



What is a “Cubit”

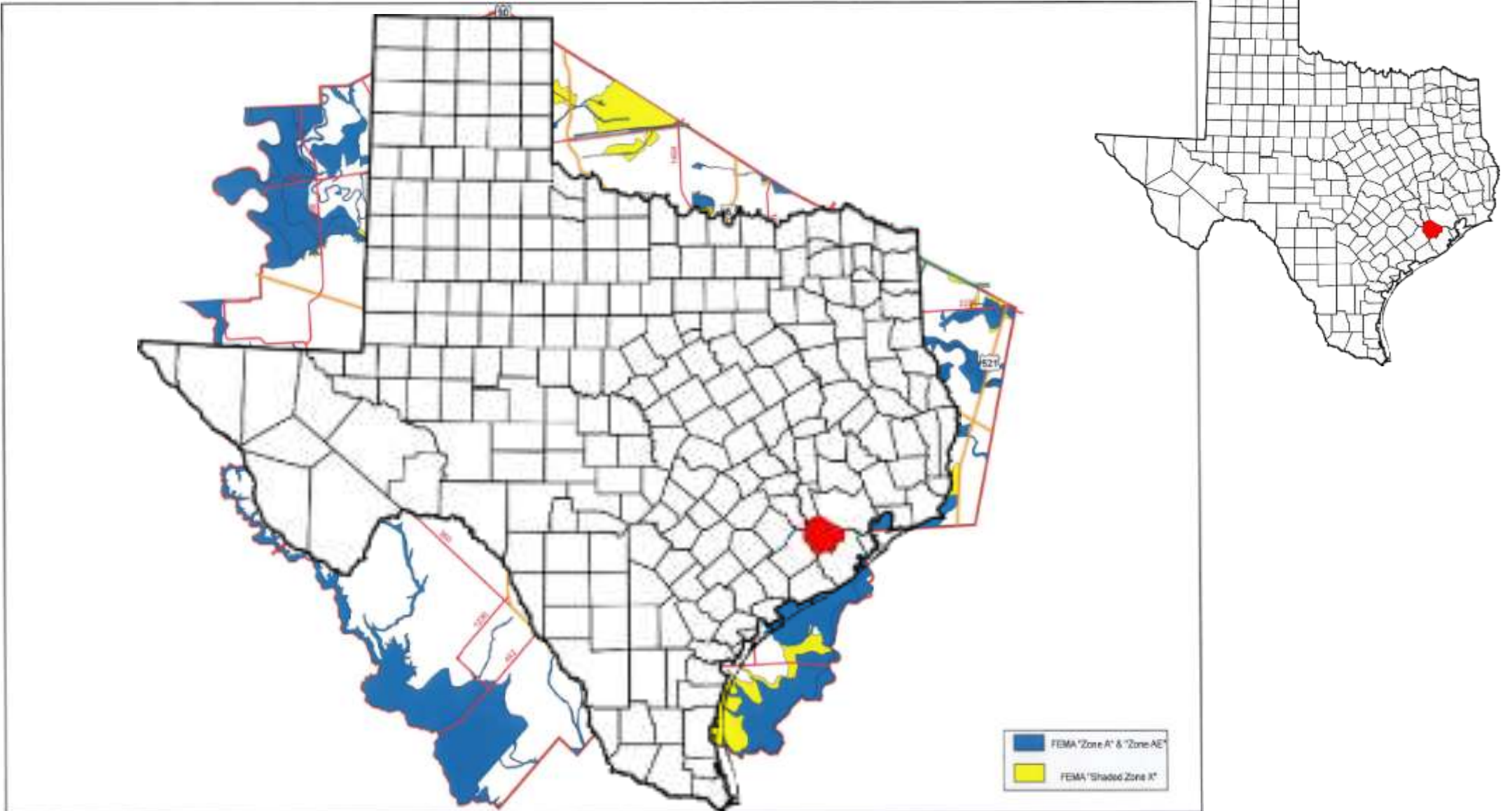
Fort Bend County Levee Improvement District No. 2's
Experience and Response to Hurricane Harvey



André McDonald / Michael E. Stone

“Elevation is the Salvation from
Inundation”... Windell Curole

Fort Bend County Floodplain







So what is a cubit?

Genesis 6:15 The length of the ark shall be three hundred cubits, the breadth of it fifty cubits, and the height thirty cubits.

Cubit [\[N\]](#) [\[S\]](#) Heb. 'ammah; i.e., "mother of the arm," the fore-arm, is a word derived from the Latin cubitus, the lower arm. It is difficult to determine the exact length of this measure, from the uncertainty whether it included the entire length from the elbow to the tip of the longest finger, or only from the elbow to the root of the hand at the wrist. The probability is that the longer was the original cubit. The common computation as to the length of the cubit makes it 20.24 inches for the ordinary cubit, and 21.888 inches for the sacred one. This is the same as the Egyptian measurements.

Biblical View of Animals Headed to The Ark





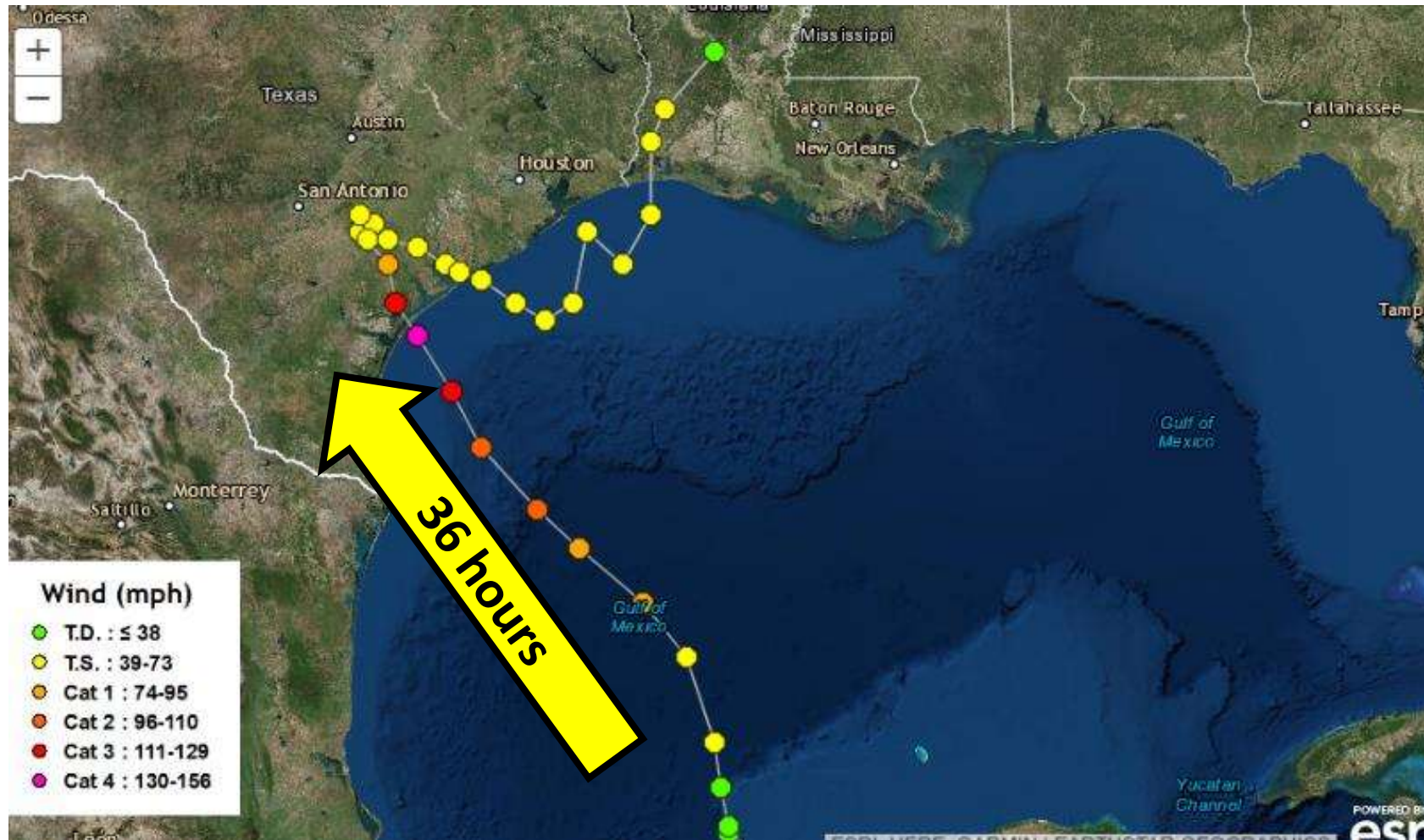
2017 View of Animals Headed to the Ark

LID 2's Experience and Response to Hurricane Harvey



- Hurricane Harvey
 - Timeline of event
 - Impact of event
 - LID 2's operations during the event
- Immediate Response & Recovery
- Long Term Solutions

Harvey Crossed the Gulf of Mexico Quickly & Had Very Rapid Development





Tuesday 22 August 2018

- Harvey has crossed the Yucatan
- It is a Tropical Depression, expected to become a Cat 1 Hurricane
- LID 2 begins preparing for a tropical storm event
 - Double checking all supplies on hand
 - Putting people and equipment on standby
 - Cleaning Flap-Gates
 - Checking all communications



