



# Kingwood Area Drainage Analysis

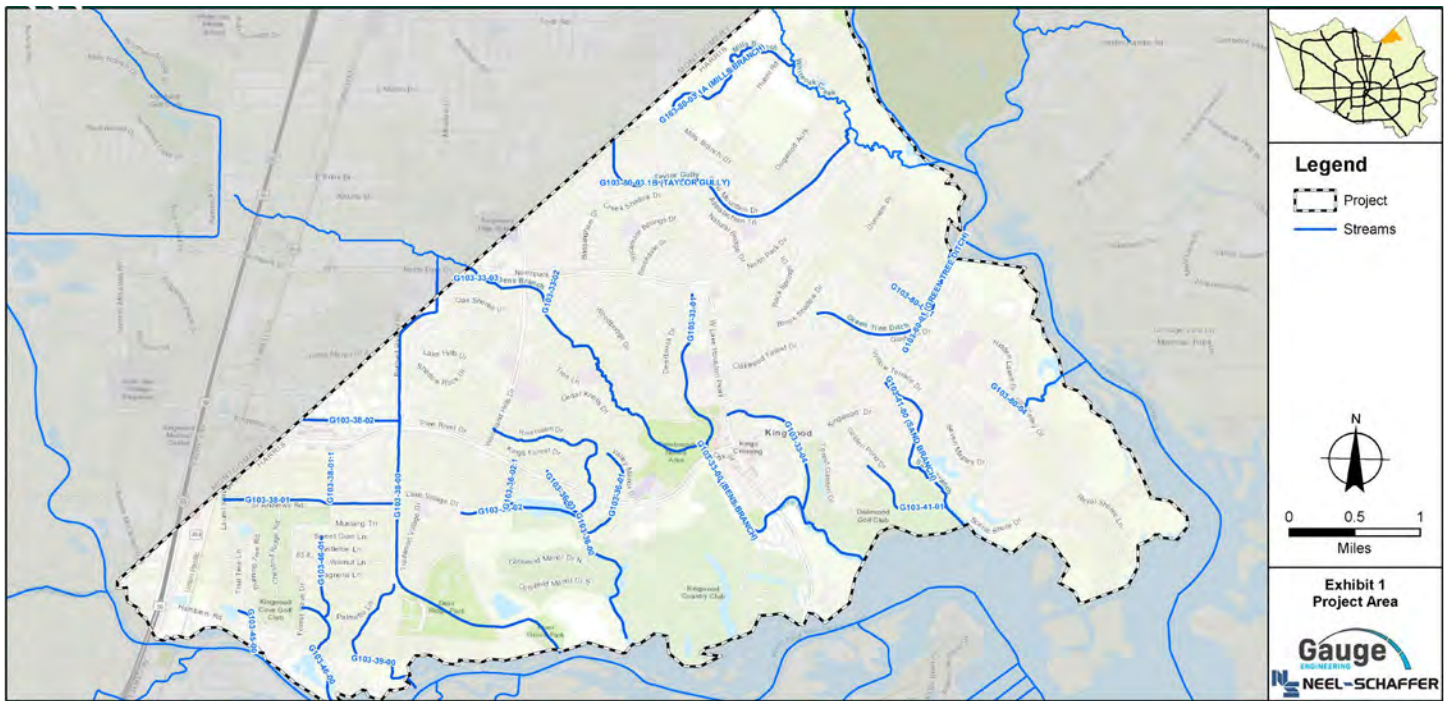
## *Technical Report Summary*

Summer 2020

## Introduction

This Summary presents the Recommended Improvements Plan (Kingwood Plan) for the Kingwood Area Drainage Analysis (Kingwood Study). The Harris County Flood Control District (Flood Control District), the Lake Houston Redevelopment Authority (TIRZ 10), and City of Houston teamed together to conduct a drainage study for the streams within the greater Kingwood area (Study Area). The Kingwood Study identified the level-of-service (LOS) within the existing open channel drainage infrastructure and developed improvement options to obtain a 1 percent annual chance event (100year) LOS for open channels throughout the Study Area. Channels with this LOS can handle 13 to 18 inches of rainfall within a 24-hour period. An interlocal agreement between the Flood Control District and the TIRZ 10 (Agreement No. 2019-153) was completed to perform the Kingwood Study and develop the Kingwood Plan. The Kingwood Study resulted in a technical report, upon which this summary is based, titled the “Kingwood Drainage Study – Conceptual Watershed Plan for Flood Damage Reduction in Kingwood,” HCFCD Project ID#: Z100-00-00-P027, Bond Program Map ID F-14, Project No. 15327.000. The technical report was prepared in May 2020 for the Flood Control District and the TIRZ 10. The public is encouraged to read the referenced report for the detailed analysis.

***The Kingwood Study identified the level-of-service (LOS) within the existing open channel drainage infrastructure and developed improvement options to obtain a 1 percent annual chance event (100-year) LOS for open channels throughout the Study Area.***



## Study Area

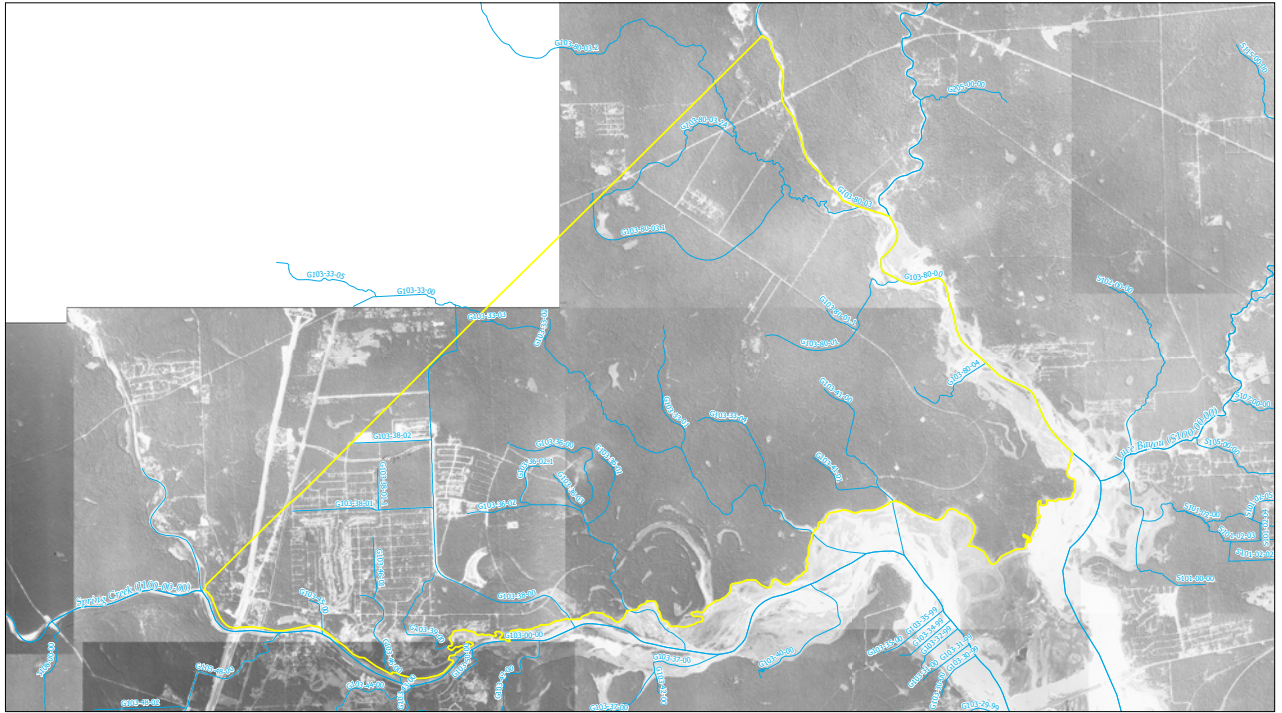
The Study Area, as shown in Exhibit 1, is located within the greater Kingwood area within Harris County. (Other portions of the Kingwood community within Montgomery County are not included.) The Study Area is bounded by the West Fork of the San Jacinto River to the west and south and by White Oak Creek and the East Fork of the San Jacinto River to the east. Being a master-planned community, the Kingwood area is mostly residential with typical suburban infill of commercial, public, and some industrial land uses. Parks and golf courses provide green space to the community. The upper and western portions of the Study Area were mostly developed within the past 35 years whereas the remaining eastern area has begun to develop more recently. The Study Area encompasses 21.7 square miles and is drained by numerous streams and man-made channels shown in Exhibit 1. This area can be impacted by out-of-bank channel flooding, overland (sheetflow) flooding, and limited storm sewer systems overloaded by intense rainfall events.

The comprehensive drainage network within any community includes the complete path stormwater runoff takes as it moves out of the area; therefore, the drainage network in Kingwood includes roads graded to convey (or store) stormwater; inlets in roads designed to intercept road drainage; underground storm sewer systems; small roadside ditches; several tributaries; and, ultimately, major bayous and streams within the area. This Kingwood Study was designed to focus on the drainage network of the greater Kingwood area within Harris County, and included consideration of only those portions of Montgomery County that naturally drain Kingwood's open channels. While this study was scoped to focus on the open channel network in Kingwood, a limited storm sewer analysis was considered to evaluate the capacity of the major open channel network. This storm sewer analysis simulated the larger storm sewer network but was not intended to be a replacement for a more detailed storm sewer analysis. Also, this Kingwood Study did not analyze flooding issues associated with the West Fork or East Forks of the San Jacinto River.

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## Kingwood Study Area: 1974



## Kingwood Study Area: 2018



There have been numerous updates to the City of Houston's and Harris County's drainage criteria since the earliest portions of Kingwood were first constructed. As such, the age of a subdivision can be a factor in its flood risk due to less stringent requirements at the time of development. The various neighborhoods within Kingwood built prior to December 1996 were located in unincorporated Harris County and were under the jurisdiction of the Harris County Permits Office. All local drainage infrastructure (including storm sewer systems and road side ditches) constructed prior to December 1996, the date Kingwood was annexed

by the City of Houston, were reviewed and approved for building permits by the Harris County Permit Office to ensure compliance with Harris County development criteria. Structures and accompanying drainage infrastructure built after December 1996 were built in compliance with City of Houston drainage criteria. The western half of the Kingwood area was mostly developed prior to 1985 and was developed without detention requirements (adopted by the Flood Control District in 1985) and extreme event sheetflow paths (adopted by Harris County Permits Office in 2000).

## Problem statement

The Kingwood area has recently experienced significant flooding events warranting a study of the Kingwood drainage channels. Intense rainfall events challenge the capacity of local drainage systems causing localized flooding exacerbated by overland flow. Future intense rainfall events will continue to challenge the Kingwood area's drainage network.

## Plan goal, purpose, and scope

The overall goal of the Kingwood Plan was to achieve a 1 percent annual chance (100-year) LOS from improved open channel drainage infrastructure within the Study Area. A 100-year channel LOS is defined as achieving no damages to structures from overbank flooding during a 1-percent annual chance (100-year) rainfall event, or 13 – 18 inches of rainfall within a 24-hour period.

