

# Friendswood Drainage Sub- Committee

Observations, Conclusions, and Recommendations to Friendswood City  
Council April 1, 2019

# One Recommendation to Solve Flooding in Friendswood



And....we are done! April Fools!

# Drainage Sub-Committee

• Chartered by Friendswood City Council June, 2018 - ad hoc team	• Formed and started meeting June 28, 2018
• Has met 35 times since then...over 500 of hours of work	• Team Members...

Person	Role	Person	Role
<b>Assigned Members</b>			
<b>James Stahl</b>	Community Representative	<b>Lee Coggins</b>	Community Representative
<b>Ron Lovely</b>	Community Representative	<b>Kenny Koncaba</b>	Community Representative
<b>Gary Harris</b>	Gal. County Cons. Drainage District	<b>Marcus Rives</b>	Gal. Co. Cons. Drainage District
<b>Ken Clark</b>	Galveston County Commissioner	<b>Carl Gustafson</b>	Friendswood City Council
<b>Morad Kabiri</b>	Friendswood City Manager	<b>Steve Rockey</b>	Friendswood City Council – Chair
<b>Myron Jones</b>	Harris County Flood Control District	<b>Lance Gillian</b>	Harris County – Rodney Ellis Office
<b>Ad Hoc Members</b>			
<b>Dawn McDonald</b>	State Rep. Dennis Paul’s Office	<b>Jed Webb</b>	US Congressman Randy Weber’s Office
<b>Jackie King</b>	State Senator Larry Taylor’s Office	<b>Fay Picard</b>	State Rep Dr. Greg Bonnen’s Office
<b>Melissa Washington</b>	Texas General Land Office	<b>Shakhar Misir</b>	US Army Corps of Engineers

# Presenting Tonight

- Team members James Stahl and Lee Coggins.....however the presentation was developed by the whole team.
- We have been following a process and have already presented our problem statement, a significant portion of the data, and analysis.
- Tonight we have some analysis to present. We will also be presenting our Observations/Conclusions and we will present recommendations.
- **AND....there are no formulas to learn tonight!!**

# Harvey Damage Data

- After Harvey, City Public Works staff visited all damaged buildings and homes and from the outside estimated the level of flooding.
- Did not enter houses, they just measured from the water marks on the outside of the house above the slab level.
- We believe this data to be accurate within a few inches in either direction.

## Flooded by Type

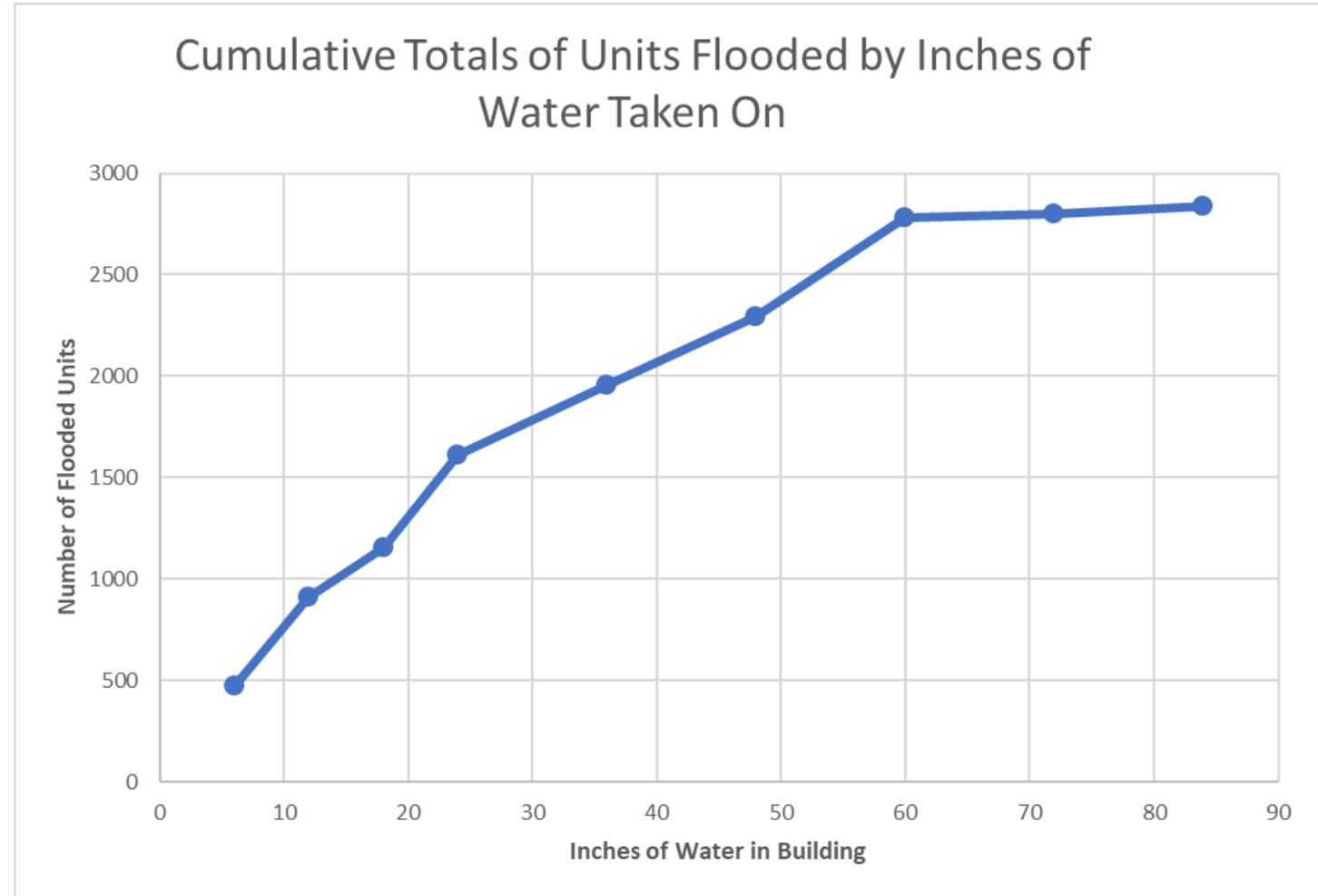
Damage Assessment	# Units Damaged	% of Units Damaged
Mobile Home	2	0%
Commercial	67	2%
Multi-Family	359	13%
Single Family Residential	2410	85%
<b>Grand Total</b>	<b>2838</b>	

## Flooded by Damage Assessment

Damage Assessment	# Units Damaged	% of Units Damaged
AFFECTED	472	17%
MINOR	941	33%
MAJOR	1075	38%
DESTROYED	350	12%
<b>Grand Total</b>	<b>2838</b>	

# Elevation of Flooding in Housing For Harvey

Unit Flooding Level	Galveston # of Units	Harris # of Units	TOTAL # of Units
Zero to 6 Inches	281	193	474
7 to 12 Inches	198	242	440
13 to 18 Inches	174	67	241
19 to 24 Inches	116	343	459
25 to 36 Inches	171	173	344
37 to 48 Inches	90	246	336
49 to 60 Inches	176	313	489
60 to 72 Inches	7	13	20
Above 72 Inches	33	2	35
<b>Grand Total</b>	<b>1246</b>	<b>1592</b>	<b>2838</b>



# Modeling the Creek by Rice University

- Recall that we hired Dr. Bedient and his team from Rice University to model Clear Creek in Friendswood.
- His team has reported back with their model and they measured the effects of various proposed projects.
- We intend to keep the relationship with Dr. Bedient's work and have future items modeled.

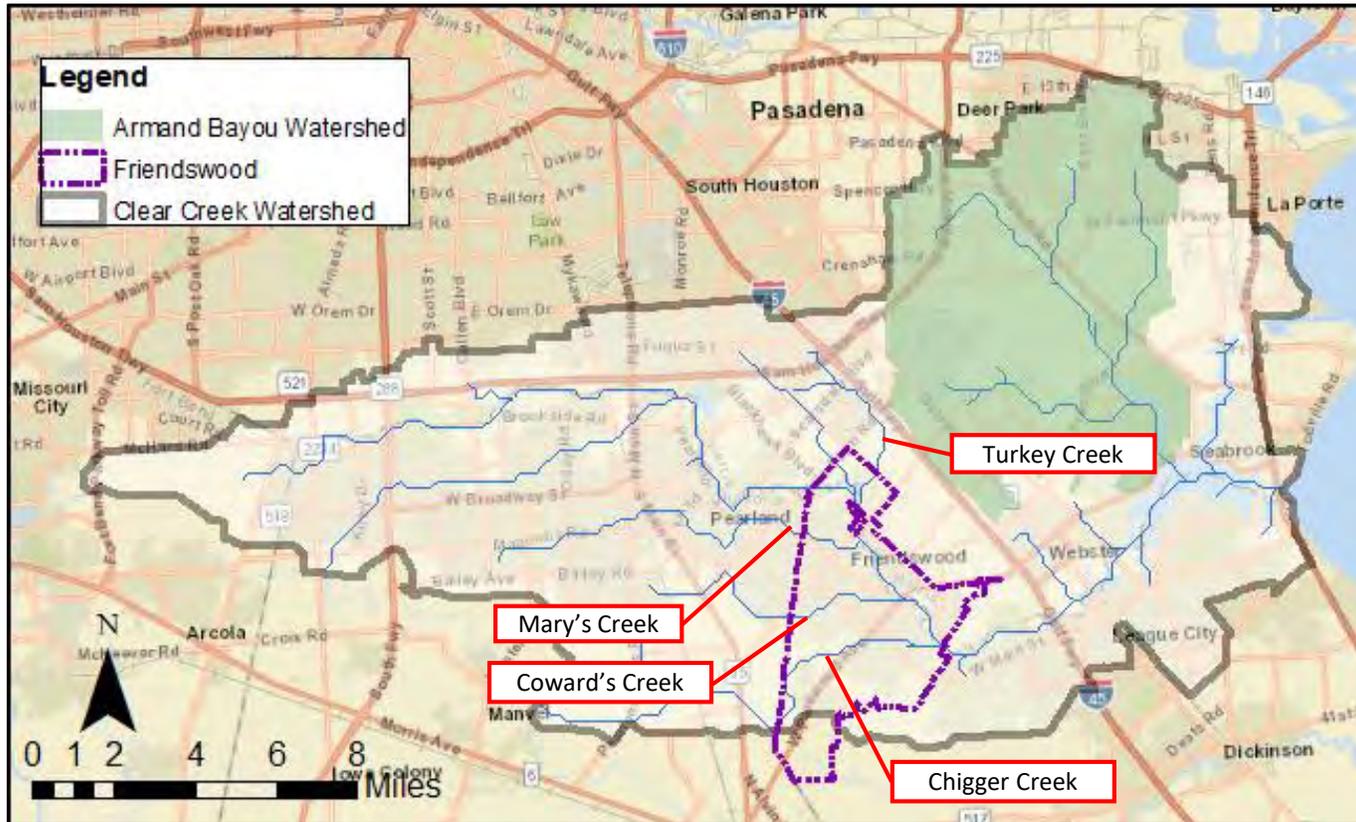
**Dr. Philip B. Bedient** is the Herman Brown Professor of Engineering in **Civil and Environmental Engineering** at **Rice University**. He teaches and performs research in surface water hydrology and



