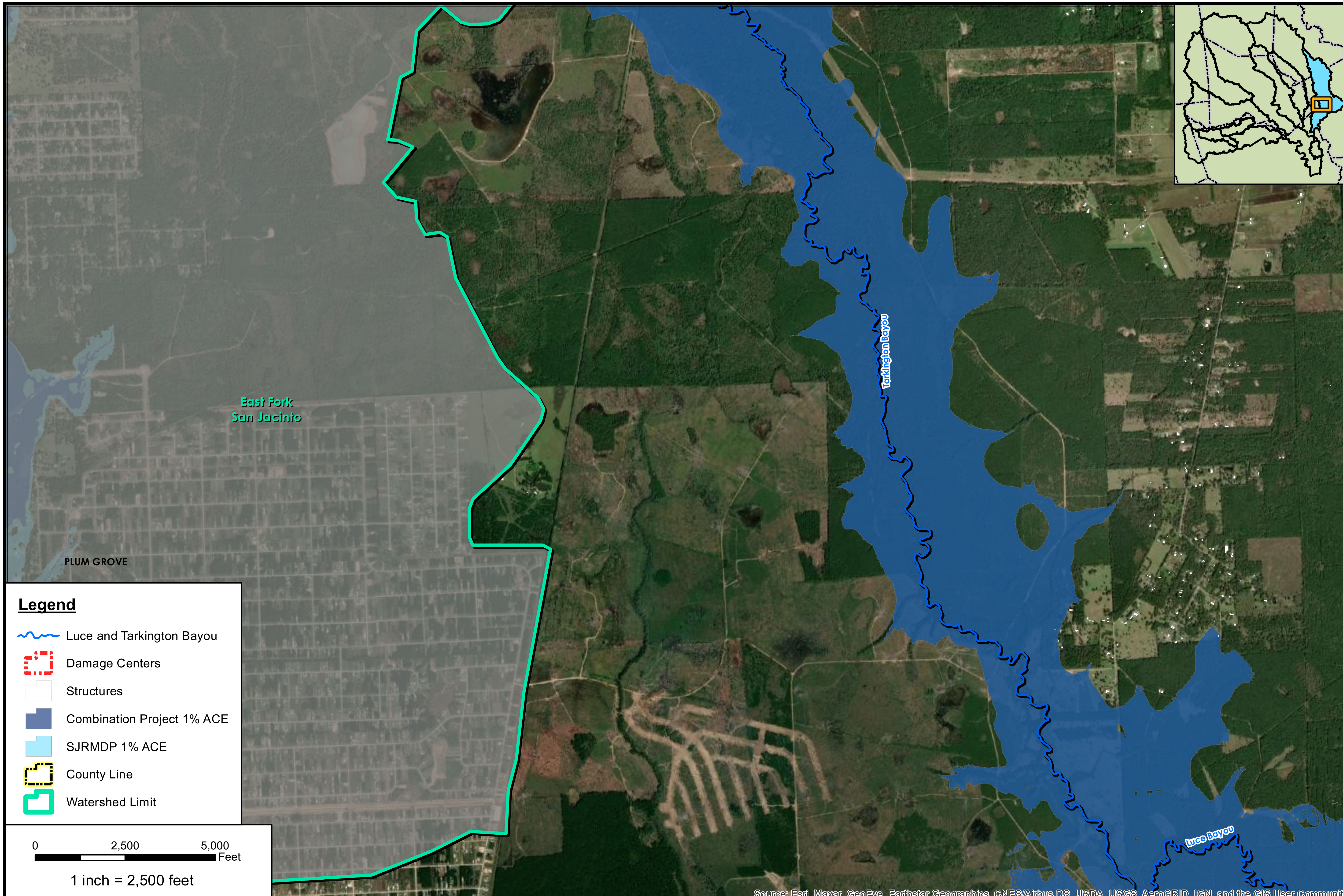
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I3



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

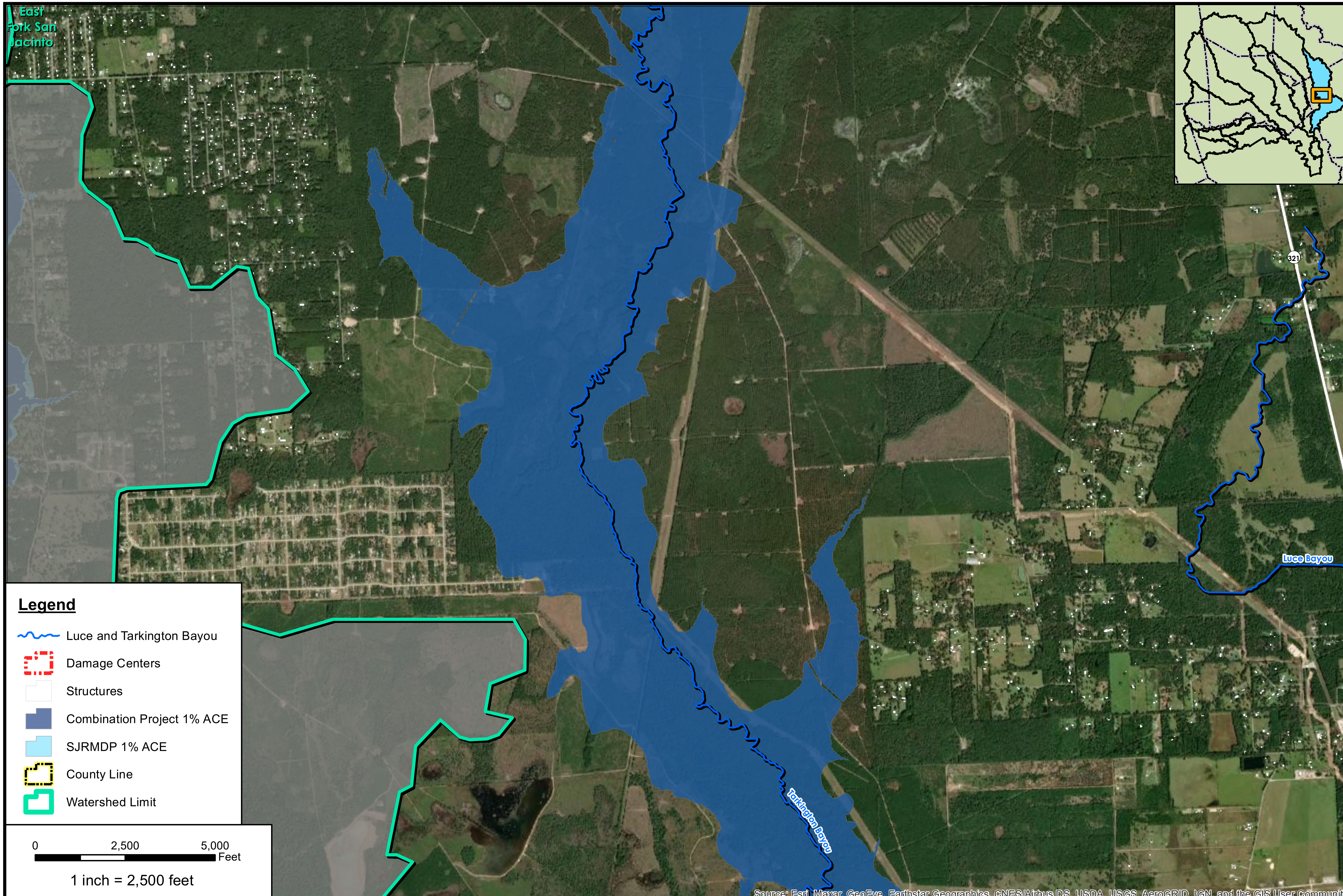
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map I5



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

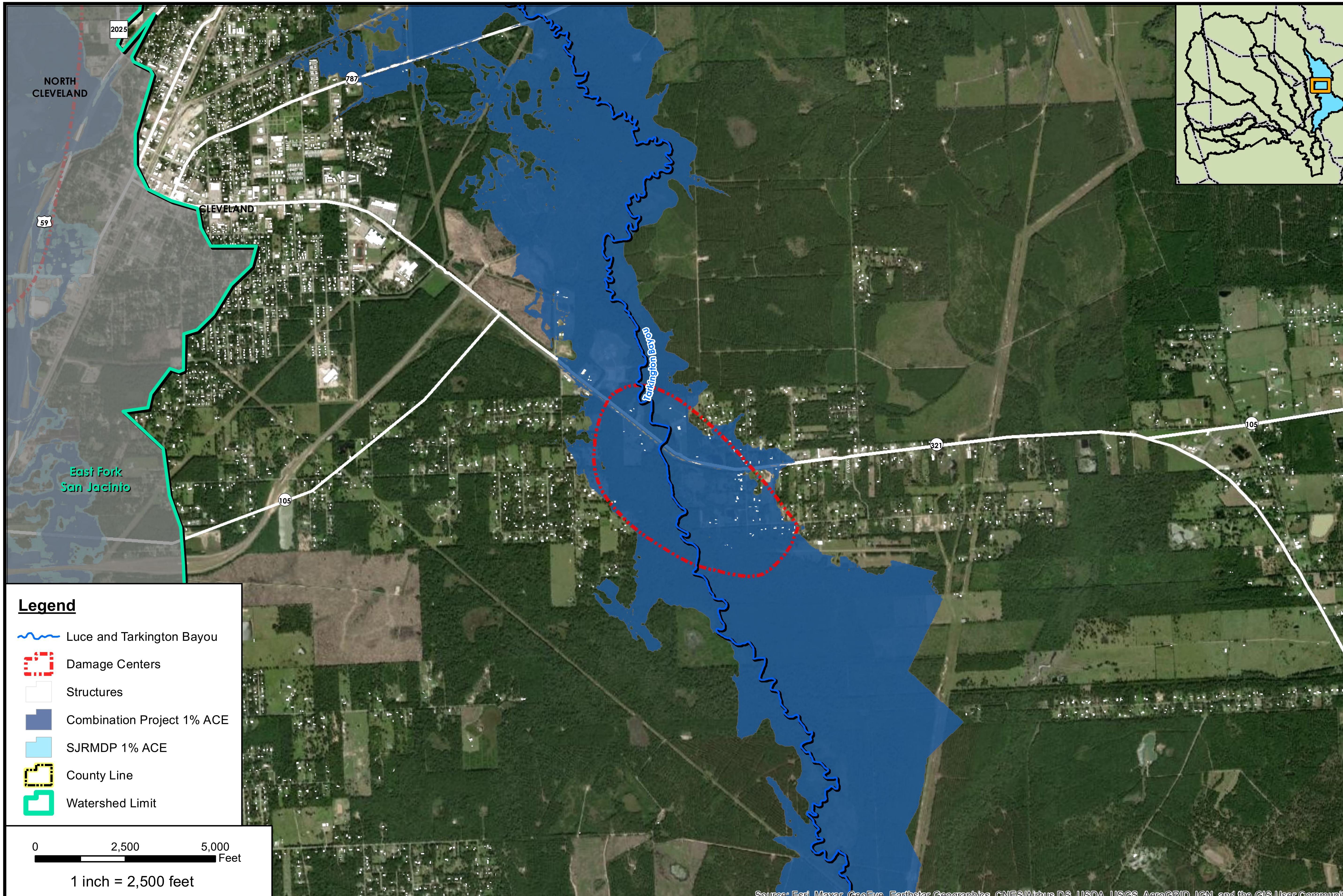
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I6



Legend

- Luce and Tarkington Bayou
- Damage Centers
- Structures
- Combination Project 1% ACE
- SJRMDP 1% ACE
- County Line
- Watershed Limit

0 2,500 5,000 Feet

1 inch = 2,500 feet

PROJECT AVO 33465

DATUM & COORDINATE SYSTEM NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

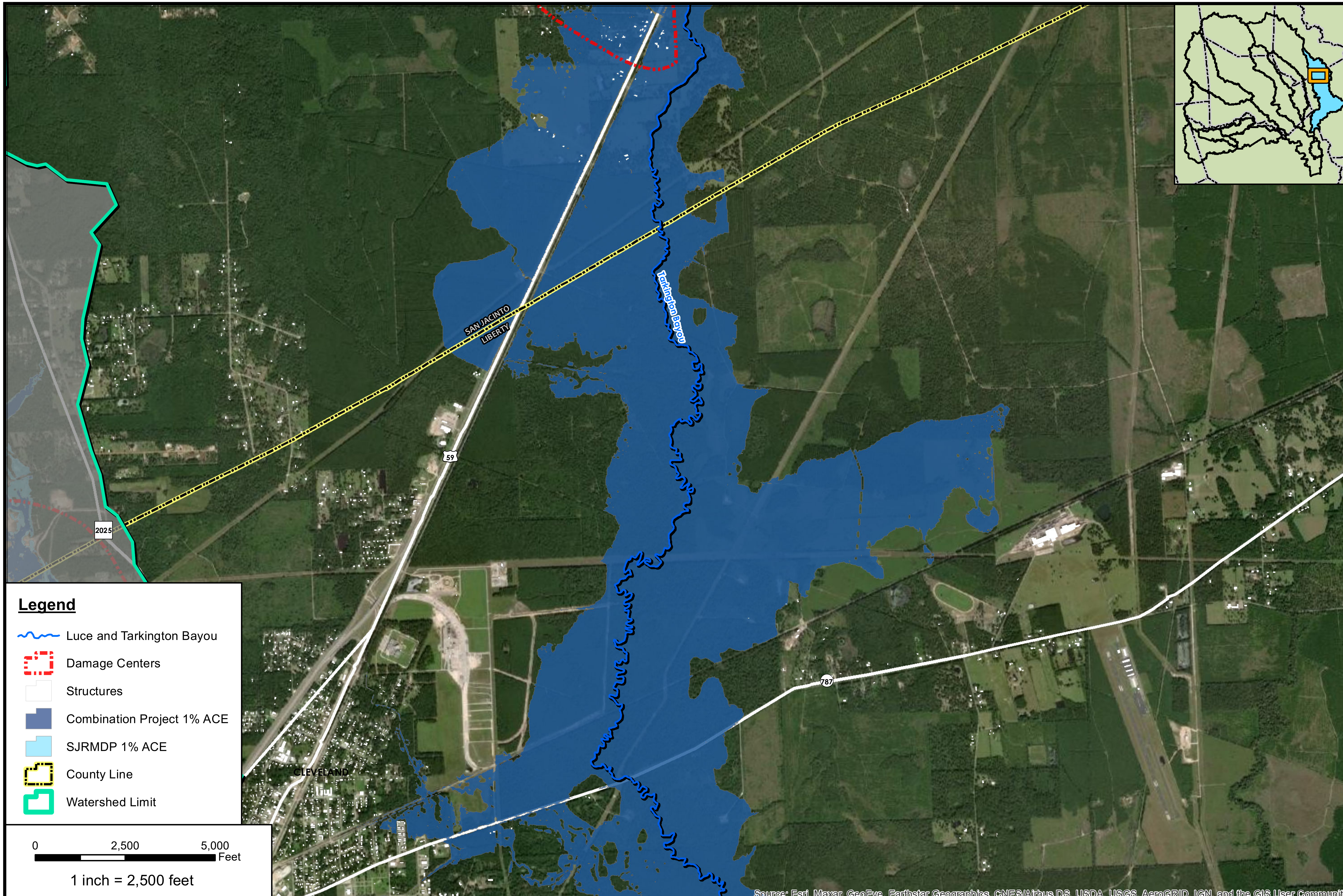
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I7



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

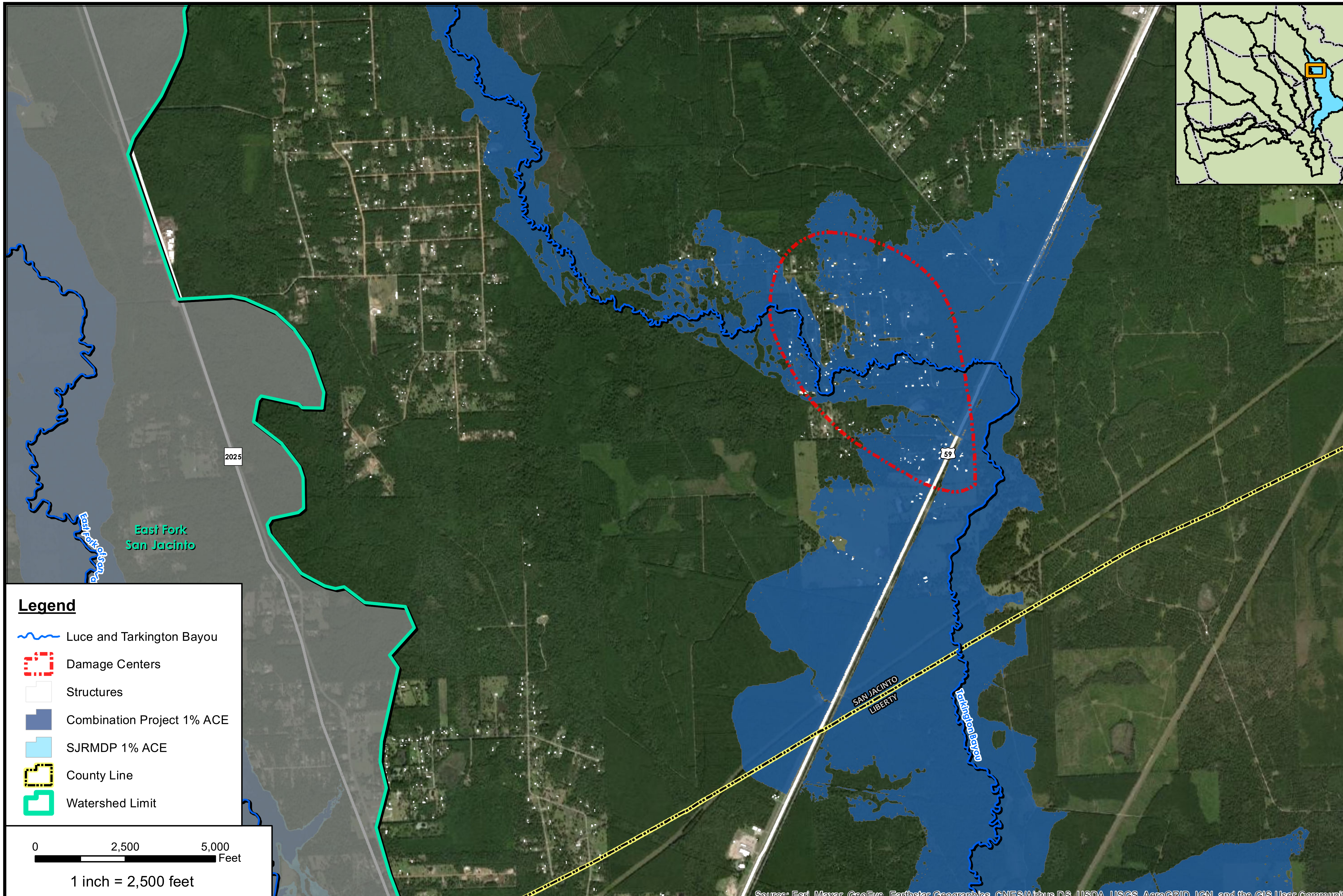
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I8



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

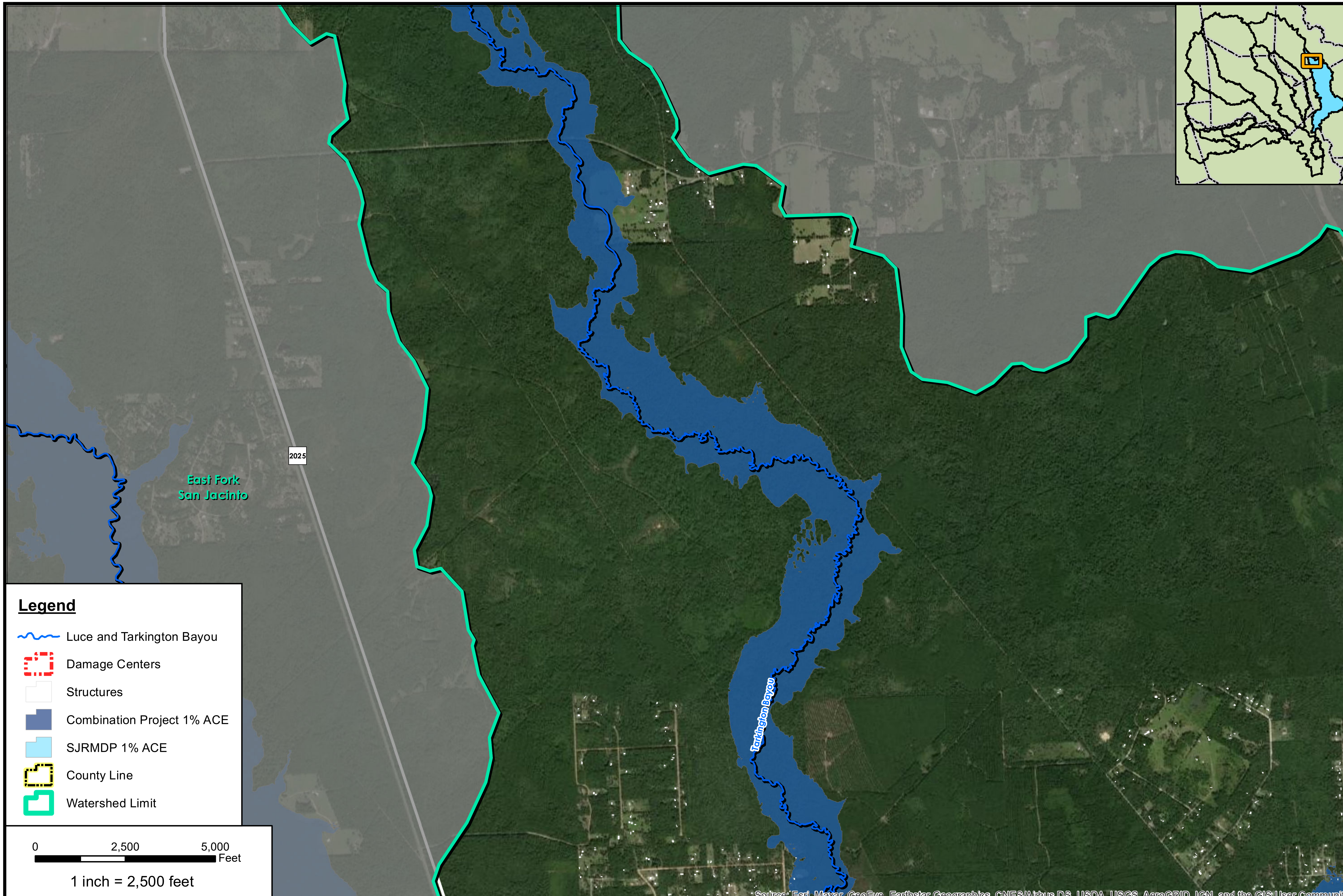
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I9



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

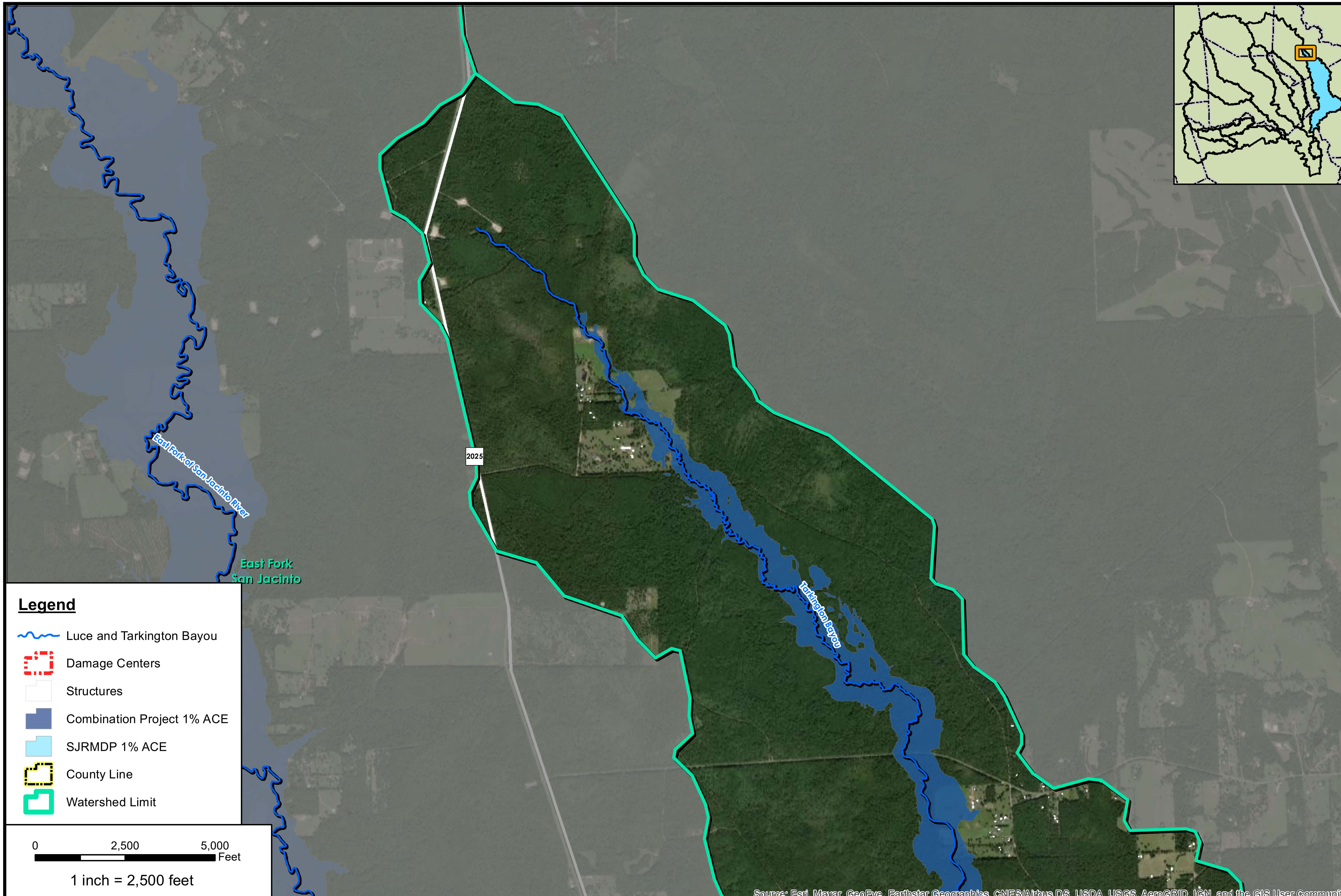
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LUCE AND TARKINGTON BAYOU
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit G-1

Map I10



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

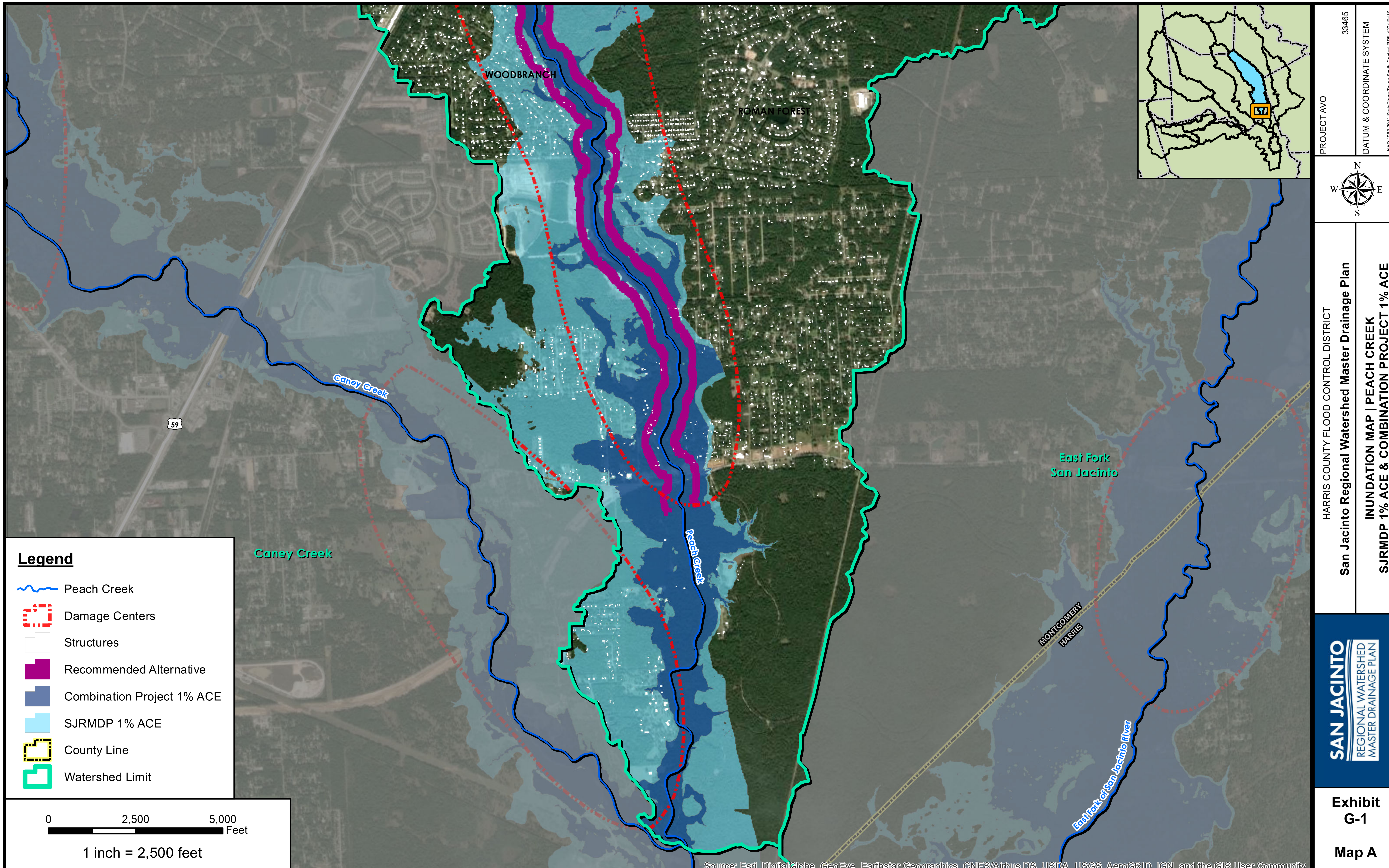
INUNDATION MAP | LUCE AND TARKINGTON BAYOU

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I11



WOODBRANCH
ROMAN FOREST
Caney Creek
59
Caney Creek
Peach Creek
East Fork
San Jacinto
MONTGOMERY
HARRIS
East Fork of San Jacinto River
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Legend
Peach Creek
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS
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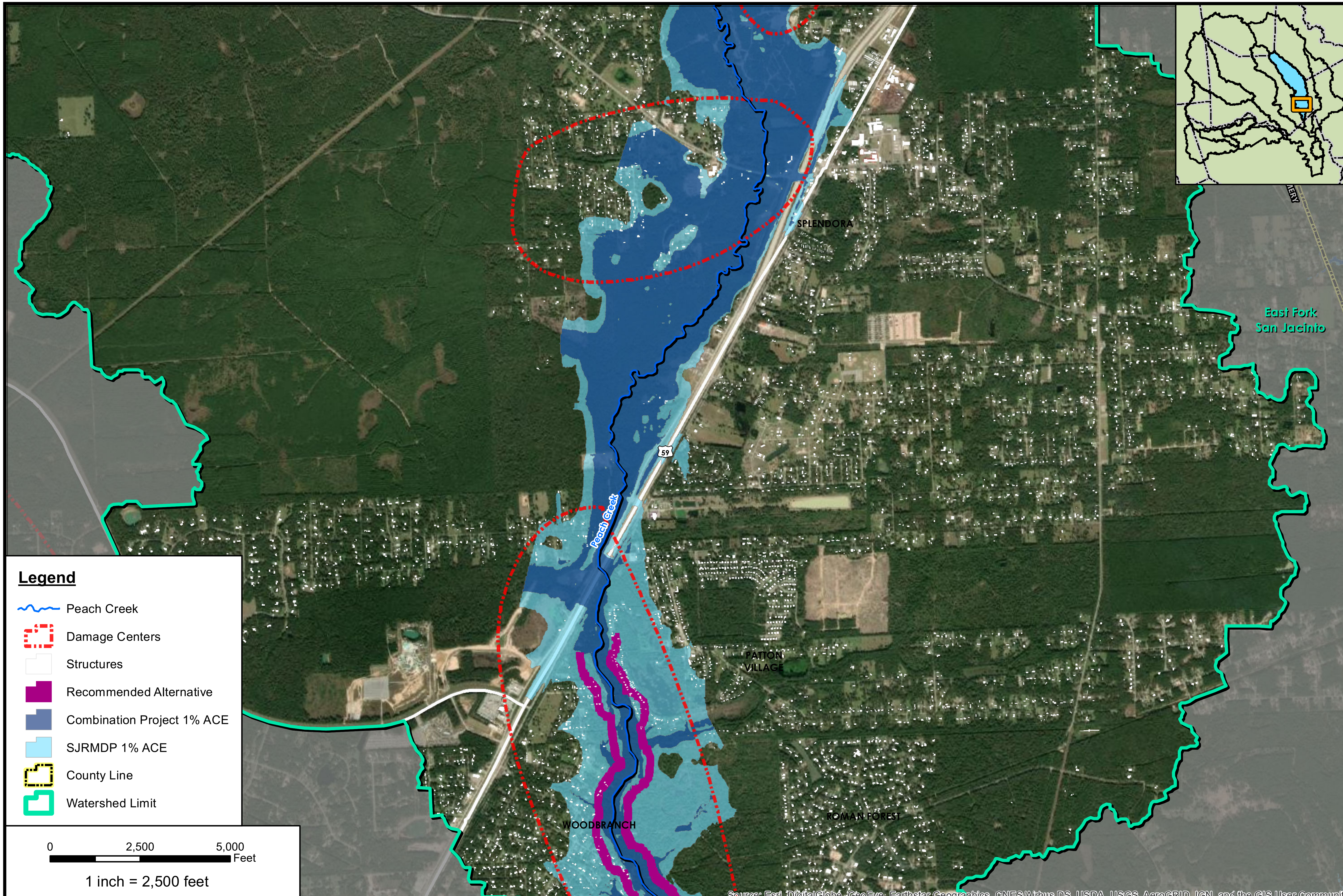
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | PEACH CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map A



