Mississippi Valley Division, Regional Planning and Environment Division South

Reach A, Hurricane and Storm Damage Risk Reduction Project Morganza to the Gulf of Mexico, Terrebonne Parish, Louisiana

Draft

Appendix I – Morganza to the Gulf Hydraulic Modeling Analysis (2023)

February 2024

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Mississippi Valley Division, Regional Planning and Environment Division South

Morganza to the Gulf HEC-RAS Hydraulic Modeling Analysis: Main Report

Morganza to the Gulf HEC-RAS Hydraulic Modeling Analysis Report

MVN-EDH

December 2023

Objective:

Determine the resulting inundation throughout the Morganza to the Gulf study area based on frequency precipitation, storm surge, and lateral Atchafalaya inflow for the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% annual exceedance probability (AEP) events. The model was analyzed for the "existing conditions" and "proposed conditions".

Model Development:

The purpose of this analysis is to describe the water levels for the various boundary frequency events and to analyze the impact of implementing and constructing the proposed levee system. The levee design elevations and peak storm surge elevations were determined in the "Morganza to the Gulf 2021 Economic Update Report". Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 6.3.1 was used to model inundation throughout the Morganza to the Gulf study area. An all-2D HEC-RAS geometry was used to model the river and floodplain. The latest "SLaMM" model (Southeast Louisiana Master Model) developed by MVN-EDH was provided as the base model, and modifications were added to better refine the geometry. The 2D model covers the entire Barataria Basin and extends west to West Cote Blanche Bay. Figure 1 displays the coverage of the 2D model. The model was calibrated using 2019 and 2021 as event years. All model elevation data and corresponding results are in feet and based off of the North American Vertical Datum of 1988 (NAVD88). The NAVD88 vertical datum is considered epoch-less for this analysis; this determination was based off of the many datum unknowns for input data into the model and overall datum uncertainty. If a specific NAVD88 epoch should be desired for any input or output datapoint from this analysis, that epoch should be directly added to that datapoint without any conversion applied. This determination is consistent with the current MVN policy.

Figure 1: 2D Model Domain

Bathymetry and Topography:

The terrain dataset used as the baseline terrain is the Unites States Geological Survey (USGS) USGS 10-meter DEM retrieved from https://www.sciencebase.gov/catalog/item/5f7783c482ce1d74e7d6c1ab; this terrain was overlayed with a more refined survey dataset, the 1-meter 2015 Gulf Islands dataset retrieved from https://maps.dotd.la.gov/imagery/rest/services/Elevation/2015_GulfIslands _1M_DEM/ImageServer. This terrain was overlayed with channel bathymetry data gathered from navigation channel surveys performed by the United States Army Corps of Engineers, New Orleans District (USACE-MVN), Operations Division. The bathymetry data included surveys along the stretch of Gulf Intracoastal Waterway (GIWW) from Harvey Lock to Bayou Boeuf Lock, the entire Houma Navigational Canal, and portions of Bayou Black, Bayou Chene, and Bayou Boeuf. The complete channel survey locations compiled for the final terrain are shown in Figure 2. The locations of each terrain dataset that was compiled for the final terrain is displayed in Figure 3. For both the 1-meter and 10-meter USGS datasets, the horizontal datum is the North American Datum of 1983 and the vertical datum is the North American Vertical Datum of 1988. For the channel bathymetry dataset, the horizontal datum is the North American Datum of 1983 and the vertical datum was in Mean Low Gulf datum. The vertical datum of the channel survey was converted to NAVD88 using local gages to best approximate the vertical conversion.

The terrain contains all available National Levee Database (NLD) alignments and elevations within the study area. Profile surveys for levee and floodwall segments were completed at different times and the most recent survey was used. Many of the local levees included in the NLD around this area did not contain elevation data; for these levees, the centerline was imported into the model and the elevation data was retrieved from the terrain dataset as a best approximation. Figure 4 displays the NLD centerlines that were imported into the model.