The purpose of the Kingwood Plan was twofold:

1. Evaluate the Study Area and quantify the existing flooding concerns along the streams, channels, and ditches as well as identify drainage issues associated with the local (storm sewer system) drainage infrastructure within the Study Area; and
2. Develop strategies to improve the open channel portion of the drainage infrastructure to achieve a 1 percent annual chance event (100-year) LOS that will reduce the flood risk for structures within the Study Area.

The scope of the Kingwood Study began with the analysis of the following five streams that are named in the interlocal agreement:

1. Bens Branch (Flood Control District Unit G103-33-00) from 3,500 feet upstream of Kingwood Blvd. to 2,000 feet downstream of Lake Houston Blvd
2. Flood Control District Unit G103-33-01
3. Kingwood Diversion Ditch (Flood Control District Unit G103-38-00)
4. Green Tree Ditch (Flood Control District Unit G103-80-01)
5. Taylor Gully (Flood Control District Unit G103-80-03.1B)

In order to formulate a better analysis of the area, the Flood Control District decided to study all of the remaining open channels within the Study Area, regardless of jurisdictional authority.

## San Jacinto Regional Watershed Master Drainage Plan Difference

The Kingwood Plan was developed at the same time as the San Jacinto Regional Watershed Master Drainage Plan (SJMDP). While both plans contained the Kingwood Area within their study limits, these plans differed in their focus and scope. The SJMDP is a comprehensive regional plan for the major tributaries of the Upper San Jacinto River watershed, from the headwaters in Walker County down to the Interstate 10 crossing of the San Jacinto River in Harris County. The SJMDP focused on analyzing major channels around Kingwood including the West Fork San Jacinto River and the East Fork San Jacinto River channels, however, the open channels that drain the interior of Kingwood were too small to be studied in the SJMDP. The goals of the SJMDP were achieved by developing a set of hydrologic and hydraulic models for the major tributaries of the Upper San Jacinto River using consistent, cohesive methodology and rainfall rates, regardless of the county in which those channels are located. Results from the SJMDP will be used to inform and update Hazard Mitigation Plans for each of the participating partners and to provide guidance on regulations for future growth within the region. Overall, the SJMDP aims to provide an up-to-date technical basis to identify flooding vulnerabilities for future growth and improve flood resiliency within the San Jacinto River watershed.

In contrast, the Kingwood Plan was focused on the open channels that drain Kingwood Area neighborhoods and included the creation of directed strategies for implementation to improve those open channels.





## Project lifecycle

Every flood damage reduction project is unique. Yet each project begins and ends, with common and predictable milestones along the way. Whether a project moves forward – and how quickly – depends on many factors, including the availability of funding at each milestone, shifting community priorities for flood damage reduction, and other changing circumstances from year to year.

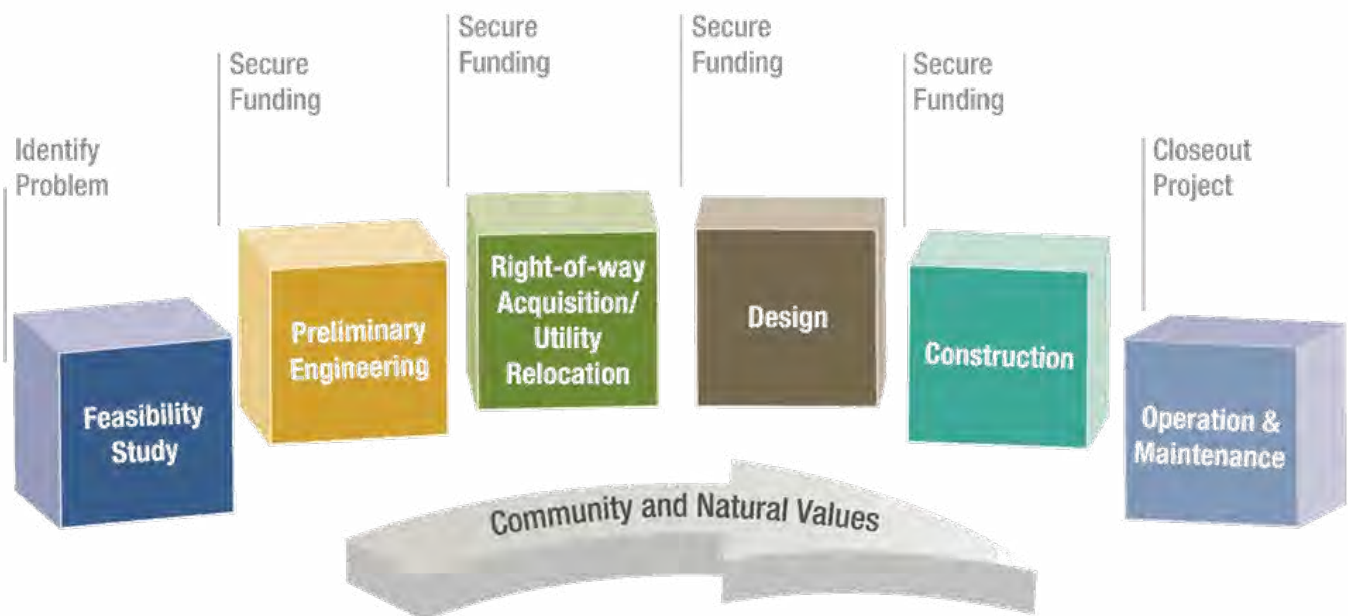
The Kingwood Area Drainage Analysis is currently in the feasibility study stage. The feasibility study involves further analysis of the flooding problem, communicating with the public and key stakeholders and determining major components of a possible plan to achieve flood damage reduction goals. This is often the stage when the public first learns about a Flood Control District project.

Once a feasibility study report has been approved, and if funding is available, the project or projects move into the project development or preliminary engineering stage. During this stage, Flood Control District engineers and environmental specialists develop and evaluate possible alternatives, prepare a project development or preliminary engineering report that includes project recommendations that meet flood damage reduction goals. This report will identify needed right-of-way, determine utility relocation, and develop a preliminary cost estimate.



*Drainage Channel*

## Flood Damage Reduction Project Lifecycle



# The Kingwood Study

## Methodology

The methodology followed for the Kingwood Study reflects current thinking and practice in engineering hydrologic and hydraulic analyses. It also incorporates the latest information with regard to expected rainfall by using the National Oceanic and Atmospheric Administration's Atlas 14 point rainfall frequency estimates. The Kingwood Study produced the most precise results that time and funding allowed. Further investigation was recommended for some aspects of the Kingwood Study to further refine the results. For example, only the 100-year LOS was investigated for this effort, whereas, a different LOS may be more appropriate for some parts of the Study Area.

### *Study assumptions and limitations*

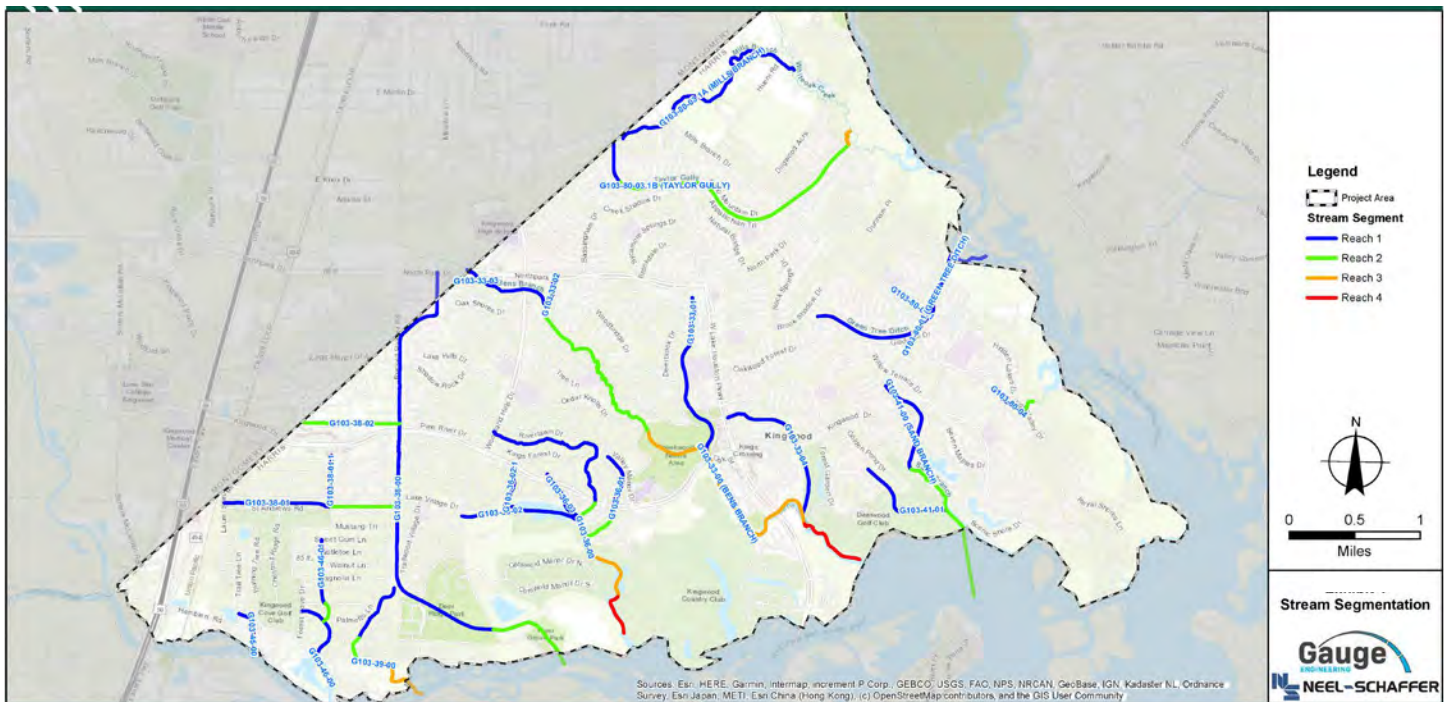
Some assumptions were made to allow the analysis to be completed. Limitations of the Kingwood Study were also noted.

1. The scope for the Kingwood Study only includes an evaluation of 100-year structural flooding.
2. No topographic surveys were performed. Rather, LiDAR, record drawings, previous surveys, and field collected data were used to perform the analysis.
3. Analysis of proposed improved condition included an analysis of the additional capacity that the open channels would need to have in the event that future local storm sewer system improvements were constructed. This study considered what impact that improvements would have on the receiving open channels if and when these projects were to be implemented.
4. No improvements within Montgomery County were accounted for except for Northpark Drive, which is currently being analyzed for roadway and drainage improvements by TIRZ 10.
5. Only a limited analysis of the storm sewer infrastructure was conducted to assist in understanding rainfall runoff patterns. A thorough evaluation of the storm sewer network was not conducted.
6. Underground storm sewers were not simulated for areas where information was not readily available, including areas outside of the City of Houston and areas within Montgomery County. Any calculated increases in peak flows to the receiving stream would be accommodated by the calculated detention requirement. Detention estimates necessary to prevent increasing flows to Lake Houston or the San Jacinto River were quantified. However, no identification of detention sites was attempted.
7. The recommended channel improvements

account for additional flow to the channels from an assumed improved local drainage system. The study recommends that a more detailed analysis be performed by the City of Houston for any improvements to the local sewer system.