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

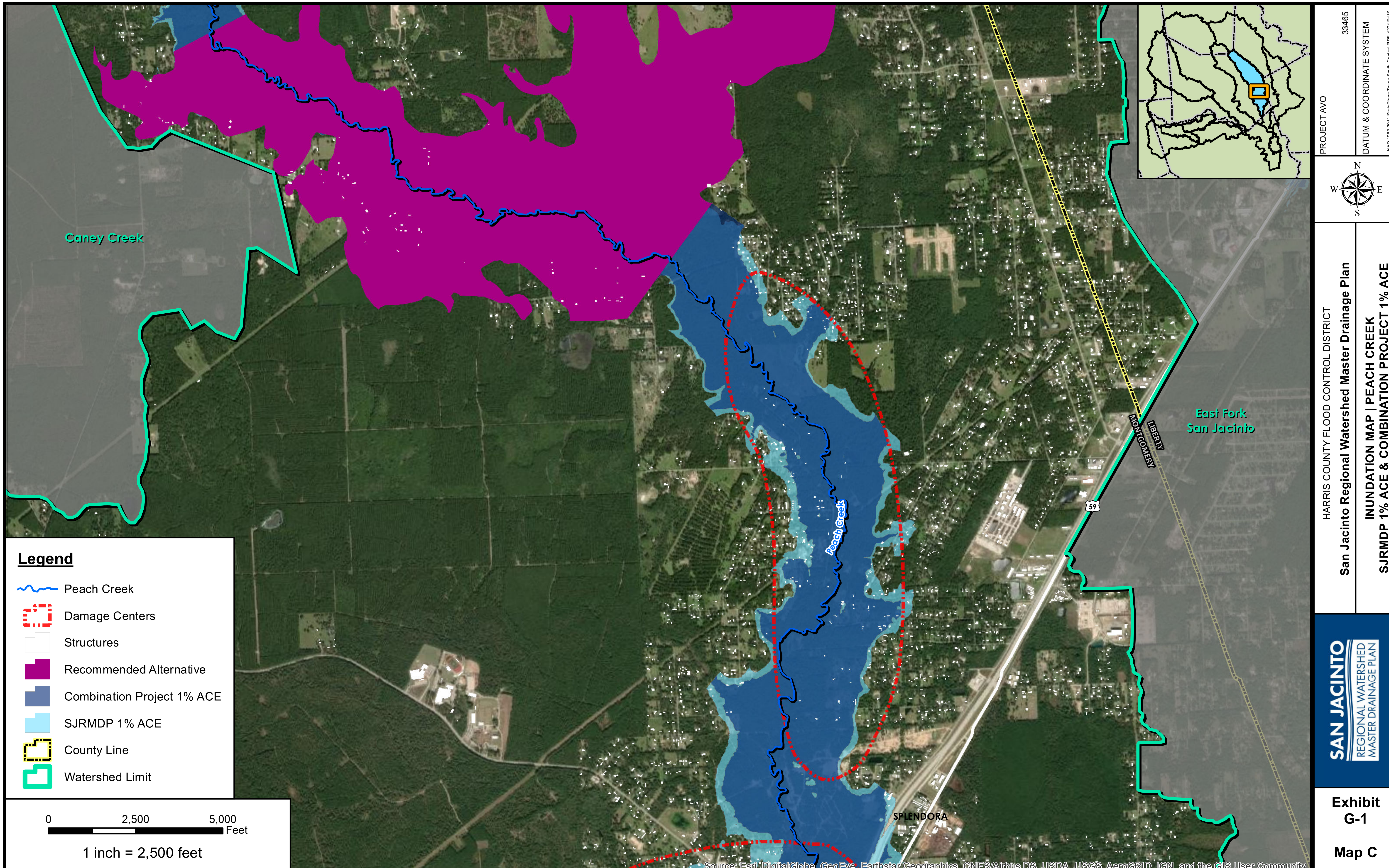
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | PEACH CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map B


Caney Creek
East Fork San Jacinto
Peach Creek
MONTGOMERY
LIBERTY
59
SPLENDORA
Legend
Peach Creek
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0 2,500 5,000 Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO 33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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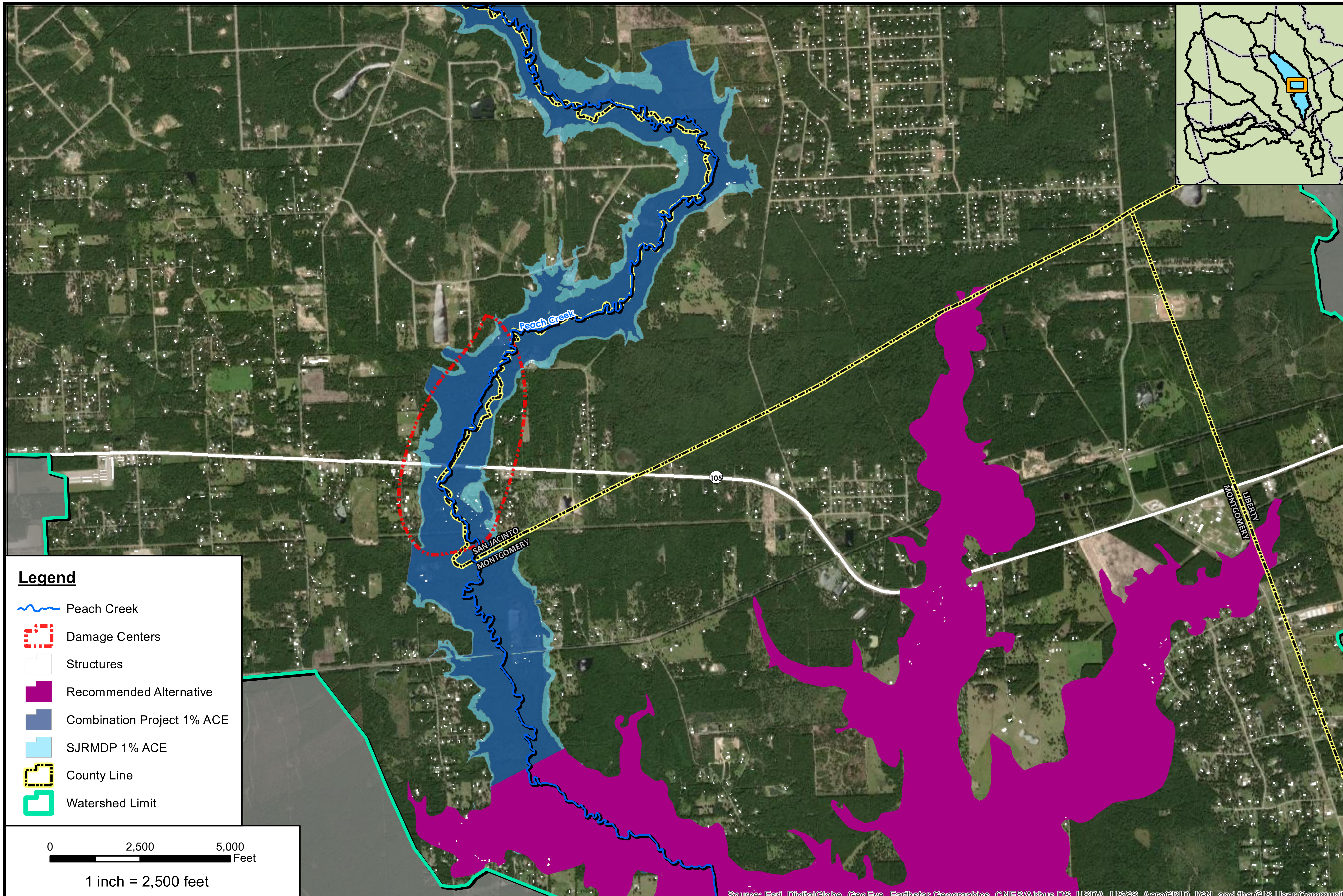
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | PEACH CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit G-1
Map C



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

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HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

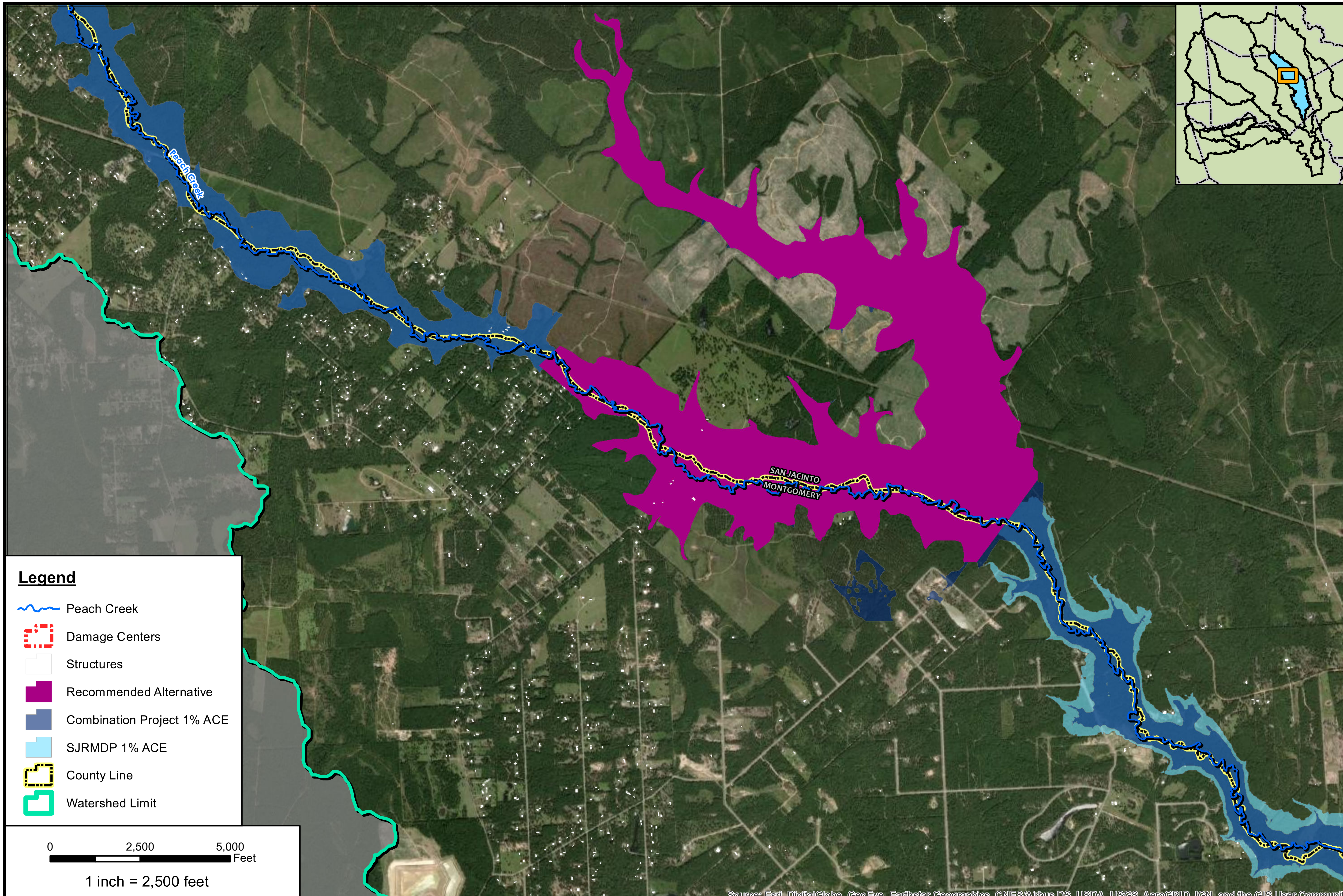
INUNDATION MAP | PEACH CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map D



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

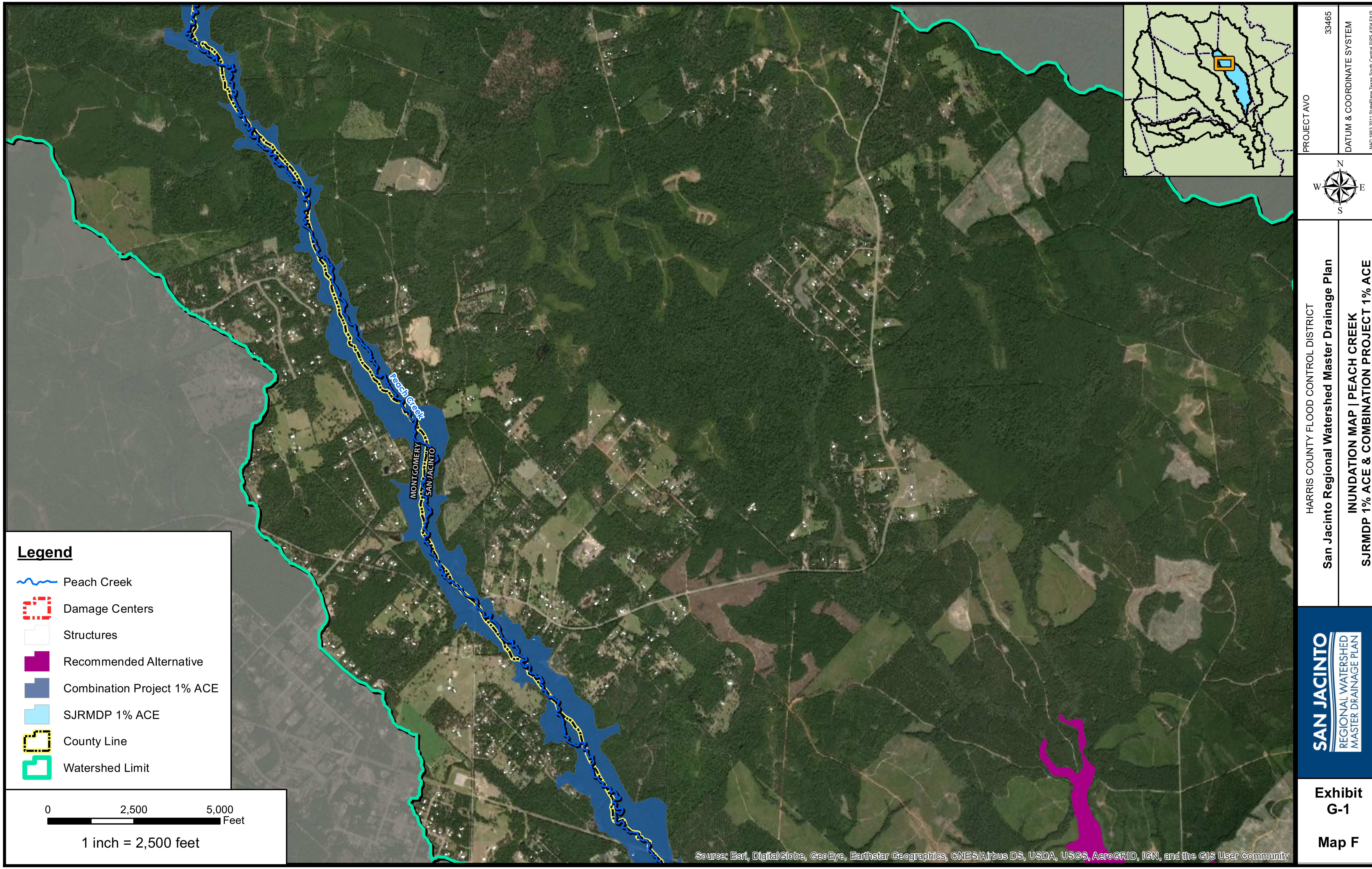
INUNDATION MAP | PEACH CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map E


Peach Creek
MONTGOMERY
SAN JACINTO
Legend
Peach Creek
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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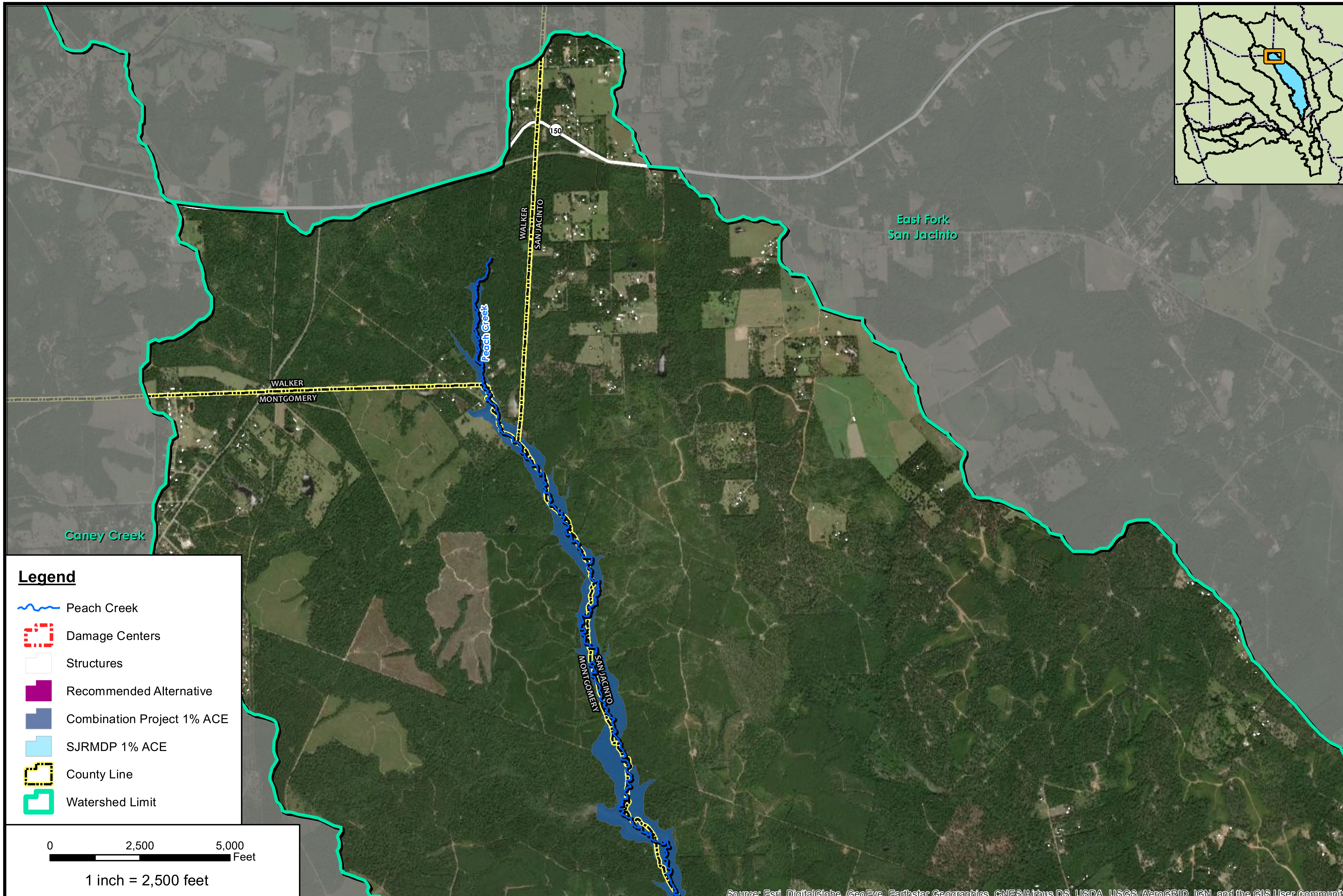
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | PEACH CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map F



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

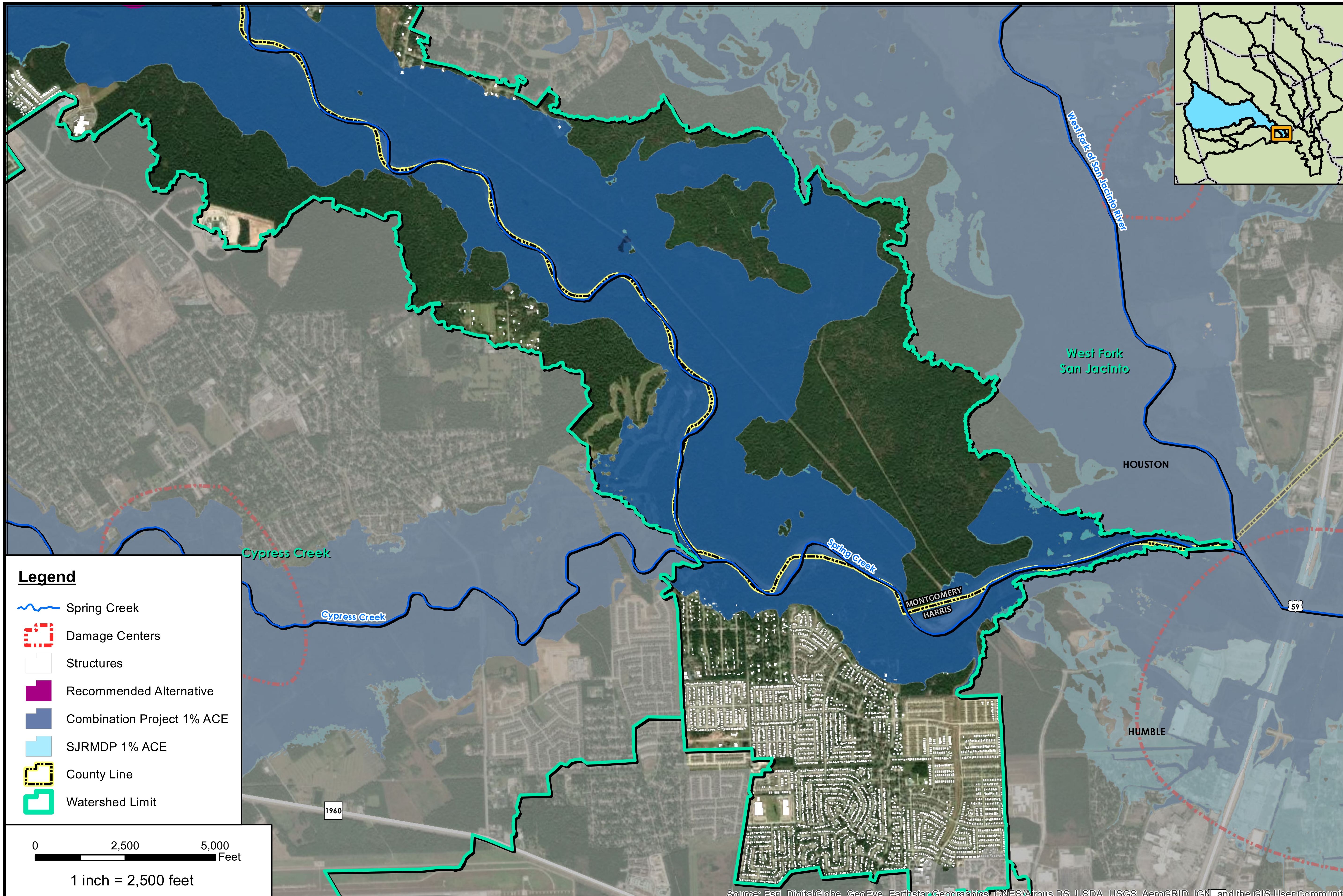
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | PEACH CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map G



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Feet

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

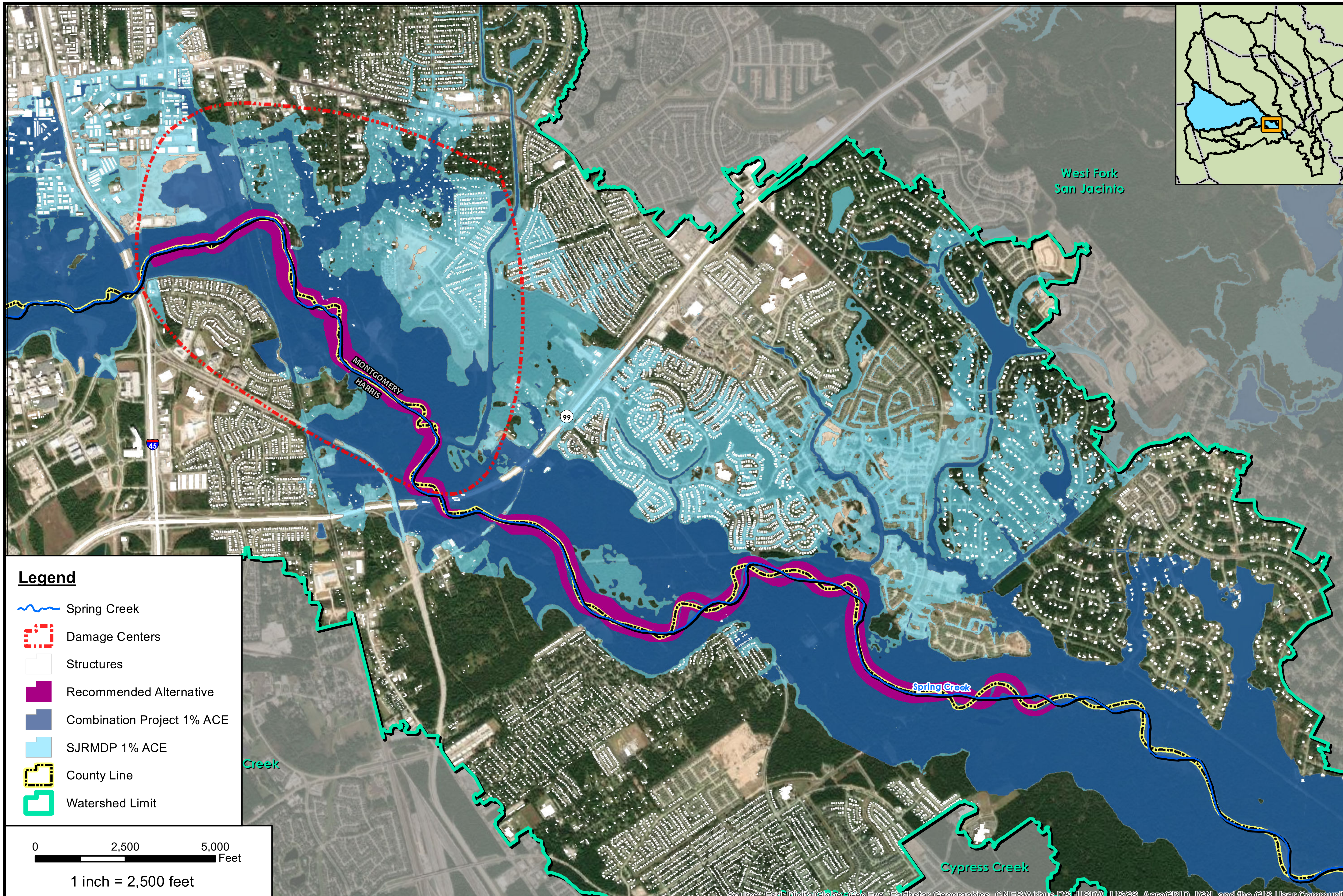
INUNDATION MAP | SPRING CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

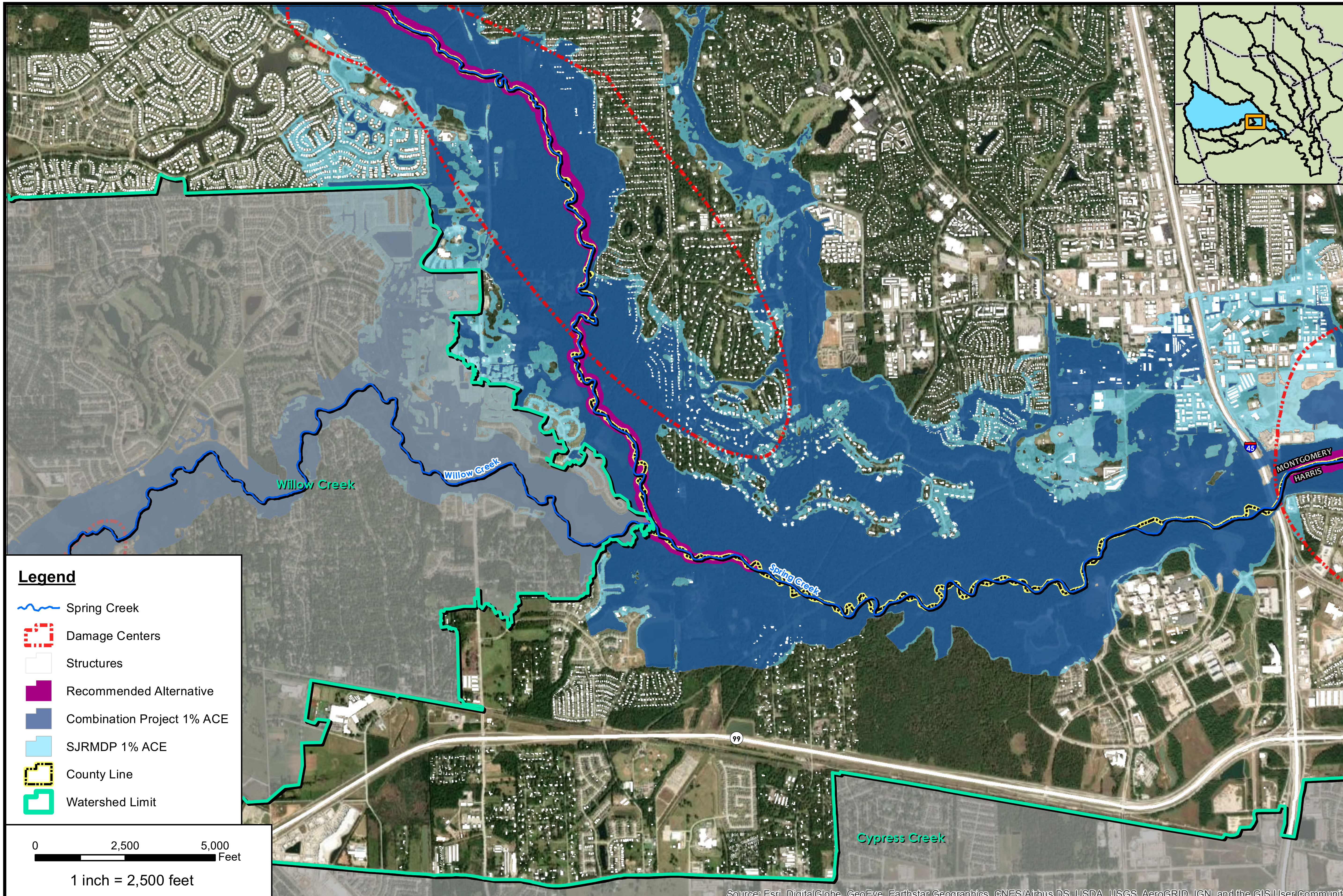
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map B



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

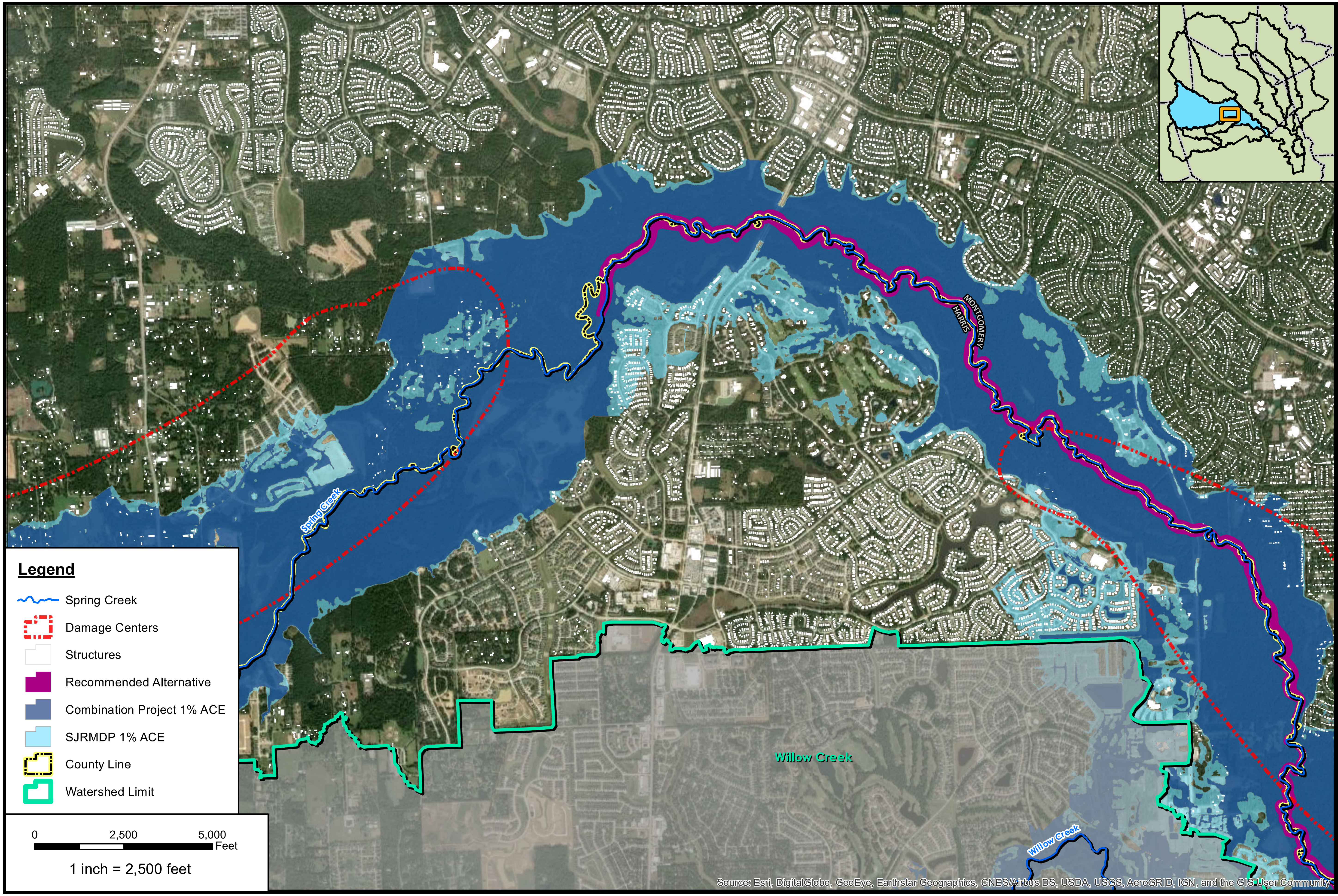
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map C



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

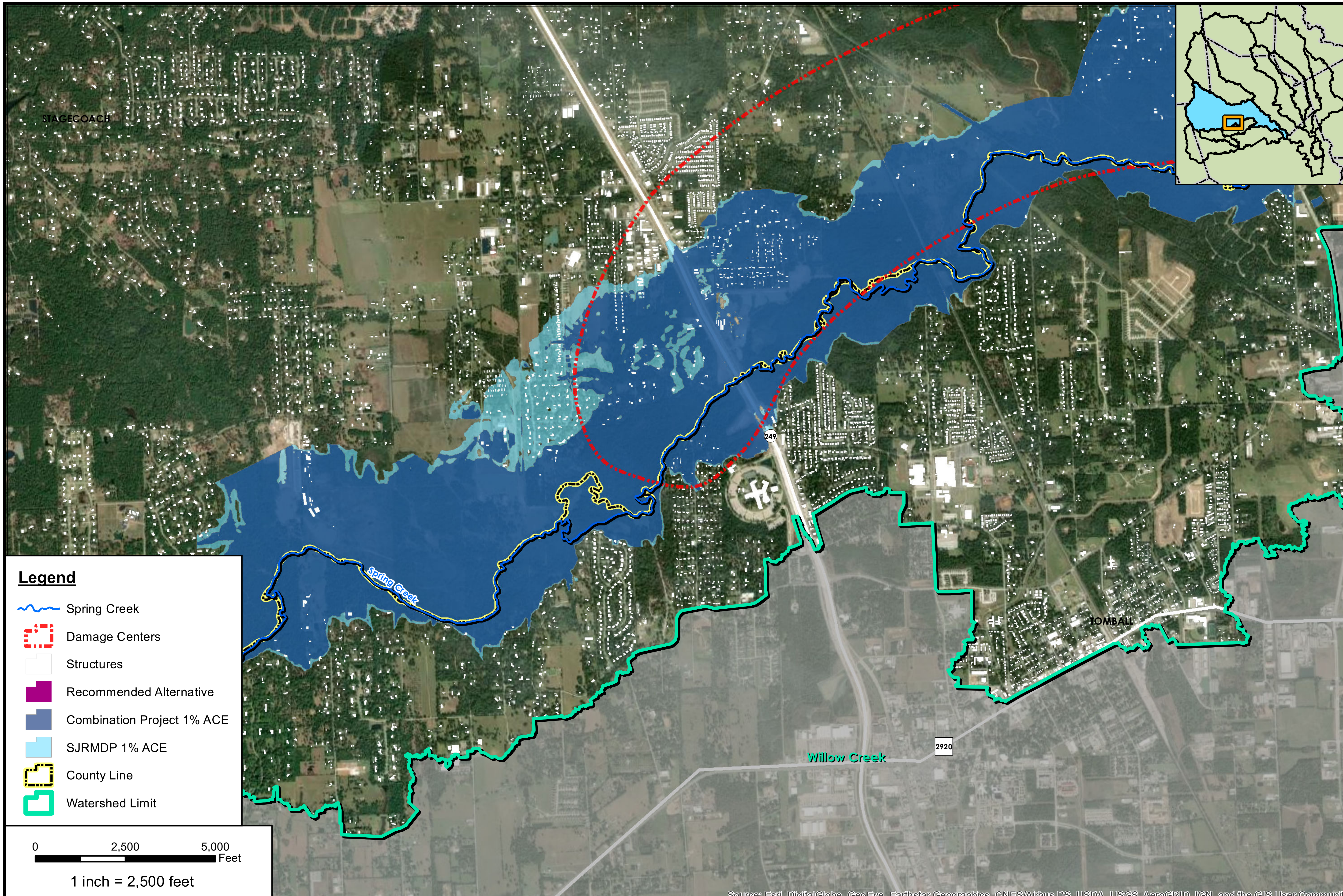
INUNDATION MAP | SPRING CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map D