Figure 2: Map of Channel Survey Data Used for Final Terrain

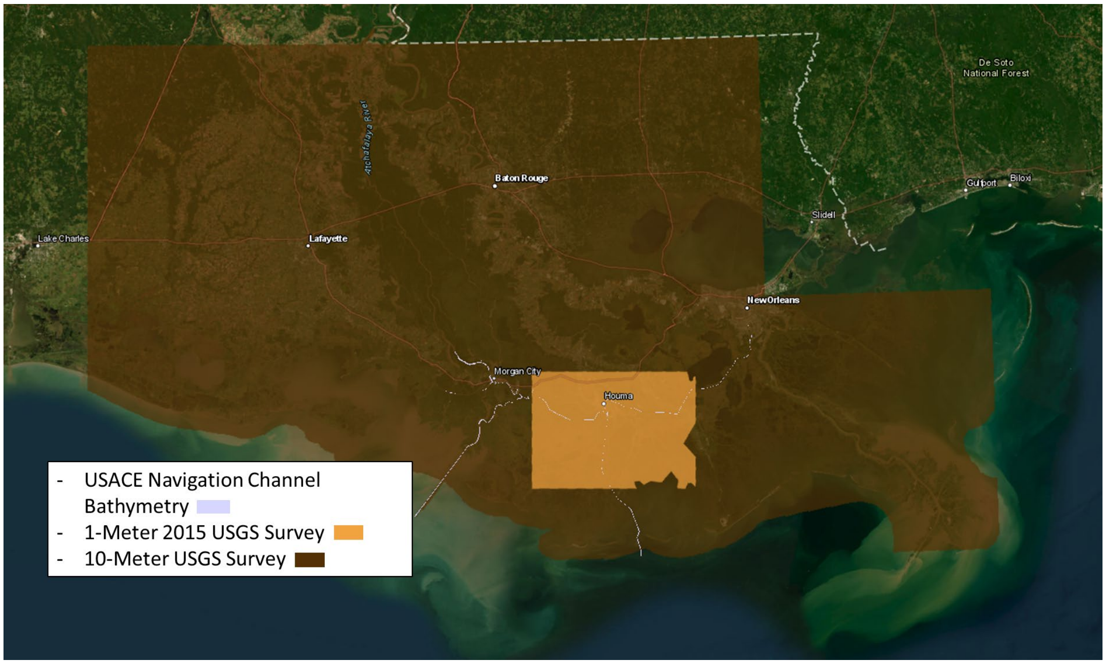

Figure 3: Locations of each terrain dataset used for final compiled terrain

Figure 4: National Levee Database levee centerlines utilized in the HEC-RAS model

The 2019 National Land Cover Dataset (NLCD) was used to allow for varying Manning's N based on the area. A soils layer was created from the National Resources Conservation Service (NRCS) "Major Land Resources Areas" soil data, covering the state of Louisiana. Using the soils layer and land cover layer, an infiltration layer was created using the SCS Curve Number methodology. The infiltration layer was used to account for precipitation infiltration during the calibration events and frequency events.

LiDAR and hydrographic (bathymetry) surveys make up a vast majority of the terrain elevations used in the modeling. The channels shown in Figure 5 did not have survey data available, and the LiDAR clearly did not capture the channel bottom. Therefore, modifications were added to the channel using the terrain and best estimates of channel dimensions to best approximate the channel.

Figure 5: Channel Modification Locations within the Final Terrain

Existing and Proposed Condition Scenarios:

Two different model scenarios were used for this analysis, the "existing conditions" and the "proposed conditions". The existing conditions scenario is meant to model the current conditions around the Morganza to the Gulf study area. This includes current levee alignments and elevations as well as current structures in place. A large percentage, roughly 60-70%, of the proposed design levee system and the proposed structures have already been constructed; therefore, those levees and structures were included in the existing conditions scenario. The existing conditions' pertinent structure and levee data was gathered from the local sponsors. It is important to note that the culvert sizing and invert elevations throughout the study area are "best estimates" from the local sponsors and are not based on surveyed information. The as-built drawings for the navigational structures were used to gather pertinent data, so this structure data should be considered correct. A top of levee survey was provided by the local sponsor for the existing Morganza to the Gulf levee system. Figure 6 shows the existing conditions levee alignment with structure locations along the alignment.

Figure 6: Existing Conditions Levee Alignment with Structures

The proposed conditions scenario is meant to model the complete proposed levee system around Morganza to the Gulf with all the proposed structures. The proposed conditions geometry contains proposed structure information from the Morganza to the Gulf Post Authorization Change Report (PACR) and top of levee and structure design elevations from the Morganza to the Gulf 2021 Economic Update (based on the 2020 Morganza to the Gulf Storm Surge Assessment Report). The authorized MTG levee system is designed to provide hurricane and storm damage risk reduction benefits to a 1% AEP while ensuring navigational passage and storm surge exchange. The levee design elevations are projected to year 2035, which is the estimated soonest date that construction would be completed on the project. The structure design elevations are projected to the year 2085, to allow for 1% AEP protection for 50-years. Figure 7 shows the proposed levee alignment with structure locations. Figure 8 displays proposed levee alignment from the PACR with names for levee reaches and structures. A full list of the existing and proposed conditions structures is displayed in Appendix A.