flood prediction systems, and radar based flood alert. He has directed 60 research projects over the past 35 years, has written over 180 articles in journals and conference proceedings. He has worked on hydrologic problems including major floodplain studies, water quality assessments, and hydrologic modeling for a number of watersheds in Texas, Florida, and Louisiana. He has been actively involved in the area of hydrologic analysis for flood prediction and warning, and has developed a real-time flood alert system for the Texas Medical Center, based on the use of NEXRAD radar data. Dr. Bedient directs the **SSPEED Center** at Rice for Severe Storm Prediction, consisting of several universities in the Gulf Coast area, which has funding to address the impacts of Hurricane Ike in the

Houston area. Both storm surge prediction, inland flooding, and long-term mitigation strategies are being studied with funding from the Houston Endowment. Dr. Bedient also is evaluating low impact development schemes with funding from the City of Houston.

# Dr. Bedient's Work - Background of Study Area



## Overall Study Area & Modeling Domain

- Clear Creek Watershed
- Armand Bayou Watershed

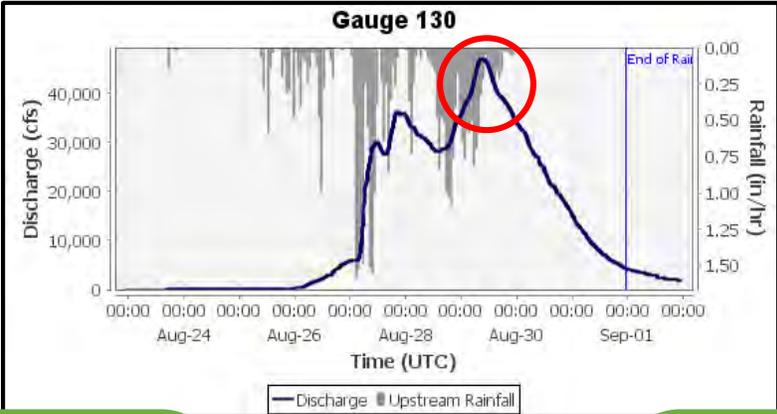
## Study Focus: City of Friendswood

- Primarily residential and commercial development
- Flood drivers:
  - Low slopes
  - High imperviousness
  - Proximity to coast

# What Was Evaluated

- Assess existing flood vulnerability with mathematical modeling.
- Validate the model against the observed flooding seen in Harvey.
- Explore a variety of mitigation scenarios:
  1. Bridge Raising
  2. De-snagging
  3. Channelization and Terracing
  4. Diversion at Outlet
  5. Proposed Detention Ponds
- Model multiple scenarios to determine best group

# Modeling Framework



Rainfall

Soils

Land Use

Vflo<sup>®</sup>  
HYDROLOGIC MODEL

Peak Flows

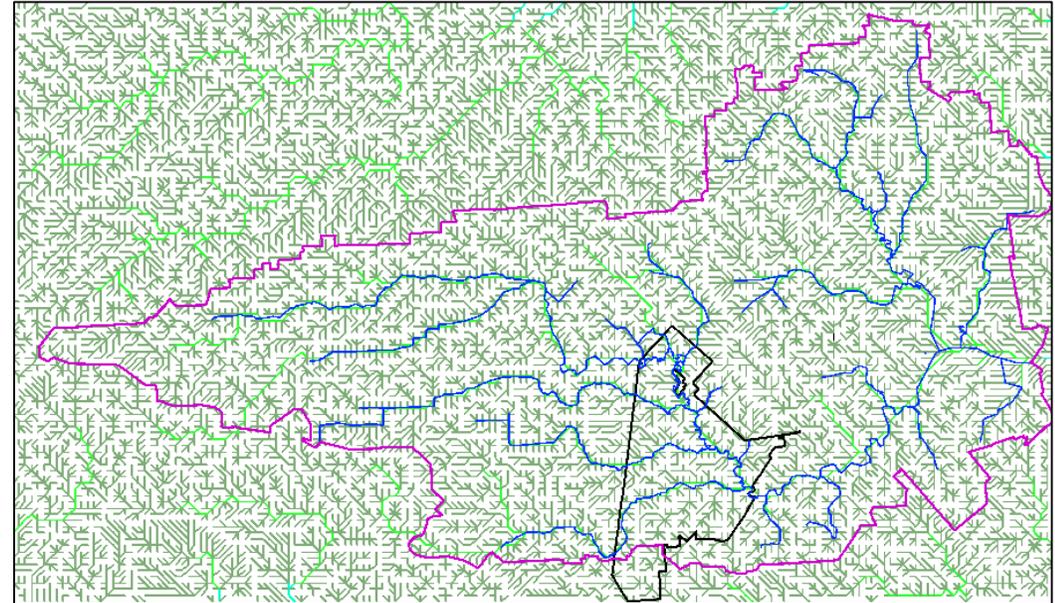
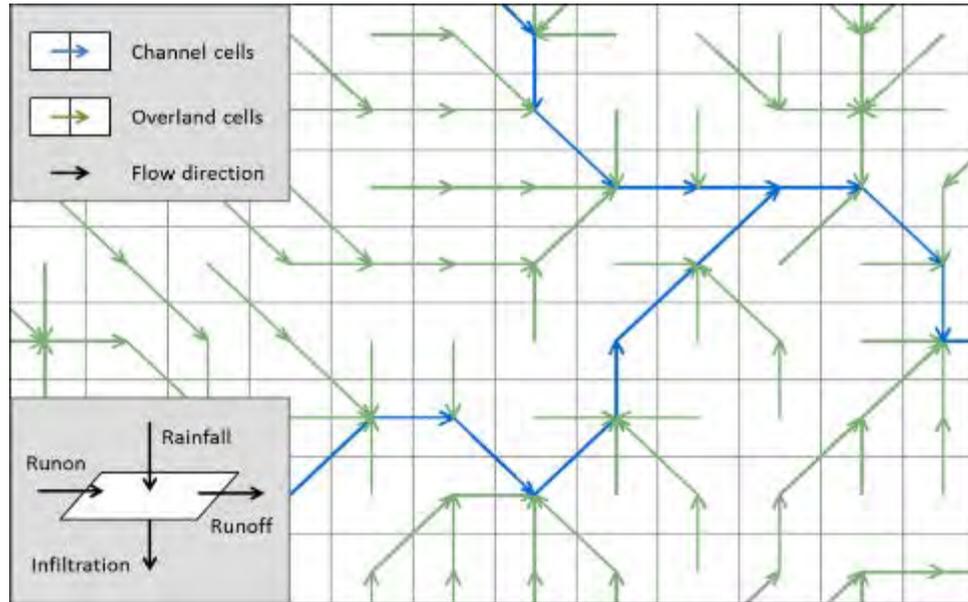
HEC-RAS  
1-D HYDRAULIC MODEL

Water Surface Elevations

Floodplain Maps

We do not intend to show all Dr. Bedient's data tonight however there is a 60 pages slide presentation that will be made public of his team's work and there will be a final report.

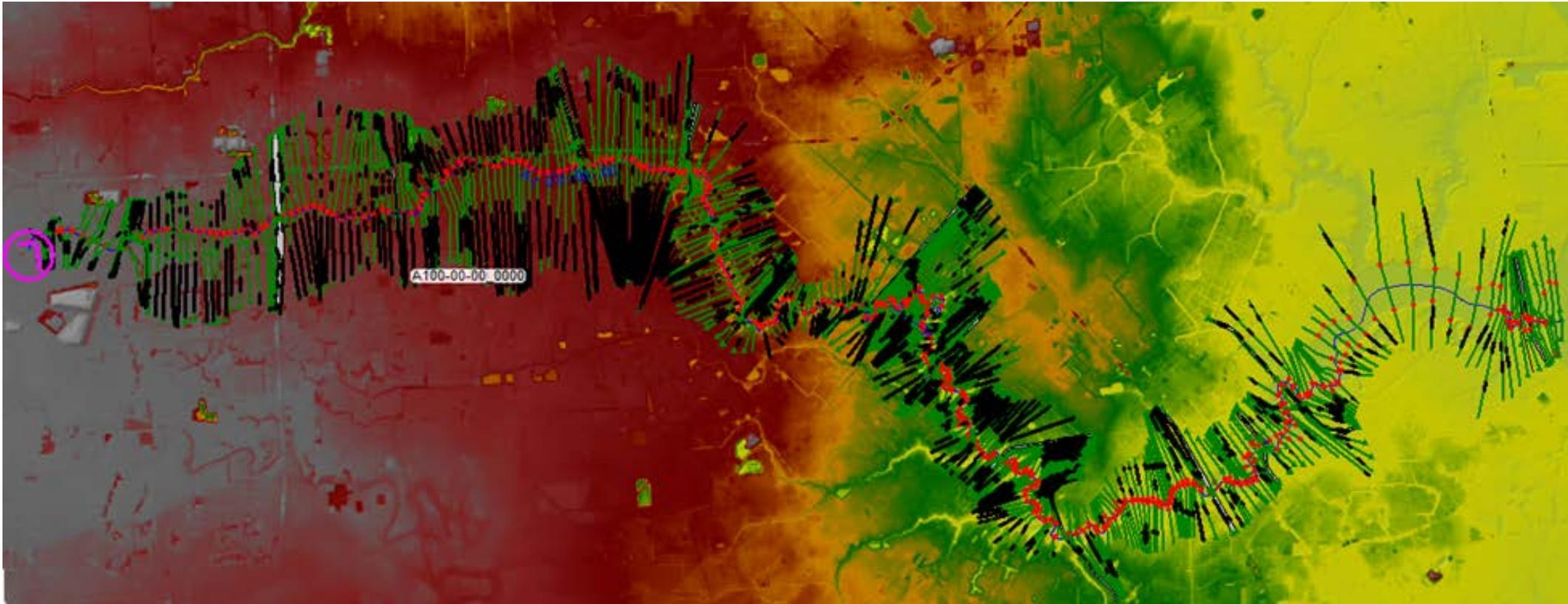
# Distributed Hydrologic Model - Vflo<sup>®</sup>