PROJECT AVO

33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

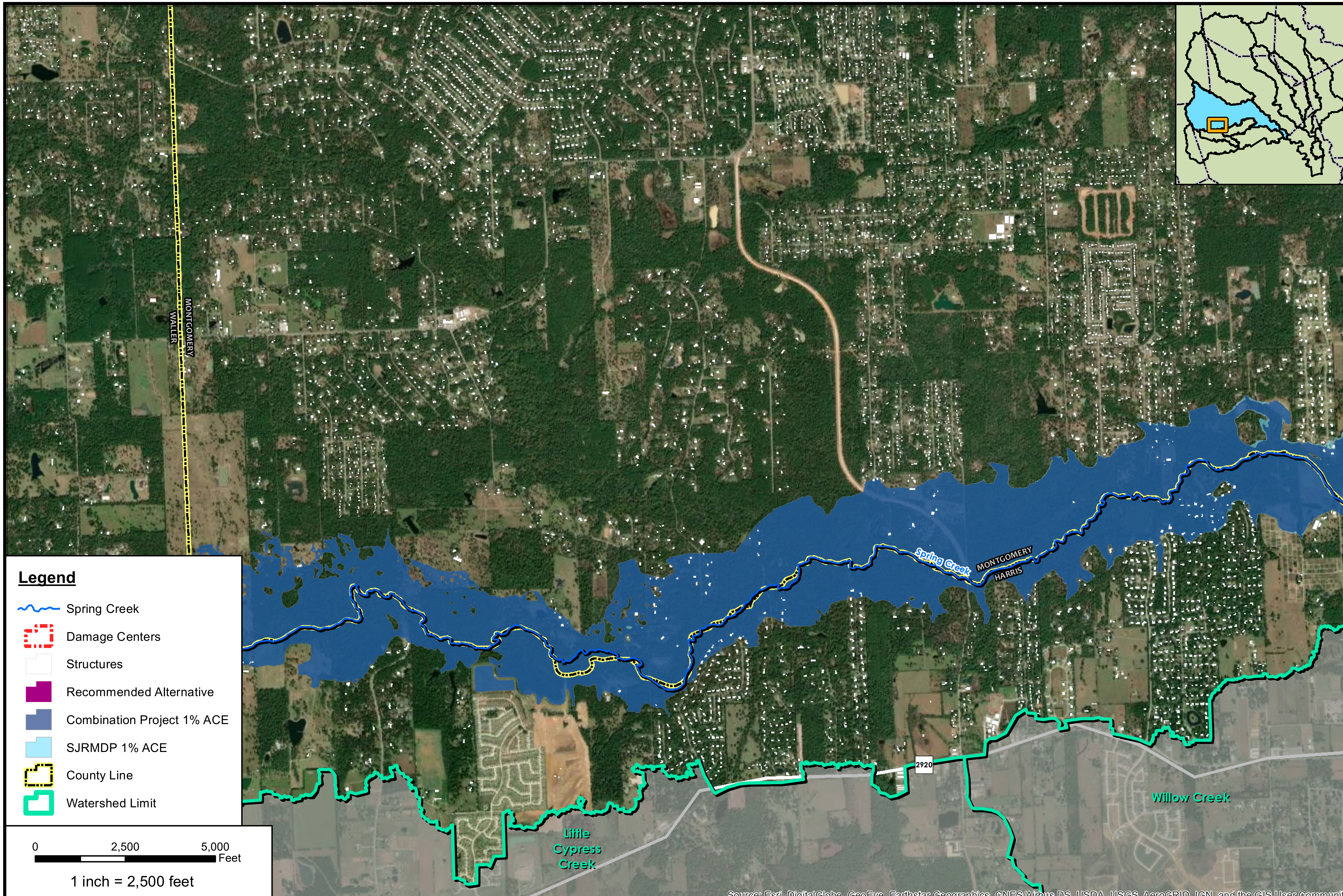
INUNDATION MAP | SPRING CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map E



Legend

- Spring Creek
- Damage Centers
- Structures
- Recommended Alternative
- Combination Project 1% ACE
- SJRMDP 1% ACE
- County Line
- Watershed Limit

0 2,500 5,000 Feet

1 inch = 2,500 feet

PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

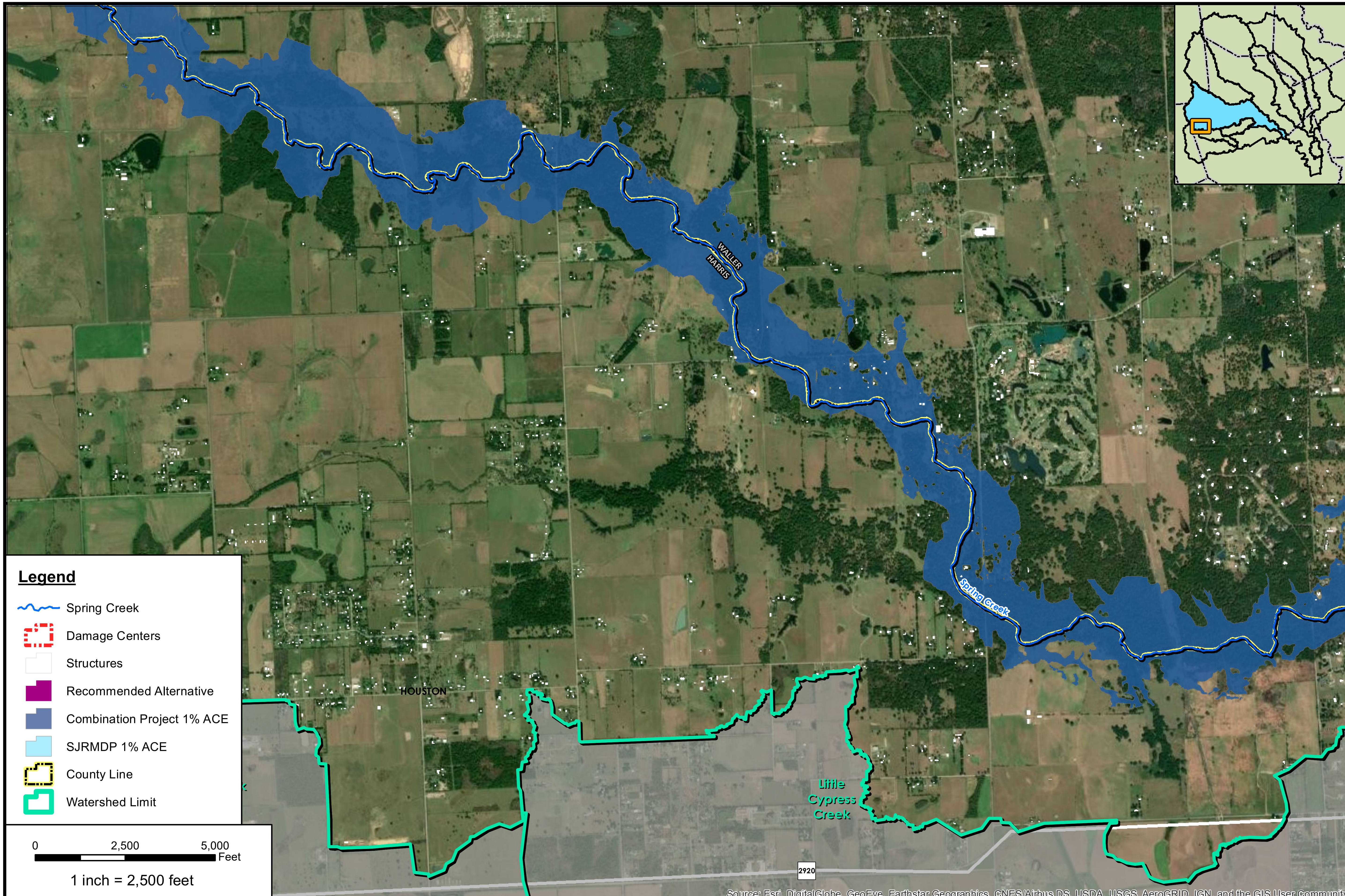
INUNDATION MAP | SPRING CREEK

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map F



PROJECT AVO 33465

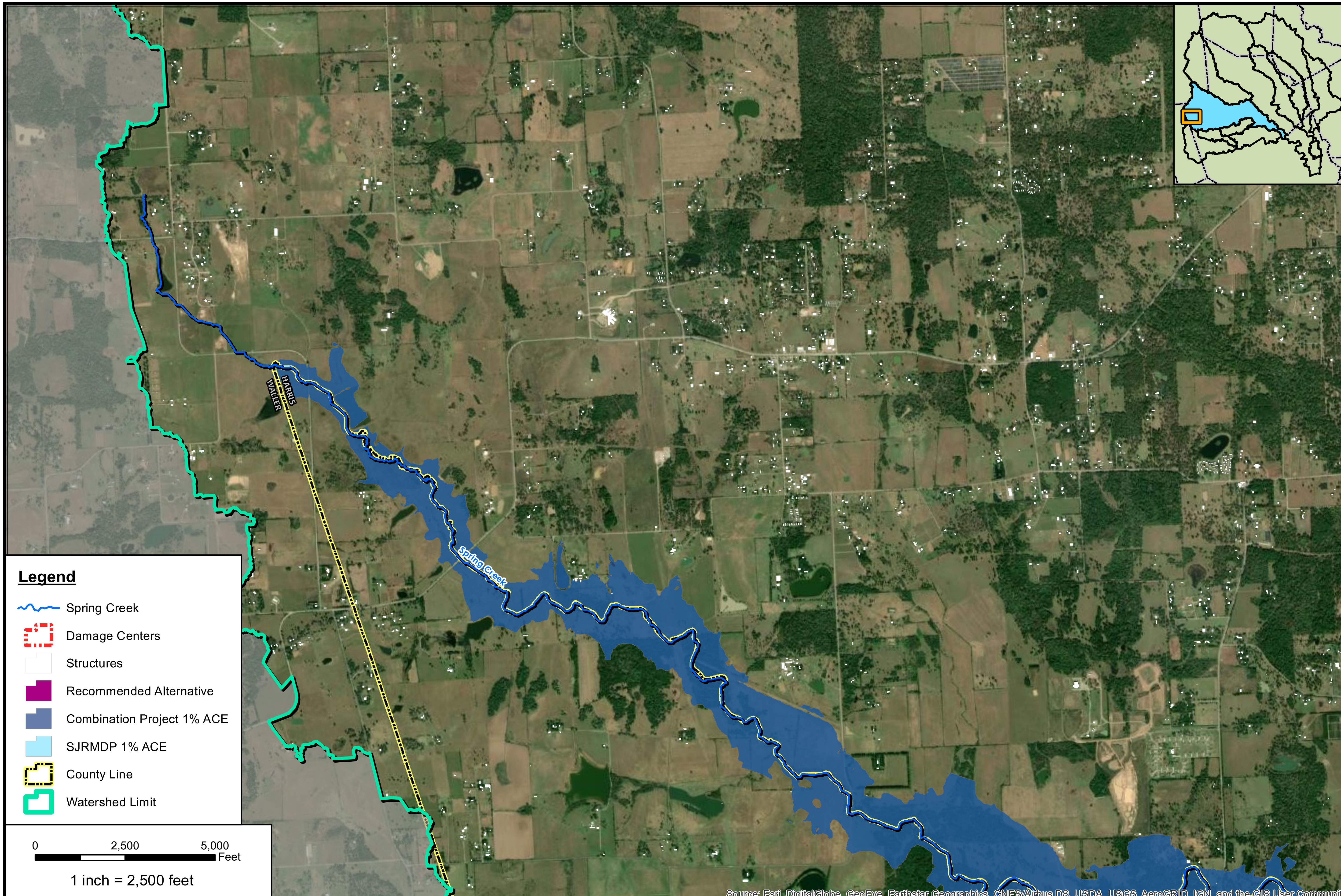
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

Exhibit G-1

Map G



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

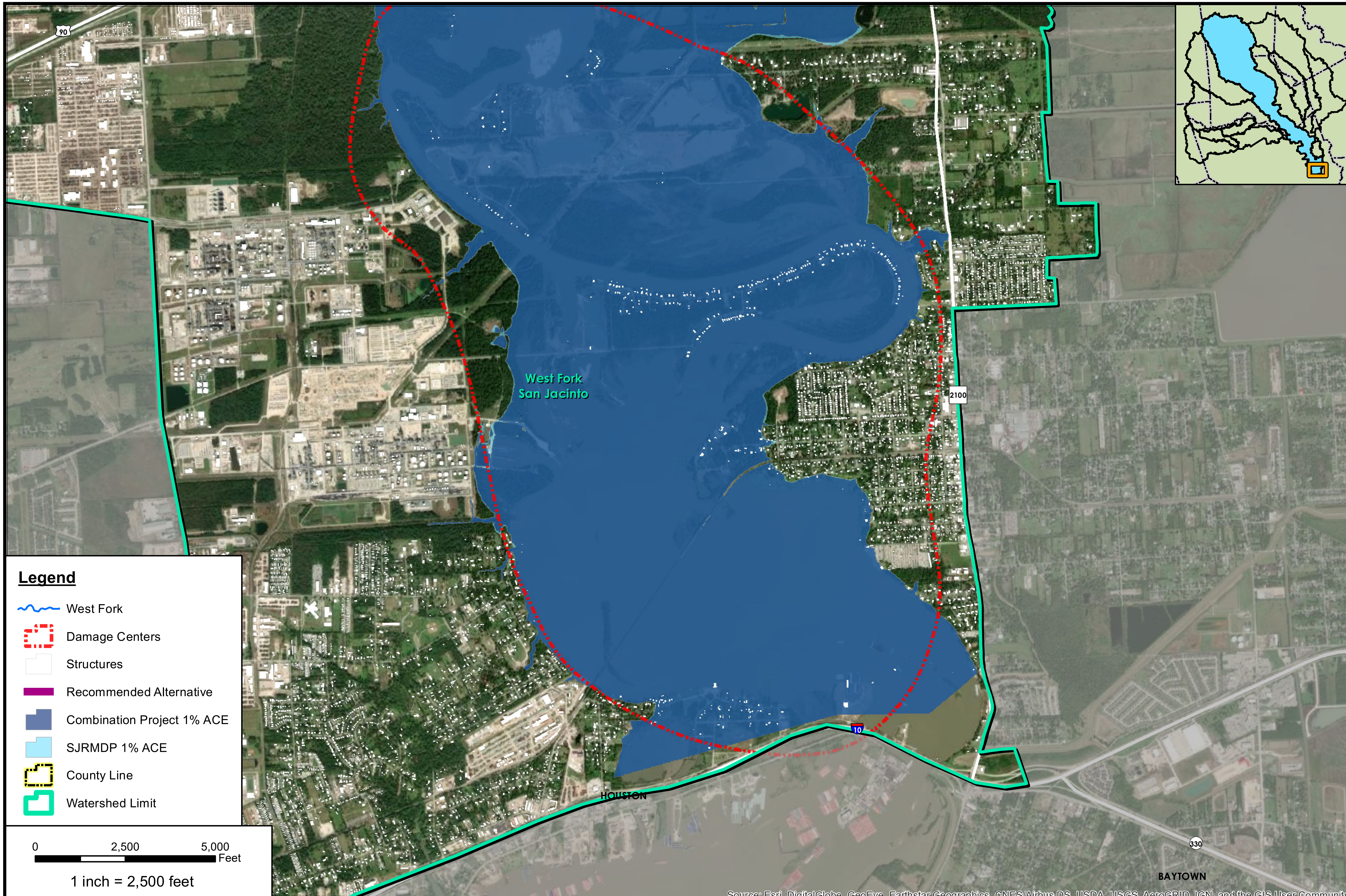
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map H



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

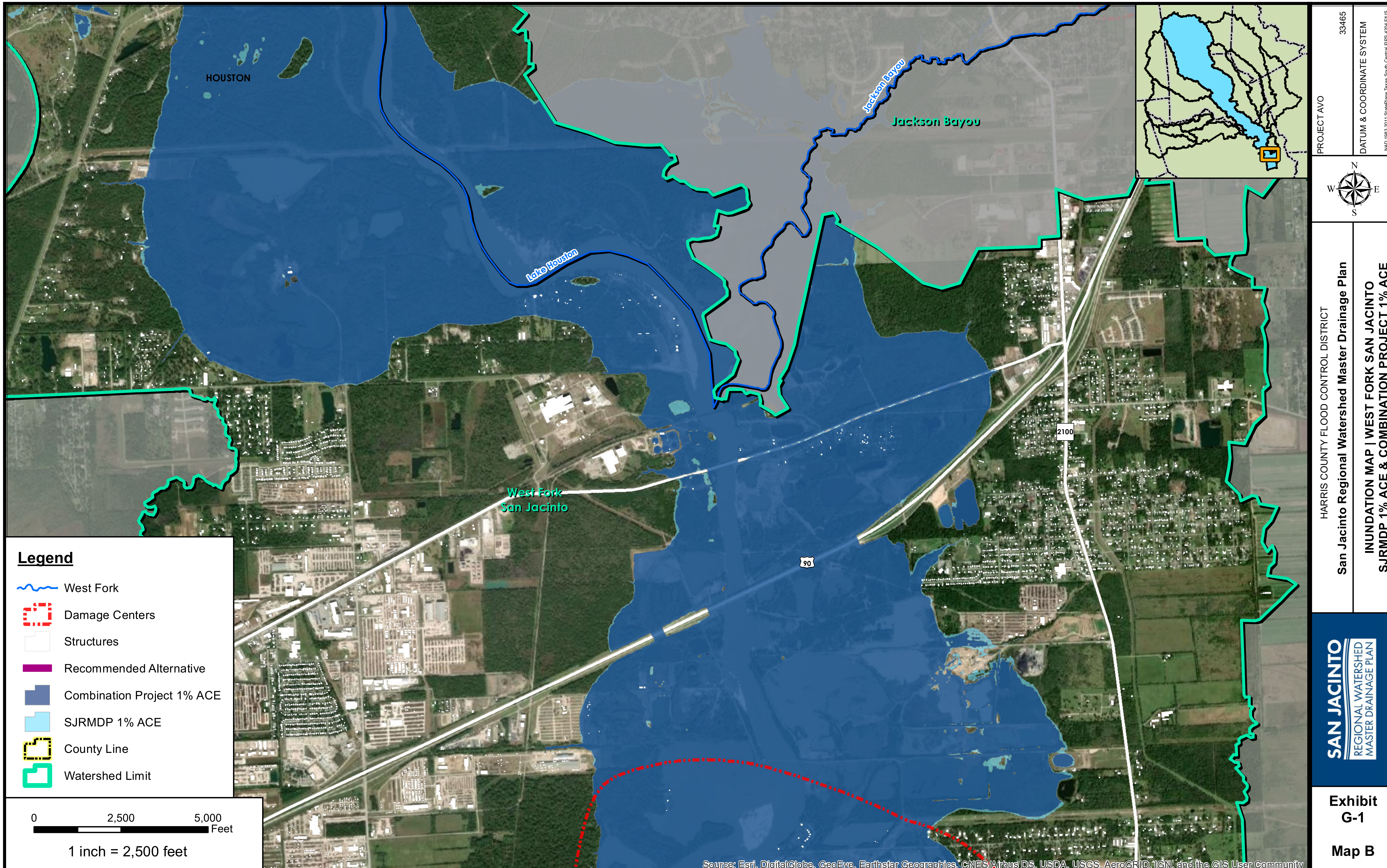
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A


HOUSTON
Lake Houston
Jackson Bayou
Jackson Bayou
West Fork
San Jacinto
2100
90
Legend
West Fork
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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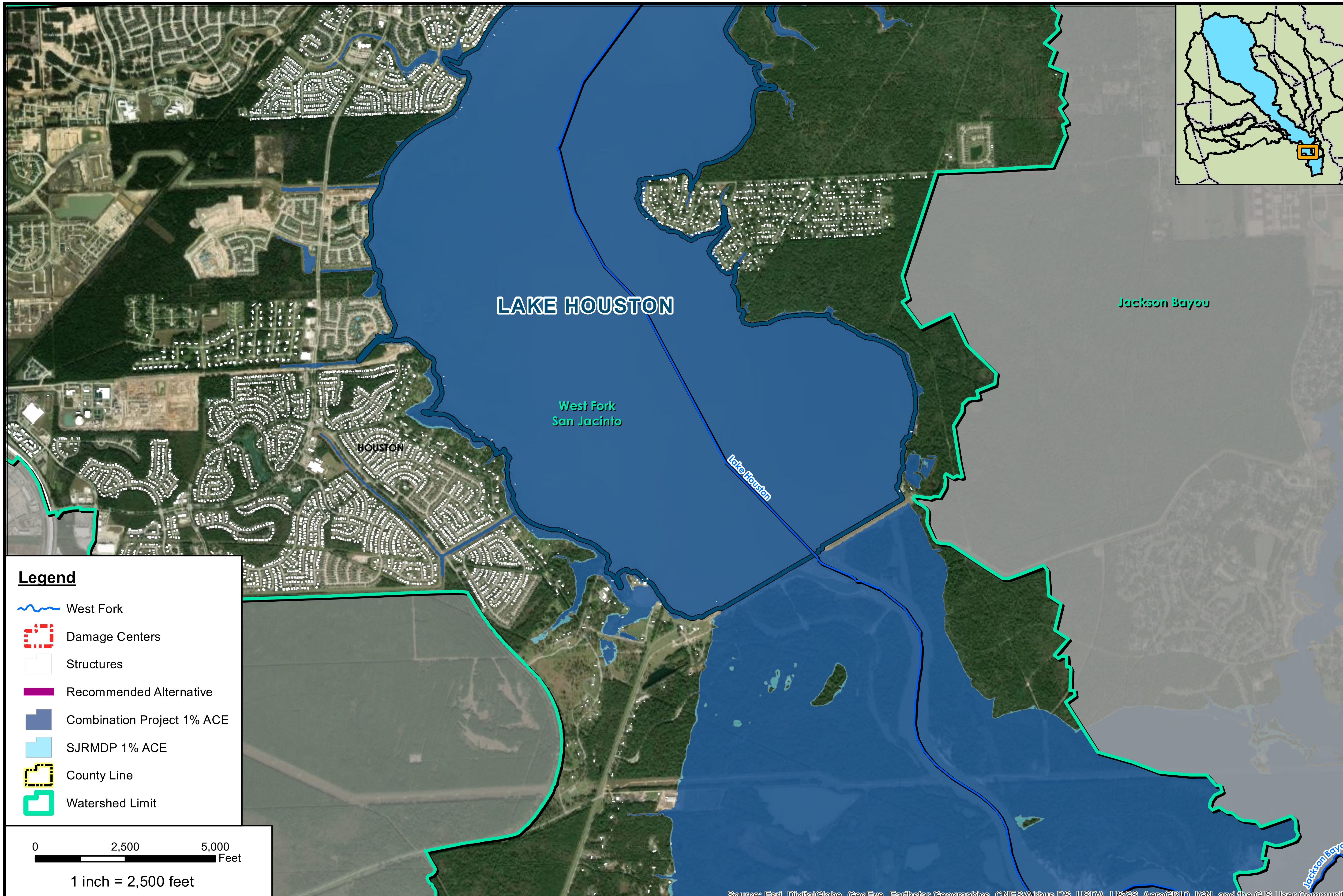
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map B



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map C

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

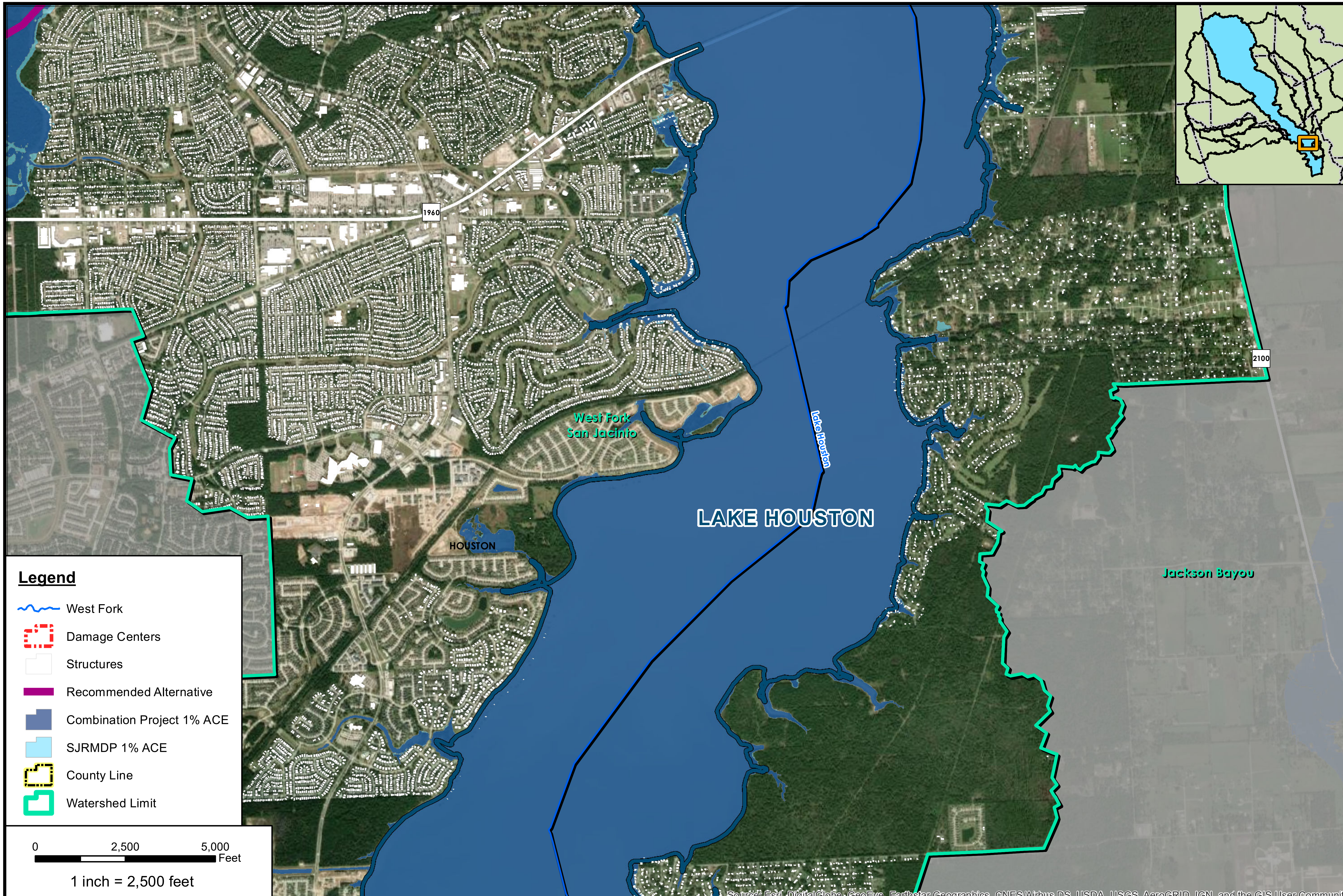
INUNDATION MAP | WEST FORK SAN JACINTO

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

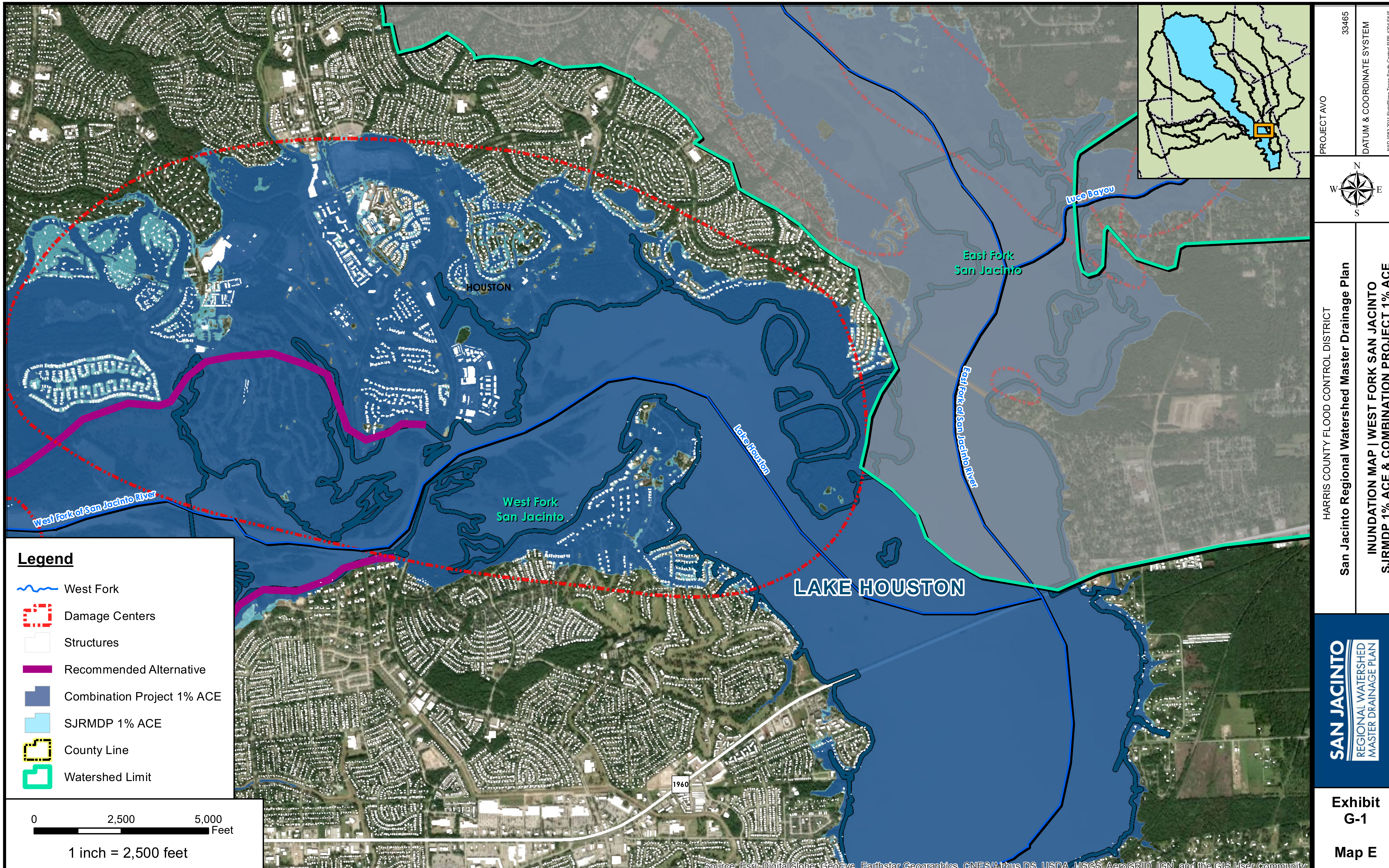
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US



SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map D


HOUSTON
LAKE HOUSTON
West Fork San Jacinto
East Fork San Jacinto
West Fork of San Jacinto River
East Fork of San Jacinto River
Lake Houston
Luce Bayou
1960
Legend
West Fork
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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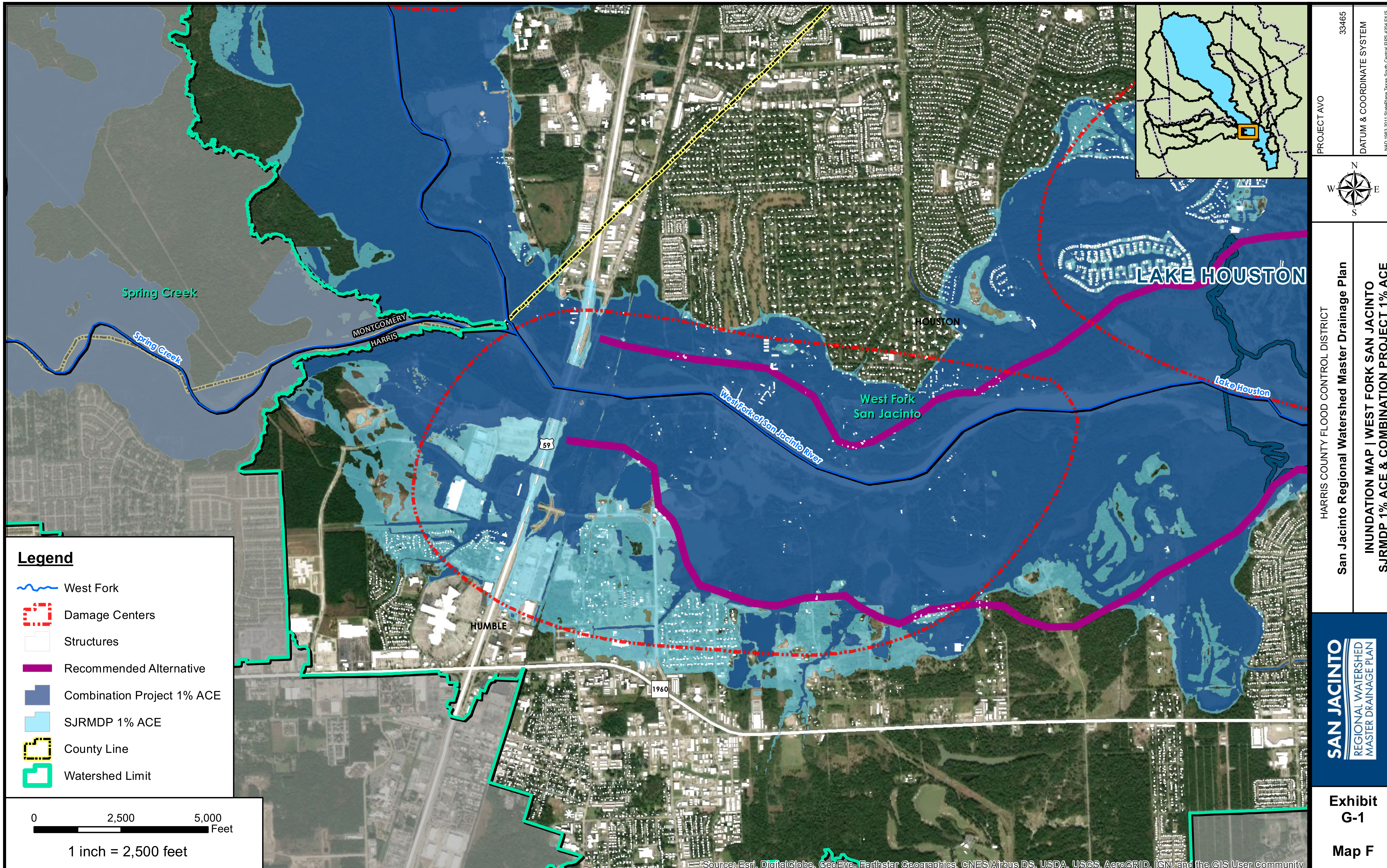
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit G-1
Map E



