Brazos River Modeling Workshop

Fort Bend County-Wide Drainage Study

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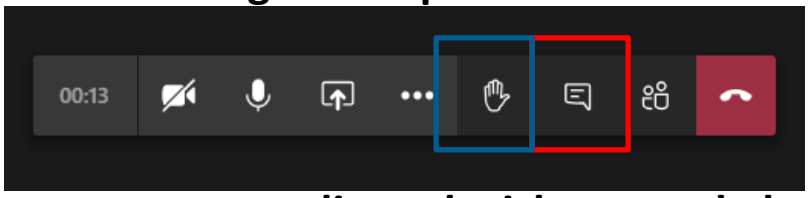
July 24th, 2020

Agenda

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

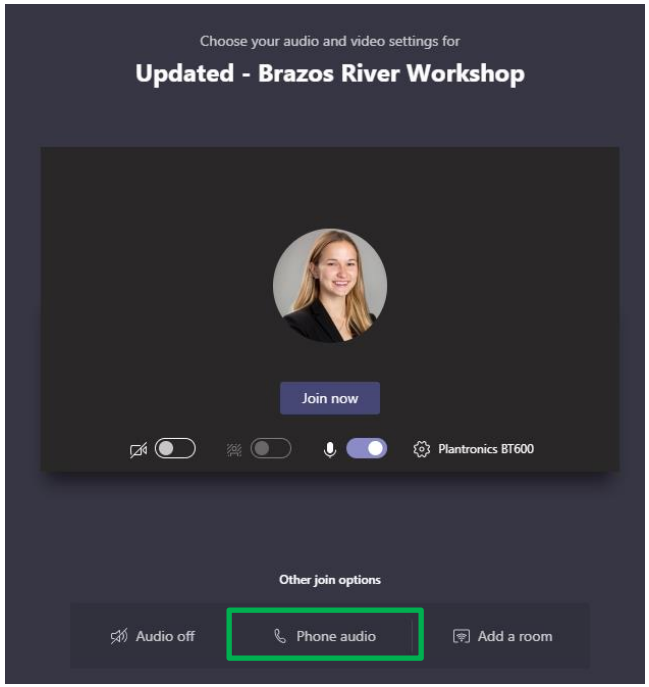
Participation Guidelines

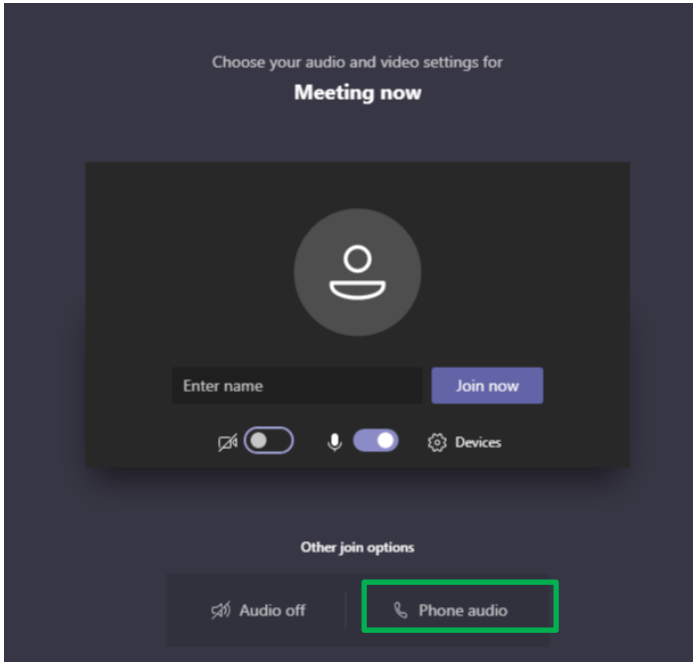
Please utilize the chat function for general questions and comments (circled in red)



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."

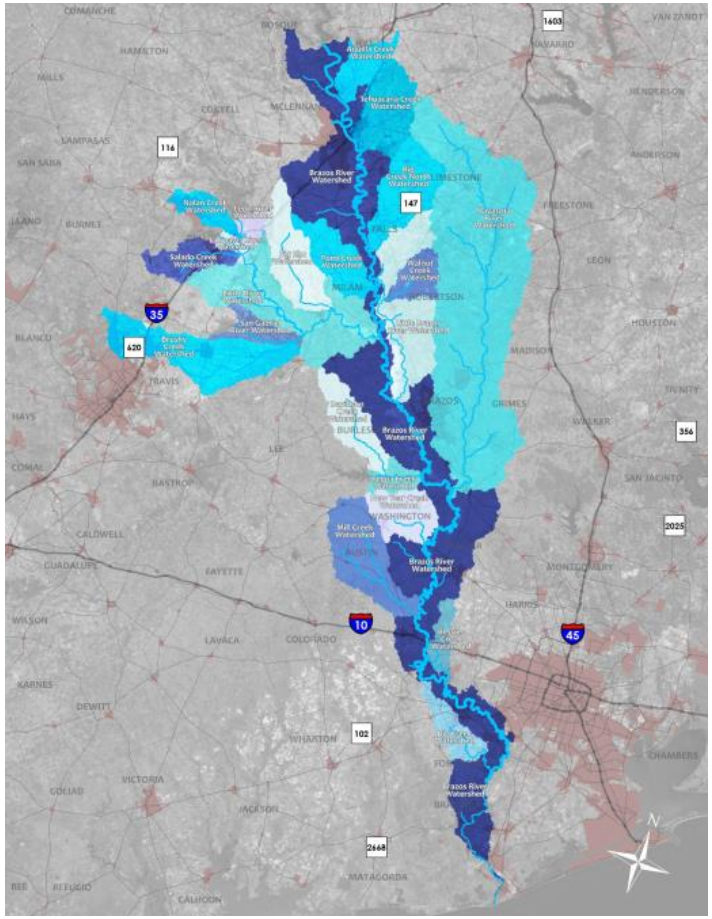
Study Leads:

- Héctor Olmos, Freese & Nichols Inc.
- Sam Hinojosa, Halff Associates Inc.

Hydrology

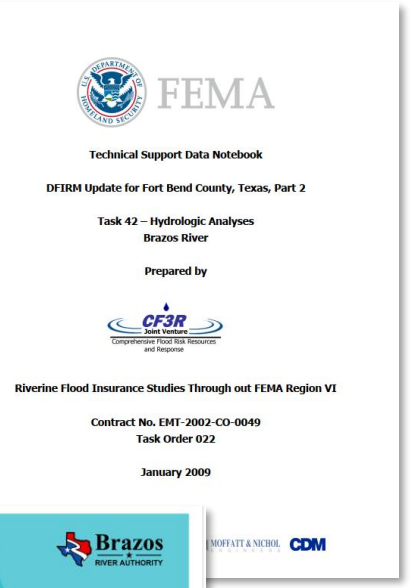
Hydrology Agenda

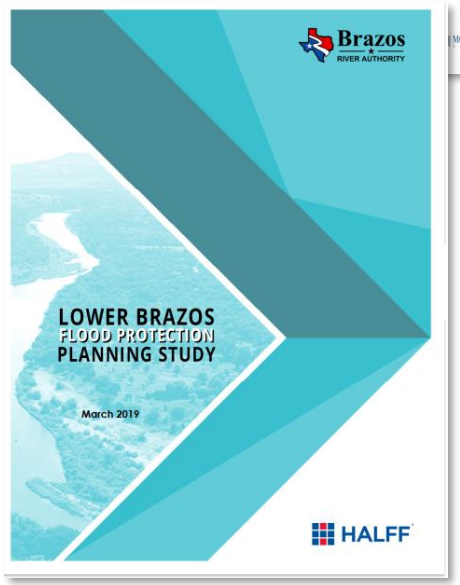
- Model History
- Model Updates and Calibration
- Historical Gage Frequency Analysis
- Design Storm Modeling
- Preliminary Conclusions



Brazos River – Study History

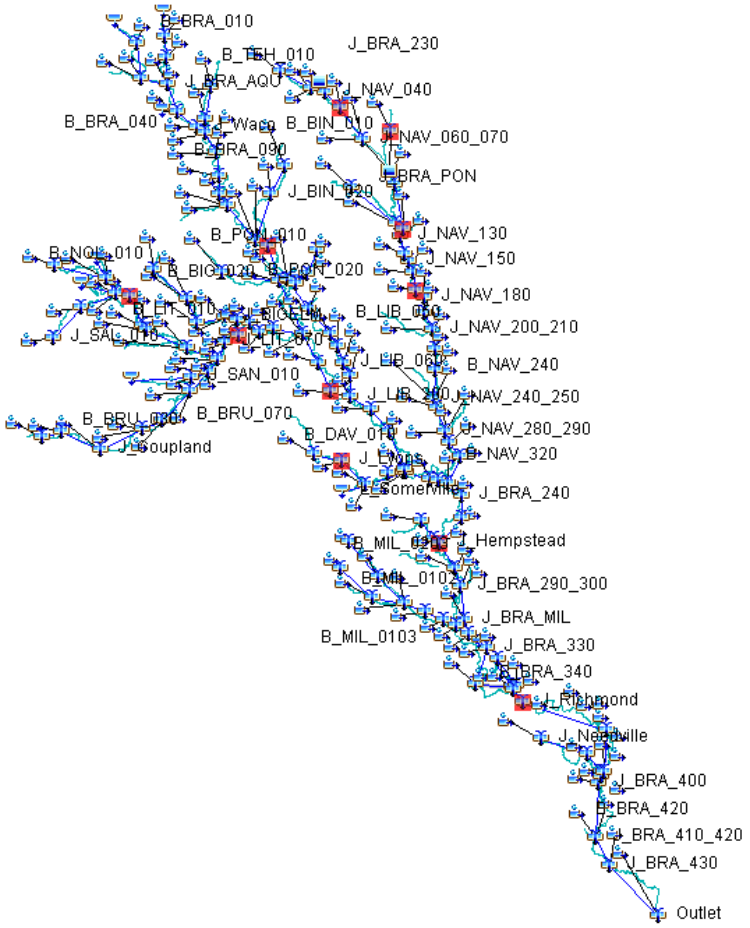
- Previous Studies along the Lower Brazos River
  - 1984 EHA Study
  - 2006 LJA Study
  - 2009 TSDN
  - 2015 RAMPP Study
  - 2019 BRA Study
    - Basic model developed for current study
  - 2020 USACE FRM Study





Brazos River – HEC-HMS Model Updates and Calibration

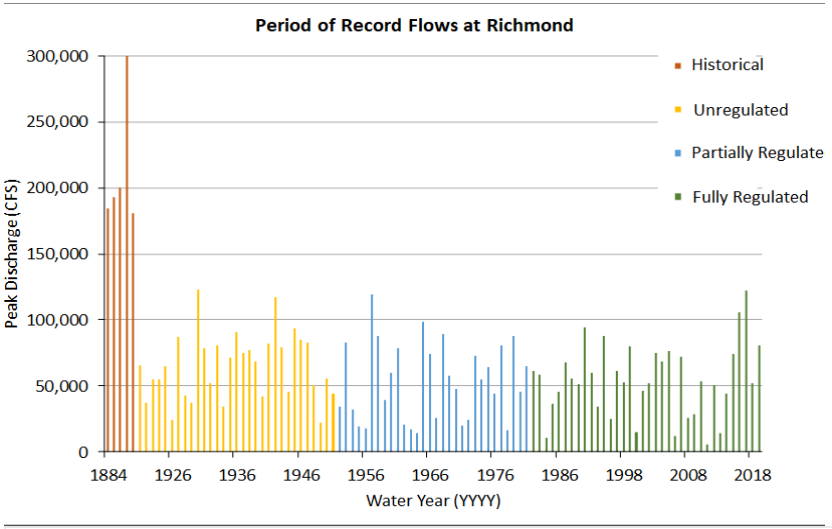
- Drainage Area Boundaries
- Unit Hydrograph Methods
- Losses based on 2016 and 2017
- Updated Routing
  - Brazos River from Bryan to Hempstead
  - Yegua Creek
  - Navasota River
- Calibration Events
  - Tax Day 2016
  - Memorial Day 2016
  - Hurricane Harvey 2017

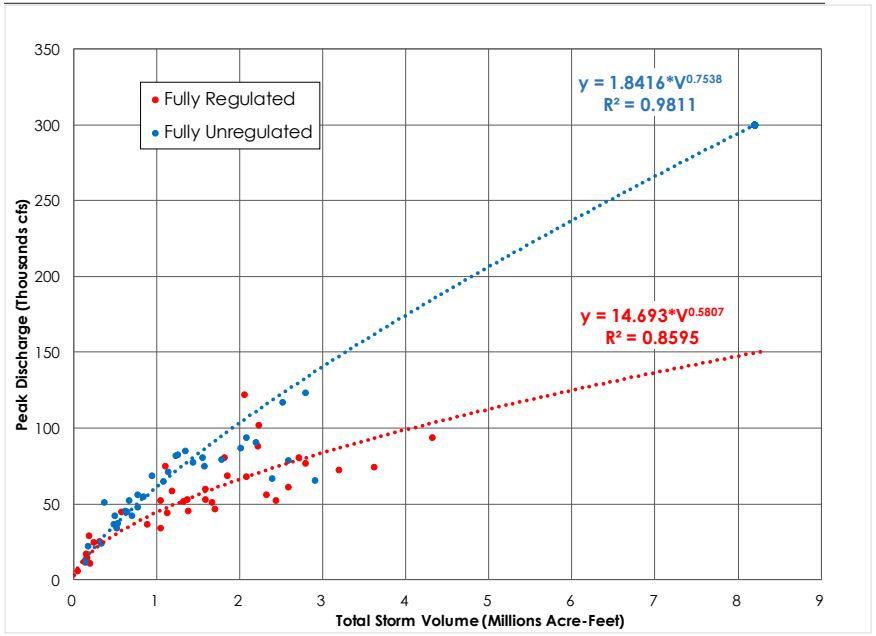


Brazos River – Historical Gage Frequency Analysis

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

Conversion Process





Brazos River – Historical Gage Frequency Analysis

Full POR Results

Event	Unregulated Flows at Hempstead (CFS)	Unregulated Flows at Richmond (CFS)	Regulated Flows at Hempstead (CFS)	Regulated Flows at Richmond (CFS)
500-Year	325,000	310,000	193,000	156,000
100-Year	254,000	249,000	**155,000**	**132,000**
50-Year	223,000	221,000	138,000	120,000
10-Year	148,000	150,000	96,000	89,000
5-Year	115,000	117,000	77,000	74,000
2-Year	66,000	67,000	48,000	48,000

Gage Location	Regulated 100-Year, 5% CI (CFS)	Regulated 100-Year, 95% CI (CFS)
Hempstead	184,000	130,000
Richmond	152,000	112,000

**All results are preliminary and subject to further investigation.*

Brazos River – Historical Gage Frequency Analysis

FFA Scenarios

- Sensitivity analysis was conducted with FFA inputs

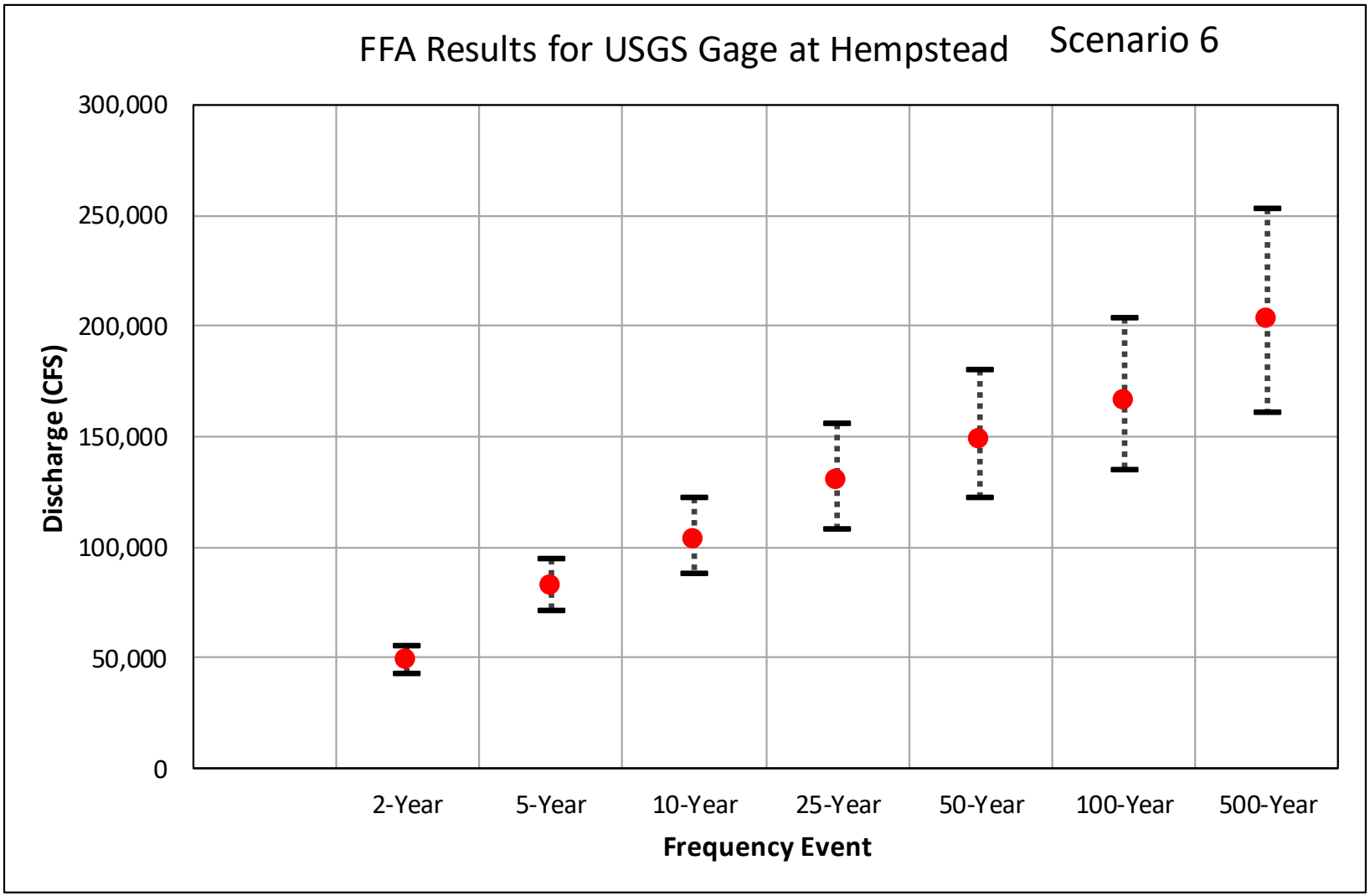
Name	Time	Conversion (unreg/reg) Used	Historic Events Used	Adjusted with 2D Model	FFA 1% Flow*	FFA 5% CI*	FFA 95% CI*
Current Study	POR	X	X		**132,000**	152,000	112,000
Scenario 1	Regulated				**127,000**	174,000	101,000
Scenario 2	POR	X			**115,000**	134,000	101,000
Scenario 3	POR	X	X	X	**132,000**	153,000	113,000
Scenario 4	POR				**134,000**	160,000	116,000
Scenario 5	Regulated			X	**135,000**	186,000	106,000
Scenario 6	POR			X	**137,000**	162,000	118,000

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.*

Brazos River – Preliminary Conclusions

Hempstead



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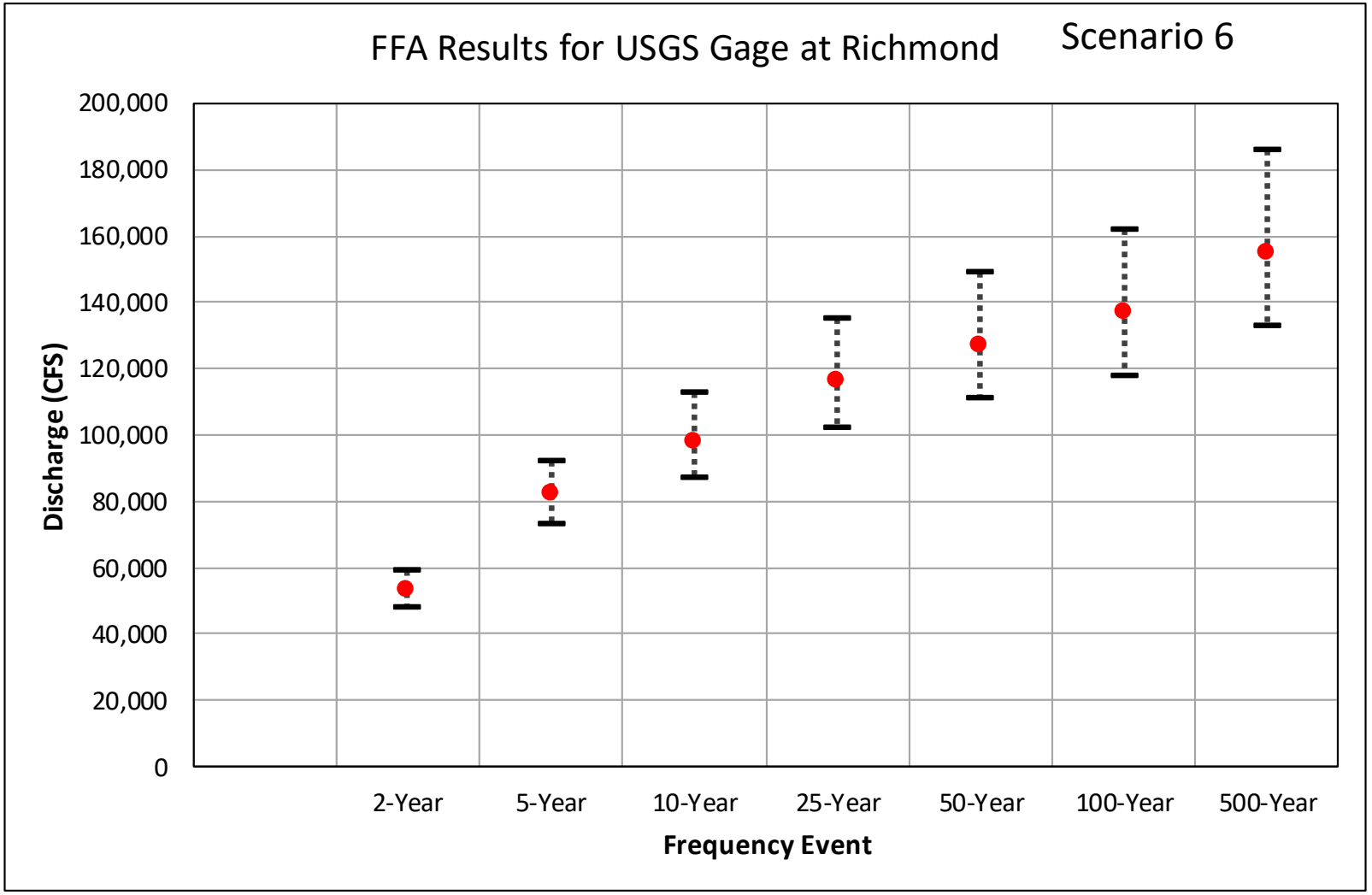
Brazos River – Preliminary Conclusions

Richmond



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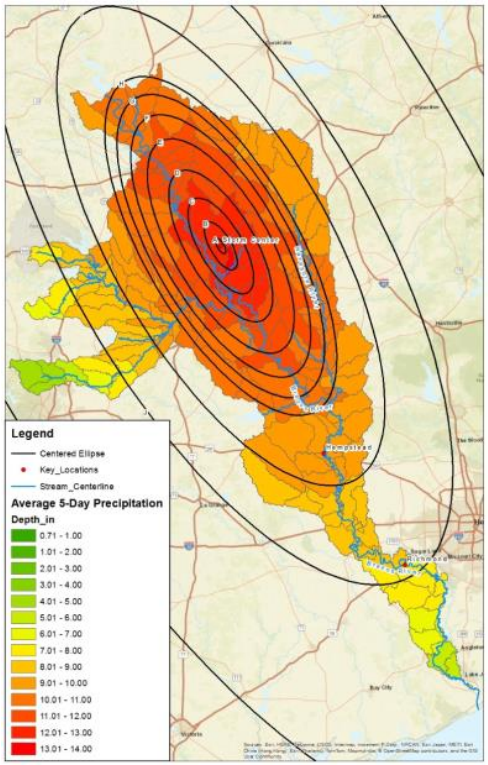
Brazos River – Design Storm Modeling

Aerial Reduction Factors

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



Based on USACE SWF Curve

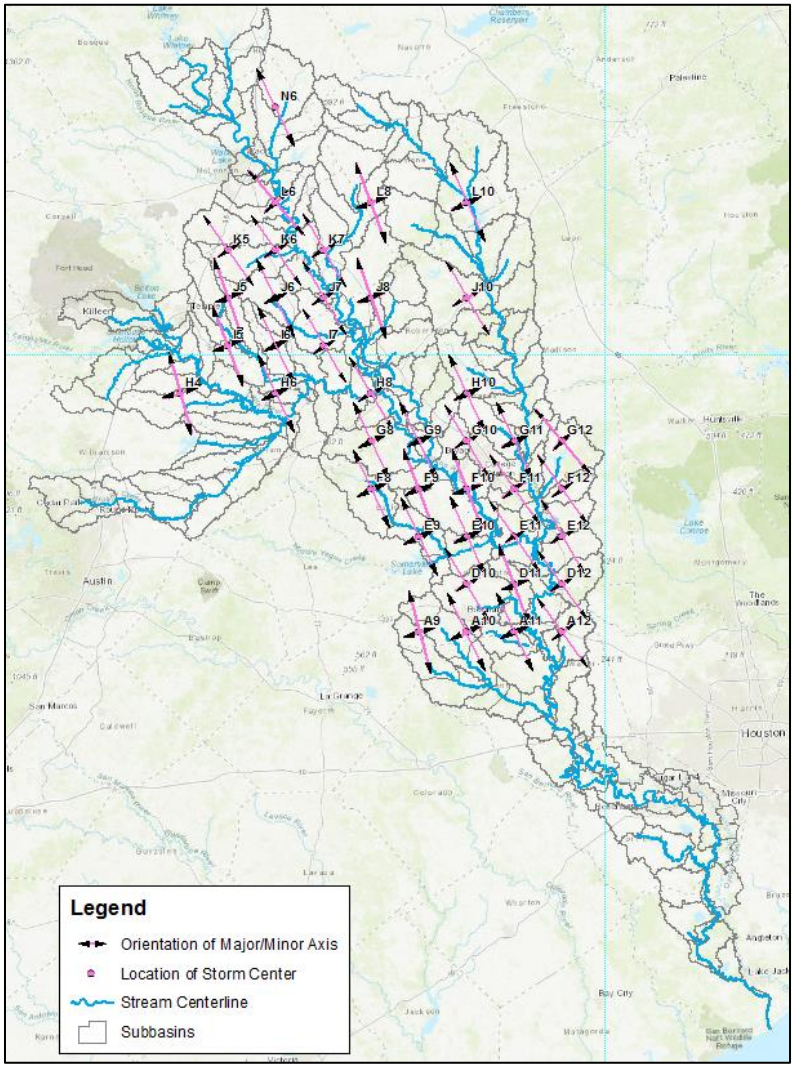
Based on Harvey Reduction Factors

Ellipse	Area of Ellipse (sq mi)	Areal Reduction Factors
A	10	1.00
B	100	0.96
C	400	0.92
D	1,000	0.85
E	2,000	0.82
F	3,000	0.80
G	4,000	0.77
H	5,000	0.74
I	10,000	0.68
J	20,000	0.51
K	60,000	0.17
L	100,000	0.09
M	200,000	0.03

Brazos River – Design Storm Modeling

Storm Centering

- 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

Hempstead									
Centering	Q Peak (cfs)	Pct Diff from Target	Volume (ac-ft)	Peak Stage (ft)	Centering	Q Peak (cfs)	Pct Diff from Target	Volume (ac-ft)	Peak Stage (ft)
A9	208,706	26%	3,424,954	167.41	G12	157,149	-5%	2,938,922	164.11
A10	216,433	30%	3,530,738	167.89	H4	152,763	-8%	2,339,832	163.72
A11	216,303	30%	3,601,268	167.89	H6	157,828	-5%	2,679,575	164.13
A12	228,019	37%	3,699,664	168.59	H8	160,531	-3%	2,893,040	164.34
D10	215,917	30%	3,531,125	167.86	H10	153,102	-8%	2,815,343	163.80
D11	197,963	19%	3,478,855	166.76	I5	156,393	-6%	2,569,495	164.01
D12	216,637	31%	3,606,857	167.91	I6	156,777	-6%	2,660,955	164.05
E9	163,552	-1%	3,148,293	164.58	I7	155,982	-6%	2,700,482	164.00
E10	202,366	22%	3,438,033	167.03	J5	155,207	-7%	2,548,279	163.92
E11	206,138	24%	3,478,981	167.91	J6	155,183	-7%	2,623,203	163.93
E12	184,704	11%	3,347,840	165.90	J7	153,436	-8%	2,632,073	163.80
F8	184,083	11%	3,133,320	165.83	J8	150,290	-9%	2,592,098	163.56
F9	186,092	12%	3,238,367	165.97	J10	142,047	-14%	2,373,149	162.72
F10	191,232	15%	3,321,986	166.31	K5	152,389	-8%	2,532,114	163.71
F11	186,562	12%	3,298,670	166.01	K6	152,268	-8%	2,565,200	163.70
F12	163,591	-1%	3,145,002	164.59	K7	150,480	-9%	2,550,327	163.57
G8	169,964	2%	3,041,173	164.94	L6	148,529	-11%	2,463,287	163.40
G9	166,195	0%	3,096,212	164.73	L8	144,879	-13%	2,423,889	163.10
G10	163,370	-2%	3,096,214	164.57	L10	120,272	-28%	2,100,131	160.67
G11	156,723	-6%	2,965,221	164.08	N6	96,642	-42%	1,460,847	157.57
	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

Richmond									
Centering	Q Peak (cfs)	Pct Diff from Target	Volume (ac-ft)	Peak Stage (ft)	Centering	Q Peak (cfs)	Pct Diff from Target	Volume (ac-ft)	Peak Stage (ft)
A9	161,786	18%	3,875,136	85.34	G12	142,168	4%	3,305,091	83.56
A10	166,555	22%	4,022,311	85.73	H4	128,454	-6%	2,642,248	82.07
A11	167,715	22%	4,108,755	85.82	H6	138,304	1%	3,025,105	83.16
A12	172,897	26%	4,176,400	86.22	H8	143,369	5%	3,250,532	83.67
D10	166,279	21%	3,990,559	85.70	H10	137,878	1%	3,186,629	83.12
D11	159,761	17%	3,970,734	85.19	I5	135,157	-1%	2,883,606	82.81
D12	167,340	22%	4,042,537	85.79	I6	137,132	0%	2,995,146	83.04
E9	148,554	8%	3,606,593	84.18	I7	137,437	0%	3,039,005	83.07
E10	160,333	17%	3,873,888	85.22	J5	133,794	-2%	2,853,127	82.66
E11	167,340	22%	4,042,537	85.79	J6	135,429	-1%	2,947,257	82.84
E12	154,564	13%	3,781,979	84.74	J7	134,361	-2%	2,957,973	82.73
F8	151,592	11%	3,524,854	84.46	J8	131,112	-4%	2,919,445	82.38
F9	153,354	12%	3,642,588	84.63	J10	116,092	-15%	2,694,577	80.57
F10	155,797	14%	3,727,613	84.84	K5	131,631	-4%	2,851,947	82.43
F11	154,222	13%	3,690,003	84.70	K6	132,136	-4%	2,880,670	82.49
F12	148,172	8%	3,541,486	84.15	K7	130,348	-5%	2,865,383	82.29
G8	148,046	8%	3,417,320	84.13	L6	126,568	-8%	2,748,747	81.85
G9	148,359	8%	3,483,756	84.16	L8	121,700	-11%	2,734,503	81.27
G10	147,613	8%	3,481,396	84.09	L10	99,412	-27%	2,401,879	78.20
G11	142,314	4%	3,361,032	83.58	N6	80,481	-41%	1,849,554	74.55
	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)

Centering	Hempstead				Richmond			
	Q Peak (cfs)	Pct Diff from Target	Volume (ac-ft)	Peak Stage (ft)	Q Peak (cfs)	Pct Diff from Target	Volume (ac-ft)	Peak Stage (ft)
E12	184,704	11%	3,347,840	165.90	154,564	13%	3,781,979	84.74
E9	163,552	-1%	3,148,293	164.58	148,554	8%	3,606,593	84.18
F10	191,232	15%	3,321,986	166.31	155,797	14%	3,727,613	84.84
F11	186,562	12%	3,298,670	166.01	154,222	13%	3,690,003	84.70
F12	163,591	-1%	3,145,002	164.59	148,172	8%	3,541,486	84.15
F8	184,083	11%	3,133,320	165.83	151,592	11%	3,524,854	84.46
F9	186,092	12%	3,238,367	165.97	153,354	12%	3,642,588	84.63
G10	163,370	-2%	3,096,214	164.57	147,613	8%	3,481,396	84.09
G11	156,723	-6%	2,965,221	164.08	142,314	4%	3,361,032	83.58
G12	157,149	-5%	2,938,922	164.11	142,168	4%	3,305,091	83.56
G8	169,964	2%	3,041,173	164.94	148,046	8%	3,417,320	84.13
G9	166,195	0%	3,096,212	164.73	148,359	8%	3,483,756	84.16
H10	153,102	-8%	2,815,343	163.80	137,878	1%	3,186,629	83.12
H4	152,763	-8%	2,339,832	163.72	128,454	-6%	2,642,248	82.07
H6	157,828	-5%	2,679,575	164.13	138,304	1%	3,025,105	83.16
H8	160,531	-3%	2,893,040	164.34	143,369	5%	3,250,532	83.67
I5	156,393	-6%	2,569,495	164.01	135,157	-1%	2,883,606	82.81
I6	156,777	-6%	2,660,955	164.05	137,132	0%	2,995,146	83.04
I7	155,982	-6%	2,700,482	164.00	137,437	0%	3,039,005	83.07
	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

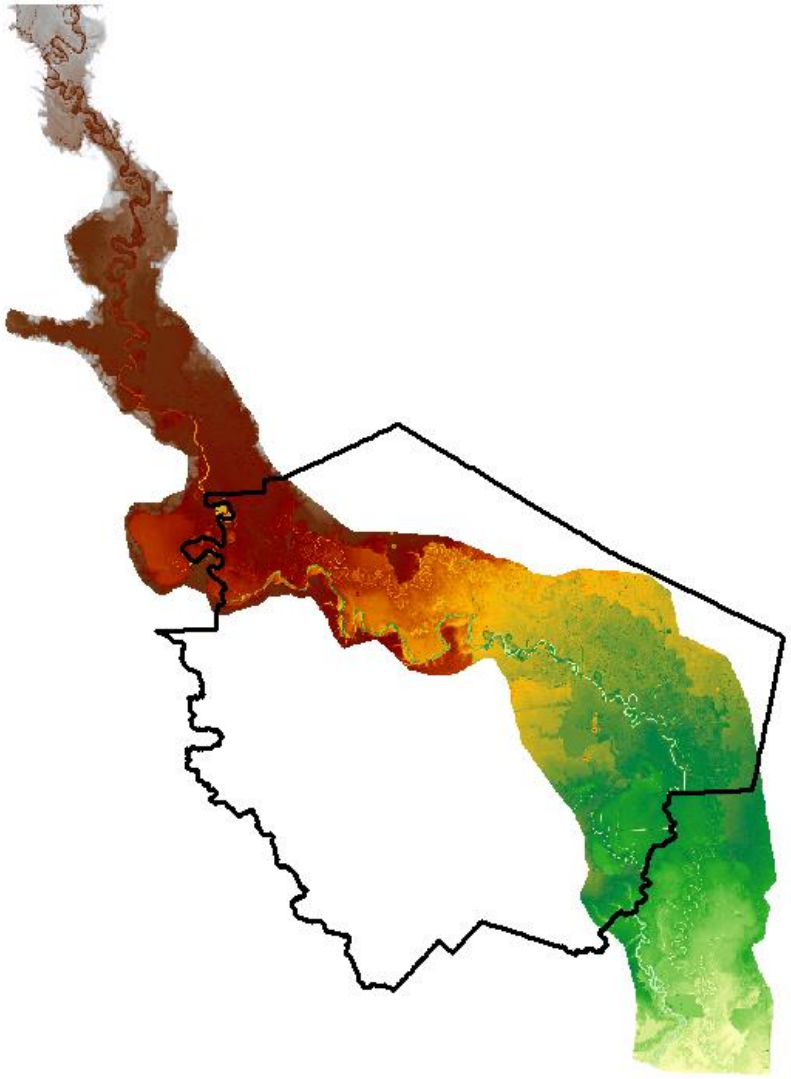
Hydraulics – Approach

- 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

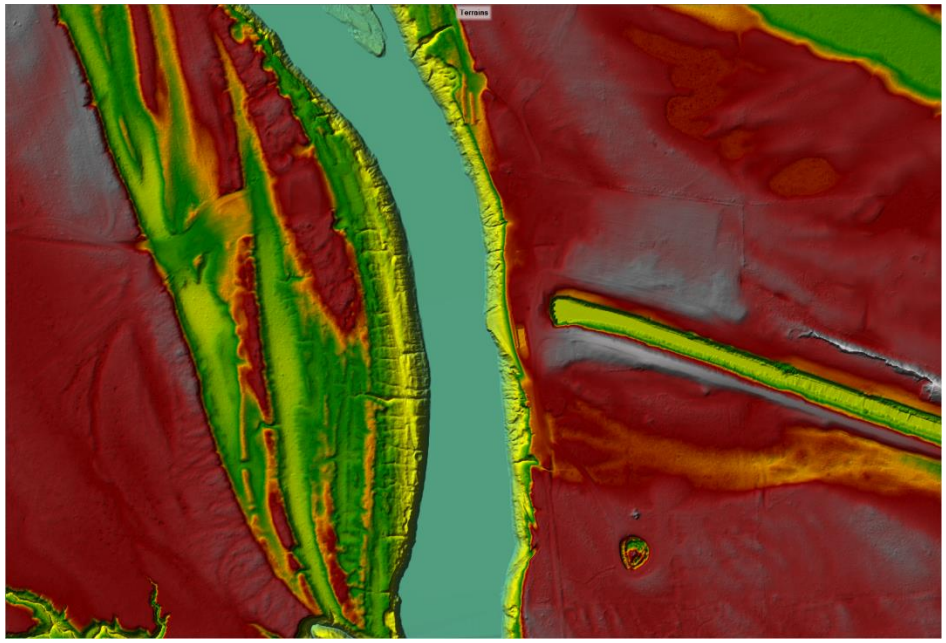
Hydraulics – Topography

- 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

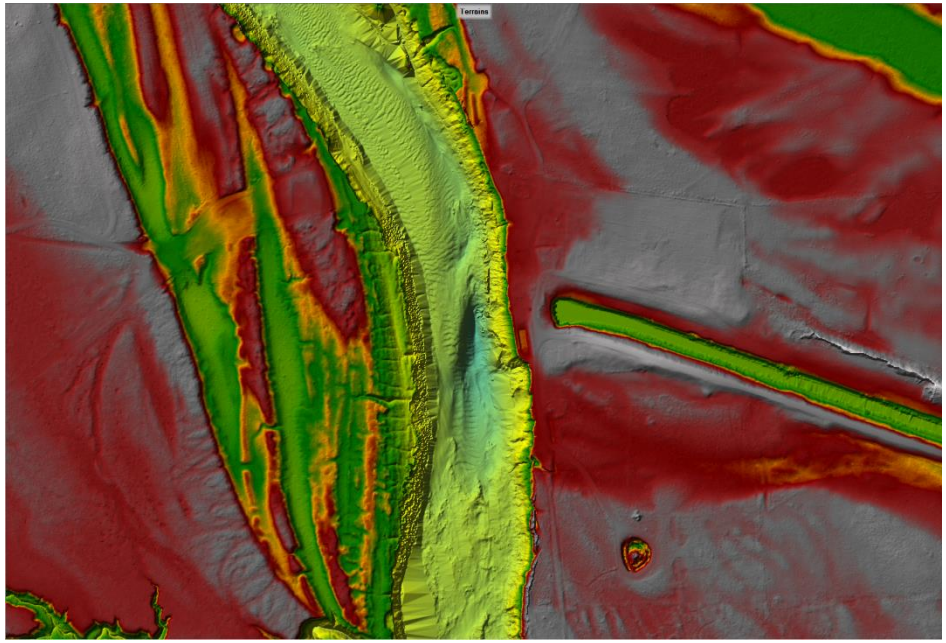
Hydraulics – Topography



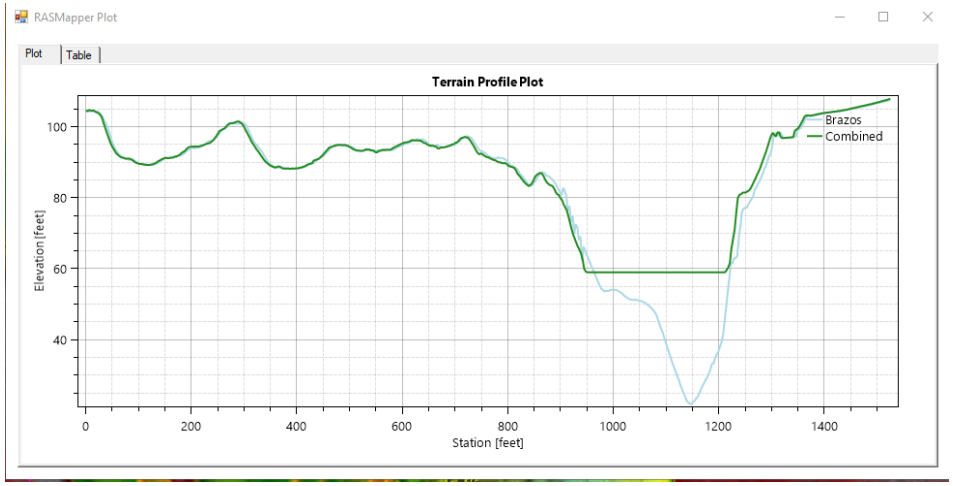
Hydraulics – Bathymetry (ERDC Survey)