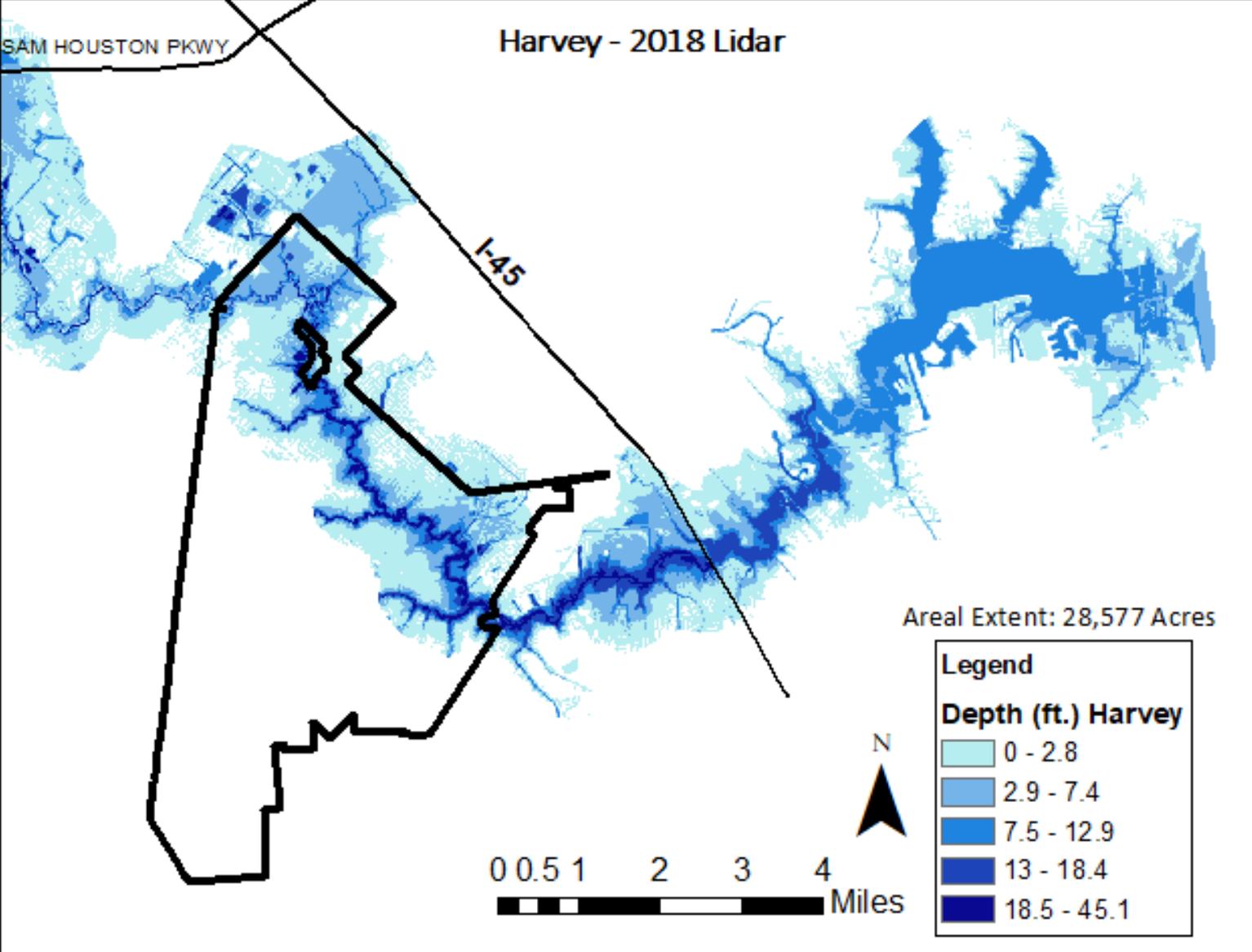
- Fully distributed physics-based hydrologic model developed by Vieux and Associates, Inc.
- Infiltration calculated by Green and Ampt Equation
- Uses Kinematic Wave to route runoff between overland grid cells and Modified Puls for channel cells
- Rainfall input can be rain gauge data or radar rainfall

# Hydraulic Model – HEC-RAS

- Developed by the Hydrologic Engineering Center (HEC) of the US Army Corps of Engineers
- Used in various floodplain studies and dam breach analyses
- 1D steady-state is used as the basis for FEMA floodplains
- Existing model was obtained from HCFCD M3 system