Wednesday 23 August 2018

- Harvey remains a Tropical Depression and is crossing the Gulf of Mexico at fairly high rate of speed.
- Land fall is predicted for South Texas
- LID 2's Tropical Storm Prep is nearing completion
- Personnel on stand-by
- Monitoring storm



Thursday 24 August 2018

- At 06:00 Harvey is upgraded to a Tropical Storm
- At 18:00 Harvey is upgraded to Cat. 1 Hurricane
- Landfall is still predicted in South Texas 200 miles south of LID 2

- LID 2's preparations are complete
- First outer bands of Harvey pass over LID 2, light, sporadic rain



Friday 25 August 2018

- At 06:00 Harvey is upgraded to a Cat. 2 Hurricane
- At 18:00 Harvey is upgraded to a Cat. 3 Hurricane.
- Landfall is predicted for South Texas coast 150 miles SW of LID 2
- LID 2 staff / management meets to make last minute plans for communications and staffing over the weekend
- Outer bands of Harvey pass over LID 2 dropping over 2.3" of rain



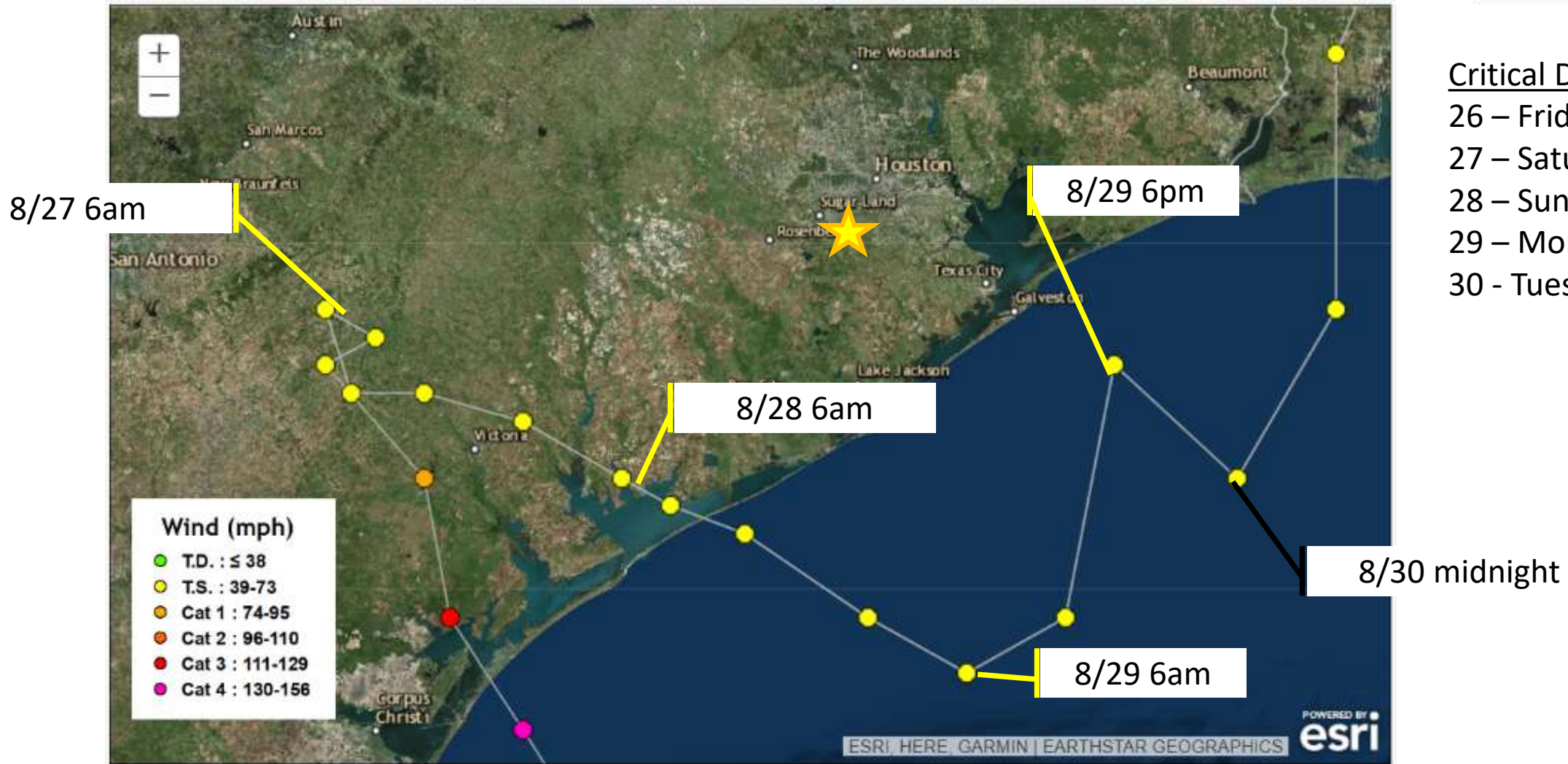
Saturday 26 August 2018

- At 00:00 Harvey is upgraded to a Cat. 4 Hurricane.
- Harvey makes land fall between midnight and 04:00
- At 06:00, Harvey is over land and downgraded to a Cat. 3 Hurricane
- By 18:00, Harvey is downgraded to a Tropical Storm

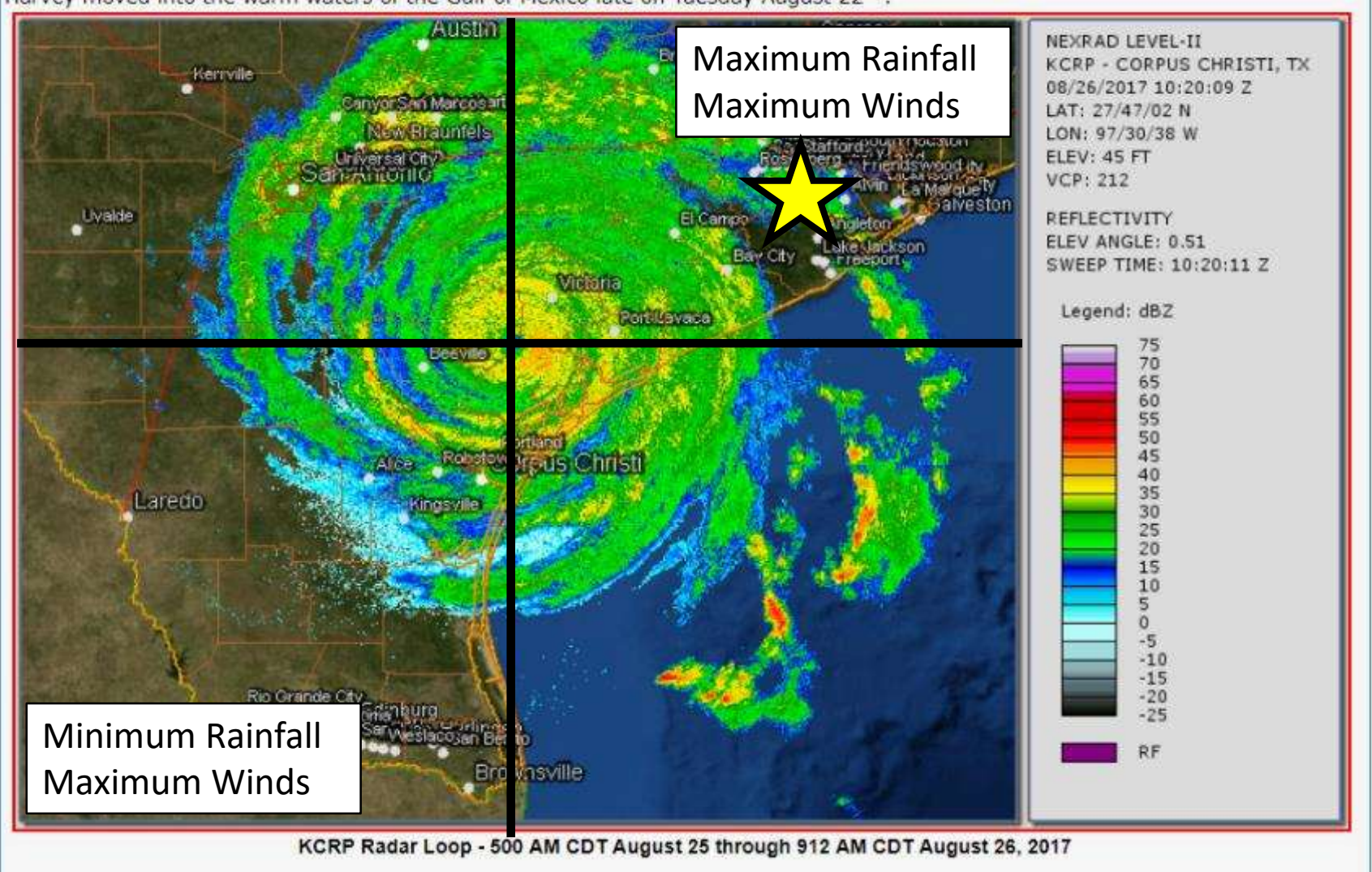
- LID 2 staff are manning their flood fighting stations
- River levels are low, internal ditch elevations are in the normal range
- Rain bands continue to move through the District dropping 8" of rain



And Then it Stalled Out on the Texas Coast



Well after it was inland, it remained very large.