Spring Creek
Spring Creek
MONTGOMERY
HARRIS
West Fork of San Jacinto River
West Fork
San Jacinto
HOUSTON
LAKE HOUSTON
Lake Houston
HUMBLE
59
1960
Legend
West Fork
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS
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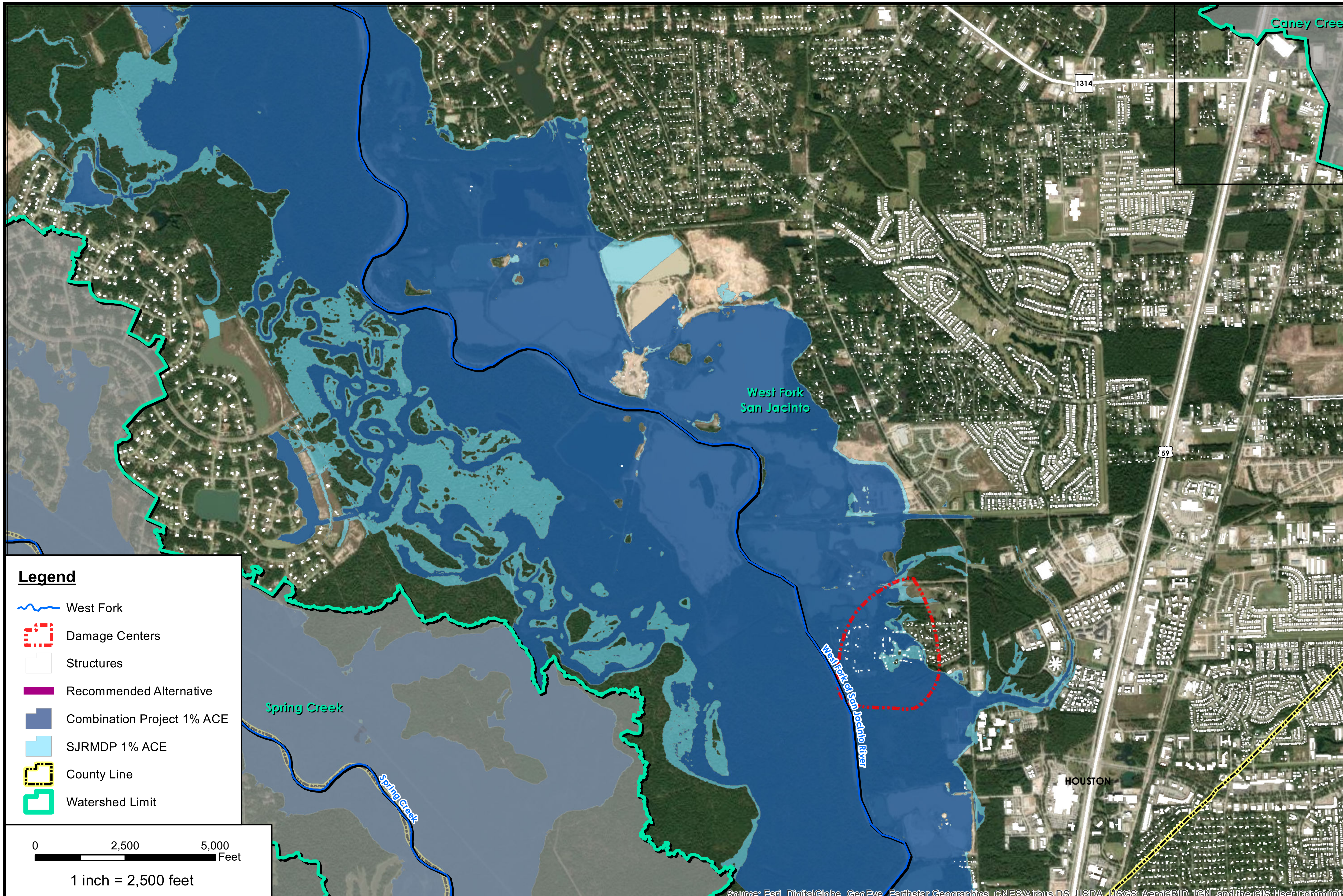
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map F



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

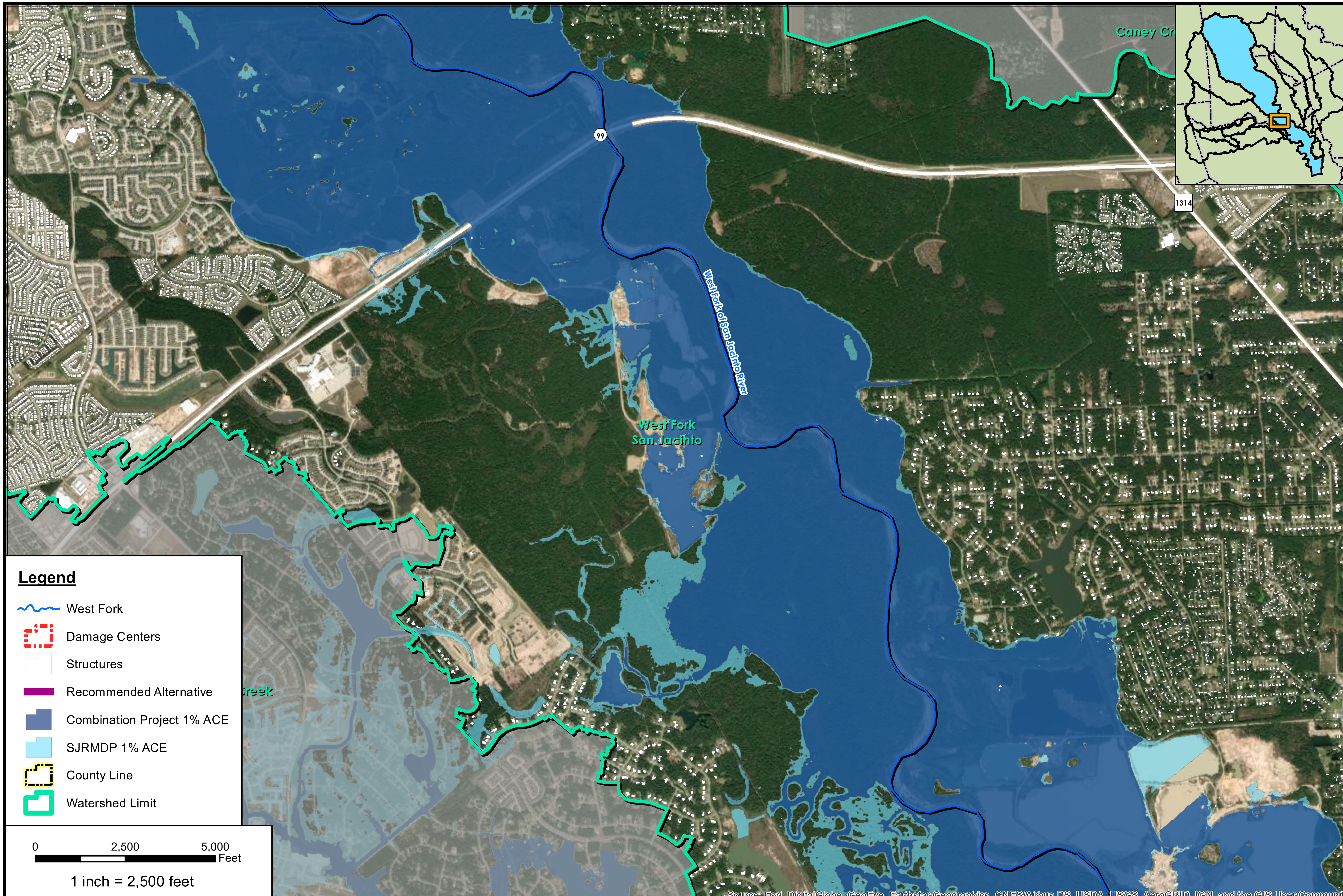
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map G



PROJECT AVO

33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

N W E S

HARRIS COUNTY FLOOD CONTROL DISTRICT

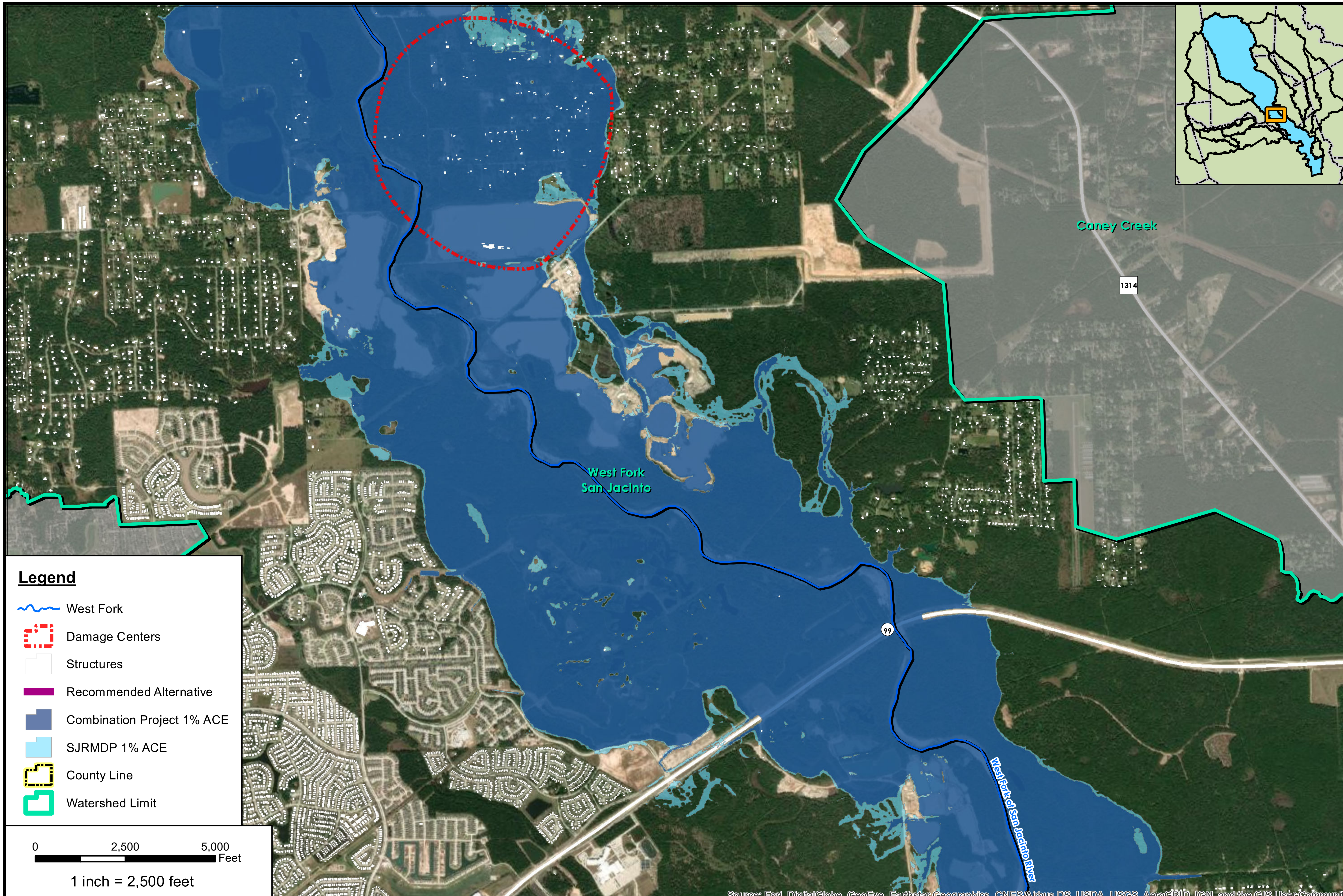
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map H



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

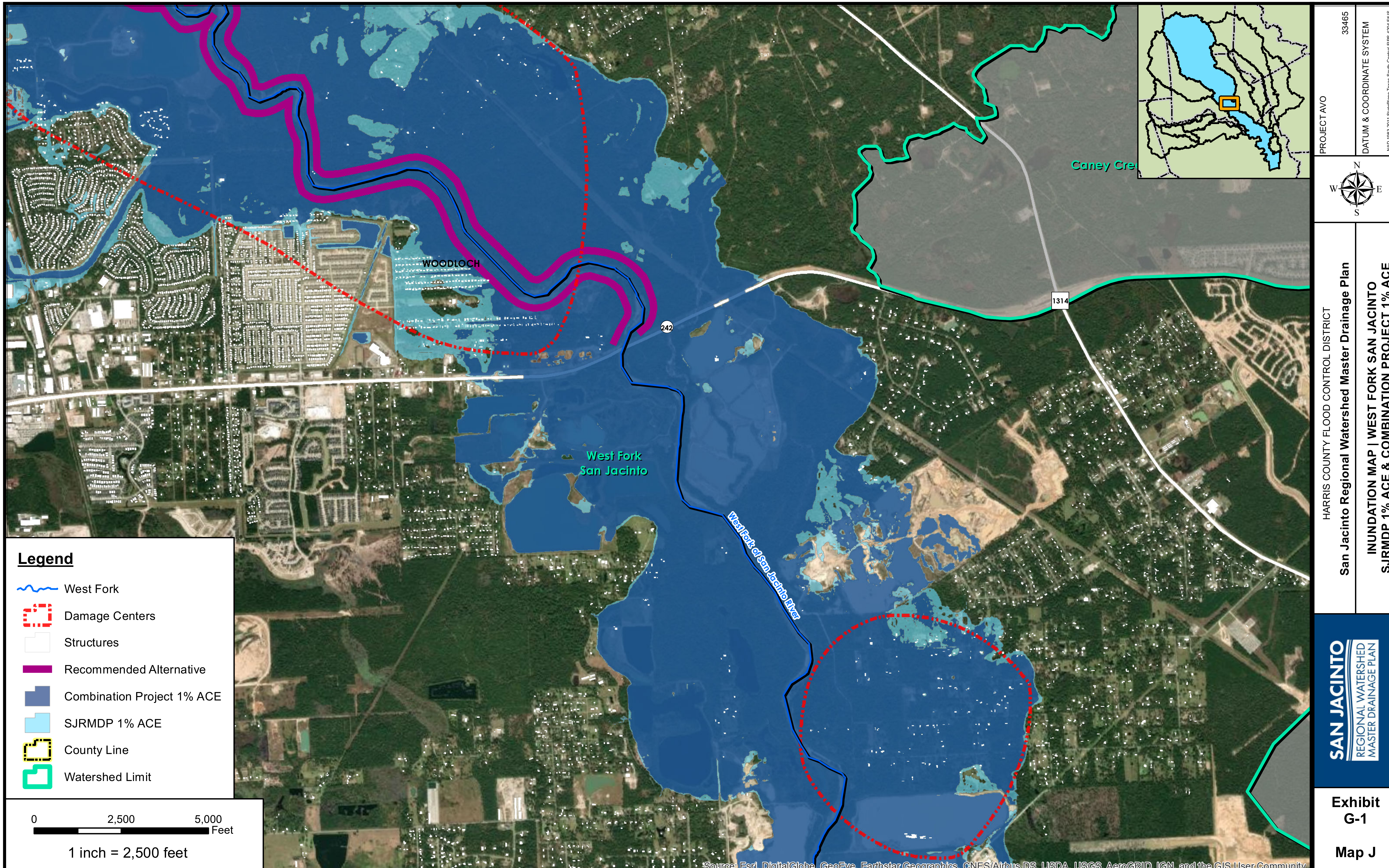
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

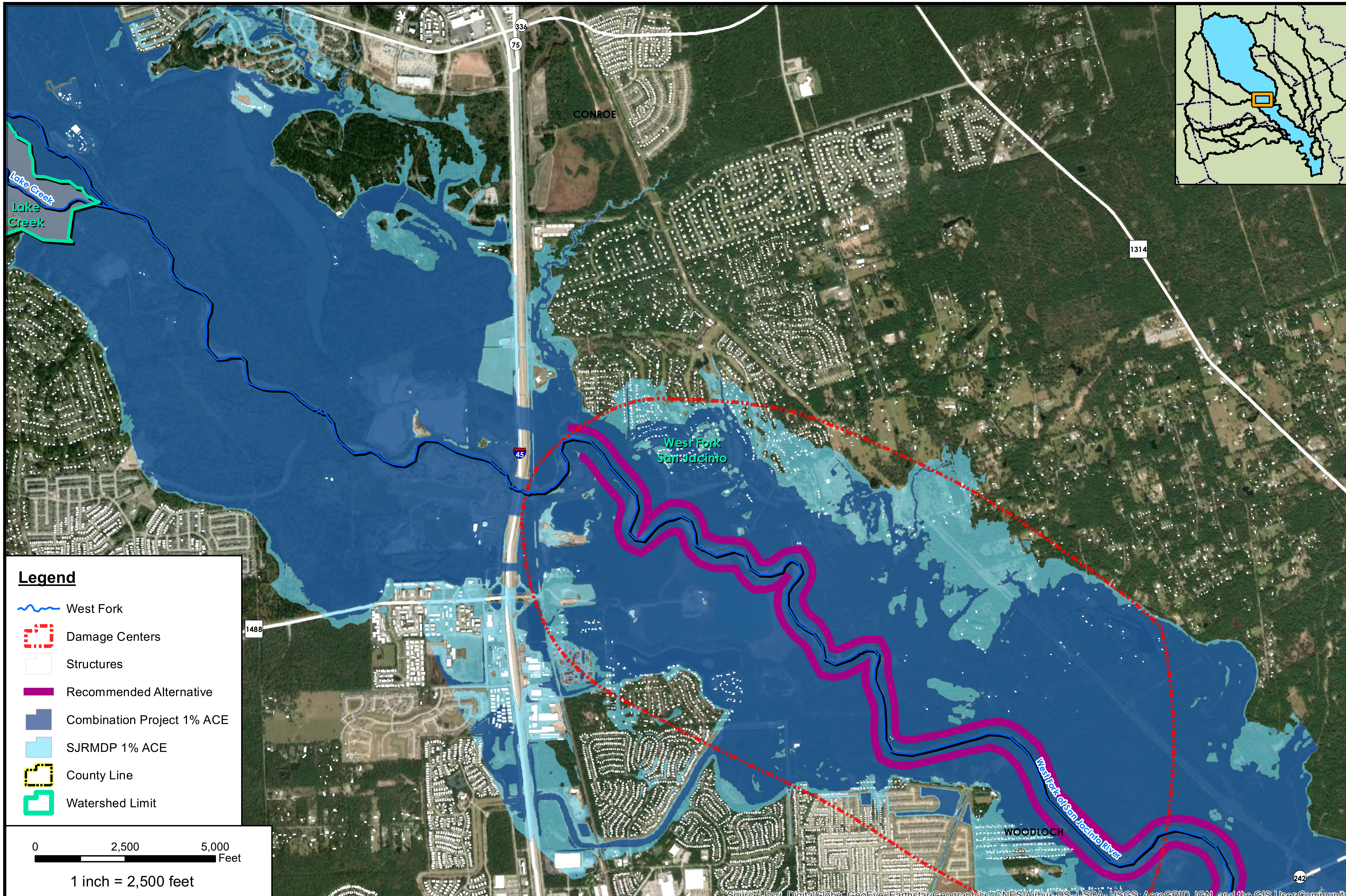
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map I



WOODLOCH
West Fork
San Jacinto
West Fork of San Jacinto River
Caney Cre
242
1314
Legend
West Fork
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map J



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

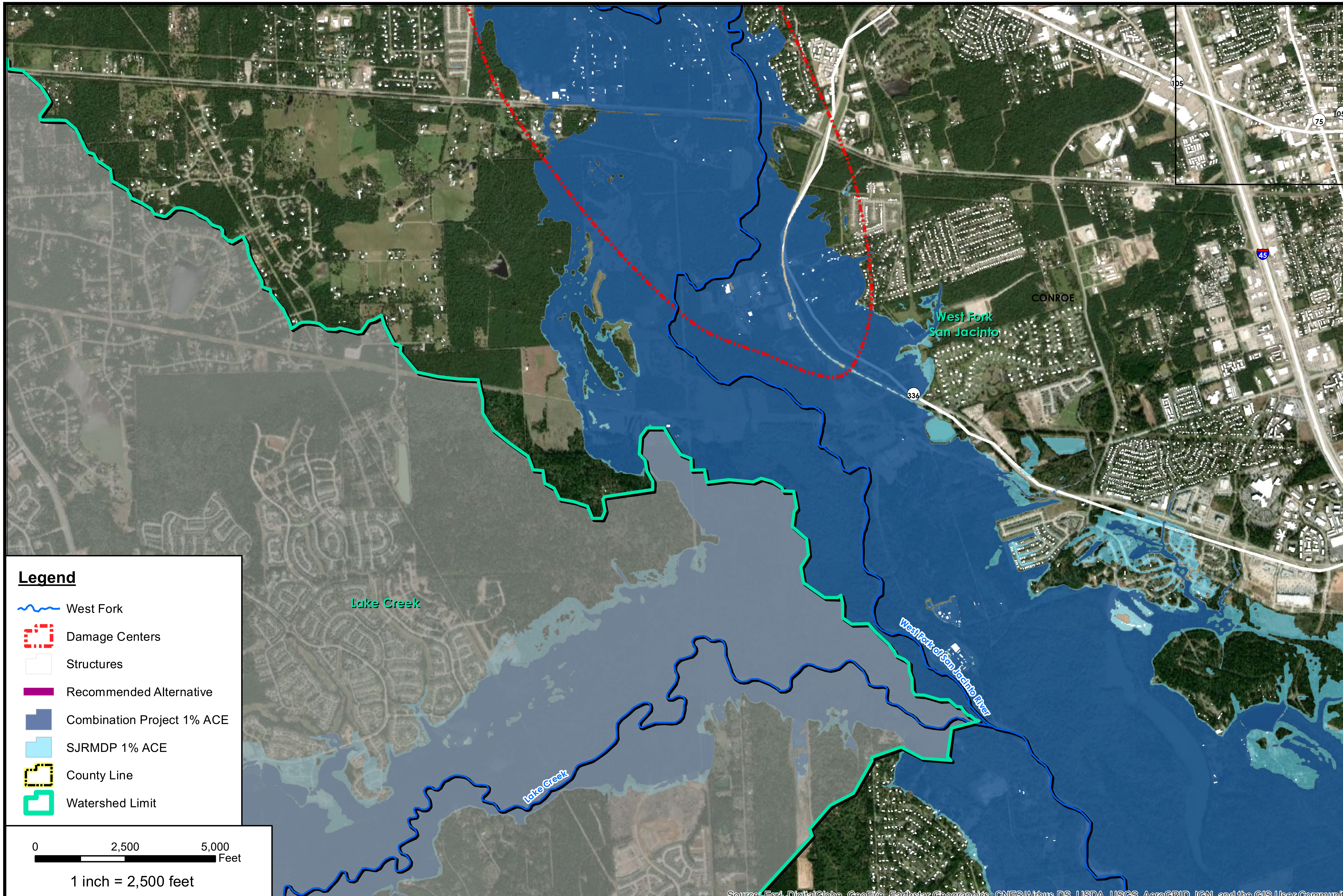
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map K



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

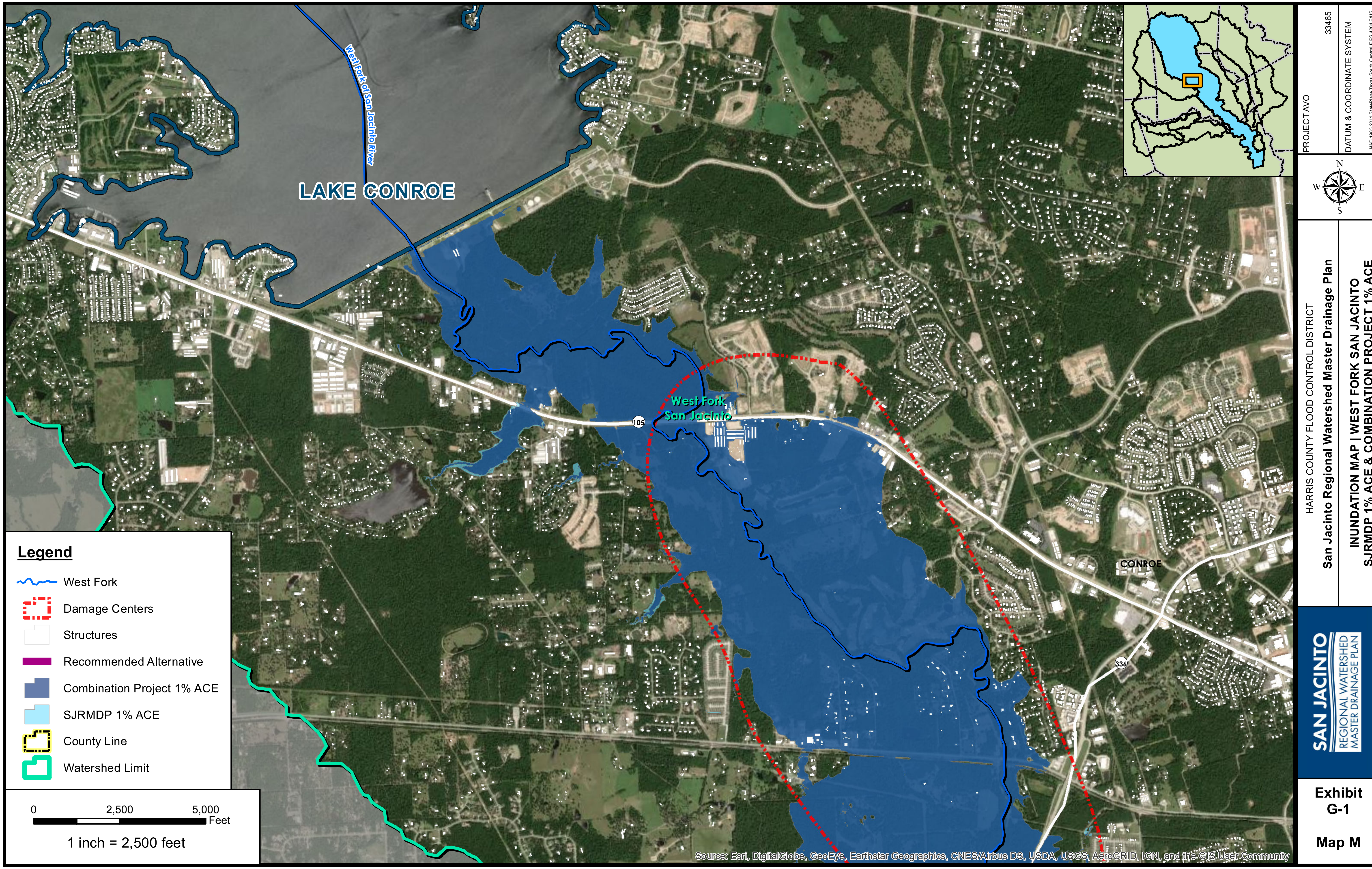
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map L


LAKE CONROE
West Fork of San Jacinto River
West Fork San Jacinto
105
CONROE
336
Legend
West Fork
Damage Centers
Structures
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS
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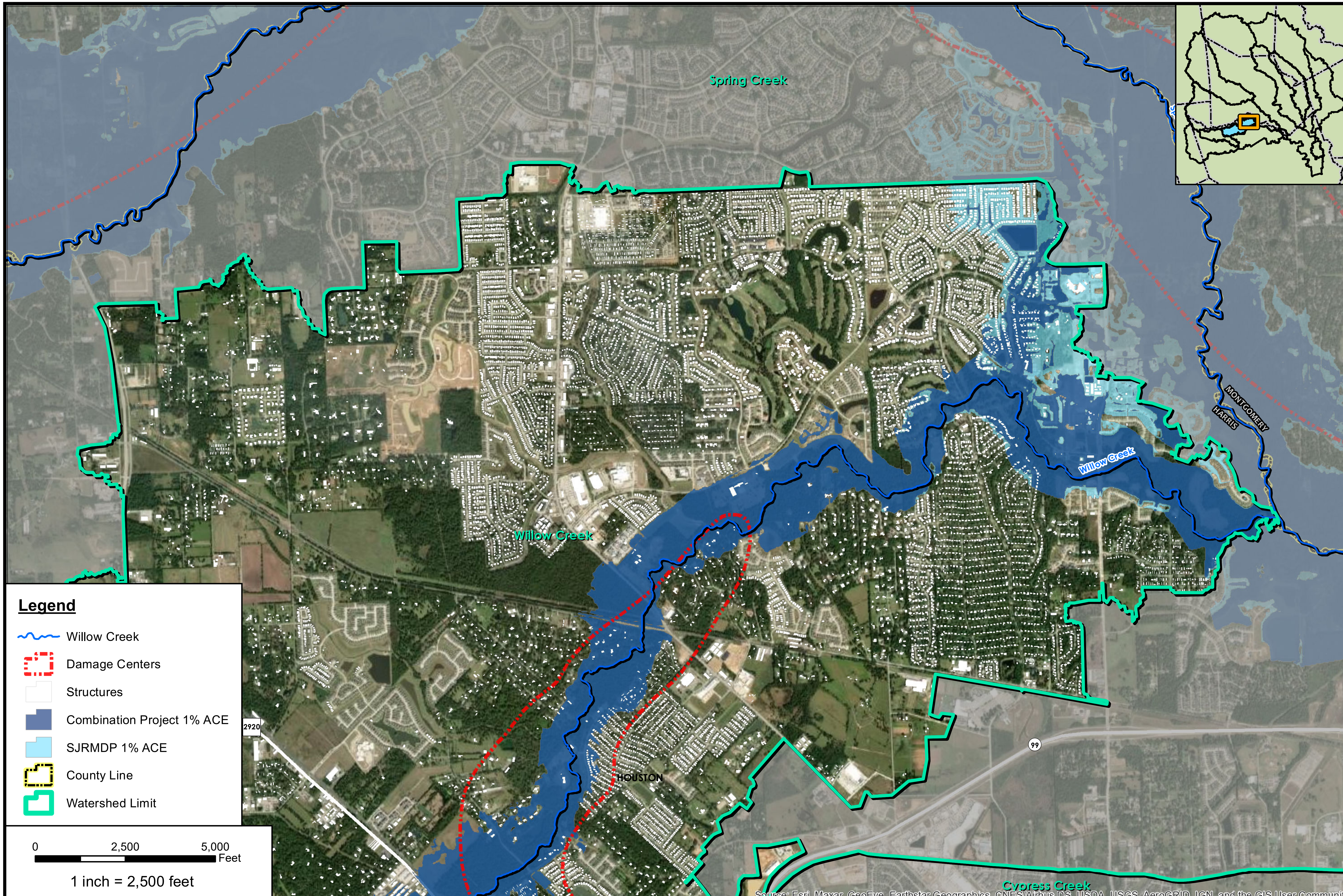
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | WEST FORK SAN JACINTO
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit G-1
Map M



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

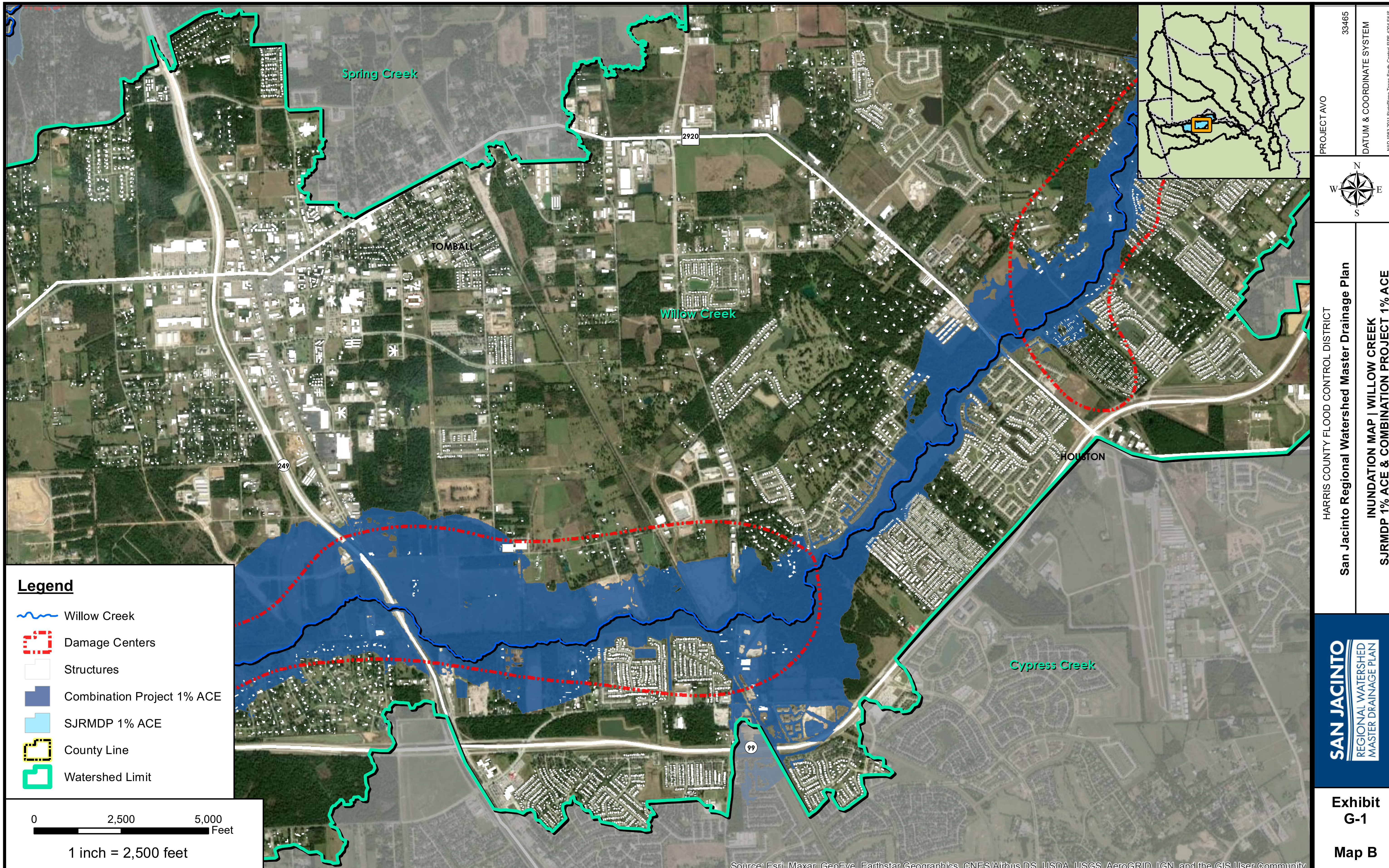
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WILLOW CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map A