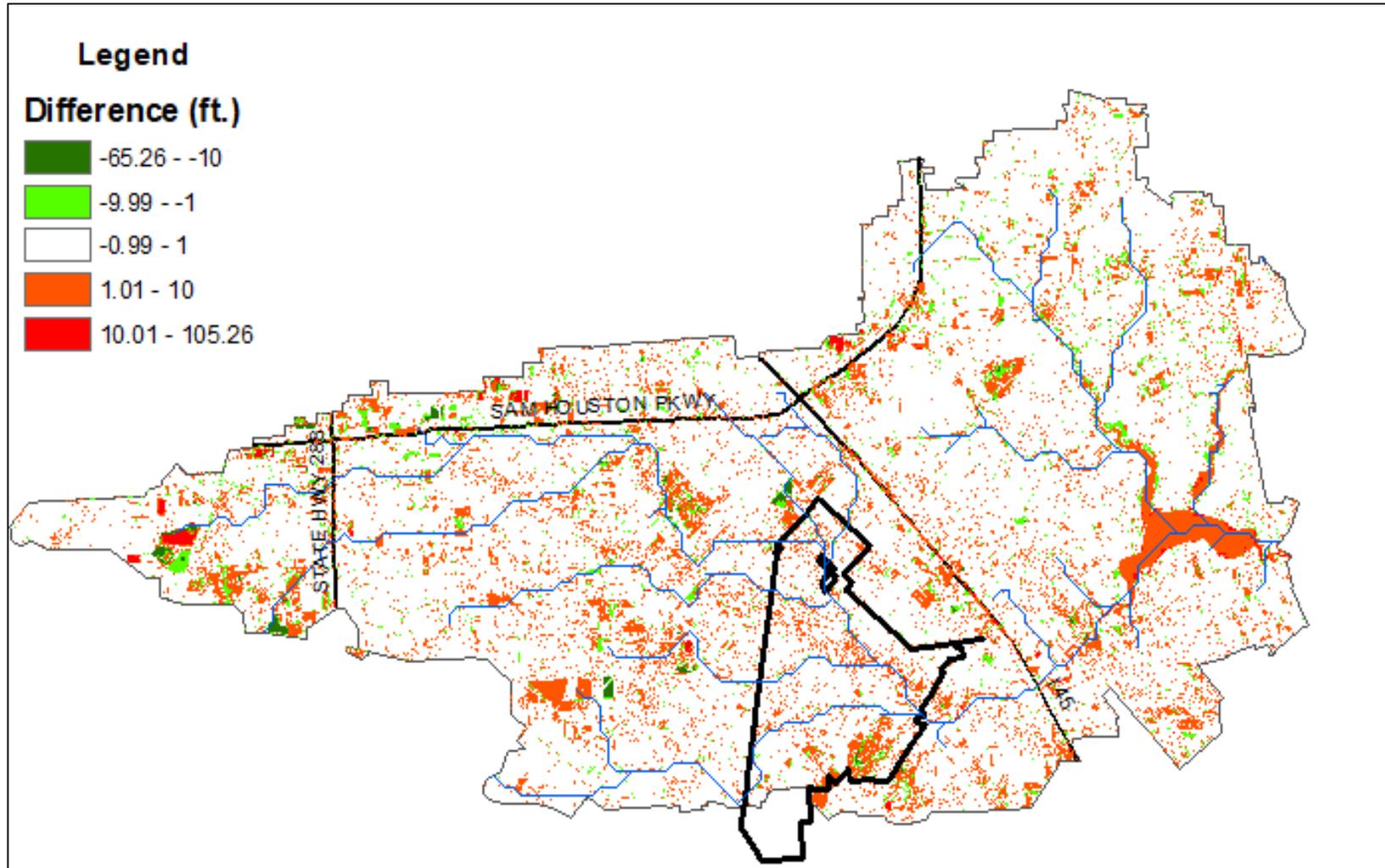


# Additionally for Each Test Scenario Flood Plain Maps Can Be Predicted



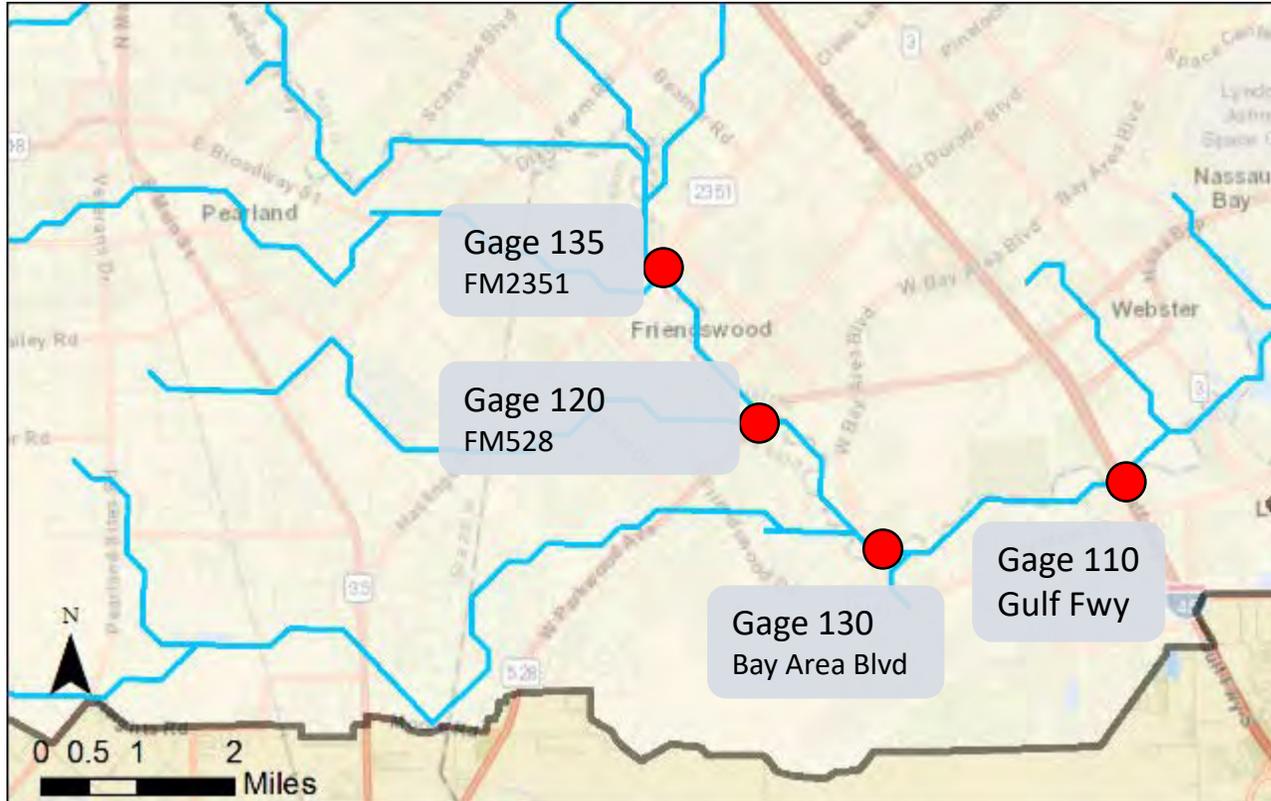
# Changes in Land Use in Clear Creek Watershed Last Decade

*This supports Team Observations and Recommendations Regarding Land Use, Permitting, and Watershed Changes*



1. Changes in land use from 2008 to 2018 using LIDAR (Light Detection and Ranging).
2. Green shows decreases in surface elevation mostly from addition of detention ponds.
3. Orange and Red shows increases in land elevations due to land development.
4. White areas remain unchanged although some likely were changed earlier than 2008,

# Model Validation – Peak Water Surface Elevation (WSEL) for Harvey

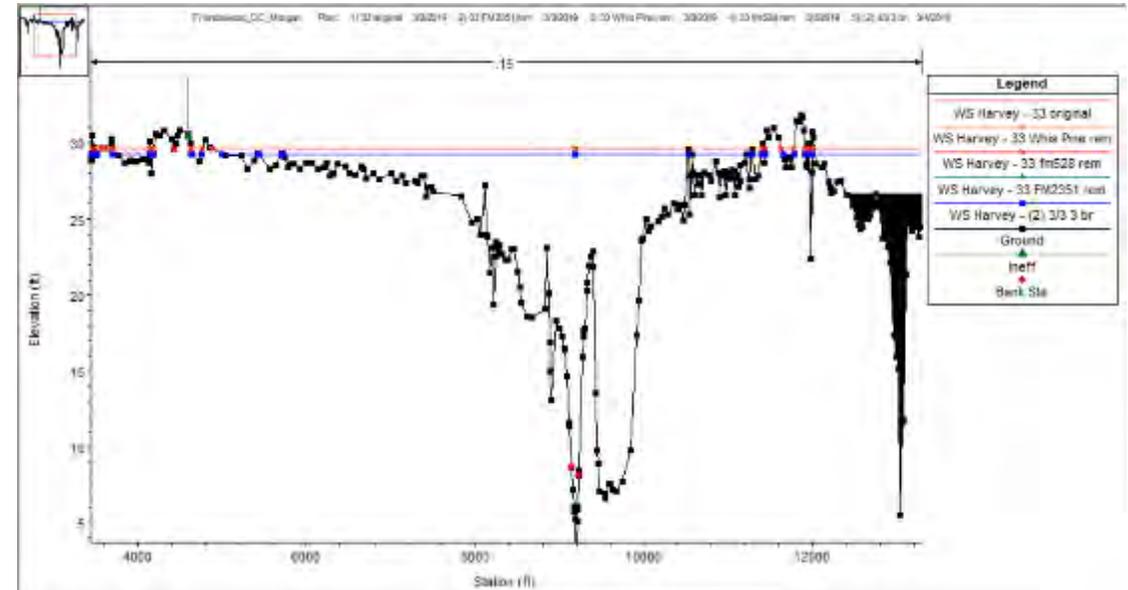


Measurement Location	Observed (HCFC) WSEL	USGS High Water Mark	Modeled Peak WSEL	Difference
Gage 135	27.7	29.43	28.94	-0.46
Gage 120	24.2	-	24.50	0.30
Gage 130	21.1	-	21.35	0.69
Gage 110	16.6	-	16.48	0.04

\*All listed values are in feet

*Differences this close are considered outstanding in the field of flood modeling*

# An Example of the Output for Just One (Raising the FM 2351 Bridge)



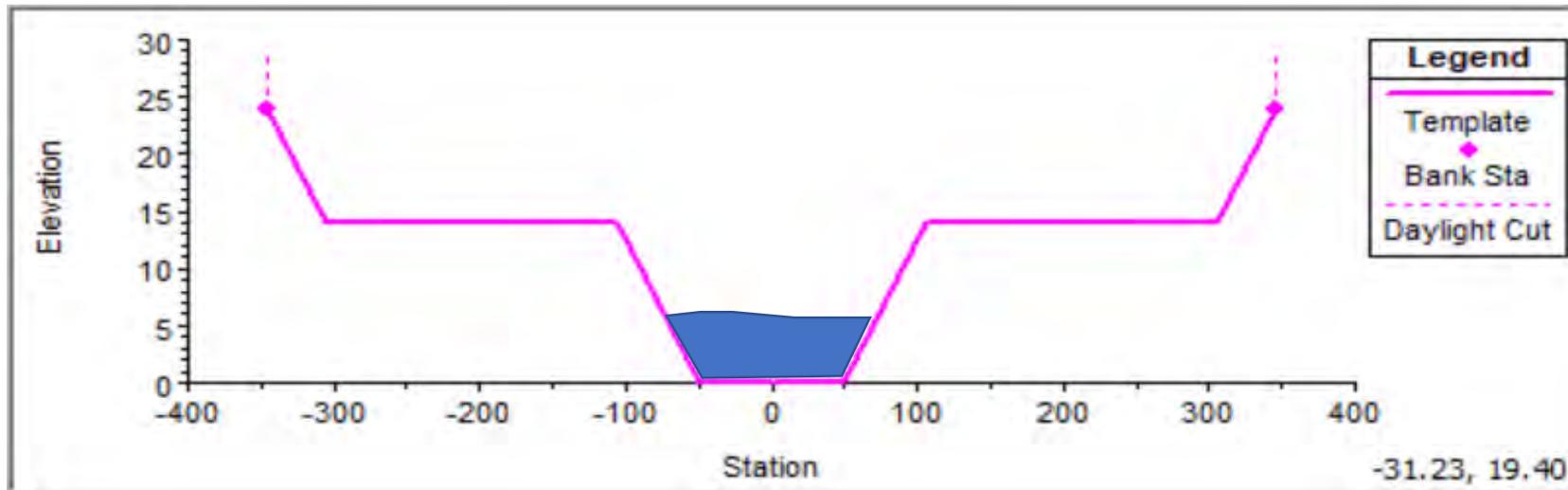
\*Plot depicts upstream bridge raising scenario

In All Cases data was shown for the effect of the project for the historical 100 yr. storm, the new 100 year storm, and Harvey. Negative numbers indicate how much lower flooding would have been had the project been in place

Storm	Changes in Peak WSEL (ft)			
	FM 2351	Whispering Pines	FM 528	All 3 bridges
100 yr.	-1.69	-0.02	-0.04	-1.86
100 yr. (ATLAS 14)	-0.57	0	-0.01	-0.59
Harvey	-0.38	-0.01	-0.01	-0.38

# Terracing - Method

- Based on the terracing design, extend a 200 ft terrace to both sides
- Channel meanders remain intact (i.e., no channel straightening)
- Grass terracing has a roughness coefficient of 0.04 on its terraces.