8. The benefits of all proposed projects were determined by considering how many structures would benefit from each project. Since the study team did not have actual surveyed slab elevations of every structure in the Kingwood Area, a structure inventory was developed to allow for an assessment of structures that would benefit from the proposed projects. This structure inventory allowed the study team to categorize two separate types of benefits: directly benefited structures are structures that are within the 100-year floodplain and would benefit from the reduction in channel floodplains, and indirectly benefited structures are structures that are not in a 100-year floodplain, but are at risk to flood due to localized sheet flow and/or street flooding. The indirectly benefitted structures were approximated using engineering judgement of benefits from future improvements which would allow for a potential reduction in ponding or uncontrolled sheetflow from the older, overloaded storm sewer systems. The determination of structures benefitting from recommended improvements is an approximation for comparison purposes. In order to determine the actual benefitted structures, a more detailed analysis would need to be performed.
9. Recent accumulated sediment within the channels in the Study Area was not surveyed; however, the San Jacinto River Authority (SJRA)(<https://www.sjra.net>) is leading efforts, with support from the Flood Control District, to perform a project to plan, design, and construct one or more "sand traps" along the West and/or East Forks of the San Jacinto River to reduce future sedimentation with the goal of mitigating flooding. The first phase of the overall project, a conceptual design effort, is currently underway. Upon completion of the conceptual design phase, the goal is to move forward with preliminary design on two sites selected from the conceptual design, with the ultimate goal being design and construction of likely one, but potentially two, sand traps. This small scale effort, involving only one or two sand traps, is intended to act as a "pilot" project from which data can be gathered as to the real-world feasibility and effectiveness of sand traps in removing material from the river(s) and mitigating sedimentation issues in the basin before a larger, and much more costly, program is potentially embarked upon. Preliminary conceptual design phase results indicate that the sand traps recommended to move forward to preliminary design





will likely be located along the West Fork of the San Jacinto River. Additionally, the SJRA has submitted an abridged Flood Infrastructure Fund grant application to the Texas Water Development Board for funding to perform a regional sedimentation study of the Upper San Jacinto River Basin (Lake Houston watershed). To identify and create a plan for implementing potential sedimentation solutions, this study would develop “sediment budgets” by evaluating the input, output, and storage of sediment for the entire basin, as well as for sub-watersheds within the basin.

## Models and Data

The Kingwood Study incorporated appropriate and available hydrologic and riverine modeling programs developed by the U.S. Army Corps of Engineers’ (USACE) Hydrologic Engineering Center (HEC) and by the Federal Emergency Management Agency (FEMA). The Kingwood Study utilized the Harris County Modeling, Assessment and Awareness Project (MAAPnext) hydrologic methodology and Atlas 14 rainfall data based on Harris County Hydrologic Region 2 and a 24-hour storm duration. Five annual chance rainfall events—50 percent (2-year), 10 percent (10-year), 4 percent (25-year), 2 percent (50-year) and 1 percent (100-year)—were simulated using USACE HEC-HMS and modeled into five respective flood inundation zones using USACE HEC-RAS and HEC-RAS Mapper.

Data collected and used in the Kingwood Study and Kingwood Plan development included the following:

1. FEMA Effective Hydrology Computer Models
2. FEMA Effective Hydraulic Computer Models
3. Flood Control District Historical Flood Data
4. Flood Control District 2018 Building Footprints
5. Flood Control District Impervious Raster
6. Flood Control District Watershed Master Plan Drainage Areas
7. Flood Control District Targeted Buyout Area
8. The Houston-Galveston Area Council’s 2018 Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM)
9. Field Reconnaissance
10. Photographic Aerials

## Stream reaches

For the purposes of presenting the data and proposed improvements, the studied streams were segmented into reaches defined by the limits in the Flood Control District Kingwood Area Drainage Assessment Reports. Each stream or tributary was divided into a maximum of four reaches. For this analysis, stream reaches begin at the upstream end and are incremented toward the stream’s confluence, so that Reach 1 is upstream from Reach 4.



*Rustling Elms Bridge*

## Information that focused and informed the study

### *Bridge crossings*

During the field reconnaissance, measurements were taken for the existing bridge structures, including deck thickness, distance from low chord to channel flowline, culvert size, rail height, and pier sizes. These measurements help determine whether bridges or road crossings restricted flow, or if the crossings could potentially allow for increased flow.

### *Project datum*

The project datum is the North American Vertical Datum (NAVD) 1988, 2001 adjustment. No topographic surveys were performed for the Kingwood Study. For this Kingwood Study, 1-meter LiDAR, 2018 Texas Strategic Mapping (StratMap) topographic data were utilized. All elevations referenced in the technical report are referenced to the project datum unless otherwise noted.

### *Topography and land use*

The topography of the channel banks within the Study Area are generally characterized by both steep and mild terrain, with the upper portion of the Study Area sloping to the east and the lower portion sloping east and southeast. The Study Area exhibits overland slopes ranging from a mild slope of 4.1 feet/mile to steep slopes of 70.4 feet/mile, with an average slope of 21.7 feet/mile. Stream gradients range from a mild slope of 0.3 feet/mile to a steep slope of 48.5 feet/mile, with an average slope of 9.0 feet/mile.

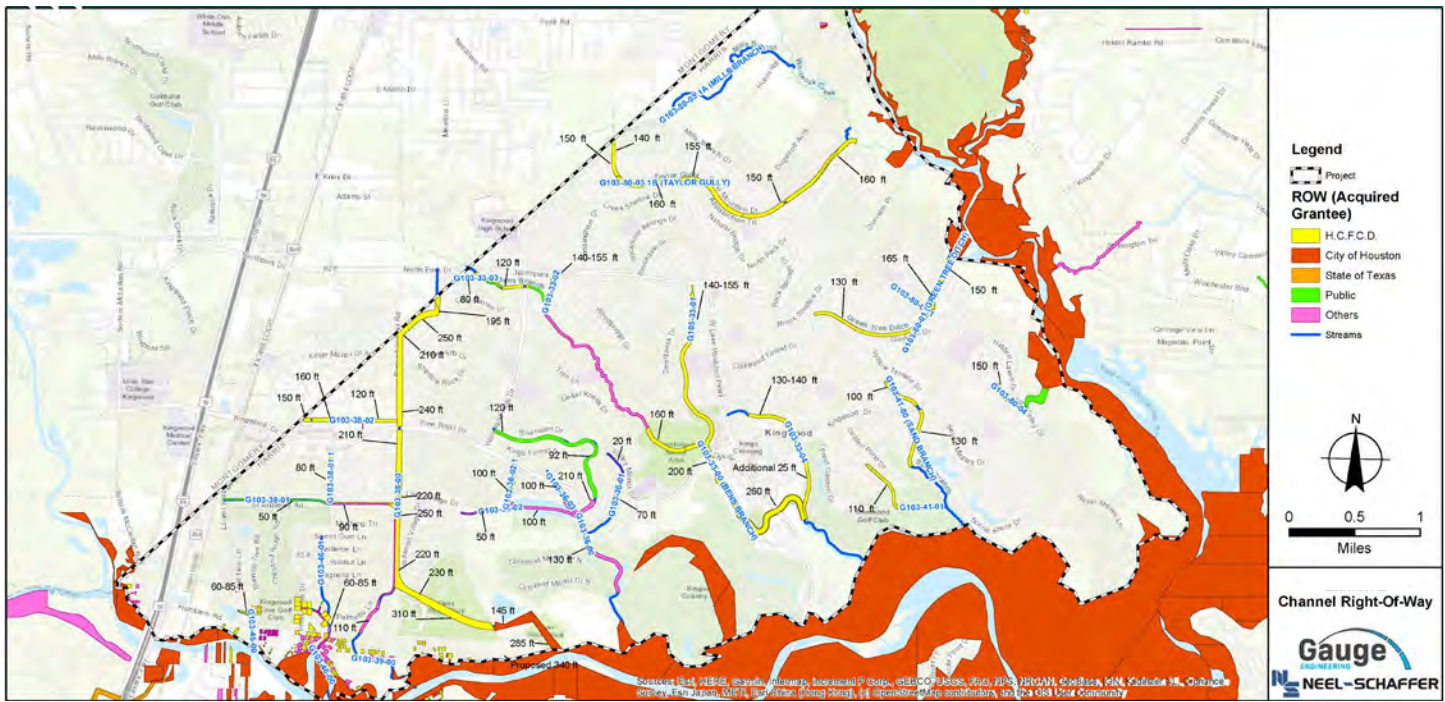
Several of the streams within the Study Area were constructed against grade and counter to the existing topography. Flood Control District Unit G103-38-00 (Kingwood Diversion Ditch) runs north to south and parallels the contours. Additionally, Flood Control District Unit G103-80-03.1B (Taylor Gully) was constructed through an existing high area. This results in inefficient channel sections.

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***During the field reconnaissance, measurements were taken for the existing bridge structures, including deck thickness, distance from low chord to channel flowline, culvert size, rail height, and pier sizes.***

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## Rights-of-way/flowage easements

The Flood Control District classifies and catalogues all streams, channels and ditches within Harris County with a systematic nomenclature that allows for identification with the receiving stream or bayou. However, the Flood Control District has authority to maintain and improve only those streams, channels and ditches over which it has authority or control. While the Flood Control District and the City of Houston have sole control over some of these streams or stream segments, other streams, channels and ditches are entirely controlled by entities other than the Flood Control District or the City of Houston, such as Harris County, utility districts, neighborhood associations/communities, or private developers in the Study Area. Within other streams or stream segments, the Flood Control District or the City of Houston share rights-of-way (ROW) with other entities. The importance of ROW along the Study Area channels is that the Flood Control District and the City of Houston cannot legally construct drainage improvements along channels for which they do not have property rights.

The Flood Control District did not confine the Kingwood Study to only those streams over which it has authority but included all streams within the Study Area for a more holistic analysis that would benefit the entire area. A list of entities who control the ROW for streams in the Kingwood Study Area is included in the Kingwood Plan Summary Table and shown in Exhibit 2.



Roadside Drainage Ditch

## Effective FEMA floodplains

Bens Branch (Flood Control District Unit G103-33-00); Taylor Gully (Flood Control District Unit G103-80-03.1B); and Mills Branch (Flood Control District Unit G103-80-03.1A) are FEMA-studied streams with the 1 percent annual chance event (100-year) regulatory floodplain in the Study Area published in the FEMA Flood Insurance Rate Maps (FIRM) for Harris County, Texas, and Incorporated areas. For Bens Branch (Flood Control District G103-33-00), the mapped regulatory floodplain south of Kingwood Drive is within the limits of the regulatory floodplain of the West Fork of the San Jacinto River. Other

streams that are located within the 100-year regulatory floodplain of the West Fork of the San Jacinto River are G103-39-00, G103-45-00 and G103-46-00.

