Brazos River Modeling Workshop

FORT BEND COUNTY-WIDE DRAINAGE STUDY

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Vice President
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July 24th, 2020
Agenda

- Participation Guidelines
- Background
- Project Objectives
- Hydrologic Analysis
- Hydraulic Analysis
- Preliminary Results
- Next Steps
Participation Guidelines

Please utilize the chat function for general questions and comments (circled in red).

If you are not using your computer audio and wish to speak during the presentation:

- Please join the meeting from your computer **FIRST** using the link provided.
- Select “phone audio” to dial out to another audio device (circled in green).
- In the meeting, use the “raise hand” feature to request to be unmuted (circled in blue).
Background
Fort Bend – Countywide Watershed Study

• Brazos River Erosion Analysis
• Barker Reservoir Engagement
• FBCDCM Updates
• Master Drainage Plan Updates to Local Watersheds
• Brazos River Modeling Update
Previous FBC Brazos River Studies

• 1987 – Fort Bend County Enters NFIP

• 2014 FEMA Study
  – 2005 LiDAR & River Cross-Sections
  – Flood Frequency Analysis (164,000 cfs at Richmond)
  – HEC-RAS 1D Model
  – LIDs Respond / FEMA Certification
  – Effective April 2, 2014
Significant Changes

• 5 Major Flood Events
• 2014 LiDAR & 2019 Bathymetry
• 2016 – HEC-RAS 2D Modeling Released
• 2018 – Atlas 14 Released
• Various New Studies
  – BRA/Halff
  – RAMPP
  – USACE-FRM
Stated Study Goal

“Develop new hydrologic and hydraulic models that can be used to better understand how the Brazos River behaves during flood events and can be used in decision making during future floods.”

Study Leads:

– Héctor Olmos, Freese & Nichols Inc.
– Sam Hinojosa, Halff Associates Inc.
Hydrology
Hydrology Agenda

- Model History
- Model Updates and Calibration
- Historical Gage Frequency Analysis
- Design Storm Modeling
- Preliminary Conclusions
Brazos River – Study History

• Previous Studies along the Lower Brazos River
  – 1984 EHA Study
  – 2006 LJA Study
  – 2009 TSDN
  – 2015 RAMPP Study
  – 2019 BRA Study
    • Basic model developed for current study
  – 2020 USACE FRM Study
Brazos River – HEC-HMS Model Updates and Calibration

- Drainage Area Boundaries
- Unit Hydrograph Methods
- Losses based on 2016 and 2017
- Updated Routing
  - Brazos River from Bryan to Hempstead
  - Yegua Creek
  - Navasota River
- Calibration Events
  - Tax Day 2016
  - Memorial Day 2016
  - Hurricane Harvey 2017
Brazos River – Historical Gage Frequency Analysis

- Considered full period of record at Hempstead and Richmond
- Peak water year flows from USGS gage data
- Considered reservoir volumes
  - Unregulated (1951 and earlier)
  - Partially regulated (1982 to 1952)
  - Fully regulated (1953 and after)
- Calculated Flood Frequency Analysis

Conversion Process

\[ y = 14.693 \times V^{0.5807} \quad R^2 = 0.8595 \]

\[ y = 1.8416 \times V^{0.7538} \quad R^2 = 0.9811 \]
# Brazos River – Historical Gage Frequency Analysis

**Full POR Results**

<table>
<thead>
<tr>
<th>Event</th>
<th>Unregulated Flows at Hempstead (CFS)</th>
<th>Unregulated Flows at Richmond (CFS)</th>
<th>Regulated Flows at Hempstead (CFS)</th>
<th>Regulated Flows at Richmond (CFS)</th>
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<tbody>
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<td>500-Year</td>
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<td>50-Year</td>
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<td>10-Year</td>
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<td>150,000</td>
<td>96,000</td>
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<td>77,000</td>
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<table>
<thead>
<tr>
<th>Gage Location</th>
<th>Regulated 100-Year, 5% CI (CFS)</th>
<th>Regulated 100-Year, 95% CI (CFS)</th>
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<tr>
<td>Hempstead</td>
<td>184,000</td>
<td>130,000</td>
</tr>
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<td>Richmond</td>
<td>152,000</td>
<td>112,000</td>
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</table>

*All results are preliminary and subject to further investigation.*
Brazos River – Historical Gage Frequency Analysis

**FFA Scenarios**

- Sensitivity analysis was conducted with FFA inputs

<table>
<thead>
<tr>
<th>Name</th>
<th>Time</th>
<th>Conversion (unreg/reg) Used</th>
<th>Historic Events Used</th>
<th>Adjusted with 2D Model</th>
<th>FFA 1% Flow*</th>
<th>FFA 5% CI*</th>
<th>FFA 95% CI*</th>
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<tbody>
<tr>
<td>Current Study</td>
<td>POR</td>
<td>X</td>
<td>X</td>
<td></td>
<td>132,000</td>
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<td>X</td>
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<td>118,000</td>
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</table>

FFA results indicate that the 100-year flow is in the 130,000 – 140,000 cfs range. Effective flow is 164,000 cfs.