Sunday 27 August 2018

- Harvey is a Tropical Storm
- At 06:00 Harvey has reached it's furthest point inland in Texas and has started back towards the coast
- LID 2 is experiencing very heavy rain – 12.2” of rain falls on Sunday
- Internal ditches are handling the run-off via gravity outfall
- Street flooding is becoming widespread
- Movement with the County has become difficult by evening



Black Monday 28 August 2018

- Harvey is moving back towards the coast, very, very slowly
- LID 2 – Rain continues to fall – an additional 8” of rain falls Monday
- All of the internal storage capacity is full but for most of the day water is still flowing out through the flap gates
- River levels are rising and gravity discharge is in nearing cut-off
- Pumps are to begin as gravity outfall is lost



Monday Night / Tuesday Morning (27/28 August)

- At 18:00 Harvey moves back into the Gulf of Mexico as a Tropical Storm
- Harvey is within 65 miles of LID 2 but approaching a point due south of LID 2 – rain begins to lighten over night but the damage is done
- LID 2 loses gravity outfall / water rises rapidly
- All pumps are running at capacity and losing ground
- Gravity outfall vs pump capacity 4,000 cfs vs 540 cfs
- LID 2 begins experiencing structural flooding about midnight
- Rain continues but getting lighter overnight



Tuesday 29 August 2018

- Harvey move to the south and east of Galveston, about 80 miles from LID 2 – the District is now on the weak side of the storm
- LID 2 receives another 1.23” of rain – most of it before noon
- Pumps begin to gain ground on internal water levels
- Brazos River levels continue to rise on the outside of the levees
- By the Tuesday afternoon – internal water levels have been lowered to a point where no water is in a structure but many streets remain impassable



Total Rainfall within the District

- Measurements varied between 31” and 36” from various observers
(or about 1½ Cubits)
- All data presented here are based upon 15 minute increments from NexRad radar services
- Over the 5,000 + acres the District received about 4.9 billion gallons of rain fall.
 - Approximately 3.7 billion gallons flowed out by gravity through the gates
 - And Approximately 1.2 billion gallons was removed by the pumps



Wednesday 30 August 2018

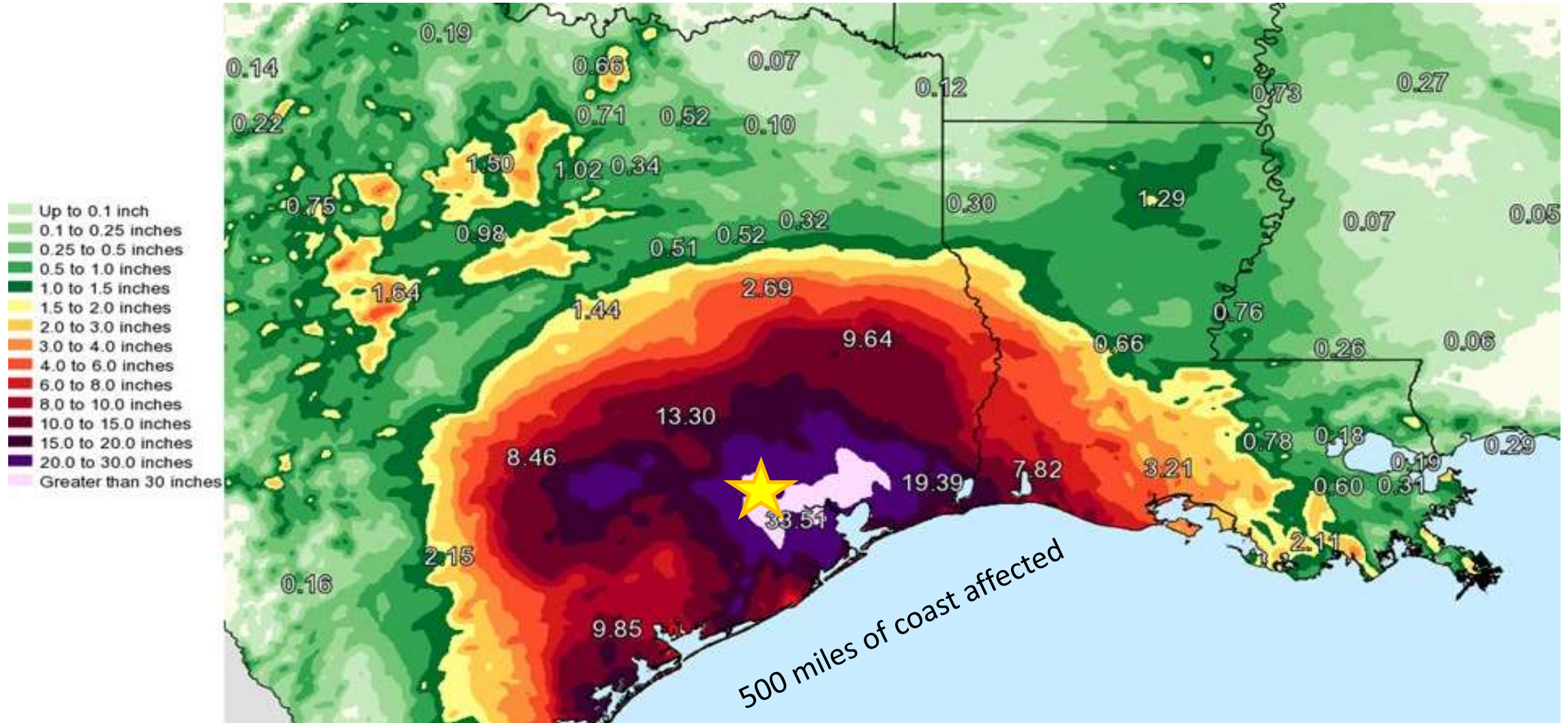
- Harvey continues as a tropical storm and at mid-day makes landfall for a second time near the Texas-Louisiana border.
- LID 2 continues to pump water down, streets are passable
- Meeting with the Mayor of Sugar Land & Public Works Director; informal agreement to begin immediately gathering data on all affected homes – **LID 2 would take the lead**



Thursday 31 August 2018

- At 10:00am water level has reached a point where all pumps are turned off due to lack of submergence
- Rapid Damage Assessment is underway by both City and LID 2 staff
- Agreement is made with engineer to survey all affected homes:
 - High water level / mark
 - Slab elevations
 - Curb elevation
 - Gutter elevation
- Deadline for study completion 45 days

Very wide impact of very high rainfall.