Bottom Width	Channel Depth	Side Slope (H:V)	Terracing Distance (each side)	Terracing Depth	Manning's n (channel)	Manning's n (grass terracing)
60 ft	14 ft	4	200 ft	10 ft	0.015	0.04

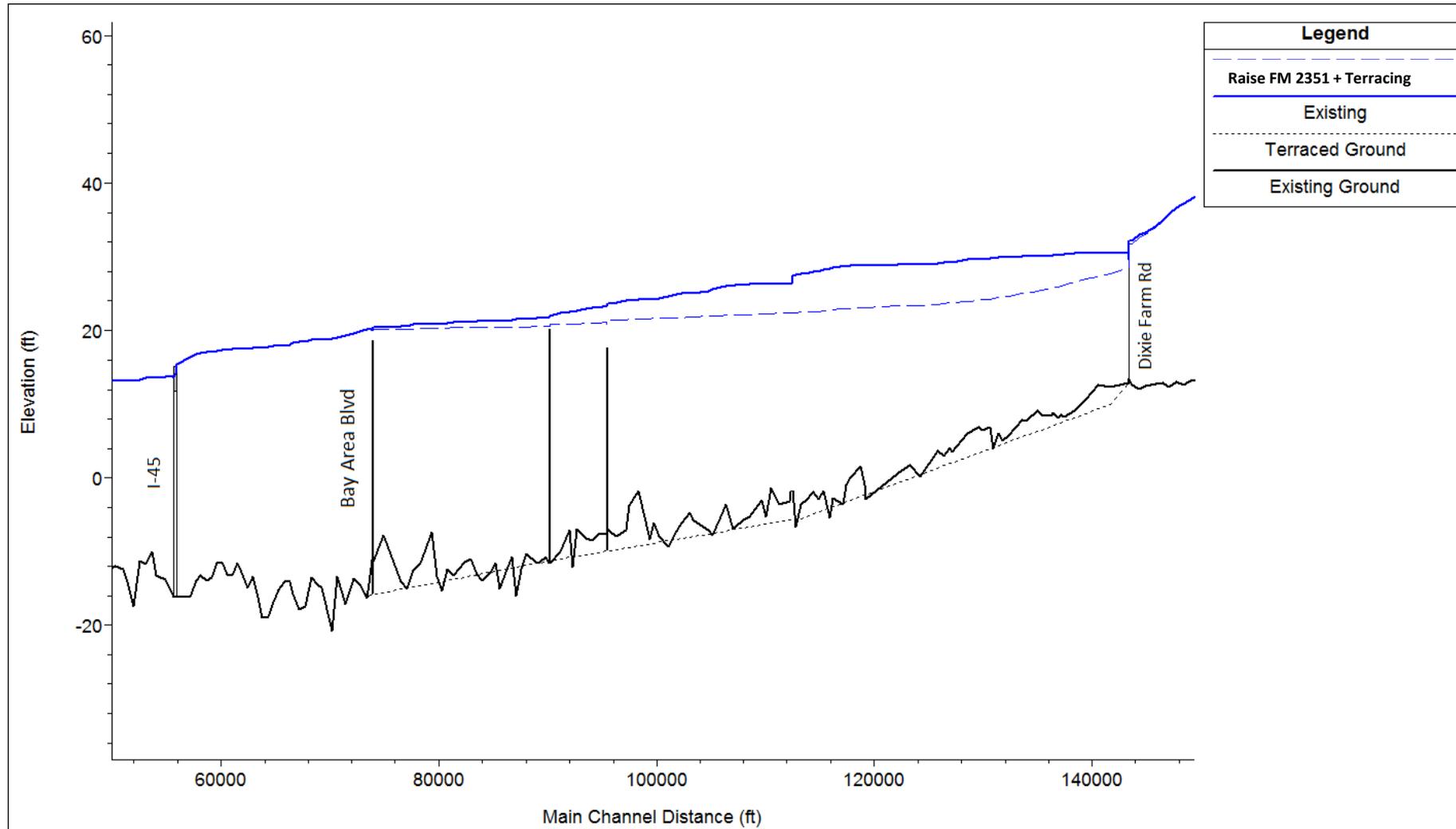
# Summary of Scenario Individual Testing – Harvey

#	Watchpoint Location	Change in Peak WSEL (ft)					
		Three-Bridge Raising	Terracing	Bridge Rm + Terracing	De-Snag	50% Diversion	Detention
1	Upstream FM 2351 Bridge	-0.79	-3.78	-4.11	-0.86	-0.11	-0.03
2	Downstream FM 2351 Bridge	-0.09	-3.38	-3.37	-1.47	-0.15	-0.04
3	Upstream Whispering Pines Bridge	-0.20	-1.83	-1.83	-0.87	-0.38	-0.04
4	Downstream Whispering Pines Bridge	-0.19	-1.56	-1.56	-0.75	-0.47	-0.04
5	Upstream FM 528 Bridge	-0.19	-1.10	-1.10	-0.44	-0.74	-0.05
6	Downstream FM 528 Bridge	0.00	-0.90	-0.90	-0.37	-1.03	-0.06
7	Downstream Bay Area Blvd Bridge	0.00	-0.09	-0.09	0.00	-2.9	-0.09
8	Downstream I-45 Bridge	0.00	0.00	0.00	0.00	-3.62	-0.06
9	Clear Lake	0.00	0.00	0.00	0.00	-1.52	-0.04

## Dr. Bedient's Team Calculated the Group of Projects That Would Have the Biggest Effect.

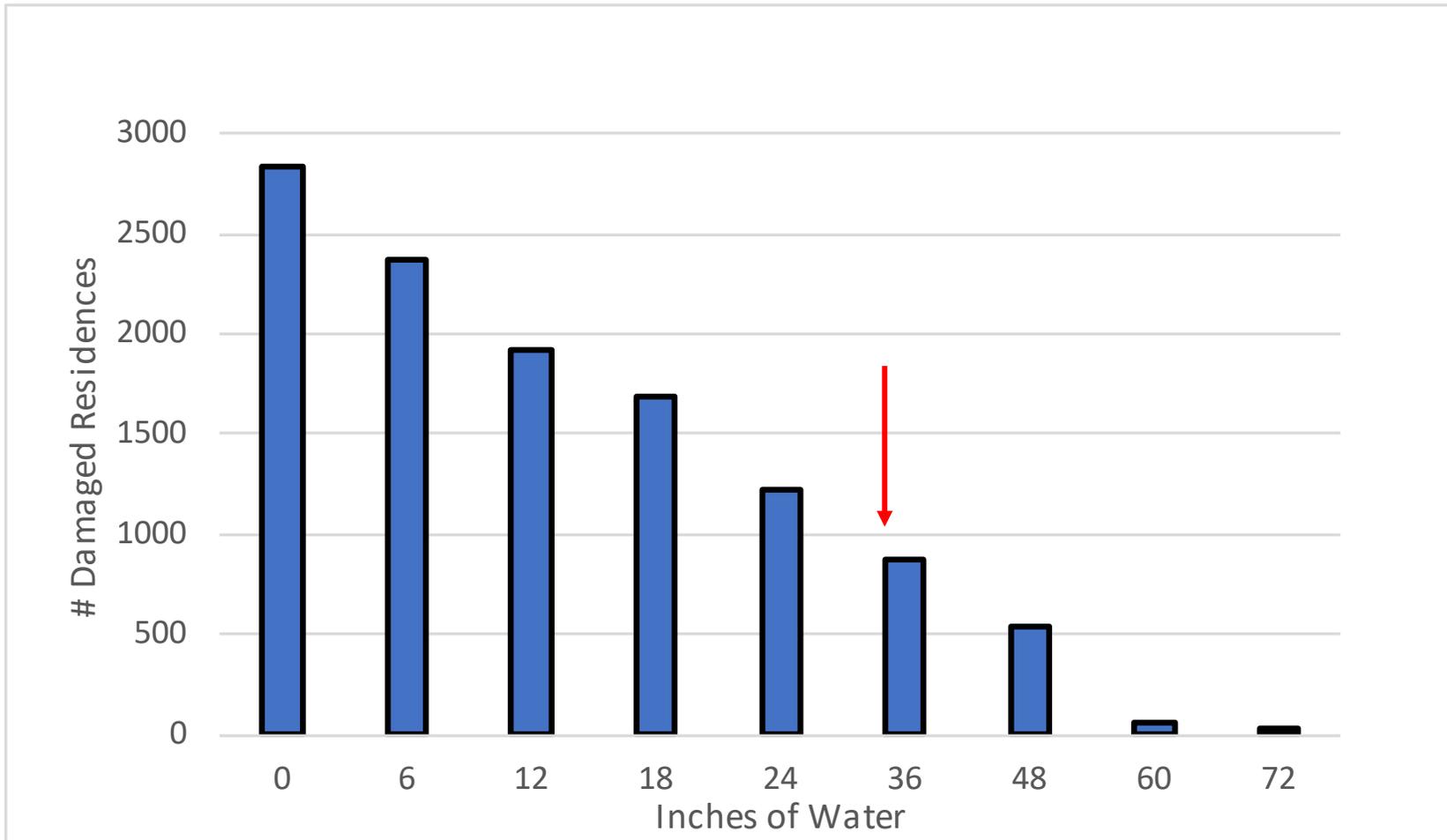
- ✓ You can't just add the numbers on the previous page because different projects interact with each other in both positive and negative ways
- ✓ It turns out that raising the FM 2351, de-snagging and terracing together have the greatest positive impact.
- ✓ Importantly those same projects don't negatively effect League City.
- ✓ Combination scenario decreases up to ~3.5 ft of water at Friendswood during Harvey.
  - The effect is more pronounced upstream of Whispering Pines and begins to diminish as you move down stream.
  - Land availability downstream of FM 528 is greater so increasing the terracing width there would likely increase the effect between FM 528 and Bay Area Blvd
  - Bedient's will model this in the future