Spring Creek
Willow Creek
Cypress Creek
TOMBALL
HOUSTON
2920
249
99
Legend
Willow Creek
Damage Centers
Structures
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS
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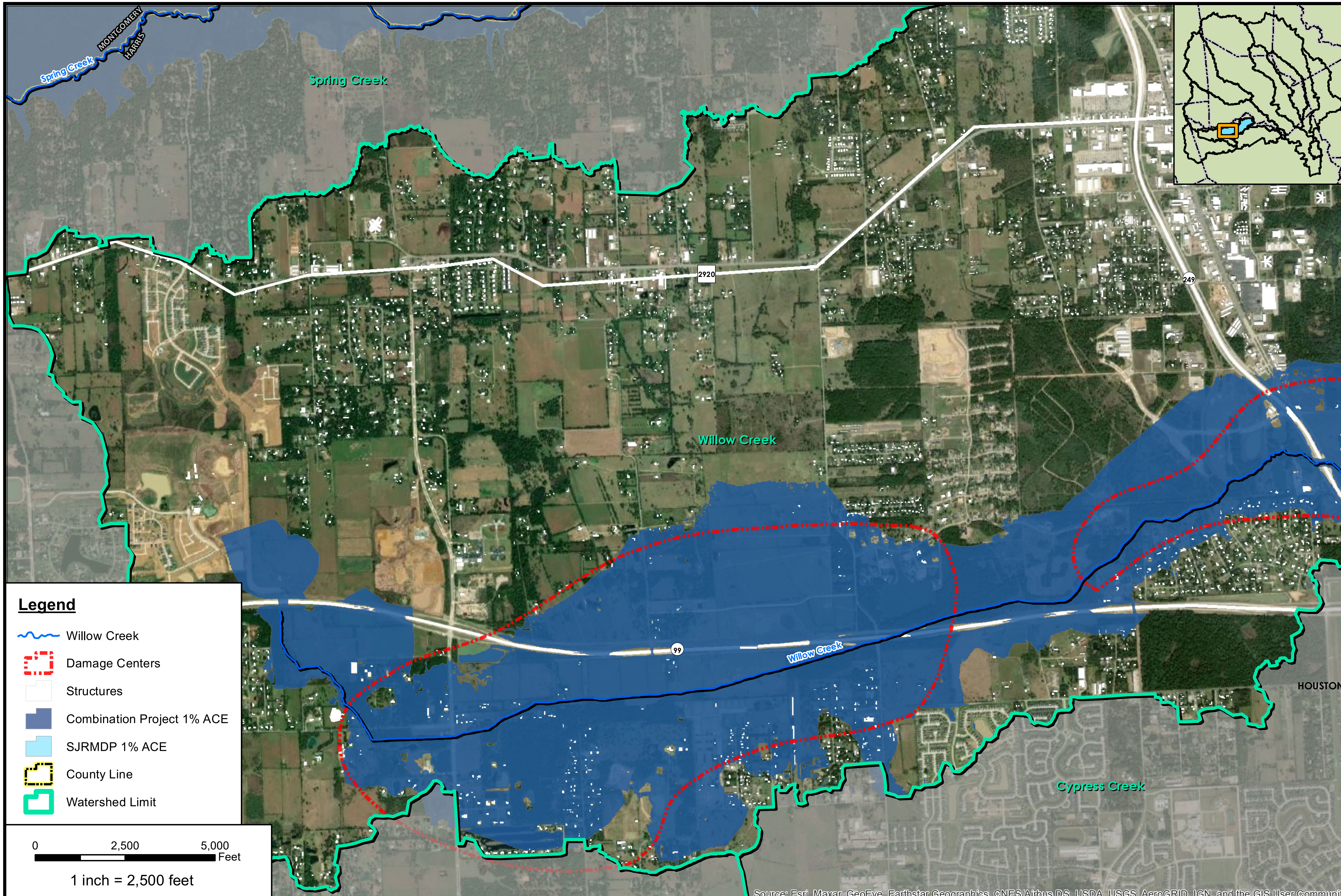
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | WILLOW CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit
G-1
Map B



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WILLOW CREEK
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map C

Appendix G.7

Alternative Fact Sheets

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

CANEY CREEK — I-69 CHANNELIZATION

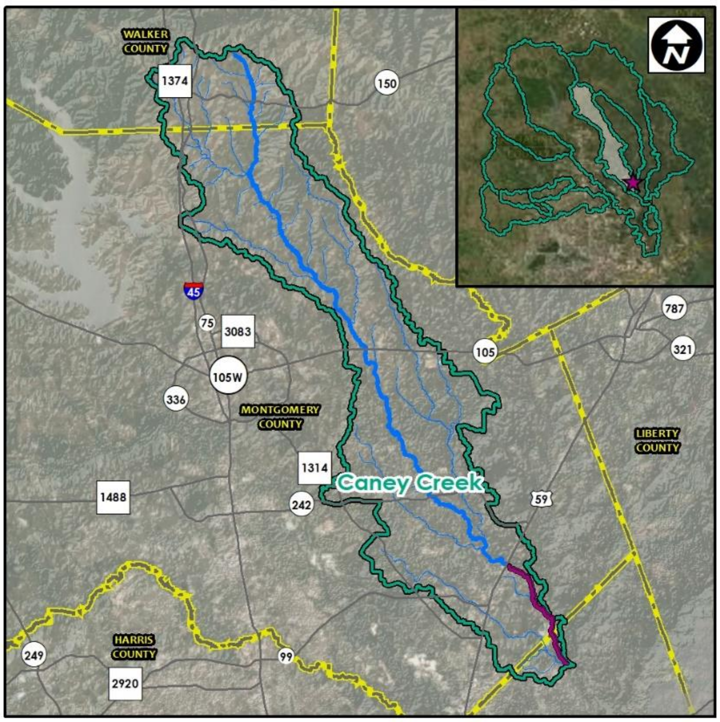
(Recommend Project in SJMDP)

LOCATION: Approximately 0.5 miles D/S of I-69 to confluence of East Fork of San Jacinto River

OBJECTIVE: Reduce flooding along Caney Creek

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 4% ACE



IMPROVEMENT SPECIFICATIONS

- 7.8 miles of channelization
- 700-foot wide bench
- 629 acres
- 4.7M cubic yards of excavation
- 530 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 509
- Reduction in instances of flooding over 50-year period: 1,122
- Benefited areas:
  - Baptist Encampment Road, New Caney
- Reduces 1% ACE WSEL at least 0.5 feet for 9.0 miles along Caney Creek
- Improves ponding depths on 5 road/rail crossings
- Net Present Value Benefit: $57.4 M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, HCFCD, TxDOT, SJRA, USACE, TWDB, GLO

REQUIRED REAL ESTATE

- 156 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 133 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 10 oil & gas pipeline conflicts
- 0.6 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$18M
Construction Cost	$146M
Environmental Cost	$20M
ROW Cost	$6M
TOTAL COSTS	$189M
20-Year Escalation Cost	$287M

BENEFIT-COST RATIO: 0.30

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

CANEY CREEK — FM 1097 DETENTION

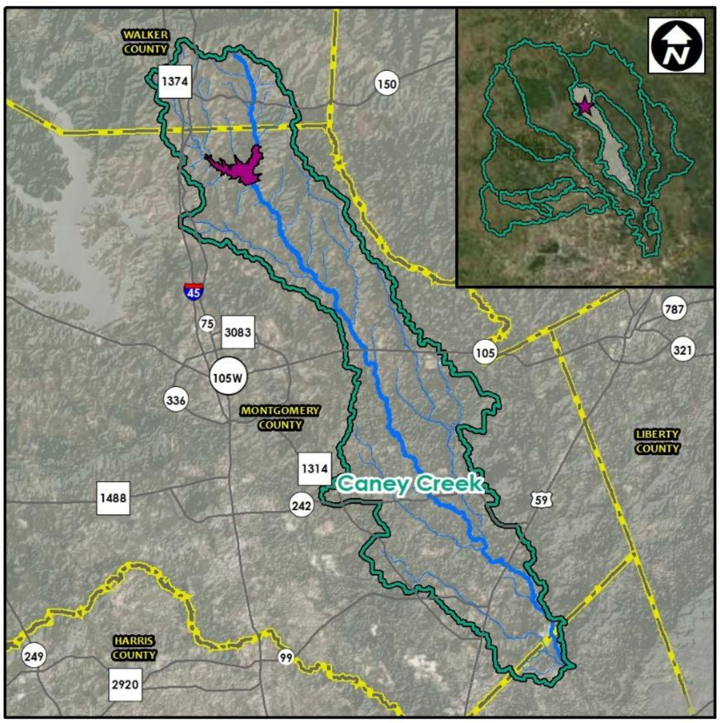
(Recommend Project in SJMDP)

LOCATION: Approximately 1.0 miles U/S of FM 1097 on Caney Creek

OBJECTIVE: Reduce flooding along Caney Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 4% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, TxDOT, SJRA, HCFCD, USACE, TWDB, GLO

REQUIRED REAL ESTATE

- 182 parcels within PMF
- 95 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 1 acre of potential wetlands
- 1,291 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- No known oil & gas pipeline conflicts
- 4.1 miles of roads (PMF)
- 1.3 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,514 acres (1% ACE)
- 2,435 acres (PMF)
- 13,900 acre-feet (1% ACE)
- Embankment: 1.5M cubic yards
- Max dam height: 53 ft
- Dam length: 1.2 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 285
- Reduction in instances of flooding over 50-year period: 783
- Benefited areas:
  - New Caney, The neighborhoods near SH 242 and FM 1484
  - Reduces 1% ACE WSEL at least 0.5 feet for 40.0 miles downstream of detention facility
- Improves ponding depths on 18 road/rail crossings
- Net Present Value Benefit: $27.7M

ESTIMATED COSTS

Design Cost..$8M
Construction Cost $65M
Environmental Cost.................................$8M
ROW Cost....................................$24M–$50M
<u>TOTAL COSTS.........................$105M–$131M</u>
20-Year Escalation Cost ....$159M–$199M

BENEFIT-COST RATIO: 0.21–0.26

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

CANEY CREEK — SH 105 DETENTION

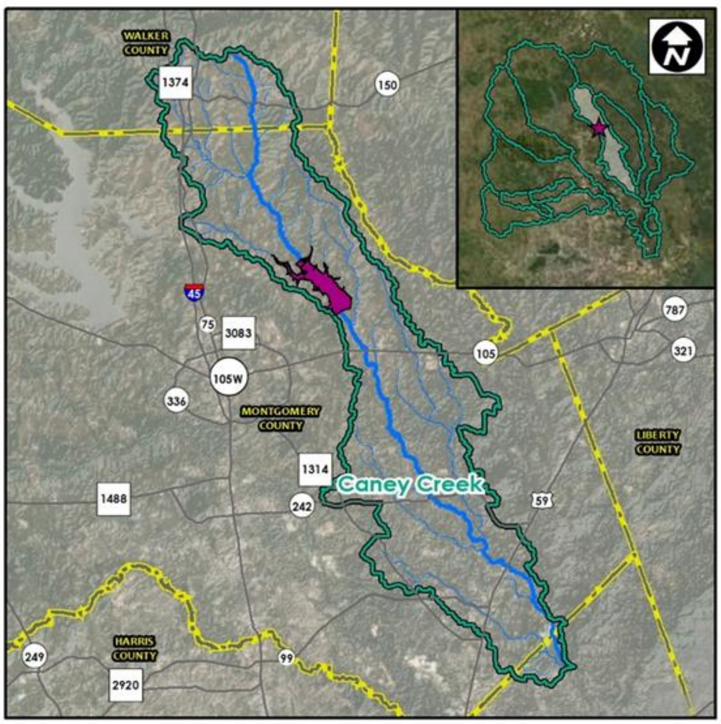
(Recommend Project in SJMDP)

LOCATION: Approximately 1.9 miles U/S of SH 105 on Caney Creek

OBJECTIVE: Reduce flooding along Caney Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 4% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, TxDOT, HCFCD, SJRA, TWDB, GLO, USACE

REQUIRED REAL ESTATE

- 402 parcels within PMF
- 227 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 4 acres of potential wetlands
- 1,058 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 1 oil & gas pipeline conflict
- 0.9 miles of roads (PMF)
- 0.5 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,502 acres (1% ACE)
- 2,310 acres (PMF)
- 28,090 acre-feet (1% ACE)
- Embankment: 1.2M cubic yards
- Max dam height: 62 ft
- Dam length: 0.8 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 658
- Reduction in instances of flooding over 50-year period: 1,596
- Benefited areas:
  - The neighborhoods near SH 242 and FM 1484
- Reduces 1% ACE WSEL at least 0.5 feet for 31.5 miles downstream of detention facility
- Improves ponding depths on 11 road/rail crossings
- Net Present Value Benefit: $55.2M

ESTIMATED COSTS

Design Cost	$7M
Construction Cost	$61M
Environmental Cost	$8M
ROW Cost	$38M–$74M
TOTAL COSTS	$114M–$149M
20-Year Escalation Cost	$173M–$227M

BENEFIT-COST RATIO: 0.37–0.48

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

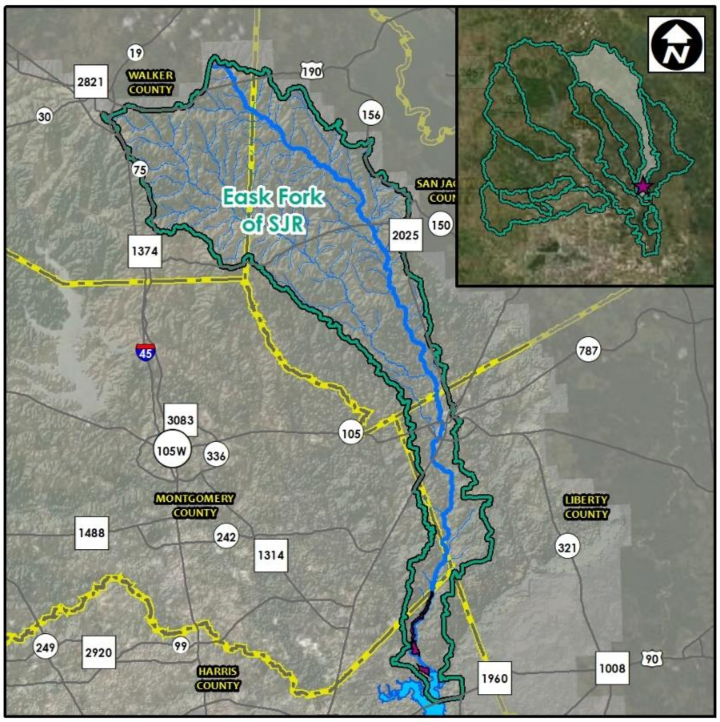
EAST FORK SAN JACINTO — FM 1485 CHANNELIZATION

LOCATION: FM 1485 to Luce Bayou confluence on East Fork of San Jacinto River

OBJECTIVE: Reduce flooding along East Fork of San Jacinto River

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 10% ACE



IMPROVEMENT SPECIFICATIONS

- 4.3 miles of channelization
- 1400-foot wide bench
- 882 acres
- 12.4 cubic yards of excavation
- 15,000 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 318
- Reduction in instances of flooding over 50-year period: 727
- Benefited areas:
  - Kingwood, River Terrace, Rolling Creek Acres
- Reduces 1% ACE WSEL at least 0.5 feet for 10.4 miles
- Improves ponding depths on 5 road/rail crossings
- Net Present Value Benefit: $26.4M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Harris County, HCFCD, SJRA, TxDOT, City of Houston, USACE, TWDB, GLO

REQUIRED REAL ESTATE

- 166 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 286 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 5 oil & gas pipeline conflicts
- 0 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$29M
Construction Cost	$243M
Environmental Cost	$36M
ROW Cost	$32M
TOTAL COSTS	$340M
20-Year Escalation Cost	$515M

BENEFIT-COST RATIO: 0.08

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

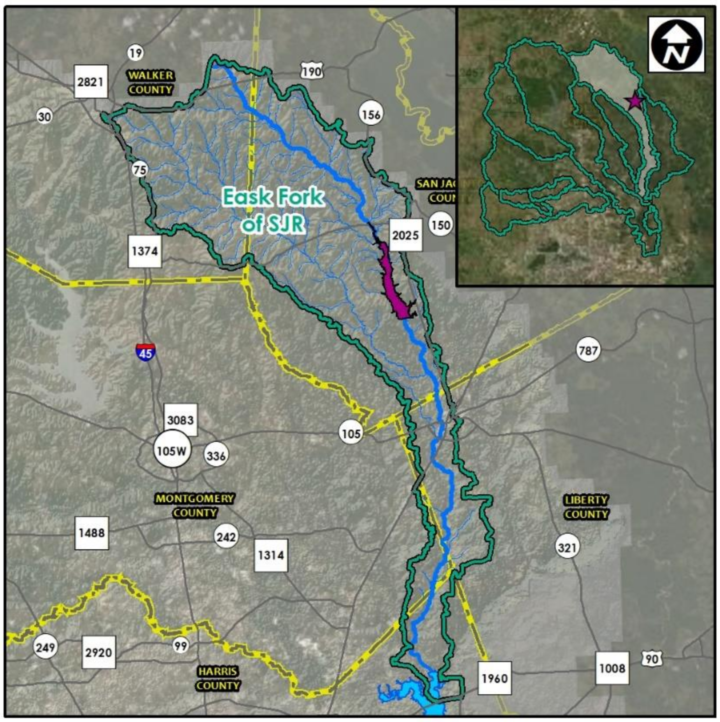
EAST FORK SAN JACINTO — FM 945 DETENTION

LOCATION: Approximately 10 miles U/S of Cleveland on East Fork of San Jacinto River

OBJECTIVE: Reduce flooding along East Fork of San Jacinto River

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 3,030 acres (1% ACE)
- 3,182 acres (PMF)
- 28,248 acre-feet (1% ACE)
- Embankment: 1.3M cubic yards
- Max dam height: 54 ft
  Dam length: 1.4 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 570
- Reduction in instances of flooding over 50-year period: 1,109
- Location of benefits:
  - Cleveland, Plum Grove
- Reduces 1% ACE WSEL at least 0.5 feet for 38.7 miles downstream of detention facility
- Improves ponding depths on 6 road/rail crossings
- Net Present Value Benefit: $51.9M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

San Jacinto County, SJRA, TxDOT, USACE, USDA, BNSF Railroad, UPRR, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 328 parcels within PMF
- 214 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 12 acres of potential wetlands
- 1,617 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 4 oil & gas pipeline conflicts
- 0.6 miles of roads (PMF)
- 0.1 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost..$9M
Construction Cost $73M
Environmental Cost................................ $11M
ROW Cost.................................... $53M–$73M
<u>TOTAL COSTS........................$146M–$166M</u>
20-Year Escalation Cost .... $221M–$251M

BENEFIT-COST RATIO: 0.31–0.36

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

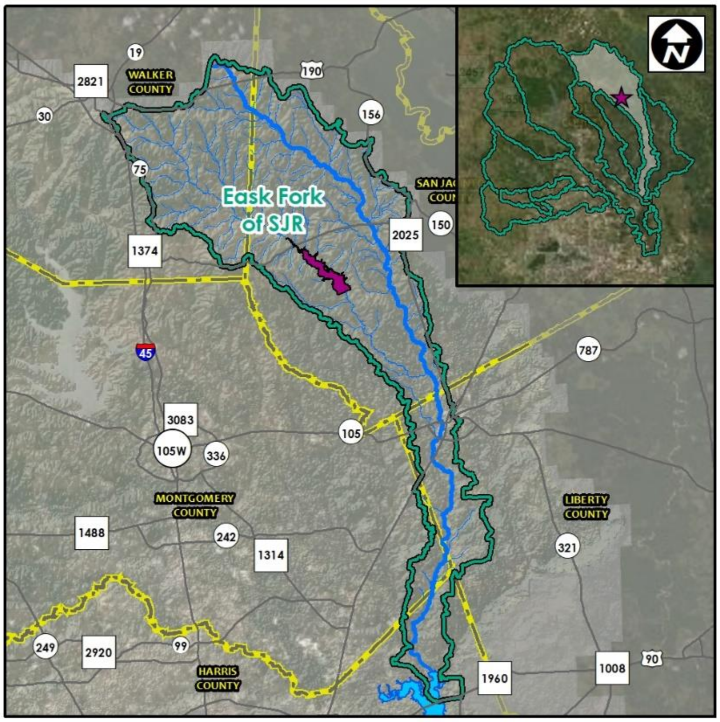
EAST FORK SAN JACINTO — WINTERS BAYOU NEBLETTS DETENTION

LOCATION: Approximately 11 miles U/S Winters Bayou from East Fork of San Jacinto River

OBJECTIVE: Reduce flooding along East Fork of San Jacinto River

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

San Jacinto County, SJRA, TxDOT, USACE, USDA, BNSF Railroad, UPRR, TWDB, GLO, HCFCD,

REQUIRED REAL ESTATE

- 182 parcels within PMF
- 105 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 7.5 acres of potential wetlands
- 1,385 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- No known oil & gas pipeline conflicts
- 0.7 miles of roads (PMF)
- 1.2 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 2,271 acres (1% ACE)
- 2,385 acres (PMF)
- 36,370 acre-feet (1% ACE)
- Embankment: 1.4M cubic yards
- Max dam height: 53 ft
  Dam length: 1.3 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 544
- Reduction in instances of flooding over 50-year period: 1,215
- Location of benefits:
  - Cleveland, Plum Grove
- Reduces 1% ACE WSEL at least 0.5 feet for 31.6 miles along East Fork
- Improves ponding depths on 10 road/rail crossings
- Net Present Value Benefit: $57.3M

ESTIMATED COSTS

Design Cost..$7M
Construction Cost $62M
Environmental Cost.................................$9M
ROW Cost.................................. $52M–$102M
TOTAL COSTS......................... $131M–$181M
20-Year Escalation Cost .... $198M–$274M

BENEFIT-COST RATIO: 0.32–0.44

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

EAST FORK SAN JACINTO — WINTERS BAYOU DETENTION

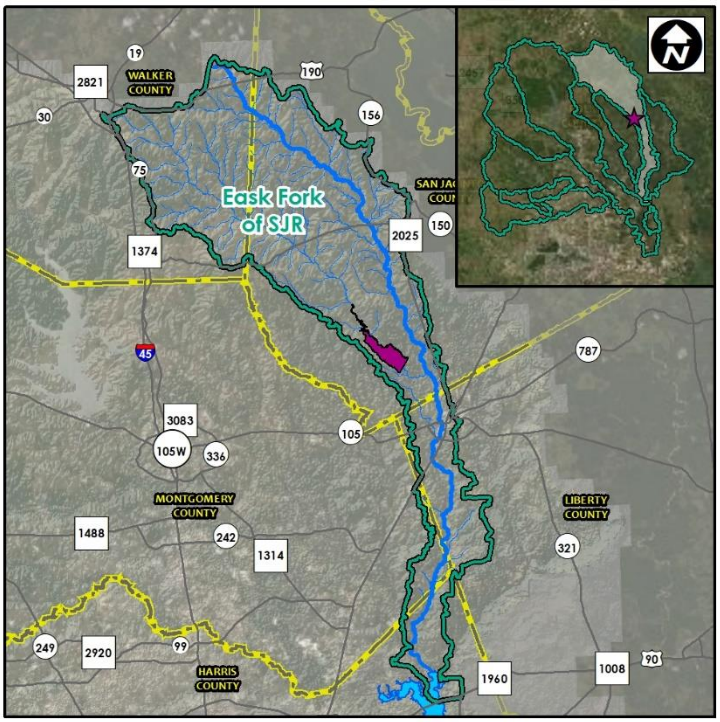
(Recommend Project in SJMDP)

LOCATION: Approximately 3 miles U/S Winters Bayou from East Fork of San Jacinto River

OBJECTIVE: Reduce flooding along East Fork of San Jacinto River

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 2,480 acres (1% ACE)
- 2,600 acres (PMF)
- 45,055 acre-feet (1% ACE)
- Embankment: 1.3M cubic yards
- Max dam height: 48 ft
  Dam length: 1.6 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 615
- Reduction in instances of flooding over 50-year period: 1,334
- Location of benefits:
  - Cleveland, Plum Grove
- Reduces 1% ACE WSEL at least 0.5 feet for 31.6 miles along East Fork
- Improves ponding depths on 10 road/rail crossings
- Net Present Value Benefit: $63.5M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

San Jacinto County, SJRA, TxDOT, USACE, USDA, BNSF Railroad, UPRR, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 181 parcels within PMF
- 88 parcels within 1% ACE

DESKTOP ENVIRONMENTAL MITIGATION

- 18 acres of potential wetlands
- 442 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 3 oil & gas pipeline conflicts
- 1.5 miles of roads (PMF)
- 1.1 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost.. $9M
Construction Cost................................ $74M
Environmental Cost.................................$7M
ROW Cost....................................$45M–$77M
<u>TOTAL COSTS........................$134M–$167M</u>
20-Year Escalation Cost .... $204M–$252M

BENEFIT-COST RATIO: 0.38–0.47

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

LAKE CREEK — CANEY CREEK DETENTION

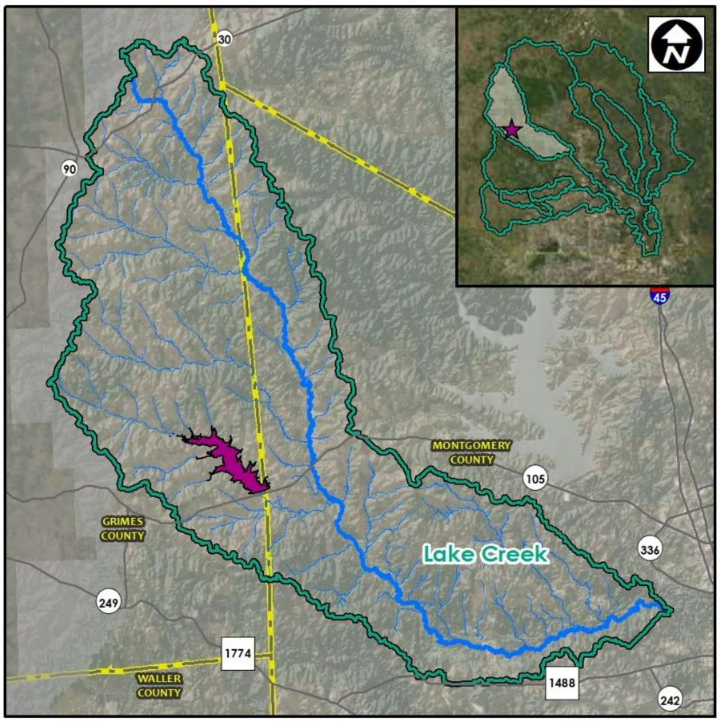
(Recommend Project in SJMDP)

LOCATION: Approximately 0.3 miles U/S of SH 105 on Caney Creek

OBJECTIVE: Reduce flooding along Lake Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Grimes County, Montgomery County, SJRA, USACE, TWDB, GLO, HCFCD,

REQUIRED REAL ESTATE

- 220 parcels within PMF
- 123 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 10 acres of potential wetlands
- 660 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- No known gas pipeline conflicts
- 4.9 miles of roads (PMF)
- 1.1 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,886 acres (1% ACE)
- 3,272 acres (PMF)
- 19,750 acre-feet (1% ACE)
- Embankment: 825k cubic yards
- Max dam height: 52 ft
- Dam length: 0.8 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 323
- Reduction in instances of flooding over 50-year period: 686
- Benefited areas:
  - Woodforest, River Plantation, City of Conroe, Woodloch
- Reduces 1% ACE WSEL at least 0.5 feet for 35.1 miles along Lake Creek
- Improves ponding depths on 4 road/rail crossings
- Net Present Value Benefit: $42.1M

ESTIMATED COSTS

Design Cost	$4M
Construction Cost	$34M
Environmental Cost	$7M
ROW Cost	$54M–$118M
TOTAL COSTS	$98M–$163M
20-Year Escalation Cost	$149M–$247M

BENEFIT-COST RATIO: 0.26–0.43

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

LAKE CREEK — GARRETT'S CREEK DETENTION

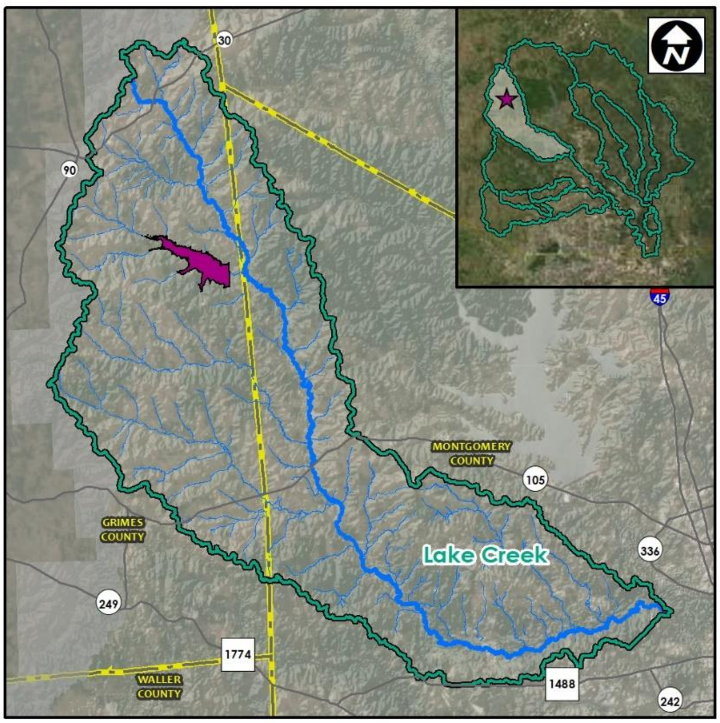
(Recommend Project in SJMDP)

LOCATION: Approximately 0.7 miles U/S of Lake Creek on Garretts Creek

OBJECTIVE: Reduce flooding along Lake Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,739 acres (1% ACE)
- 3,009 acres (PMF)
- 16,850 acre-feet (1% ACE)
- Embankment: 1.0M cubic yards
- Max dam height: 43 ft
- Dam length: 1.2 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 295
- Reduction in instances of flooding over 50-year period: 684
- Benefited areas:
  - Dobbin, River Plantation, City of Conroe, Woodloch, Woodforest
- Reduces 1% ACE WSEL at least 0.5 feet for 53.2 miles along Lake Creek
- Improves ponding depths on 7 road/rail crossings
- Net Present Value Benefit: $39.8M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Grimes County, Montgomery County, TxDOT, SJRA, USACE, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 74 parcels within PMF
- 36 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 35 acres of potential wetlands
- 2,590 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 2 oil & gas pipeline conflicts
- 4.6 miles of roads (PMF)
- 1.5 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$6M
Construction Cost	$51M
Environmental Cost	$17M
ROW Cost	$32M–$56M
TOTAL COSTS	$107M–$131M
20-Year Escalation Cost	$162M–$198M

BENEFIT-COST RATIO: 0.31–0.37

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

LAKE CREEK — LITTLE CANEY CREEK DETENTION

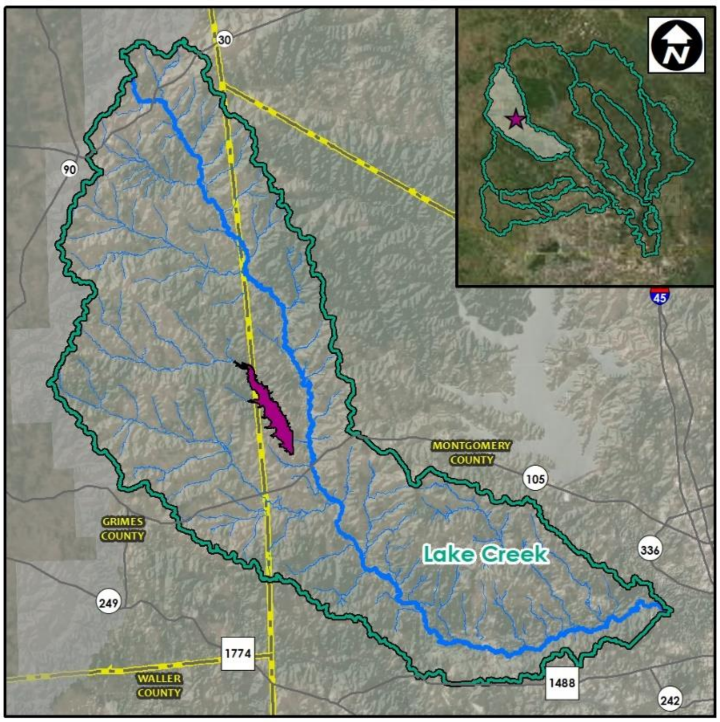
(Recommend Project in SJMDP)

LOCATION: Approximately 1.1 miles U/S of Lake Creek on Little Caney Creek, West of FM 1486

OBJECTIVE: Reduce flooding along Lake Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, Grimes County, SJRA, USACE, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 215 parcels within PMF
- 111 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 8.9 acres of potential wetlands
- 1,105 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 6 oil & gas pipeline conflicts
- 3.5 miles of roads (PMF)
- 1.2 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,612 acres (1% ACE)
- 2,976 acres (PMF)
- 17,500 acre-feet (1% ACE)
- Embankment: 1.2M cubic yards
- Max dam height: 51 ft
- Dam length: 0.8 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 248
- Reduction in instances of flooding over 50-year period: 564
- Benefited areas:
  - Woodforest, River Plantation, City of Conroe, Dobbin, Woodloch
- Reduces 1% ACE WSEL at least 0.5 feet for 40.1 miles along Lake Creek
- Improves ponding depths on 6 road/rail crossings
- Net Present Value Benefit: $35.0M

ESTIMATED COSTS

Design Cost... $6M
Construction Cost $49M
Environmental Cost................................ $10M
ROW Cost....................................$33M–$63M
<u>TOTAL COSTS.......................... $98M–$128M</u>
20-Year Escalation Cost ....$149M–$195M

BENEFIT-COST RATIO: 0.27–0.36

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

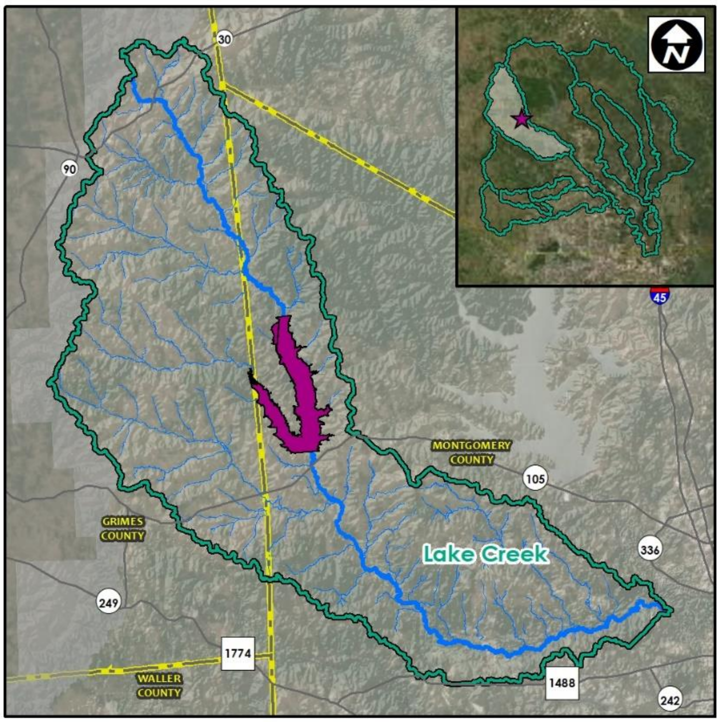
LAKE CREEK — MAINSTEM DETENTION

LOCATION: Approximately 0.8 miles U/S of SH 105 on Lake Creek

OBJECTIVE: Reduce flooding along Lake Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 4,942 acres (1% ACE)
- 8,060 acres (PMF)
- 75,100 acre-feet (1% ACE)
- Embankment: 3.0M cubic yards
- Max dam height: 58 ft
- Dam length: 1.3 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 931
- Reduction in instances of flooding over 50-year period: 1,694
- Benefited areas:
  - Woodforest, River Plantation, City of Conroe, Dobbin, Woodloch
- Reduces 1% ACE WSEL at least 0.5 feet for 36.1 miles downstream of detention facility
- Improves ponding depths on 6 road/rail crossings
- Net Present Value Benefit: $100.4M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, TxDOT, SJRA, USACE, GLO, HCFCD