LiDAR only



LiDAR + Bathymetry

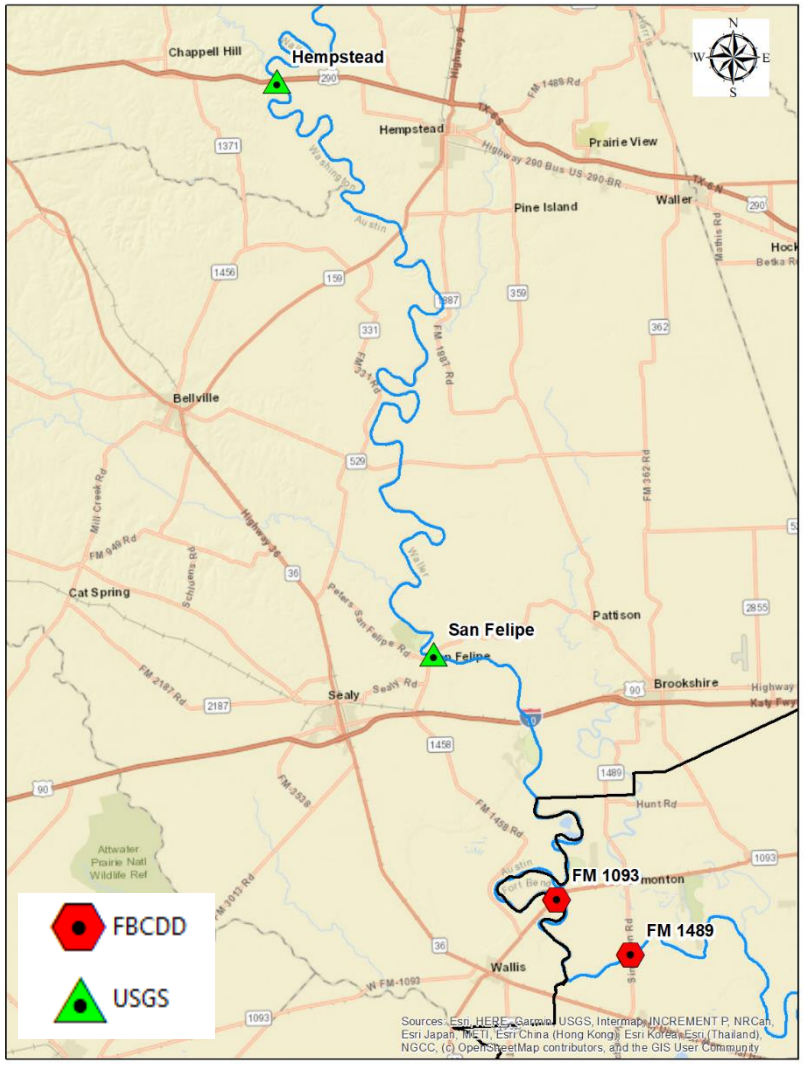


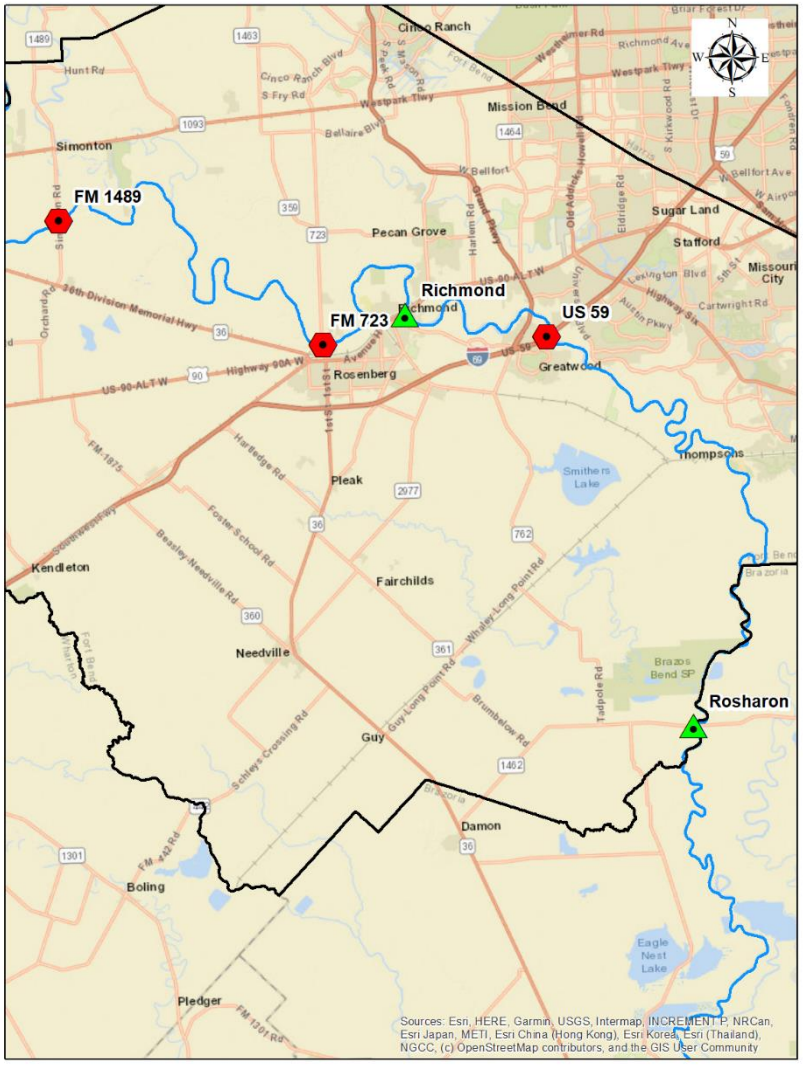
Hydraulics – Calibration

- 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

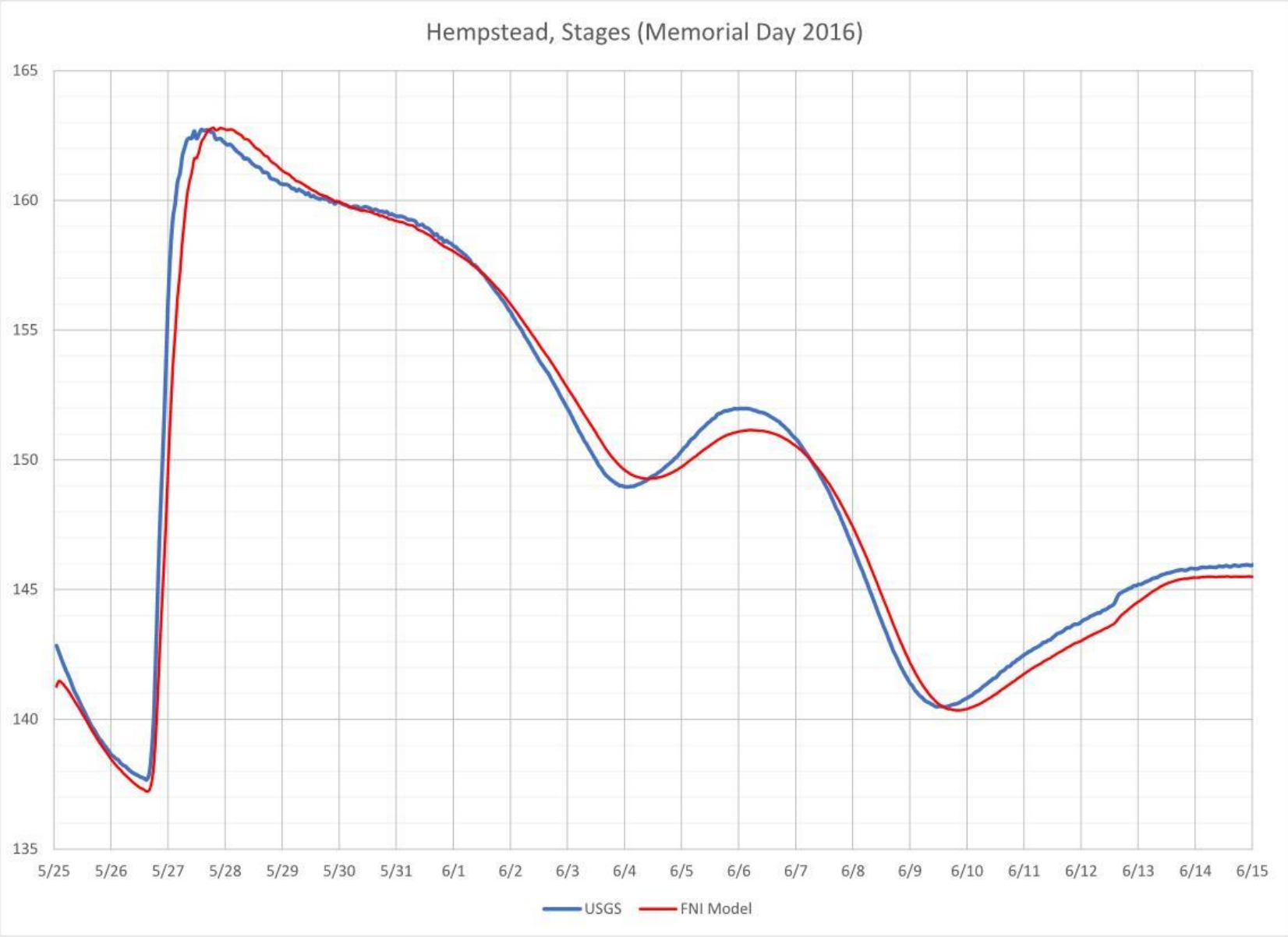
Hydraulics – Calibration Points



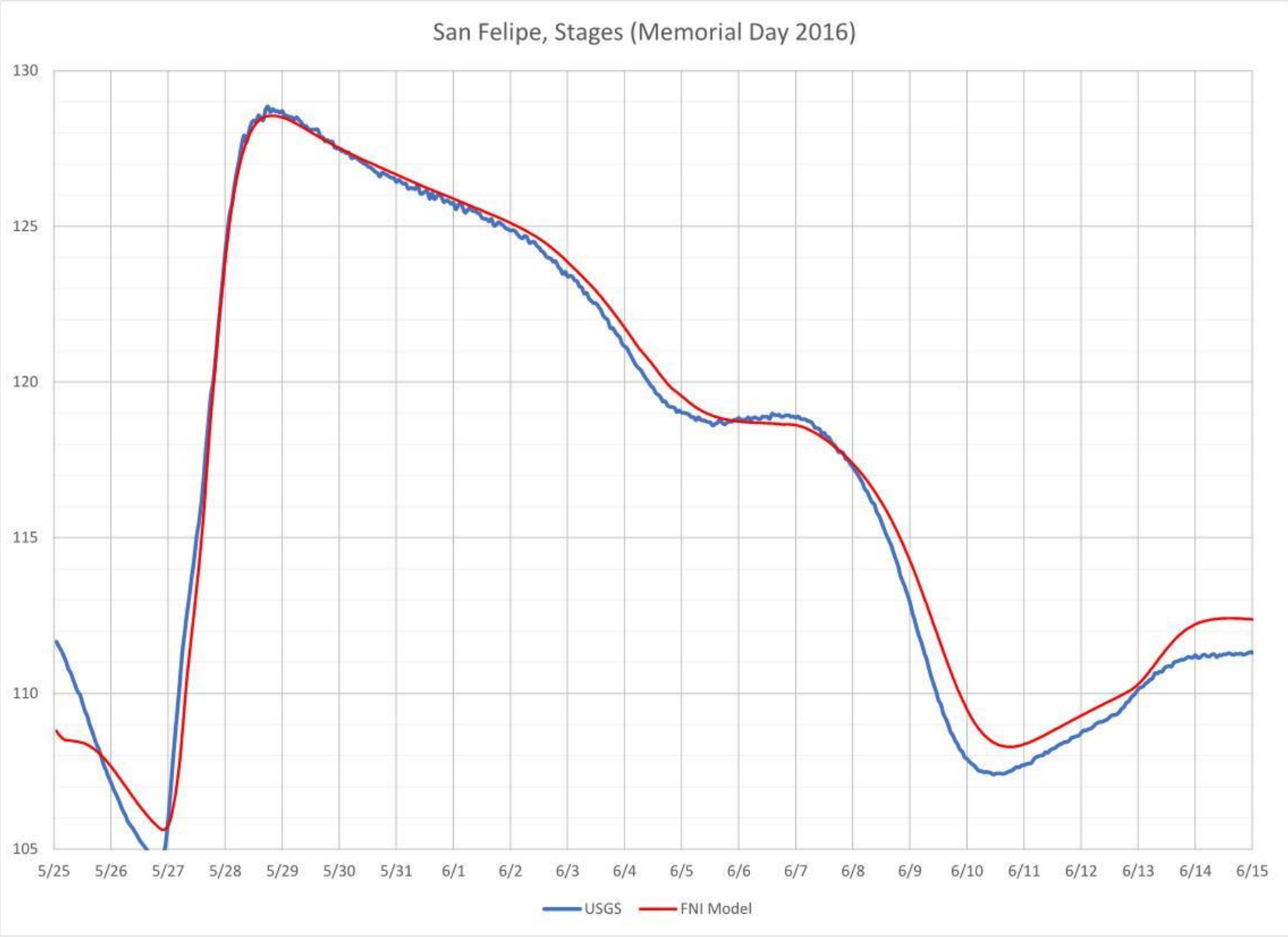


Memorial Day 2016

Brazos River – Memorial Day 2016

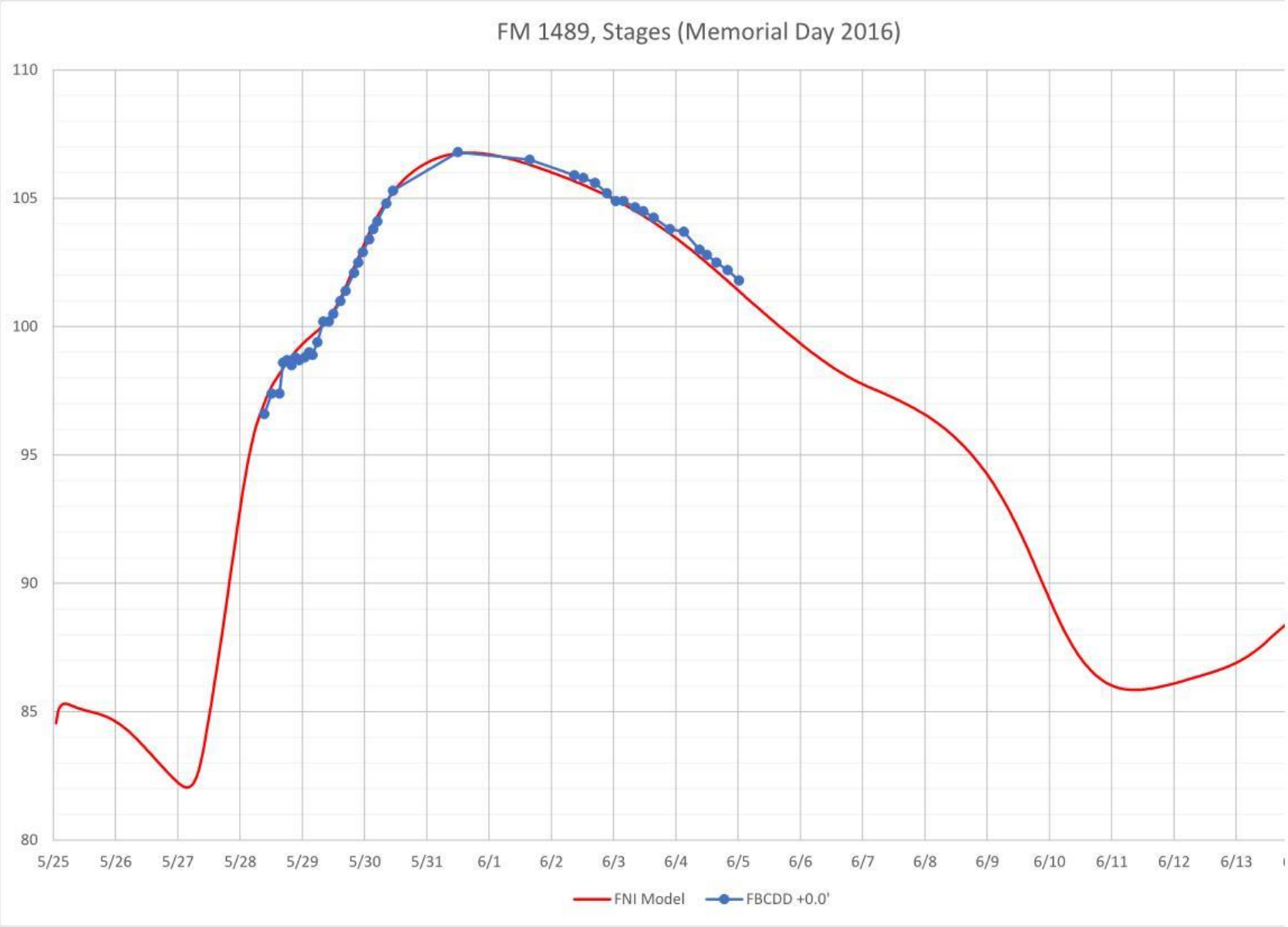


Brazos River – Memorial Day 2016

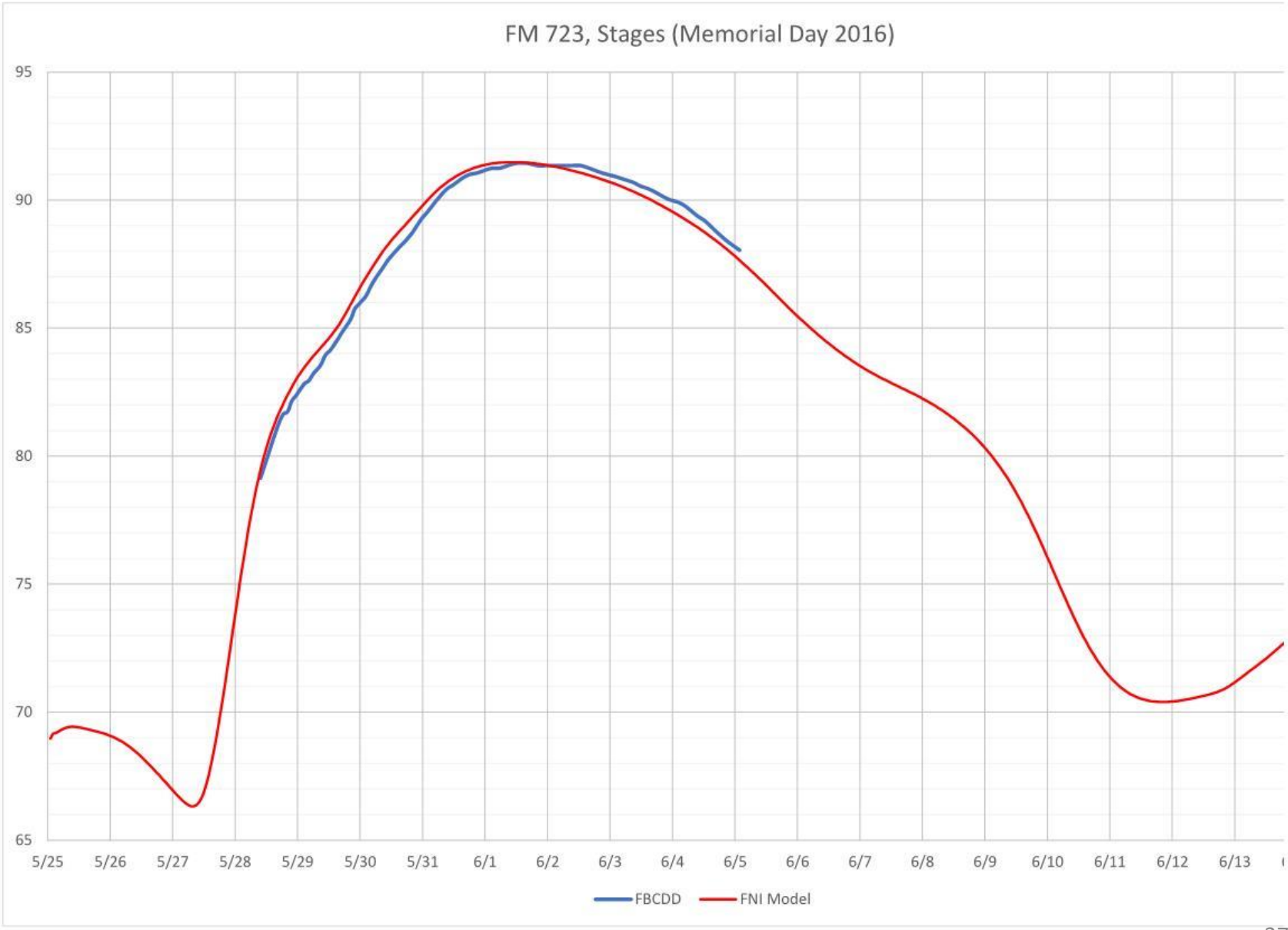


Brazos River – Memorial Day 2016

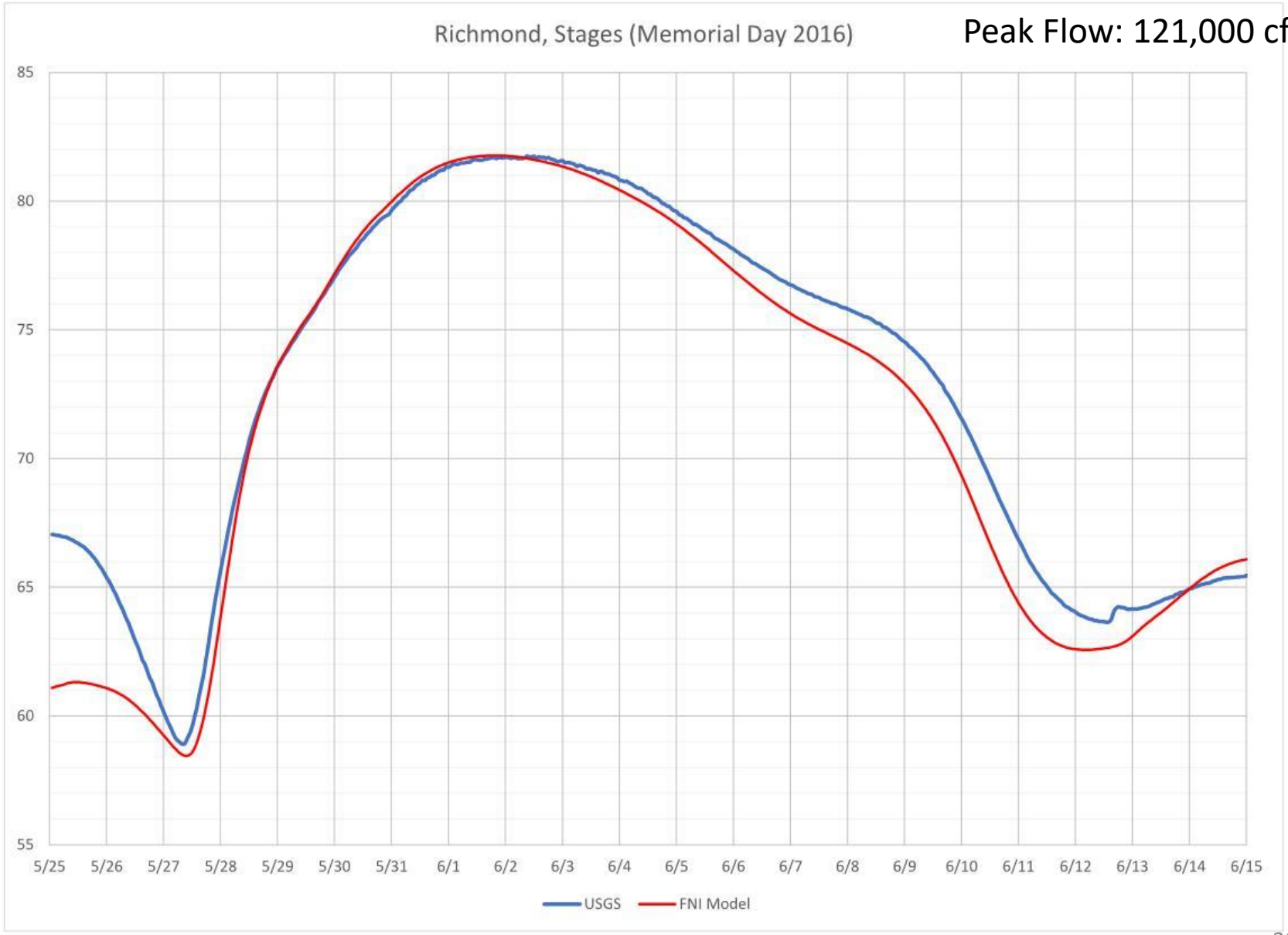
Brazos River – Memorial Day 2016



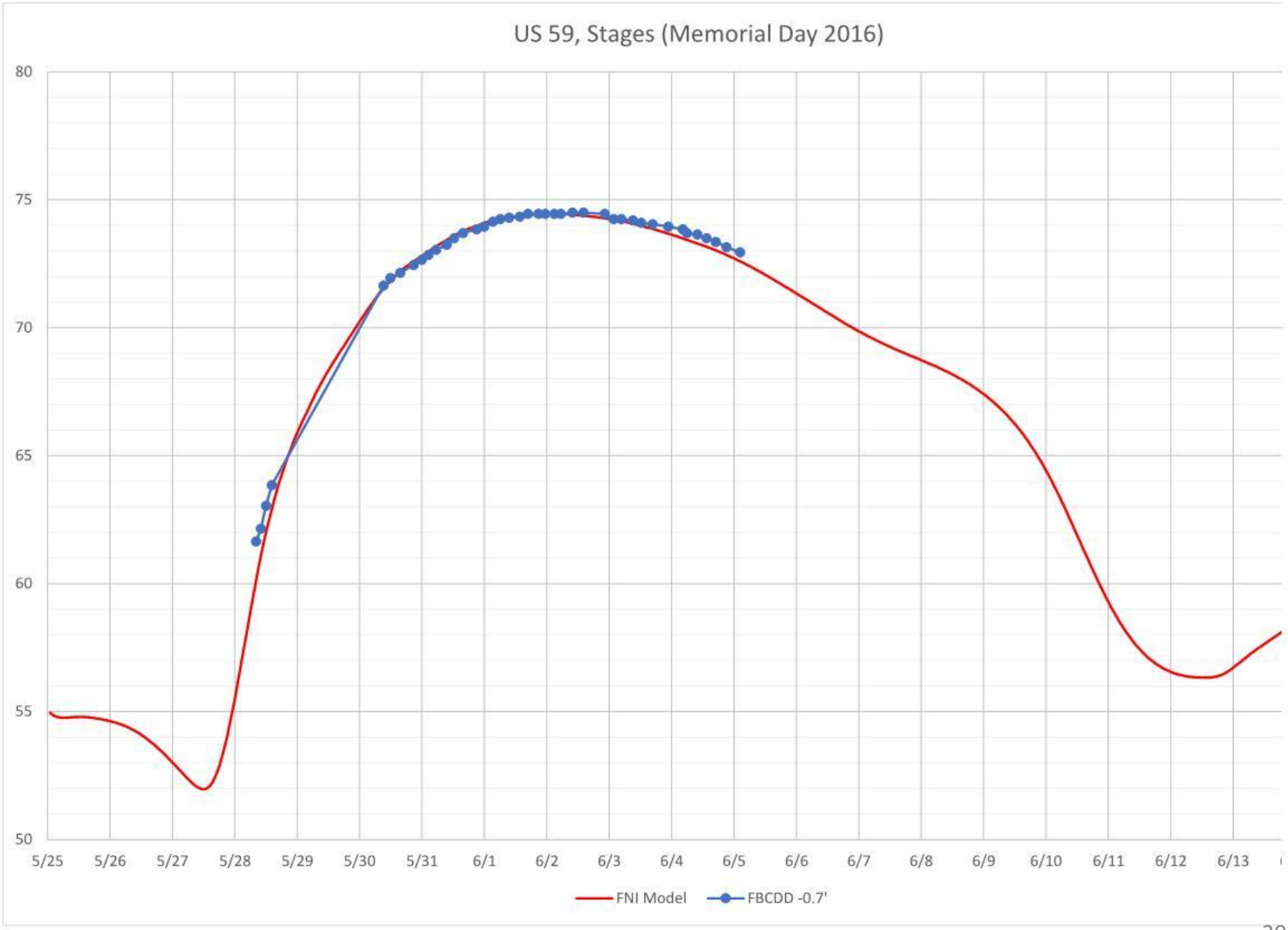
Brazos River – Memorial Day 2016



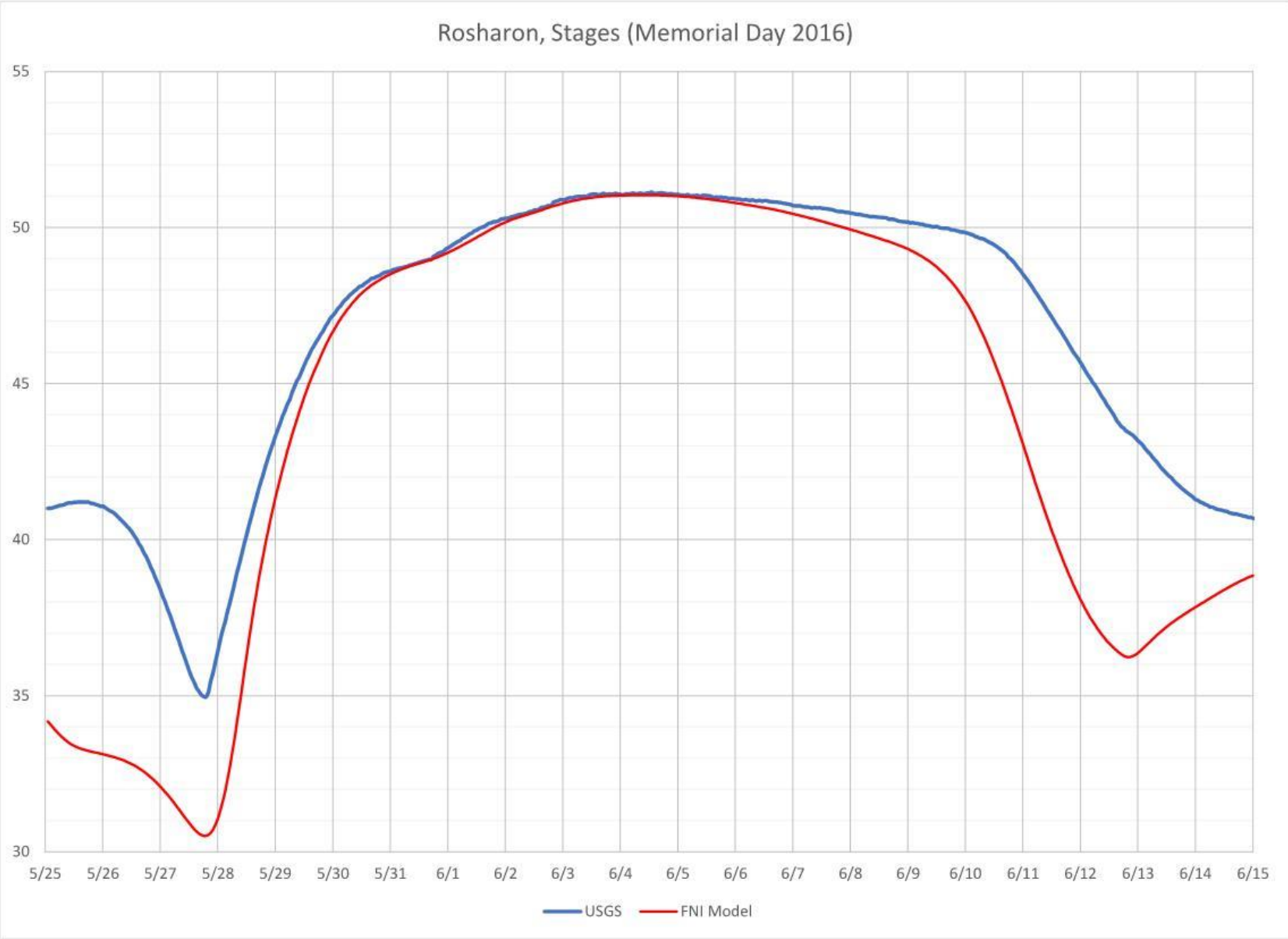
Brazos River – Memorial Day 2016



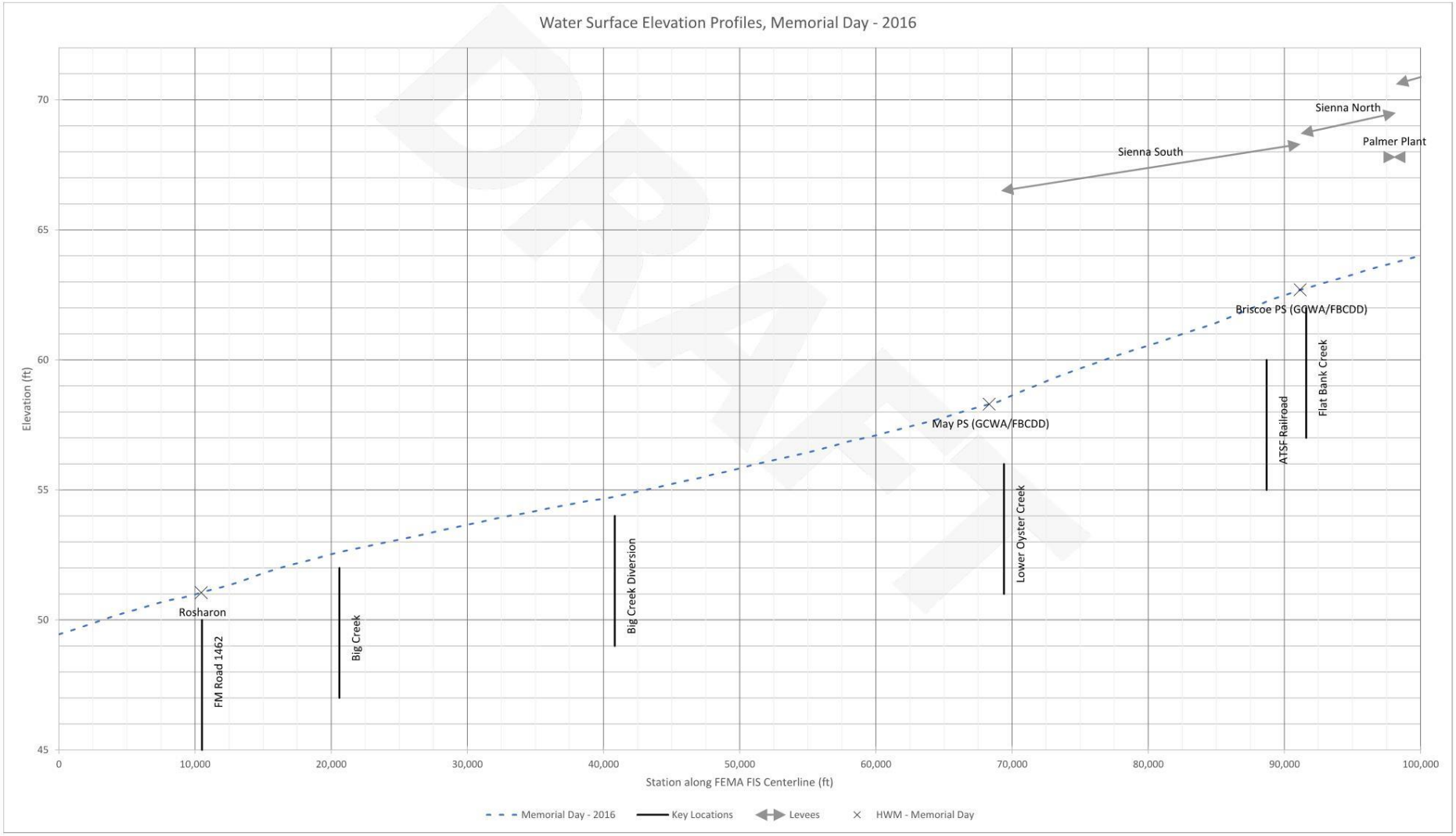
Brazos River – Memorial Day 2016



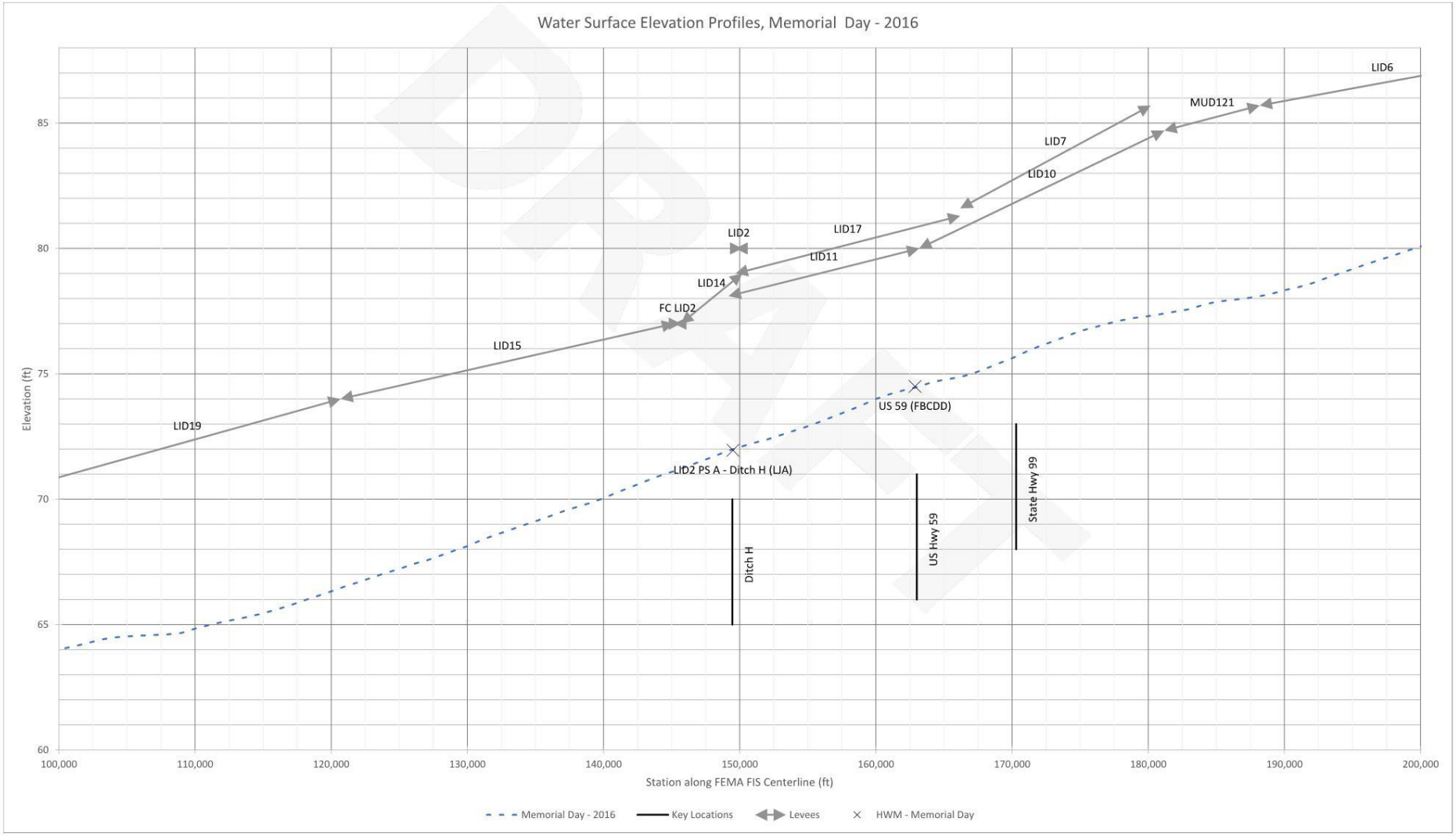
Brazos River – Memorial Day 2016



PROFILE – Memorial Day 2016



PROFILE – Memorial Day 2016



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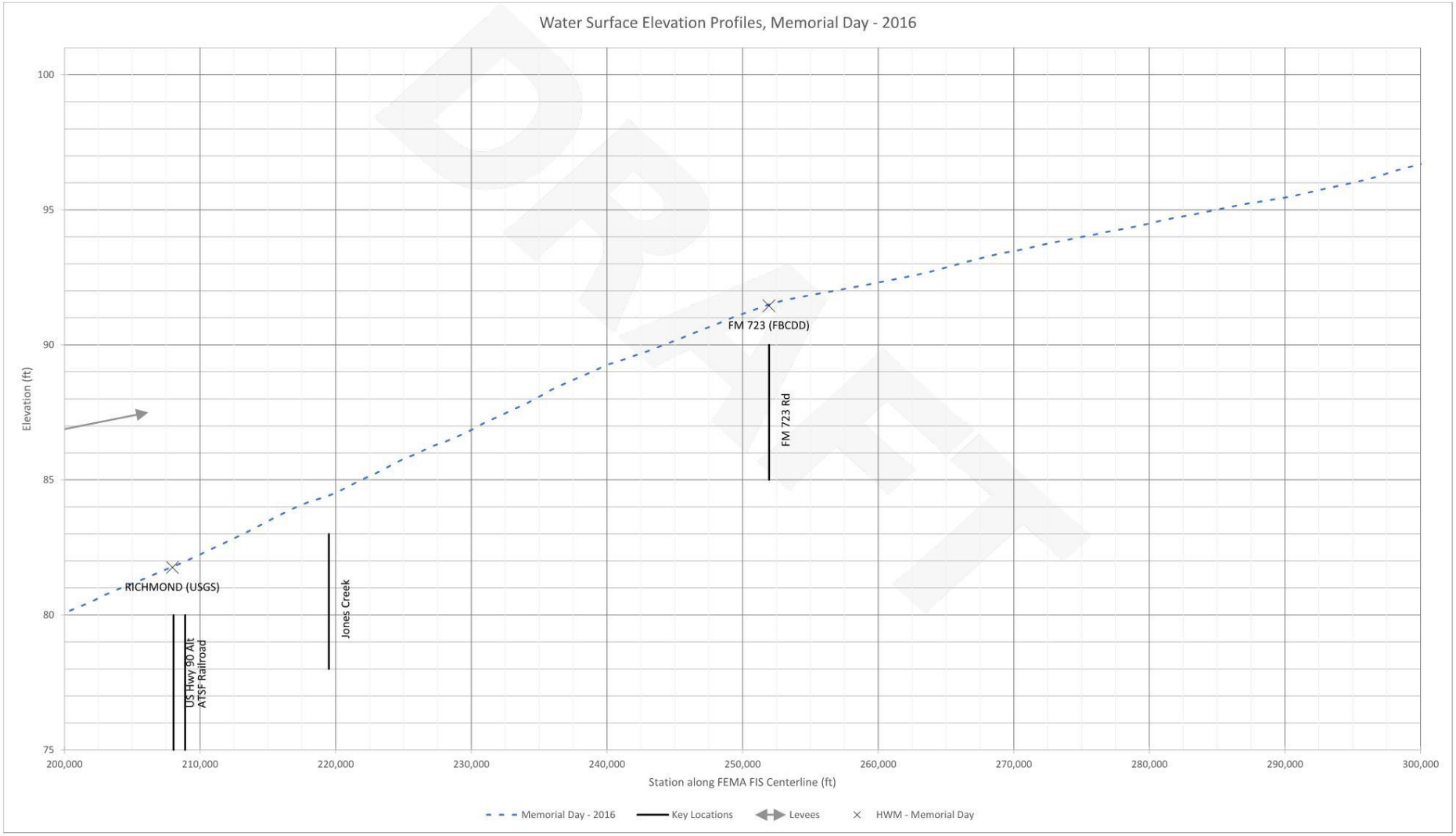