## Effect of Raising FM 2351 Bridge and Terracing on Harvey Flood Levels



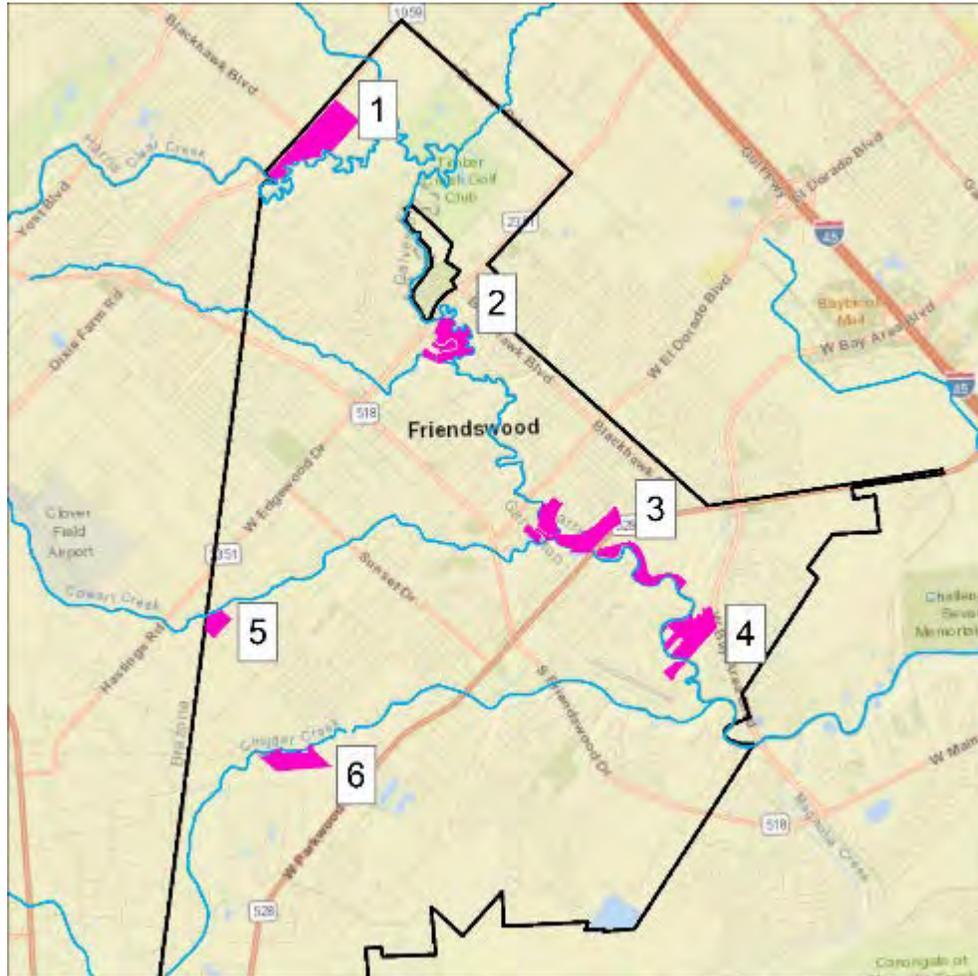
- As Noted increasing terracing width downstream of FM 528 will increase positive effect
- Current I45 Bridge was an issue in Harvey. The current work raises the Bridge and Feeder Bridges and should help water move out better

# Reduction as Modeled through Friendswood Would Have the Following Effect



- Assuming Best Project Case was completed before Harvey.
- Using locations of where the houses flooded and possible reduction basis modelling.
- We would have seen 850 houses flood instead of 2830.
- And the houses that did flood
  - 250 of them would have gotten 6" of water or less
  - 550 of them would have gotten between 6" to 2 feet.
- **Please note further work can define this better almost to the house.**

# We did Ask For Modeling of 6 Proposed Detention Ponds

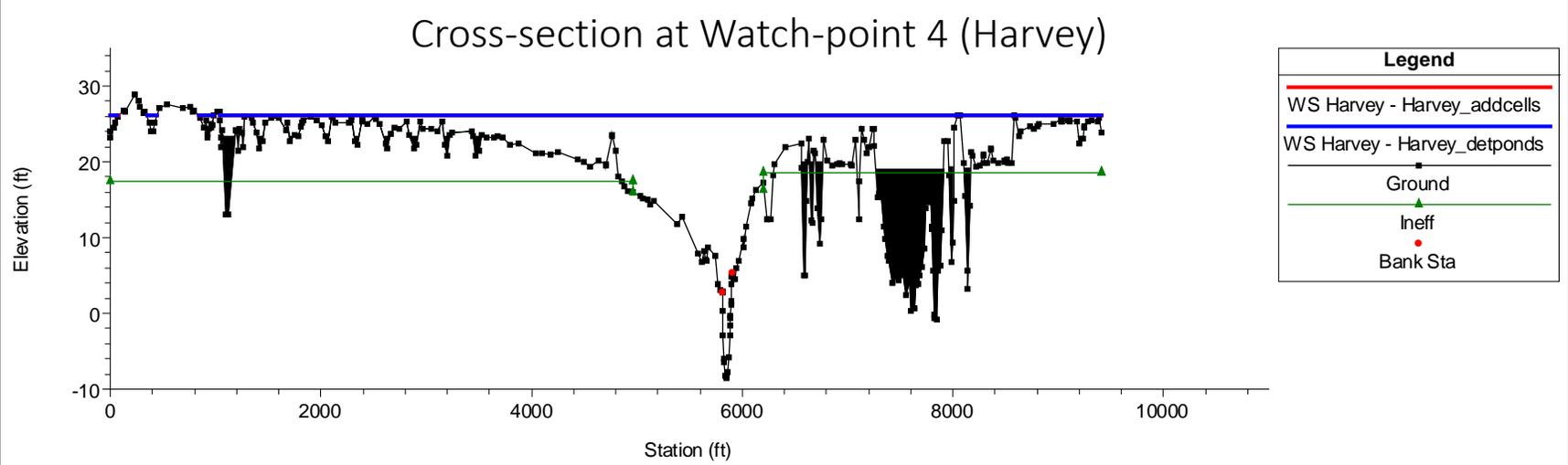


Six proposed ponds were modeled simultaneously in Vflo using GIS shapefiles provided.

Pond #	Designed Acreage
1	73.0
2	36.5
3	64.2
4	53.1
5	21.2
6	33.3

\*When modeling, drainage areas into ponds were assumed to be about 3x the designed acreage.

# As Example Detention Pond at Whispering Pines



Water Elevation Changes Due to Detention – 100 Yr. Storm

Location	WSEL change (ft)
FM 2351	-0.01
Whispering Pines	-0.02
FM 528	-0.05
Bay Area Blvd.	-0.14
I-45	-0.20
Clear Lake	-0.15

- Changes are minimal.
- In Harvey Storm even less held due to filling up early.
- To have an affect in Harvey would need a 4500 acre pond somewhere upstream.

# Diversion

Modeled diverting water out of Clear Creek at Bay Area Bridge and finding another path to the Gulf other than going down and out Clear Lake.

- The positive effects occur mainly near and below the diversion point.
- Further modelling needed to better define
- Does require moving the water across other watersheds
- Significant land acquisition needed, little of this actually in Friendswood.
- Project cost would exceed \$300M and would have to be done by USACE.
- Friendswood's portion of cost would be less than 5%.
- Other cities and agencies would control this.
- There are other diversion type projects that need to be modeled and we will be asking Dr. Bedient's group to do these
- Friendswood should remain interested in this and if the project was triggered by other agencies we would want to support

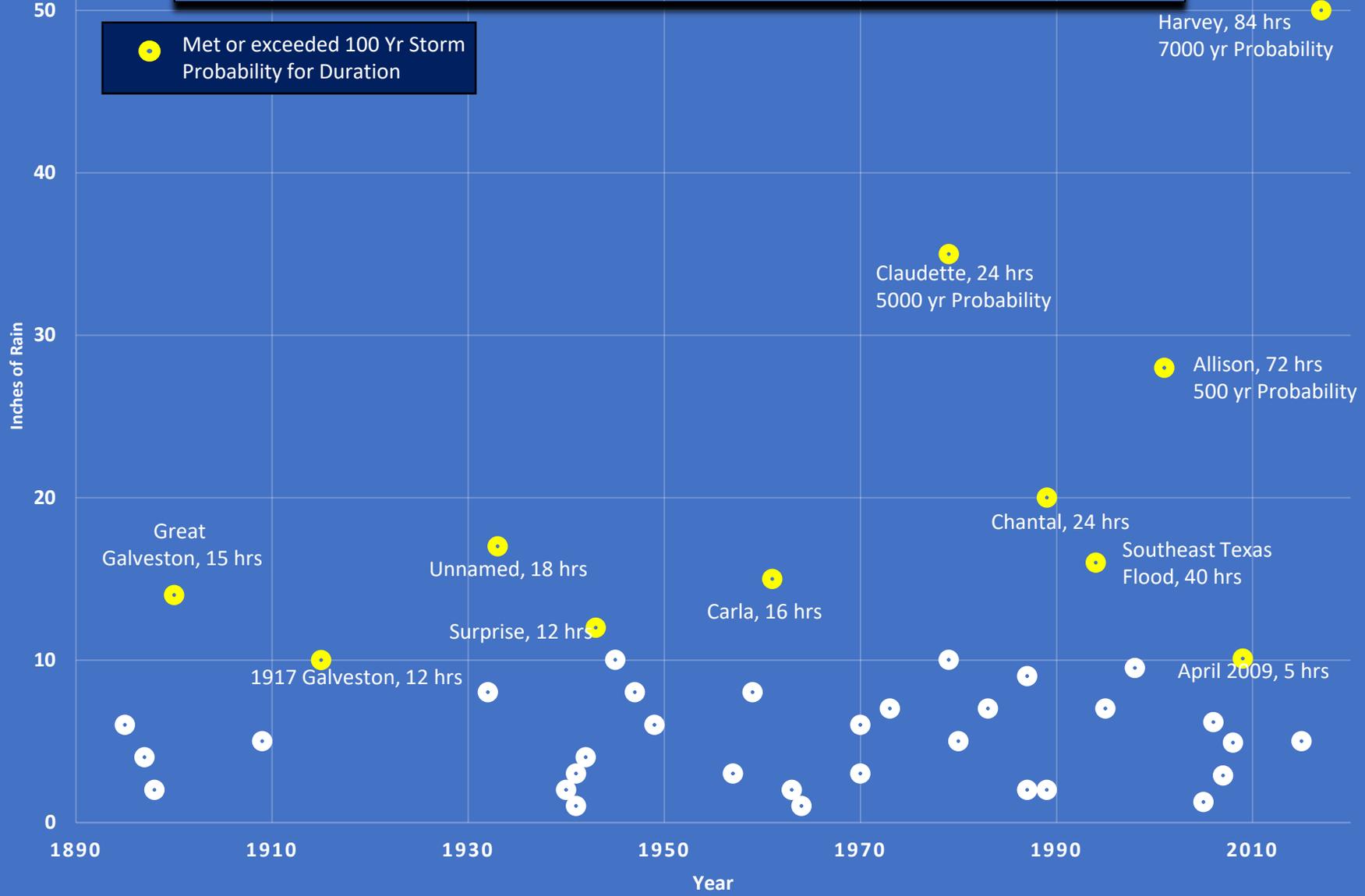
	WSEL Change (ft), Diversion Pt at Bay Area Blvd		
Location	10% Div	25% Div	50% Div
FM 2351	-0.02	-0.04	-0.07
Whispering Pines	-0.08	-0.18	-0.31
FM 528	-0.17	-0.37	-0.64
Bay Area Blvd.	-0.65	-1.54	-2.77
I-45	-0.68	-1.63	-3.03
Clear Lake	-0.40	-0.65	-0.67