REQUIRED REAL ESTATE

- 483 parcels within PMF
- 209 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 23 acres of potential wetlands
- 810 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 5 oil & gas pipeline conflicts
- 10.1 miles of roads (PMF)
- 2.8 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$11M
Construction Cost	$97M
Environmental Cost	$7M
ROW Cost	$74M–$154M
TOTAL COSTS	$187M–$267M
20-Year Escalation Cost	$284M–$405M

BENEFIT-COST RATIO: 0.38–0.54

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

PEACH CREEK — I-69 CHANNELIZATION

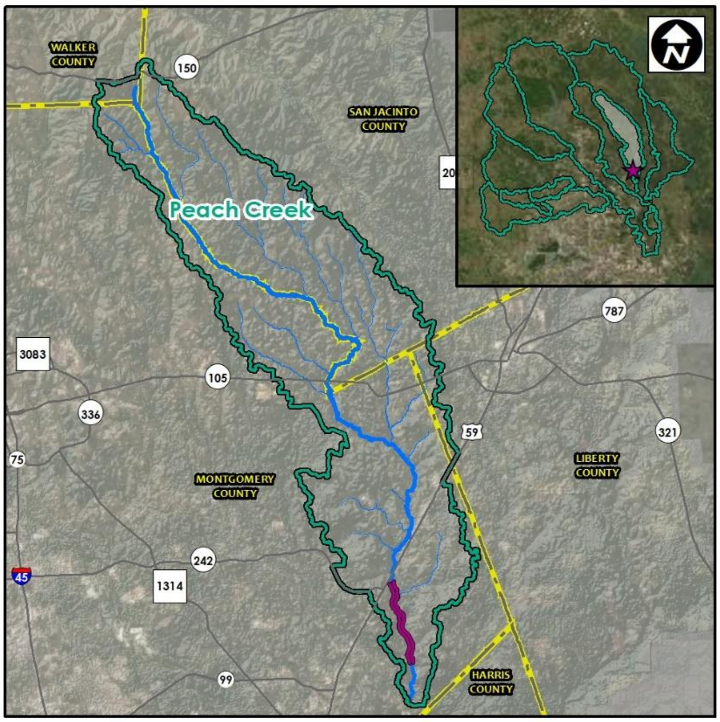
(Recommend Project in SJMDP)

LOCATION: D/S of I-69 to FM 1485 on Peach Creek

OBJECTIVE: Reduce flooding along Peach Creek

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 4% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, SJRA, USACE, TWDB, GLO

REQUIRED REAL ESTATE

- 286 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 28 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 3 oil & gas pipeline conflicts
- 1.9 miles of roads

IMPROVEMENT SPECIFICATIONS

- 4.3 miles of channelization
- 800-foot wide bench
- 417 acres
- 7M cubic yards of excavation
- 800 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 383
- Reduction in instances of flooding over 50-year period: 1,880
- Benefited areas:
  - Woodbranch, Patton Village, Roman Forest
- Reduces 1% ACE WSEL at least 0.5 feet for 6.2 miles along Peach Creek
- Improves ponding depths on 4 road/rail crossings
- Net Present Value Benefit: $73.6M

ESTIMATED COSTS

Design Cost	$15M
Construction Cost	$129M
Environmental Cost	$7M
ROW Cost	$8M
TOTAL COSTS	$159M
20-Year Escalation Cost	$241M

BENEFIT-COST RATIO: 0.46

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

PEACH CREEK — SH 105 DETENTION

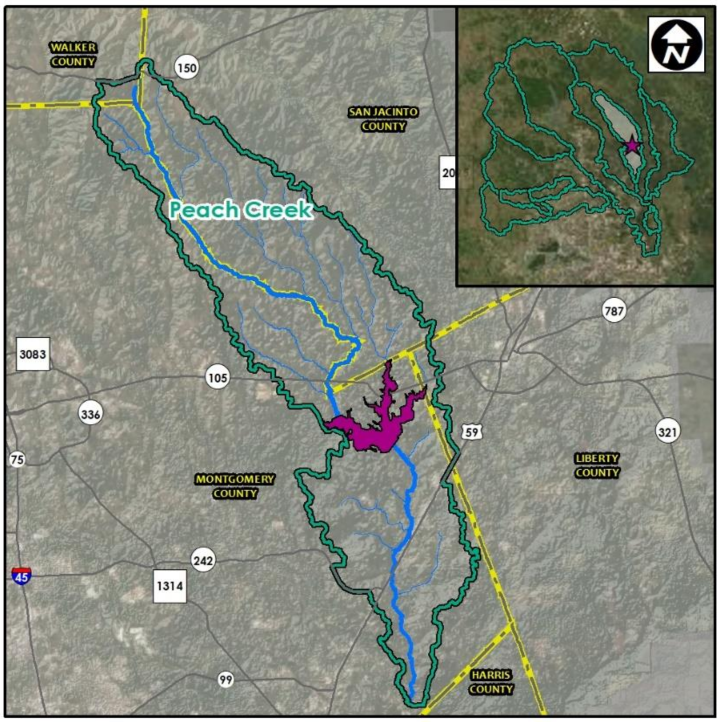
(Recommend Project in SJMDP)

LOCATION: Approximately 12 miles U/S of New Caney on Peach Creek

OBJECTIVE: Reduce flooding along Peach Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 4% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, SJRA, USACE, TWDB, GLO

REQUIRED REAL ESTATE

- 505 parcels within PMF
- 273 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 7 acres of potential wetlands
- 900 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 1 oil & gas pipeline conflict
- 10.7 miles of roads (PMF)
- 4.7 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 3,025 acres (1% ACE)
- 5,195 acres (PMF)
- 36,197 acre-feet (1% ACE)
- Embankment: 6.4M cubic yards
- Max dam height: 46 ft
- Dam length: 4.7 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 400
- Reduction in instances of flooding over 50-year period: 1,768
- Benefited areas:
  - Woodbranch and Splendora
- Reduces 1% ACE WSEL at least 0.5 feet for 15.4 miles downstream of detention facility
- Improves ponding depths on 6 road/rail crossings
- Net Present Value Benefit: $81.5M

ESTIMATED COSTS

Design Cost	$26M
Construction Cost	$214M
Environmental Cost	$7M
ROW Cost	$110M–$187M
TOTAL COSTS	$356M–$433M
20-Year Escalation Cost	$540M–$657M

BENEFIT-COST RATIO: 0.19–0.23

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

PEACH CREEK — WALKER DETENTION

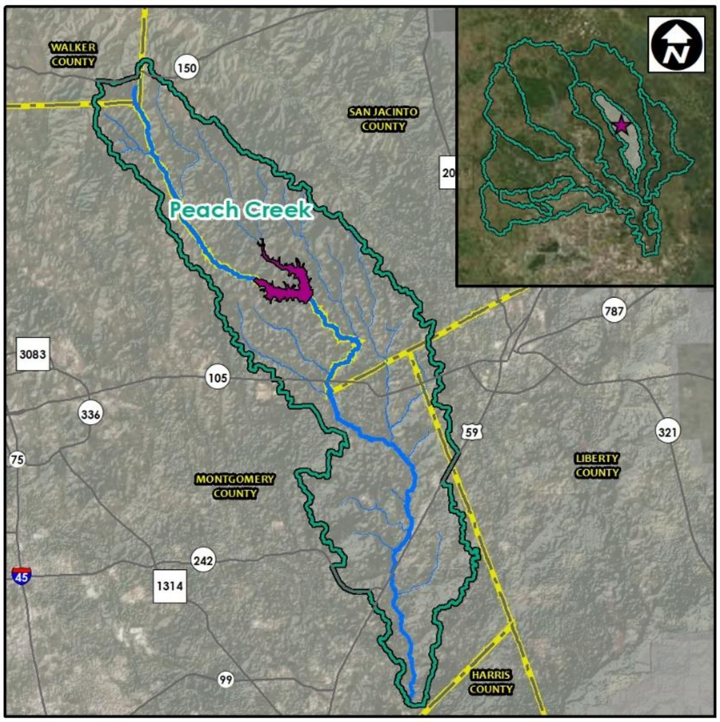
(Recommend Project in SJMDP)

LOCATION: Approximately 19 miles U/S of New Caney on Peach Creek

OBJECTIVE: Reduce flooding along Peach Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 10% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, San Jacinto County, TxDOT, SJRA, USACE, TWDB, GLO

REQUIRED REAL ESTATE

- 60 parcels within PMF
- 42 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 9 acres of potential wetlands
- 1,365 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 1 oil & gas pipeline conflict
- 1.1 miles of roads (PMF)
- 0.4 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,235 acres (1% ACE)
- 2,191 acres (PMF)
- 36,000 acre-feet (1% ACE)
- Embankment: 4.7M cubic yards
- Max dam height: 51 ft
- Dam length: 3.2 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 261
- Reduction in instances of flooding over 50-year period: 1,073
- Benefited areas:
  - Woodbranch, Patton Village, Splendora
- Reduces 1% ACE WSEL at least 0.5 feet for 30.5 miles downstream of detention facility
- Improves ponding depths on 9 road/rail crossings
- Net Present Value Benefit: $56.3M

ESTIMATED COSTS

Design Cost... $19M
Construction Cost $160M
Environmental Cost................................ $9M
ROW Cost.................................... $13M–$30M
TOTAL COSTS......................... $201M–$218M
20-Year Escalation Cost .... $305M–$331M

BENEFIT-COST RATIO: 0.26–0.28

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SPRING CREEK — WOODLANDS CHANNELIZATION (200-ft)

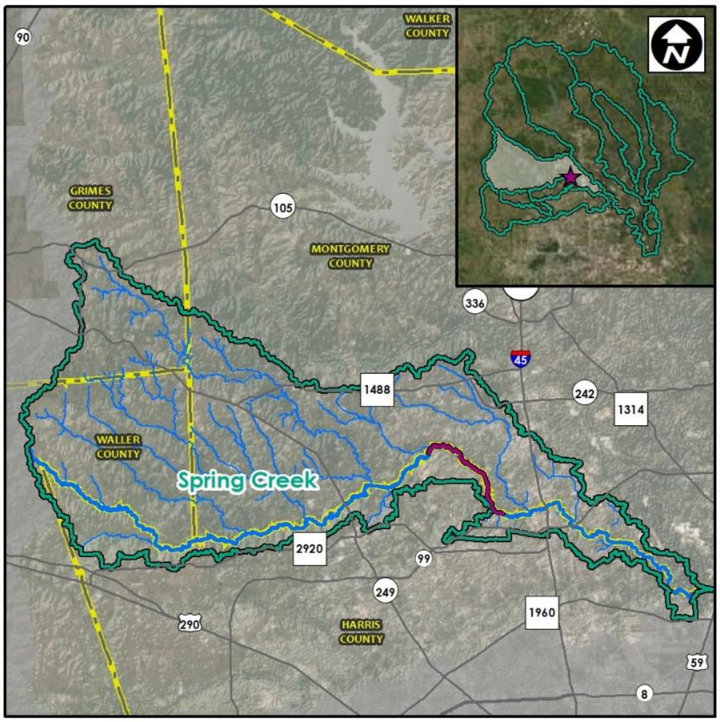
(Recommend Project in SJMDP)

LOCATION: U/S of Kuykendahl Road to D/S of Willow Creek confluence on Spring Creek

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- 8.8 miles of channelization
- 200-foot wide bench
- 155 acres
- 1.9M cubic yards of excavation
- 7,200 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 221
- Reduction in instances of flooding over 50-year period: 477
- Benefited areas:
  - The Woodlands, Timber Lakes
- Reduces 1% ACE WSEL at least 0.5 feet for 11.8 miles along Spring Creek
- Improves ponding depths on 2 road/rail crossings
- Net Present Value Benefit: $34.7M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, SJRA, USACE, MUD 386, The Woodlands Township, Woodlands Water Agency, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 113 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 11 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 2 oil & gas pipeline conflicts
- 0.10 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$6M
Construction Cost	$47M
Environmental Cost	$1M
ROW Cost	$2M
TOTAL COSTS	$56M
20-Year Escalation Cost	$85M

BENEFIT-COST RATIO: 0.62

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

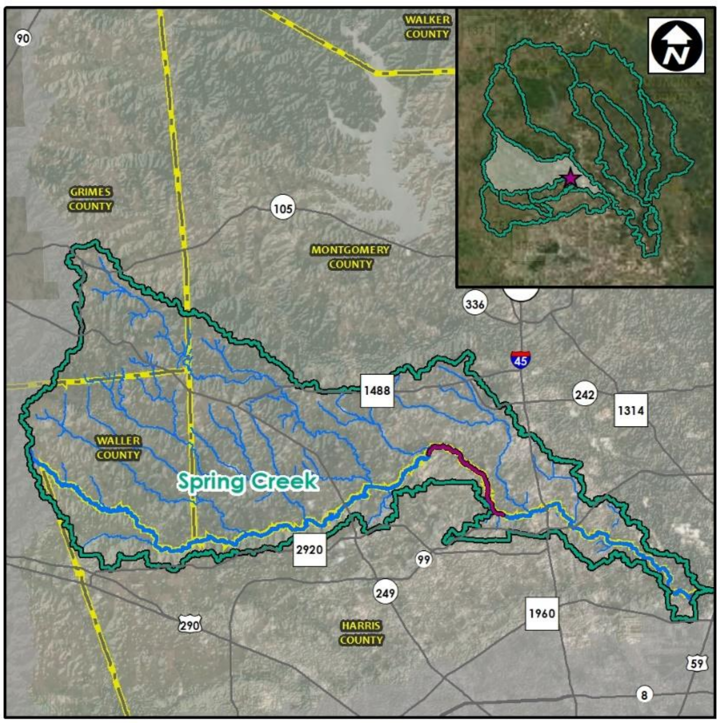
SPRING CREEK — WOODLANDS CHANNELIZATION (500-ft)

LOCATION: U/S of Kuykendahl Road to D/S of Willow Creek confluence on Spring Creek

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 10% ACE



IMPROVEMENT SPECIFICATIONS

- 9.7 miles of channelization
- 500-foot wide bench
- 577 acres
- 6.0M cubic yards of excavation
- 12,500 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 357
- Reduction in instances of flooding over 50-year period: 776
- Benefited areas:
  - The Woodlands, Timber Lakes
- Reduces 1% ACE WSEL at least 0.5 feet for 12.7 miles along Spring Creek
- Improves ponding depths on 4 road/rail crossings
- Net Present Value Benefit: $48.1M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, Harris County, SJRA, USACE, The Woodlands Township, Woodlands Water Agency, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 119 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 53 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 2 oil & gas pipeline conflicts
- 0.20 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$15M
Construction Cost	$124M
Environmental Cost	$7M
ROW Cost	$4M
TOTAL COSTS	$149M
20-Year Escalation Cost	$226M

BENEFIT-COST RATIO: 0.32

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

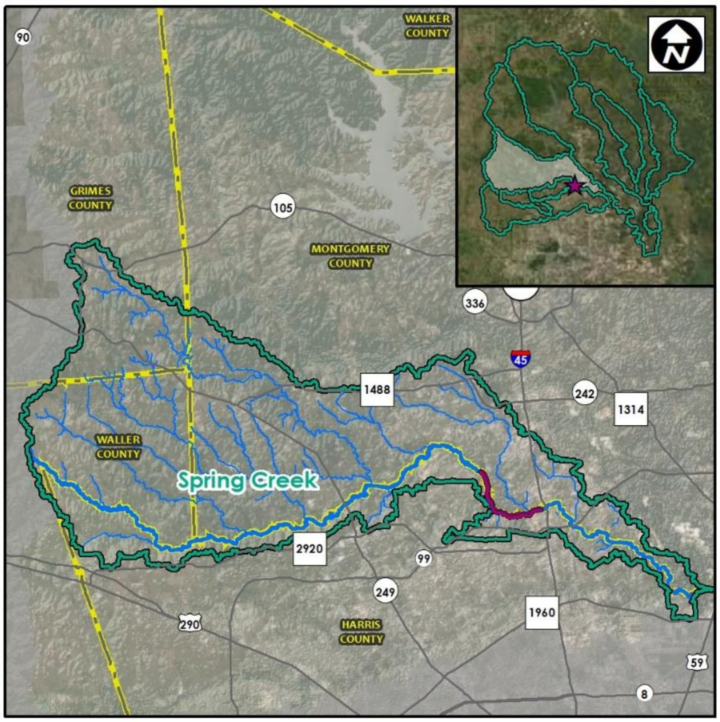
SPRING CREEK — GOSLING CHANNELIZATION

LOCATION: Between Gosling Road and I-45

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 4% ACE



IMPROVEMENT SPECIFICATIONS

- 5.2 miles of channelization
- 500-foot wide bench
- 311 acres
- 5.4M cubic yards of excavation
- 9,000 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 676
- Reduction in instances of flooding over 50-year period: 991
- Benefited areas:
  - The Woodlands, Timber Lake, Timber Ridge, Grogan's Point
- Reduces 1% ACE WSEL at least 0.5 feet for 10.0 miles along Spring Creek
- Improves ponding depths on 2 road/rail crossings
- Net Present Value Benefit: $63.2M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, Harris County, SJRA, USACE, TWDB, GLO, HCFCD. The Woodlands Township, Woodlands Water Agency,

REQUIRED REAL ESTATE

- 160 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 43 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 8 oil & gas pipeline conflicts

ESTIMATED COSTS

Design Cost $12M
Construction Cost $103M
Environmental Cost $5M
ROW Cost $12M
<u>TOTAL COSTS .... $132M</u>
20-Year Escalation Cost..................... $200M

BENEFIT-COST RATIO: 0.48

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

SPRING CREEK — I-45 CHANNELIZATION

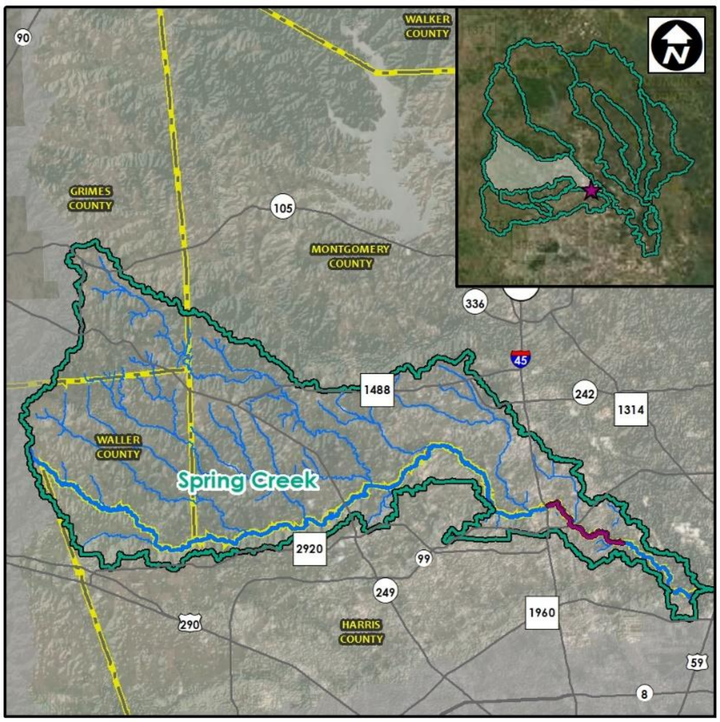
(Recommend Project in SJMDP)

LOCATION: From I-45 to approximately 4 miles D/S of Riley Fuzzel Road on Spring Creek

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in this watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 4% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, TxDOT, SJRA, USACE, TWDB, GLO, FEMA, HCFCD

REQUIRED REAL ESTATE

- 137 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 35 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 5 oil & gas pipeline conflicts
- 0.05 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- 6.9 miles of channelization
- 300-foot wide bench
- 188 acres
- 3.7M cubic yards of embankment
- 8,000 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 1,240
- Reduction in instances of flooding over 50-year period: 1,739
- Benefited areas:
  - Northgate Crossing, Lexington Woods, Spring
- Reduces 1% ACE WSEL at least 0.5 feet for 10.7 miles along Spring Creek
- Improves ponding depths on 4 road/rail crossings
- Net Present Value Benefit: $99.4M

ESTIMATED COSTS

Design Cost $8M
Construction Cost $69M
Environmental Cost..................................$4M
ROW Cost..$4M
TOTAL COSTS..................................... $85M
20-Year Escalation Cost $129M

BENEFIT-COST RATIO: 1.17

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

SPRING CREEK — BIRCH CREEK DETENTION

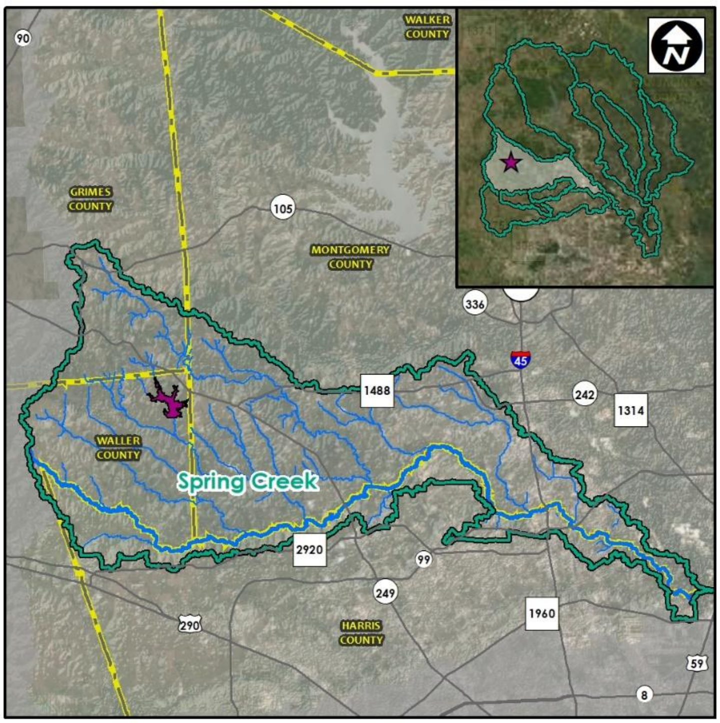
(Recommend Project in SJMDP)

LOCATION: Approximately 12 miles U/S of Spring Creek on Birch Creek

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Waller County, Montgomery County, SJRA, USACE, MUD 386, The Woodlands Township, Woodlands Water Agency, City of Tomball, TWDB, GLO, FEMA, HCFCD

REQUIRED REAL ESTATE

- 71 parcels within PMF
- 15 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 2.1 acres of potential wetlands
- 1,370 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 1 oil & gas pipeline conflicts
- 0.6 miles of roads (PMF)
- 0.3 miles of roads (1% ACE)

IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 873 acres (1% ACE)
- 917 acres (PMF)
- 7,731 acre-feet (1% ACE)
- Embankment: 460k cubic yards
- Max dam height: 41 ft
- Dam length: 0.7 miles

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 815
- Reduction in instances of flooding over 50-year period: 1,084
- Benefited areas:
    - The Woodlands, Tomball, Stagecoach
- Reduces 1% ACE WSEL at least 0.5 feet for 25.9 miles along Spring Creek
- Improves ponding depths on 13 road/rail crossings
- Net Present Value Benefit: $66.0M

ESTIMATED COSTS

Design Cost	$3M
Construction Cost	$23M
Environmental Cost	$6M
ROW Cost	$48M–$88M
TOTAL COSTS	**$80M–$120M**
20-Year Escalation Cost	$121M–$181M

BENEFIT-COST RATIO: 0.55–0.83

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

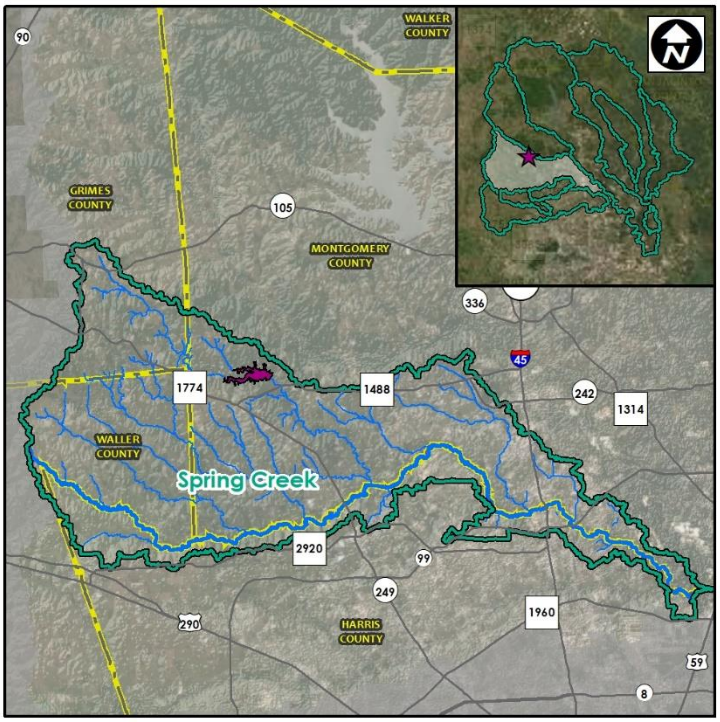
SPRING CREEK — MILL CREEK DETENTION

LOCATION: Approximately 10 miles U/S of Spring Creek on Mill Creek

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 4–10% ACE



IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 989 acres (1% ACE)
- 1,039 acres (PMF)
- 11,159 acre-feet (1% ACE)
- Embankment: 500k cubic yards
- Max dam height: 44 ft
- 0.9 miles in length

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 885
- Reduction in instances of flooding over 50-year period: 1,015
- Benefited areas:
    - Tomball, The Woodlands
- Reduces 1% ACE WSEL at least 0.5 feet for 23.8 miles along Spring Creek
- Improves ponding depths on 9 road/rail crossings
- Net Present Value Benefit: $65.1M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, SJRA, USACE, MUD 386, The Woodlands Township, Woodlands Water Agency, TWDB, GLO, HCFCD

REQUIRED REAL ESTATE

- 234 parcels within PMF
- 129 parcels within 1% ACE WSL

DESKTOP ENVIRONMENTAL MITIGATION

- <0.1 acres of potential wetlands
- 1,250 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION*

- 4 oil & gas pipeline conflicts
- 0 miles of roads (PMF)
- 0 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$4M
Construction Cost	$30M
Environmental Cost	$8M
ROW Cost	$58M–$89M
TOTAL COSTS	$99M–$131M
20-Year Escalation Cost	$150M–$198M

BENEFIT-COST RATIO: 0.50–0.67

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

SPRING CREEK — WALNUT CREEK DETENTION

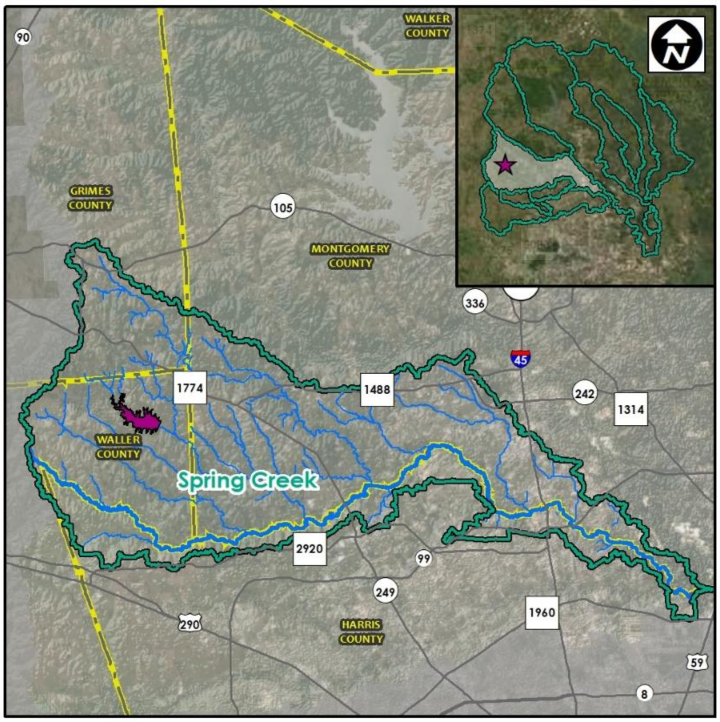
(Recommend Project in SJMDP)

LOCATION: Approximately 12 miles U/S of Spring Creek on Walnut Creek

OBJECTIVE: Reduce flooding along Spring Creek

HOW IT WORKS: Dry dam detention facility impounds stream flow during flood events

IMMEDIATE DOWNSTREAM BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- Dry dam detention facility
- 1,218 acres (1% ACE)
- 1,279 acres (PMF)
- 12,159 acre-feet (1% ACE)
- Embankment: 670k cubic yards
- Max dam height: 46 ft
- 1.2 miles in length

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 1,205
- Reduction in instances of flooding over 50-year period: 1,653
- Benefited areas:
  - Tomball, The Woodlands
- Reduces 1% ACE WSEL at least 0.5 feet for 41.2 miles along Spring Creek
- Improves ponding depths on 13 road/rail crossings
- Net Present Value Benefit: $101.2M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Waller County, Montgomery County, SJRA, USACE, MUD 386, City of Tomball, The Woodlands Township, Woodlands Water Agency, TWDB, GLO, FEMA, HCFCD, Harris County

REQUIRED REAL ESTATE

- 37 parcels within PMF
- 30 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 6 acres of potential wetlands
- 840 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION

- 1 oil & gas pipeline conflicts
- 1.3 miles of roads (PMF)
- 1.3 miles of roads (1% ACE)

ESTIMATED COSTS

Design Cost	$4M
Construction Cost	$37M
Environmental Cost	$8M
ROW Cost	$49M–$84M
TOTAL COSTS	$97M–$132M
20-Year Escalation Cost	$147M–$200M

BENEFIT-COST RATIO: 0.77–1.04

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

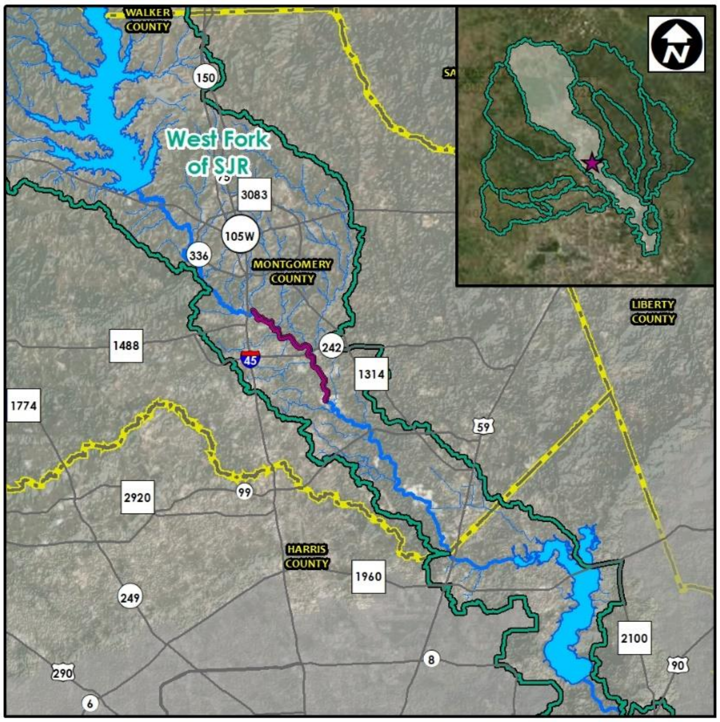
WEST FORK SAN JACINTO RIVER — RIVER PLANTATION CHANNELIZATION

LOCATION: I-45 to between SH 242 and SH 99 on West Fork of San Jacinto River

OBJECTIVE: Reduce flooding along West Fork of San Jacinto River

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in the Lake Creek watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- 9.3 miles of channelization
- 500-foot wide bench
- 560 acres
- 6.17M cubic yards of excavation
- 13,200 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 383
- Reduction in instances of flooding over 50-year period: 1,016
- Benefited areas:
  - River Plantation, Montgomery Creek Ranch, The Woodlands, Sleepy Hollow
- Reduces 1% ACE WSEL at least 0.5 feet for 12.6 miles along West Fork
- Improves ponding depths on 3 road/rail crossings
- Net Present Value Benefit: $44.4M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, SJRA, TWDB, GLO

REQUIRED REAL ESTATE

- 212 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 228 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION

- 6 oil & gas pipeline conflicts
- 0.1 miles of roads

ESTIMATED COSTS

Design Cost	$15M
Construction Cost	$126M
Environmental Cost	$32M
ROW Cost	$14M
TOTAL COSTS	$187M
20-Year Escalation Cost	$283M

BENEFIT-COST RATIO: 0.24

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

WEST FORK SAN JACINTO RIVER — HIGHWAY 242 CHANNELIZATION

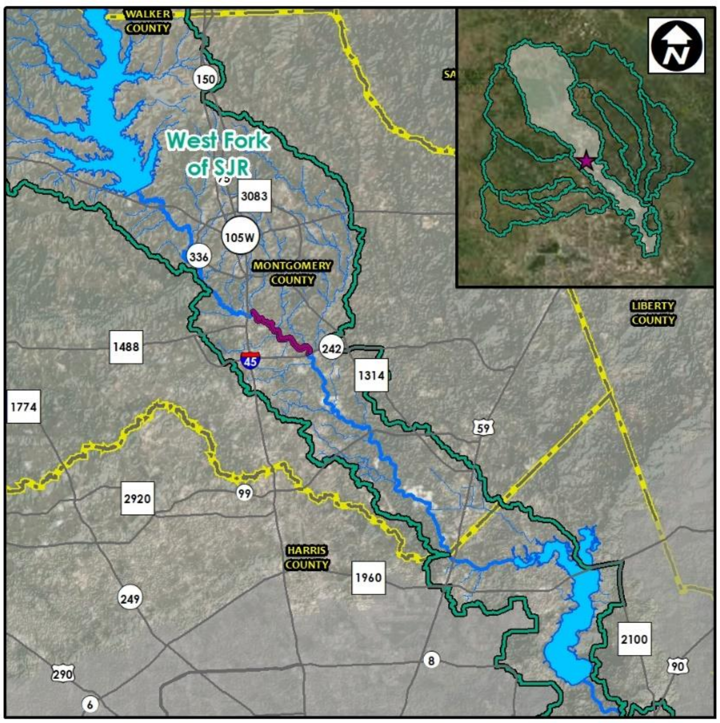
(Recommend Project in SJMDP)