## Study tasks

The Kingwood Study included the following tasks:

1. Evaluate historical flooding
2. Perform an overland flow (sheetflow) analysis
3. Perform existing open channel LOS analysis
4. Structure inventory analysis
5. Perform an improvement analysis
6. Develop a detention requirement estimate
7. Develop a preliminary cost estimate

## Evaluation of historical flooding

Recent historical flooding events, including Hurricane Harvey and Tropical Storm Imelda, revealed capacity limitations of existing channels and neighborhood drainage systems, resulting in recognition of the need for channel and other drainage infrastructure improvements. Other historical storms were also reviewed for their respective impacts.

## Overland flow analysis

In an effort to understand the overland flow paths in the Study Area, a 2D hydraulic model was developed for Kingwood and the surrounding area, which allows the study of both the overland flow and local storm sewer systems. The overland flow analysis was intended to be a high-level analysis of the drainage trends in the area, and a basis to confirm results for the drainage channels within the Study Area. The Kingwood Study identified potential areas that are at risk of open channel flooding and areas at risk of overland flow and storm sewer capacity limitations. The City of Houston has inspected the storm sewer network in Kingwood and found the storm sewer systems are functioning to their design specifications, which were in compliance with codes at the time they were built. The storm sewer systems within the west side of Kingwood are older and therefore not in compliance with current criteria for storm sewers. Also, the west side of Kingwood was not built with extreme event sheet flow paths to enable runoff from large scale rainfall events to drain neighborhoods. Because of this, certain areas of Kingwood are particularly more vulnerable to flooding due to street ponding and neighborhood sheet flow.

## Existing level of service analysis

The data from the hydrologic and hydraulic models were used to develop five frequency storm event flood limits for the Kingwood Study Area. The LOS was determined for each stream's reaches based on whether the storm event flood limits were contained within the streams' ROW or within the undeveloped wooded trails and areas next to the stream. Additionally, the streams were evaluated to determine whether the roadway crossings (bridges) were overtopped during specific frequency events which would potentially require modifications or replacements to those structures.



*Drop structure at Taylor Gully*

Other streams with an existing 100-year LOS are located within older portions of Kingwood and were reanalyzed assuming future improvements to the City of Houston storm sewer and roadside ditch systems. The assumption regarding the future improvement of the local drainage system by the City of Houston was made to make sure that the proposed improvements needed to upsize the open channel drainage system in Kingwood would take into account local storm sewer and roadside ditch improvements that would allow for additional flows to these channels. If the streams were determined to maintain a 1 percent annual chance event (100-year) LOS, with no flooding of structures within the limits of the stream's 1 percent annual chance event (100-year) flood limits, no improvements were proposed.



## Streams and stream reaches identified for no improvements

The existing LOS analysis identified several channels within the Study Area with a 100-year LOS. Some of these streams are located within newer portions of Kingwood that have been constructed with storm sewer systems that were designed to more current design standards (post-1984); therefore, no changes were made to modeling assumptions. The following streams were found to have a 100-year LOS and no improvements are proposed:

- Flood Control District Unit G103-41-00 (Sand Branch)
- Flood Control District Unit G103-41-01 (50-year level of service, but with 100-year flow confined to golf course)
- Flood Control District Unit G103-80-04
- Flood Control District Unit G103-80-01 (Green Tree Ditch)
- Flood Control District Unit G103-80-01.1
- Flood Control District Unit G103-80-03.1A (Mills Branch)

Other streams with an existing 100-year LOS are located within older portions of Kingwood (pre-1984) that were designed using older criteria. These streams were reanalyzed assuming improvements to the local drainage

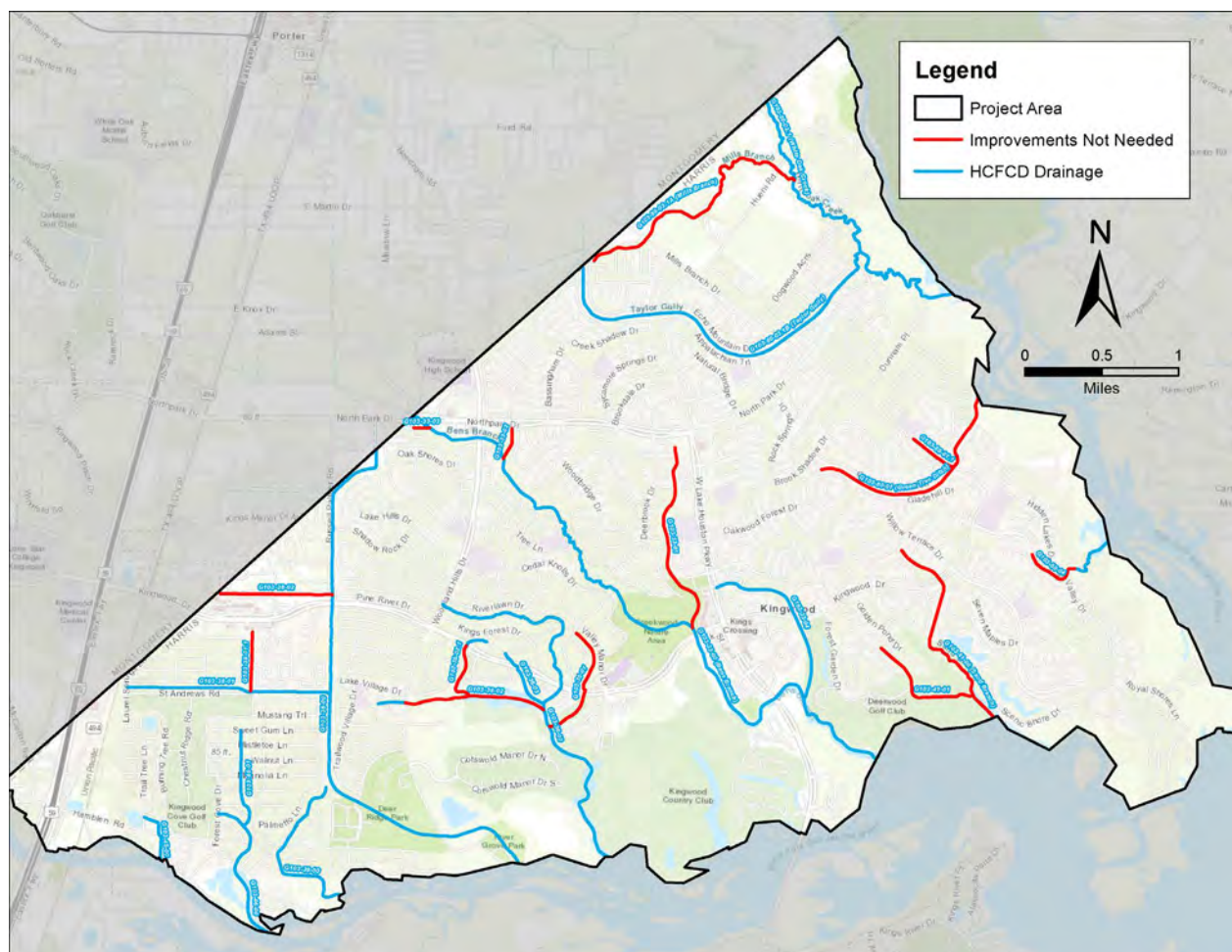
systems serving the surrounding neighborhoods. The analysis found that the following streams still have a 100-year LOS with no structures located within the 100-year stream flood limits:

- Flood Control District Unit G103-33-01
- Flood Control District Unit G103-33-02
- Flood Control District Unit G103-33-03
- Flood Control District Unit G103-38-02
- Flood Control District Unit G103-36-01
- Flood Control District Unit G103-36-02
- Flood Control District Unit G103-36-02.1

No improvements are needed for these streams and stream segments.(see figure below)

## Improvement analysis

Improvements to the open channel network were developed to provide structural flood protection from the 1 percent annual chance (100-year) storm event within the Study Area. As directed by the Flood Control District, the improvement analysis was performed assuming improvements to the open channel network within the Study Area and a portion of Northpark Drive within Montgomery County.



For those streams or stream segments (reaches) that were found to be deficient in LOS, improvements were recommended. Improvements considered include:

- Improved drainage channels including widening, deepening, and/or lining for increased conveyance capacity
- Improved conveyance capacity of existing roadway crossings through lengthening or raising existing bridge structures or additional culverts
- Watershed diversions using enclosed conduits (following existing roadway alignments or other public ROW) or along existing streams
- Property buy-outs—for streams or stream segments for which the West Fork of the San Jacinto River controls the local floodplain.

The Kingwood Plan includes a review of each stream's recommendations for improvements to LOS.

### *Structure inventory analysis*

A structure inventory analysis was performed to identify structures located within the 1 percent annual chance event (100-year) flood limits. A structure inventory file, supplied by the Flood Control District, was used and an average structure ground elevation was estimated from 2018 LiDAR data. For every instance where the average ground elevation of a structure fell below the computed water surface elevation of the 1 percent annual chance (100-year) storm event, that structure was considered "flooded" and tallied into a count of "structures at risk."

A structural benefit analysis was performed as a result of any expected lowering of water surface elevations from recommended improvements in the Kingwood Plan. "Structures at risk" identified as flooding from a 1 percent annual chance (100-year) event were deemed to "benefit" if a drop in the water surface elevations from recommended improvements reduced the floodplain such that the "structures at risk" would no longer be at risk to flood for the new 100-year floodplain elevation. These structures are noted on accompanying maps and stream summary sheets as "removed," meaning their footprints are no longer within the 1 percent annual chance event (100-year) flood limits.

As channel modifications were identified not based on the stormwater carrying capacity but in order for local drainage improvements to be made, indirectly benefitted structures were also identified. The indirectly benefitted

structures are those historically flooded structures—from Hurricanes Ike or Harvey, Tropical Storm Imelda, or the Memorial Day or Tax Day floods—that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.

### *Detention estimate*

A discharge mitigation analysis was performed to determine additional stormwater detention requirements due to increased runoff to Lake Houston or the San Jacinto River associated with the proposed channel conveyance improvements and assumed local drainage improvements. Due to the scale of improvements analyzed throughout the Study Area, detention would need to be provided regionally in large stormwater detention basins. Peak flow impacts and mitigation volume needs were measured at outfall locations within the Study Area to conform to Harris County's policy requirement (also adopted by the Flood Control District) that detention be included for any projects that outfall into Lake Houston.

The additional detention volume was calculated by comparing the difference between the existing and proposed outflow at identified outfall locations. A 20 percent contingency was added to the resulting calculated volume. Increased downstream flood volume created by proposed stream improvements must be accommodated with detention for a "no net increase" to downstream flows or outfall discharges. These detention requirements by stream are included in the Kingwood Plan Summary Table. However, this Kingwood Plan does not include identification of stormwater detention basin sites, but, rather, included only estimates of the detention volume required to achieve a "no net increase." Therefore, the cost of ROW to implement needed detention would increase the overall detention costs presented in the Kingwood Plan.

### *Cost of improvements*

Preliminary cost estimates were developed for all improvement options and stormwater detention requirements. The construction costs were allocated among the channel reaches. The results of the proposed improvements and preliminary cost estimates are included in the Kingwood Plan Summary Tables.