*All results are preliminary and subject to further investigation.*
*All results are preliminary and subject to further investigation.
Brazos River – Preliminary Conclusions

*All results are preliminary and subject to further investigation.*
Brazos River – Design Storm Modeling

• Reduction Factors
  – Areas up to 20,000 sq. mi. utilize USACE SWF Curve
  – Areas greater than 20,000 sq. mi. consider Harvey

<table>
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<th>Ellipse</th>
<th>Area of Ellipse (sq mi)</th>
<th>Areal Reduction Factors</th>
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<td>1.00</td>
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<tr>
<td>B</td>
<td>100</td>
<td>0.96</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>0.92</td>
</tr>
<tr>
<td>D</td>
<td>1,000</td>
<td>0.85</td>
</tr>
<tr>
<td>E</td>
<td>2,000</td>
<td>0.82</td>
</tr>
<tr>
<td>F</td>
<td>3,000</td>
<td>0.80</td>
</tr>
<tr>
<td>G</td>
<td>4,000</td>
<td>0.77</td>
</tr>
<tr>
<td>H</td>
<td>5,000</td>
<td>0.74</td>
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<tr>
<td>I</td>
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<td>J</td>
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<td>0.51</td>
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<tr>
<td>K</td>
<td>60,000</td>
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<tr>
<td>L</td>
<td>100,000</td>
<td>0.09</td>
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<tr>
<td>M</td>
<td>200,000</td>
<td>0.03</td>
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</table>
Brazos River – Design Storm Modeling

• Respective Atlas 14 rainfall depth applied at center of storm
  – Reduced by areal reduction curves as distance from center increases

• Storms placed on 20-mile grid
  – Basic orientation aligns with basin shape
# Brazos River – Design Storm Modeling

## Results - Hempstead

<table>
<thead>
<tr>
<th>Centering</th>
<th>Q Peak (cfs)</th>
<th>Pct Diff from Target</th>
<th>Volume (ac-ft)</th>
<th>Peak Stage (ft)</th>
<th>Centering</th>
<th>Q Peak (cfs)</th>
<th>Pct Diff from Target</th>
<th>Volume (ac-ft)</th>
<th>Peak Stage (ft)</th>
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<td>3,424,954</td>
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<td>A11</td>
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<td>3,601,268</td>
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<td>-3%</td>
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<td>E10</td>
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<td>F8</td>
<td>184,083</td>
<td>11%</td>
<td>3,133,320</td>
<td>165.83</td>
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<td>150,290</td>
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<td>186,092</td>
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<td>3,238,367</td>
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<td>-14%</td>
<td>2,373,149</td>
<td>162.72</td>
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<td>191,232</td>
<td>15%</td>
<td>3,321,986</td>
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<td>3,298,670</td>
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<td>F12</td>
<td>163,591</td>
<td>-1%</td>
<td>3,145,002</td>
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<td>K7</td>
<td>150,480</td>
<td>-9%</td>
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<td>G8</td>
<td>169,964</td>
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<td>148,529</td>
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<td>2,463,287</td>
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<td>166,195</td>
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<td>144,879</td>
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<td>120,272</td>
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<td>N6</td>
<td>96,642</td>
<td>-42%</td>
<td>1,460,847</td>
<td>157.57</td>
</tr>
</tbody>
</table>

**Orange**: Within +10% of FFA 100-year target flow  
**Green**: Within +5% of FFA 100-year target flow  

*All results are preliminary and subject to further investigation.*
## Brazos River – Design Storm Modeling

### Results - Richmond

<table>
<thead>
<tr>
<th>Centering</th>
<th>Q Peak (cfs)</th>
<th>Pct Diff from Target</th>
<th>Volume (ac-ft)</th>
<th>Peak Stage (ft)</th>
<th>Centering</th>
<th>Q Peak (cfs)</th>
<th>Pct Diff from Target</th>
<th>Volume (ac-ft)</th>
<th>Peak Stage (ft)</th>
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<tbody>
<tr>
<td>A9</td>
<td>161,786</td>
<td>18%</td>
<td>3,875,136</td>
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<td>8%</td>
<td>3,483,756</td>
<td>84.16</td>
<td>L8</td>
<td>121,700</td>
<td>-11%</td>
<td>2,734,503</td>
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<tr>
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<td>3,361,032</td>
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<td>1,849,554</td>
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**Orange**  Within +10% of FFA 100-year target flow  
**Green**   Within +5% of FFA 100-year target flow