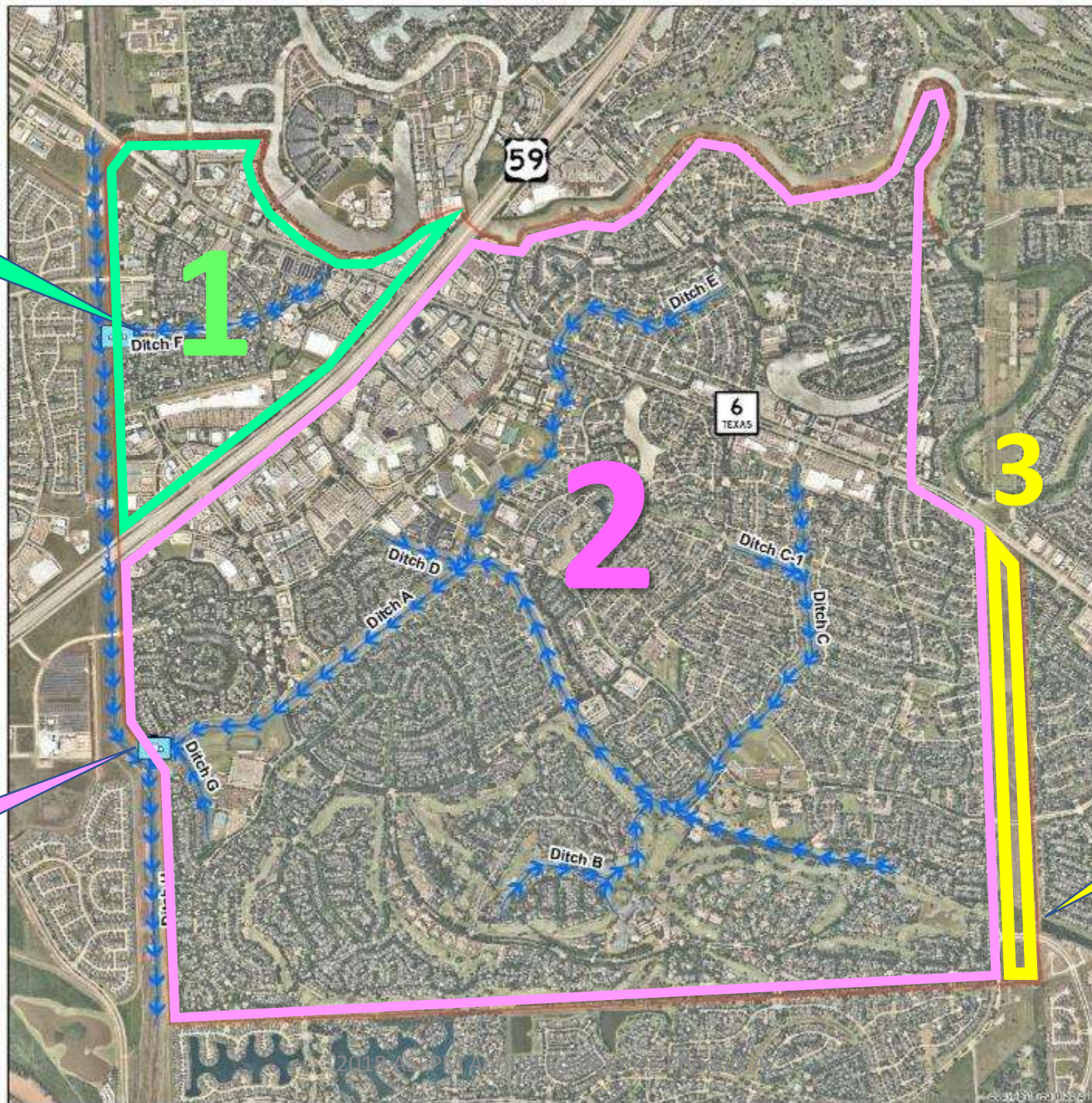




PUMP STATION "F"
90,000 GPM

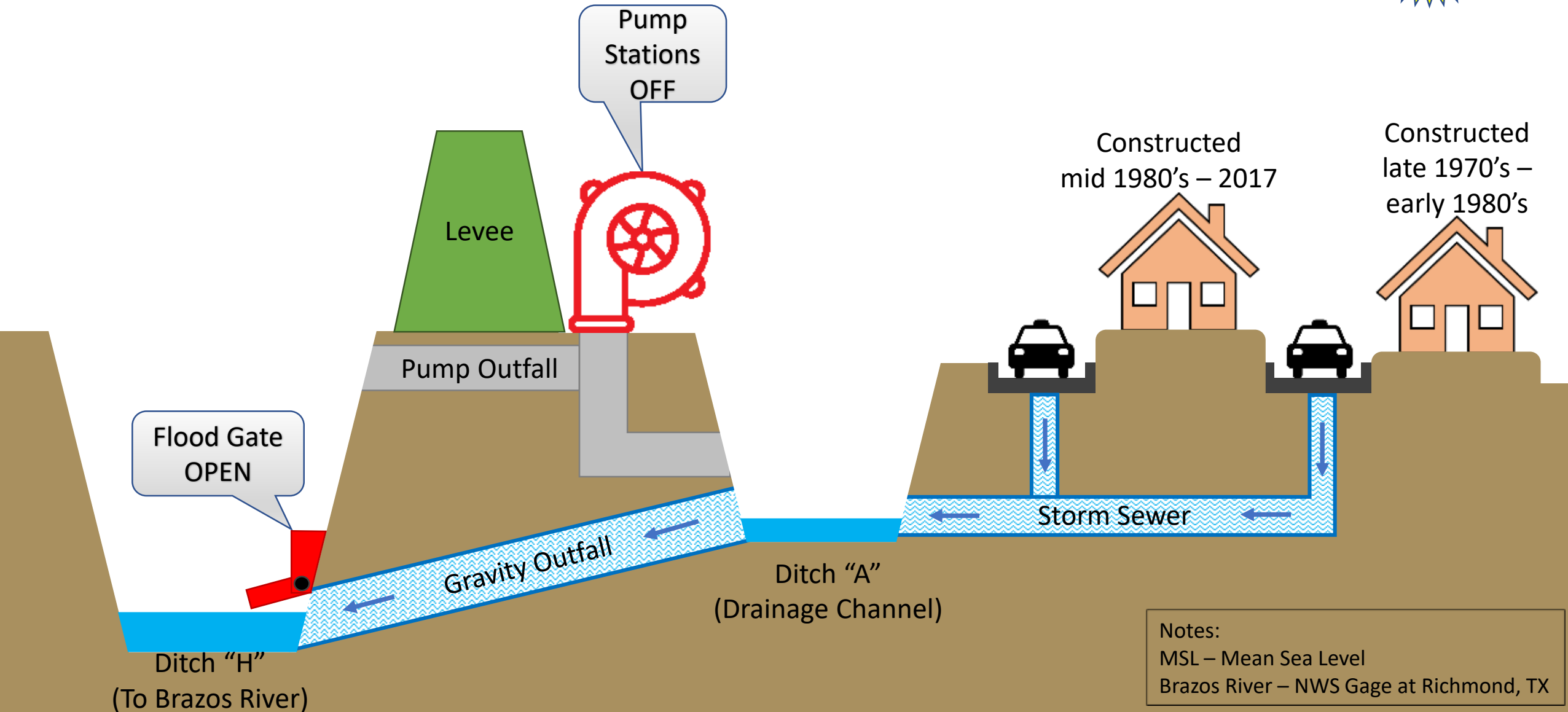
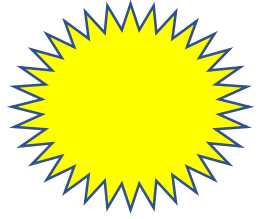
FBC LID 2
Internal
Ditch
System
and
Pump
Stations