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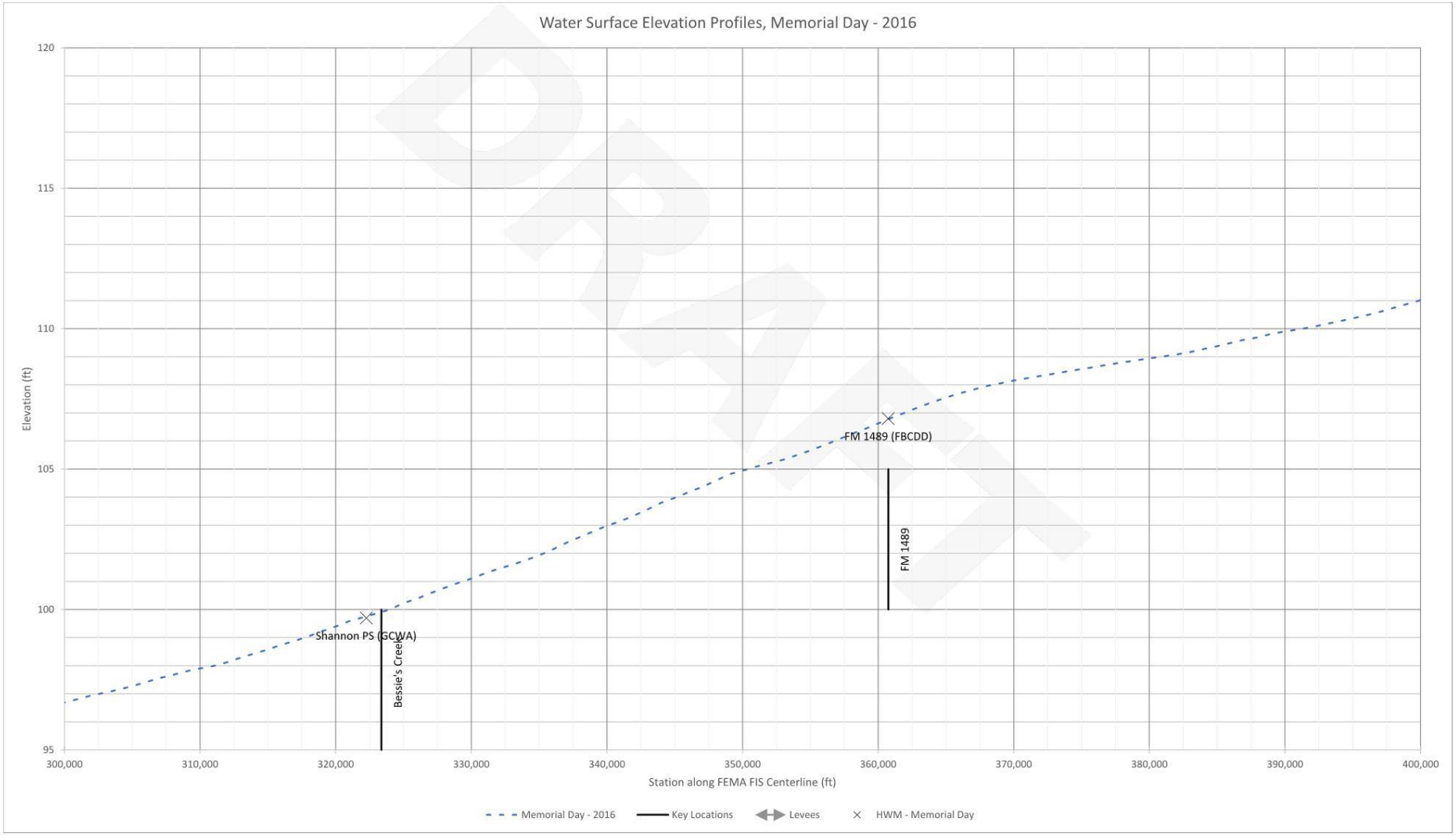
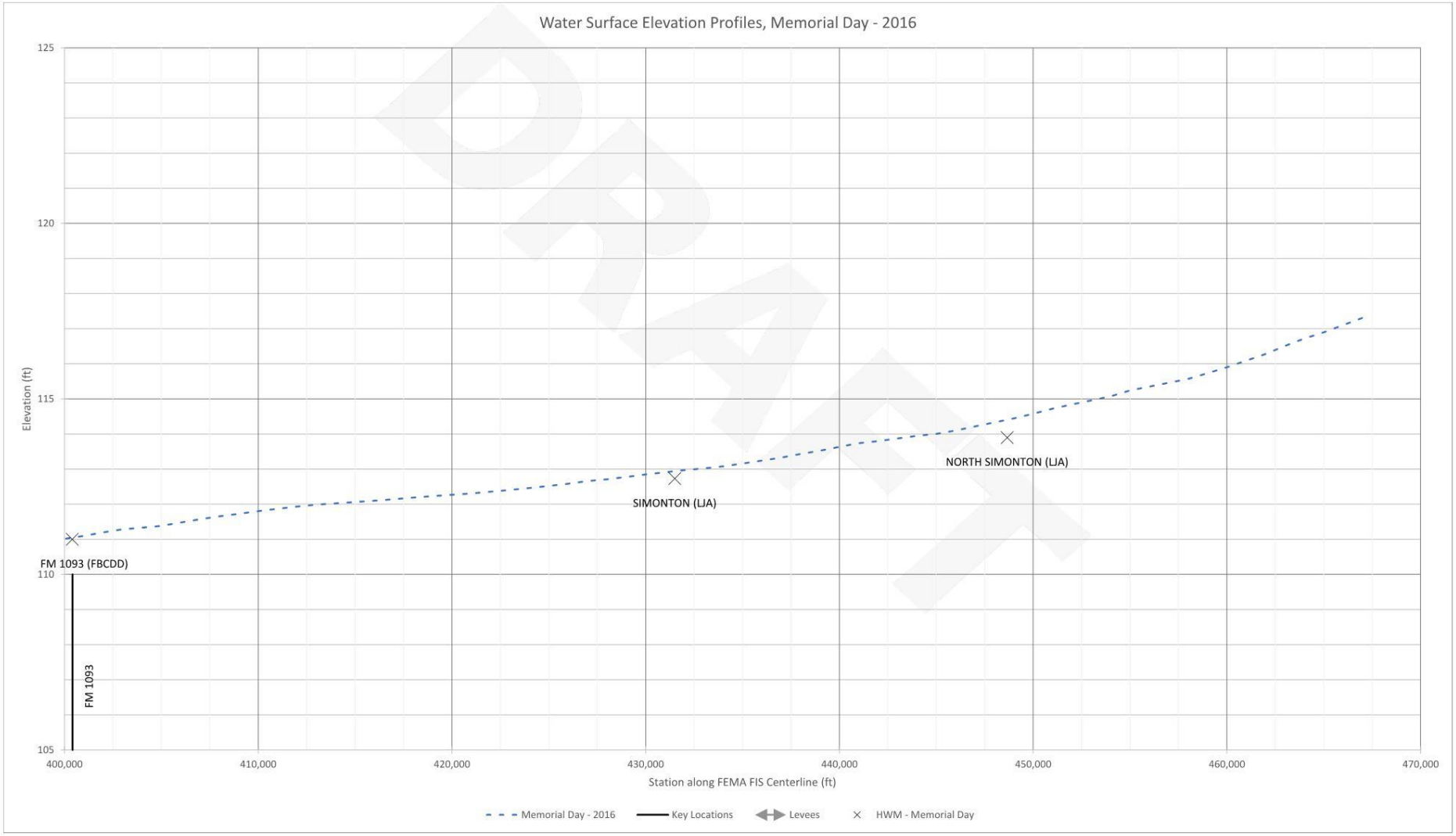