*All results are preliminary and subject to further investigation.*
### Brazos River – Preliminary Conclusions

**• Considerations**

– Peak Flows within +5.0% of FFA 100-year target flow (green highlight)

<table>
<thead>
<tr>
<th>Centering</th>
<th><strong>Hempstead</strong></th>
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<th><strong>Richmond</strong></th>
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<td></td>
<td><strong>Q Peak (cfs)</strong></td>
<td><strong>Pct Diff from Target</strong></td>
<td><strong>Volume (ac-ft)</strong></td>
<td><strong>Peak Stage (ft)</strong></td>
<td><strong>Q Peak (cfs)</strong></td>
<td><strong>Pct Diff from Target</strong></td>
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<td>191,232</td>
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<tr>
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<td>184,083</td>
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<td>151,592</td>
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</tr>
</tbody>
</table>

*Orange* Within +10% of FFA 100-year target flow  
*Green* Within +5% of FFA 100-year target flow

*All results are preliminary and subject to further investigation.*
Questions on Hydrology?

Memorial Day 2016 at Big Creek Diversion
Hydraulics
Hydraulics – Previous Studies

• FEMA effective model
  – 2005 topography
  – 1D hydraulic model
  – Steady flow (snapshot in time)
  – Does not account for storage

• BRA Study
  – Completed in 2019
  – 1D hydraulic model
  – Unsteady flow (varies over time)
  – Calibrated to several storms, including Harvey
  – Better accounting of storage
  – Extents from HWY-290 to the Gulf
  – Used pre-Harvey field survey and LiDAR
  – Used effective model within Fort Bend County
Hydraulics – Approach

• Current study
  – Best available topography + bathymetry
  – 2D hydraulic model
  – Unsteady flow (varies over time)
  – Best way of accounting for storage
  – Calibrated to Memorial Day 2016, Harvey, in-bank flows
  – Extents from HWY-290 to Harris Reservoir (Brazoria Co.)
  – 1D/2D hydraulic model in the works
Hydraulics – Topography

• Vertical Datum: NAVD88

• LiDAR
  – 2014 LiDAR for Fort Bend County
  – 2018 LiDAR for Brazoria County
  – Most current LiDAR for:
    • Waller
    • Austin
    • Washington

• Bathymetry & In-channel LiDAR
  – Collected by ERDC (USACE) in March 2019

• Survey from BRA study
  – Incorporated survey into terrain
Hydraulics – Topography
Hydraulics – Bathymetry (ERDC Survey)

LiDAR only

LiDAR + Bathymetry

Terrain Profile Plot

Brazos, Combined
Hydraulics – Calibration

- Hydraulic Calibration
  - Memorial Day 2016
  - Harvey
  - Winter 18/19

- Calibrated to:
  - Stages at USGS gages
    - Hempstead
    - San Felipe
    - Richmond
    - Rosharon
  - FBCDD stages
    - FM 1093
    - FM 1489
    - FM 723
    - US 59

- Used verified HWM as a check
Hydraulics – Calibration Points
Memorial Day 2016
Brazos River – Memorial Day 2016
Brazos River – Memorial Day 2016

FM 1093, Stages (Memorial Day 2016)
Brazos River – Memorial Day 2016

FM 1489, Stages (Memorial Day 2016)
Brazos River – Memorial Day 2016
Brazos River – Memorial Day 2016

Peak Flow: 121,000 cfs
Brazos River – Memorial Day 2016

US 59, Stages (Memorial Day 2016)
Brazos River – Memorial Day 2016

Rosharon, Stages (Memorial Day 2016)
PROFILE – Memorial Day 2016

Water Surface Elevation Profiles, Memorial Day - 2016

- Rosharon
- FM Road 1462
- Big Creek
- Big Creek Diversion
- Lower Oyster Creek
- Briscoe PS (GCWA/FBCDD)
- Ray PS (GCWA/FBCDD)
- ATSP-Harvey
- Flat Rock Creek
- Sienna North
- Sienna South
- Palmer Plant

Legend:
- **Dashed Line:** Memorial Day - 2016
- **Solid Line:** Key Locations
- **Arrows:** Levees
- **X:** HWM - Memorial Day

Station along FEMA FIS Centerline (ft)

Elevation (ft)
PROFILE – Memorial Day 2016
PROFILE – Memorial Day 2016
PROFILE – Memorial Day 2016
Harvey
Brazos River – Harvey