# What is an Observation

- It is a conclusion the team has reached basis its research, much of which has been presented to council already, and is supported by a majority of our team.
- Each Observation has multiple premises that help us reach the conclusion
- Observations can be in the area of mitigation projects, costs, implementation, political concerns, safety, and environmental....and more.
- To change an observation to something better one needs to attack the premises.
- From the Observations and Premises we have formulated recommendations.

**Please Note: As we go through these we sometimes show reminder data but in most cases we assumed Council remembers things we have shown in the past. If something is confusing please ask.**

# HISTORICAL RAINFALL EVENTS FRIENDSWOOD, INCHES FELL ON CITY ADJUSTED FOR 2018 ATLAS 14 CHANGES



# Observation 1

**Friendswood experiences catastrophic flooding when the watershed receives rainstorms of 24 inches or more in less than two days.**

## *Why Do We Say This?*

- A. From previous chart....such storms are occurring more frequently than the published probabilities of 0.2% (500 yr.) in any given year.
- B. There have been three major storms (Claudette (1979), Allison (2001) and Harvey (2017) that have occurred in the last 40 years (Statistically at a 7.5% per year likelihood.)
- C. Storms of lesser severity can cause localized flooding but do not create the wholesale flooding of significant portions of the city.
- D. Further development of the watershed will exacerbate the effects of such storms or will cause smaller storms to have the same impact. Note the changes just in the last decade.

## Observation 2

**In Friendswood, and all other areas, flooding of Clear Creek occurs because enough water cannot either be stored upstream or drain fast enough to the ocean during storms as shown in Observation 1.**

### *Why Do We Say This?*

- A. Methods to reduce flooding:
  - 1) Reduce the amount of water entering Clear Creek in Friendswood during storms (DS)
  - 2) Increase the ability to flow water out of Clear Creek during storms (R).
- B. About 300,000 acre-feet of water came to Friendswood in Harvey. ~2/3 that in Allison and Claudette.
- C. Acquisition of property will be required to implement these options.
- D. In Harvey, tributaries in Friendswood were not restrictions but backed up when they couldn't exit to Clear Creek.

## Observation 3

**Over the last 80 years, the Clear Creek watershed has been significantly changed by humans for land use. This has altered the physics of the flow.**

### *Why Do We Say This?*

- A. Portions were straightened and widened to reclaim wetlands for farm use and later for residential areas.
- B. Some areas have not been altered and retain their natural unimproved watercourse such as we have in Friendswood.
- C. Clear Lake, is extensively developed at the outlets of the Clear Creek watershed to Galveston Bay.
- D. Again note the Lidar changes in just the last 10 years.

## Observation 4

**There are multiple jurisdictions in the Clear Creek watershed that pass water into Clear Creek without any further responsibility.**

### *Why Do We Say This?*

- A. The land mass of the jurisdictions that drain to Clear Creek in Friendswood is seven times the size of Friendswood.
- B. Jurisdictions generally apply a 1% storm criteria for land use which are not the type of storms that currently cause wholesale flooding. Some jurisdictions are beginning to make changes.
- C. There is no overall governing body although the current Clear Creek Watershed Steering Team has an advisory role.

## Observation 5

**Currently the City of Friendswood considers their role is to move water effectively from property owner boundaries to the nearest creek or drainage waterway to Clear Creek.**

### *Why Do We Say This?*

- A. This is consistent with other jurisdictions in the watershed.
- B. To the extent that the infrastructure exists.
- C. There are some areas or pockets of the city that flood in big storms, that shouldn't and may have a local drainage issue.

## Observation 6

**The City of Friendswood's general fund is inadequate to fund projects necessary to mitigate flooding of Clear Creek from the storms in question.**

### *Why Do We Say This?*

- A. The city is hampered by not having capital funds to support shared funding or pre-funding and payback projects.
- B. The city's yearly general fund is ~\$25M whereas mitigation projects could be an order of magnitude larger.
- C. Funding will be required from other sources and the city will be required to aggressively pursue this funding and be vocal about how funds are disbursed

## Observation 7

Cities and areas that are successful in advancing flooding projects nationwide have built in a structure that ensures a Constancy of Purpose to create a long term strategy..

### Why Do We Say This?

- A. Review HCFCD, Rochester, MN, others studied, Cedar Rapids, Iowa, New Orleans...ect.
- B. This is a deceptively important observation.**

## Observation 8

**There are multiple Harvey related funding streams available (Federal, State, County). Some agencies (USACE, Harris County) have already been funded and projects in early stages of implementation. The impacts on Friendswood of these projects has not be adequately demonstrated to the Sub-Committee.**

### *Why Do We Say This?*

- A. Harris County had received direct Federal Funds. Other counties, including Galveston, have not received direct funds yet. It is currently not clear how the money will be shared.
- B. Friendswood has applied for Federal and State funding for property buy-outs but some have not been approved and some are pending.
- C. Projects are scheduled on areas like upstream Clear Creek in Pearland, Mud Gully, and Turkey Creek.
- D. Simulations results shared with the sub-committee were for 1% storms only. Sub-committee has requested USACE perform simulations on storms like Harvey but have not received the information yet.

# Caveats of Observations

**The Team Stayed within its Charter to examine flooding and fixes. There are a number of areas not addressed but some of the important ones are:**

- A. Projects might have environmental impacts that will have to be addressed.
- B. Projects such as retention, detention, and terracing of Clear Creek may afford opportunities to create appealing benefits such as parks, sport fields, nature trails, etc.
  - The Sub-Team did not define the cost of this
  - This could be part of the presentation to voters regarding the bond

# Recommendations

- Our recommendations are based on the data we collected and the observations we have shown both tonight and in previous report-outs to the City Council of Friendswood.
- Some recommendations attack multiple observations.
- We intend for all recommendations to be actionable by the Friendswood City Council if it so chooses.

# Recommendation 1

**The City of Friendswood City Council needs to clearly state, through a resolution, that the work of the sub-committee generates a cause for action to mitigate rainstorm flood events.**

## Why?

- A. Does the City Council of Friendswood agree that catastrophic flooding rainstorm events give cause for action? The back-up has been provided in all sub-committee presentations.
- B. A resolution would demonstrate commitment.
- C. The sub-committee can recommend wording but we believe the council can generate the wording they prefer

## Recommendation 2

**The City of Friendswood City Council accepts that there are a number of mitigation projects that need to be pursued to completion to significantly reduce flooding in Friendswood. These all involve the main stem of Clear Creek.**

### Why?

- A. The main stem of the creek is the problem. Tributaries flood by backing up.
- B. The methods to reduce flooding are either store more water, drain it faster, or remove structures from properties that flood.
- C. The mitigation is expensive and will take time to acquire matching funds, perform engineering, acquire rights-of-way, and implement the projects

## Recommendation 3

**Go to the Friendswood voters with a bond vote that would provide a cost share of \$32M in projects over the next 15 years. This money can ONLY be spent on drainage projects associated with the main channel of Clear Creek.**