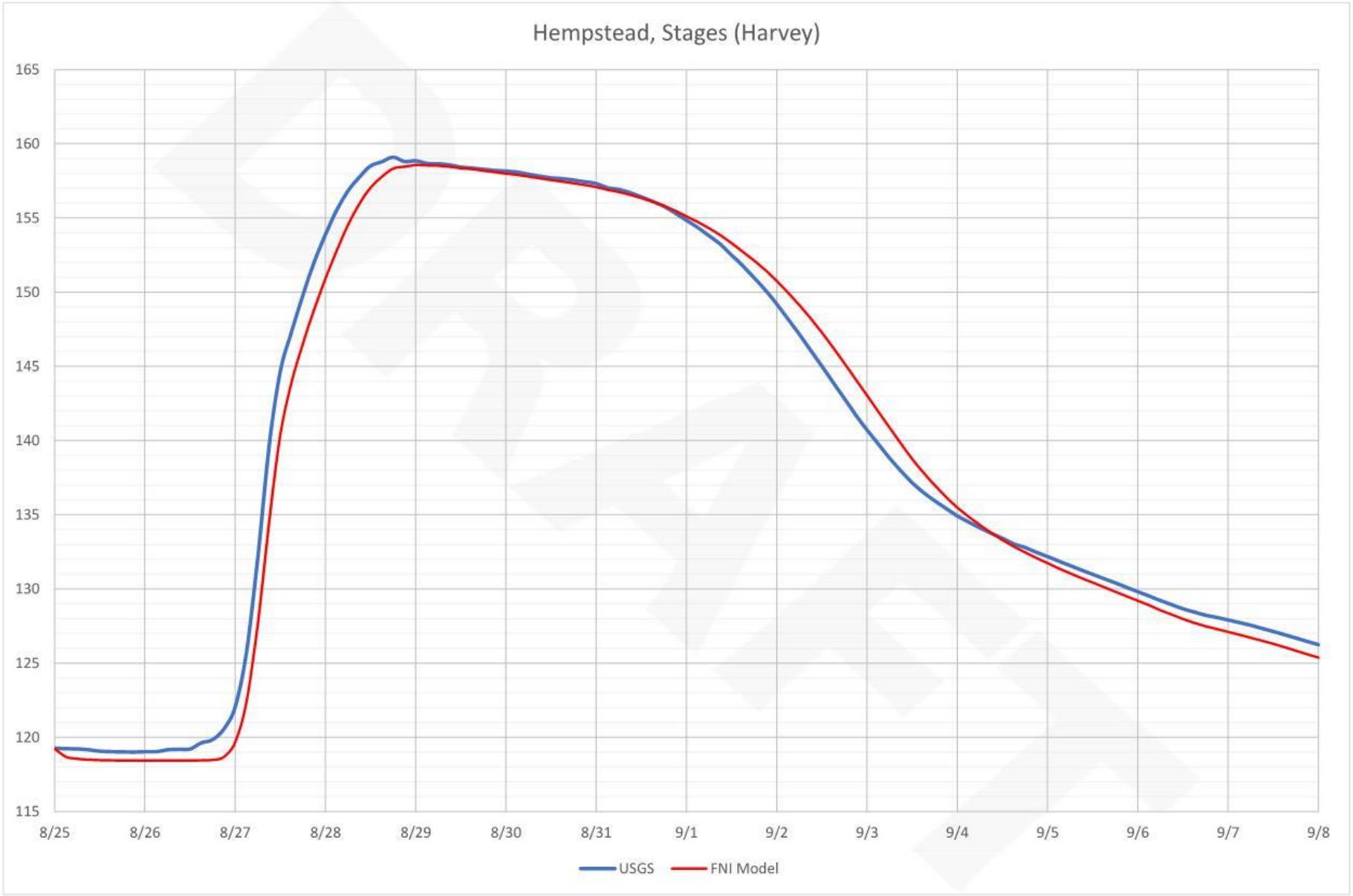
PROFILE – Memorial Day 2016



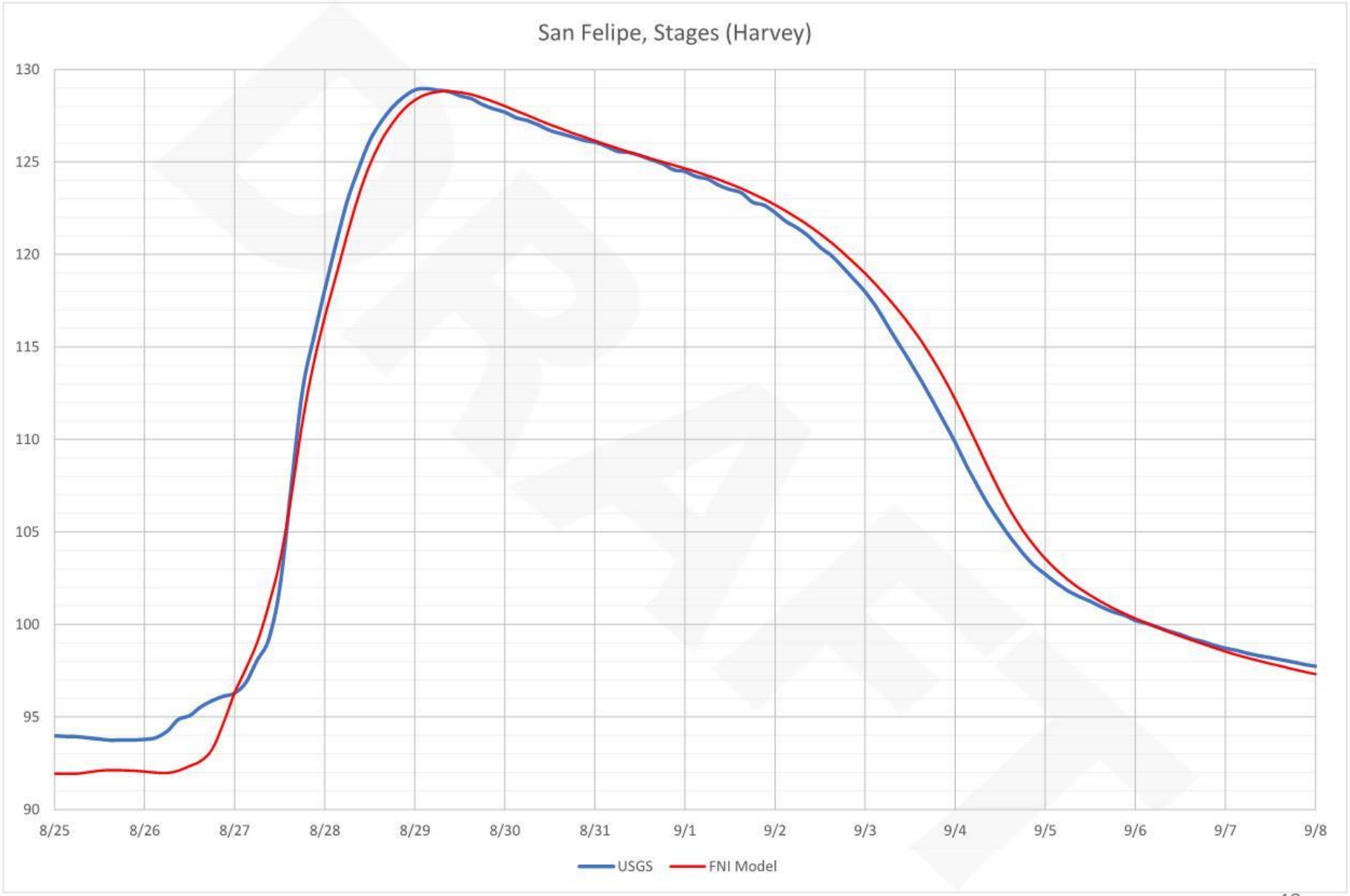
DRAFT

Harvey

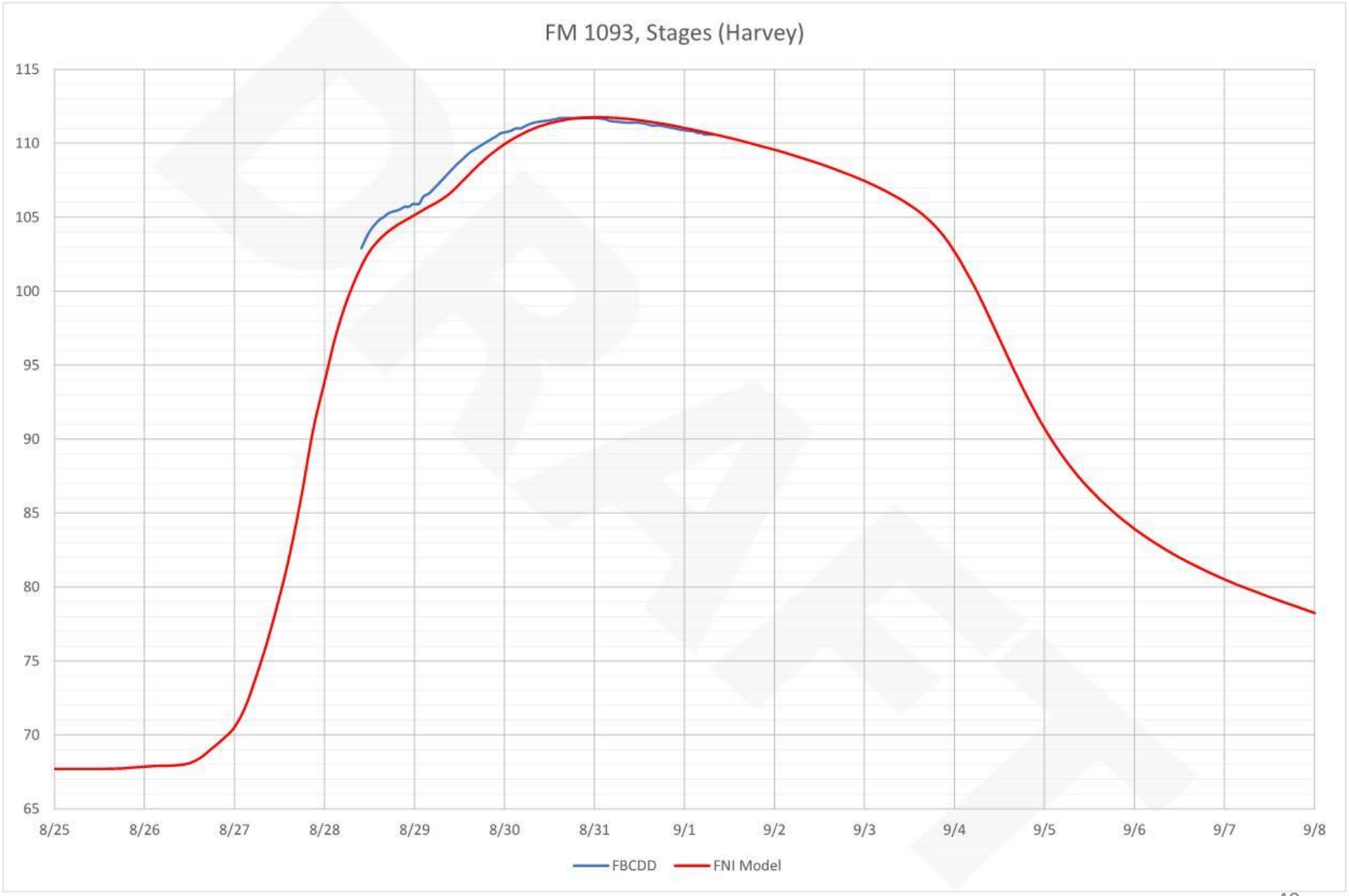
Brazos River – Harvey



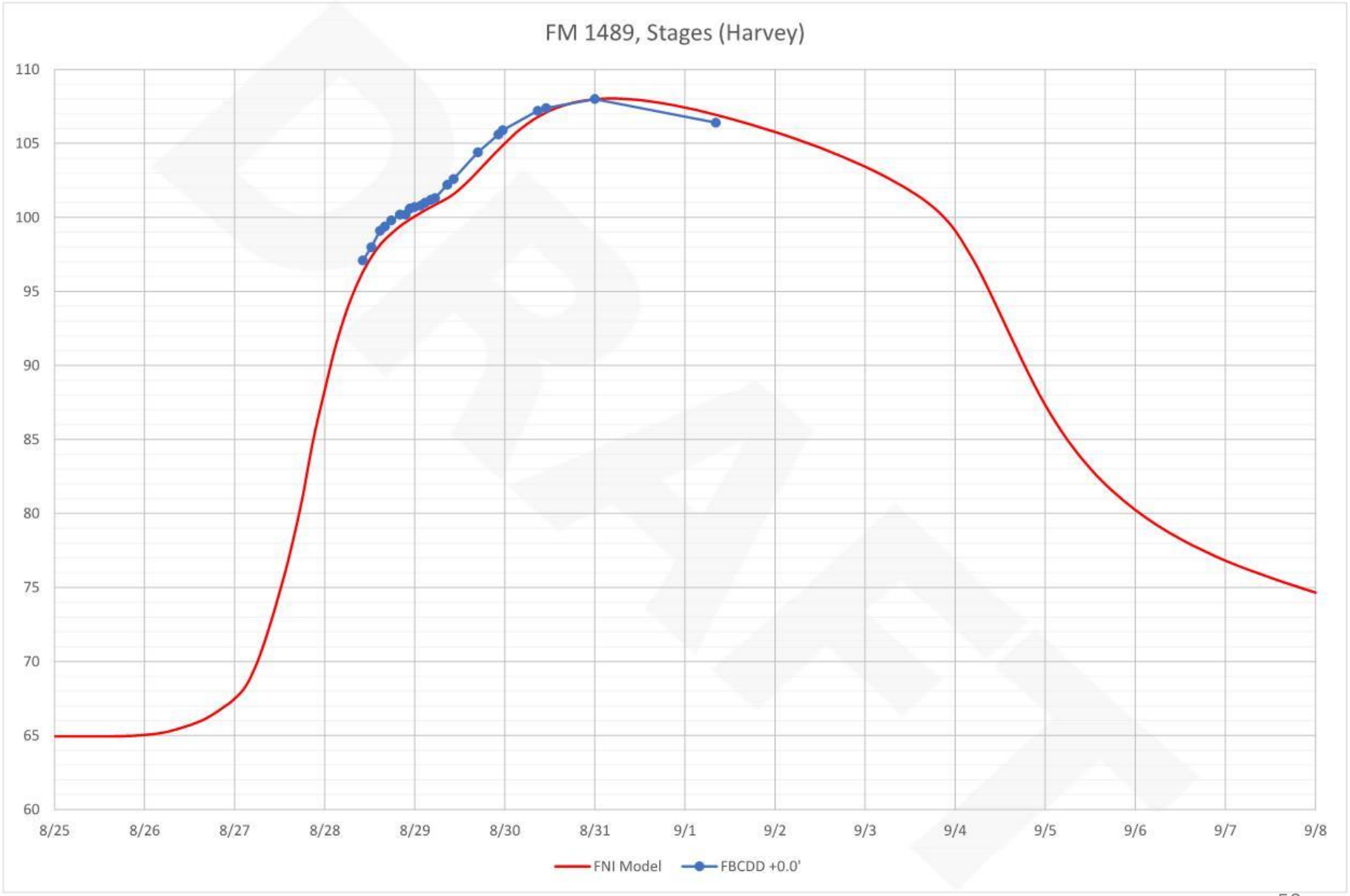
Brazos River – Harvey



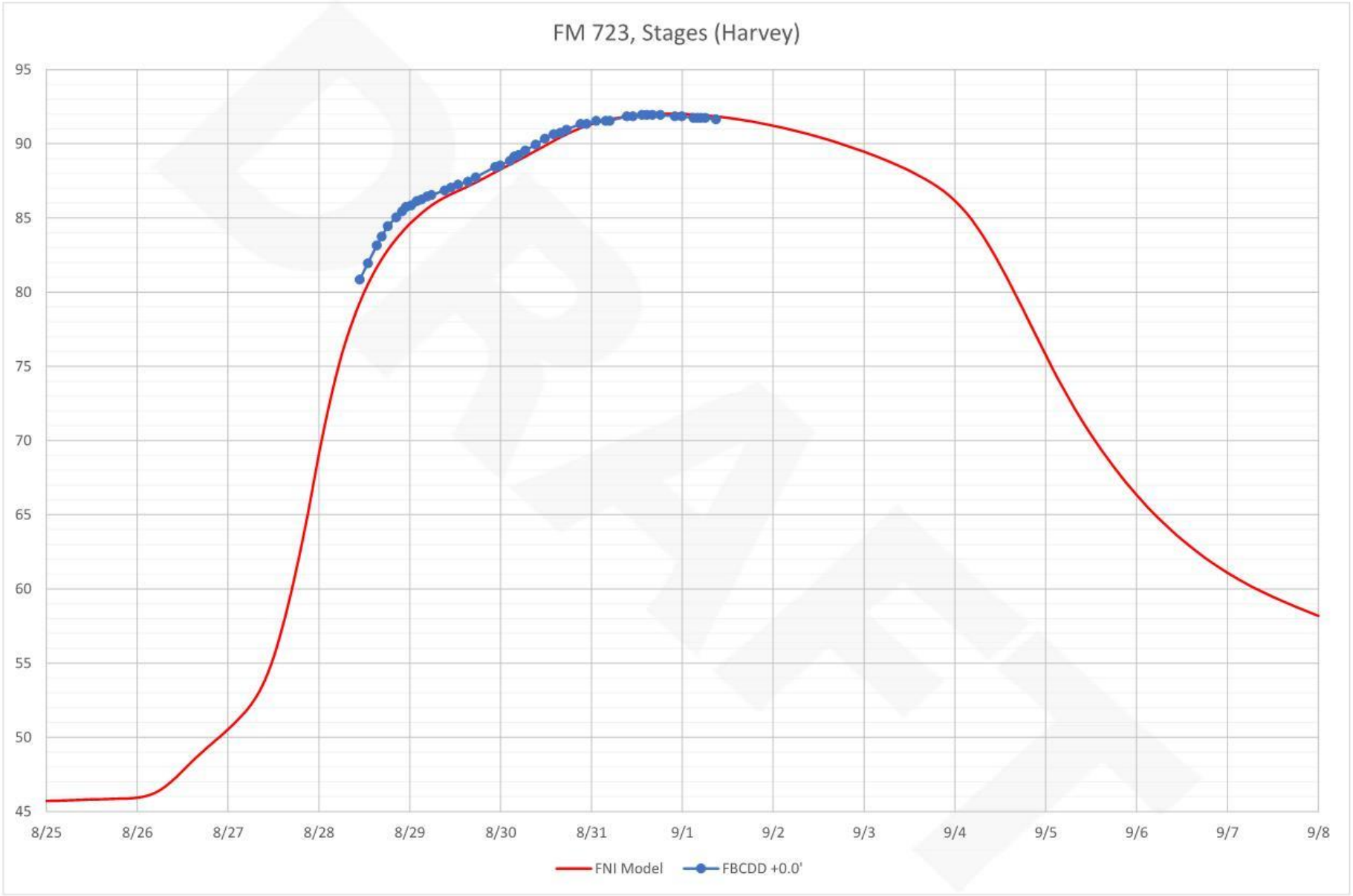
Brazos River – Harvey



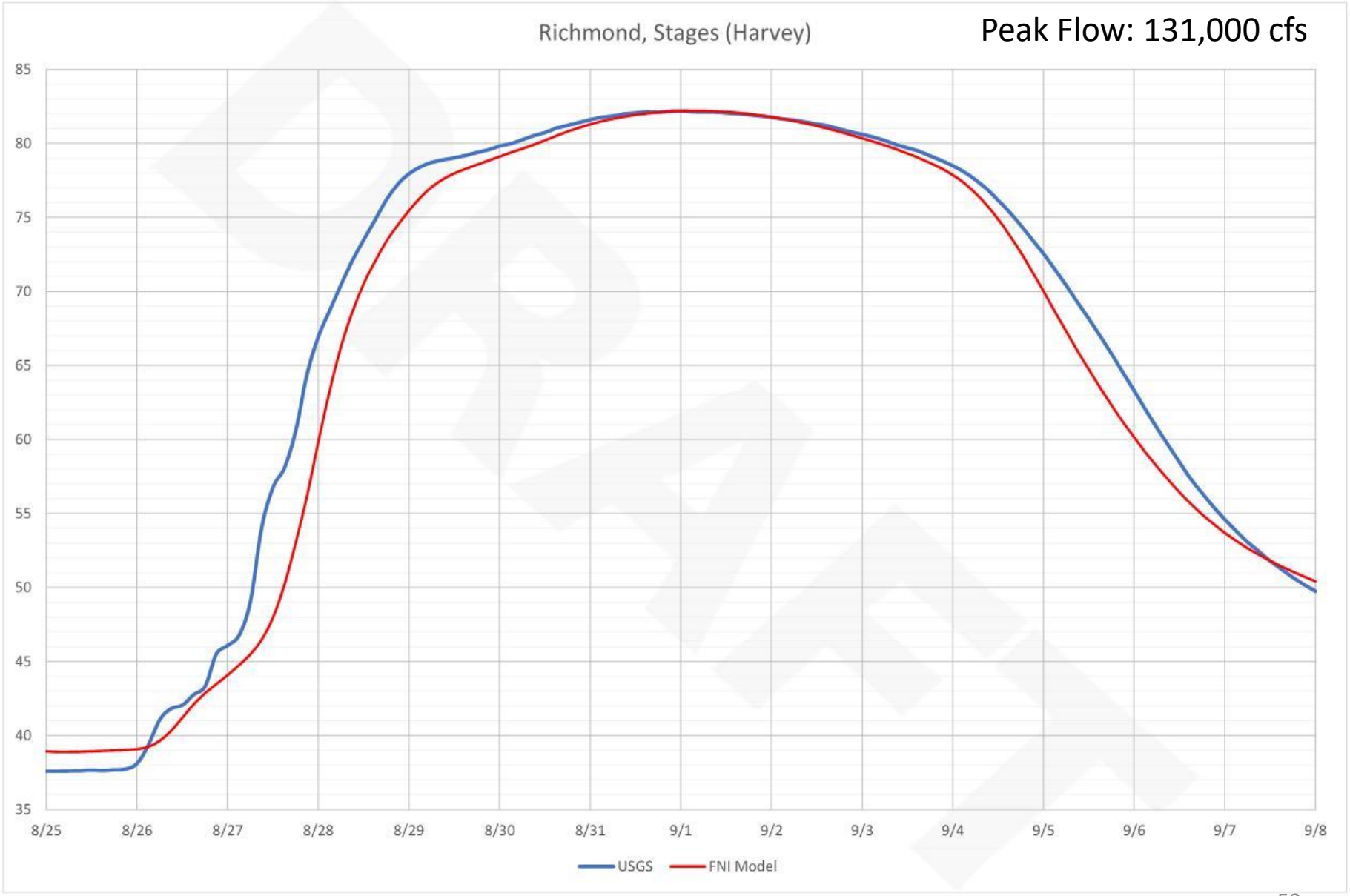
Brazos River – Harvey



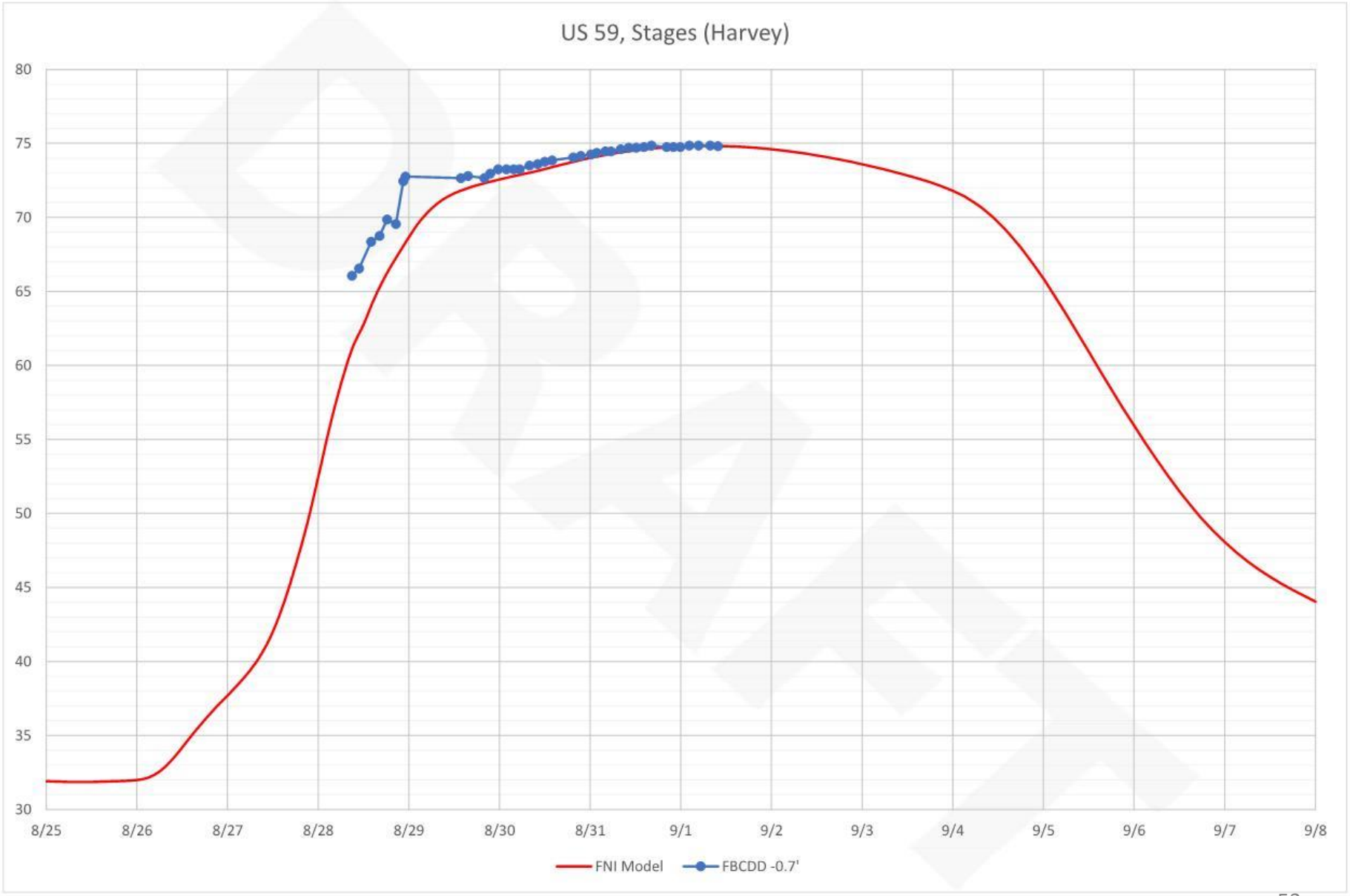
Brazos River – Harvey



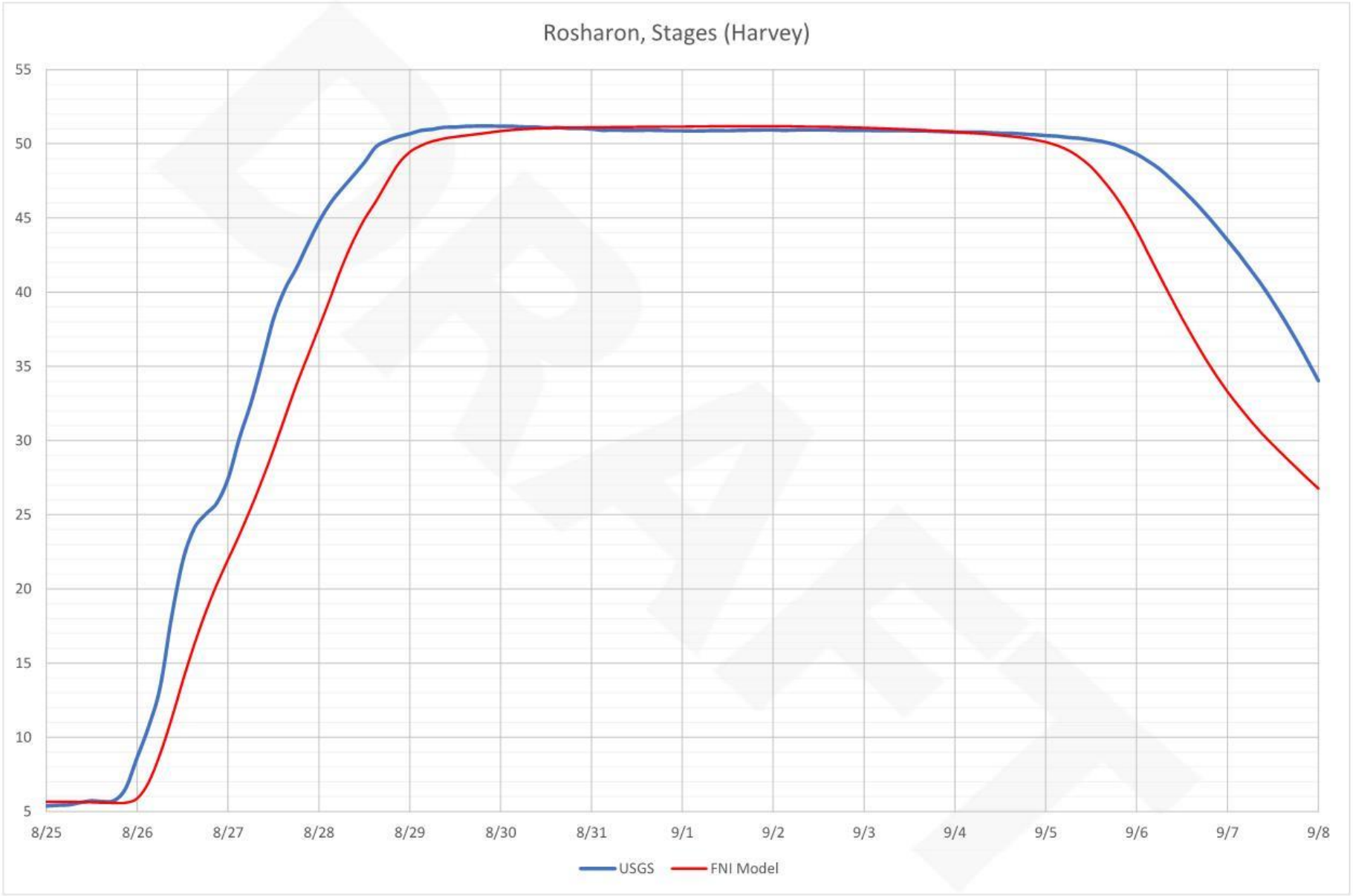
Brazos River – Harvey



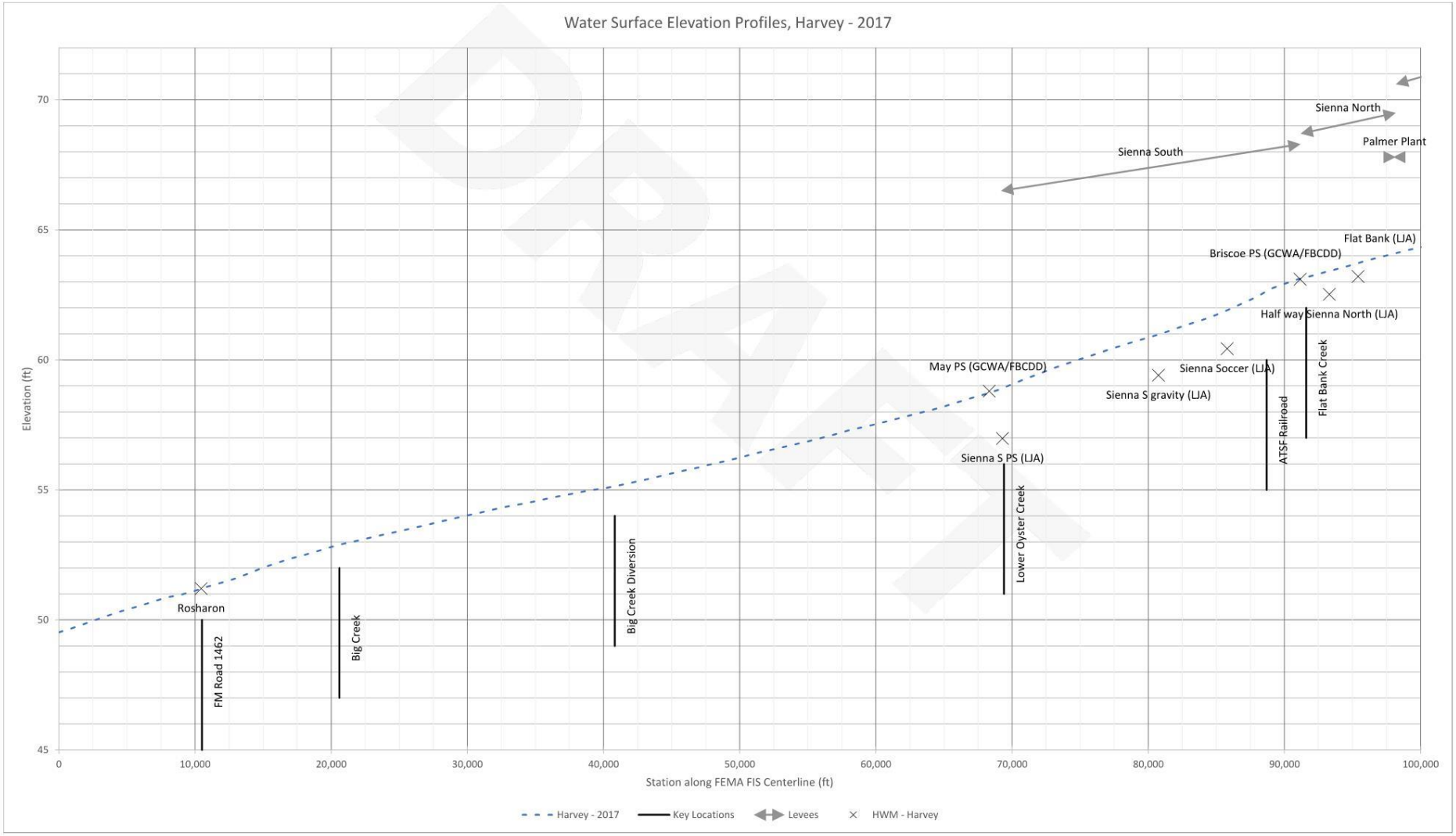
Brazos River – Harvey



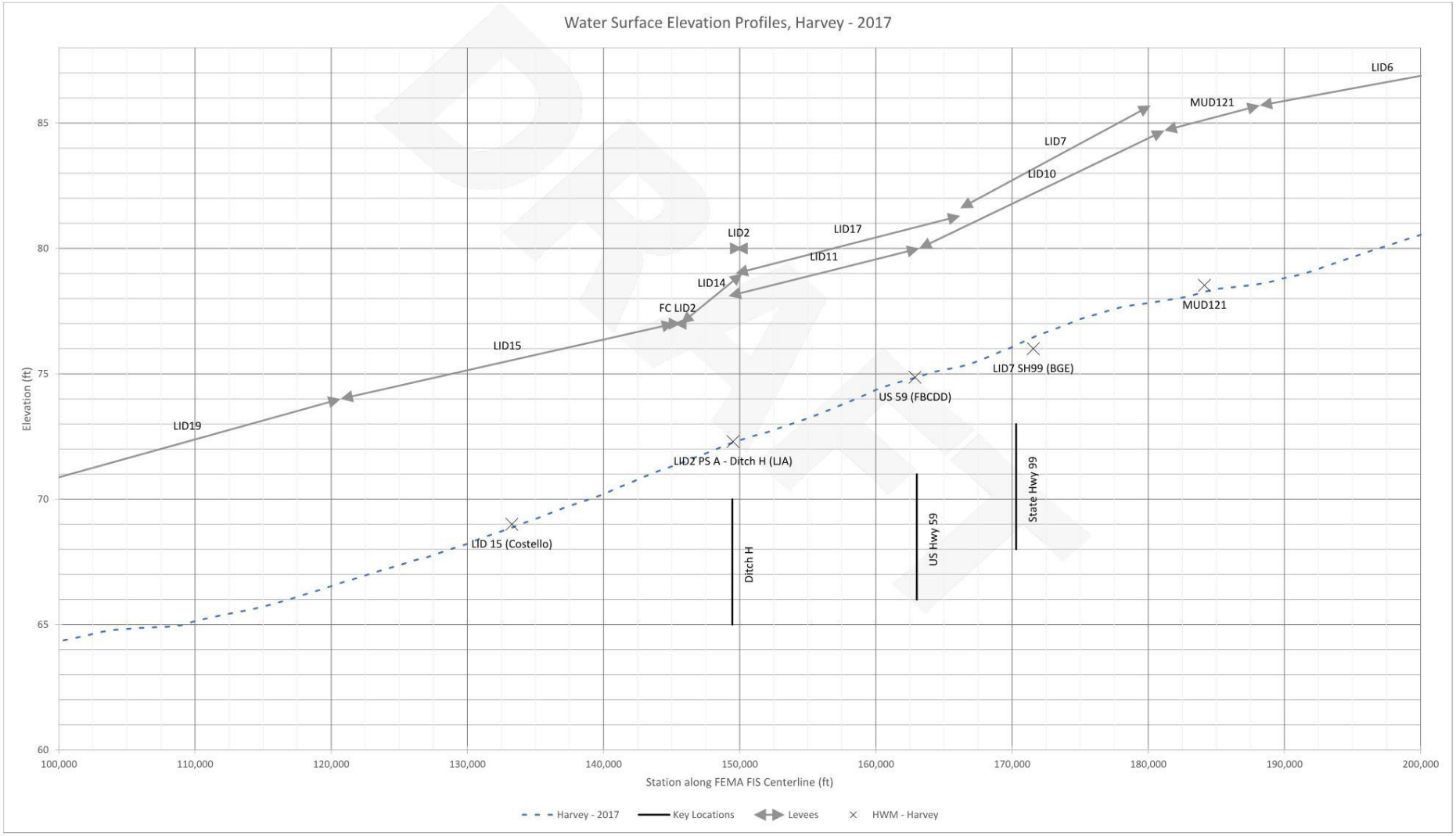
Brazos River – Harvey



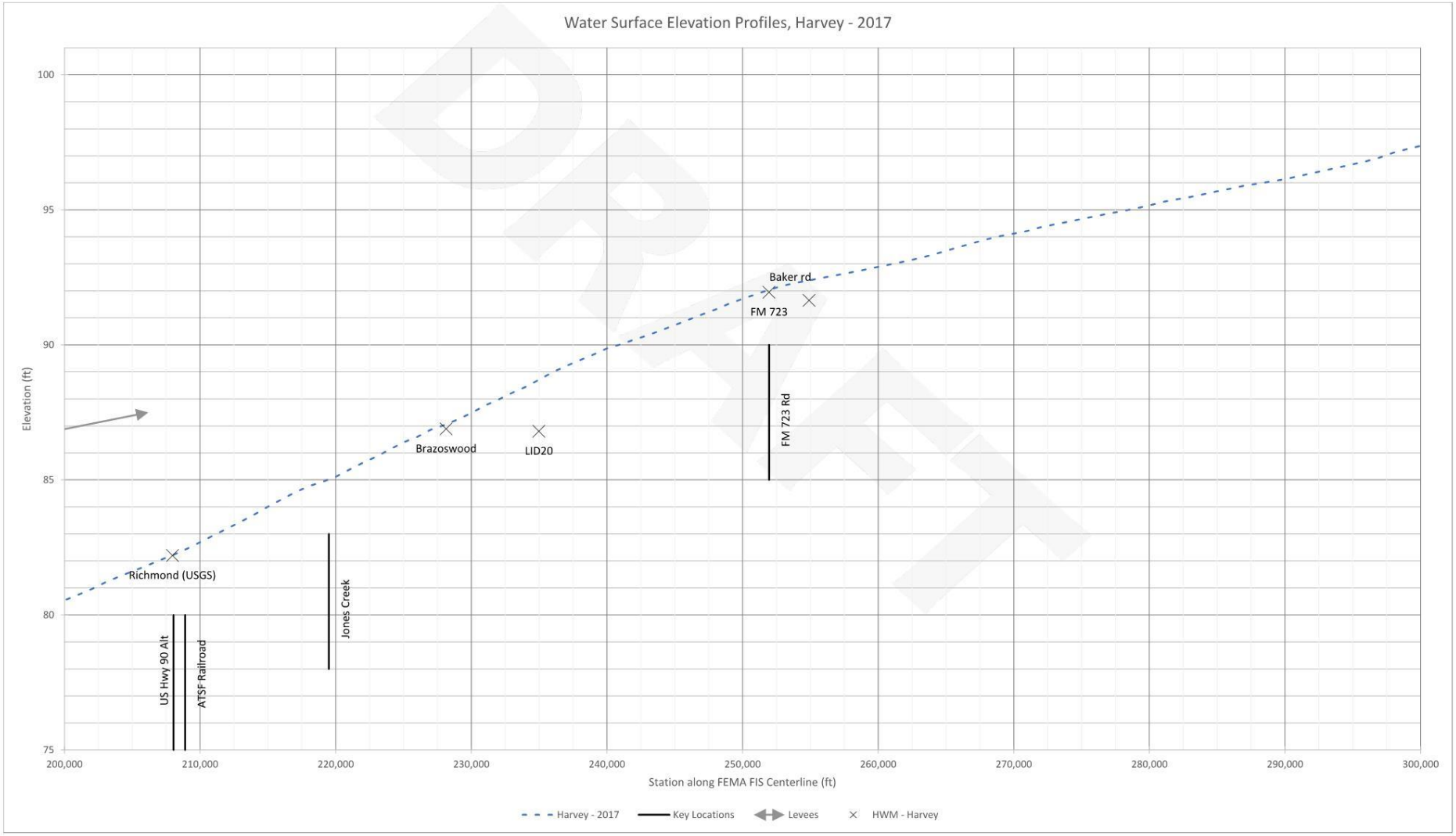
PROFILE – Harvey



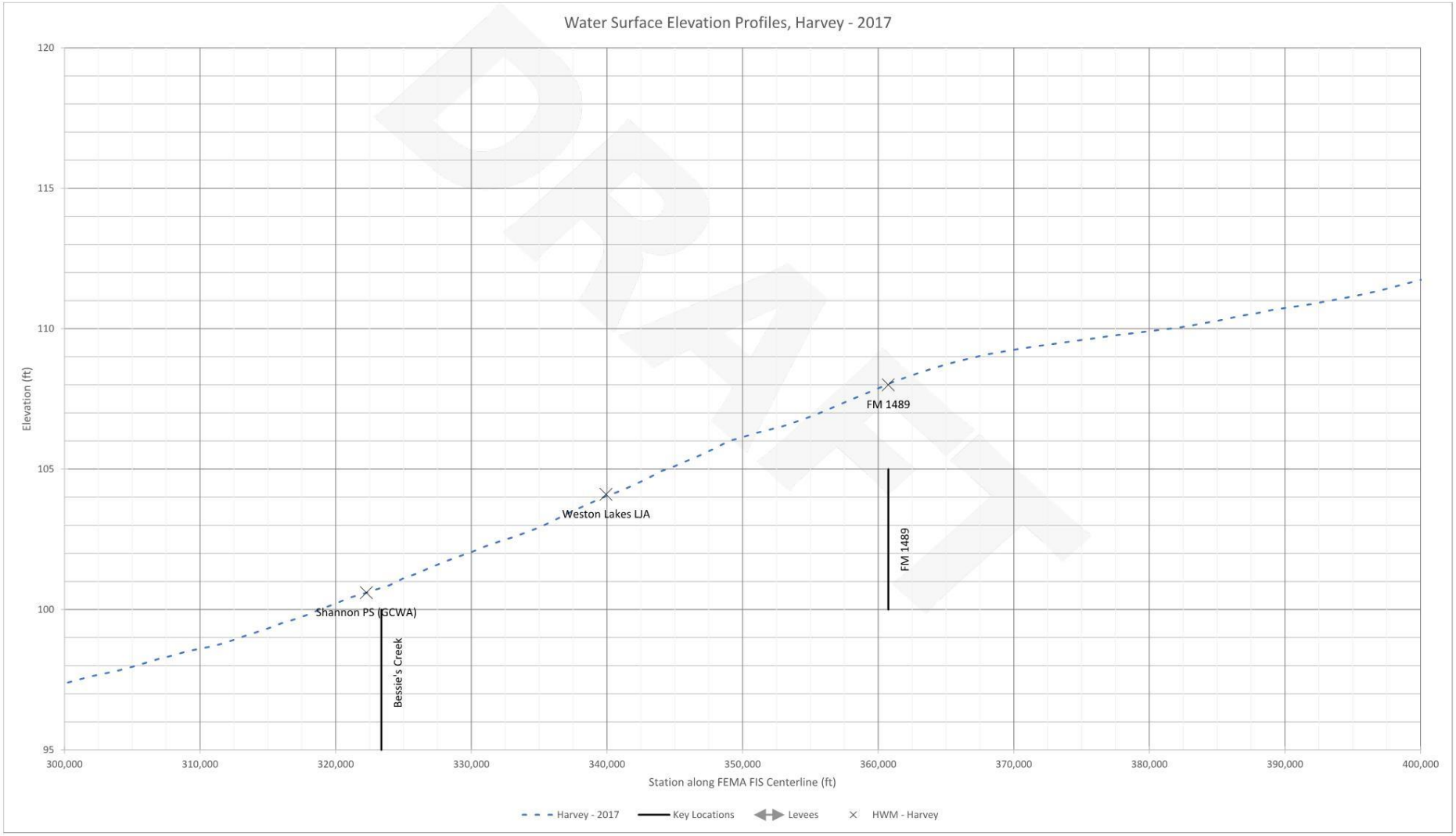
PROFILE – Harvey



PROFILE – Harvey

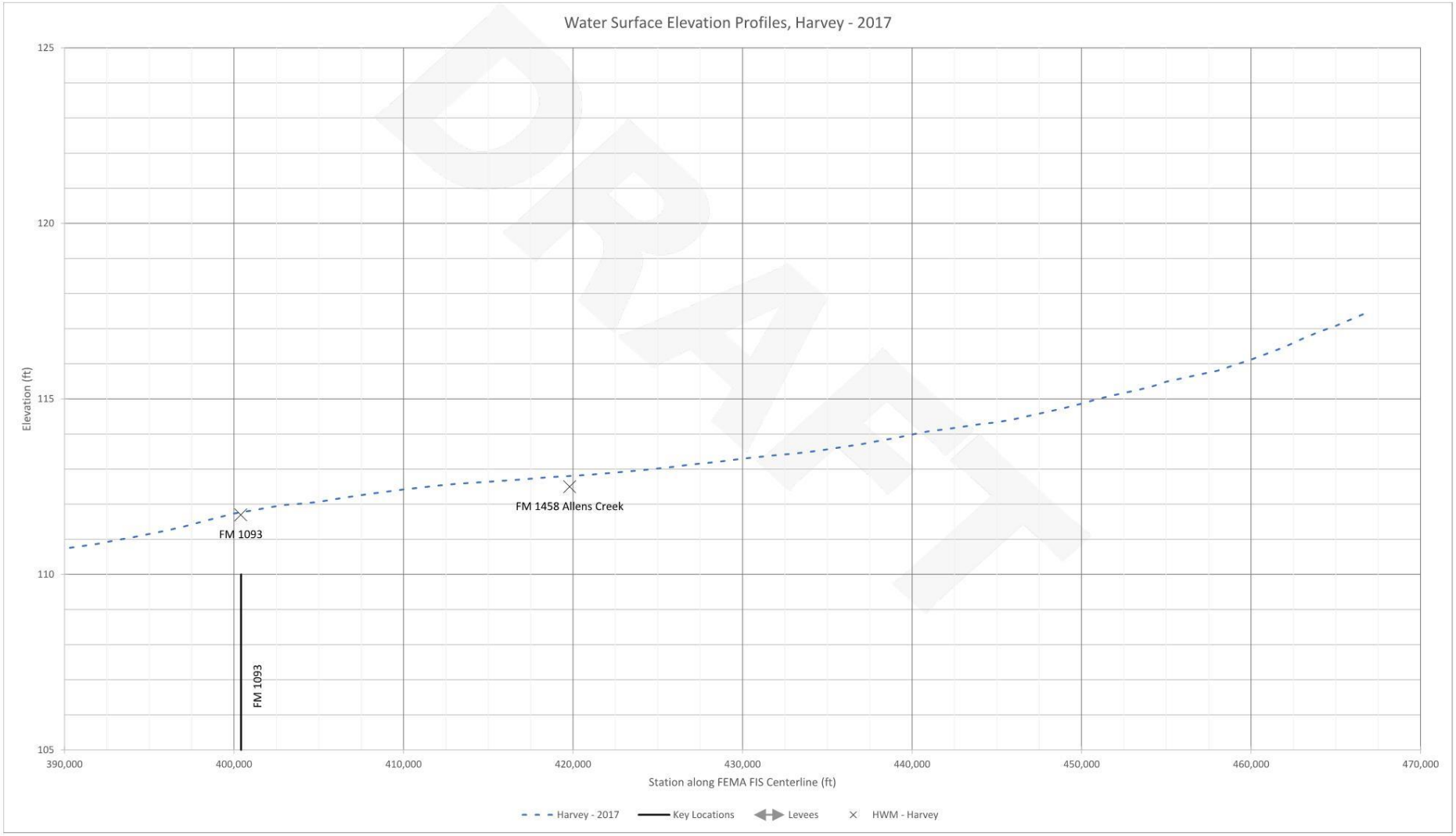


PROFILE – Harvey



DRAFT

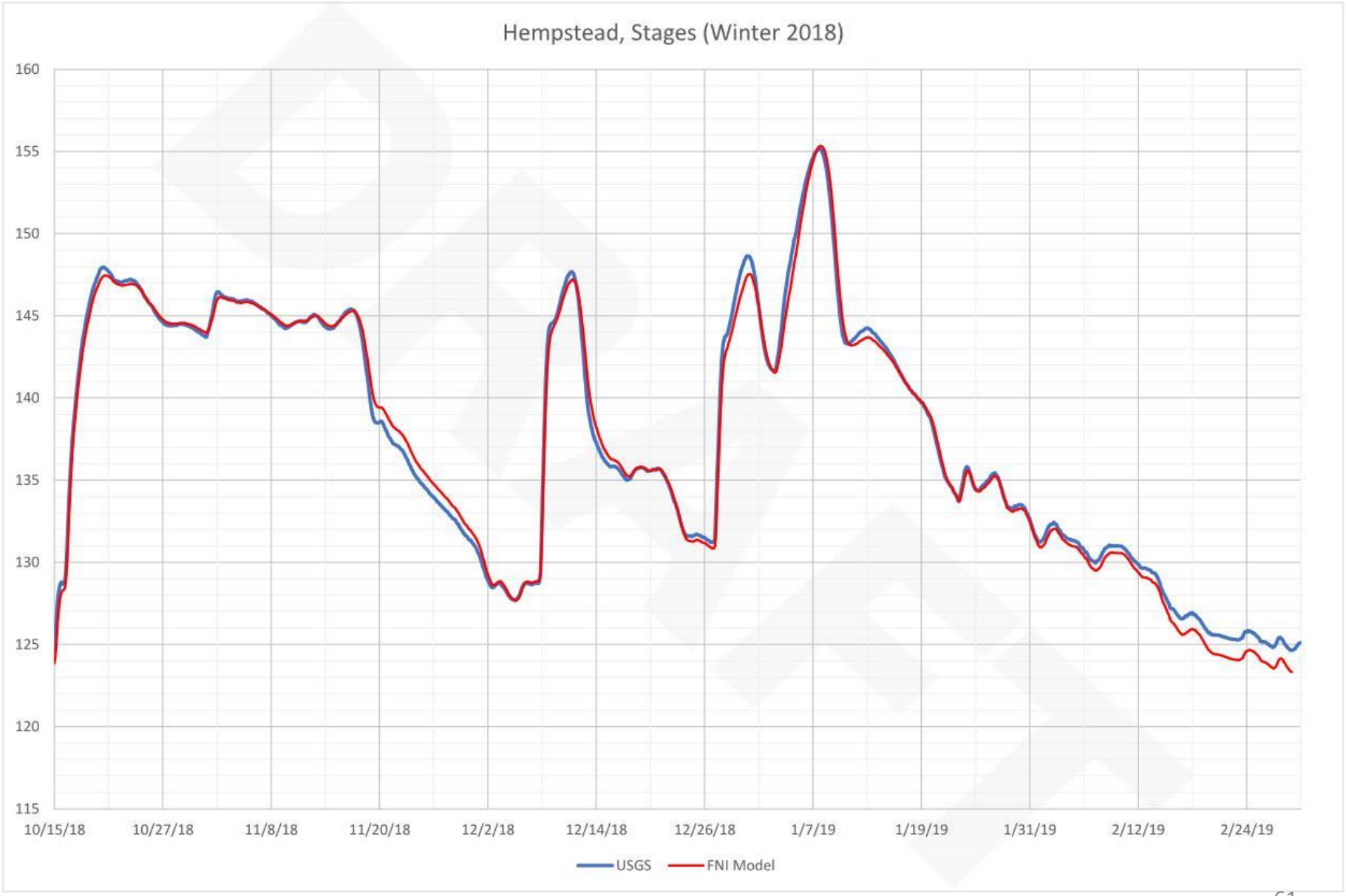
PROFILE – Harvey



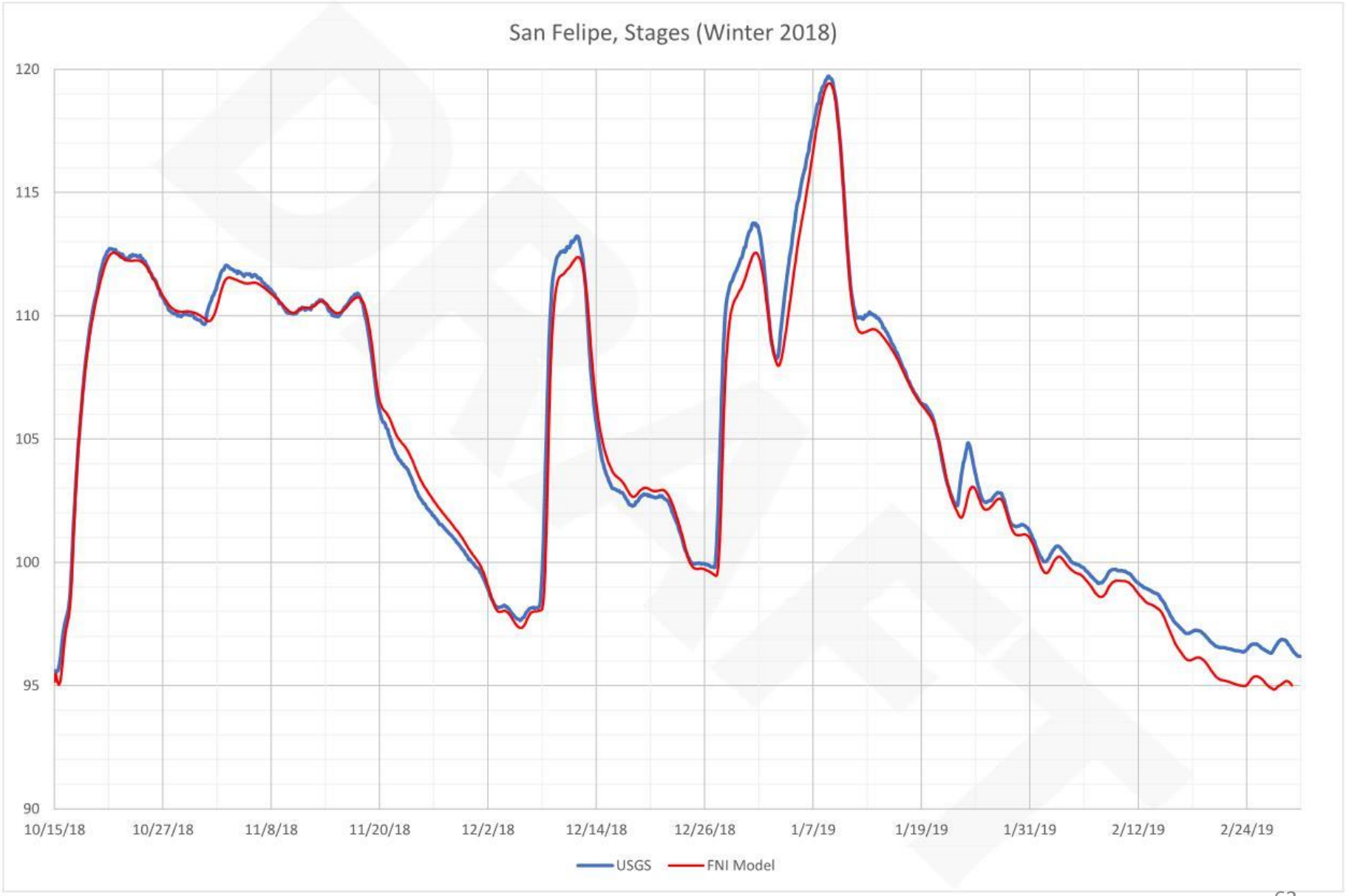
DRAFT

Winter 18/19

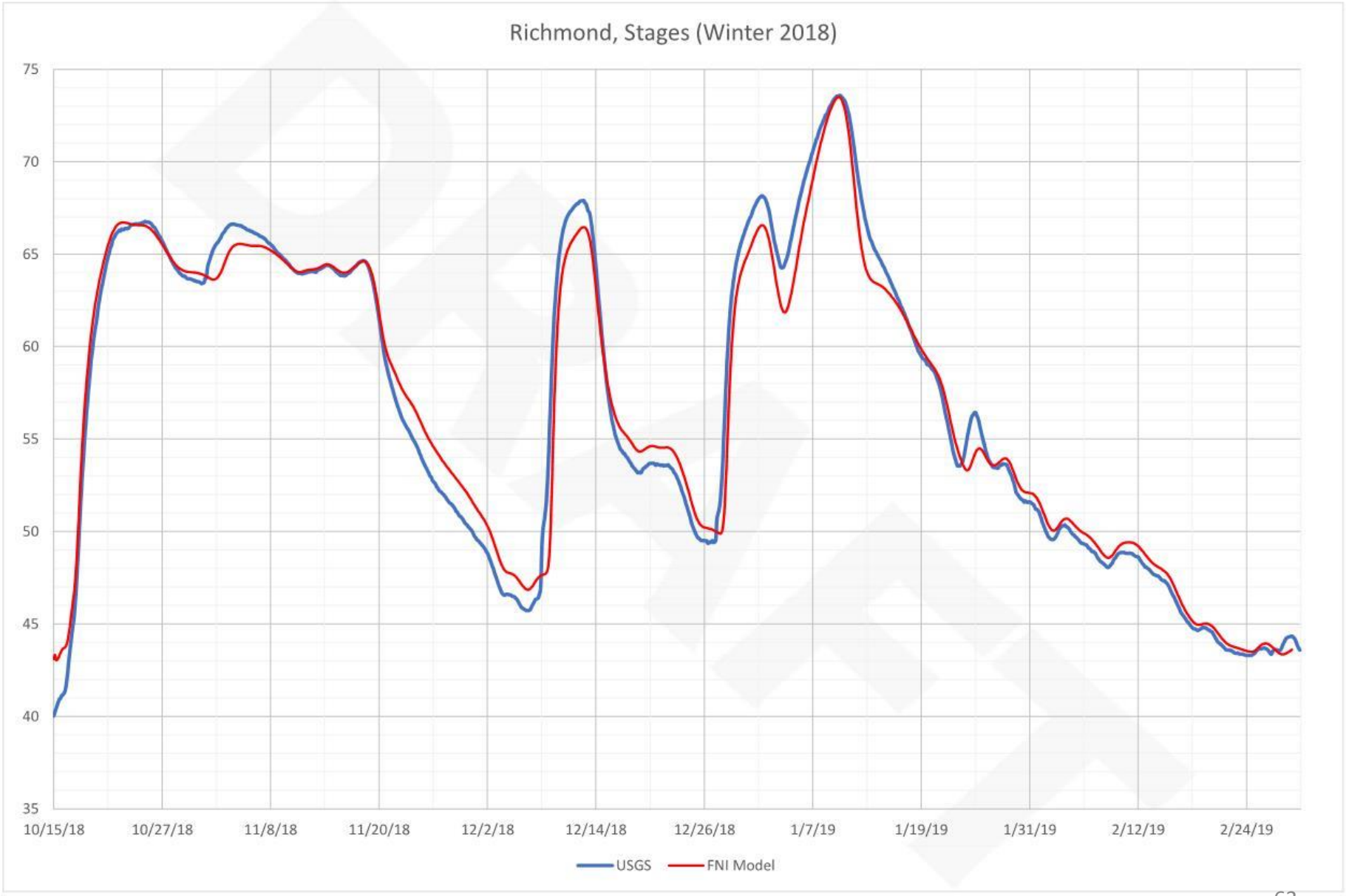
Brazos River – Winter



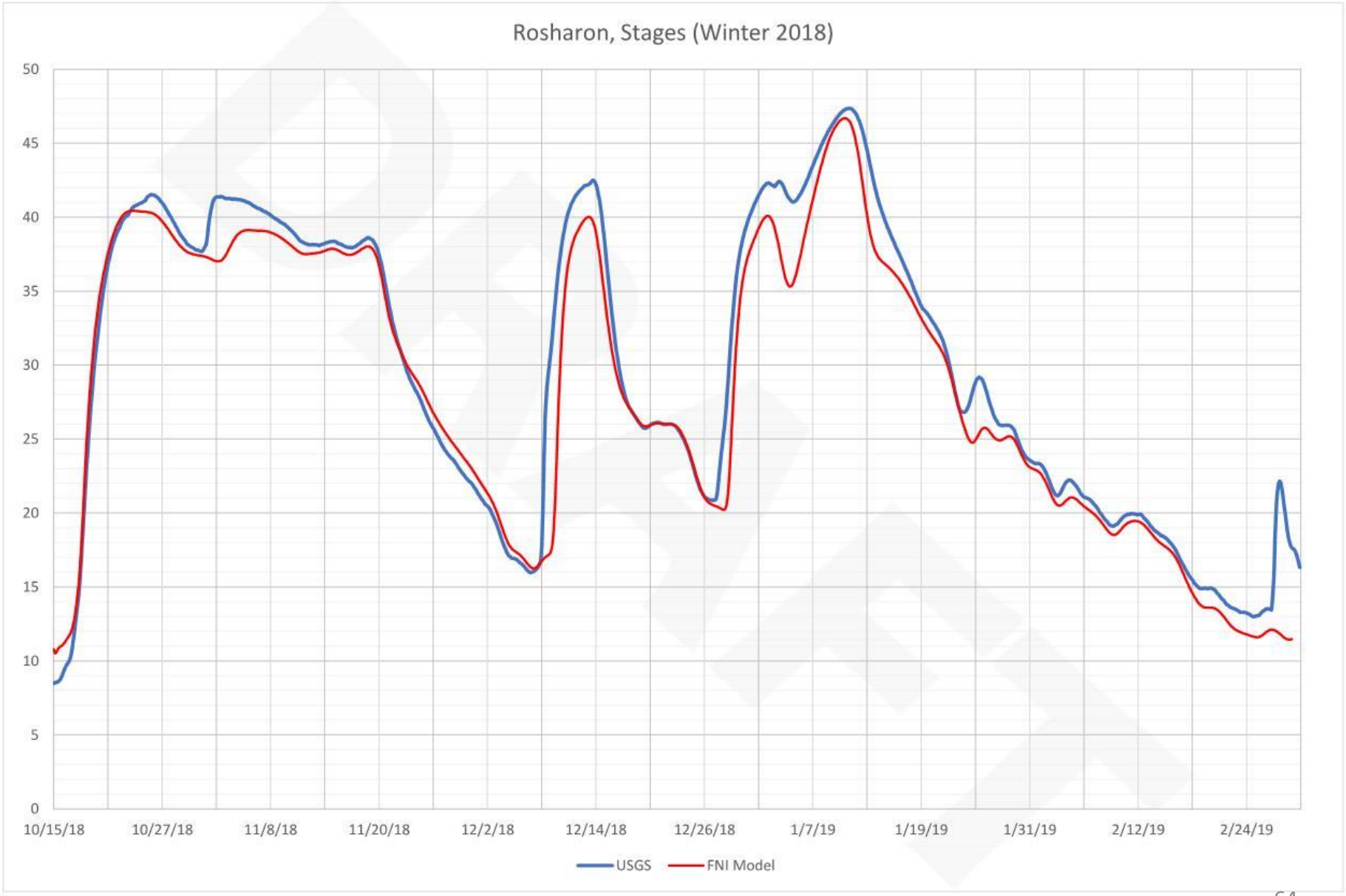
Brazos River – Winter



Brazos River – Winter

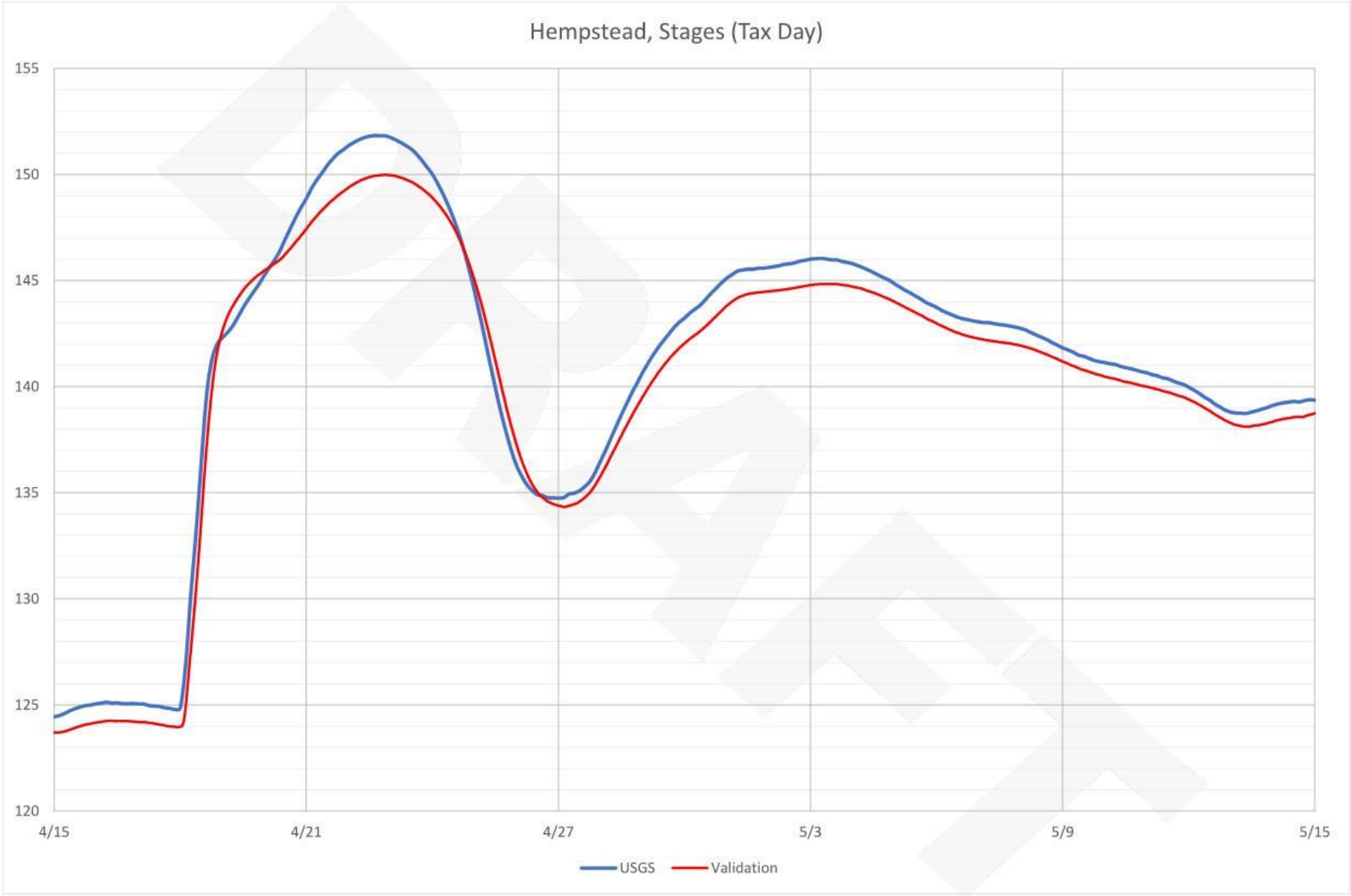


Brazos River – Winter

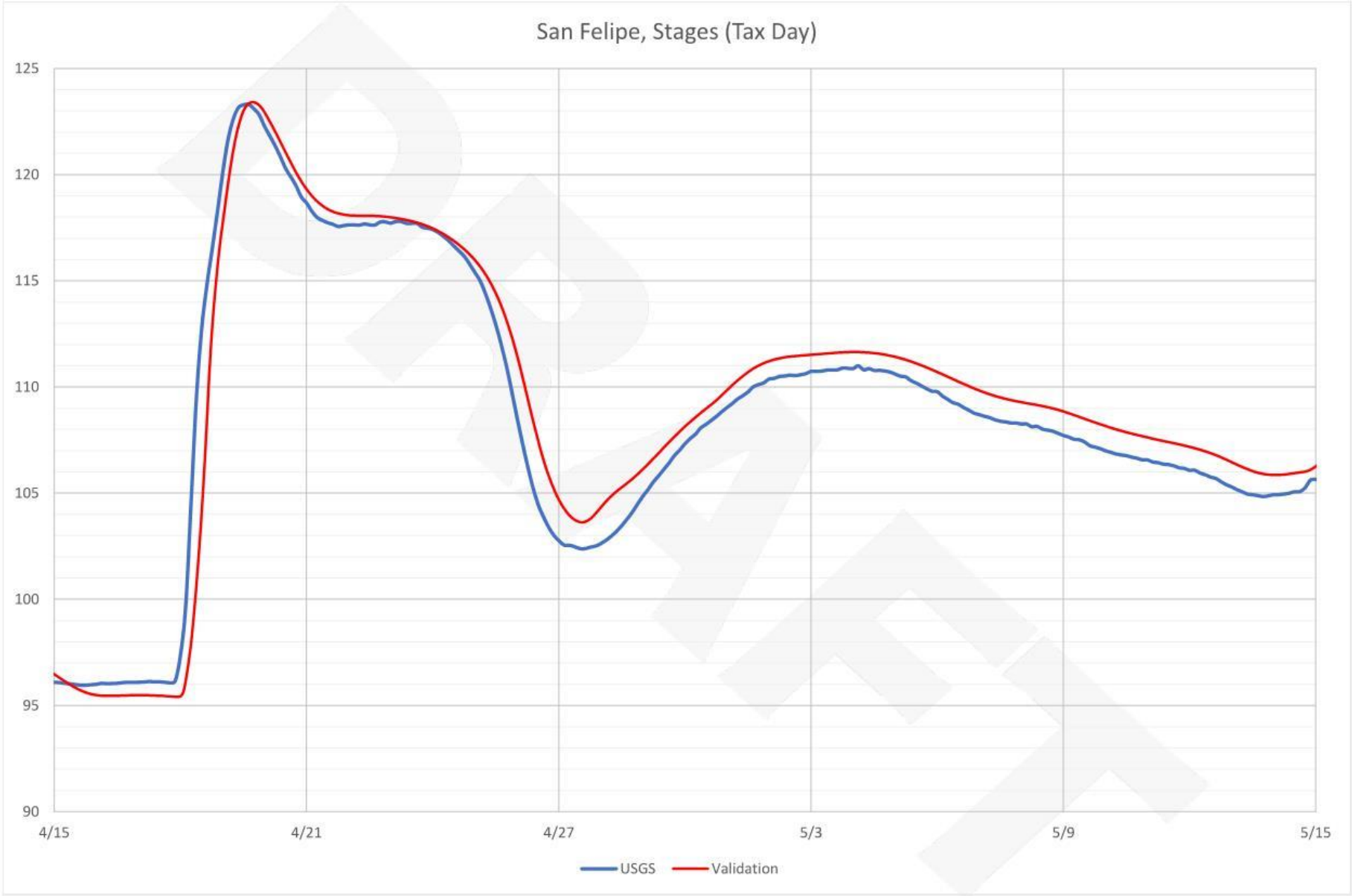


Validation (Tax Day 2016)