Hempstead, Stages (Harvey)
Brazos River – Harvey

San Felipe, Stages (Harvey)
Brazos River – Harvey
Brazos River – Harvey

FM 1489, Stages (Harvey)
Brazos River – Harvey
Brazos River – Harvey

Richmond, Stages (Harvey)

Peak Flow: 131,000 cfs
Brazos River – Harvey
Brazos River – Harvey

Rosharon, Stages (Harvey)

- USGS
- FNI Model
PROFILE – Harvey

Water Surface Elevation Profiles, Harvey - 2017

Station along FEMA FIS Centerline (ft)

- Harvey - 2017
- Key Locations
- Levees
- HWM - Harvey

Profiles include:
- Saratoga PS (GCWA/FBCDD)
- May PS (GCWA/FBCDD)
- Flat Bank (LJA)
- Flat Bank Creek
- FM Road 1462
- Big Creek
- Big Creek Diversion
- Levee Oyster Creek
- Half way Sienna North (LJA)
- Sienna S gravity (LJA)
- Sienna S PS (LJA)
- Sienna North
- Briscoe PS (GCWA/FBCDD)
- Palmer Plant
- Sienna South
- ATSP-Ramar
PROFILE – Harvey

Water Surface Elevation Profiles, Harvey - 2017

Station along FEMA FIS Centerline (ft)

- Harvey - 2017
- Key Locations
- Levees
- HWM - Harvey
PROFILE – Harvey
PROFILE – Harvey

Water Surface Elevation Profiles, Harvey - 2017

Station along FEMA FIS Centerline (ft)

- Harvey - 2017
- Key Locations
- Levees
- HWM - Harvey
PROFILE – Harvey
Winter 18/19
Brazos River – Winter

Hempstead, Stages (Winter 2018)
Brazos River – Winter

San Felipe, Stages (Winter 2018)
Brazos River – Winter
Brazos River – Winter

Rosharon, Stages (Winter 2018)
Validation (Tax Day 2016)
Brazos River – Tax Day 2016

Hempstead, Stages (Tax Day)
Brazos River – Tax Day 2016

San Felipe, Stages (Tax Day)
Brazos River – Tax Day 2016
Brazos River – Tax Day 2016

Rosharon, Stages (Tax Day)

10 15 20 25 30 35 40 45 50 55

USGS Validation
# Manning’s n values

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<th>Memorial Day 2016</th>
<th></th>
<th>Harvey</th>
<th></th>
<th>Winter 18/19</th>
<th></th>
<th>Existing Conditions*</th>
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<td>Maximum</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Minimum</td>
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<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
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</tbody>
</table>

* Existing conditions n values calculated as: 1/3 Memorial Day n value + 2/3 Harvey n value
Main Channel Reaches
Memorial Day 2016 at FM 723
Comparison of 100-yr elevations (PRELIMINARY)
DISCLAIMER

• Flows
  – Preliminary flows: Scenario 6

• Elevation datum
  – NAVD88 (Same as 2014 LiDAR)

• Topography
  – 2014 LiDAR

• Limitations (2D only)
  – Doesn’t include bridges

• Results are subject to change
## PRELIMINARY 100-YR WSEL

<table>
<thead>
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<th>Gage</th>
<th>Effective</th>
<th>BRA Study</th>
<th>Preliminary</th>
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<tbody>
<tr>
<td>Richmond</td>
<td>82.80’</td>
<td>84.43’</td>
<td>83.03’</td>
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<tr>
<td>Rosharon</td>
<td>51.50’</td>
<td>51.29’</td>
<td>51.21’</td>
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</tbody>
</table>
PRELIMINARY 100-YR PROFILE
PRELIMINARY 100-YR PROFILE

Water Surface Elevation Profiles, 100-yr (Preliminary)

Station along FEMA FIS Centerline (ft)

Elevation (ft)

- FEMA FIS WSE
- Prelim 100-yr
- BRA 1D
- Key Locations
- Levees
PRELIMINARY 100-YR PROFILE
PRELIMINARY 100-YR PROFILE

Water Surface Elevation Profiles, 100-yr (Preliminary)

Station along FEMA FIS Centerline (ft)

Elevation (ft)

FEMA FIS WSE
Prelim 100-yr
BRA 1D
Key Locations
Levees
PRELIMINARY 100-YR PROFILE
PRELIMINARY 100-YR (Brazos River only)
100-yr and 500-yr profiles (PRELIMINARY)
DISCLAIMER

• Flows
  – Preliminary flows: Scenario 6

• Elevation datum
  – NAVD88 (Same as 2014 LiDAR)