PUMP STATION "A"
241,800 GPM

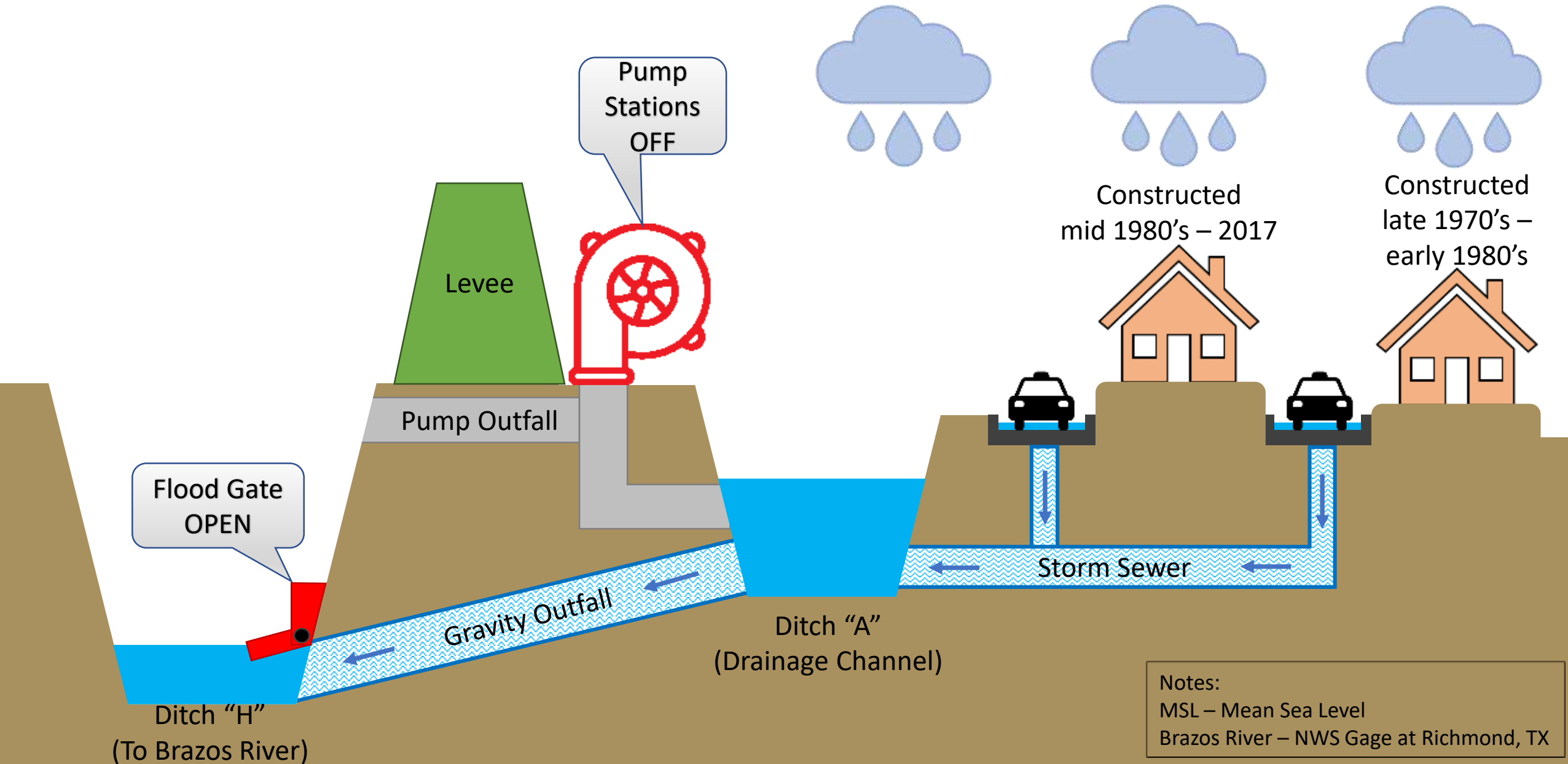


Steep Bank
Creek Outfall
Structure
Gravity Only
No Pumps

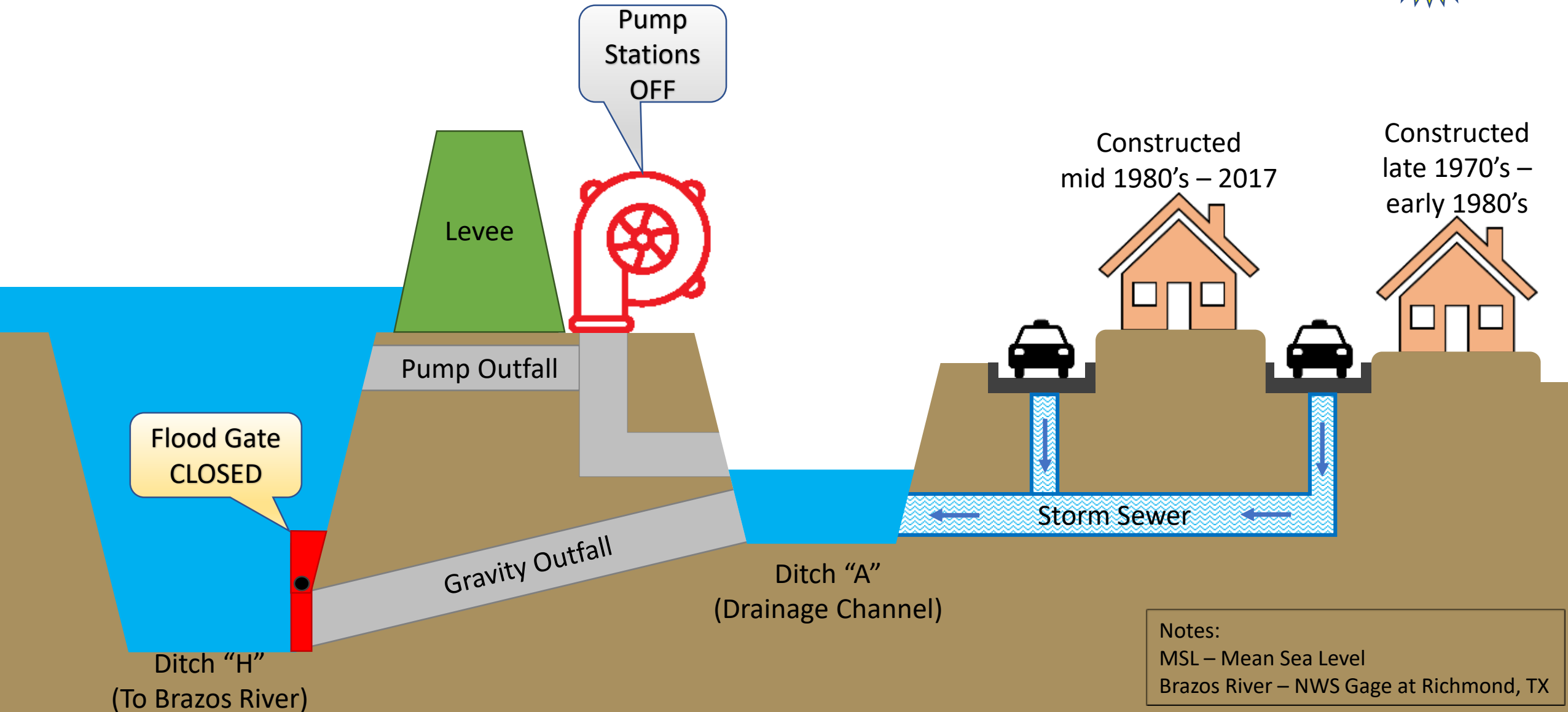
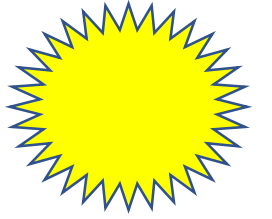
1 Normal Operations – Sunny Day



2 Normal Operations – Rainy Day



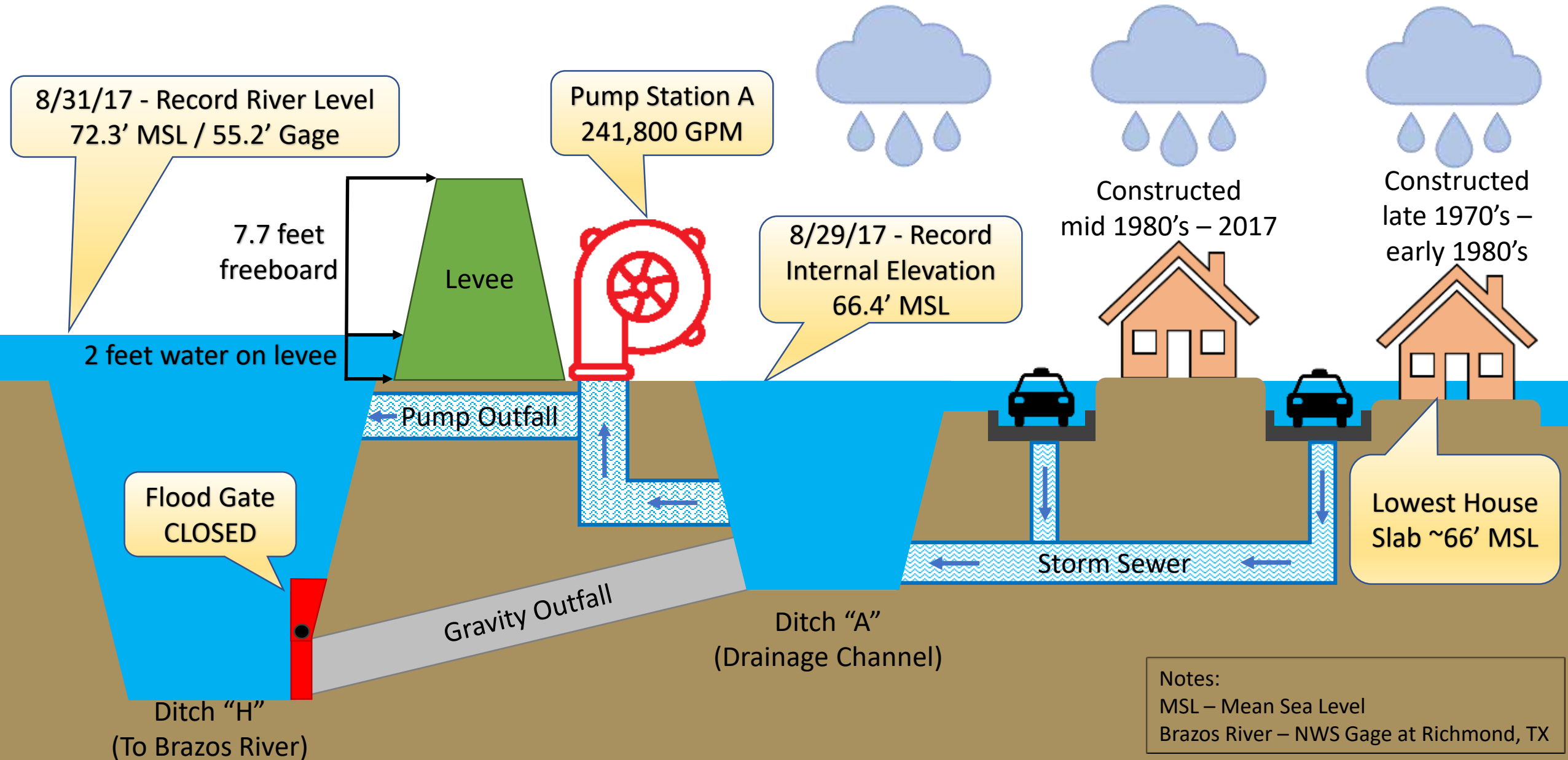
3 Typical River Flood Event



Notes:
MSL – Mean Sea Level
Brazos River – NWS Gage at Richmond, TX

Peak of High Water During Harvey

Flood Gates closed by water pressure beginning at elevation 58' MSL (32' Brazos River).