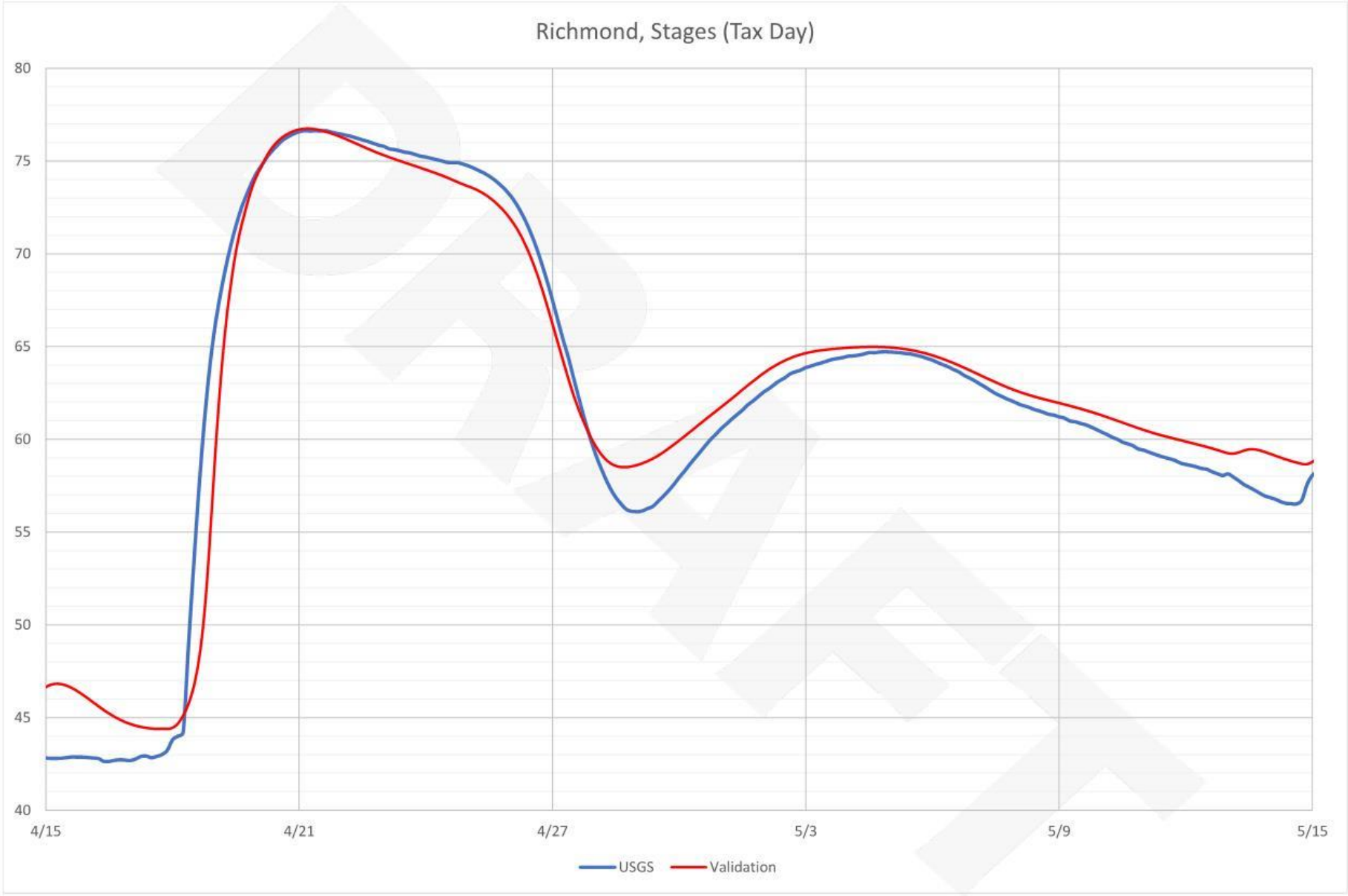
Brazos River – Tax Day 2016



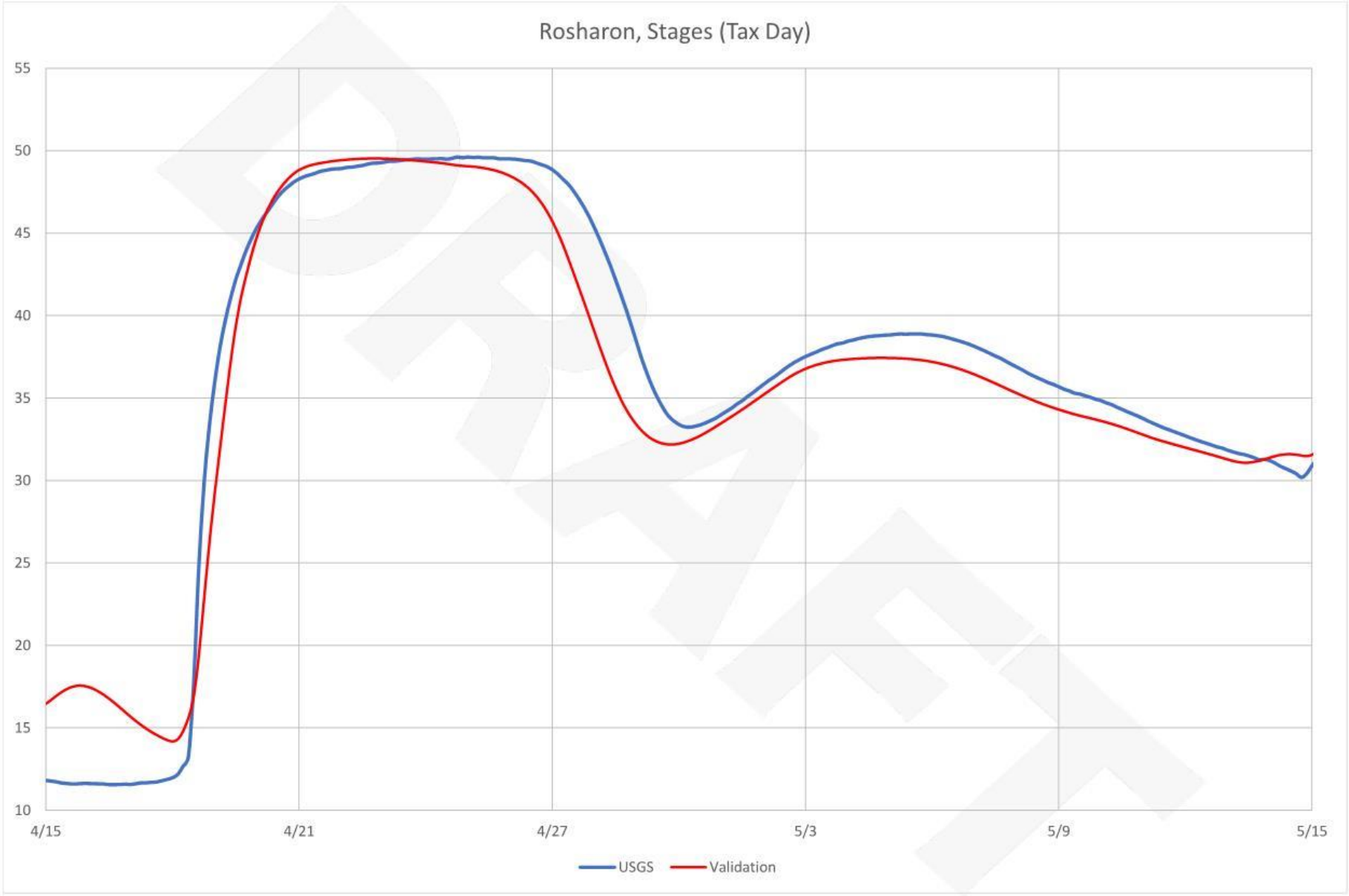
Brazos River – Tax Day 2016



Brazos River – Tax Day 2016



Brazos River – Tax Day 2016

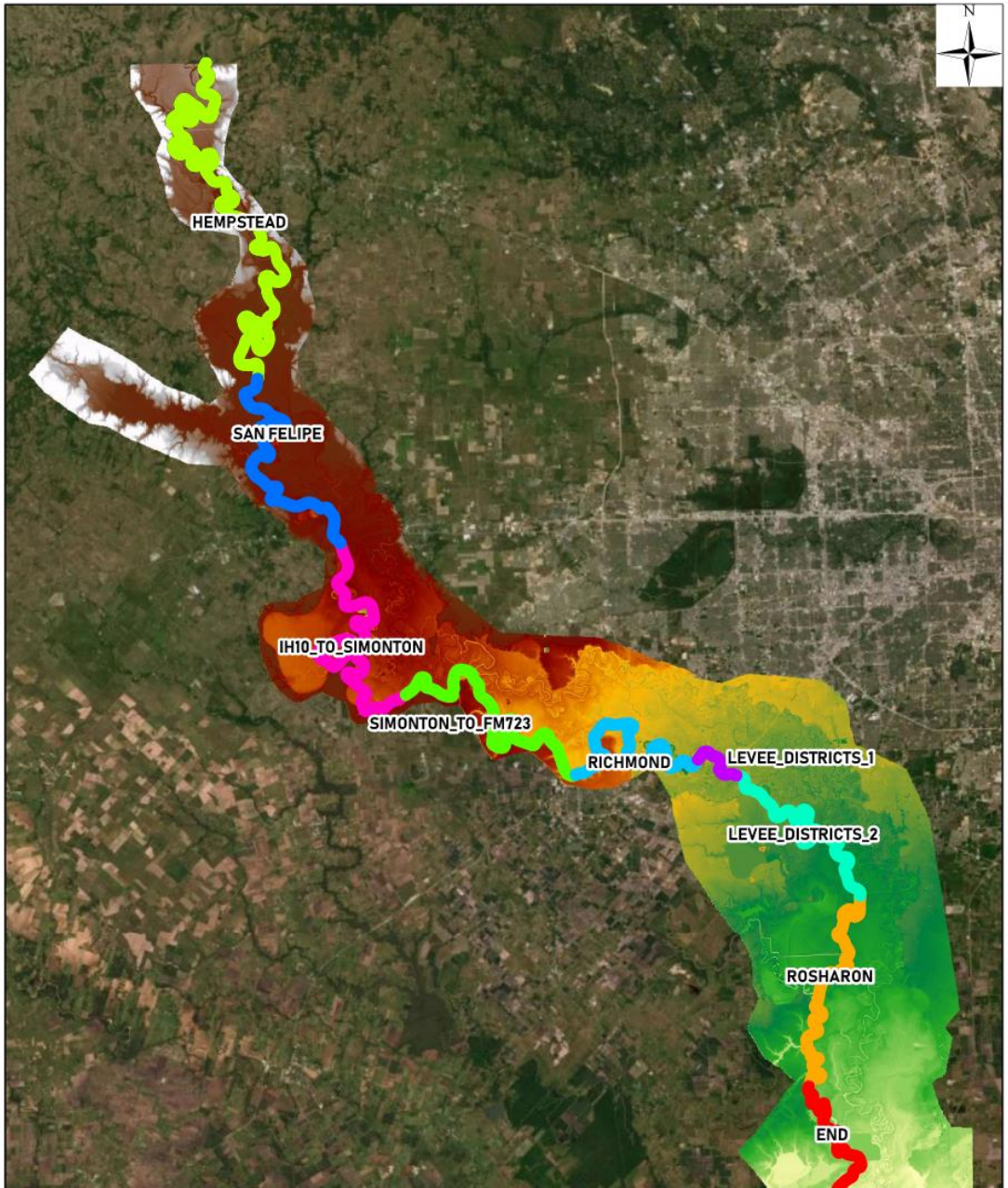


Manning's n values

		Memorial Day 2016		Harvey		Winter 18/19		Existing Conditions*	
	Land Use	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Main Channel	Hempstead	0.035	0.040	0.035	0.040	0.030	0.033	0.035	0.040
	San Felipe	0.035	0.040	0.035	0.040	0.030	0.030	0.035	0.040
	IH10-Simonton	0.033	0.038	0.032	0.036	0.030	0.035	0.033	0.038
	Simonton to FM723	0.031	0.039	0.032	0.039	0.035	0.035	0.031	0.039
	Richmond	0.038	0.043	0.036	0.042	0.035	0.035	0.036	0.043
	Levee Districts 1	0.038	0.042	0.038	0.040	0.034	0.034	0.038	0.042
	Levee Districts 2	0.038	0.047	0.037	0.040	0.038	0.041	0.038	0.047
	Rosharon	0.037	0.045	0.034	0.040	0.038	0.040	0.035	0.045
	End	0.038	0.045	0.038	0.040	0.040	0.040	0.038	0.045
Overbanks	Open water	0.037	1.000	0.034	1.000			0.035	1.000
	Developed high intensity	0.030	0.030	0.030	0.030			0.030	0.030
	Developed medium intensity	0.120	0.171	0.120	0.171			0.120	0.171
	Developed Low intensity	0.090	0.181	0.090	0.181			0.090	0.181
	Developed open space	0.050	0.060	0.050	0.060			0.000	0.060
	Barren Lands	0.040	0.040	0.040	0.040			0.040	0.040
	Forest/Shrubs	0.250	0.300	0.250	0.300			0.250	0.300
	Pasture/Grasslands	0.060	0.220	0.060	0.220			0.060	0.220
	Cultivated Crops	0.100	0.170	0.080	0.170			0.093	0.170
	Wetlands	0.250	0.300	0.250	0.300			0.250	0.300
Other areas	Upper Mill Creek	0.035	0.035	0.035	0.035			0.035	0.035
	Lower Mill Creek	0.033	0.033	0.033	0.033			0.033	0.033
	Ditch H	0.033	0.033	0.033	0.033			0.033	0.033
	Flat Bank Creek	0.033	0.033	0.033	0.033			0.033	0.033
	Oyster Creek	0.040	0.040	0.040	0.040			0.040	0.040
	Lower Oyster River	0.038	0.038	0.038	0.038			0.038	0.038
	Lower Oyster Creek	0.045	0.045	0.045	0.045			0.045	0.045
	Big Creek	0.040	0.040	0.040	0.040			0.040	0.040
	Big Creek Div	0.040	0.040	0.040	0.040			0.040	0.040
	Upper Bessies	0.055	0.055	0.055	0.055			0.055	0.055
	Bessies	0.050	0.050	0.050	0.050			0.050	0.050

* Existing conditions n values calculated as: 1/3 Memorial Day n value + 2/3 Harvey n value

Main Channel Reaches



Questions on Calibration?

Memorial Day 2016 at FM 723

Comparison of 100-yr elevations (PRELIMINARY)

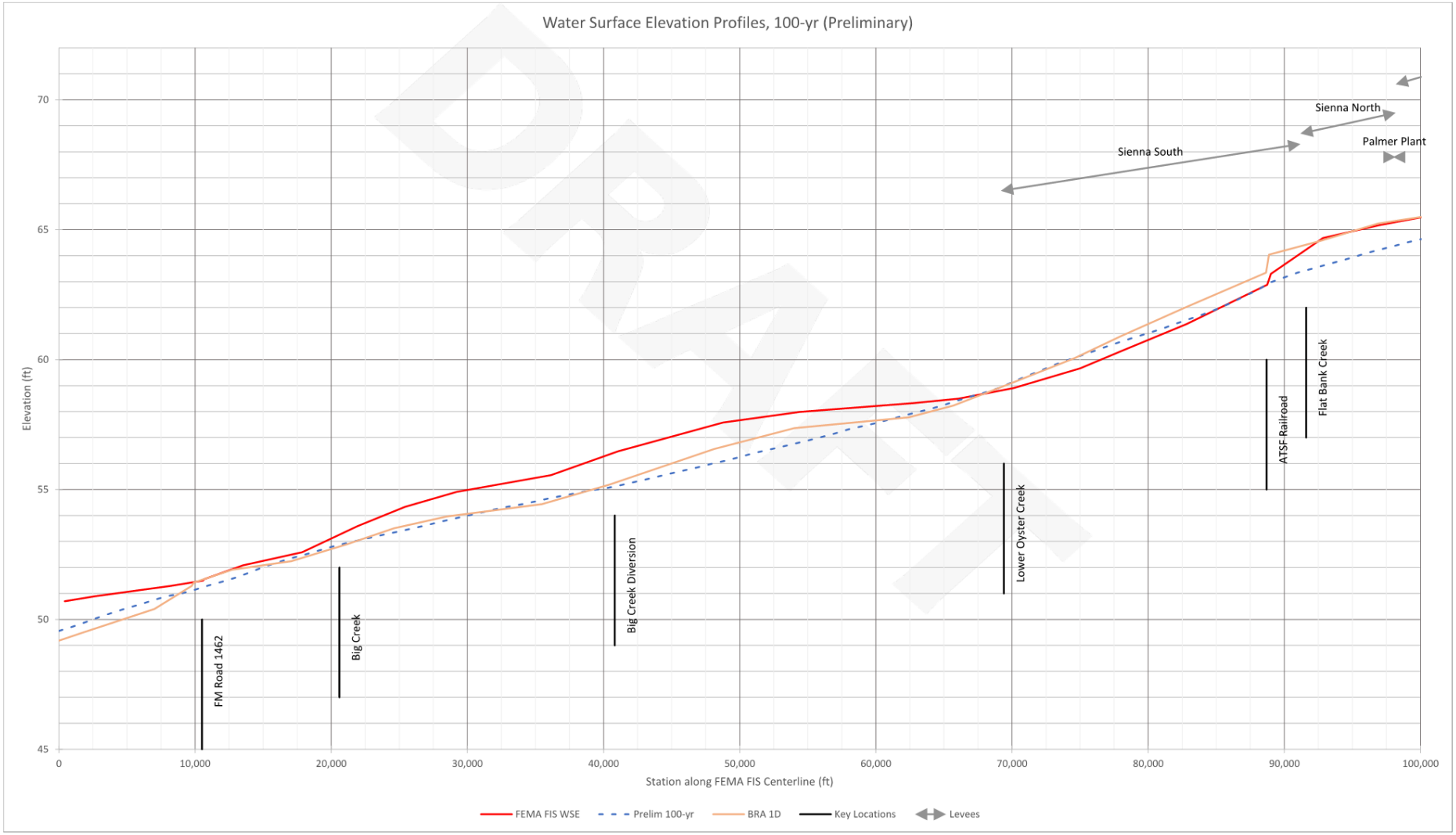
DISCLAIMER

- 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

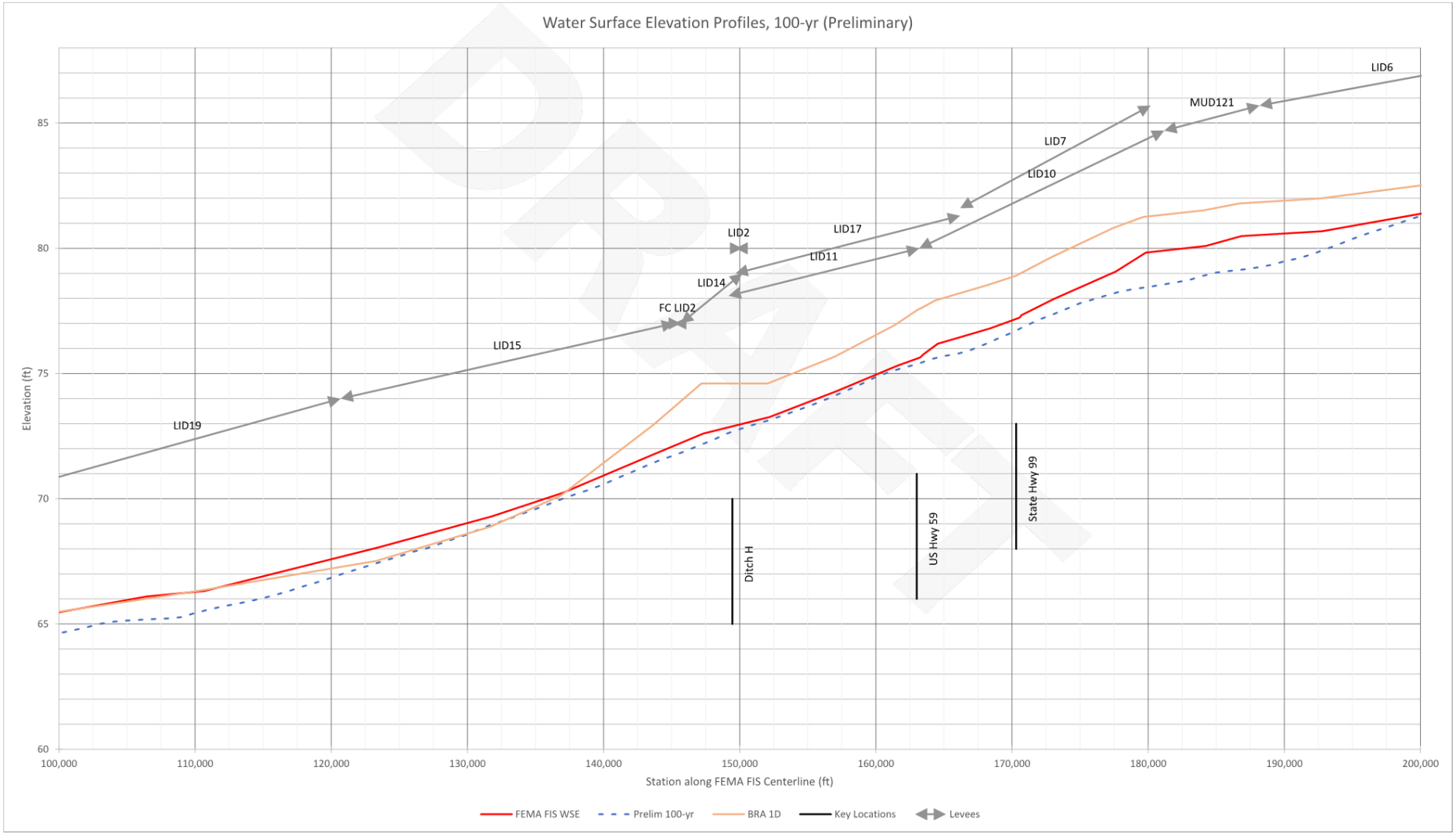
PRELIMINARY 100-YR WSEL

Gage	Effective	BRA Study	Preliminary
Richmond	82.80’	84.43’	83.03’
Rosharon	51.50’	51.29’	51.21’

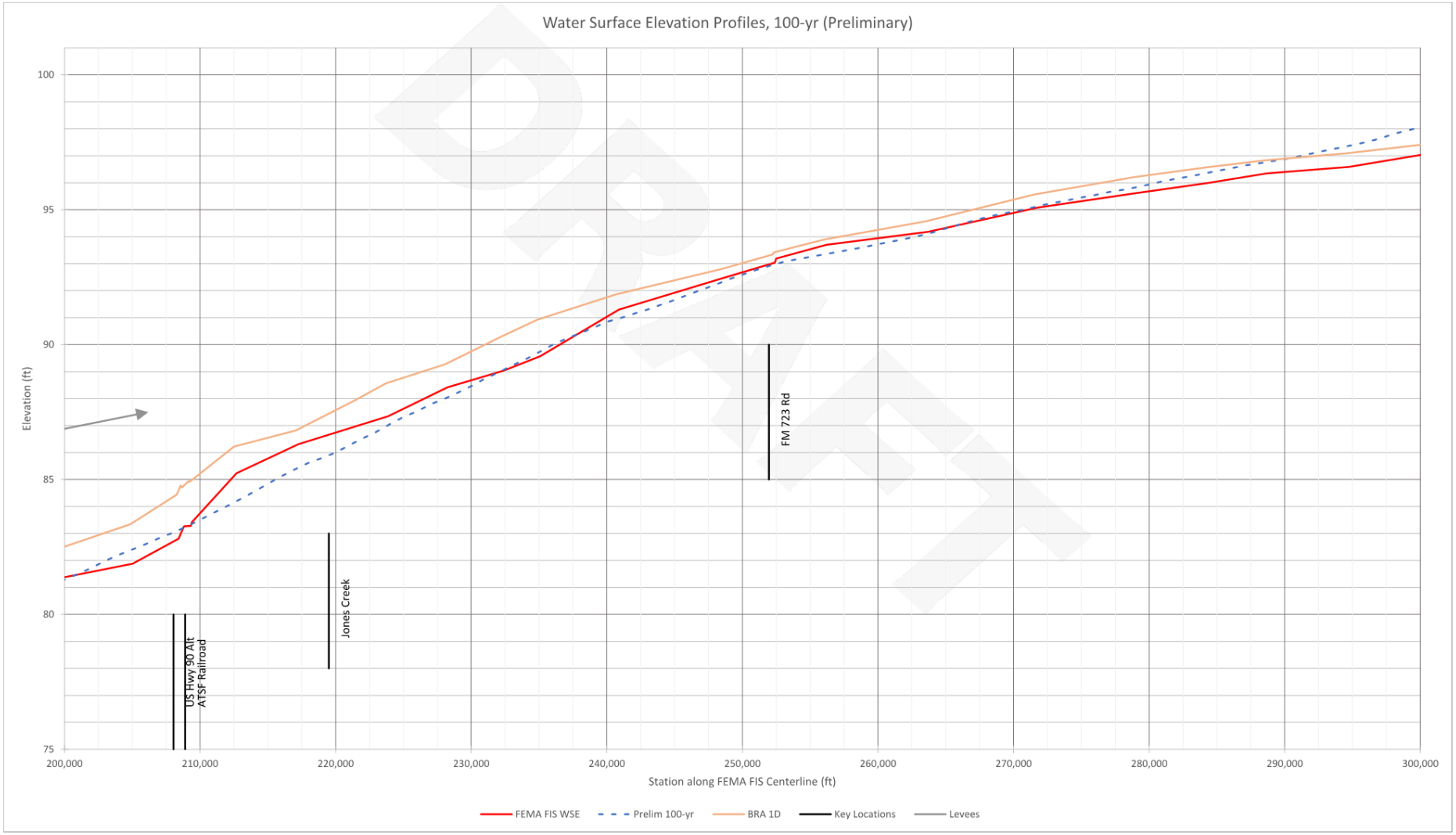
PRELIMINARY 100-YR PROFILE



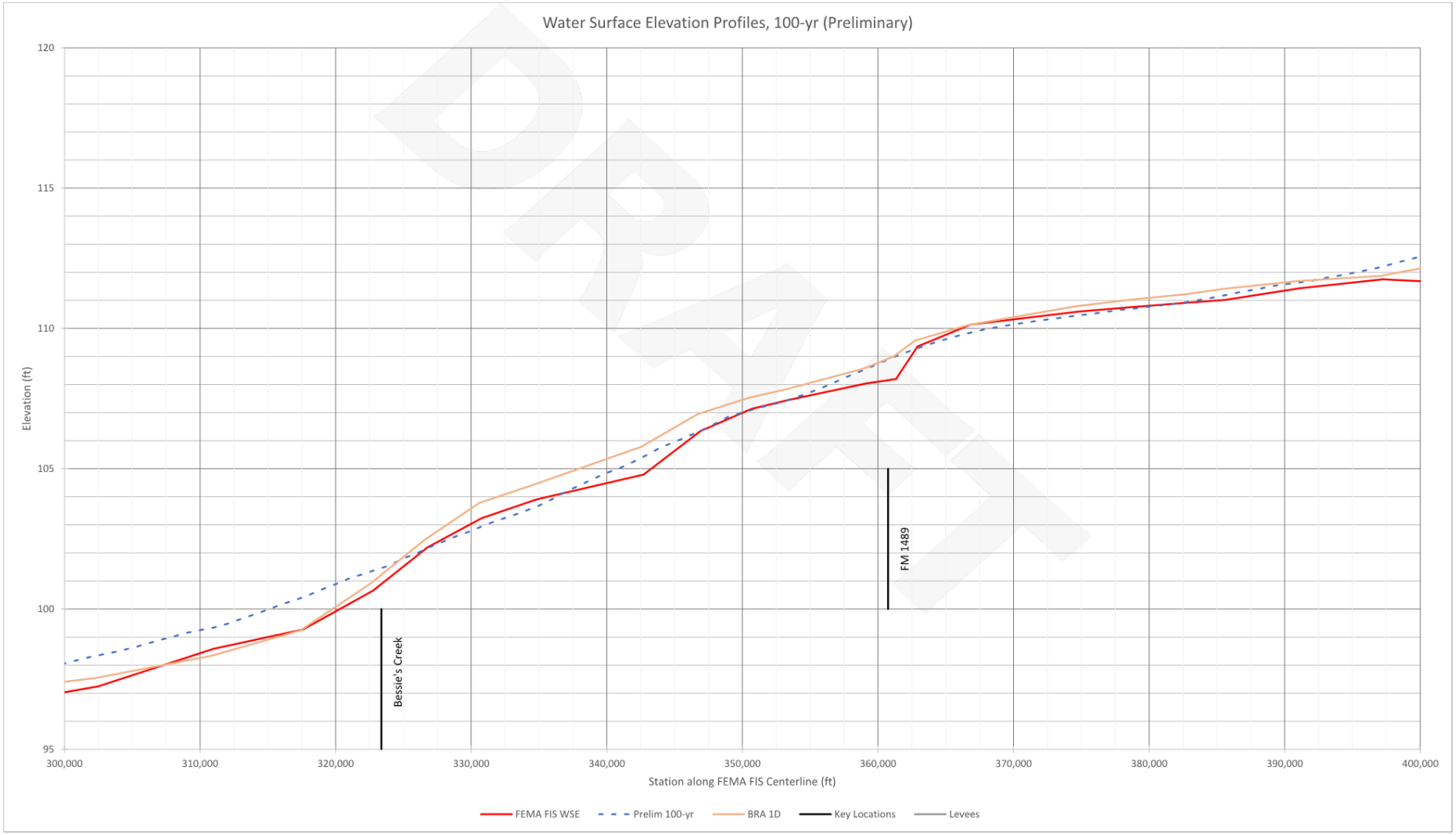
PRELIMINARY 100-YR PROFILE



PRELIMINARY 100-YR PROFILE



PRELIMINARY 100-YR PROFILE



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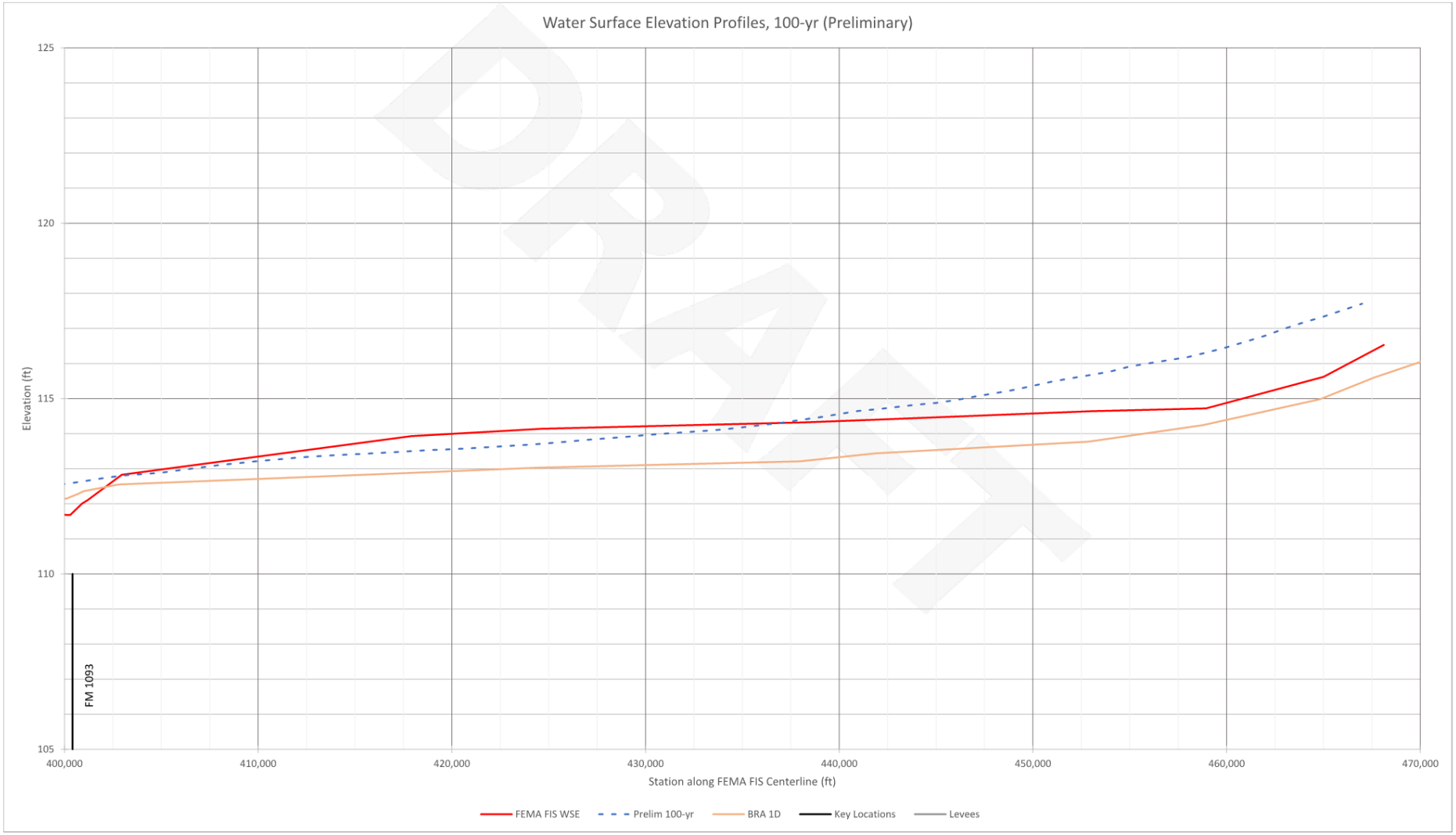
PRELIMINARY 100-YR PROFILE



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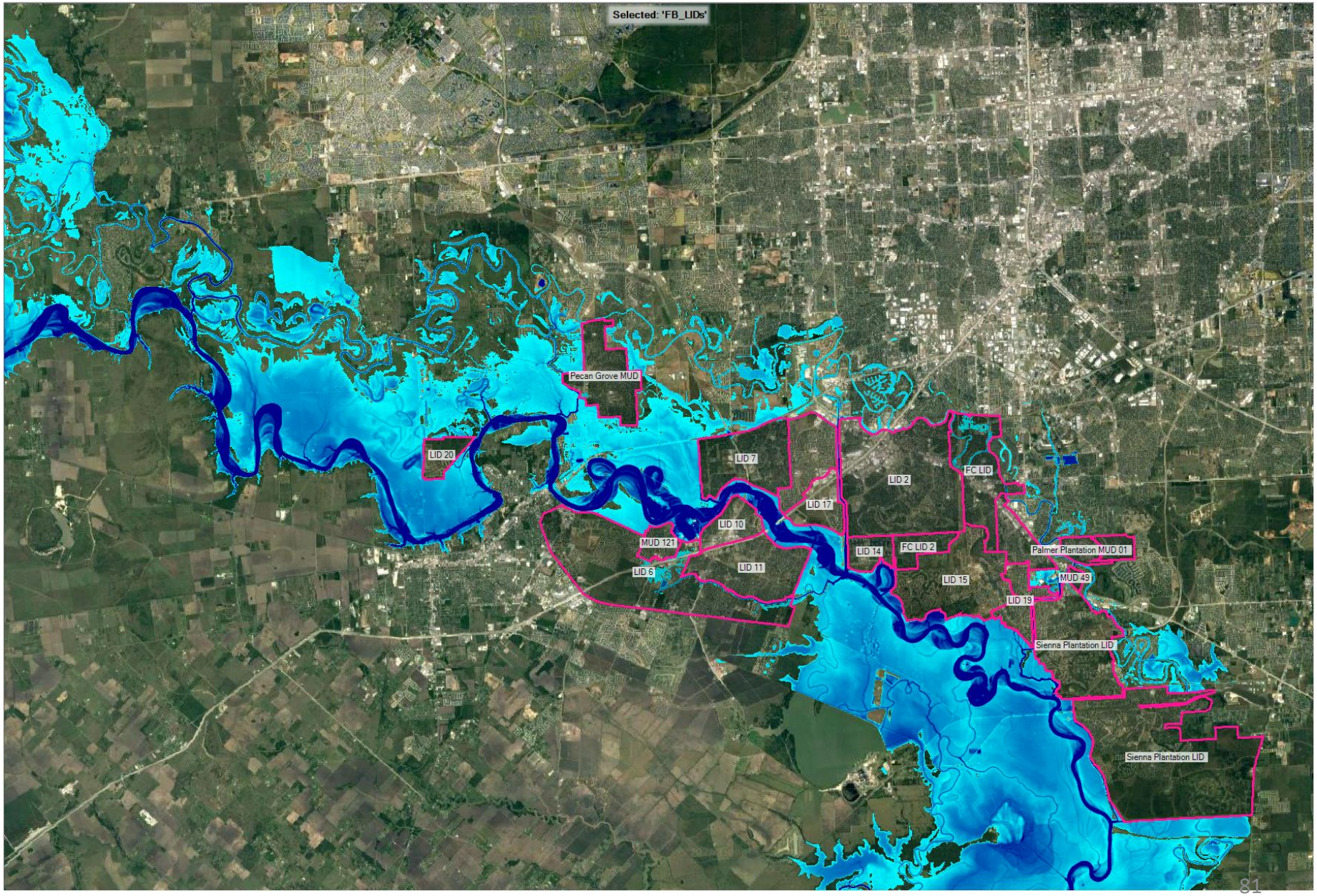
PRELIMINARY 100-YR (Brazos River only)



100-yr and 500-yr profiles (PRELIMINARY)

DISCLAIMER

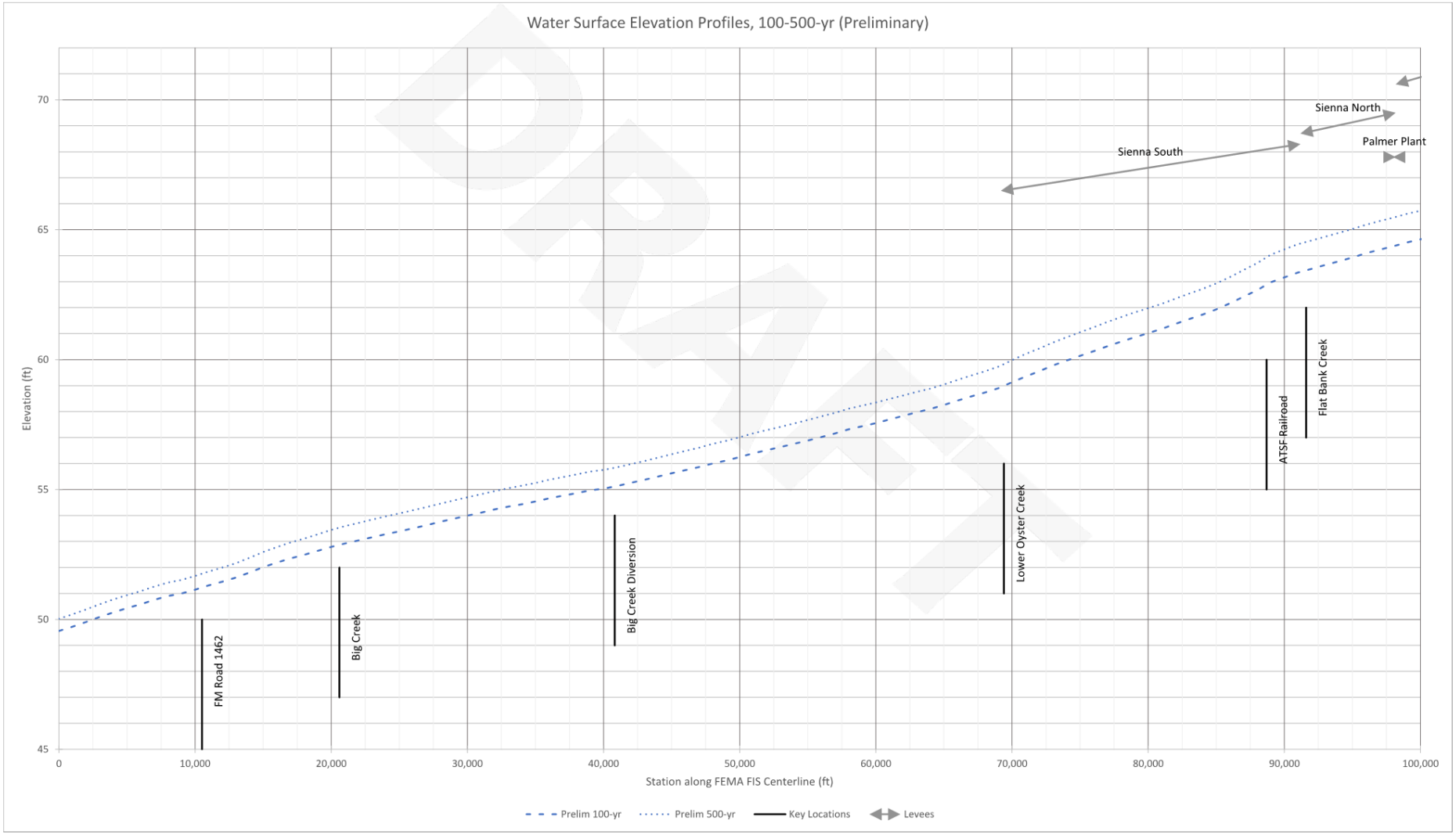
- Flows
  - Preliminary flows: Scenario 6
- Elevation datum
  - NAVD88 (Same as 2014 LiDAR)
- Topography
  - 2014 LiDAR
- Limitations (2D only)
  - Doesn’t include bridges
- Results are subject to change

PRELIMINARY 100 and 500-YR WSEL

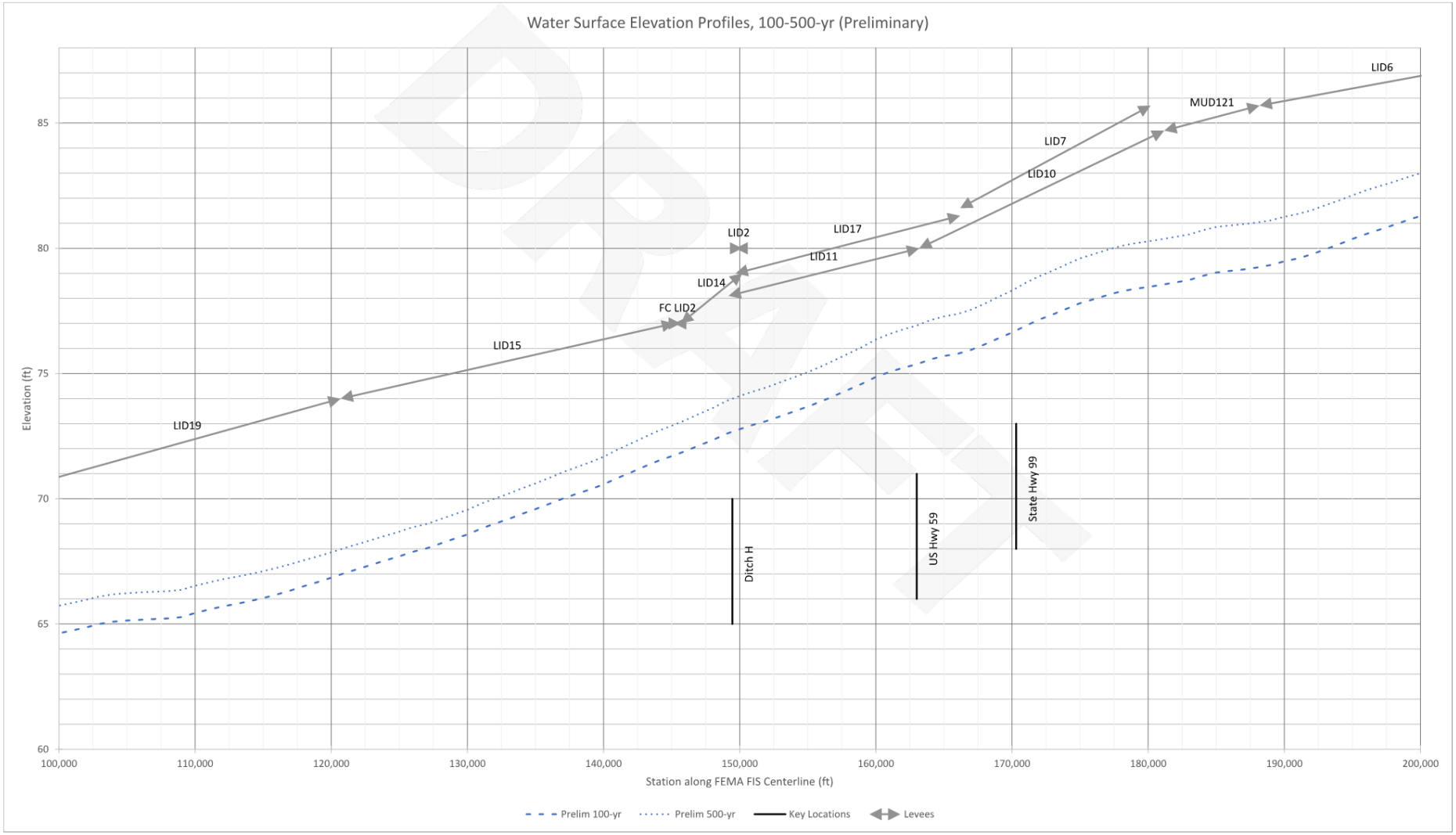
Gage	100-yr	500-yr
Richmond	83.03’ (56.01)	84.73’ (57.71)
Rosharon	51.21’ (52.63)	51.74’ (53.16)