• Topography
  – 2014 LiDAR

• Limitations (2D only)
  – Doesn’t include bridges

• Results are subject to change
**PRELIMINARY 100 and 500-YR WSEL**

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<th>Gage</th>
<th>100-yr</th>
<th>500-yr</th>
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<tbody>
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<td>84.73’ (57.71)</td>
</tr>
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<td>Rosharon</td>
<td>51.21’ (52.63)</td>
<td>51.74’ (53.16)</td>
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</tbody>
</table>

Numbers in parenthesis correspond to stage at USGS gages
PRELIMINARY 100 and 500-YR PROFILES
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Water Surface Elevation Profiles, 100-500-yr (Preliminary)
100-yr and 500-yr elevations
Levee Improvement Districts
(PRELIMINARY)
LEVEE IMPROVEMENT DISTRICTS
DISCLAIMER

• Flows
  – Preliminary flows: Scenario 6

• Elevation datum
  – NAVD88 (Same as 2014 LiDAR)

• Topography
  – 2014 LiDAR

• Limitations (2D only)
  – Doesn’t include bridges

• Results are subject to change
LID20 – Preliminary 100-yr WSEL

93.32’

89.80’

88.90’

91.10’

91.90’

93.17’
LID20 – Preliminary 500-yr WSEL
Pecan Grove – Preliminary 100-yr WSEL
Pecan Grove – Preliminary 500-yr WSEL
LID6 & MUD121 – Preliminary 100-yr WSEL

82.60’

81.74’

79.77’

79.14’

78.60’

78.53’

78.38’

72.59’
LID6 & MUD121 – Preliminary 500-yr WSEL

- 84.30'
- 83.46'
- 82.16'
- 81.04'
- 80.42'
- 80.34'
- 80.22'
- 74.00'
LID10—Preliminary 100-yr WSEL

77.43'
76.90'
76.19'
78.00'
75.80'
75.48'
78.38'
LID10– Preliminary 500-yr WSEL
LID11– Preliminary 100-yr WSEL

75.32'
75.13'
75.13'
72.59'
74.96'
73.92'
73.11'
LID11—Preliminary 500-yr WSEL
LID7– Preliminary 100-yr WSEL
LID7– Preliminary 500-yr WSEL

81.21’
80.50’
79.85’
79.67’
78.52’
78.38’
78.22’
77.60’
77.44’
79.47’
LID17– Preliminary 100-yr WSEL

73.00’

72.76’

72.68’

75.84’

75.65’

74.23’

75.65’

75.10’

72.68’
LID17– Preliminary 500-yr WSEL
LID14 and FC LID2 – Preliminary 100-yr WSEL
LID14 and FC LID2—Preliminary 500-yr WSEL
LID2– Preliminary 100-yr WSEL

Dam 3 not modeled

70.00’

64.12’

72.68’
LID2– Preliminary 500-yr WSEL

- 74.09’
- 73.34’
- 74.03’
- 70.59’
- 65.26’

Dam 3 not modeled
FCLID– Preliminary 100-yr WSEL

Dam 3 not modeled

70.00’

66.70’

63.84’
FCLID– Preliminary 500-yr WSEL

Dam 3 not modeled

- 70.59’
- 67.13’
- 65.18’
- 65.26’
- 66.70’
- 65.11’
- 65.18’
- 65.11’
MUD46, MUD49, Palmer P. – Preliminary 100-yr WSEL
LID15 and LID19– Preliminary 100-yr WSEL
LID15 and LID19—Preliminary 500-yr WSEL
Sienna North – Preliminary 100-yr WSEL
Sienna North – Preliminary 500-yr WSEL
Sienna South – Preliminary 100-yr WSEL
Sienna South – Preliminary 500-yr WSEL
1D/2D Hydraulic Model
1D/2D Hydraulic Model

- Utilizes cross sections to represent river channel
- Utilizes 2D to represent overbanks (floodplain)
- Most accurate type of hydraulic model
- Includes bridges
- Oyster Creek, Bullhead Bayou, Ditch H, Brooks Lake Diversion
- Uses same topography as 2D model

- Model being calibrated
1D/2D Hydraulic Model
1D/2D Hydraulic Model
NEXT STEPS

• Finalize selection of flows and storm
• Finalize 1D/2D hydraulic model
• 2\textsuperscript{nd} and final workshop (1D/2D results)
• Draft deliverables (models/report/profiles/maps)
  – Available for review in early Fall
• Final deliverables 4\textsuperscript{th} quarter 2020
• Coordination with NWS
Final Questions?

Memorial Day 2016 near Thompsons