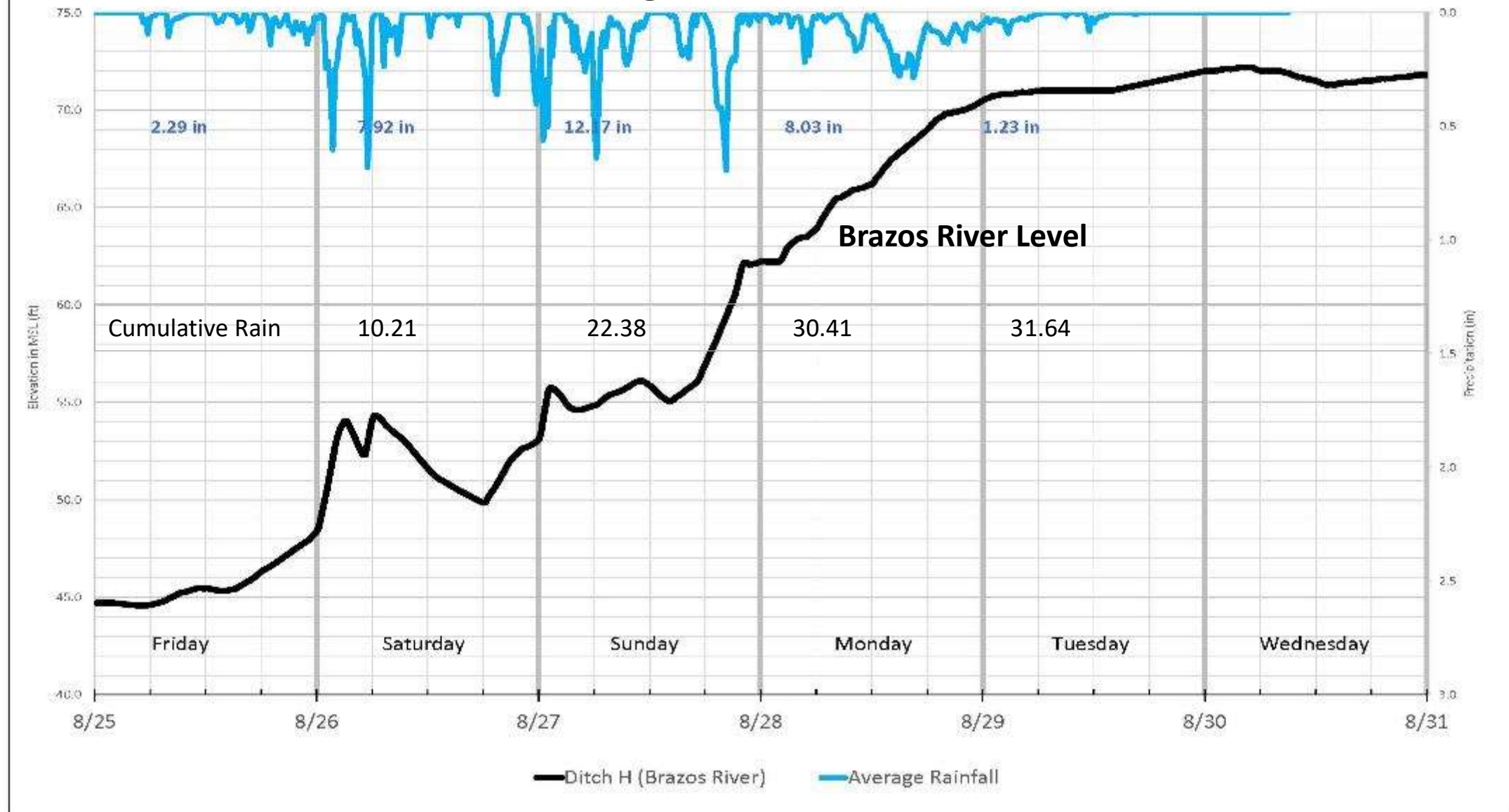




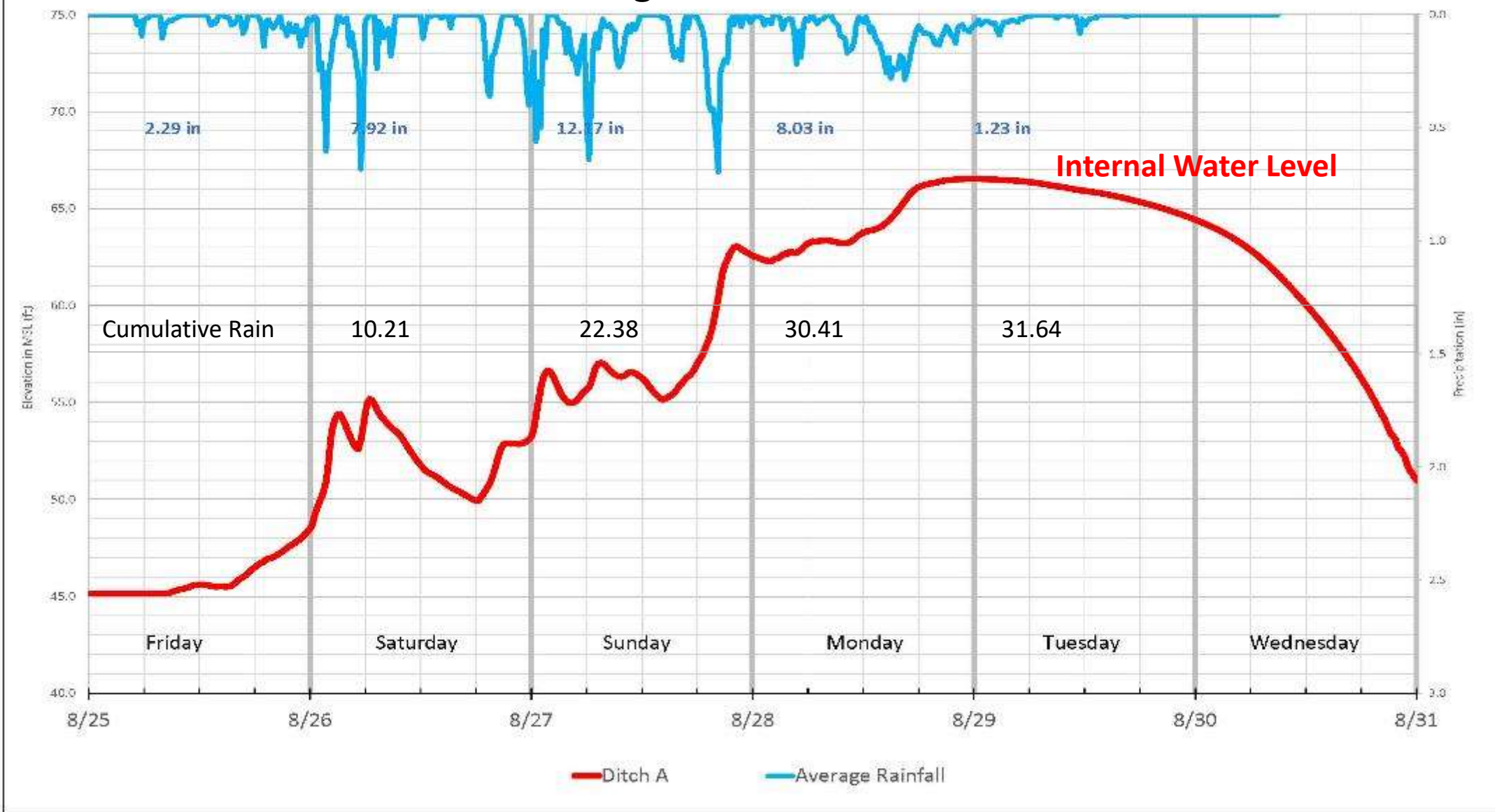
You don't know what you don't know!

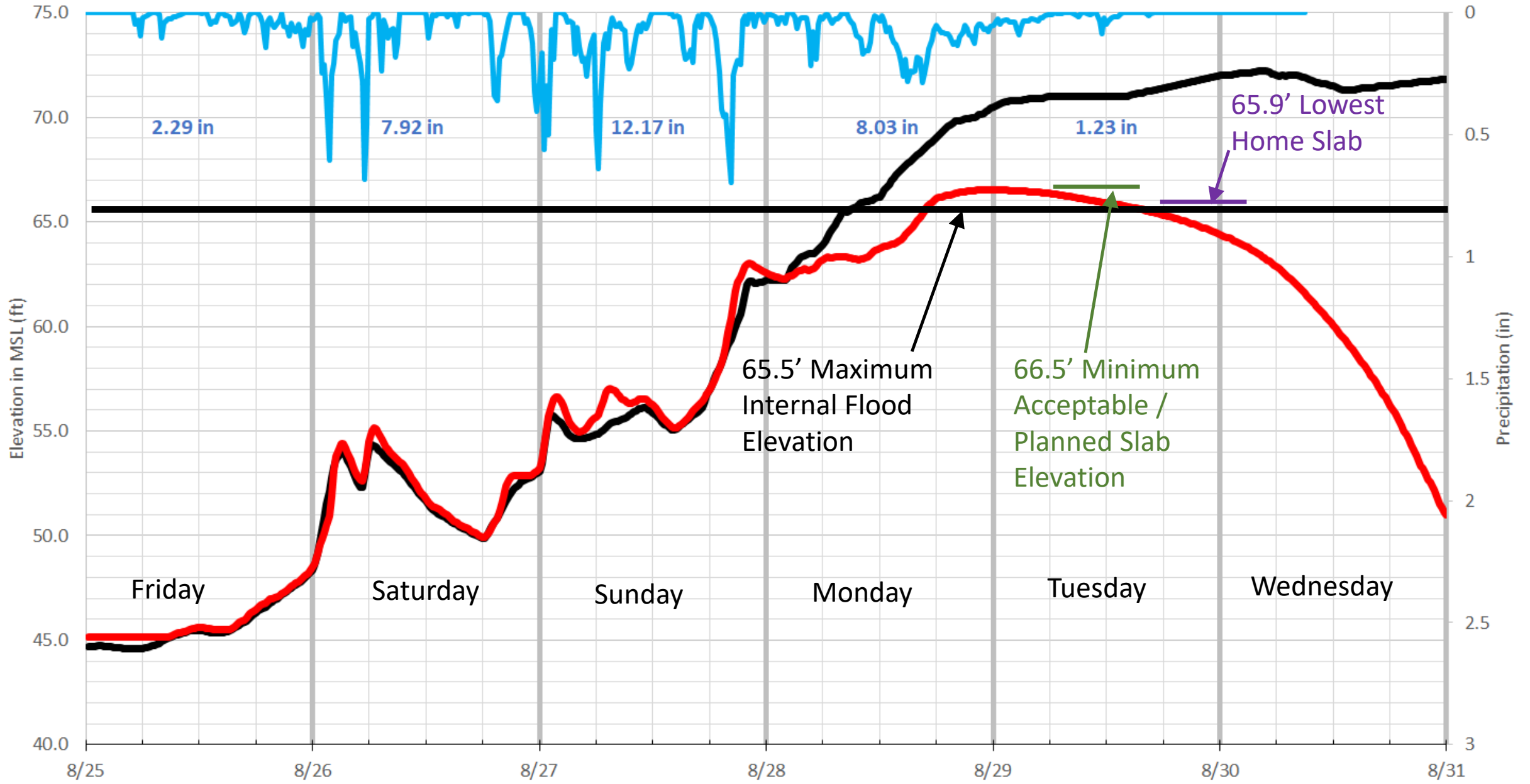
Most significant discovery during the post Harvey study was the number of homes with slab elevations below the minimum building slab elevation of 66.5'