## Construction phasing

New stormwater detention capacity must be installed in advance of any channel conveyance improvements, to prevent downstream impacts. A detention mitigation plan will have to be developed and implemented for Flood Control District Unit G103-33-00 (Bens Branch), Flood Control District Unit G103-38-00 (Kingwood Diversion Ditch), and Flood Control District Unit G103-80-03.1B (Taylor Gully) prior to construction of channel improvements. The detention mitigation plan will also need to account for the recommended improvements to the tributaries of Flood Control District Unit G103-33-00 (Bens Branch) and Flood Control District Unit G103-38-00 (Kingwood Diversion Ditch).

It is recommended that the improvement options be constructed and implemented in a phased approach from downstream to upstream. This will help to ensure that the receiving systems have the necessary capacity without some form of flow restriction which limits the benefit of the constructed improvements and does not result in downstream impacts during construction. Additionally, the improvement options for the tributaries to Flood Control District Unit G103-33-00 (Bens Branch) and Flood Control District Unit G103-38-00 (Kingwood Diversion Ditch) cannot be constructed until the improvement options for Flood Control District Unit G103-33-00 (Bens Branch) and Flood Control District Unit G103-38-00 (Kingwood Diversion Ditch) have been constructed. Likewise, local drainage improvements cannot be constructed until after the detention mitigation plan and improvement options have been implemented for the receiving channel. Construction predecessors are noted in the individual summary sheets.



*Pedestrian Bridge Over Taylor Gully*

# The Recommended Improvements Plan (Kingwood Plan)

## Streams and stream reaches identified for improvements

To reach the goal of providing 1 percent annual chance event (100-year) LOS protection to structures within the Study Area, the following improvement options are proposed.

- Six streams or stream segments whose rights-of-way are controlled by the Flood Control District are proposed for improvements.

<b>Bens Branch</b>	G103-33-00
<b>Kings Crossing Ditch</b>	G103-33-04
<b>Kingwood Diversion Ditch</b>	G103-38-00
<b>no common name</b>	G103-38-01
<b>no common name</b>	G103-38-01.1
<b>Taylor Gully</b>	G103-80-03.1

- Three streams or stream segments whose rights-of-way are controlled by entities other than the Flood Control District are recommended for improvements.

<b>Bear Branch</b>	G103-36-00
<b>no common name</b>	G103-36-03
<b>no common name</b>	G103-46-01

A summary sheet and maps of existing and improved conditions follow for each stream or stream segment for which improvement options are recommended. A summary of recommendations for all streams studied are presented in the Kingwood Plan Summary Tables.

Based on the results of the Kingwood Study, it is advised that the recommended projects along Flood Control District Unit G103-38-00 (Kingwood Diversion Ditch) and Flood Control District Unit G103-80-03.1B (Taylor Gully) move to engineering design so that a Preliminary Engineering Report (30 percent plan design) can be completed subject to input from Kingwood area residents. Additionally, it is recommended that the proposed Flood Control District Unit G103-80-03.1B (Taylor Gully) project be reanalyzed to determine how the use of Woodridge Village for detention could modify the recommended plan.

Stream	Reach	EXISTING CHANNEL DESCRIPTION					RECOMMENDED IMPROVEMENT							
		Channel Type	Maint. Berm	ROW (ft)	Owner	Level of Service	Improvement Description	ROW Required (ft)	Add. ROW Required (ac)	Construction Cost Estimate (Including ROW) (\$)	Total Benefited Structures	Detention Estimate Channel Improvement		
HARRIS COUNTY FLOOD CONTROL MAINTAINED STREAMS														
G103-33-00 (Ben's Branch)	R1	Improved	No	100-120	HCFCF Public	<2-Yr	Flow Diversion, Culvert Replacement			\$179,124	8	504.9		\$14,698,913
	R2	Natural	No	100	Other	2-Yr	Channel modifications, bridge replacement, low water crossing removal	180	19.2	\$8,650,665	2			
	R3	Improved	No	160-260	HCFCF	<2-Yr	Channel modifications, bridge replacement	200-260	2.4	\$6,354,556	29			
	R4	Improved	No	--	COH Private	2-Yr	Channel modifications	270-300	20.8	\$9,044,541	18			
G103-33-01	R1	Improved	Yes	140-150	HCFCF	100-Yr				NO IMPROVEMENT				
G103-33-02	R1	Improved	Yes	100-150	HCFCF	100-Yr				NO IMPROVEMENT				
G103-33-03	R1	Improved	Yes	80	HCFCF	100-Yr				NO IMPROVEMENT				
G103-33-04	R1	Improved	No	110-130	HCFCF	<2-Yr	Channel modifications, culvert replacement	110-140	0.5	\$2,168,237	18			
G103-38-00 (Ben's Branch Diversion)	R1	Improved	Yes	195-300	HCFCF	100-Yr	Channel Control Structure, Flow Diversion, Channel modifications, bridge replacement	210-340	12.8	\$25,428,114	282	834.3	414.2	\$33,928,339
	R1-R4	G103-33-00 (Ben's Branch)					NO IMPROVEMENTS CONSTRUCTED					356		
	R2	Improved	No	140-300	COH	<2-Yr				NO IMPROVEMENT				
G103-38-01	R1	Improved	Yes	50	Public	100-Yr				NO IMPROVEMENT				
	R2	Concrete	Yes	90	HCFCF Other	100-Yr	Revise existing concrete channel section			\$2,156,872	130			
G103-38-01.1	R1	Improved	Yes	80	HCFCF Public	25-Yr	Channel modifications			\$578,010	26			
G103-38-02	R1	Improved/Concrete	No	130-160	HCFCF	100-Yr				NO IMPROVEMENT				
G103-41-00	R1	Improved	Yes	130	HCFCF Public	100-Yr				NO IMPROVEMENT				
	R2	Improved	Yes	130	Private	>100-Yr				NO IMPROVEMENT				
G103-41-01	R1	Improved	Yes	110-130	HCFCF Public	50-Yr				NO IMPROVEMENT				
G103-45-00	R1	Improved	No	60-85	HCFCF	<2-Yr	TARGETED BUYOUT AREA							
G103-80-01	R1	Natural	Yes	130-145	HCFCF Public	100-Yr				NO IMPROVEMENT				
G103-80-03.1B (Taylor Gully)	R1	Improved	Yes	140	HCFCF	10-Yr	Channel Improvements			\$2,599,678	132			
	R2	Improved	Yes	140-150	HCFCF	10-Yr	Channel Improvements			\$14,938,054	317	115.6		\$3,121,535
	R3	Natural Channel	No	150	HCFCF	100-Yr	Channel Improvement, New Outlet			\$480,164	0			



Stream	Reach	EXISTING CHANNEL DESCRIPTION					Improvement Description	ROW Required (ft)	Add. ROW Required (ac)	RECOMMENDED IMPROVEMENT				
		Channel Type	Maint. Berm	ROW (ft)	Owner	Level of Service				Construction Cost Estimate (Including ROW) (\$)	Total Benefited Structures	Detention Estimate Channel Improvement		
												Channel (ac-ft)	Local (ac-ft)	Constr. Cost (W/O ROW) (ac-ft)
STREAMS MAINTAINED BY OTHERS														
G103-36-00	R1	Natural	No	90-180	Public	<2-Yr	Channel improvements			\$1,748,581	66	18.0	105.5	\$3,357,392
	R2	Improved	No	130-210	Other	100-Yr				NO IMPROVEMENT				
	R3	Improved	No	135	Other	100-Yr				NO IMPROVEMENT				
	R4	Improved	No	135	Other	100-Yr				NO IMPROVEMENT				
G103-36-01	R1	Natural	No	20-70	Other	100-Yr				NO IMPROVEMENT				
	R2	Natural	No	--	Other	100-Yr				NO IMPROVEMENT				
G103-36-02	R1	Improved/Natural	No	50	Other	100-Yr				NO IMPROVEMENT				
G103-36-02.1	R1	Improved	No	100	Public	100-Yr				NO IMPROVEMENT				
G103-36-03	R1	Improved	No	100	Public	<2-Yr	Upsize Culverts			\$659,687				
G103-39-00	R1	Natural	No	100	Other	100-Yr				NO IMPROVEMENT				
	R2	Natural	No	--	--	<2-Yr	Targeted Buyout Area							
	R3	Natural	No	--	--	<2-Yr	Targeted Buyout Area							
G103-46-00	R1	Improved	No	35-85	HCFCDOther	<2-Yr	Targeted Buyout Area							
G103-46-01	R1	Improved	No	--	--	<2-Yr	Upsize Culverts			\$889,020	52			
	R2	Concrete	--	50	PublicOther	<2-Yr	Upsize Culverts			\$1,420,155	3		19.3	\$523,641
G103-80-03.1A (Mills Branch)	R1	Natural	No	--	--	100-Yr				NO IMPROVEMENT				
G103-80-04	R1	Improved	Yes	150	Public	100-Yr				NO IMPROVEMENT				
	R2	Natural	No	150-260	Public	100-Yr				NO IMPROVEMENT				

## Bens Branch

HCFCFCD designation: G103-33-00








### Proposed Project Reaches:

1. Confluence with Kingwood Diversion Ditch to Woodland Hills Drive
2. Woodland Hills Drive to Tree Lane
3. Tree Lane to West Lake Houston Parkway
4. West Lake Houston Parkway to West Fork of San Jacinto River

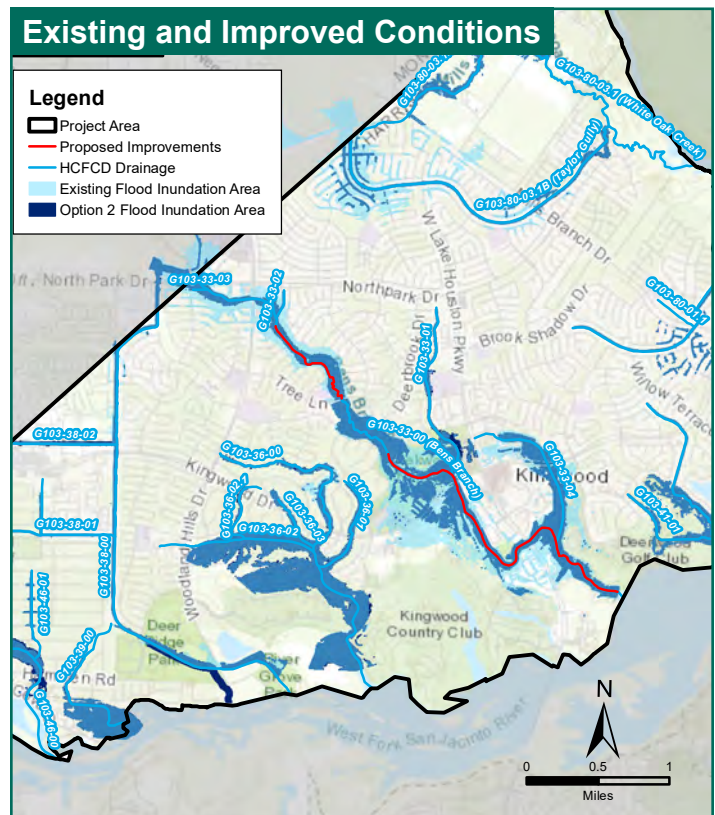
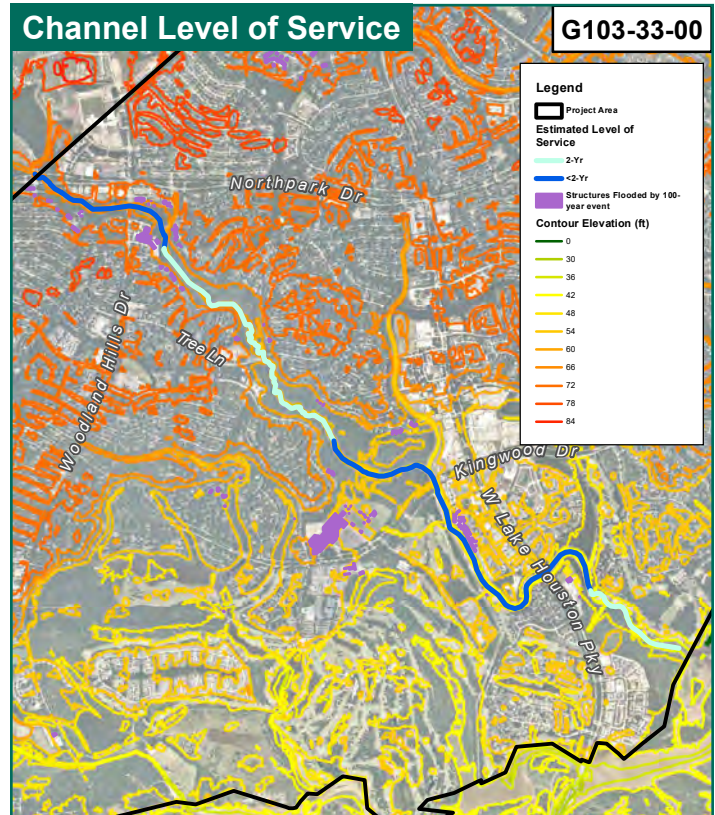
### Recommended Improvement:

Bens Branch Option 2

- Reach 1: Flow Diversion, culvert replacement
- Reach 2: Channel modifications, bridge replacement, low water crossing removal
- Reach 3: Channel modifications, bridge replacement
- Reach 4: Channel modifications

	<b>Construction Predecessor:</b>	Kingwood Diversion Ditch
	<b>Cost:</b>	Construction: \$24.2 M Detention: \$14.7 M
	<b>Additional ROW required:</b>	\$11.8 M
	<b>Jurisdiction:</b>	HCFCFCD/Private Entity
	<b>Inundation area removed from structures:</b>	39
	<b>Structures indirectly benefited:</b>	18*
	<b>Environmental Concerns:</b>	USACE permitting required if jurisdictional

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.





# Kingwood Diversion Ditch

HCFCDD designation: G103-38-00








## Proposed Project Reaches:

1. Confluence with Bens Branch to Deer Ridge Estates Blvd.
2. Deer Ridge Estates Blvd. to West Fork of San Jacinto River

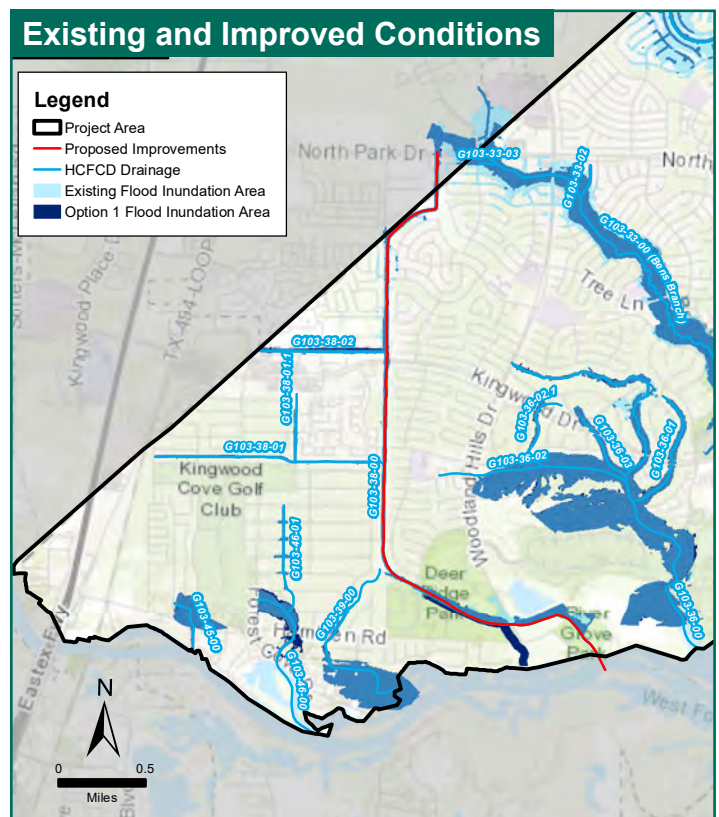
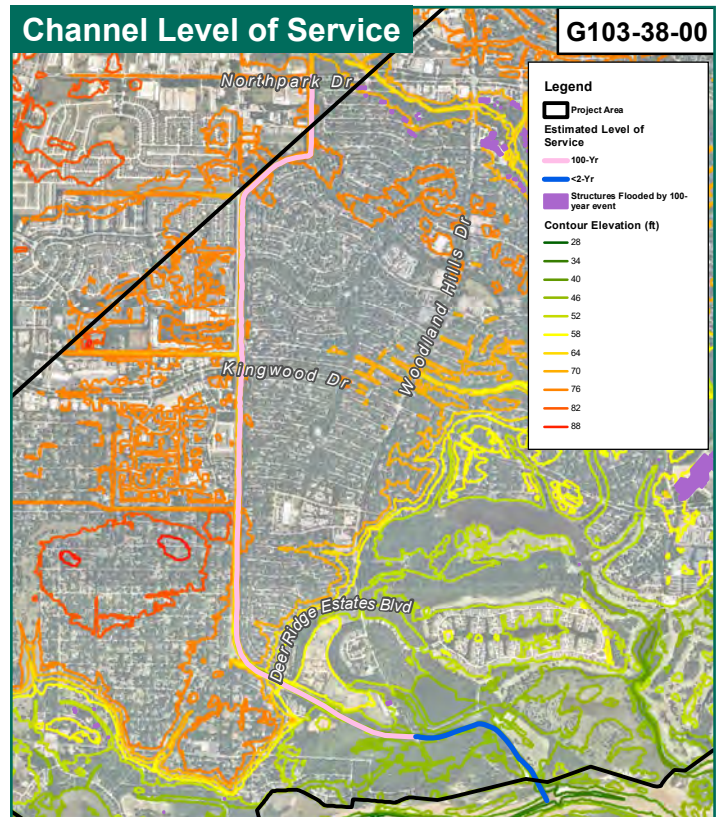
## Recommended Improvement:

Option 1

- Reach 1: Channel control structure, flow diversion, channel modifications, bridge replacement

	<b>Construction Predecessor:</b>	None
	<b>Cost:</b>	Construction: \$25.4 M Detention: \$33.9 M
	<b>Additional ROW required:</b>	\$3.6 M
	<b>ROW control:</b>	HCFCDD
	<b>Inundation area removed from structures:</b>	62
	<b>Structures indirectly benefited:</b>	586*
	<b>Environmental Concerns:</b>	USACE permitting required if jurisdictional

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## Kings Crossing Ditch








HCFCDD designation: G103-33-04

### Proposed Project Reaches:

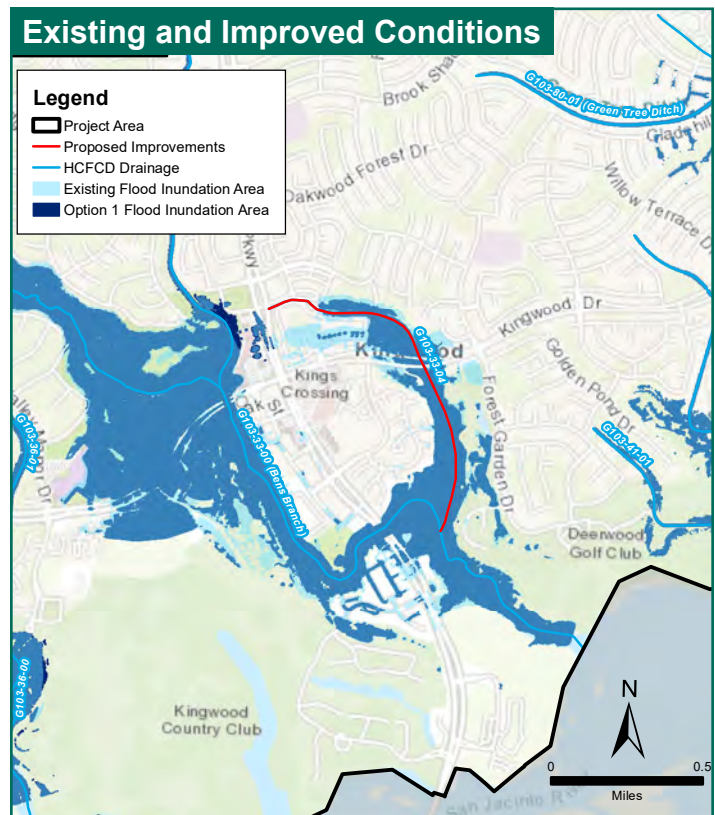
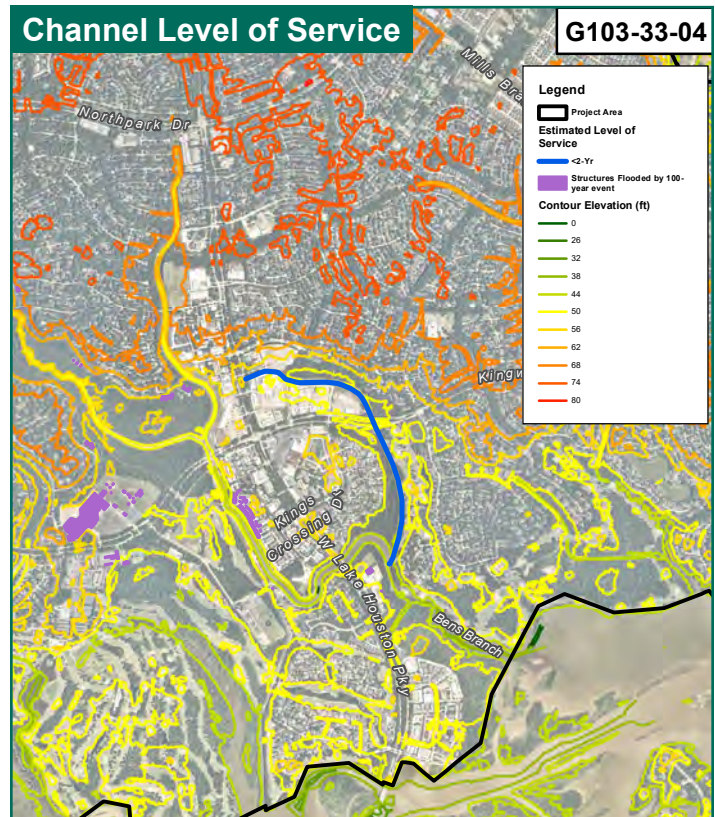
1. Upper limits to confluence with Bens Branch

### Recommended Improvement:

- Reach 1: Channel modifications, culvert replacement

	<b>Construction Predecessor:</b>	Bens Branch R4
	<b>Cost:</b>	Construction: \$2.2 M
	<b>Additional ROW required:</b>	Limited, no cost assigned
	<b>ROW control:</b>	HCFCDD
	<b>Inundation area removed from structures:</b>	0
	<b>Structures indirectly benefited:</b>	18*
	<b>Environmental Concerns:</b>	USACE permitting required if jurisdictional

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.