### Why?

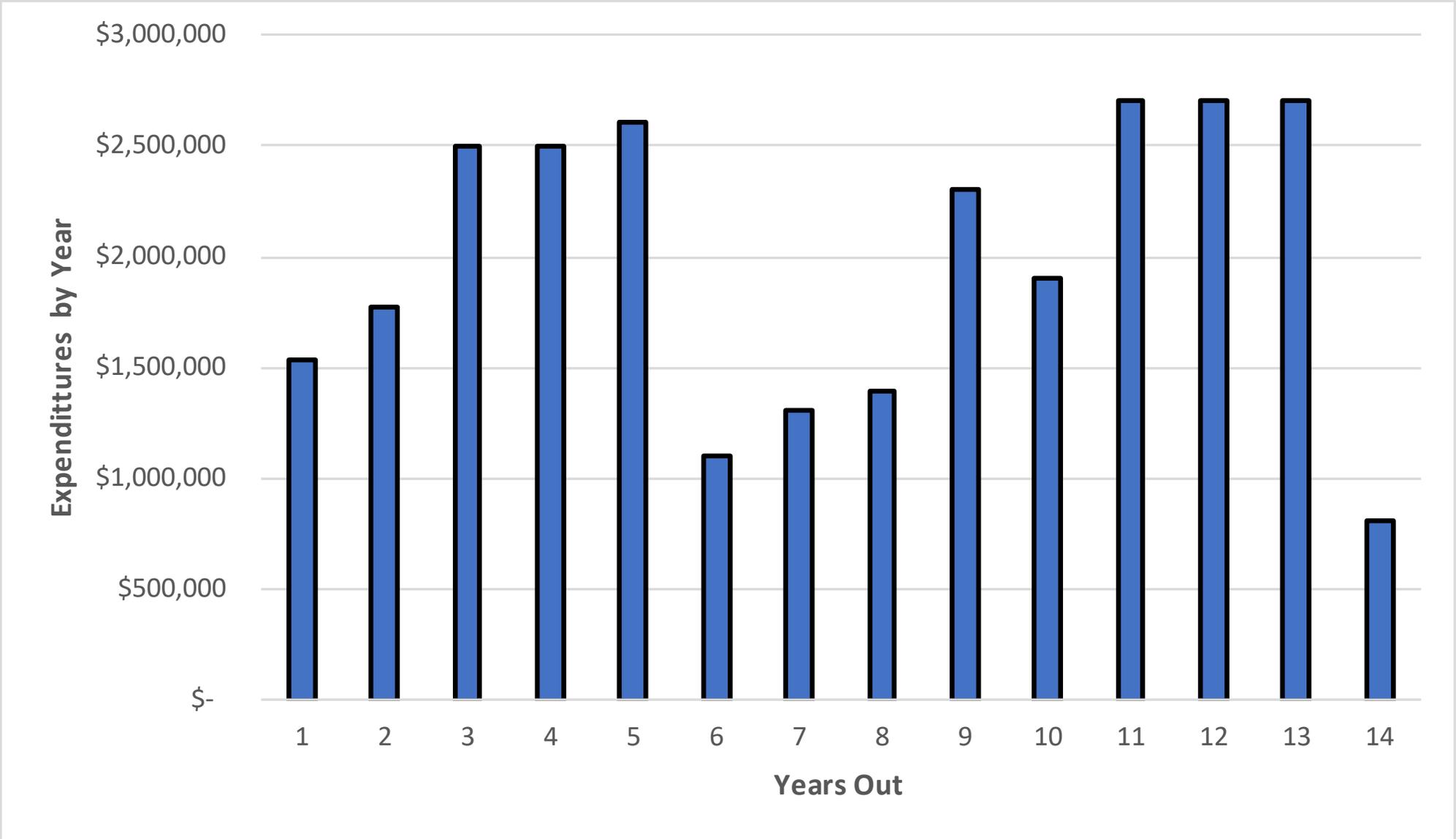
- A. The cost to complete the needed projects is much higher than the \$32M, but this amount allows us to leverage other funds available.
- B. Without having money to spend on flood projects Friendswood will be frozen out of consideration for many direct impact projects.
- C. Amount determined by the number of projects, their positive effects, their costs, expected percentage Friendswood would have to contribute and the time frame.
- D. Determine the net impact on taxes for bonds drawing over that period of time.
- E. Rely on Drainage districts to continue to work on tributaries.

# Estimated Costs of Projects with the Best Benefit

#	Mitigation Tyes	Details	TOTAL COST	COF %	Cost to COF	Years to Complete
1	De-Snagging	200 ft	\$ 3,000,000	10%	\$ 300,000	2
2	Bridge/Road Raising	FM 2351 - East Edgewood Drive	\$ 20,000,000	10%	\$ 2,000,000	10
3	Bridge/Road Raising	FM 528 - East Parkwood Ave	\$ 20,000,000	10%	\$ 2,000,000	10
4	Terracing	Dixie Farm Road to FM 2351	\$ 28,000,000	20%	\$ 5,600,000	15
5	Terracing	FM 2351 to Whispering Pines Ave	\$ 22,000,000	20%	\$ 4,400,000	15
6	Terracing	Whispering Pines Ave to FM 528	\$ 10,000,000	20%	\$ 2,000,000	15
7	Terracing	FM 528 to West Bay Area Blvd	\$ 30,000,000	20%	\$ 6,000,000	15
8	Buy Outs	Associated with all Projects	\$ 30,000,000	25%	\$ 7,500,000	5
9	Engineering	Engineering and environmental Impact Studies	\$ 10,000,000	20%	\$ 2,000,000	4
		<b>TOTAL --&gt;</b>	<b>\$ 173,000,000</b>	<b>18%</b>	<b>\$ 31,800,000</b>	

1. Costs based on engineering estimates for similar work.
2. While Dr. Bedient's work showed the FM2351 Bridge that while raising has a bigger impact, we believe for public safety two bridges should be elevated. But also note the terracing should reduce the flood heights which also help bridges stay passable

# Estimated Spend Rate for Projects Listed



## Recommendation 4

**Hire a long term Clear Creek Watershed Drainage coordinator for in the City of Friendswood to create a long term strategy and a Constancy of Purpose**

### Why?

- A. Experience shows with government to ensure something gets done and to have a long term approach it has to be one person's clear job and that they are held accountable for progress.
- B. City Manager is responsible for defining the job description, hiring, and managing the performance toward the long term goals.
- C. The City Council should be very active in the progress of this work and expect routine reporting in Council meetings
- D. Needs to have a budget to successfully complete the project and continues the sub-committee work on mathematical simulations.
- E. Responsible for Clear Creek drainage project definition, spending, grant writing, interaction with other jurisdictions, and interaction with the public. .
- F. Monitors projects on Clear Creek and requires simulations that show the effect of these projects during storms sizes that flood Friendswood.

## Recommendation 5

The City of Friendswood should review and change its current permitting criteria regarding drainage to reflect the realities of the types of storms that occur here.

### Why?

- A. Design criteria for new construction at the 1% storm level are inadequate.
- B. Optimally this should be done in conjunction with other municipalities up and down the creek.
- C. Current existing structures would be grandfathered unless substantially altered.

## Recommendation 6

**The acquisition of properties will be required to adapt Clear Creek to meet the demand for drainage. The City of Friendswood will need to have the means to acquire properties for drainage projects.**

### Why?

- A. This is included in our calculations for the Bond needs
- B. Quick response to purchase damaged properties after a flood event
- C. Purchase of properties as they go on the market at any time.
- D. Unsolicited offers.
- E. Privately owned properties cannot be used for drainage projects.

## Recommendation 7

**The City of Friendswood needs to be proactive regarding the management of the flow of water down Clear Creek. The City of Friendswood should take the leadership role in organizing municipalities along Clear Creek to create a common purpose in fixing the creek.**

### Why?

- A. It is our citizens who flood.
- B. There are over a half dozen agencies involved in Clear Creek. Recognize the responsibilities of other entities and need to increase our presence to support these groups.
- C. The current master plan for the watershed needs improvement.
- D. Solutions have to involve land use and the larger cities on the watershed control this.
- E. As a city council reach out to other cities to initiate communications. Initial discussions with League City leadership indicate they are of a like mind on this.

## Recommendation 8

**There are currently several efforts to restructure watershed management being contemplated at the county and state level. The City Council needs to be active and participating in this and determining if these efforts will be beneficial to Friendswood and resisted if not.**

### Why?

- A. Generating watershed control systems can be hugely helpful so long as they are focused on the entire watershed, they are governed fairly, and they are resourced properly.
- B. Care should be given to ensure that changes do not reduce effective current drainage system.
- C. Until the Drainage Coordinator job is filled, Council should determine a method to evaluate changes coming from either the counties, or state.

## Recommendation 9

**The focus should entirely be toward the future. There is no justification to seek redress directed at upstream or downstream entities for the changes that have occurred along Clear Creek.**

### Why?

- A. Many of the significant alterations of the Creek were done a long time ago and continue to this day and will continue in the future.
- B. All municipalities comply with current laws and ordinances.
- C. State and Federal law would not support being successful in legal action
- D. Friendswood too has allowed development, including houses built right on the creek, that have also contributed to the problem.

## Recommendation 10

**There are small areas of Friendswood that flooded during Harvey that were not caused by Clear Creek. The city should be directed to research these and propose fixes.**

### Why?

- A. May require funding not part of bond capital which is dedicated to Clear Creek's main stem.
- B. This may require general funds to budget for and to perform the repairs.

## Recommendation 11

**For both flooding and safety during flooding events, greatly increase the monitoring of creeks in Friendswood. There are blind spots on Clear Creek and tributaries in Friendswood regarding inundation levels and rain gauges. This affects safety and the ability to give first alerts to issues. Add more of these in critical areas.**

### Why?

- A. Work with the flood control districts to increase the number in critical areas.
- B. These instruments can give valuable real time data in storms that can trigger local or large evacuations and later rescue work.
- C. The information is valuable in later analysis of what occurred during storms of all levels.
- D. Consider adding flow rate sensors and video monitoring at critical spots.
- E. All this information should be available to the Friendswood Emergency Operations Command Center and available to the public in real time.

# Summary of Actions for Council Needed Tonight

1. **The Sub-Team should present information to the Bond Citizen's Advisory team about the bond portions of the recommendations.**
  - A. This should be done soon!
  - B. Do we have Council's permission to do this?
  - C. If so, what instructions should be relayed to the Advisory team about this information and their ability to interact with it?
  
2. **The Drainage Sub-Committee as met its original charter to make recommendations back to the city council that are fact-based only and include project types, costs, societal impacts, and political obstacles.**
  - Originally expected to make recommendations back within 6 months.....it took us 8 months! But at least we were faster than the Mueller report!
  - Will be producing a written report capturing all the information gained for posterity.
  - There is on-going work with Dr. Bedient's group to further define project effects and this will continue for some time. Options:
    - Staff could keep this moving.
    - Council could re-charter the current team to do this work
    - Council could charter a new sub-committee to continue this work

# Summary of Actions Needed in the Next Few Months

- Recommendation 1 .... Does Council agree with the overall findings and recommendations and will they generate a resolution to that?
- Do they support the Bond numbers for Drainage?
- Develop plan and budgeting for Clear Creek Drainage coordinator
- To city staff and P&Z on whether to review permitting requirements in light of Subcommittee data.
- Focus for staff on buy out programs which will be taken over by drainage coordinator.
- Have already had discussions with League City leadership and they are interested in linking up with Friendswood regarding Clear Creek.
- Ask staff to keep council up-to-date on watershed bills in the legislature
- Ask staff to create a plan and budget for 2019-20 for isolated drainage area repairs.
- Work with Drainage districts to submit plan and cost sharing for improvements to measurement of the creek.