Rainfall and Rising Levels of the Brazos River



Rainfall and Rising Levels Within the District





2018 ASFPM Annual Conference Phoenix AZ

— Ditch H (Brazos River) — Ditch A — Average Rainfall



Monday 11 September 2018

- First public meeting with 80+ homeowners who flooded
- City and District both presenting and available for questions
- Presented 8 point Action Plan
 - Survey work was already underway, about 30% complete at that point
 - Inundation study was underway
 - Data collection on all flooded homes about 50% complete



LID 2 – 8 Step Action Plan

1. Identify every affected home
2. Create a map showing all of the affected areas
3. Gather data:
 1. Slab elevation
 2. Curb elevation
 3. High water elevation
 4. Time water entered home
4. Determine exact cause of flooding
5. Determine possible corrective actions to prevent recurrence
6. Present findings to affected homeowners in a public meeting
7. Conduct a public meeting with all LID 2 residents about Harvey and the plan forward
8. Begin work on projects



Wednesday 20 September 2018

- Second public meeting with another 60-80 homeowners who had water in their homes
- Both City and District participating
- Update on the Action Plan
 - Nearly 90% of all homes identified and on the list
 - Survey work was about 75% complete
 - Inundation study using new survey data
 - Engineers working around the clock



Remainder of September and October 2018

- Multiple smaller meetings with groups of homeowners, neighborhood associations, etc.
- Multiple coordination meetings with engineers, City staff, County OEM staff, and elected officials
- Tremendous amount of leg work by the engineers and staff to collect data from every home that was flooded.



Last week of October 2018

- Inundation modeling & study complete
- Report on findings of all the survey data etc. prepared
- Multiple meetings to review this data
- Public meeting scheduled for all homeowners who suffered flooding
- 2nd public meeting scheduled for all residents

Wednesday 8 November 2018

1st Large Public Meeting



- Meeting was specifically organized for home owners who actually had water in their homes
- Approximately 150 attendees
- LID 2's meeting; City was available
- FEMA Representatives available
- Report on the findings of the study
- Reported on Actions the District was taking to prevent recurrence

Affected Area Within The District

230 structures
out of 10,000
structures within
the District had
between ½" and 8"
of water in them.