Numbers in parenthesis correspond to stage at USGS gages

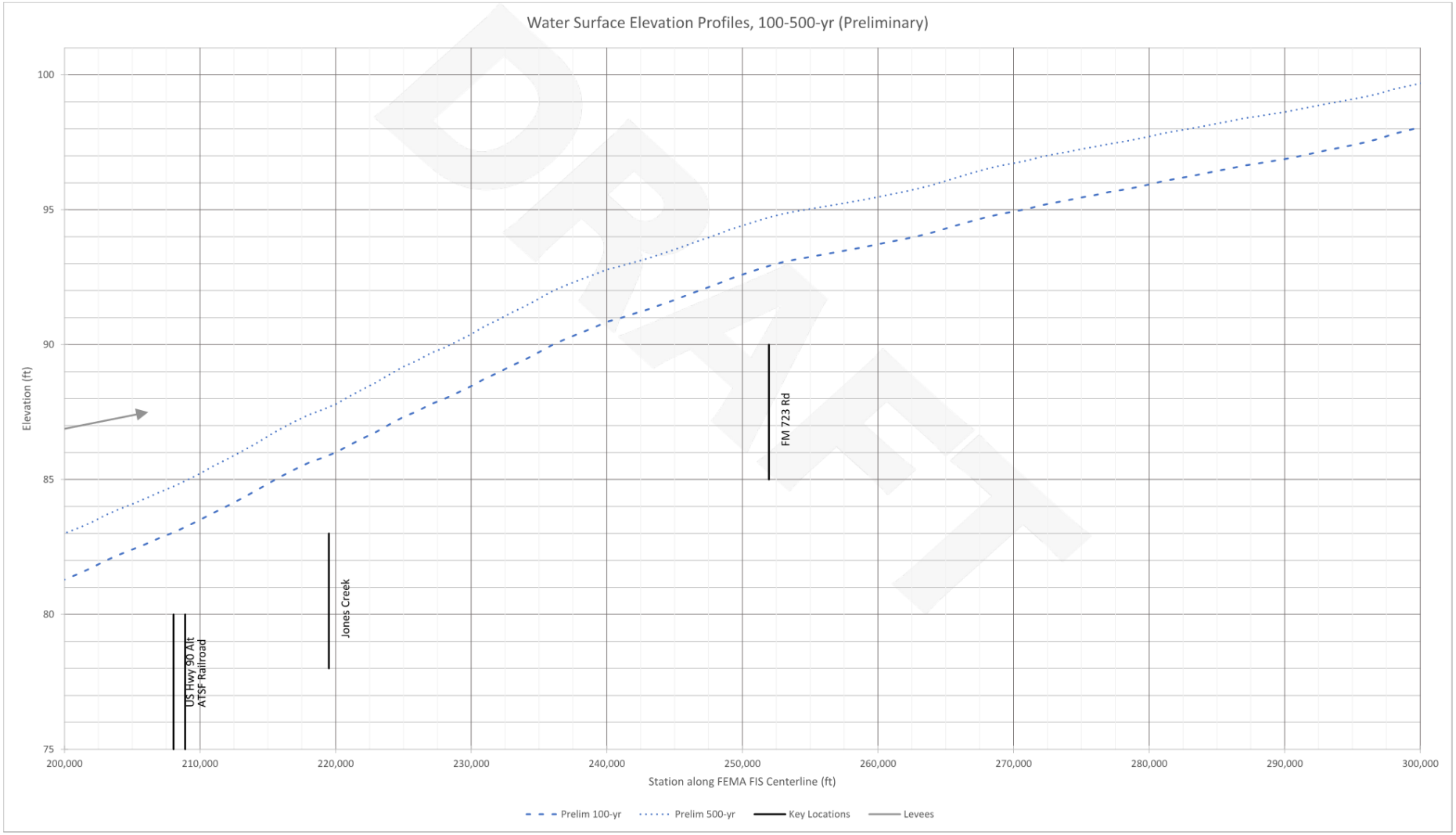
PRELIMINARY 100 and 500-YR PROFILES



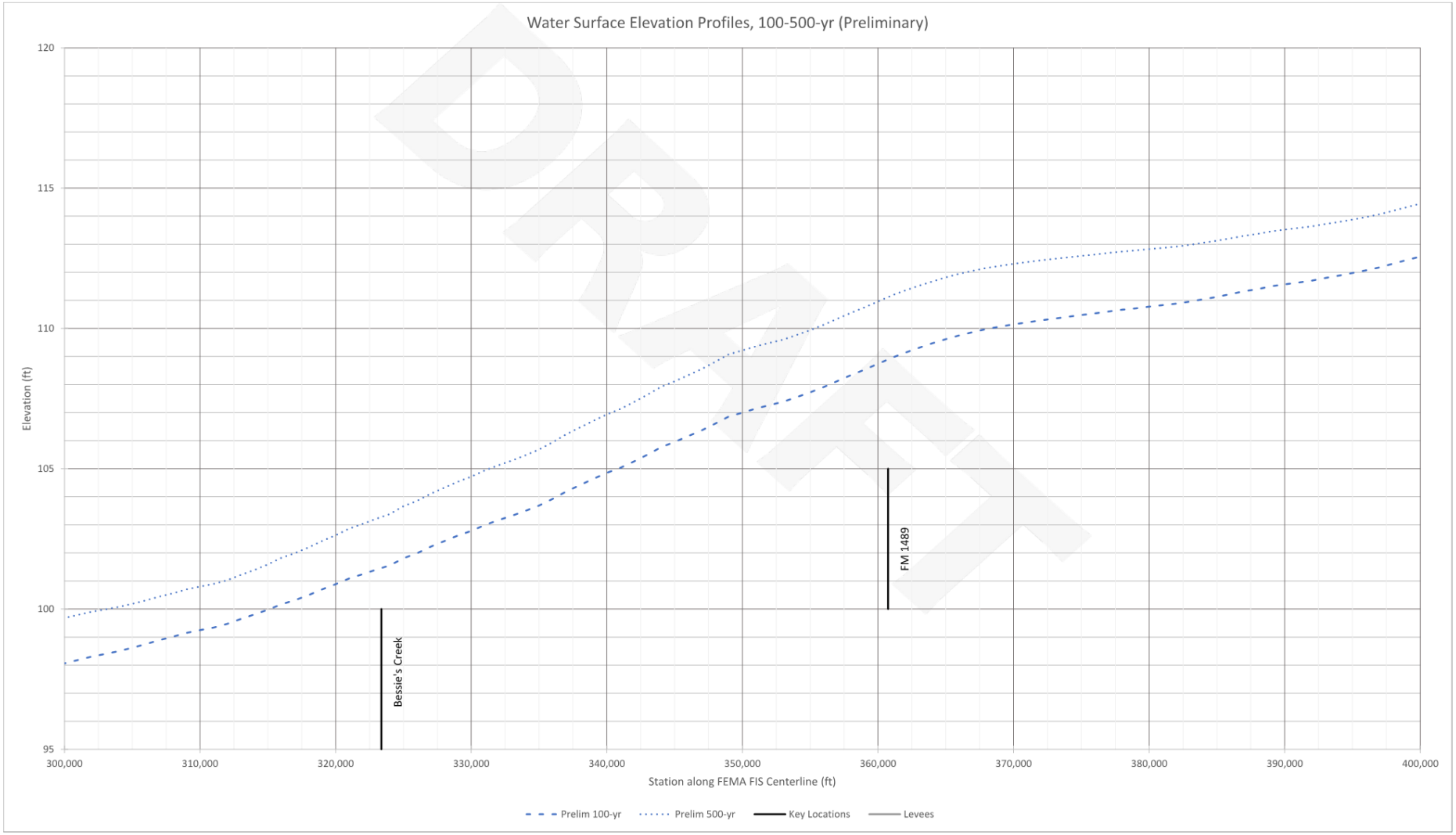
PRELIMINARY 100 and 500-YR PROFILES



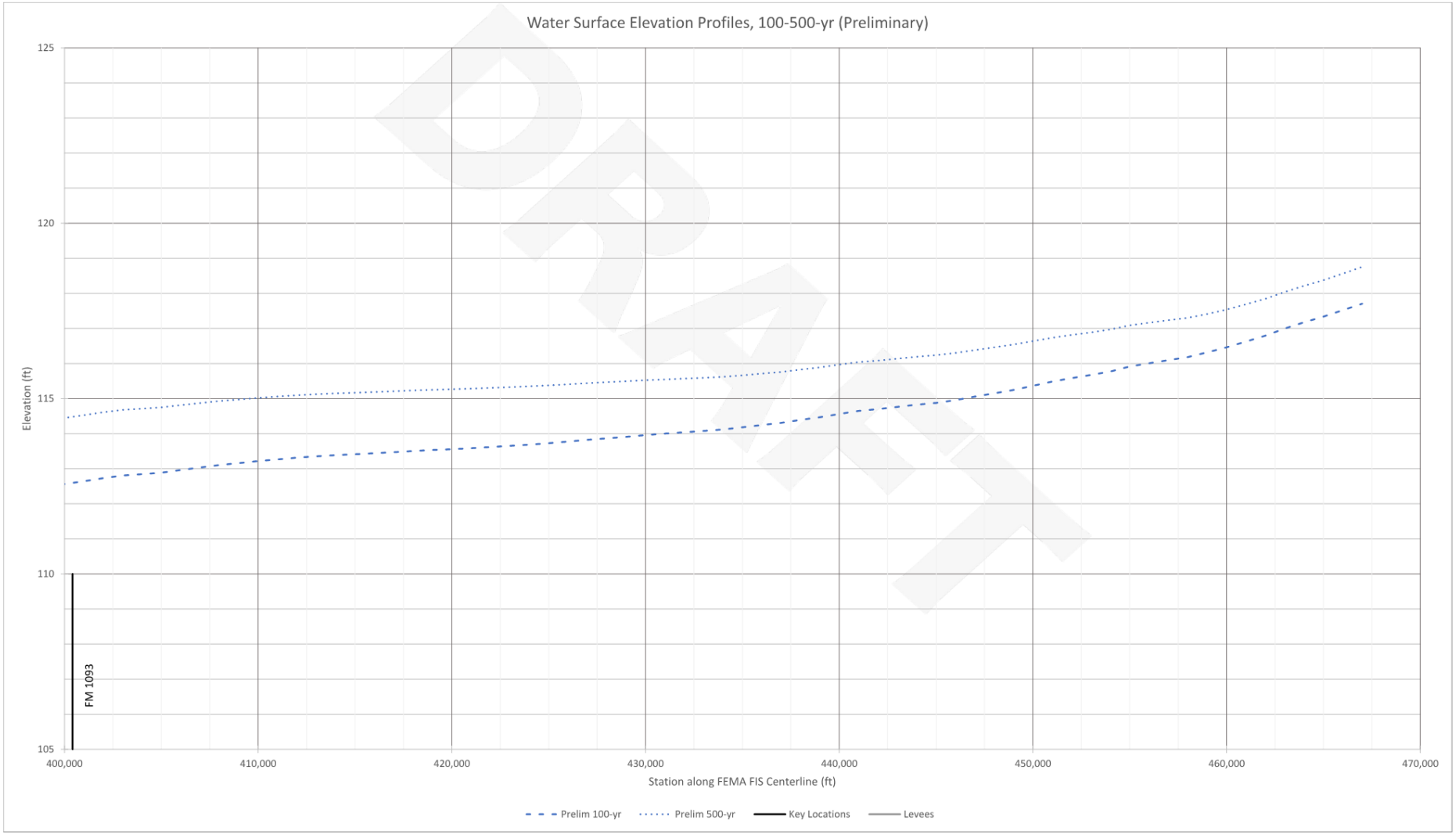
PRELIMINARY 100 and 500-YR PROFILES



PRELIMINARY 100 and 500-YR PROFILES

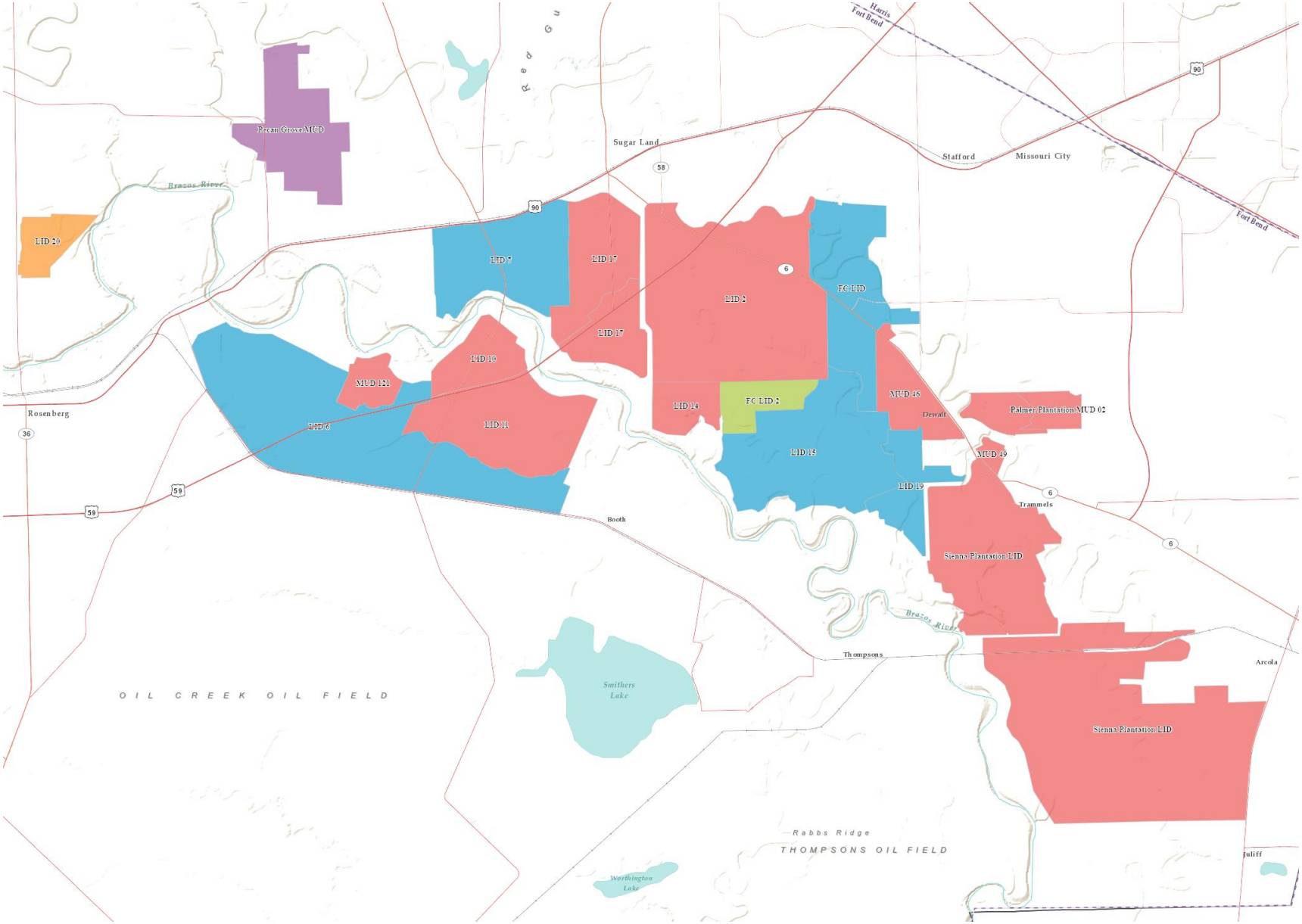


PRELIMINARY 100 and 500-YR PROFILES



100-yr and 500-yr elevations Levee Improvement Districts (PRELIMINARY)