LOCATION: I-45 to SH 242 on West Fork of San Jacinto River

OBJECTIVE: Reduce flooding along West Fork of San Jacinto River

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in the Lake Creek watershed must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- 5.7 miles of channelization
- 750-foot wide bench
- 520 acres
- 5.7M cubic yards of excavation
- 12,400 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 383
- Reduction in instances of flooding over 50-year period: 1,004
- Benefited areas:
  - River Plantation, Montgomery Creek Ranch
- Reduces 1% ACE WSEL at least 0.5 feet for 9.1 miles along West Fork
- Improves ponding depths on 2 road/rail crossings
- Net Present Value Benefit: $45.5M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Montgomery County, SJRA, TWDB, GLO

REQUIRED REAL ESTATE

- 225 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 152 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION

- 6 oil & gas pipeline conflicts
- 0.1 miles of roads

ESTIMATED COSTS

Design Cost	$13M
Construction Cost	$110M
Environmental Cost	$22M
ROW Cost	$11M
TOTAL COSTS	$157M
20-Year Escalation Cost	$238M

BENEFIT-COST RATIO: 0.29

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

WEST FORK SAN JACINTO RIVER — KINGWOOD BENCHING

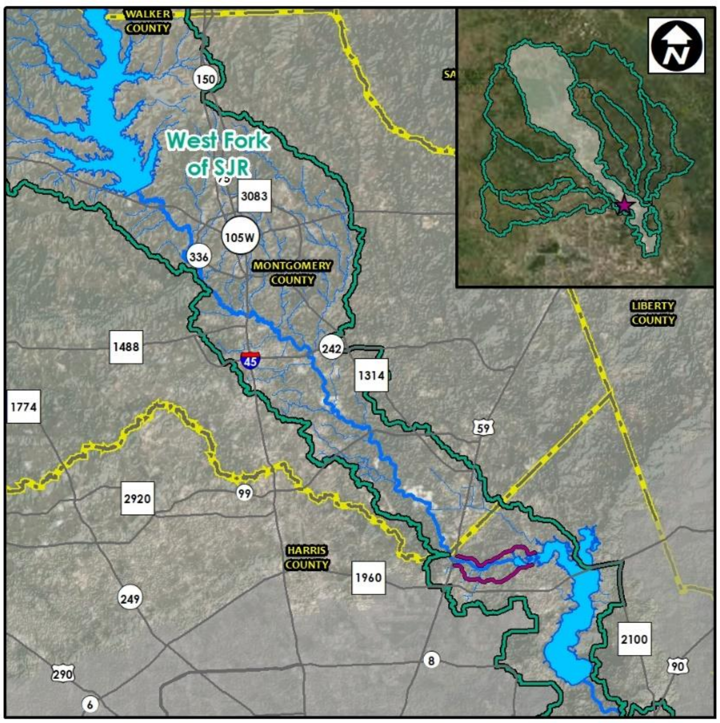
(Recommend Project in SJMDP)

LOCATION: I-69 to West Lake Houston Parkway on West Fork of San Jacinto River

OBJECTIVE: Reduce flooding along West Fork of San Jacinto River

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in the Lake Creek or Spring Creek watersheds must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction along the channel – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- 5 miles of channel benching
- 3,500-foot wide bench
- 3,527 acres
- 30.5 M cubic yards of excavation
- 923 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 743
- Reduction in instances of flooding over 50-year period: 963
- Benefited areas:
  - Kingwood, Atascocita, Humble
- Reduces 1% ACE WSEL at least 0.5 feet for 9.2 miles along West Fork
- Improves ponding depths on 2 road/rail crossings
- Net Present Value Benefit: $60.5M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Harris County, HCFCD, Montgomery County, SJRA, USACE, GLO, City of Houston

REQUIRED REAL ESTATE

- 1,301 parcels within 1% ACE WSEL

DESKTOP ENVIRONMENTAL MITIGATION

- 1,416 acres of potential wetlands
- 0 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION

- 4 oil & gas pipeline conflicts
- 9.9 miles of roads

ESTIMATED COSTS

Design Cost	$64M
Construction Cost	$537M
Environmental Cost	$180M
ROW Cost	$56M
TOTAL COSTS	$837M
20-Year Escalation Cost	$1.3B

BENEFIT-COST RATIO: 0.07

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

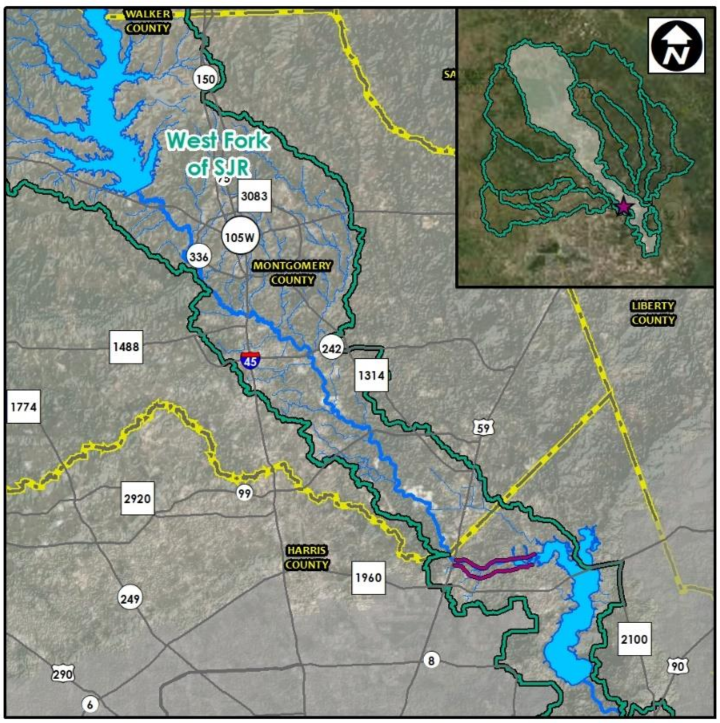
WEST FORK SAN JACINTO RIVER — KINGWOOD CHANNELIZATION

LOCATION: I-69 to West Lake Houston Parkway on West Fork of San Jacinto River

OBJECTIVE: Reduce flooding along West Fork of San Jacinto River

HOW IT WORKS: Channelization increases conveyance capacity; a separate upstream detention project in the Lake Creek or Spring Creek watersheds must be constructed first to mitigate adverse impact

IMMEDIATE AREA BENEFIT: Incremental Atlas 14 WSEL reduction – 1% ACE to 2% ACE



IMPROVEMENT SPECIFICATIONS

- 5 miles of channelization
- 3,000-foot wide channel
- 1,700 acres
- 31M cubic yards of excavation
- 1,365 acre-feet mitigation required

ESTIMATED BENEFITS

- Structures removed from 1% ACE floodplain: 895
- Reduction in instances of flooding over 50-year period: 1,140
- Benefited areas:
    - Kingwood, Atascocita, Humble
- Reduces 1% ACE WSEL at least 0.5 feet for 9.9 miles along West Fork
- Improves ponding depths on 2 road/rail crossings
- Net Present Value Benefit: $72.2M

OPPORTUNITIES AND CHALLENGES

POTENTIAL PARTNERS

Harris County, HCFCD, Montgomery County, SJRA, USACE, GLO, City of Houston

REQUIRED REAL ESTATE

- 737 parcels

DESKTOP ENVIRONMENTAL MITIGATION

- 948 acres of potential wetlands
- 61,950 linear feet of NHD streams

RELOCATIONS/RECONSTRUCTION

- 3 oil & gas pipeline conflicts
- 5.1 miles of roads

ESTIMATED COSTS

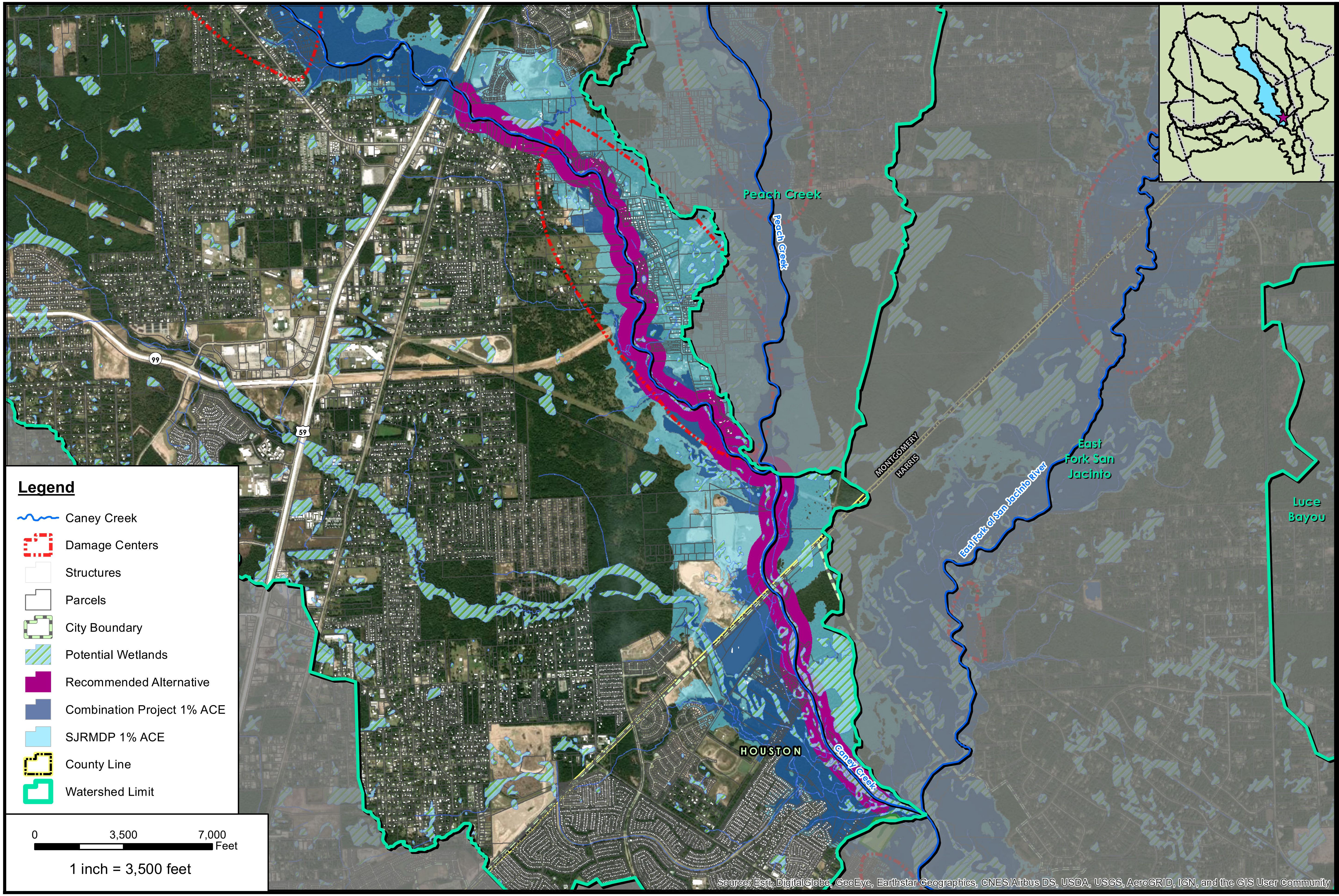
Design Cost.. $64M
Construction Cost $534M
Environmental Cost..............................$354M
ROW Cost..$23M
<u>TOTAL COSTS................................... $976M</u>
20-Year Escalation Cost $1.5B

BENEFIT-COST RATIO: 0.07

*Costs for these items are not explicitly included in the project estimate; however, a 30% contingency was added to the project that may cover all or a portion of these relocations. More detailed information should be provided during project development.

Appendix G.8

Alternative Layout Exhibits



HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

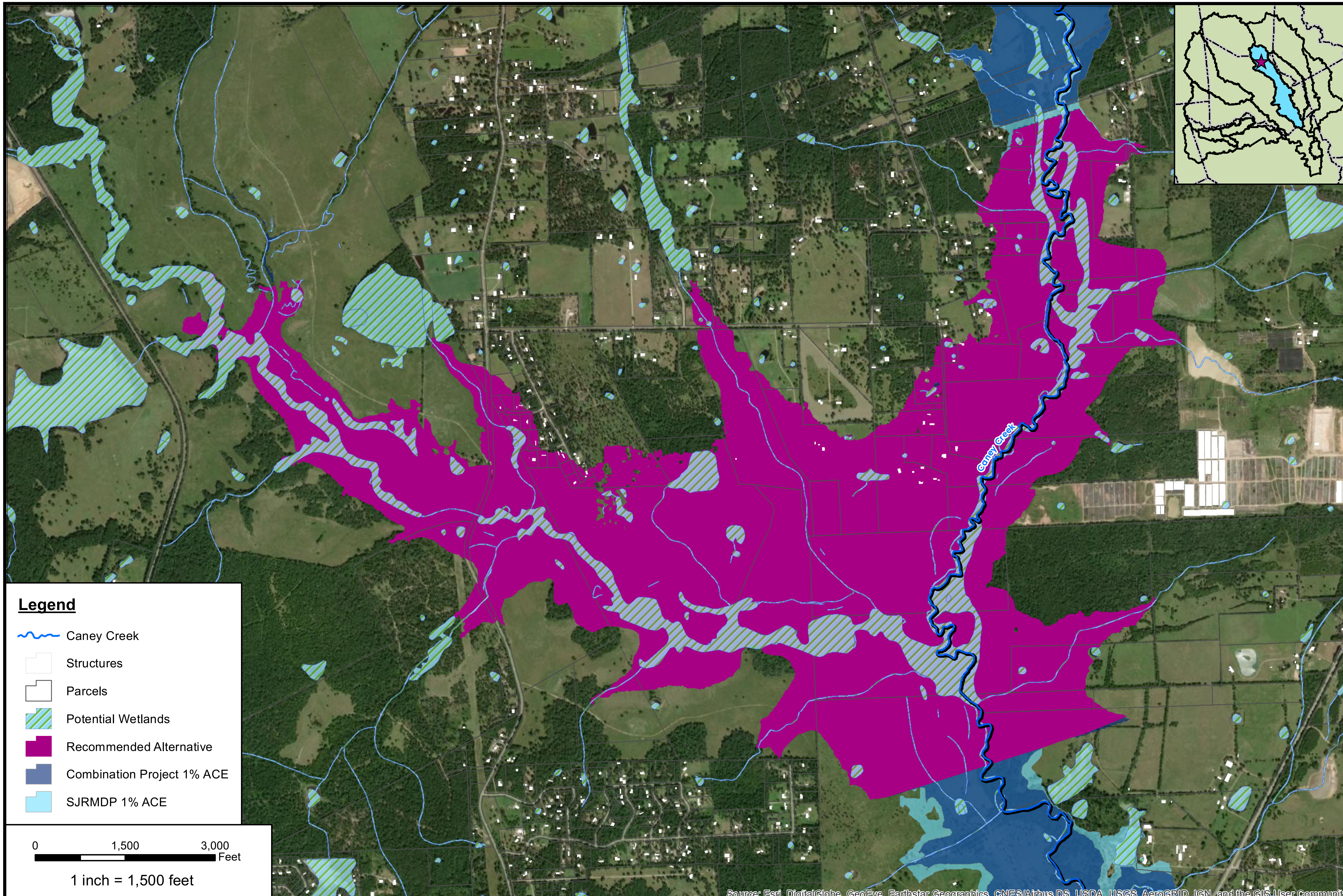
INUNDATION MAP | CANEY CREEK - Channelization at US-69
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

Exhibit G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

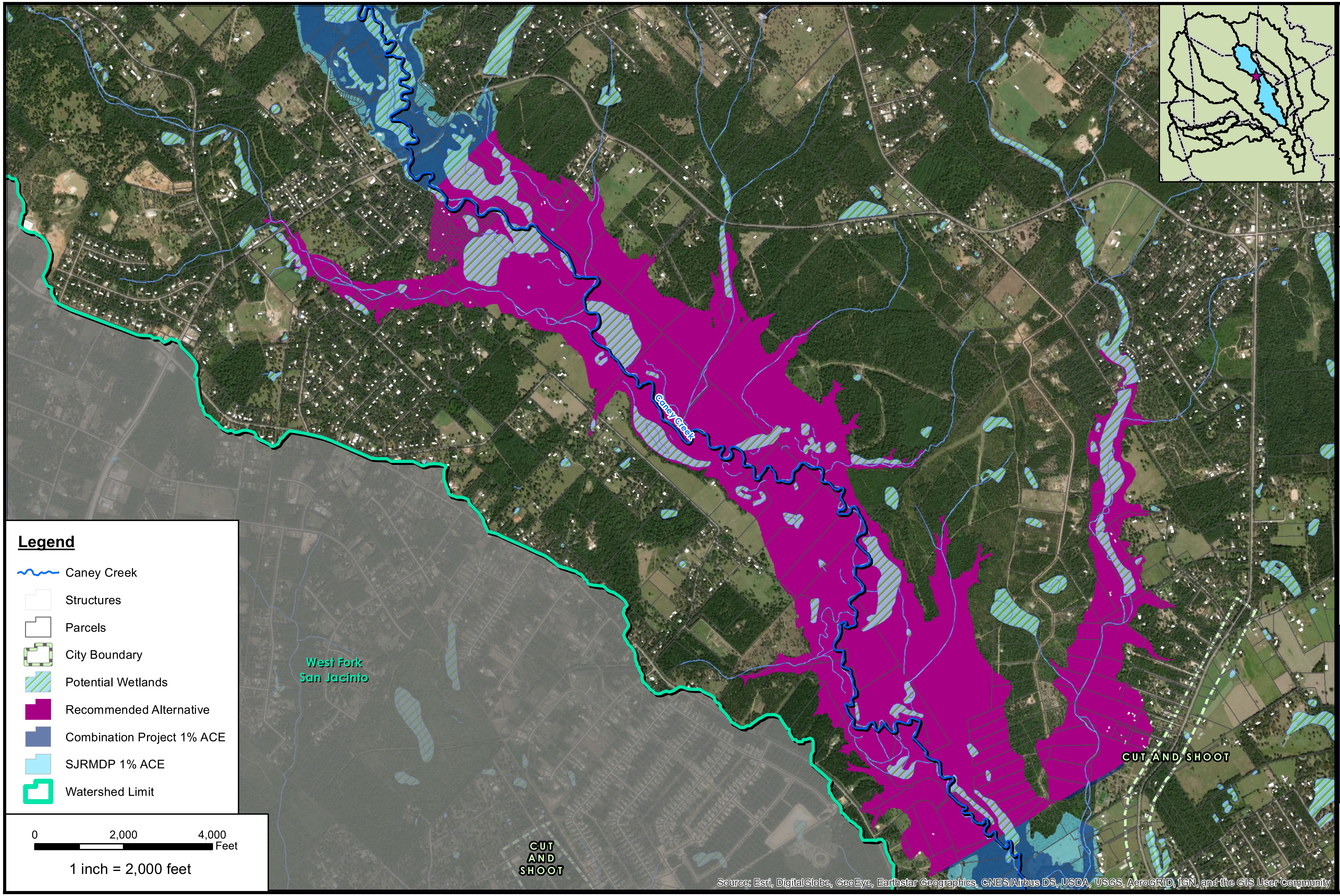
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK - Detention at FM 1097
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map



HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | CANEY CREEK - Detention at SH 105
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

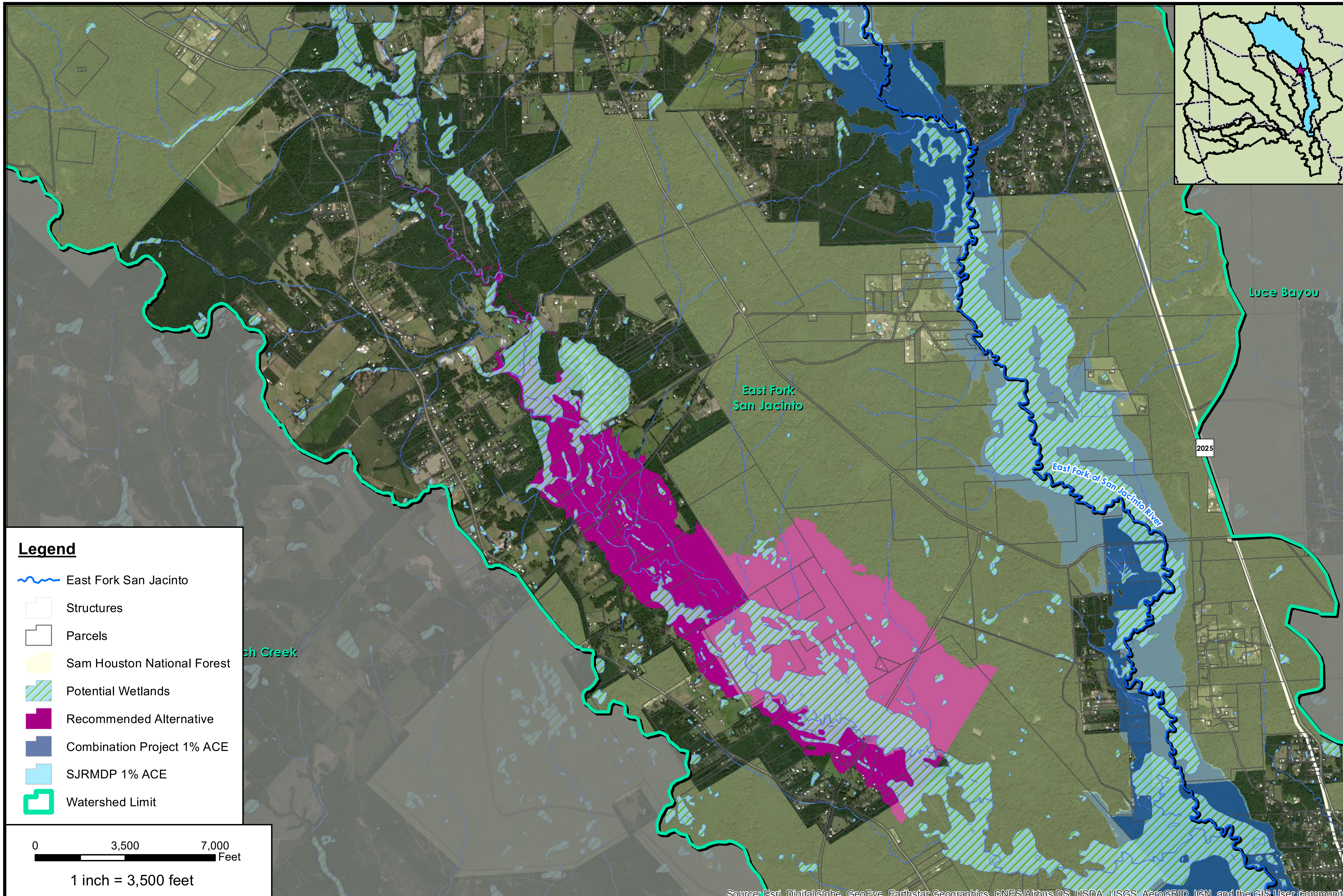
PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

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HARRIS COUNTY FLOOD CONTROL DISTRICT

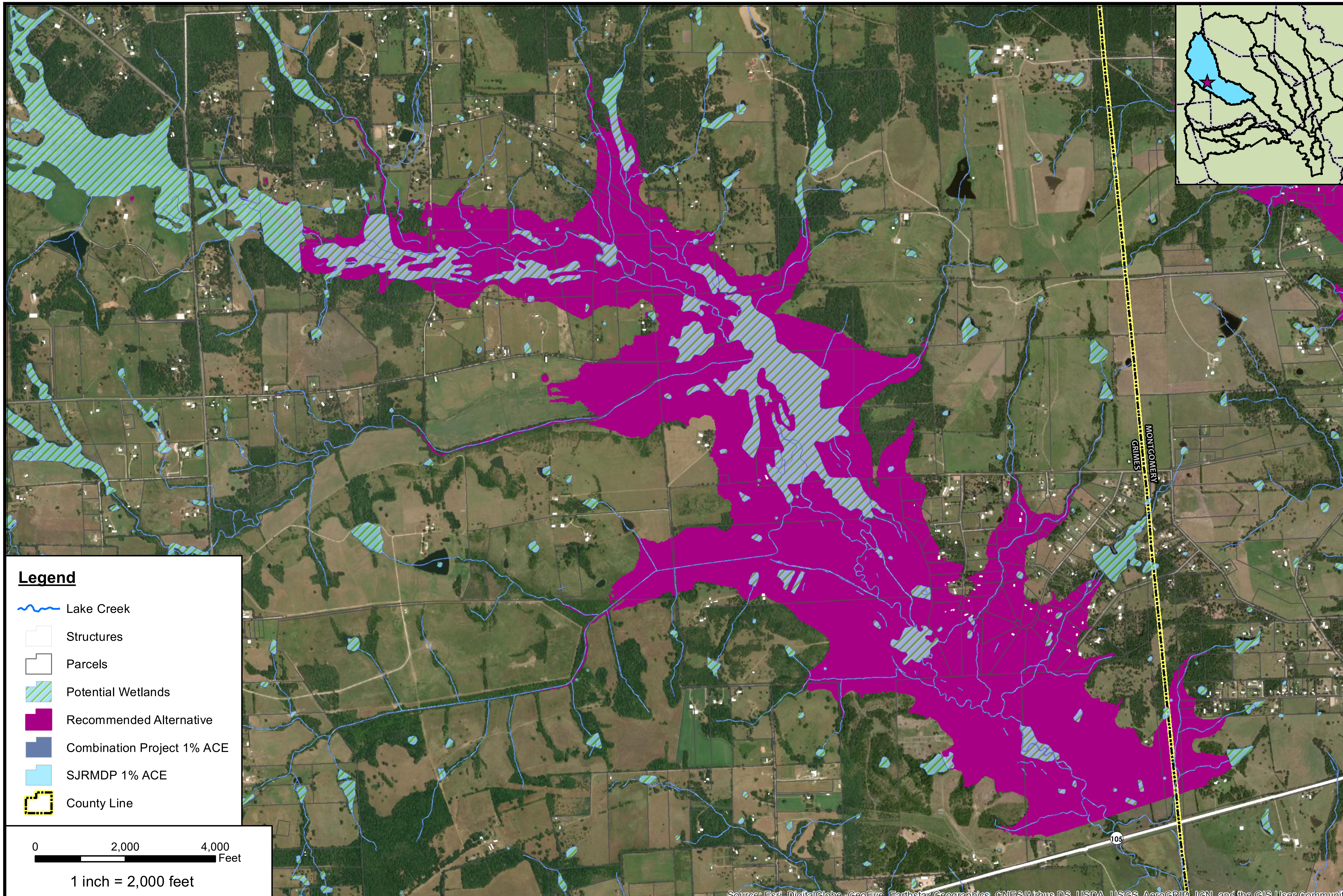
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | EAST FORK SAN JACINTO - Winters Bayou Dam SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

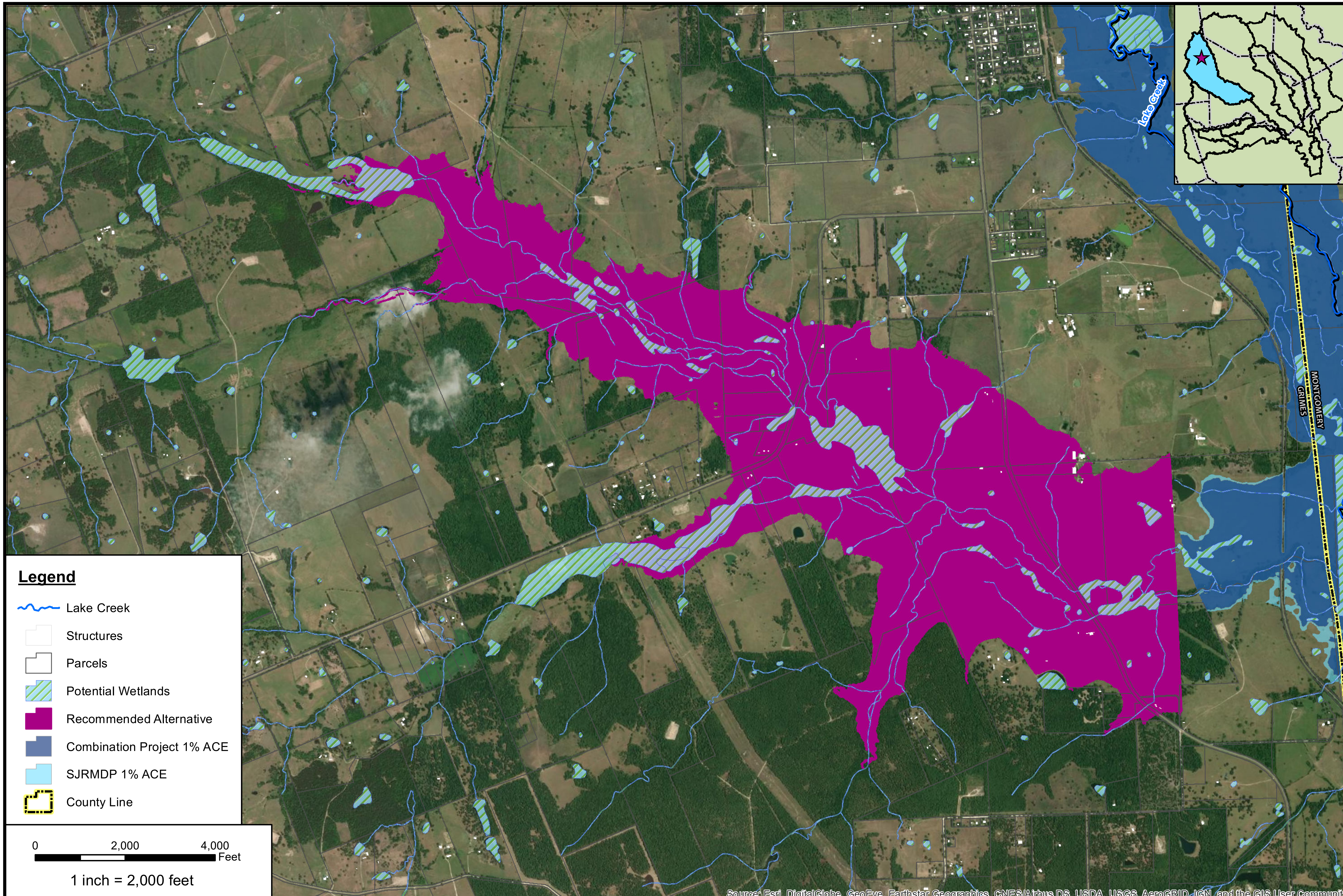
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | LAKE CREEK - Caney Creek Detention
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

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HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

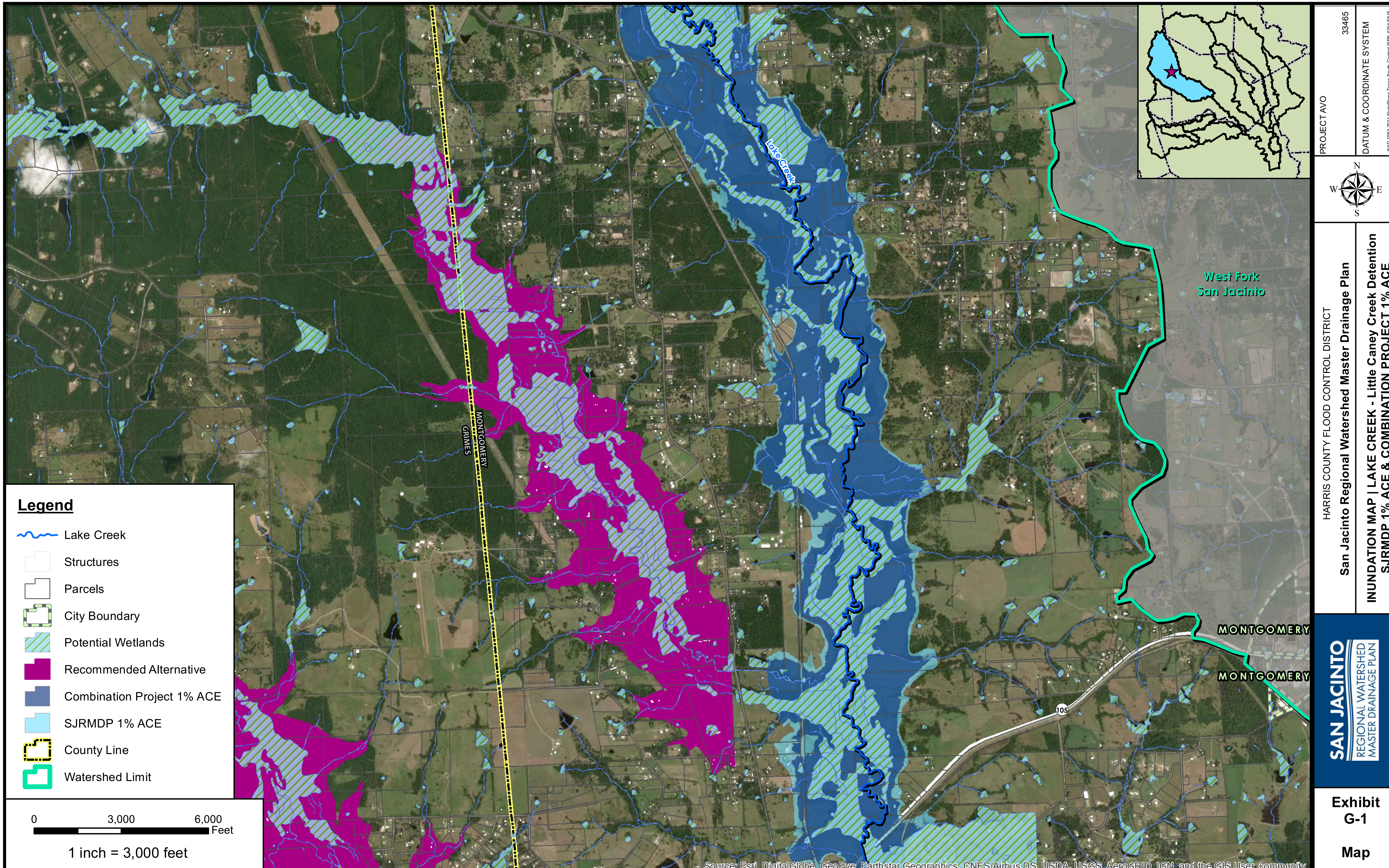
INUNDATION MAP | LAKE CREEK - Garrett's Creek Detention