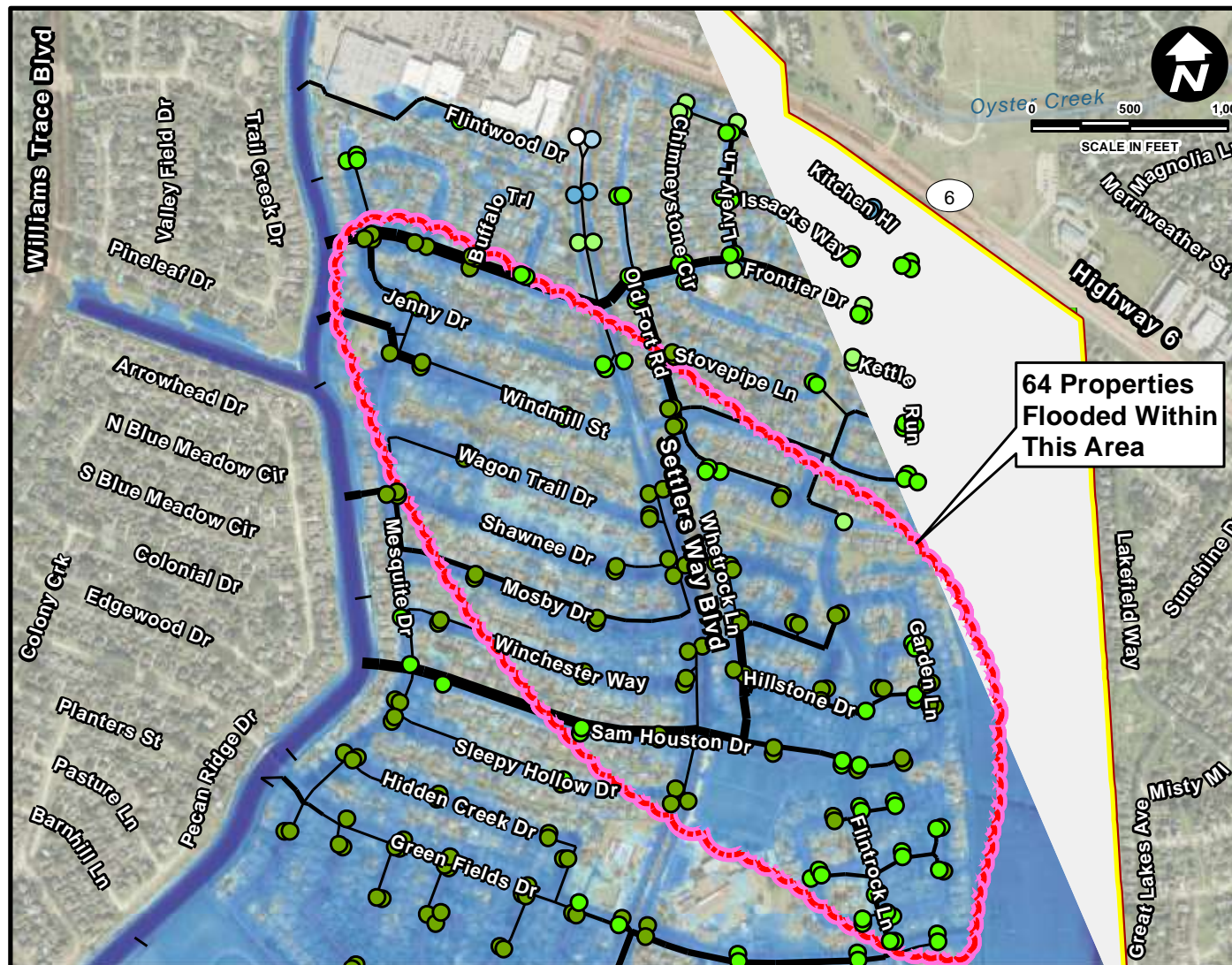


EXHIBIT 3
Hurricane Harvey Event
Peak Depths After Losing Gravity Outfall

Inundation Depth
High : 18.693
Low : 0

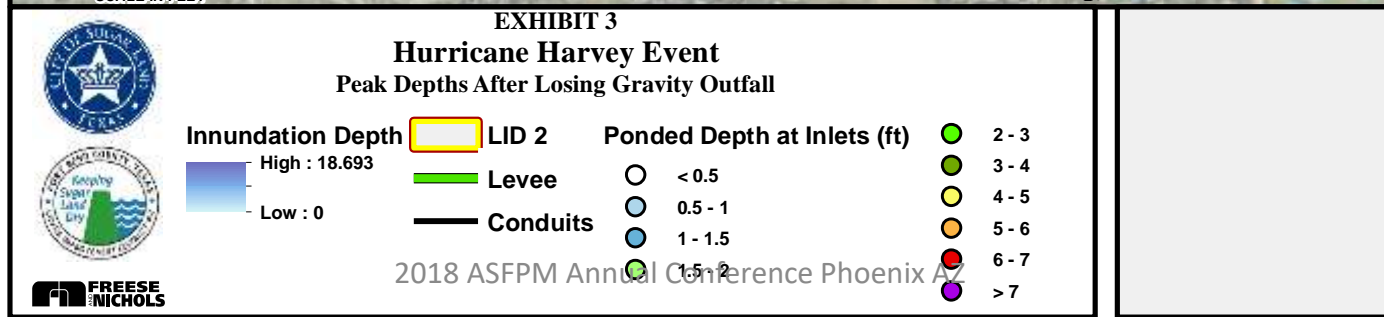
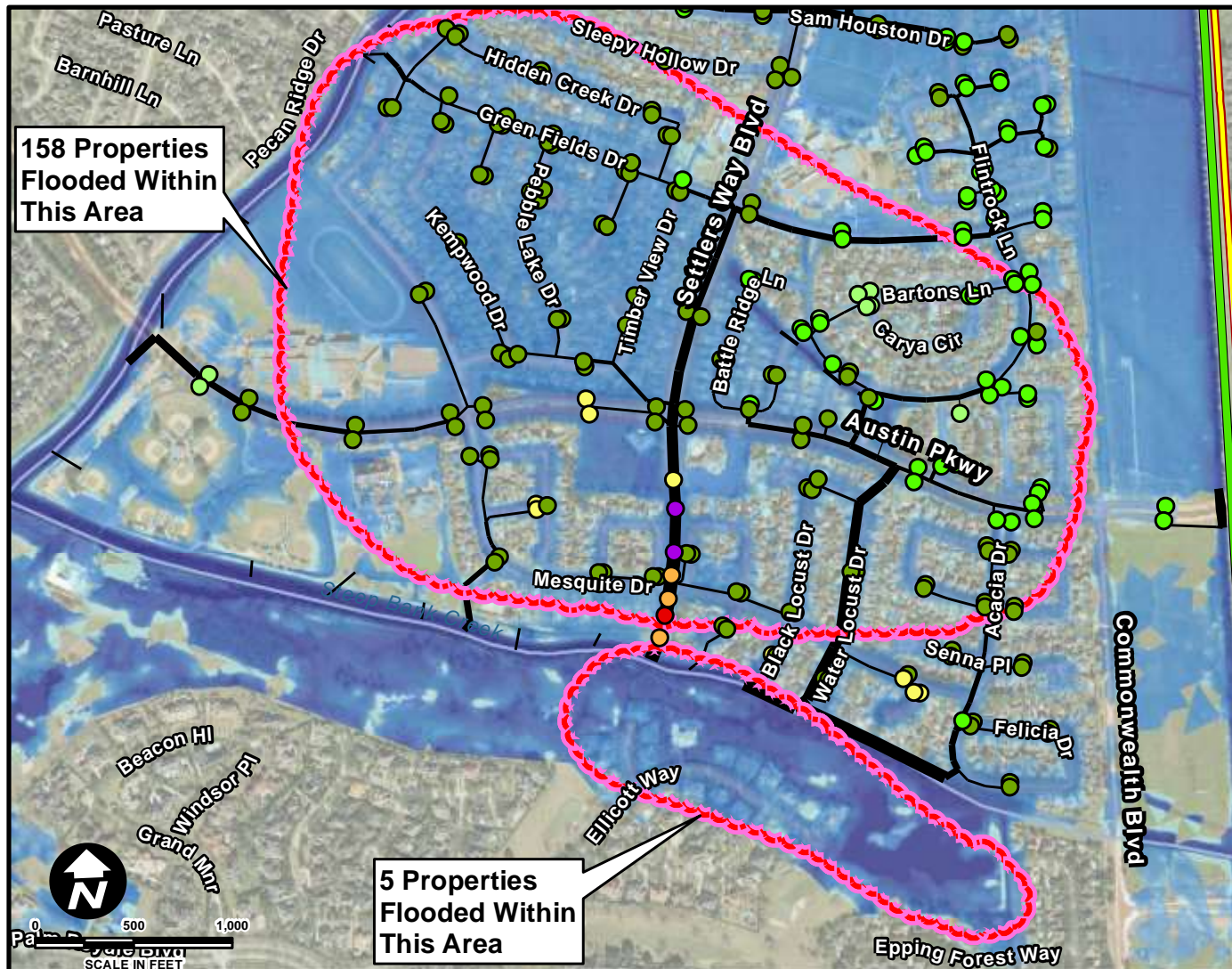
LID 2
Levee
Conduits

Ponded Depth at Inlets (ft)

○ < 0.5
○ 0.5 - 1
○ 1 - 1.5
○ 1.5 - 2

● 2 - 3
● 3 - 4
● 4 - 5
● 5 - 6
● 6 - 7
● > 7

2018 ASFPM Annual Conference Phoenix AZ



Tuesday 14 November 2018

2nd Large Public Meeting



- Approximately 200 attendees
- LID 2's meeting; City was available
- FEMA Representatives available
- Update on the Action Plan
- Report on the findings of the study
- Report on LID's plan to prevent recurrence



Ongoing Public Outreach

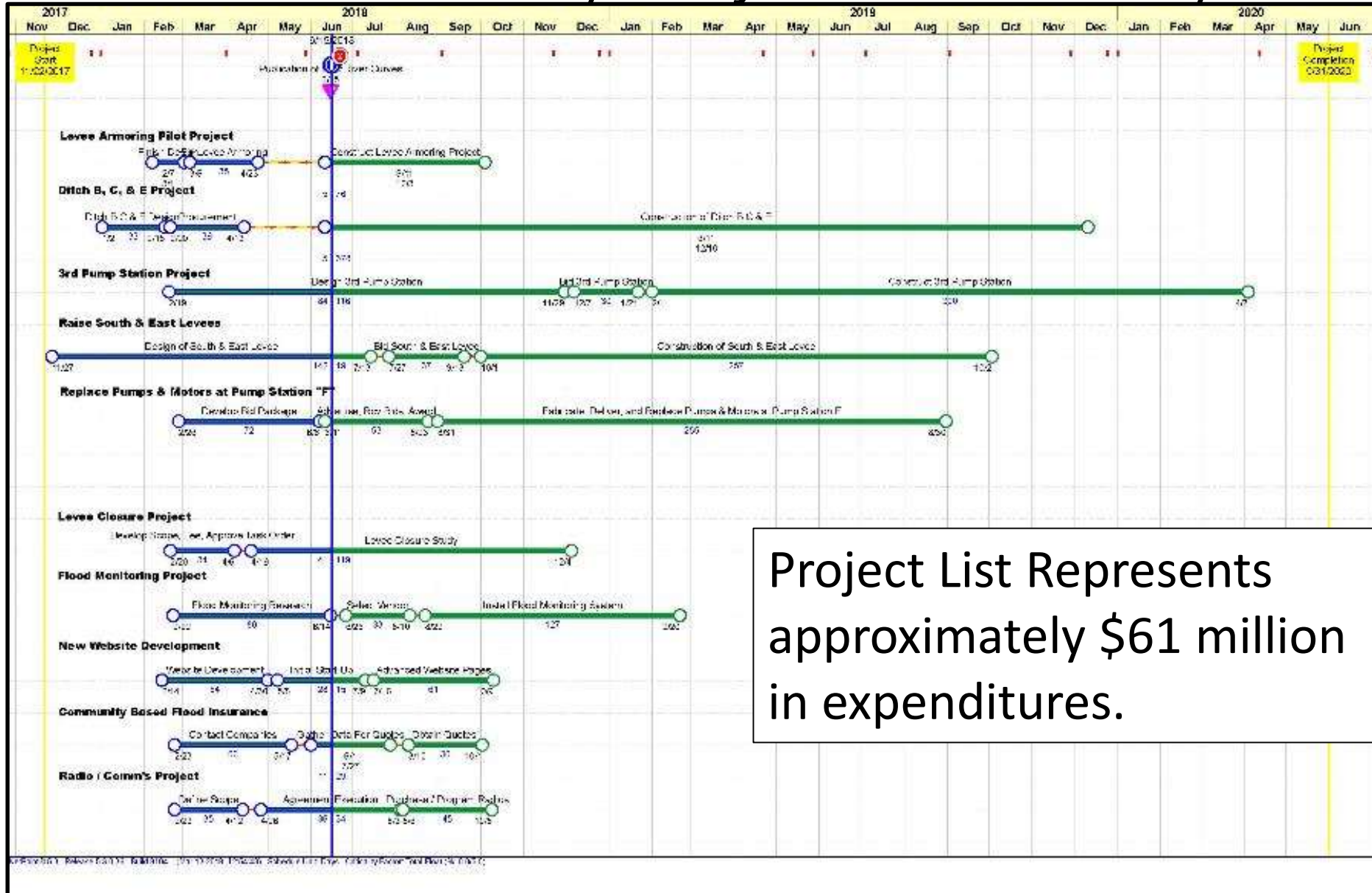
- Continuous public outreach
- Our policy is if any association can get at least 5 people together we'll go make a presentation on:
 - What the District does
 - What happened during Hurricane Harvey
 - What we're doing to make sure that we are "Keeping Sugar Land Dry"



Monday / Tuesday 11-12 December 2018

- Board Retreat
- Develop project list
 - 3rd Pump Station
 - Ditch Improvement Project
 - Levee Closure
- Set hard deadlines for completion

Series of Post Harvey Projects Underway





Big 3 Projects for FBC-LID 2

1. Improvements to Ditches B, C, & E
 - Bids received on March 28, 2018
 - Complete by August of 2019
2. Third Pump Station – Design is well underway
 - Design complete in 2018
 - 20 month construction period, complete in 3Q of 2020
3. Replacement of Pumps and Motors at Pump Station “F”
 - Bid package being prepared
 - Complete by June of 2019



Wednesday 4 April 2018

Public Update on Post Harvey Actions

- Approximately 200 attendees
- LID 2's meeting in Conjunction with City of Sugar Land
- Review of projects in progress
- Update on start and completion dates
- Update on potential tax impact



LID 2 - Funding

- **Levee District is funded solely by property taxes**
 - No Federal Funds
 - No State Funds
 - No County Funds
 - No City Funds



Impact of Projects on LID Tax Rates

- LID 2 has roughly \$5 billion in Taxable Assessed Value
- Current Tax Rate is \$0.111
- Average District Tax Rate in Ft Bend Count is \$0.32
- LID has authorization to sell \$48 million in bonds

Lessons Learned



- All emergency planning and exercises are good, but they are only a guide.
- **Share information** with your partners in the community
- **Do the right thing** – act decisively and quickly
- **Be open and honest with the public**, even when it is painful
- ***You don't know what you don't know***
- Have a reserve fund

“Without Flood Control, Nothing Else Matters”

Association of Levee Boards of Louisiana



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Questions / Comments?

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