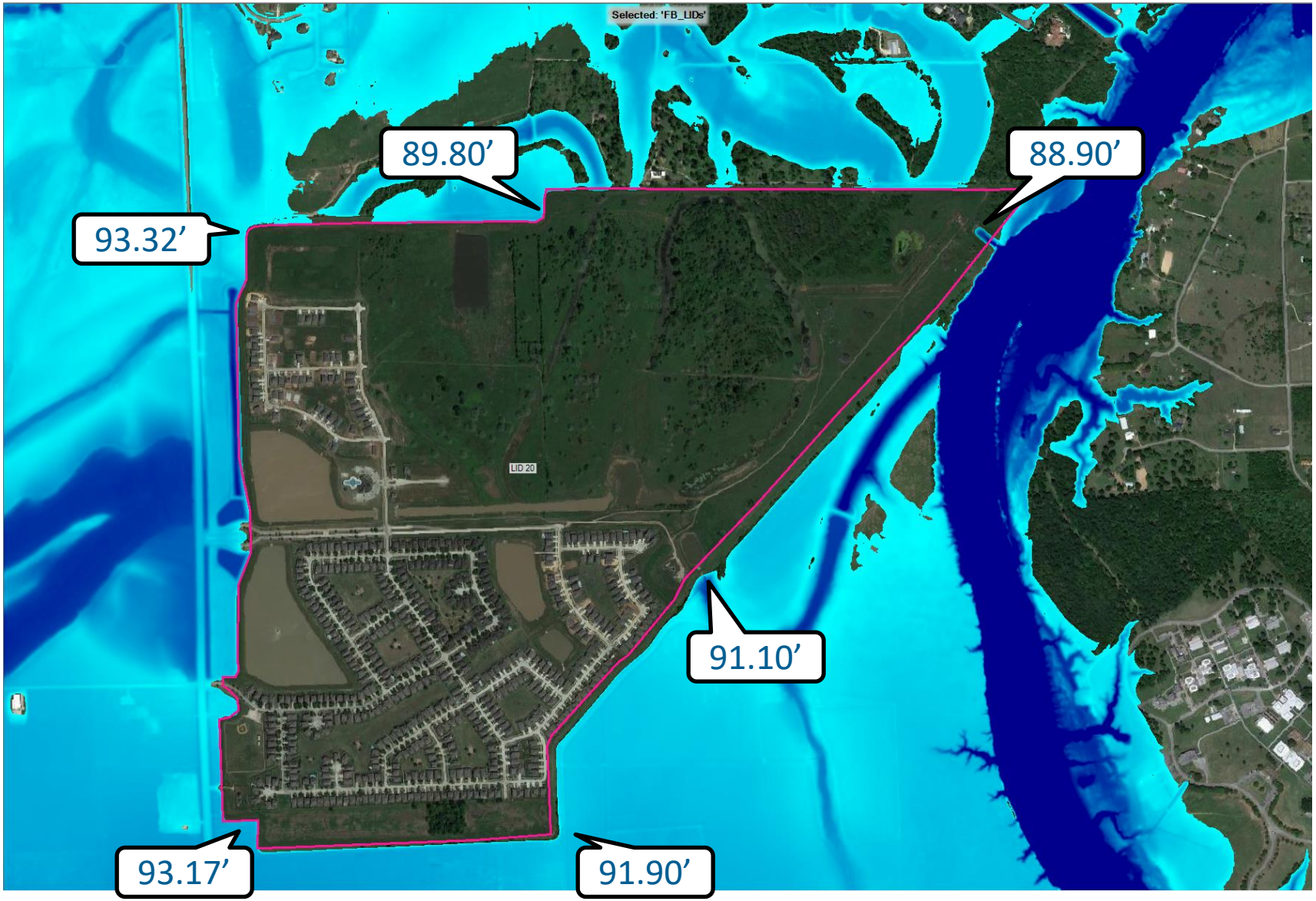
LEVEE IMPROVEMENT DISTRICTS



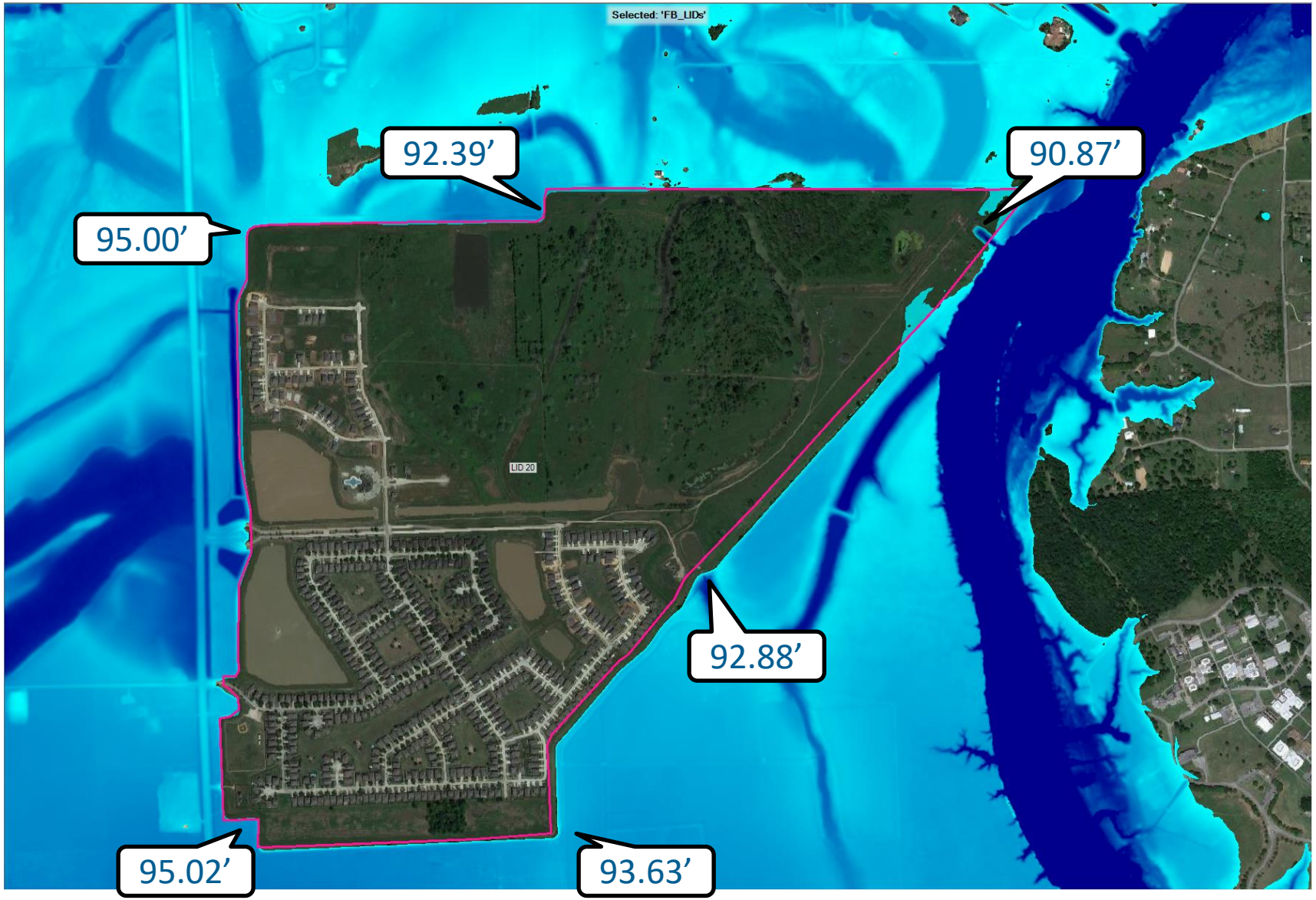
DISCLAIMER

- 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

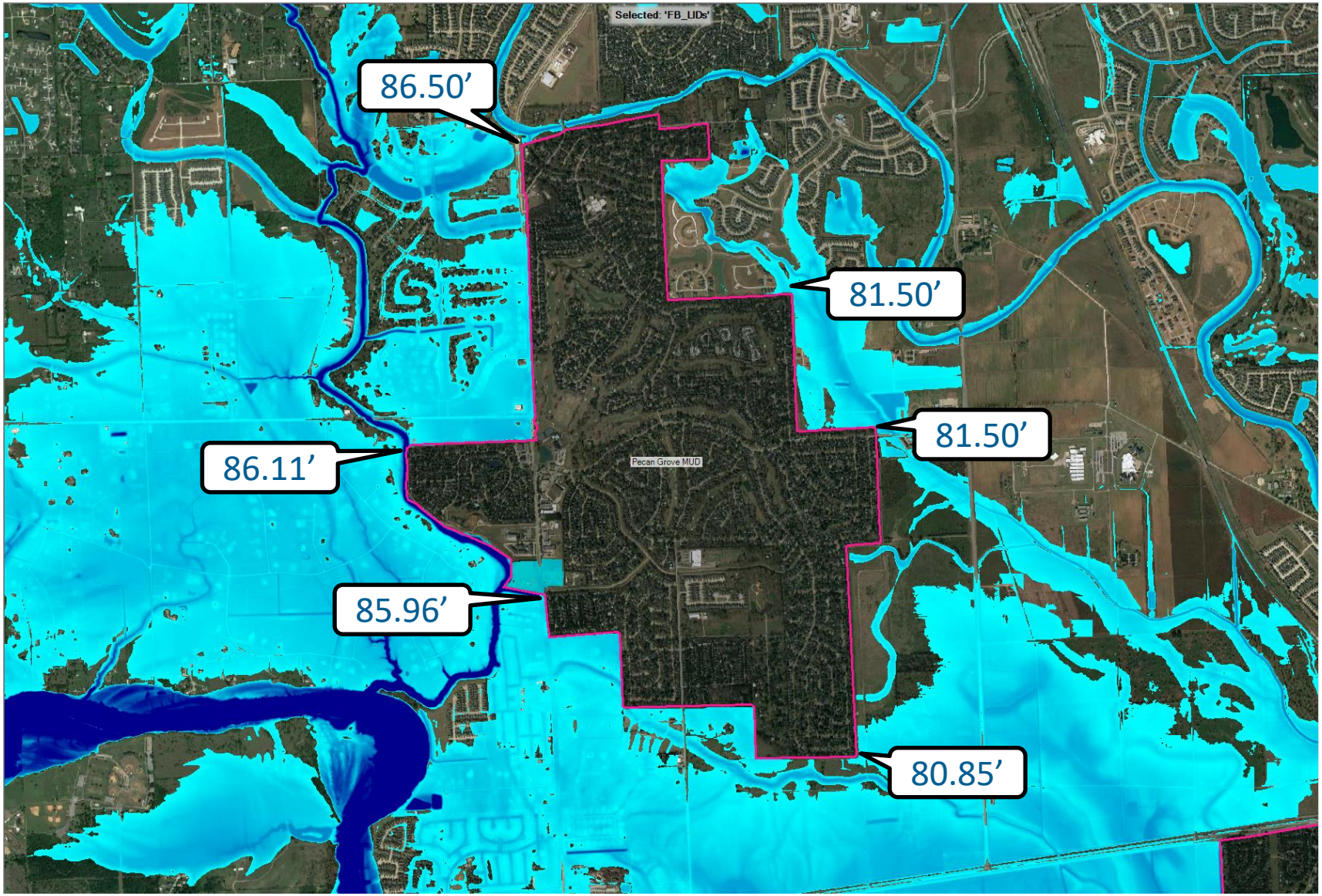
LID20 – Preliminary 100-yr WSEL



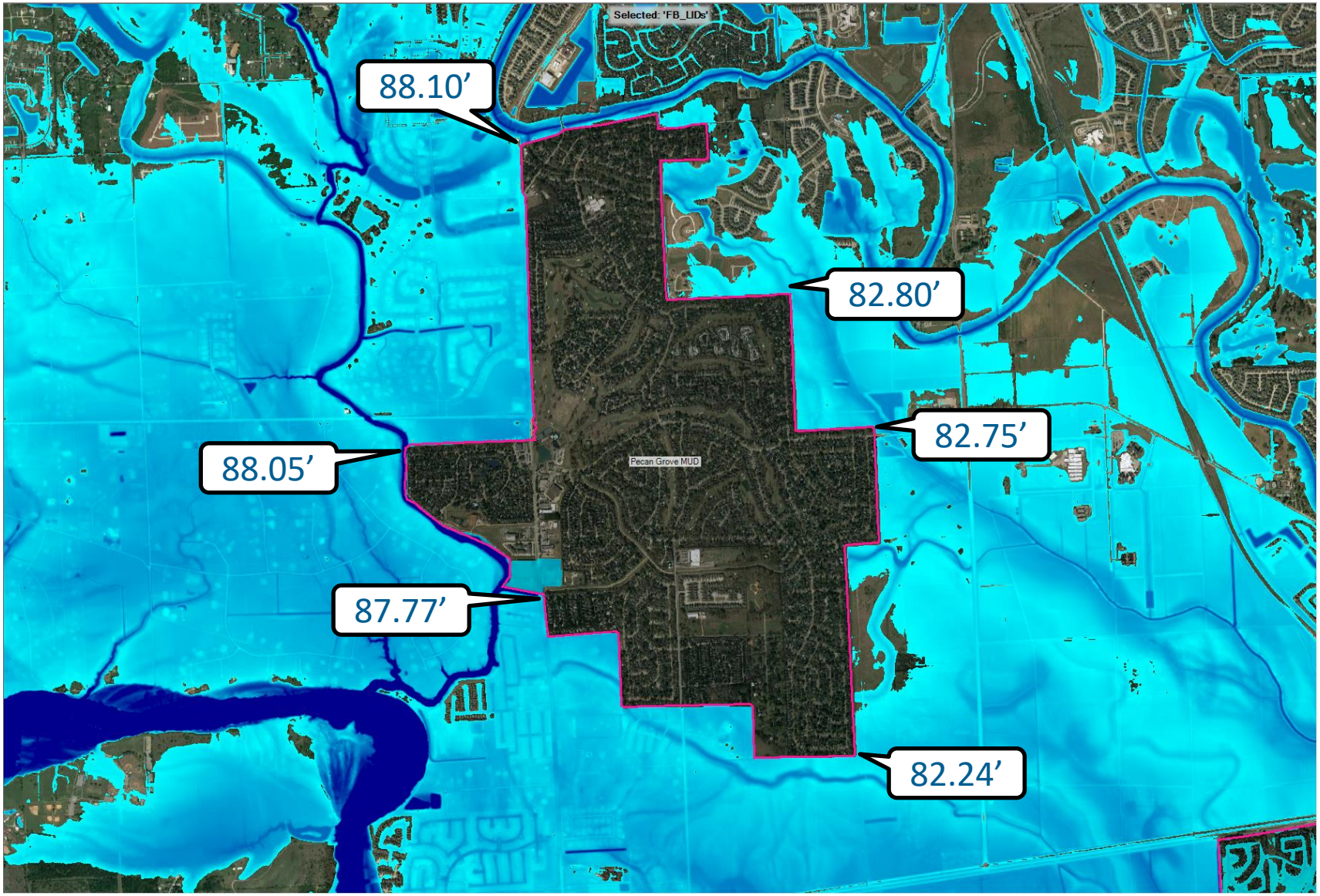
LID20 – Preliminary 500-yr WSEL



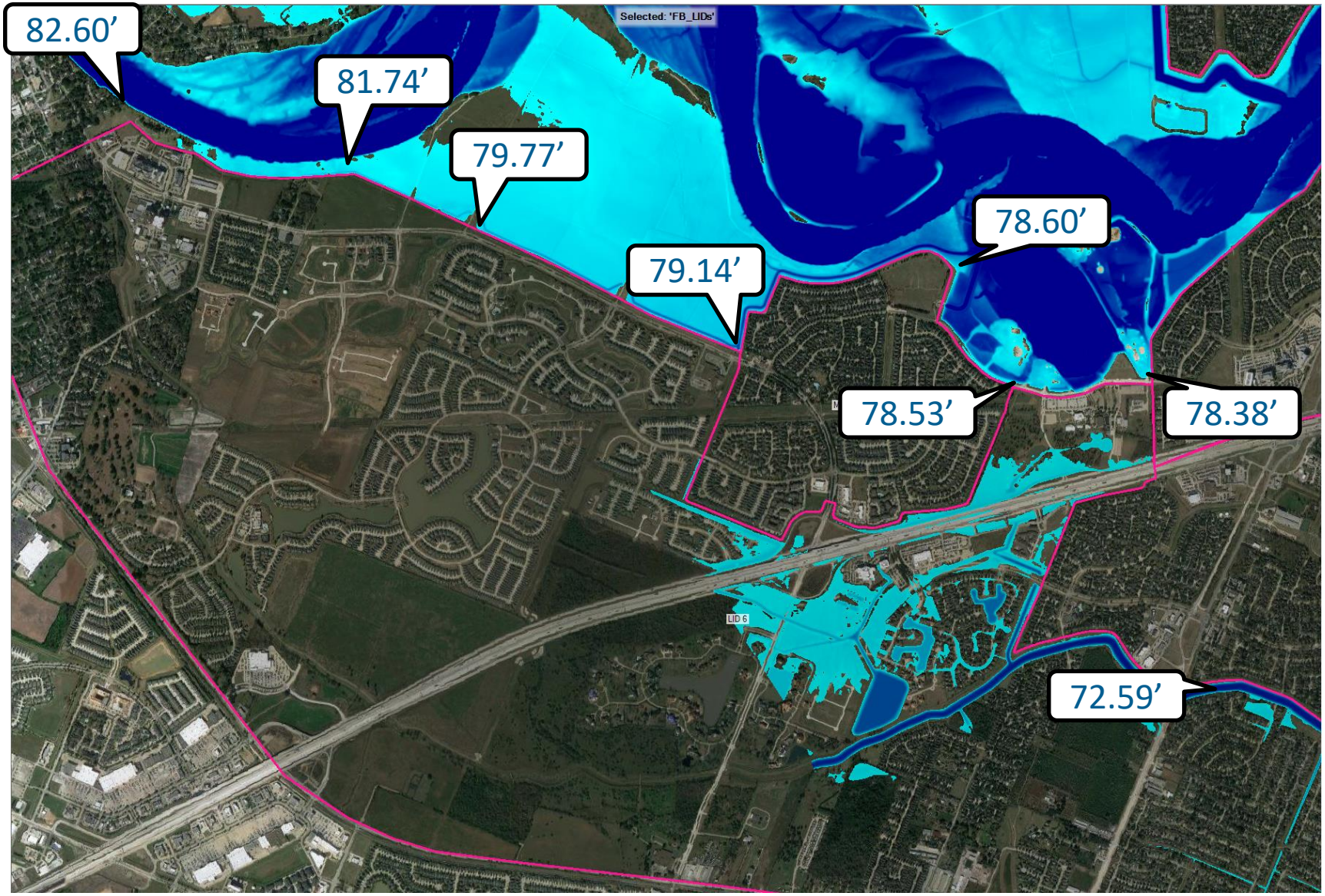
Pecan Grove – Preliminary 100-yr WSEL



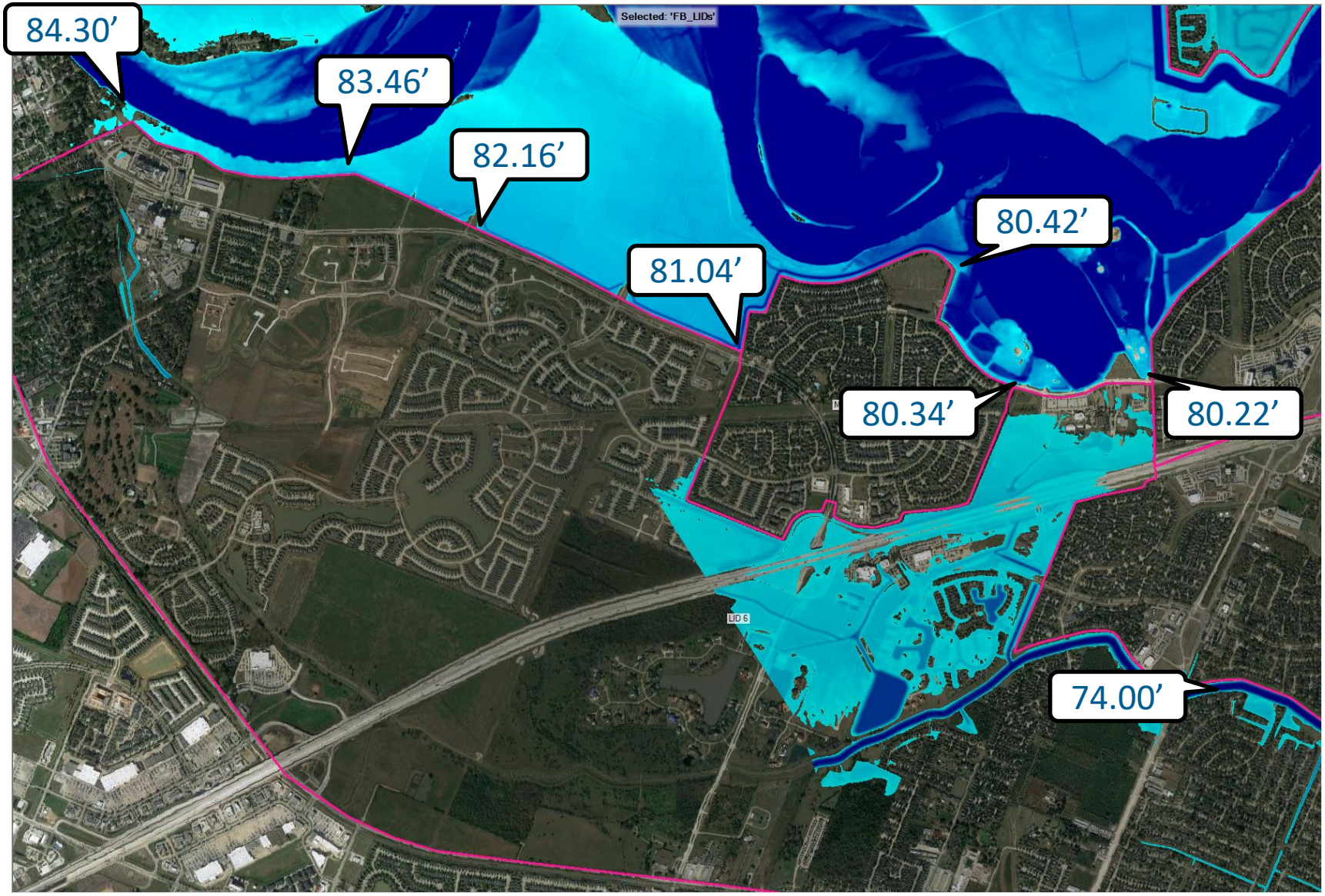
Pecan Grove – Preliminary 500-yr WSEL



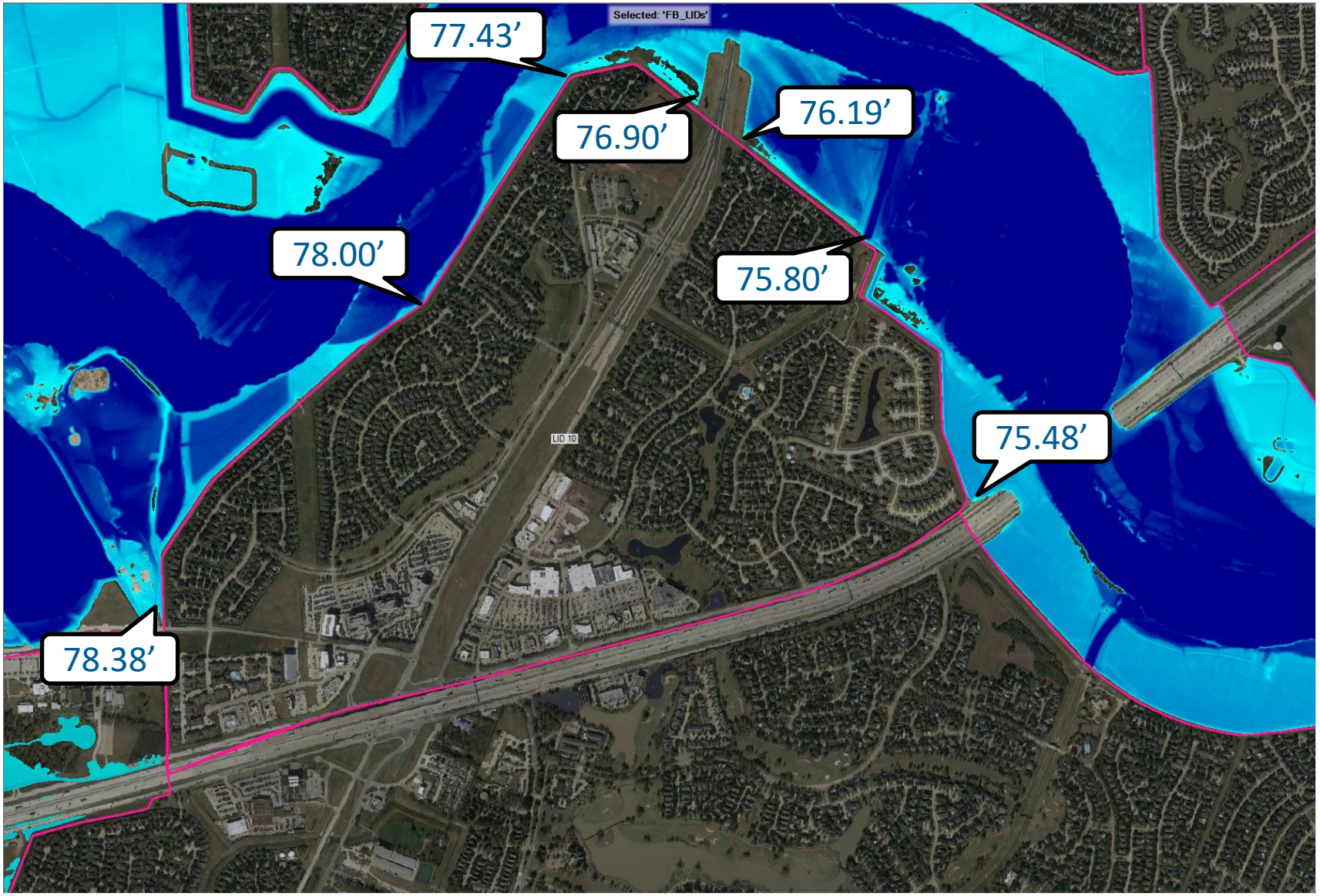
LID6 & MUD121 – Preliminary 100-yr WSEL



LID6 & MUD121 – Preliminary 500-yr WSEL



LID10– Preliminary 100-yr WSEL



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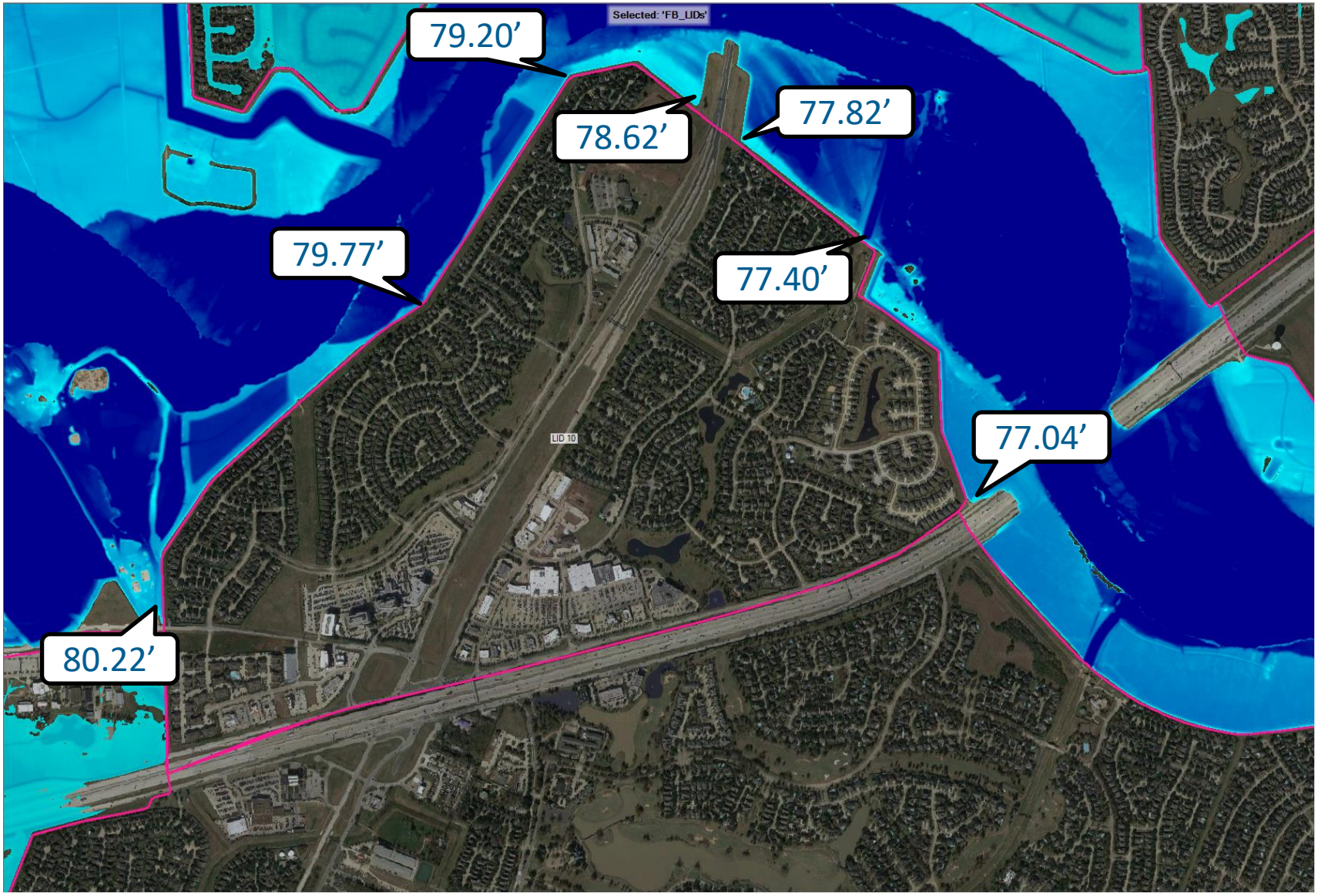
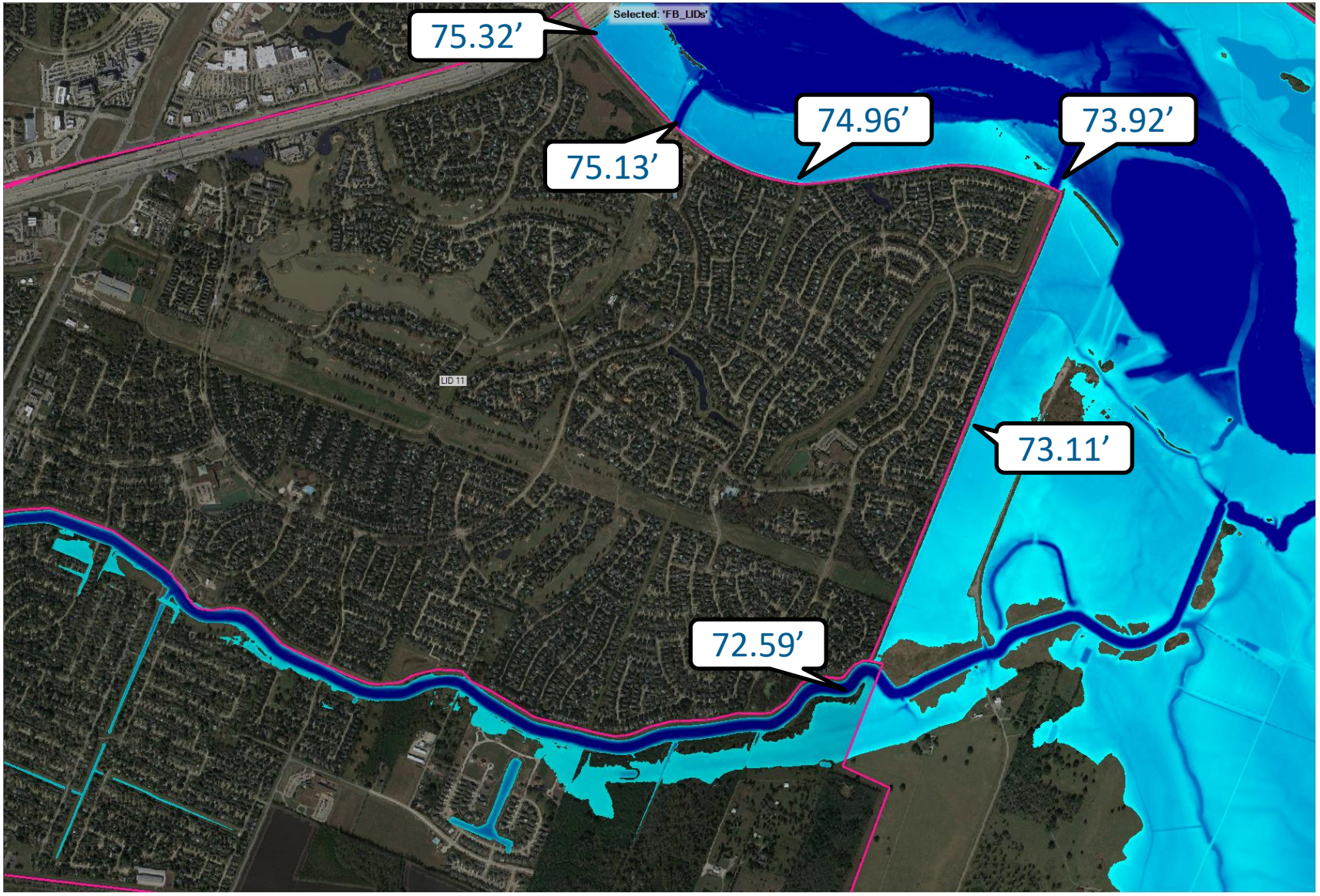
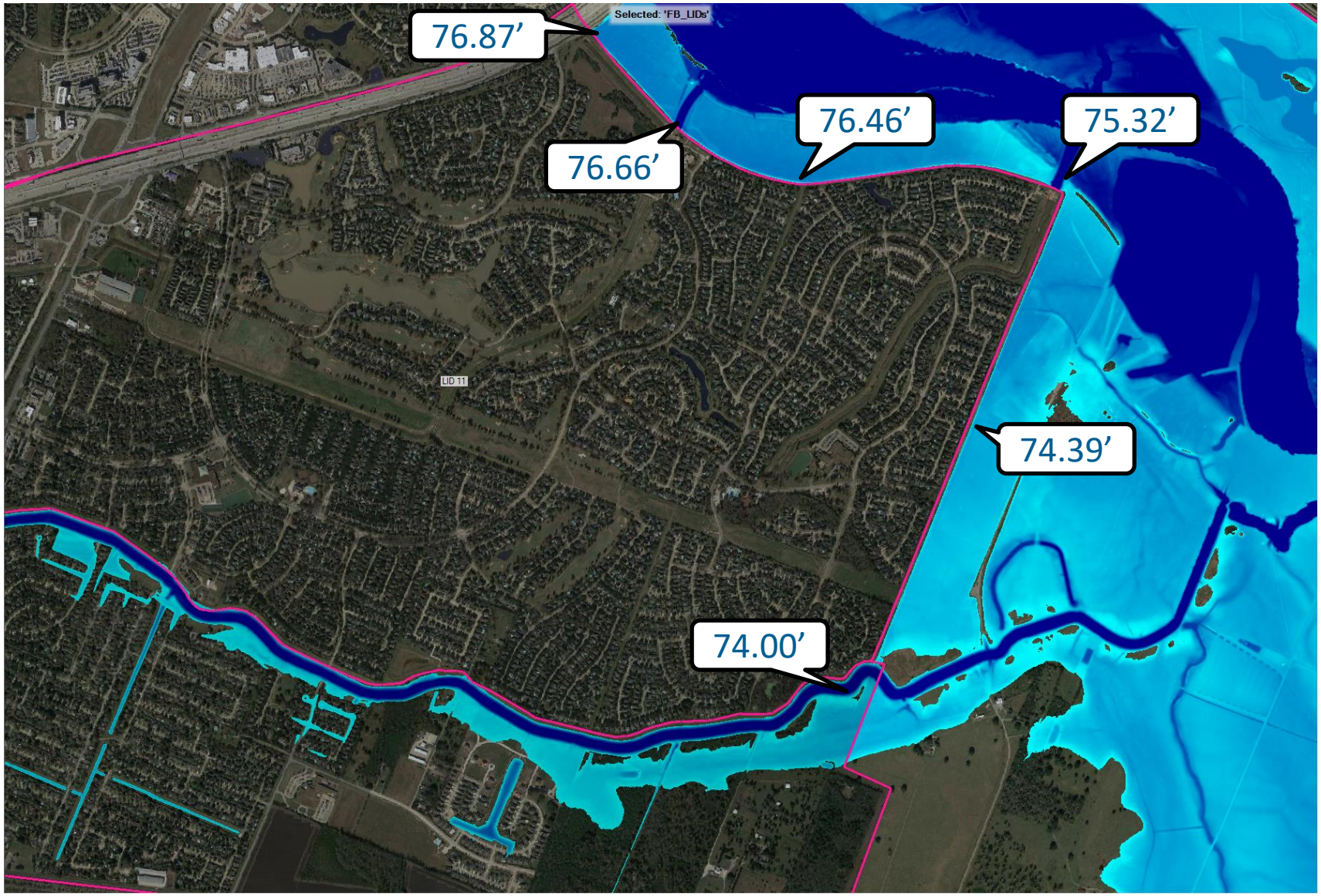


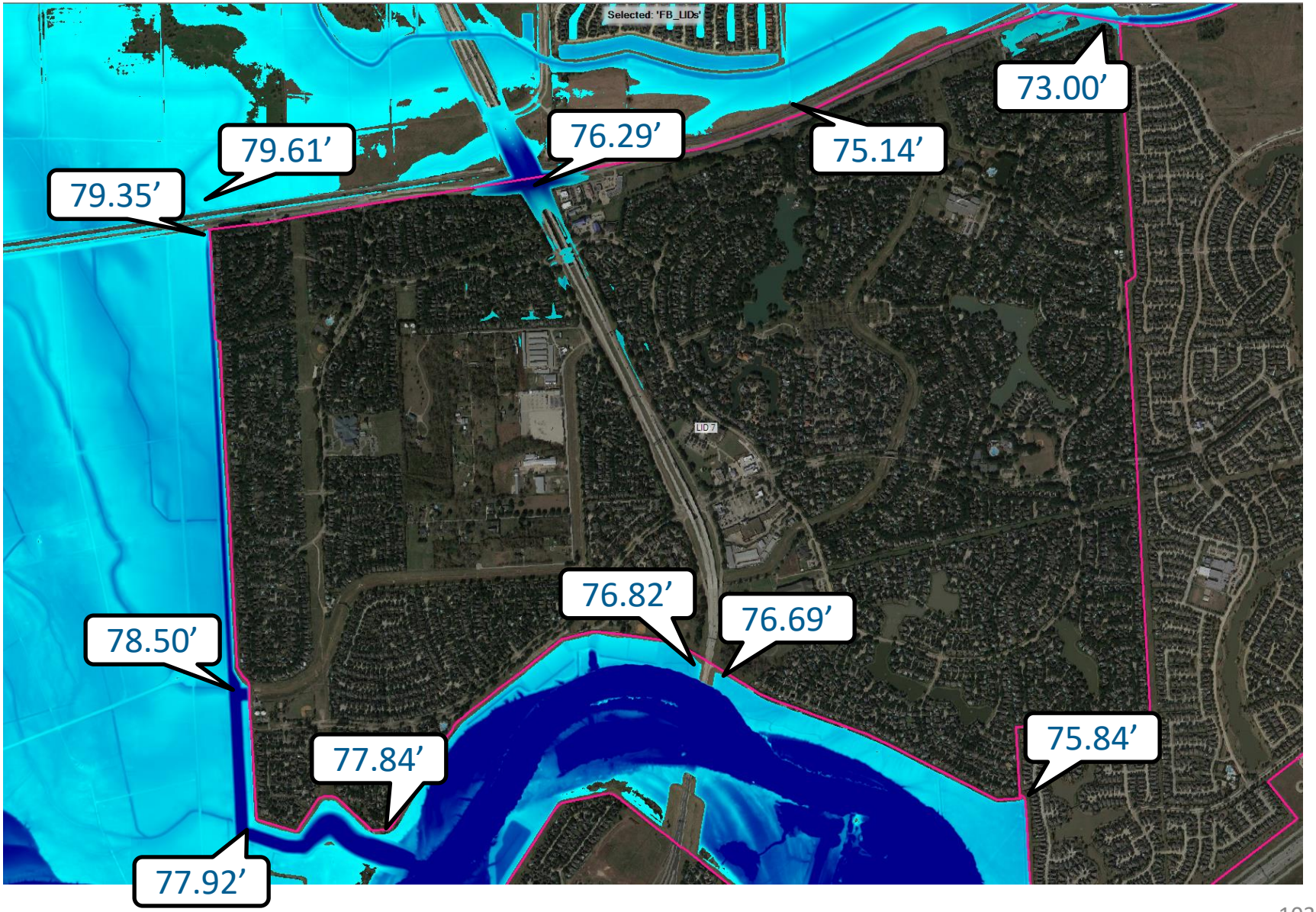
LID11– Preliminary 100-yr WSEL



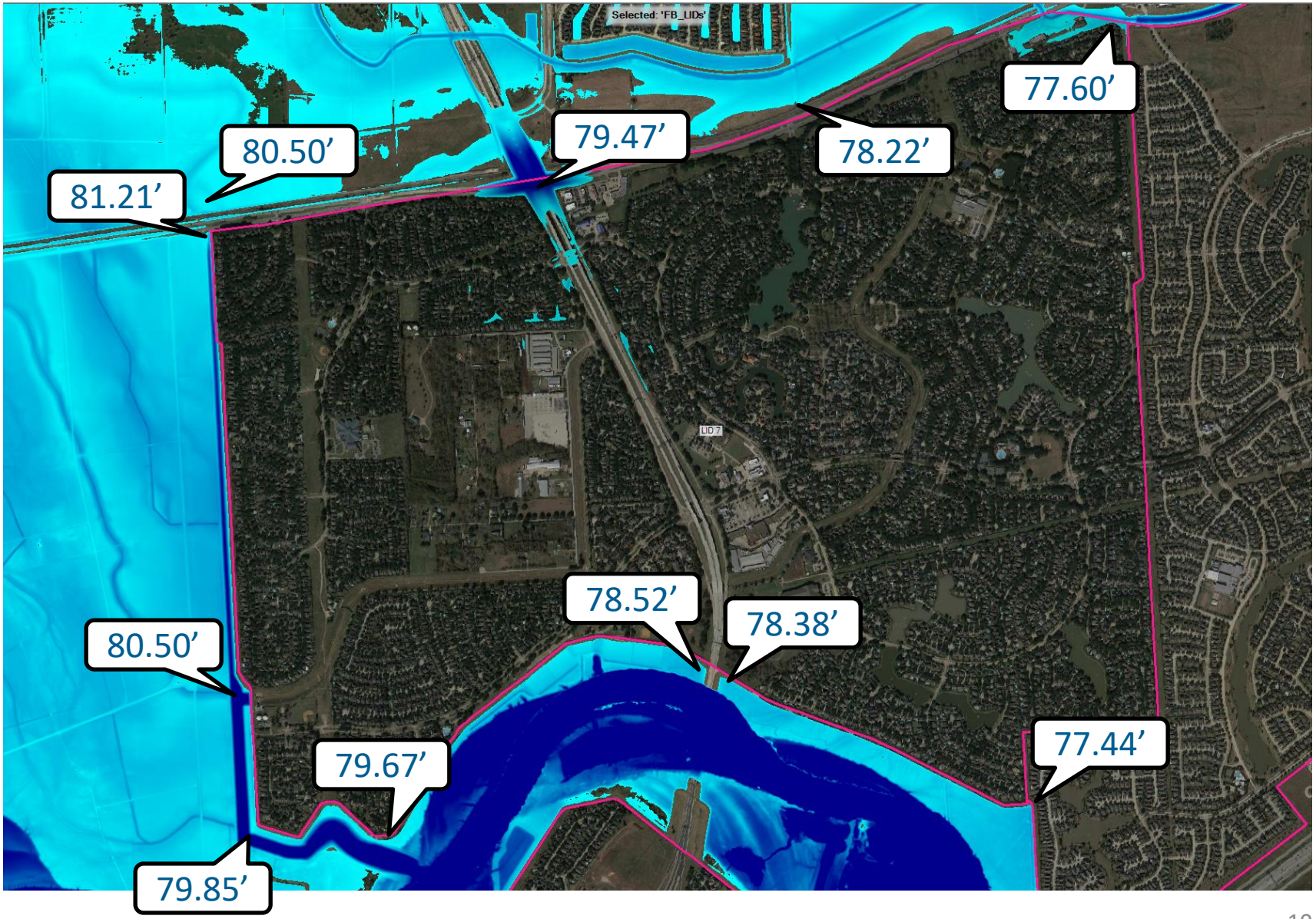
LID11– Preliminary 500-yr WSEL



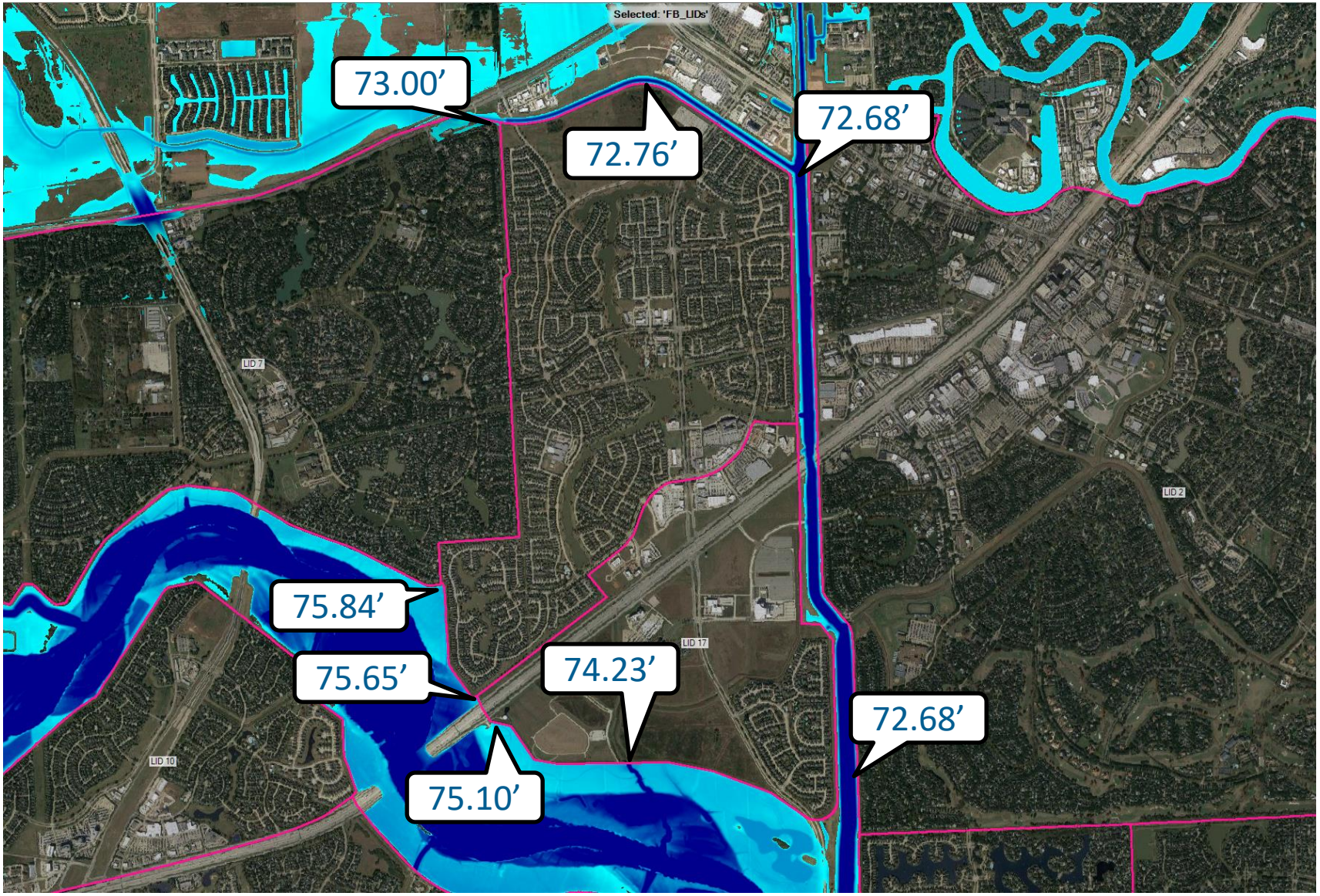
LID7– Preliminary 100-yr WSEL



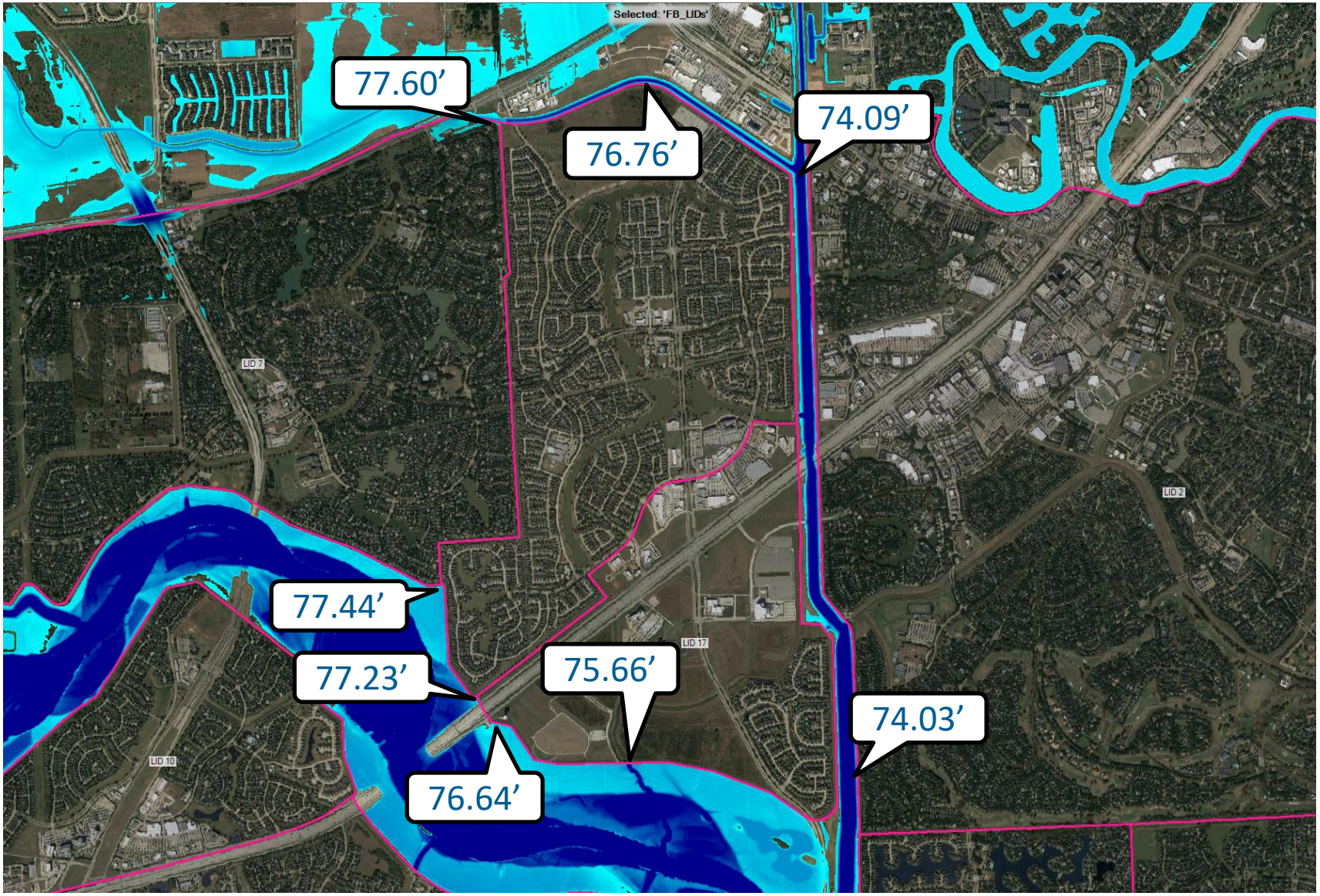
LID7– Preliminary 500-yr WSEL



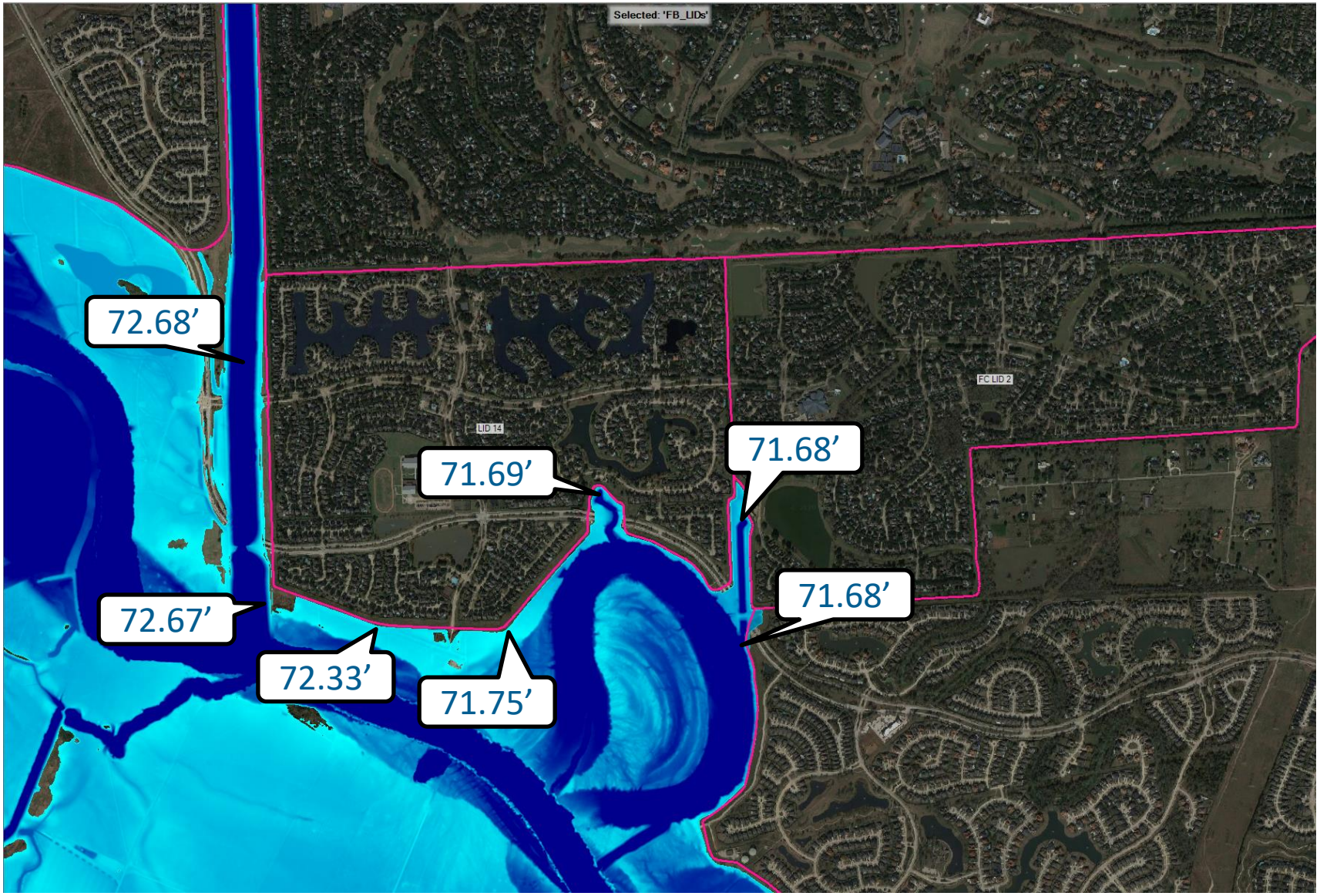
LID17– Preliminary 100-yr WSEL



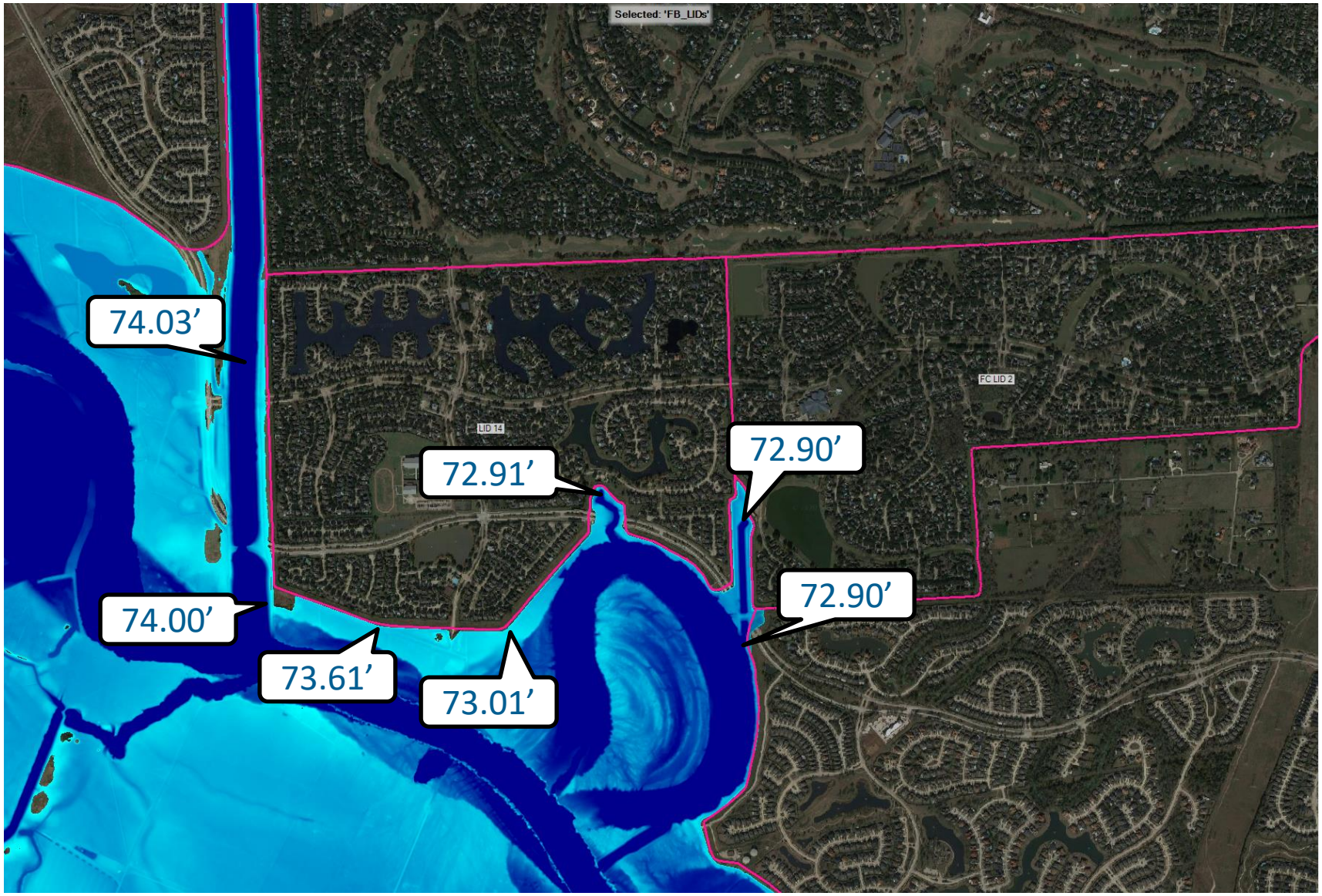
LID17– Preliminary 500-yr WSEL



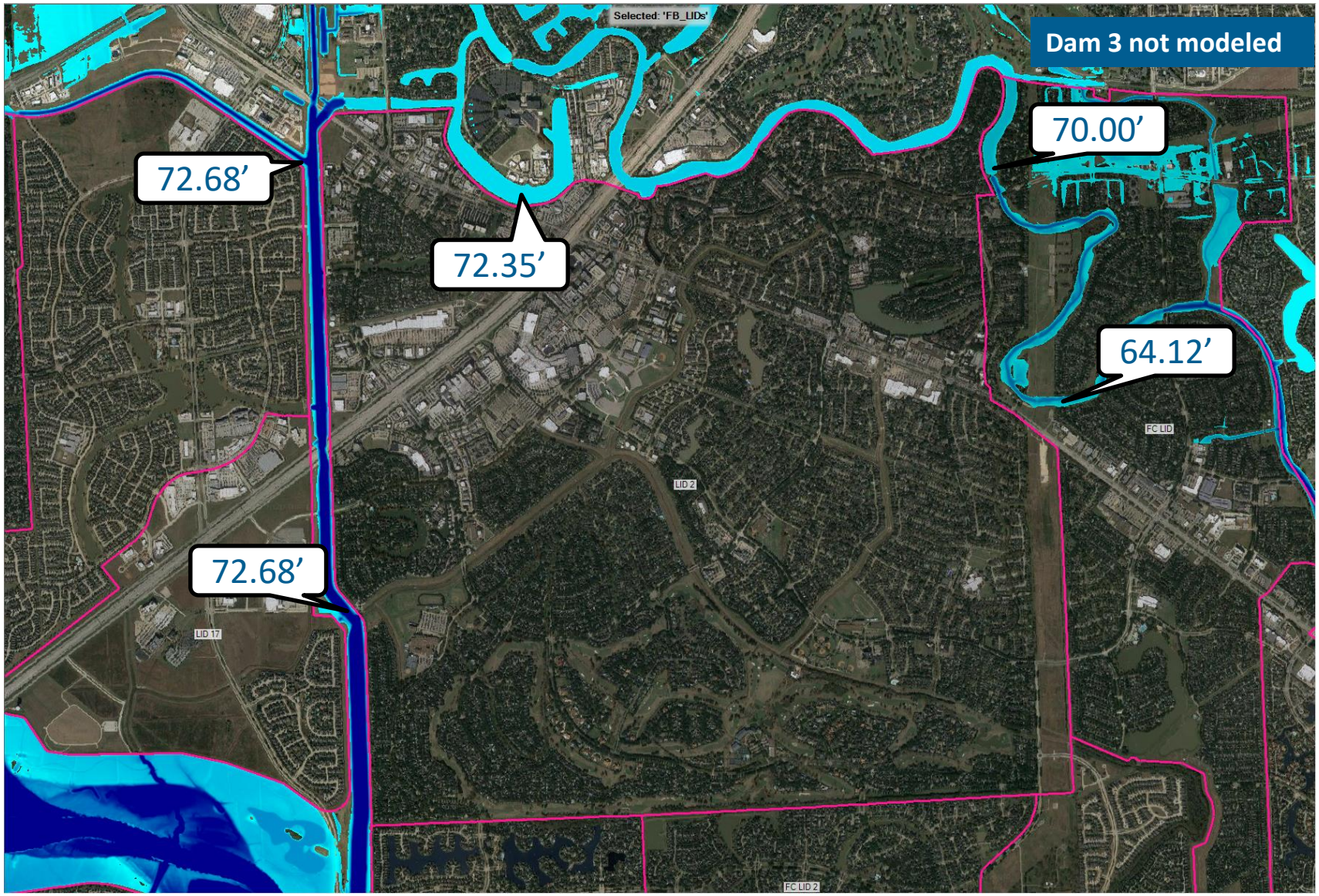
LID14 and FC LID2– Preliminary 100-yr WSEL



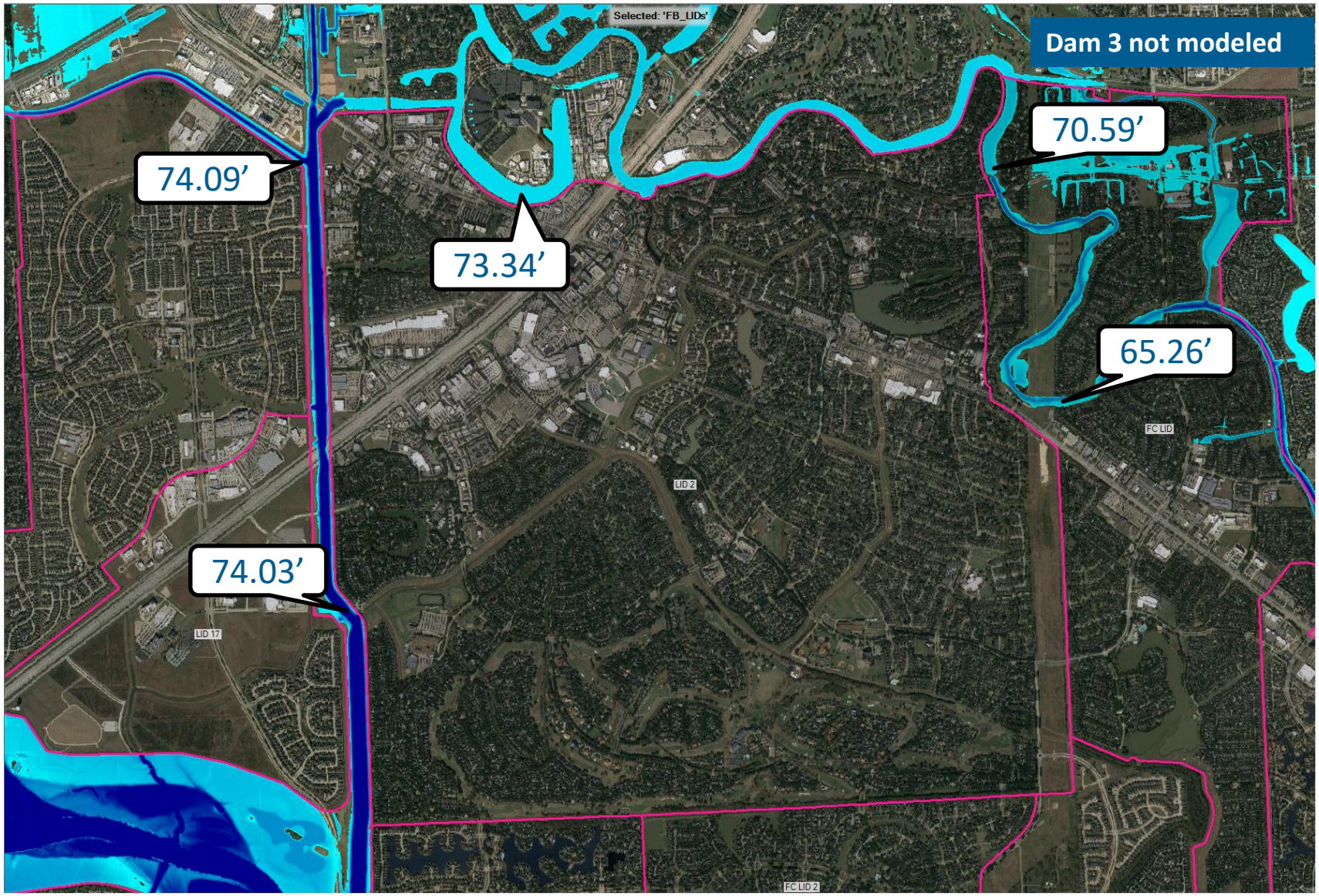
LID14 and FC LID2– Preliminary 500-yr WSEL