## No Common Name (G103-38-01)








HCFCDD designation: G103-38-01

### Proposed Project Reaches:

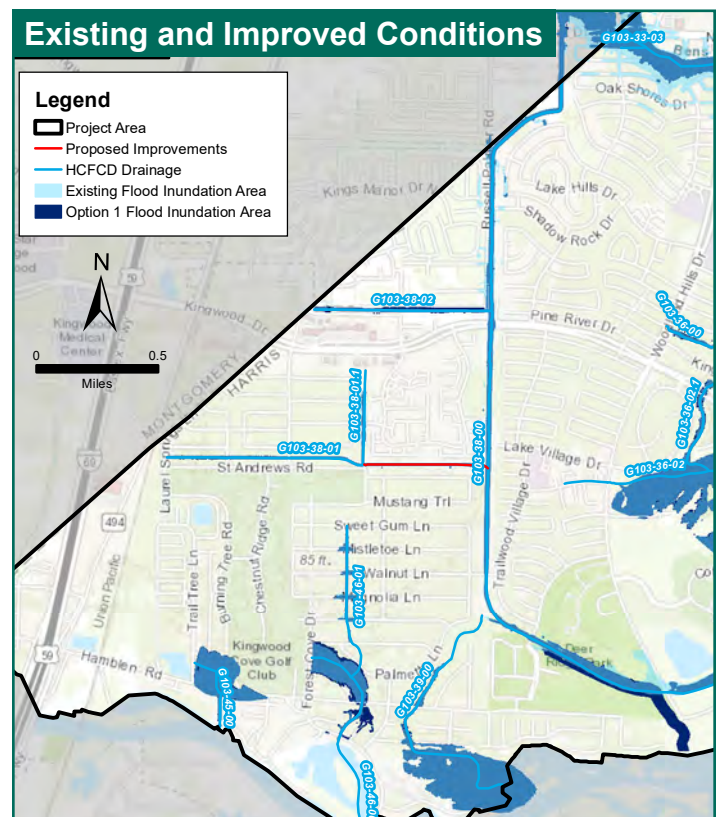
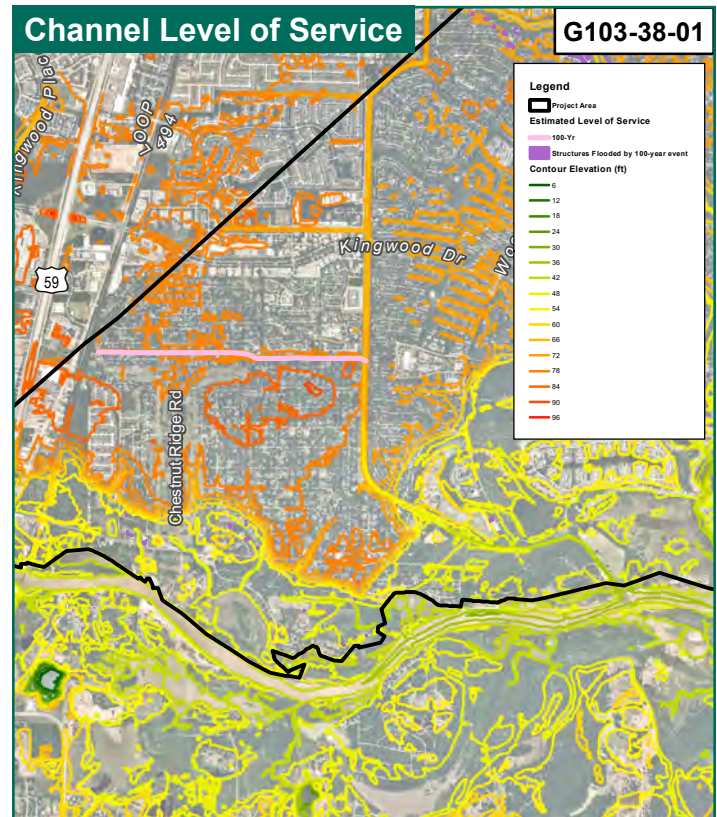
1. Upper limits to Chestnut Ridge Rd.
2. Chestnut Ridge Rd to confluence with Kingwood Diversion Ditch

### Recommended Improvement:

- Reach 2: Revise existing concrete channel section

	<b>Construction Predecessor:</b>	Kingwood Diversion Ditch Reach 1
	<b>Cost:</b>	Construction: \$2.2 M
	<b>Additional ROW required:</b>	None
	<b>ROW control:</b>	HCFCDD
	<b>Inundation area removed from structures:</b>	0
	<b>Structures indirectly benefited:</b>	130*
	<b>Environmental Concerns:</b>	None

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.



## No Common Name (G103-38-01.1)

HCFCFD designation: G103-38-01.1

### Proposed Project Reaches:

1. Upper limits to confluence with HCFCFD Unit G103-38-01

### Recommended Improvement:

- Reach 1: Channel modifications



**Construction  
Predecessor:**

G103-38-01 Reach 2



**Cost:**

Construction: \$0.6 M



**Additional ROW  
required:**

None



**ROW control:**

HCFCFD



**Inundation area  
removed from  
structures:**

0



**Structures  
indirectly  
benefited:**

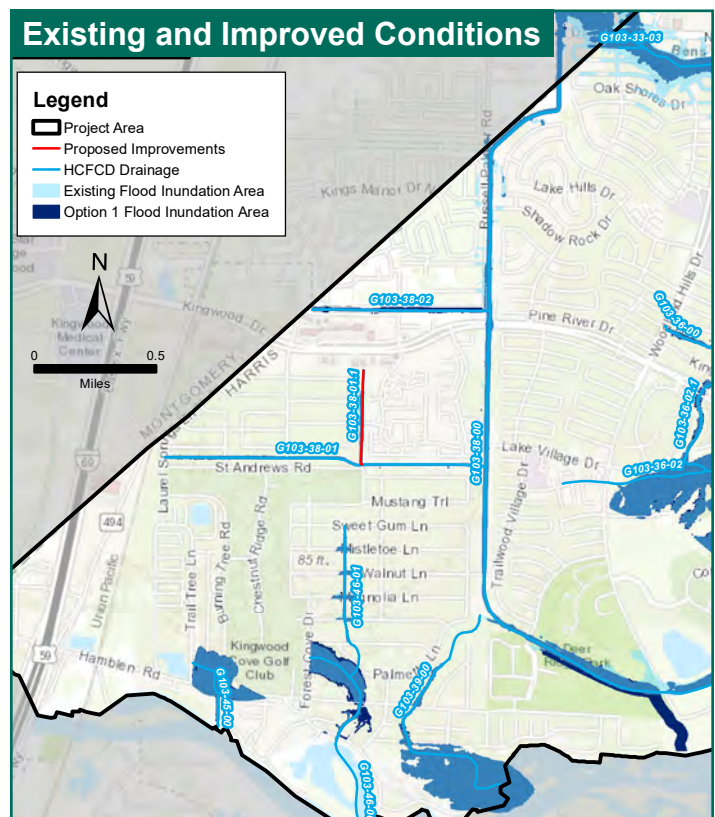
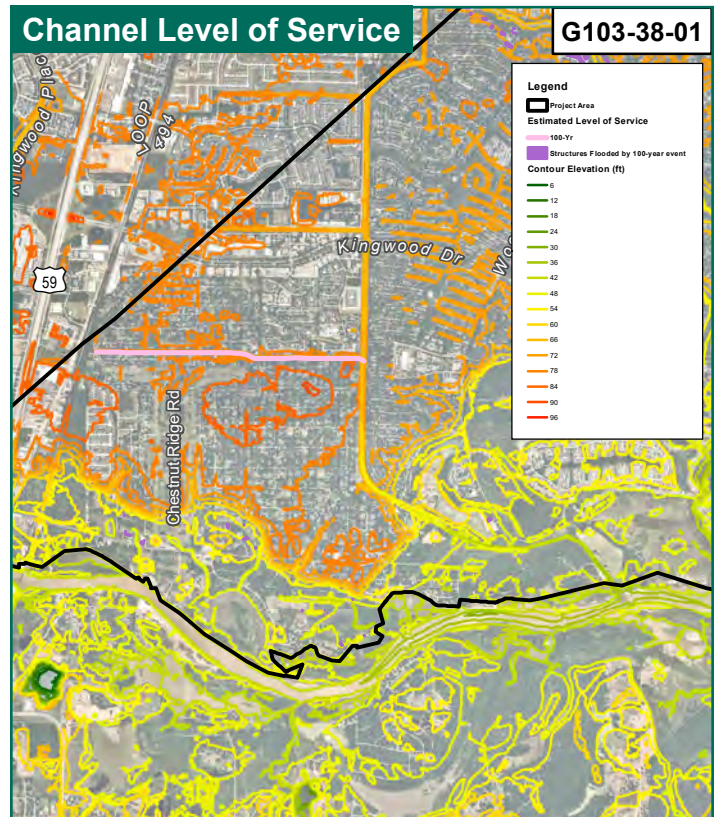
26\*



**Environmental  
Concerns:**

None

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.