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map


Lake Creek
West Fork San Jacinto
MONTGOMERY
GRIMES
MONTGOMERY
MONTGOMERY
105
Legend
Lake Creek
Structures
Parcels
City Boundary
Potential Wetlands
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
3,000
6,000
Feet
1 inch = 3,000 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
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DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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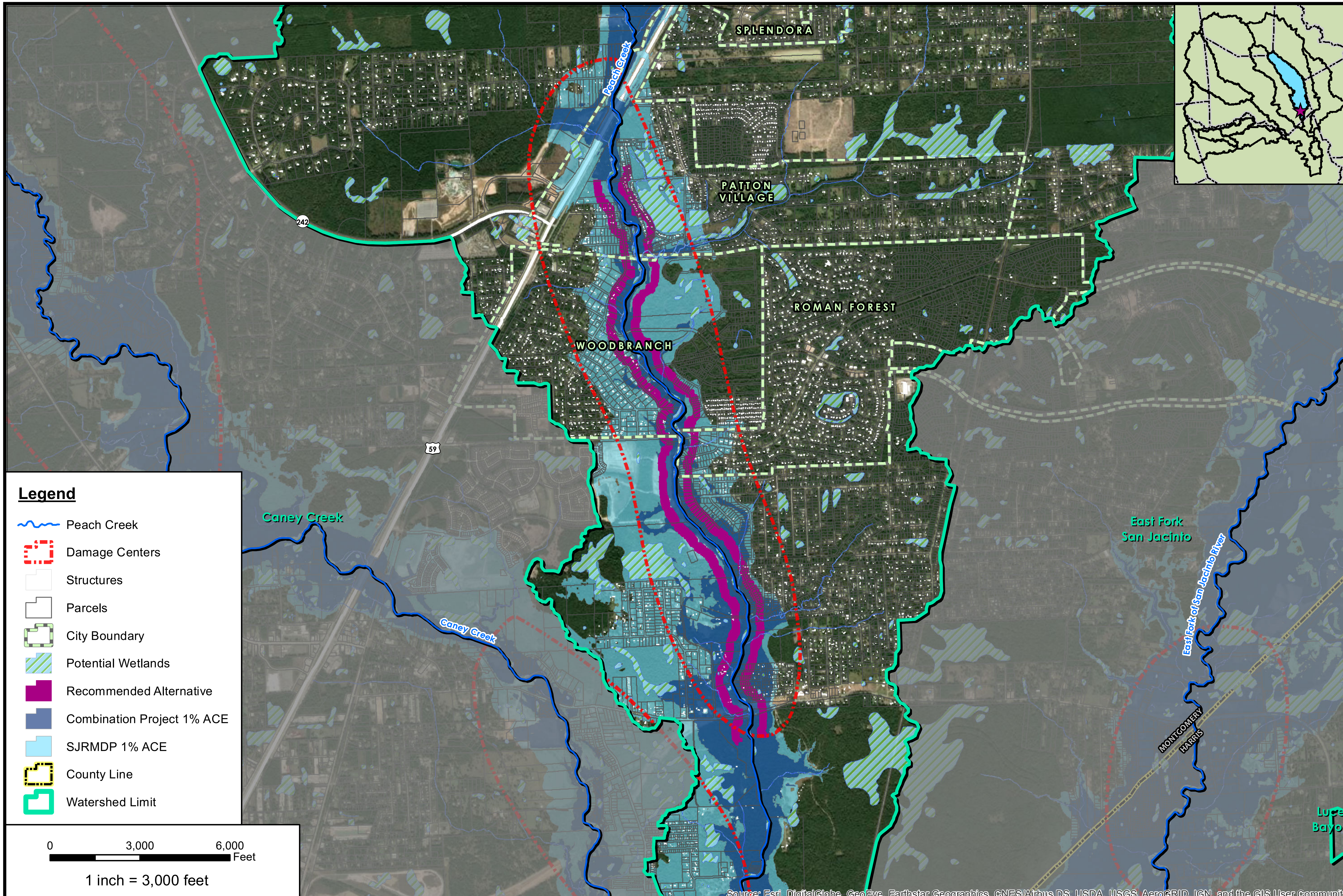
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | LAKE CREEK - Little Caney Creek Detention
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN
Exhibit
G-1
Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

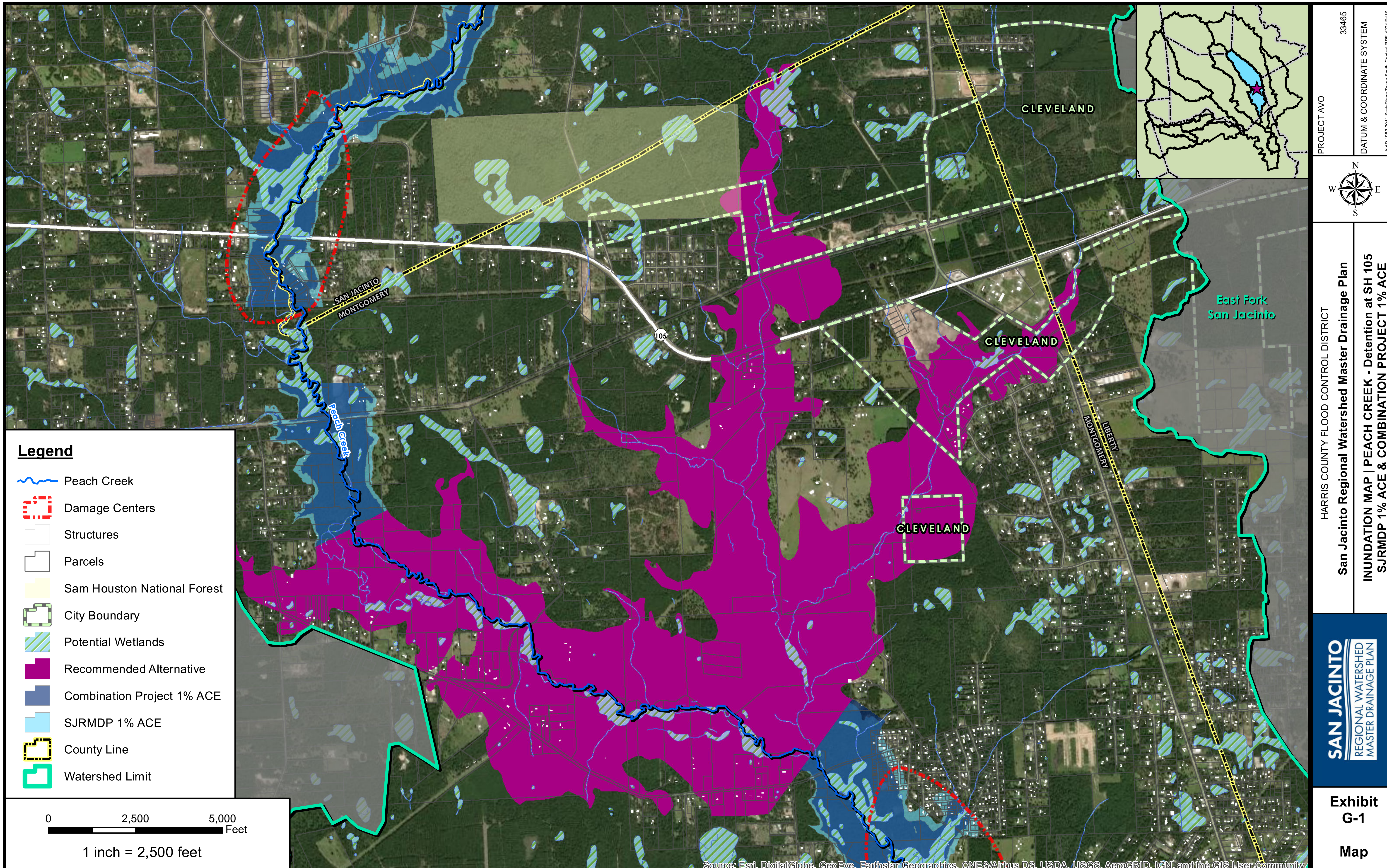
INUNDATION MAP | PEACH CREEK - Channelization at I-59

SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map


CLEVELAND
CLEVELAND
CLEVELAND
East Fork
San Jacinto
SAN JACINTO
MONTGOMERY
105
Peach Creek
LIBERTY
MONTGOMERY
Legend
Peach Creek
Damage Centers
Structures
Parcels
Sam Houston National Forest
City Boundary
Potential Wetlands
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
Watershed Limit
0
2,500
5,000
Feet
1 inch = 2,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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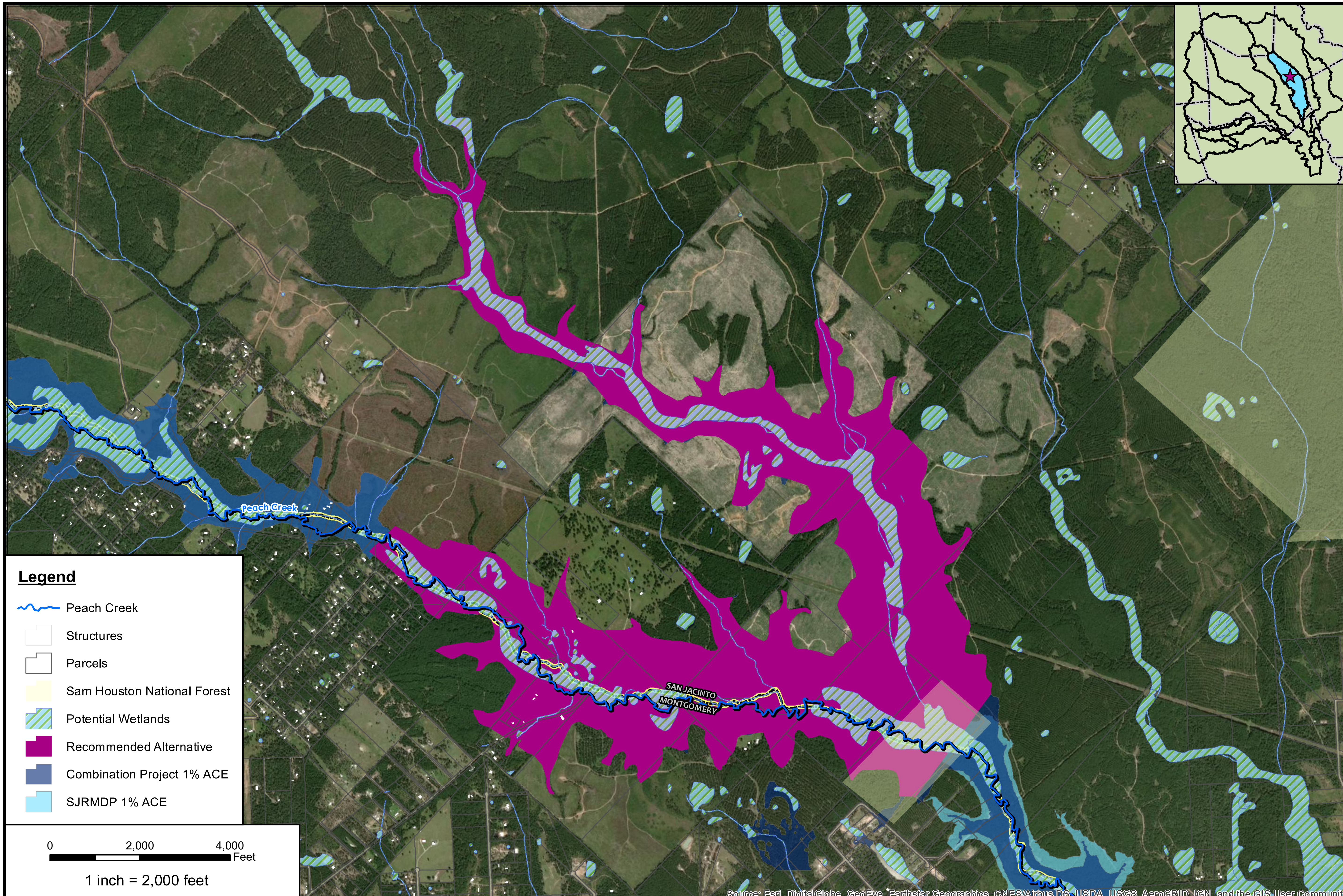
PROJECT AVO
33465
DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | PEACH CREEK - Detention at SH 105
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map



PROJECT AVO
33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

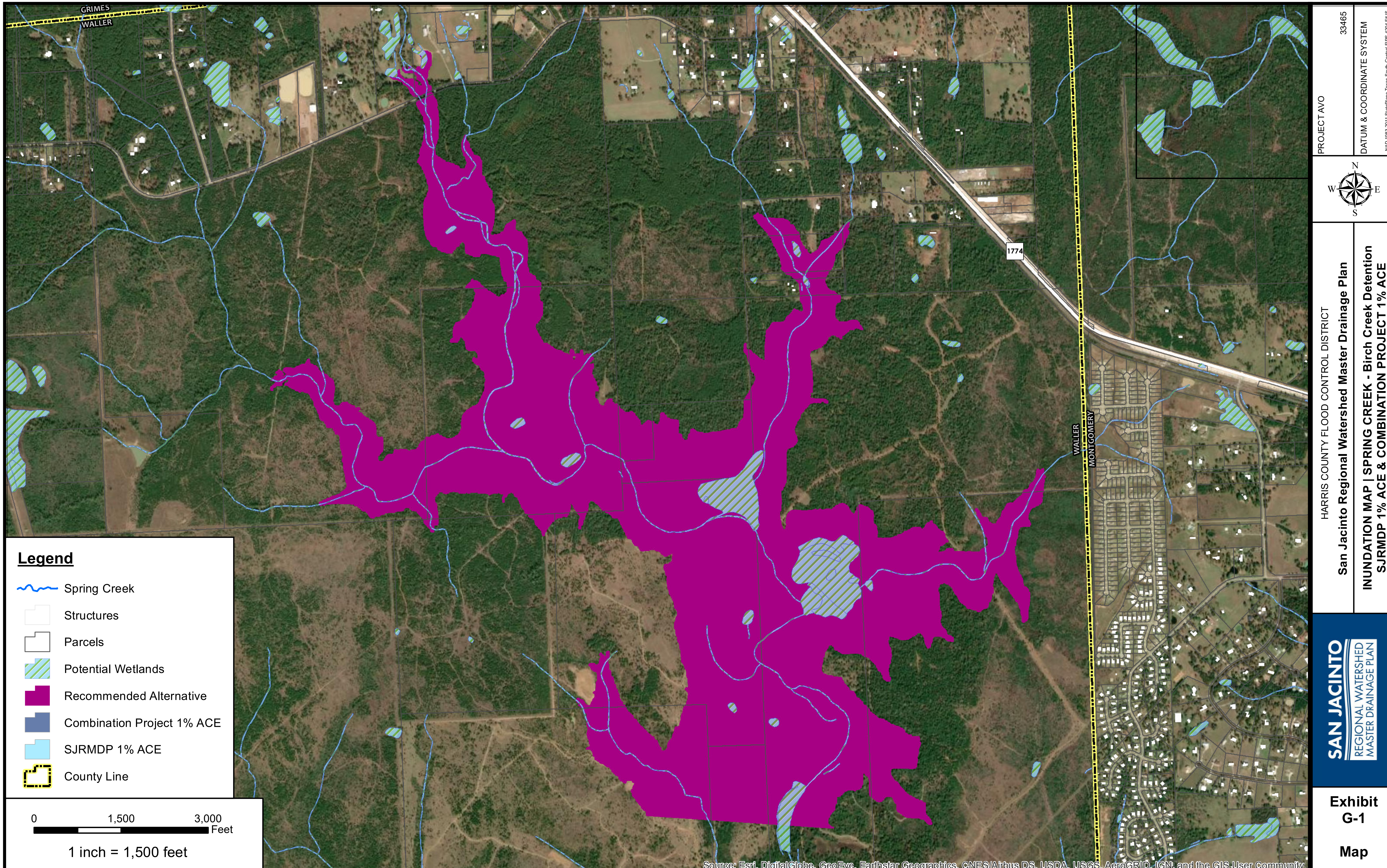
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | PEACH CREEK - Detention at Walker
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit
G-1

Map


GRIMES
WALLER
1774
WALLER
MONTGOMERY
Legend
Spring Creek
Structures
Parcels
Potential Wetlands
Recommended Alternative
Combination Project 1% ACE
SJRMDP 1% ACE
County Line
0
1,500
3,000
Feet
1 inch = 1,500 feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
PROJECT AVO
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DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 Ft US
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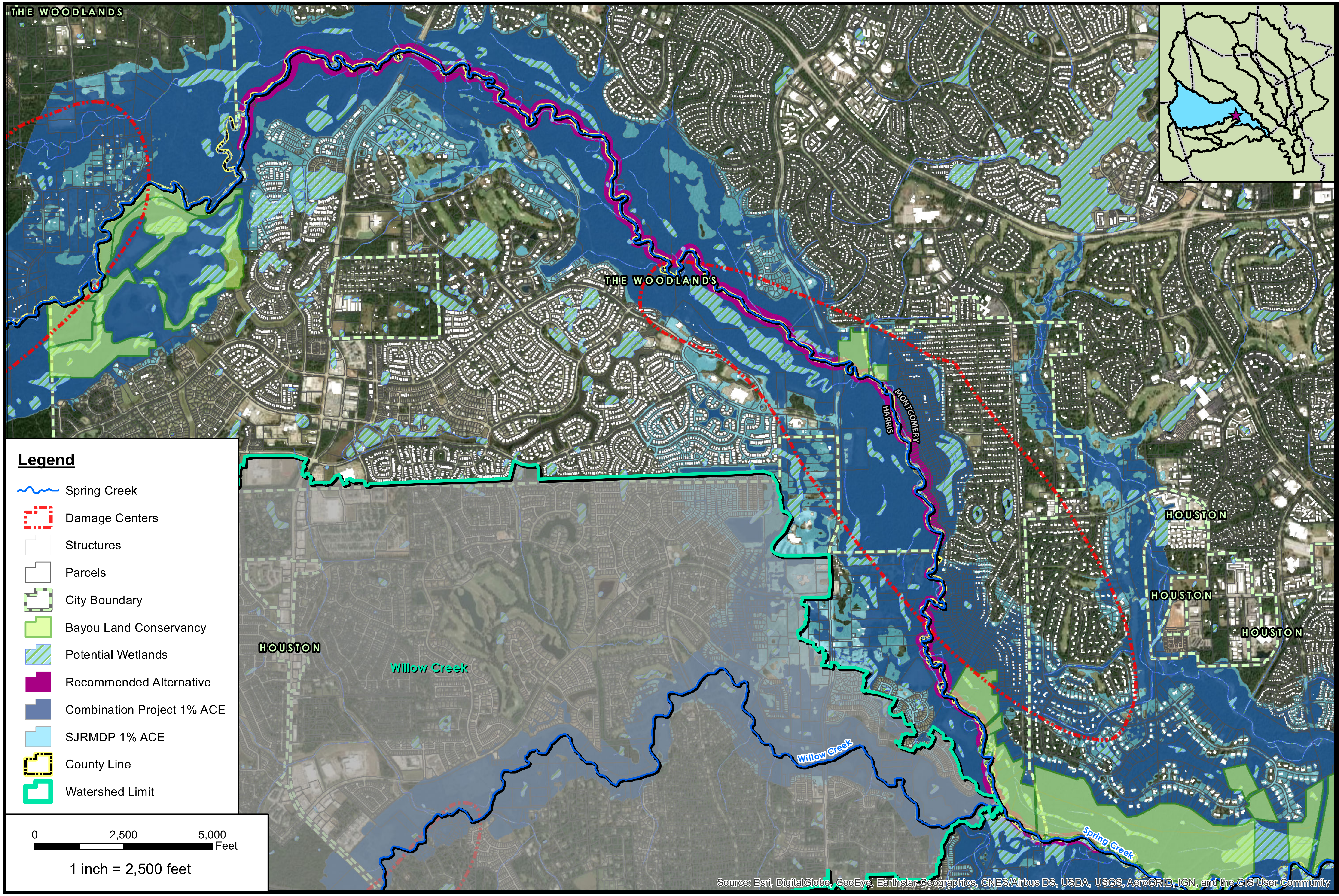
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan
INUNDATION MAP | SPRING CREEK - Birch Creek Detention
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE
SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN
Exhibit
G-1
Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM

NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

N S E W

HARRIS COUNTY FLOOD CONTROL DISTRICT

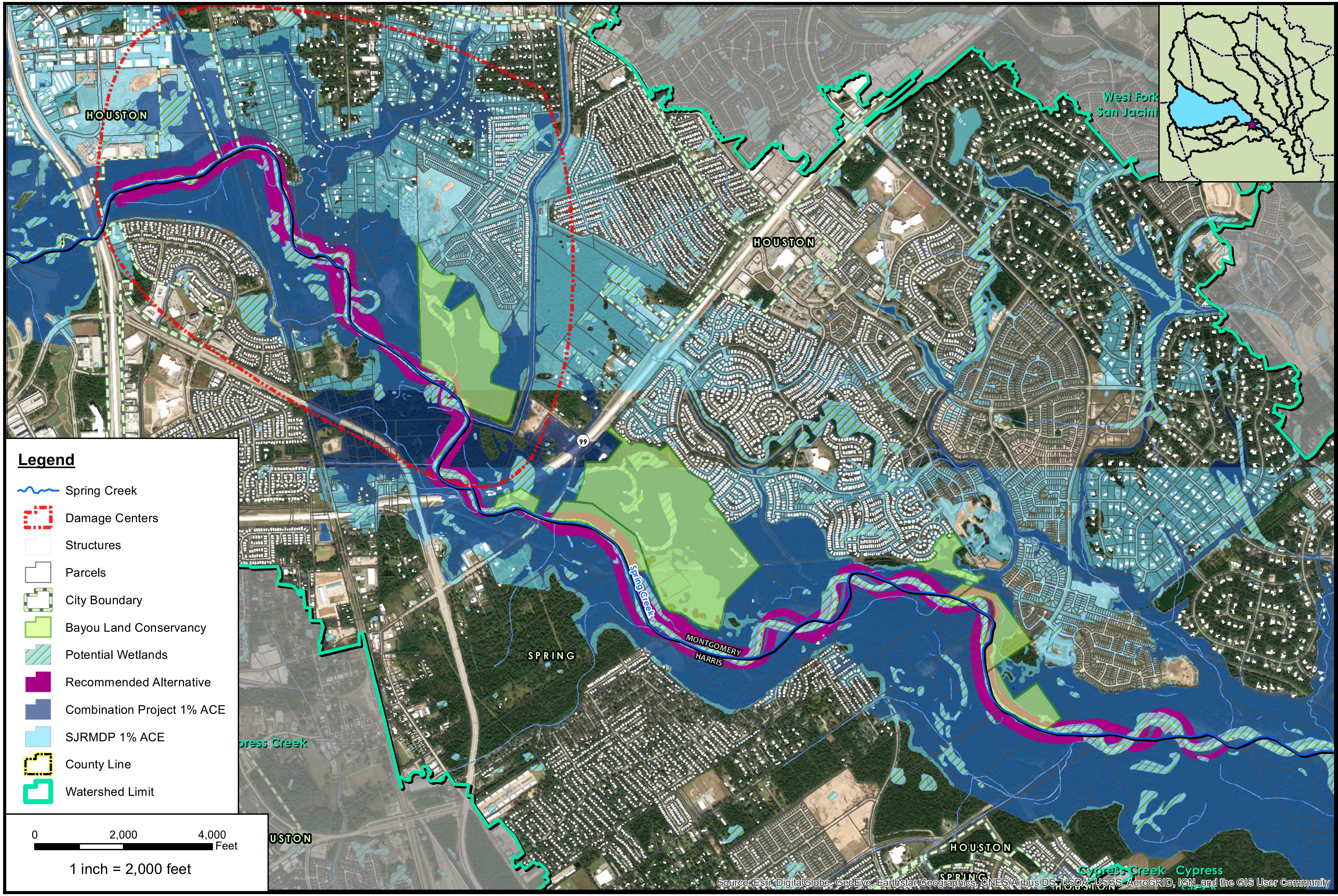
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK - DC2-200 Channelization SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

N S E W

HARRIS COUNTY FLOOD CONTROL DISTRICT

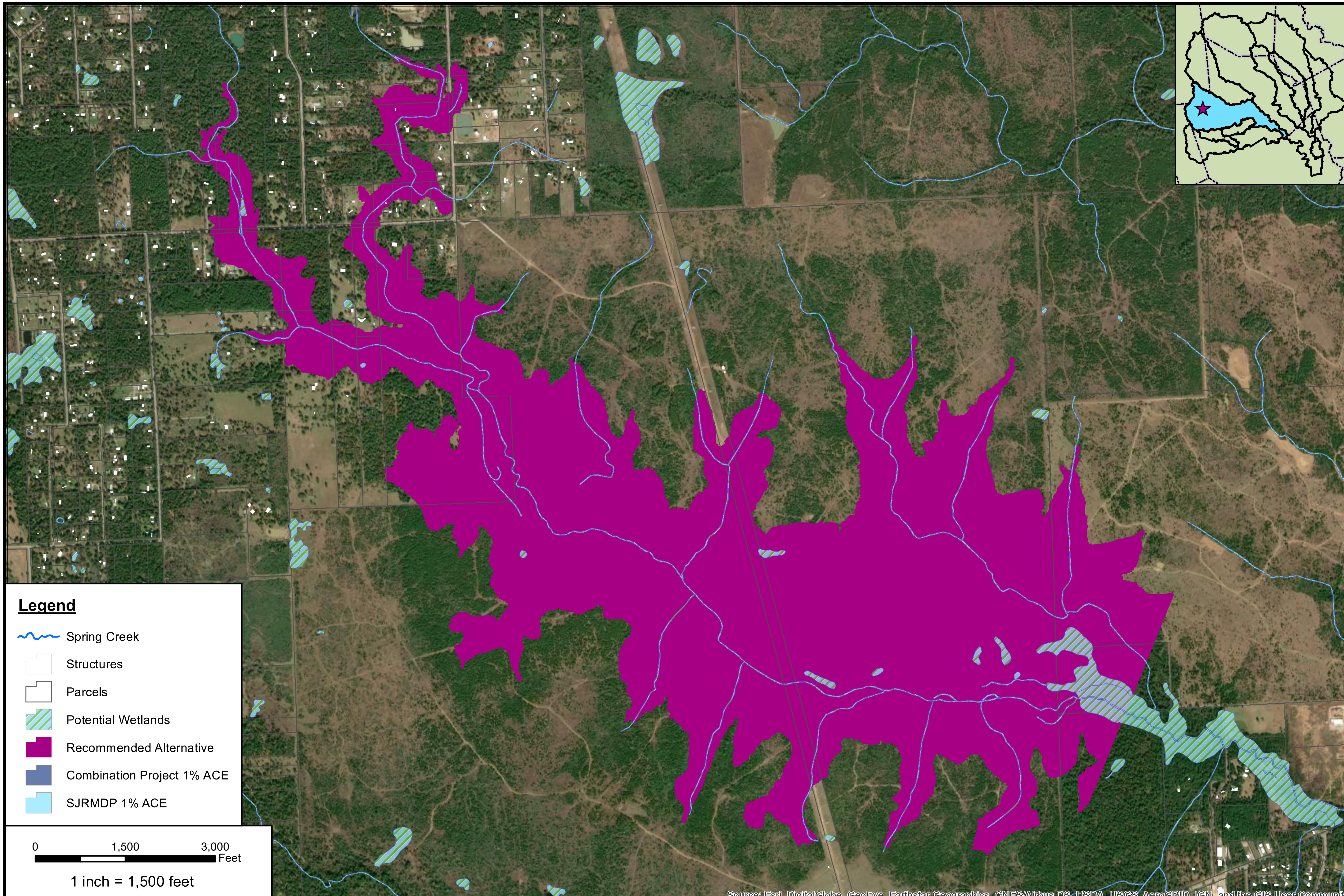
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK - I-45 Channelization
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

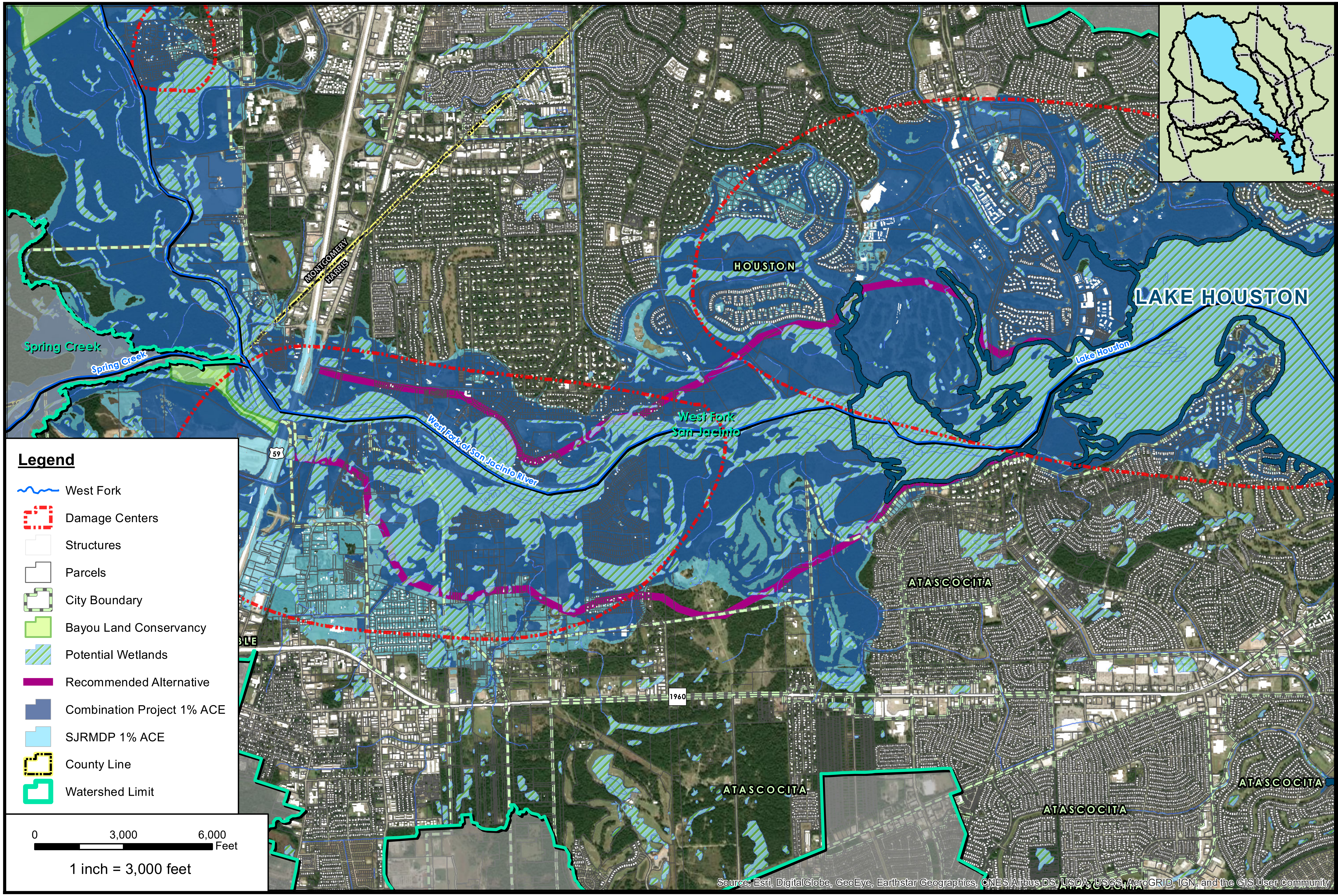
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | SPRING CREEK - Walnut Creek Detention
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

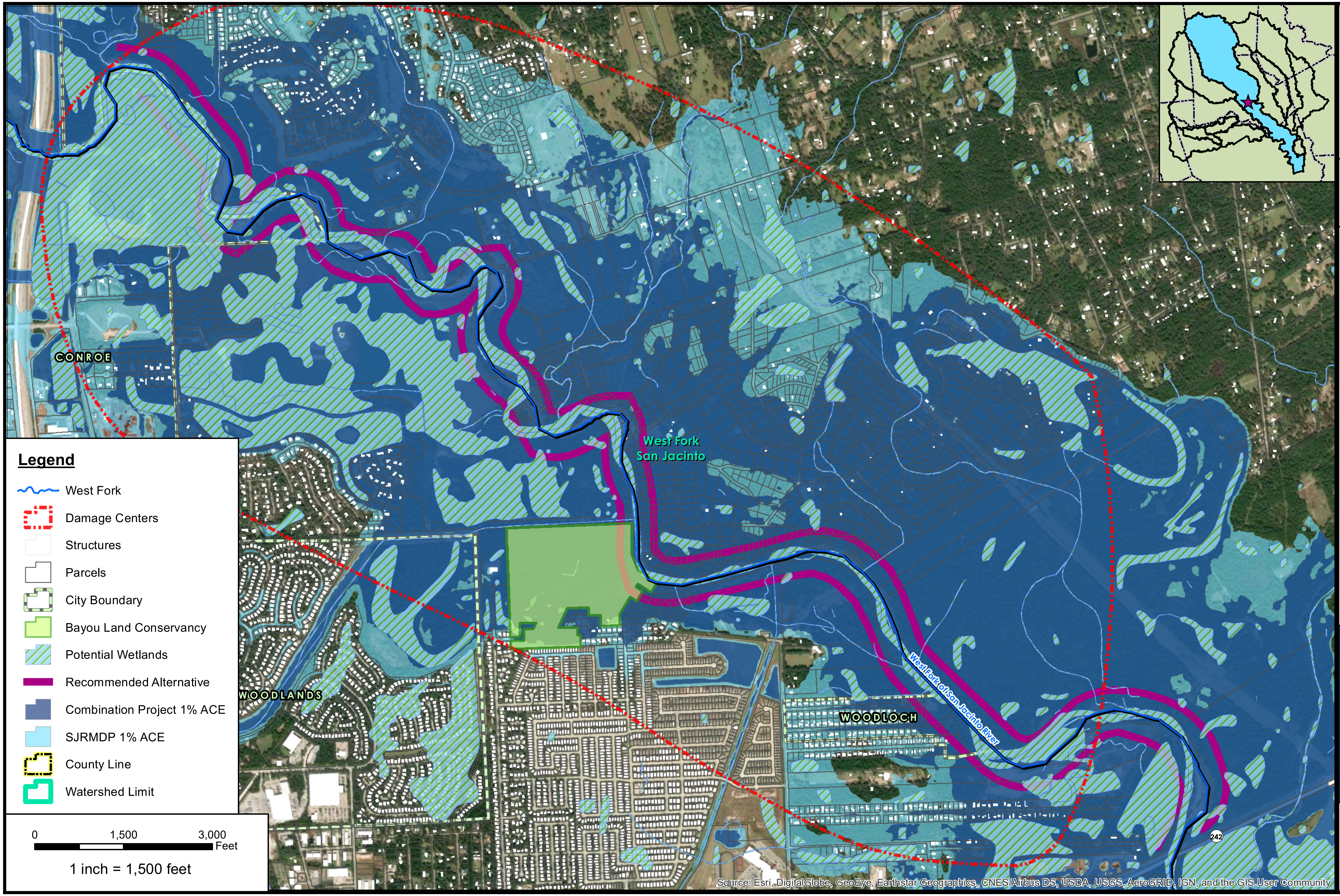
HARRIS COUNTY FLOOD CONTROL DISTRICT
San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO - Kingwood Bench
SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO
REGIONAL WATERSHED
MASTER DRAINAGE PLAN

Exhibit
G-1

Map



PROJECT AVO 33465

DATUM & COORDINATE SYSTEM
NAD 1983 2011 StatePlane Texas South Central FIPS 4204 FtUS

HARRIS COUNTY FLOOD CONTROL DISTRICT

San Jacinto Regional Watershed Master Drainage Plan

INUNDATION MAP | WEST FORK SAN JACINTO - River Plantation Channel SJRMDP 1% ACE & COMBINATION PROJECT 1% ACE

SAN JACINTO REGIONAL WATERSHED MASTER DRAINAGE PLAN

Exhibit G-1

Map