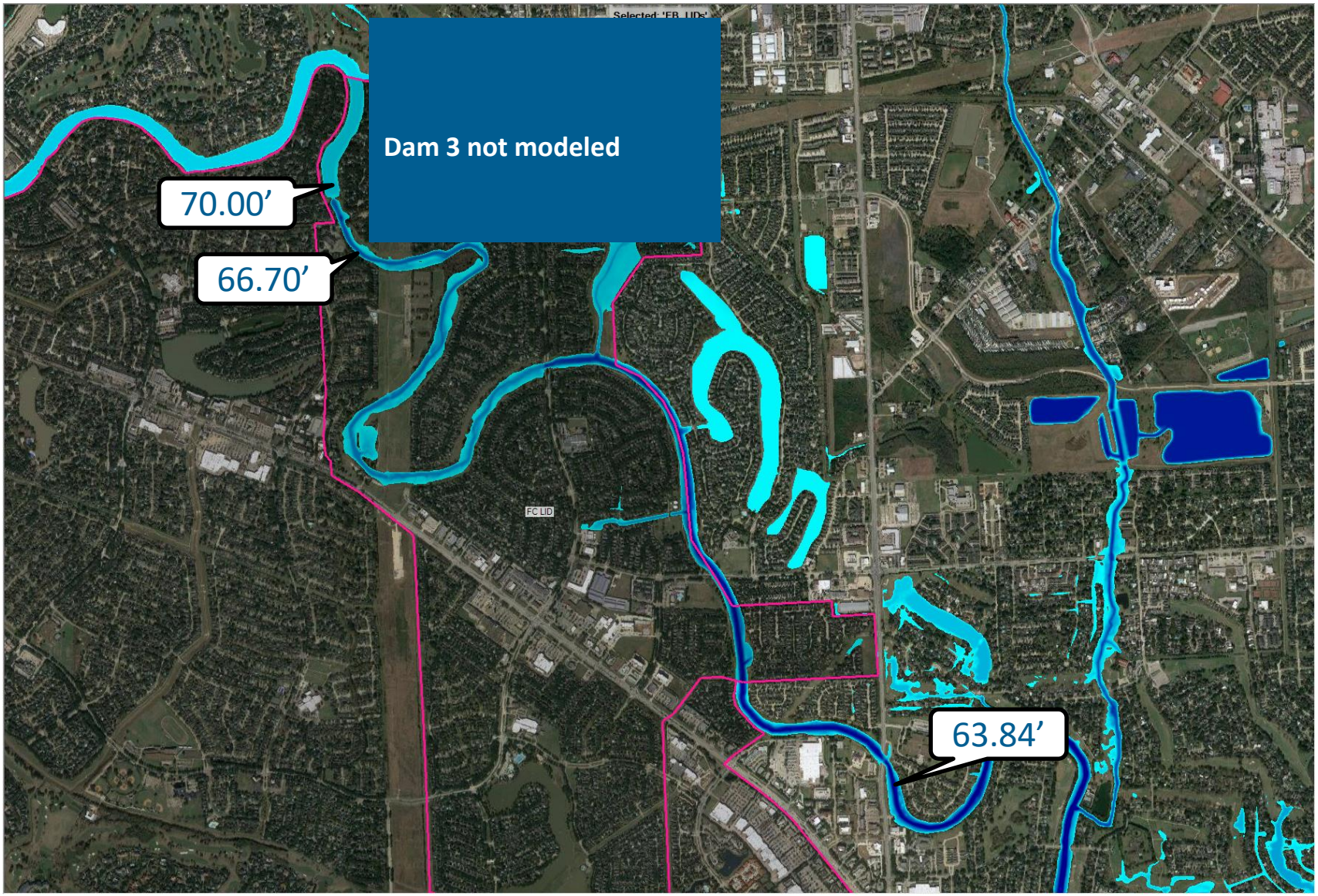
LID2– Preliminary 100-yr WSEL



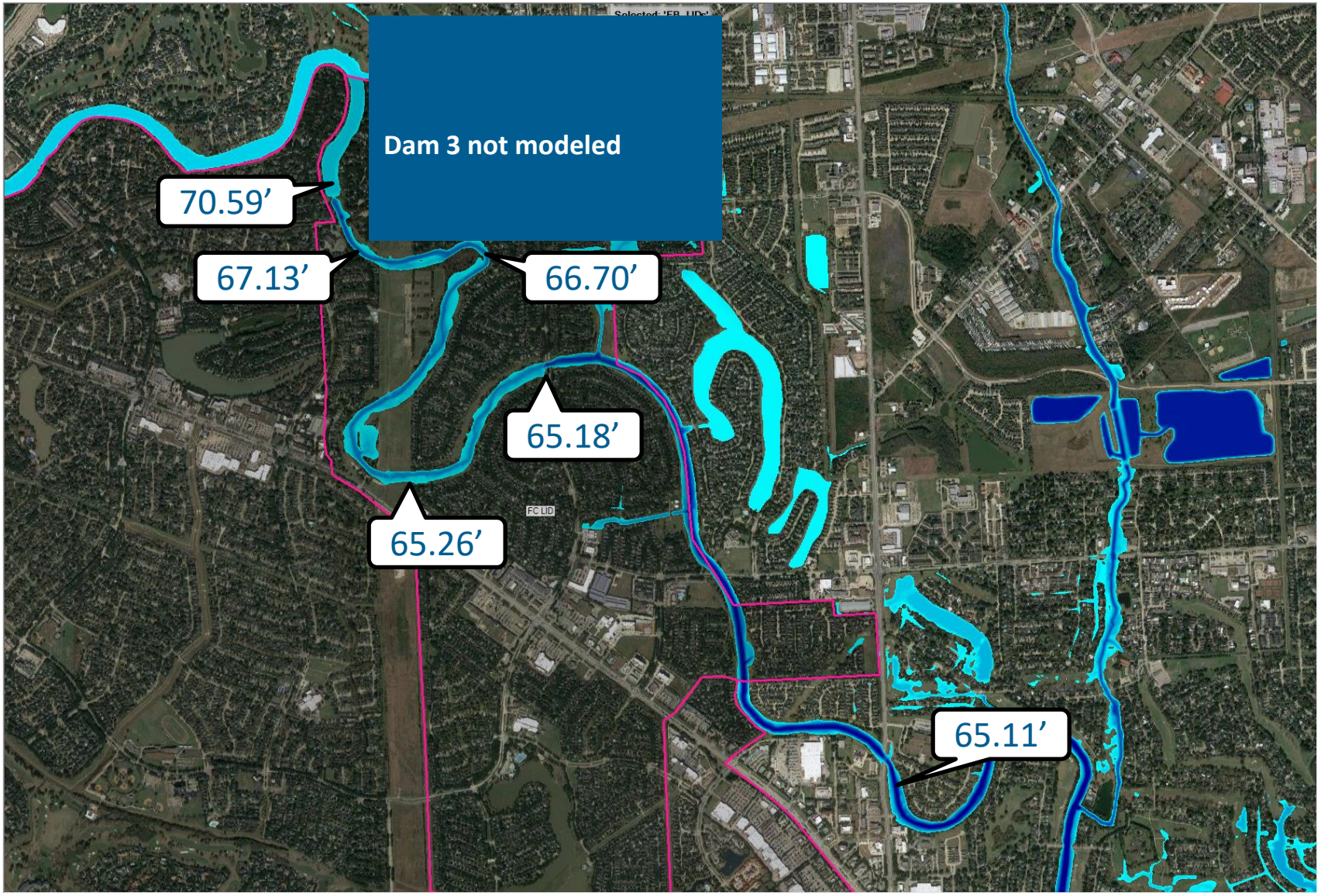
LID2– Preliminary 500-yr WSEL



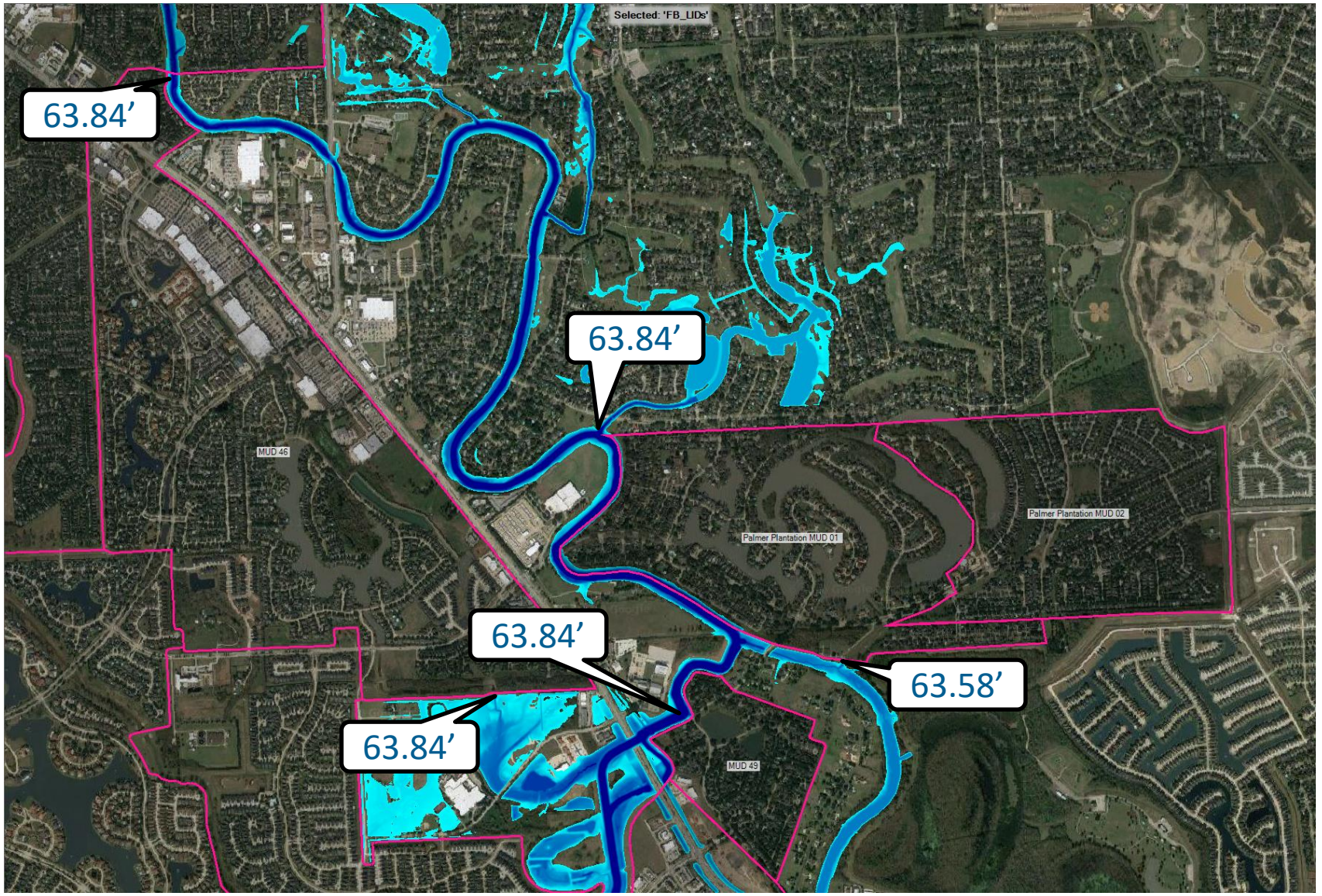
FCLID– Preliminary 100-yr WSEL



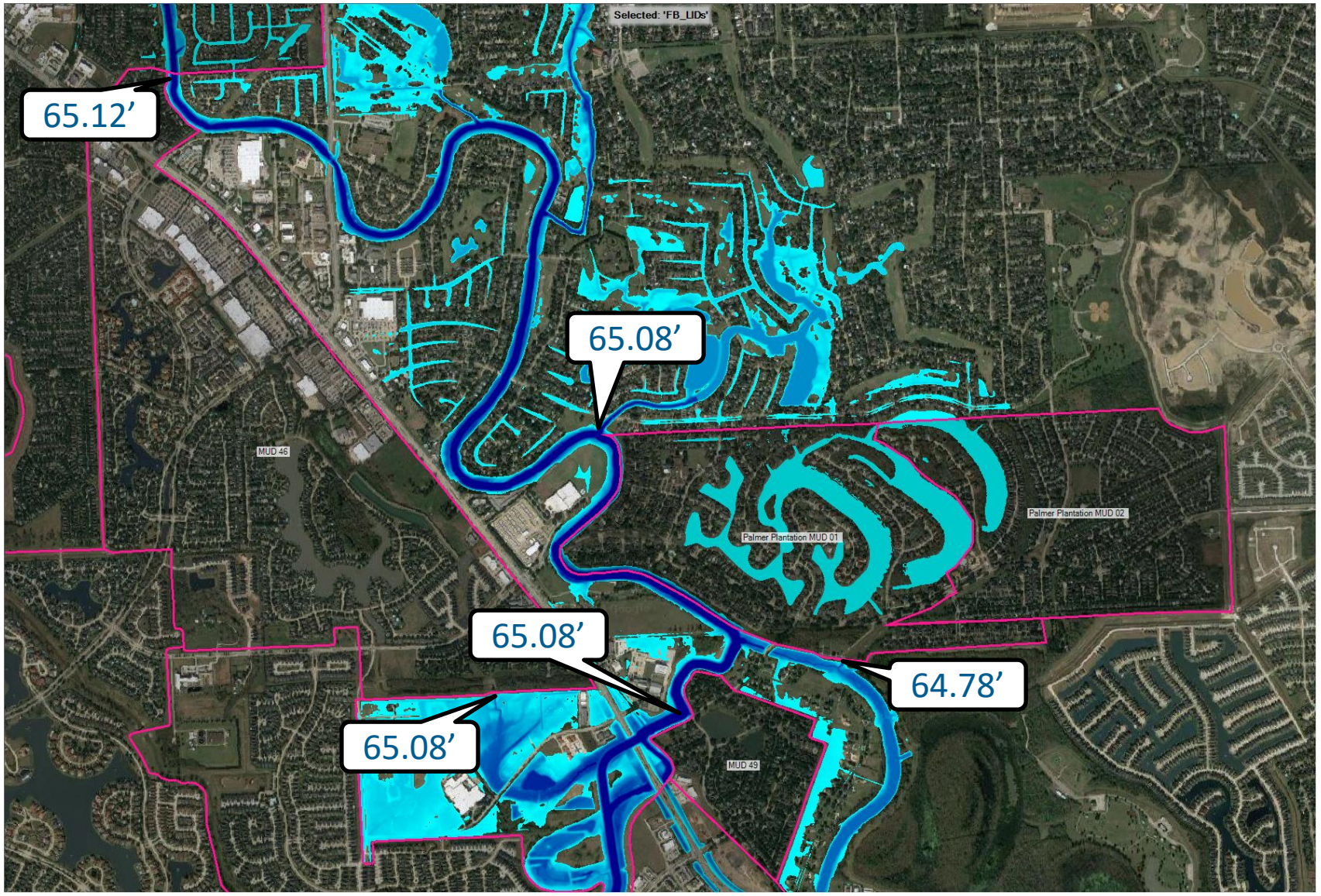
FCLID– Preliminary 500-yr WSEL



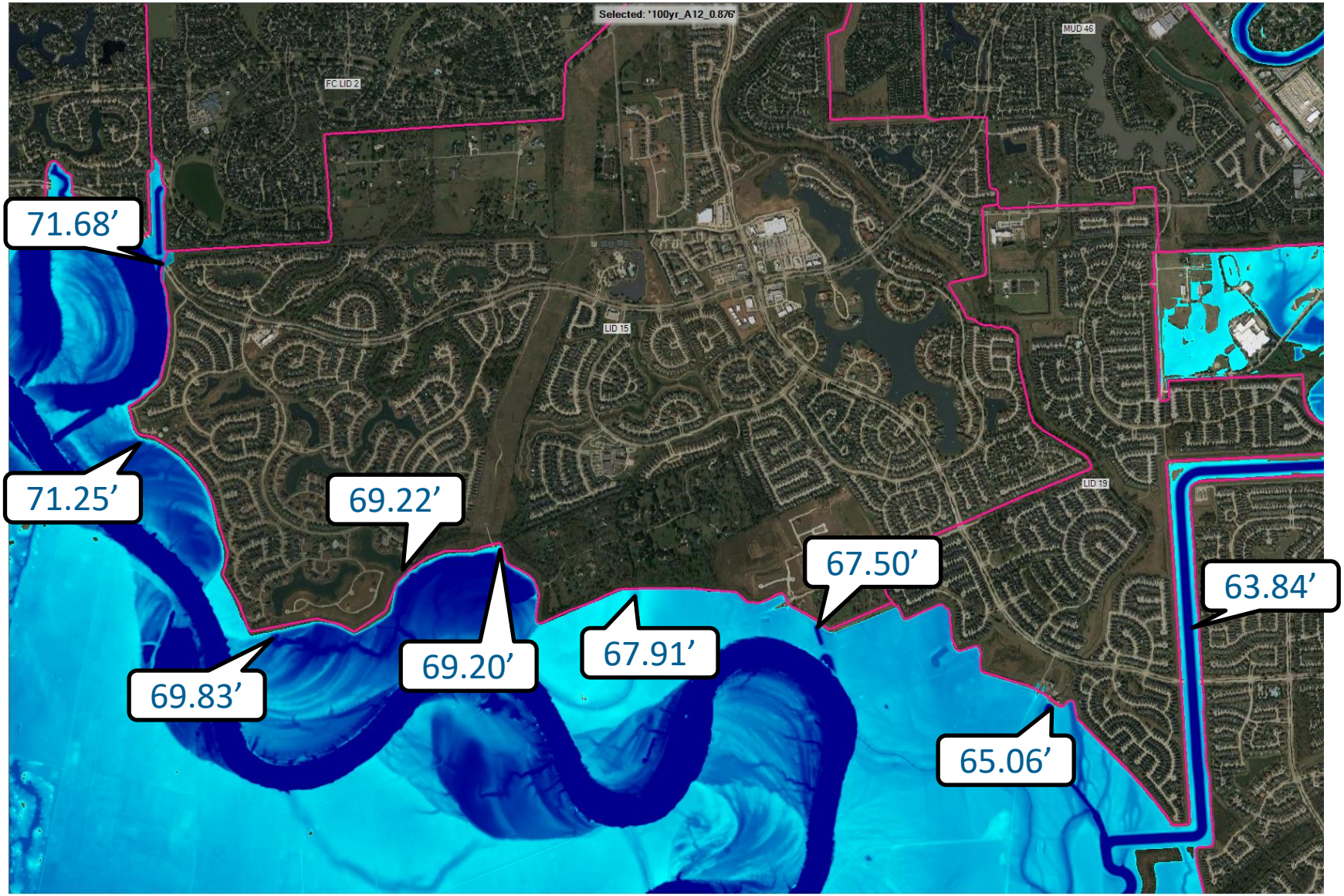
MUD46, MUD49, Palmer P. – Preliminary 100-yr WSEL



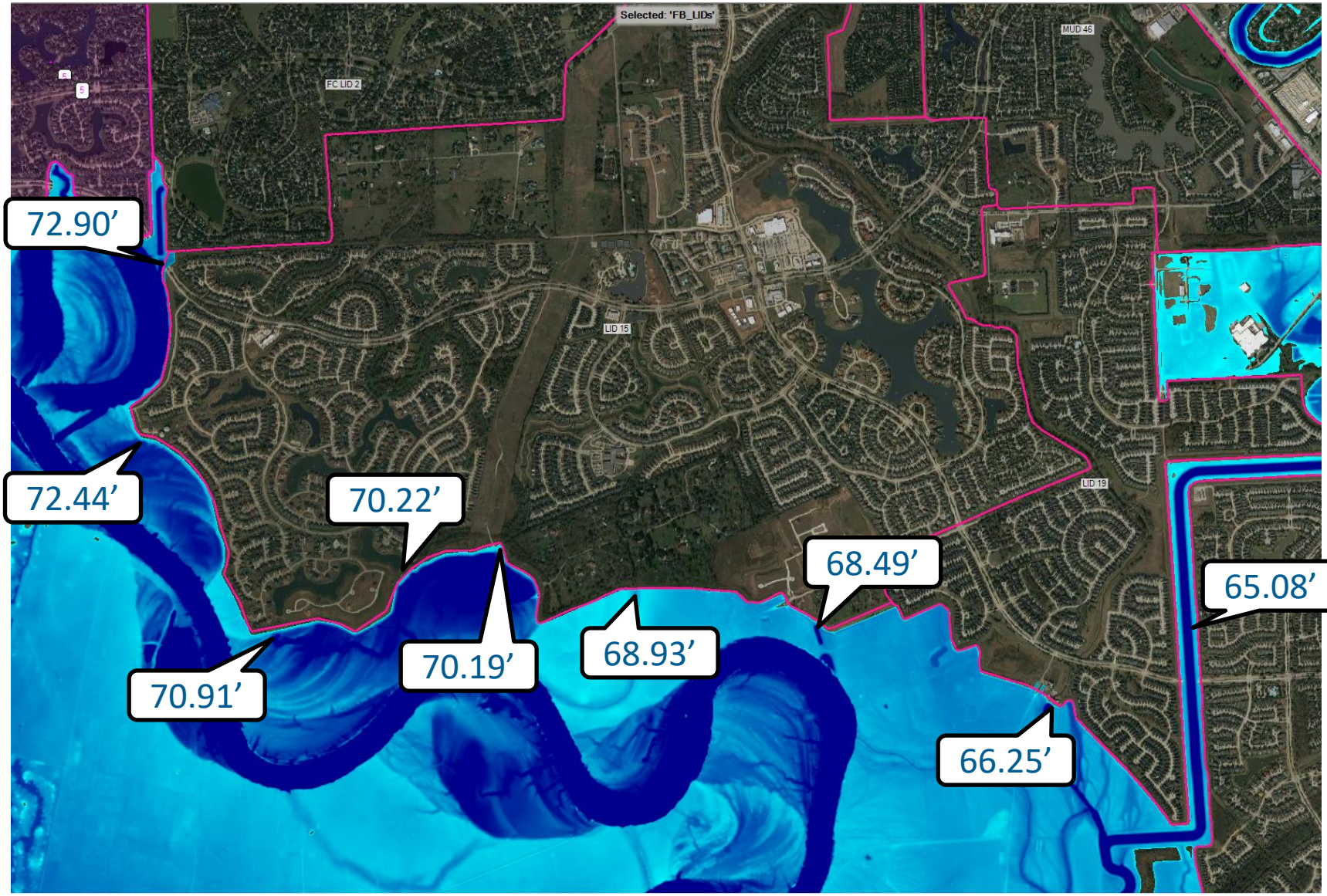
MUD46, MUD49, Palmer P. – Preliminary 500-yr WSEL



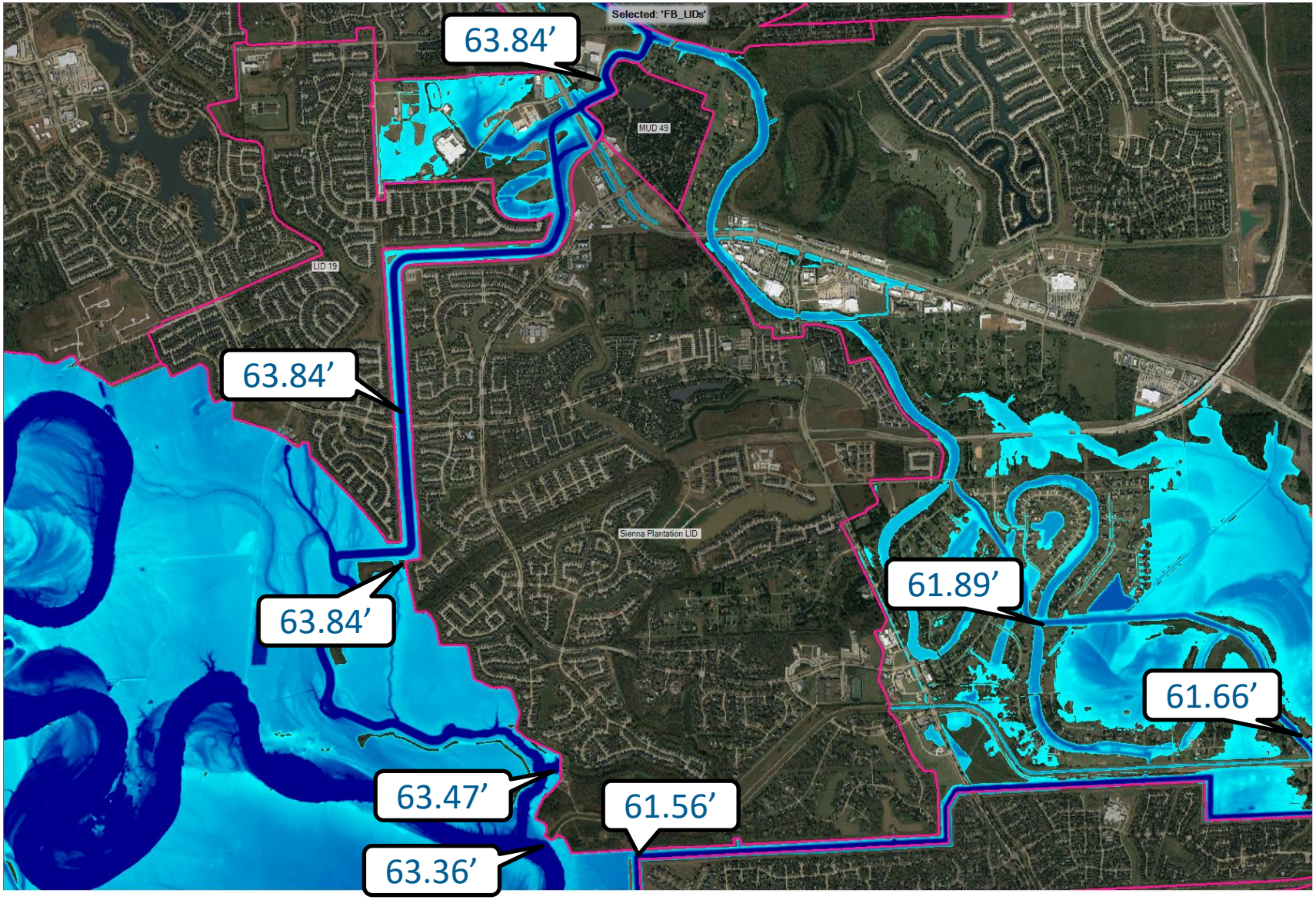
LID15 and LID19– Preliminary 100-yr WSEL



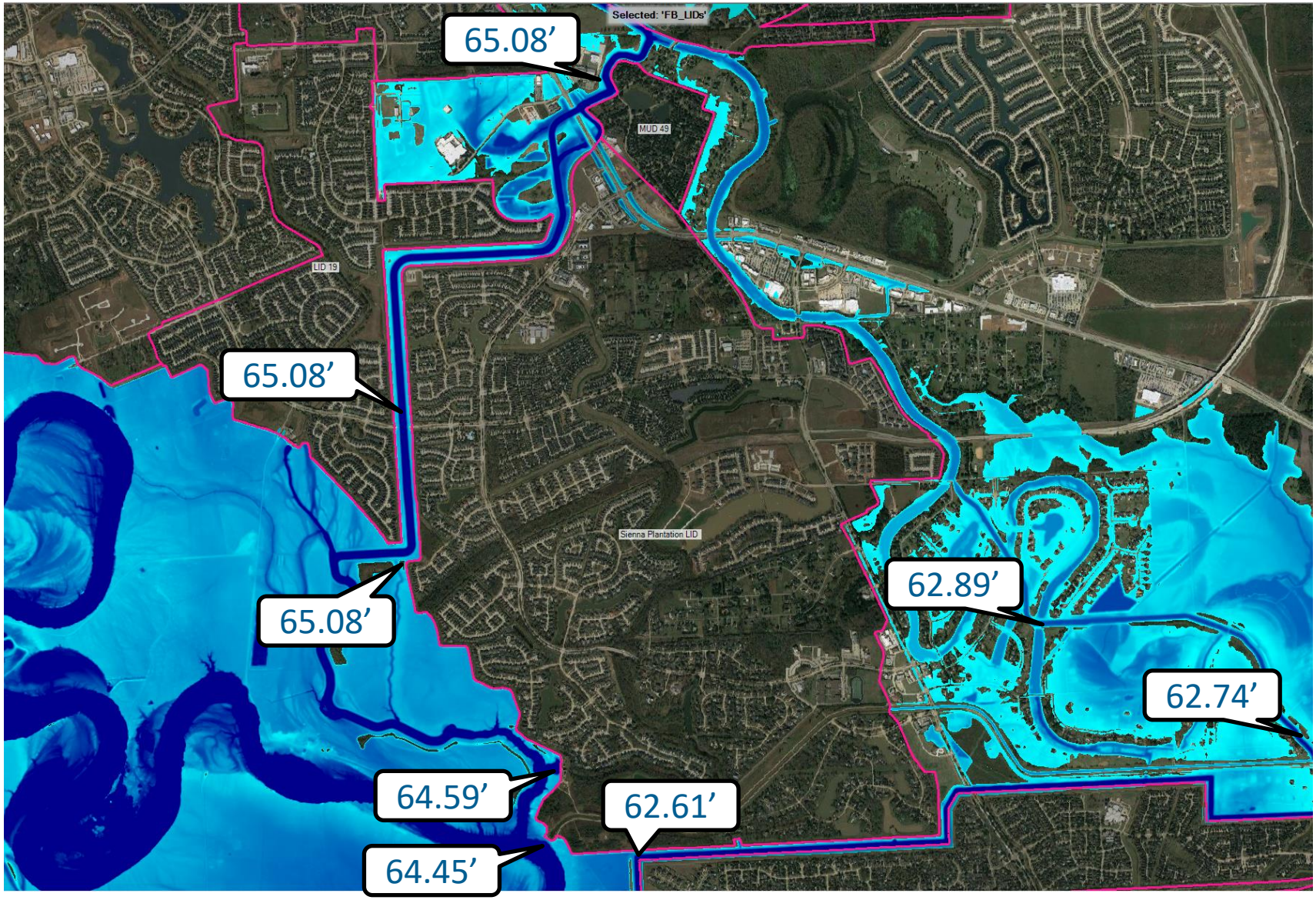
LID15 and LID19– Preliminary 500-yr WSEL



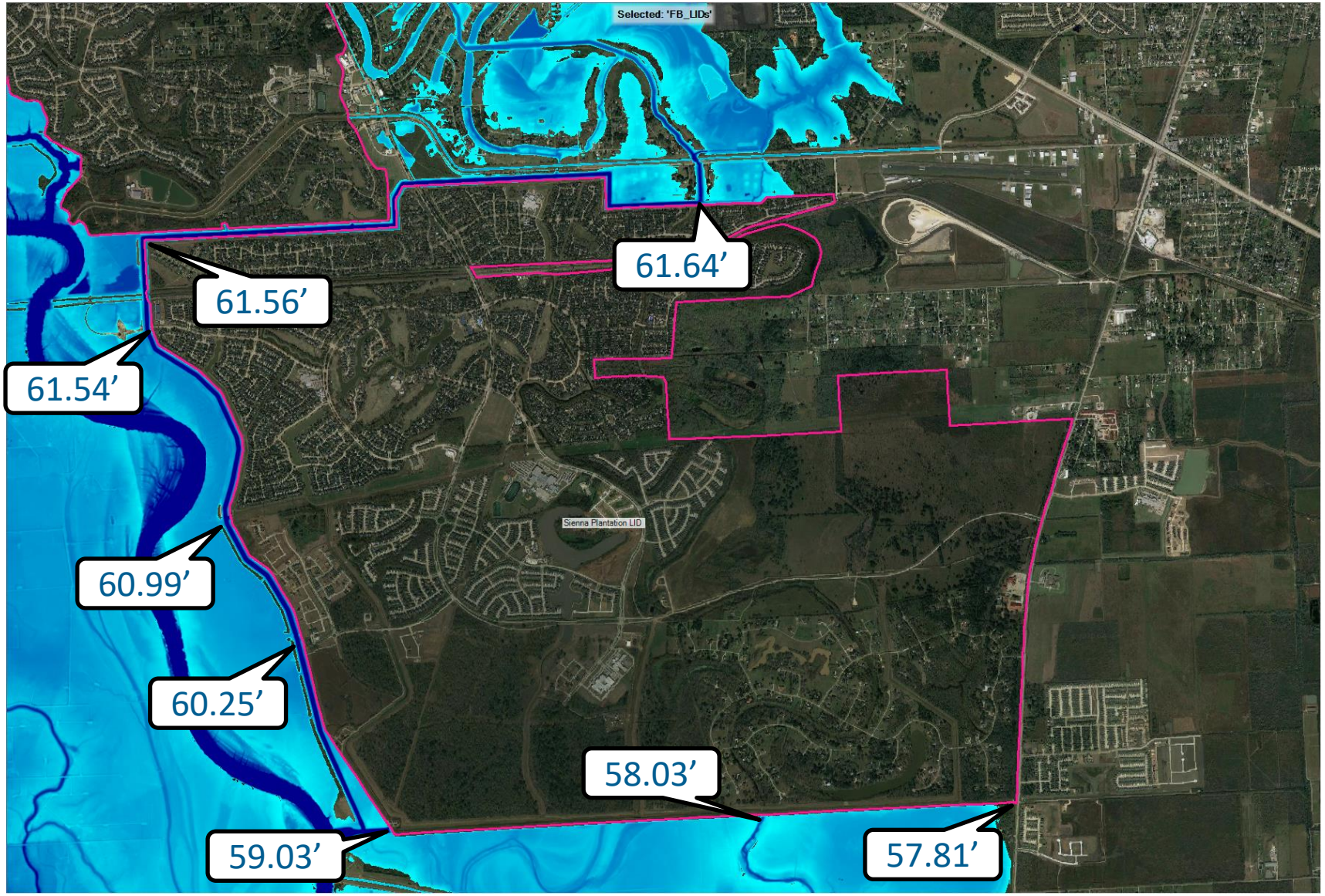
Sienna North – Preliminary 100-yr WSEL



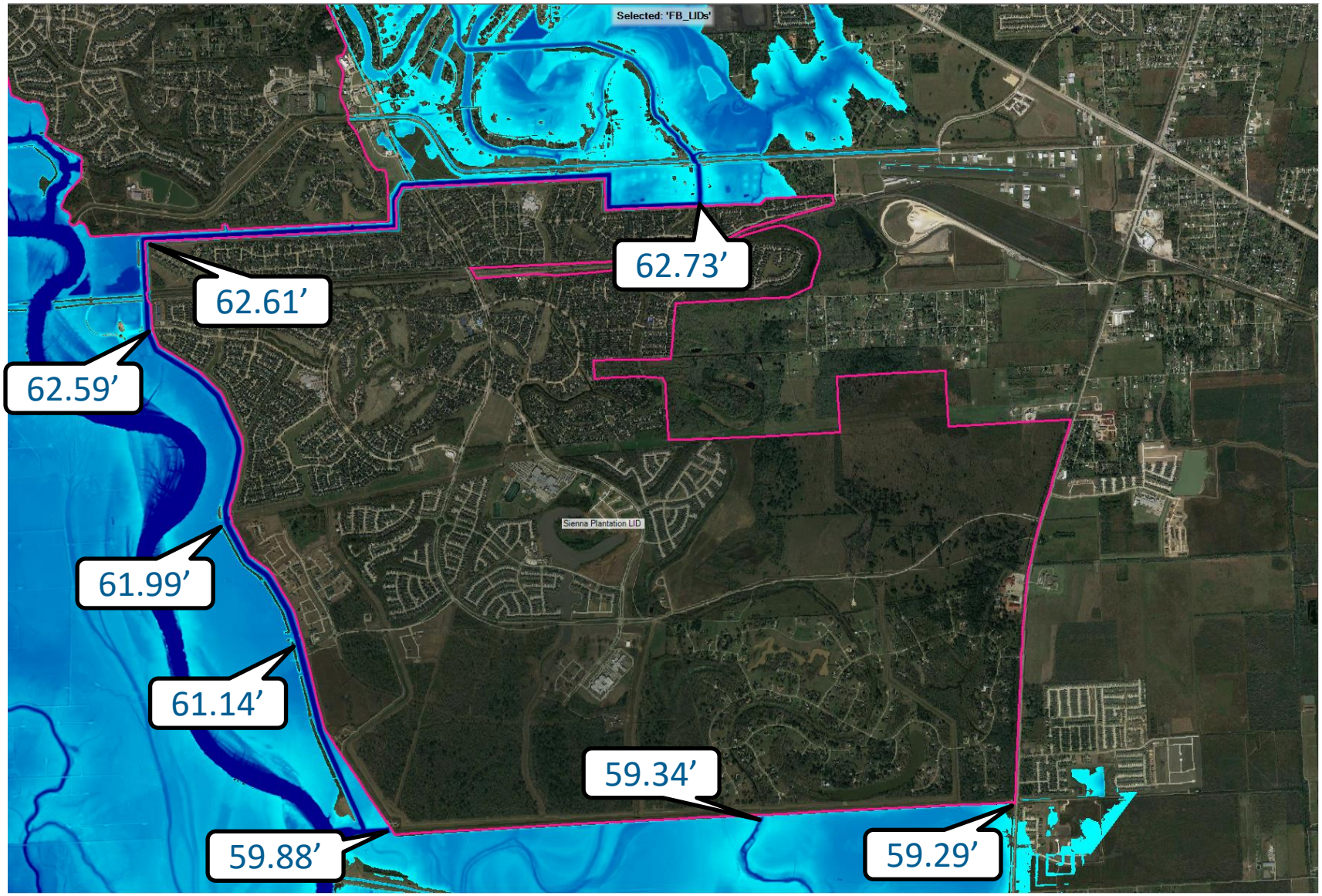
Sienna North – Preliminary 500-yr WSEL



Sienna South – Preliminary 100-yr WSEL



Sienna South – Preliminary 500-yr WSEL



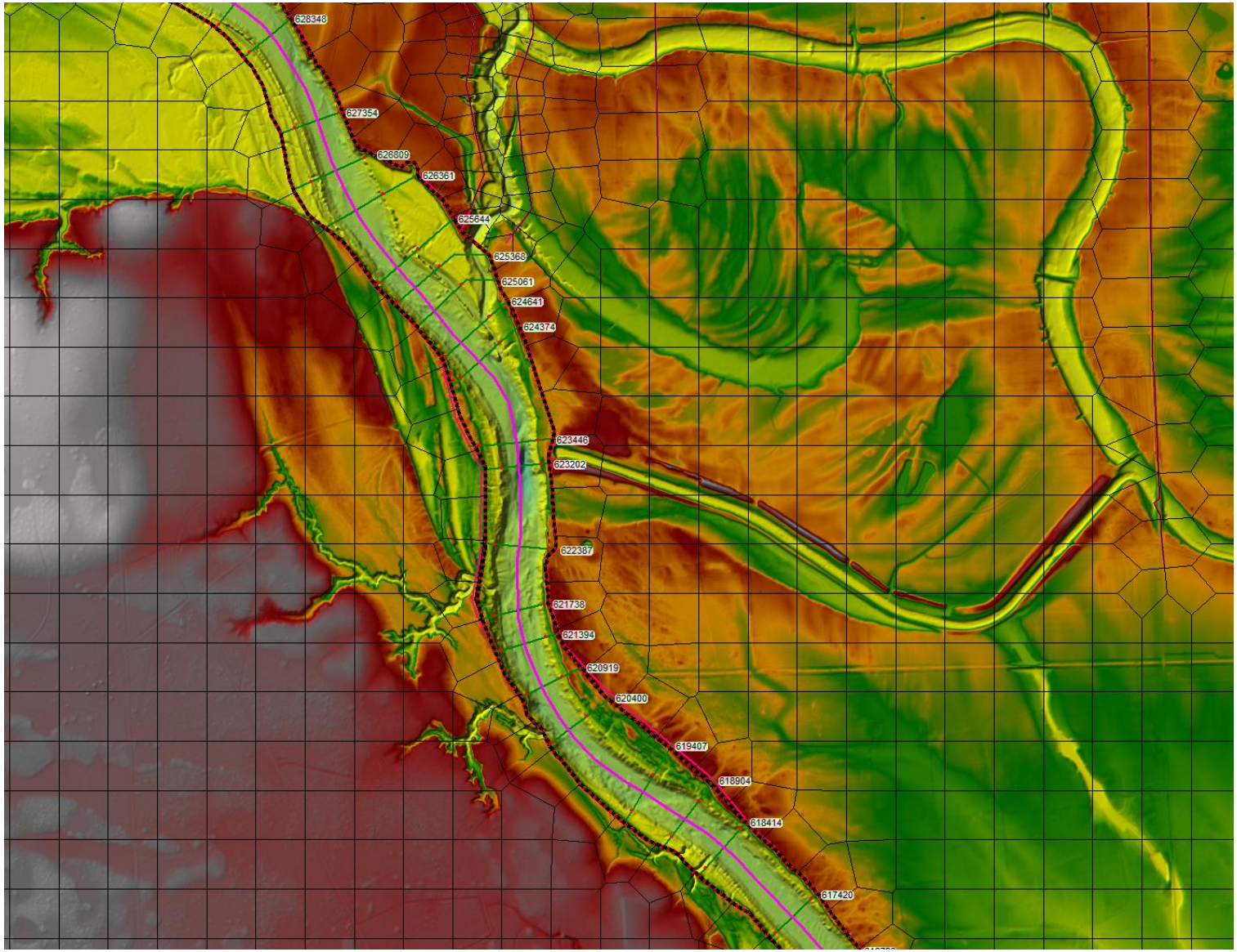
1D/2D Hydraulic Model

1D/2D Hydraulic Model

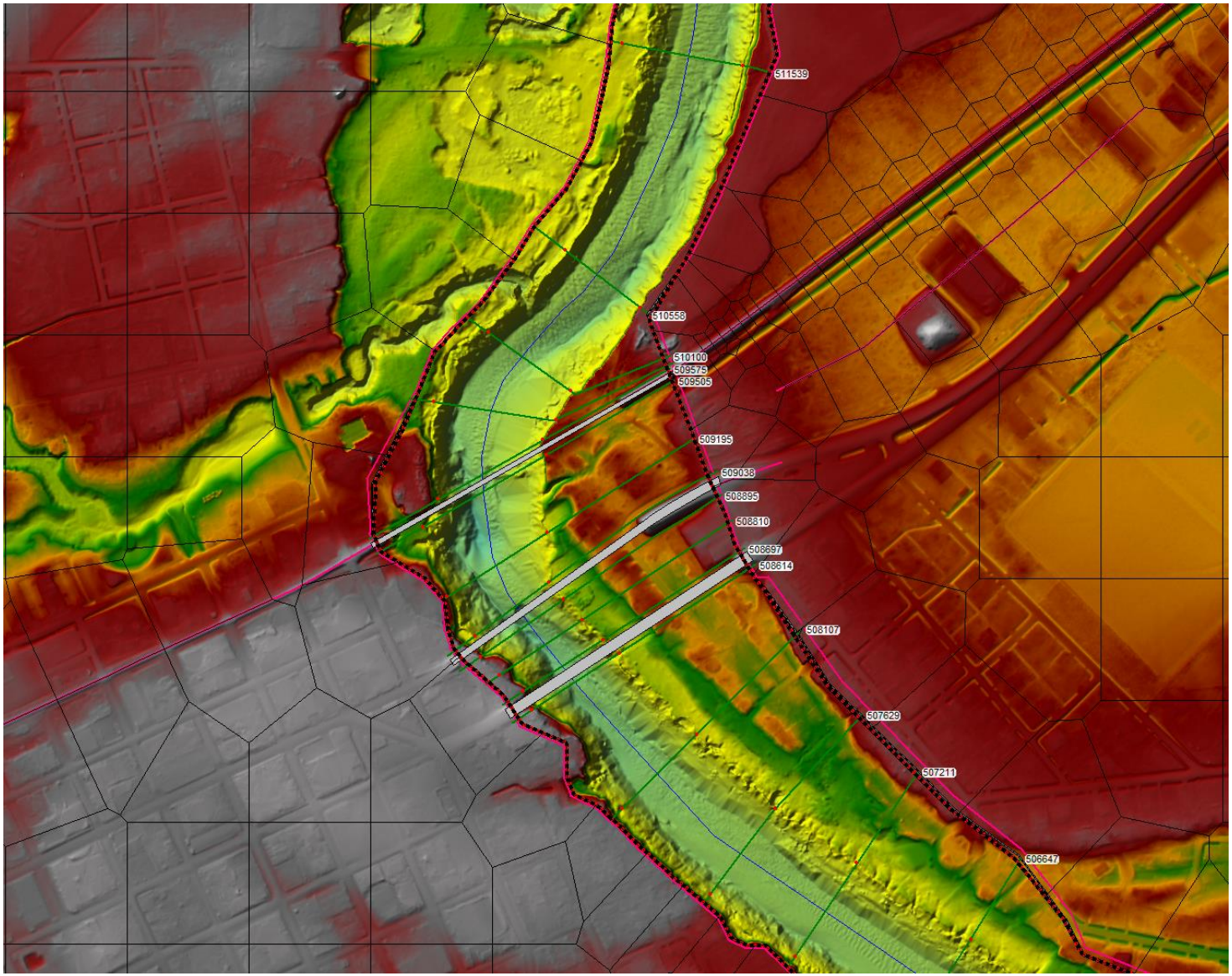
- Utilizes cross sections to represent river channel
- Utilizes 2D to represent overbanks (floodplain)
- Most accurate type of hydraulic model
- Includes bridges
- Oyster Creek, Bullhead Bayou, Ditch H, Brooks Lake Diversion
- Uses same topography as 2D model

- Model being calibrated

1D/2D Hydraulic Model



1D/2D Hydraulic Model



NEXT STEPS

- Finalize selection of flows and storm
- Finalize 1D/2D hydraulic model
- 2nd and final workshop (1D/2D results)
- Draft deliverables (models/report/profiles/maps)
  - Available for review in early Fall
- Final deliverables 4th quarter 2020

- Coordination with NWS

Final Questions?

Memorial Day 2016 near Thompsons