## Taylor Gully








HCFCFCD designation: 103-80-03.1B

### Proposed Project Reaches:

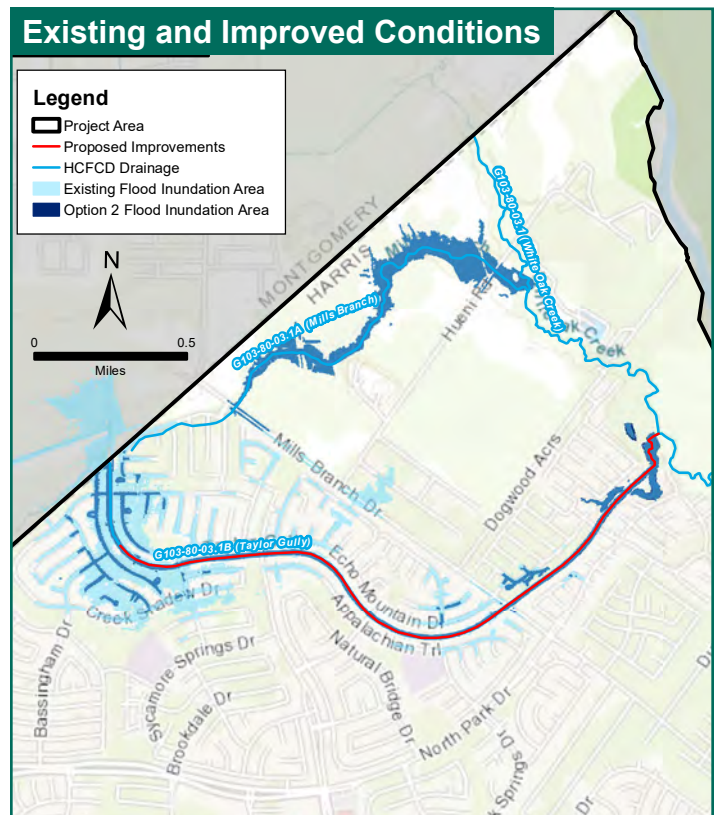
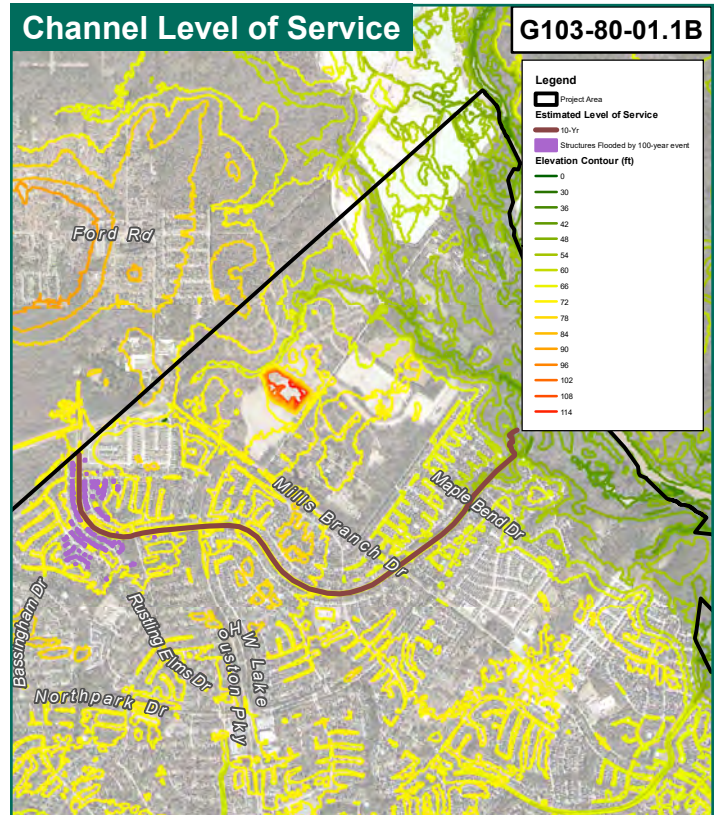
1. Bassingham to Rustling Elms
2. Rustling Elms to Maple Bend
3. Maple Bend to confluence with White Oak Creek

### Recommended Improvement:

- Reach 1: Channel improvements
- Reach 2: Channel improvements
- Reach 3: Channel improvements, new outlet

	<b>Construction Predecessor:</b>	Each downstream reach improvement should precede the upstream improvements
	<b>Cost:</b>	Construction: \$18.0 M Detention: \$3.1 M
	<b>Additional ROW required:</b>	None
	<b>ROW control:</b>	HCFCFCD
	<b>Inundation area removed from structures:</b>	387
	<b>Structures indirectly benefited:</b>	62*
	<b>Environmental Concerns:</b>	USACE permitting required if jurisdictional

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## Bear Branch








HCFCDD designation: G103-36-00

### Proposed Project Reaches:

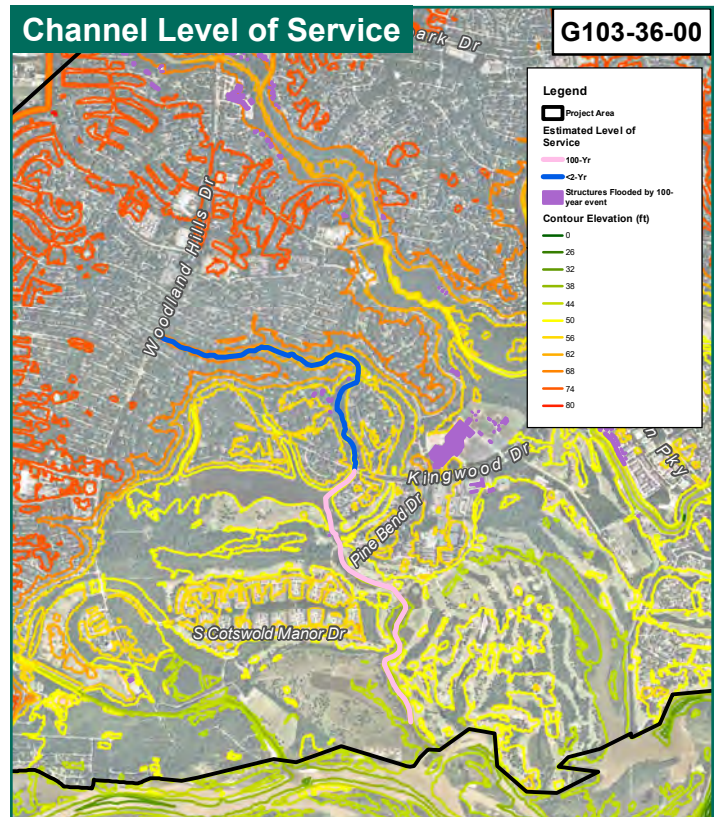
1. Woodland Hills Drive to Kingwood Drive
2. Kingwood Drive to Pine Bend Drive
3. Pine Bend Drive to Cotswold Manor Drive S
4. Cotswold Manor Drive S to West Fork of San Jacinto River

### Recommended Improvement:

- Reach 1: Channel improvements

	<b>Construction Predecessor:</b>	None
	<b>Cost:</b>	Construction: \$1.75 M Detention: \$3.4 M
	<b>Additional ROW required:</b>	None
	<b>ROW control:</b>	Public, not HCFCDD
	<b>Inundation area removed from structures:</b>	6
	<b>Structures indirectly benefited:</b>	60*
	<b>Environmental Concerns:</b>	USACE permitting required if jurisdictional

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.





## No Common Name (G103-36-03)








HCFCDD designation: G103-36-03

### Proposed Project Reaches:

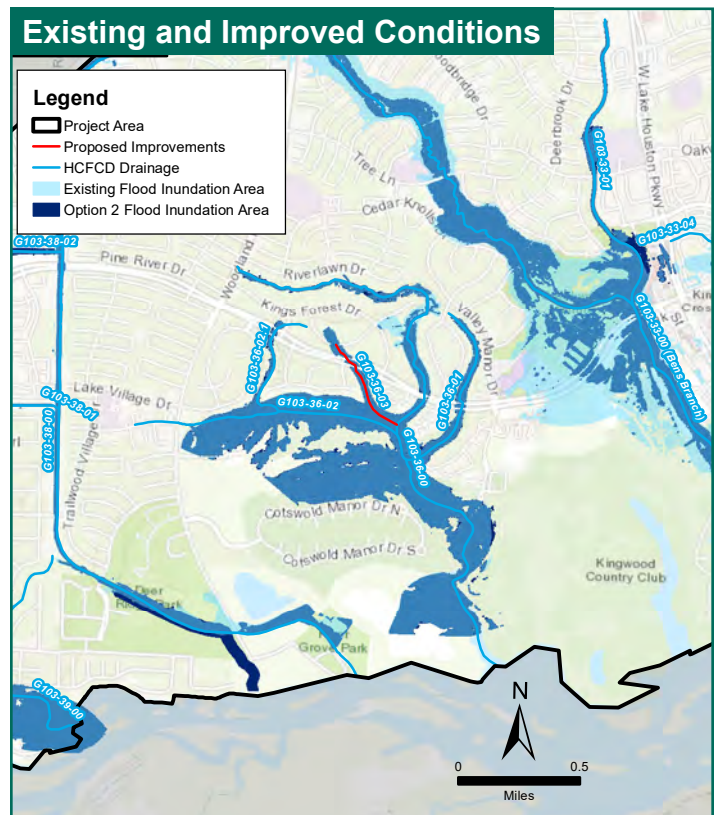
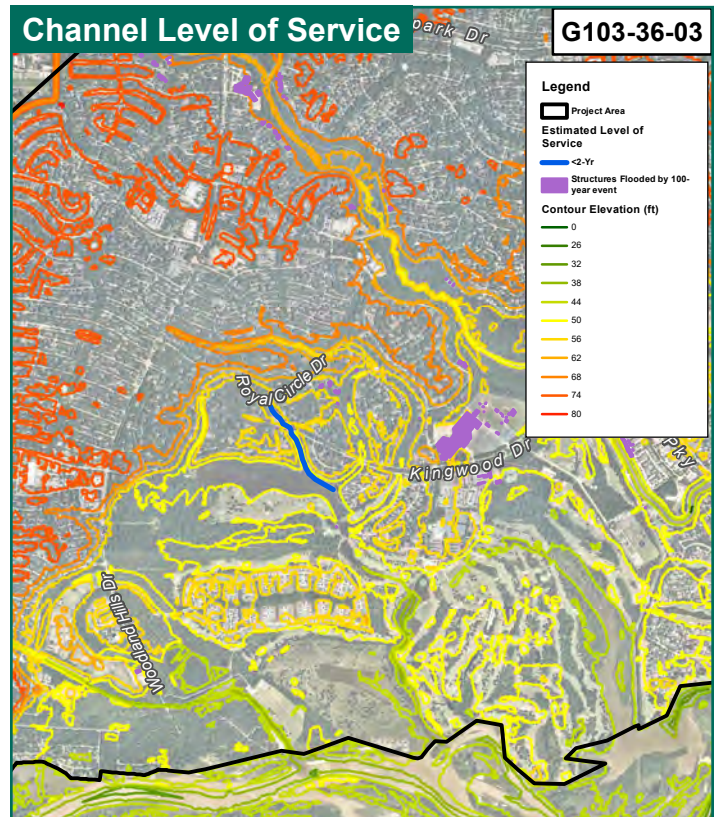
1. Royal Circle Drive to confluence with HCFCDD Unit G103-36-02

### Recommended Improvement:

- Reach 1: Upsize culverts for roadway crossing improvements

	<b>Construction Predecessor:</b>	None
	<b>Cost:</b>	Construction: \$0.7 M
	<b>Additional ROW required:</b>	None
	<b>ROW control:</b>	Public, not HCFCDD
	<b>Inundation area removed from structures:</b>	0
	<b>Structures indirectly benefited:</b>	0*
	<b>Environmental Concerns:</b>	None

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.



## No Common Name (G103-46-01)








HCFCDD designation: G103-46-01

### Proposed Project Reaches:

1. Sweet Gum Lane to Cypress Lane
2. Cypress Lane to confluence with HCFCDD Unit G103-46-00

### Recommended Improvement:

- Reach 1: Upsize culverts for roadway crossing improvements
- Reach 2: Upsize culverts for roadway crossing improvements

	<b>Construction Predecessor:</b>	None
	<b>Cost:</b>	Construction: \$2.3 M Detention: \$0.5 M
	<b>Additional ROW required:</b>	None
	<b>ROW control:</b>	No drainage ROW exists between Sweet Gum and Cypress Lane
	<b>Inundation area removed from structures:</b>	0
	<b>Structures indirectly benefited:</b>	0*
	<b>Environmental Concerns:</b>	None

\*Indirectly benefited structures are historically flooded structures that are located well outside the mapped open channel floodplain and may benefit from local drainage improvements.