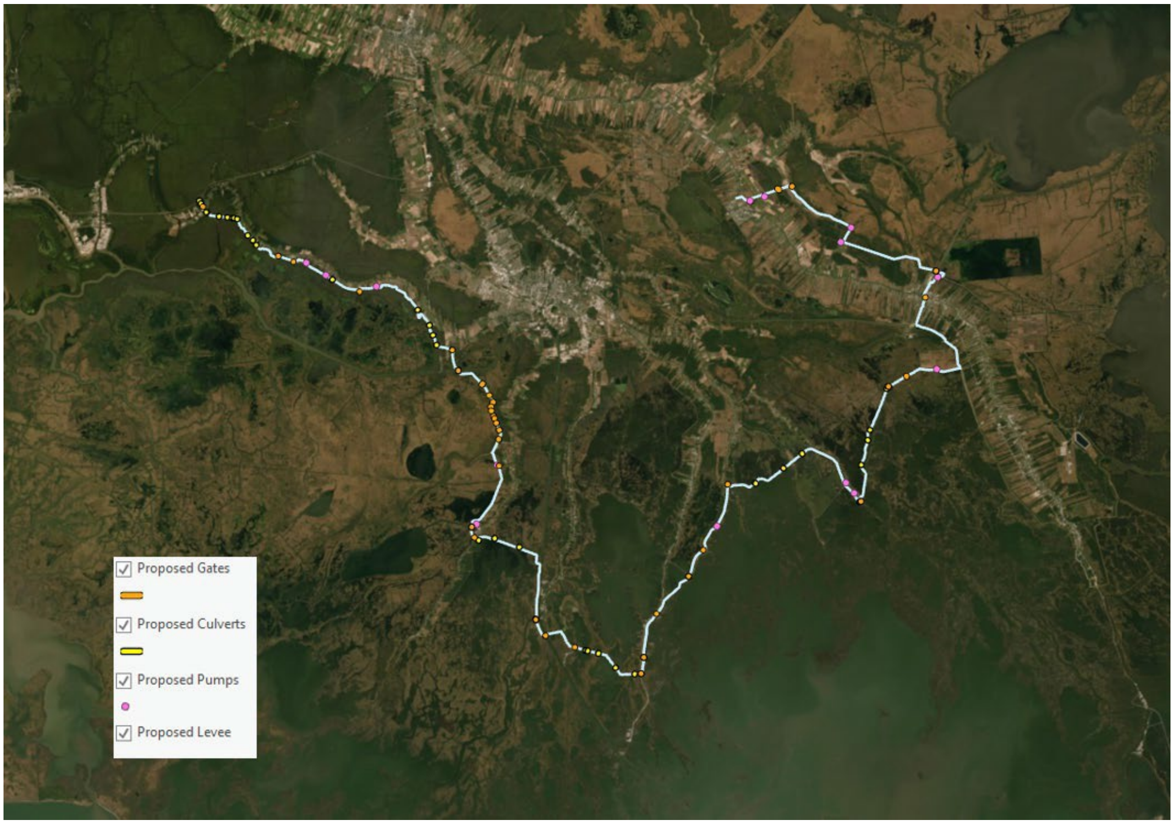

Figure 7: Proposed Conditions Levee Alignment with Structures

Figure 8: Proposed Alignment from the PACR

Model Boundary Conditions:

Storm Surge Boundary

The downstream water level boundary condition of the model is the Gulf of Mexico. For the calibration events, the USGS gage “Caillou Lake (Sister Lake) SW Of Dulac” was used as the “Left” and “Left-Left” downstream boundary, “Caillou Bay SW of Cocodrie” was used as the “Middle”, “Right”, and “Right-Right” boundaries, and “Little Lake” was used as the “Larose” and “Larose-Right” boundary conditions. For the “Precipitation Only” frequency runs, a constant downstream stage boundary of 0.7 feet NAVD88 was used as a mean low water surface elevation. For the “Precipitation and storm surge” and “Storm Surge Only” frequency runs, a storm surge boundary hydrograph was developed from the peak frequency storm surge elevations in the 2020 Morganza to the Gulf Storm Surge Assessment Report. The peak storm surge elevations for each frequency event were retrieved from the Storm Surge report at five locations, which are described in the model as “Left”, “Middle”, “Right”, “Right-Right”, and “Larose”. The locations of these storm surge boundary condition lines are shown in Figure 9. To develop a hydrograph for the peak storm surge elevations, a storm from the list of synthetic storms used in the Storm Surge Assessment was used as the baseline storm and scaled accordingly for each frequency event. Storm 77 from the list of synthetic storms was chosen because it produced a high water surface elevation near the study location and produced an average shaped hydrograph at each of the five storm surge boundary locations. Table 1 lists the peak frequency elevations at each storm surge boundary location and the multiplier used on the base storm hydrograph to reach that peak elevation. Although using one synthetic storm as a base event and scaling it up and down according to the peak storm surge elevations is a simplification of the duration/ shape of each event, it was deemed appropriate to use for each frequency event due to the variability in the speed of storms (primarily hurricanes) that move through the basin, which directly affects the duration and shape of the storm surge hydrograph. A sixth boundary location referred to as “Left-Left” was added into the model, which is 70% of the “Left” hydrograph for each event. This 30% reduction in the left hydrograph was to simulate a storm still pushing through that area of the model, but with the boundary being further away from the center of the baseline storm. Similarly, a seventh boundary location referred to as “Larose-Right” was added which is 80% of the “Larose” hydrograph for each event. The frequency storm surge hydrographs are displayed in Appendix B. Because the storm surge boundary condition lines within the model join at adjacent 2D cells, the model produces a high velocity output at these locations. Because the boundary lines are far enough away from the area of interest, this does not affect the results, but this should be noted if further analysis is performed looking at structures near the boundary.

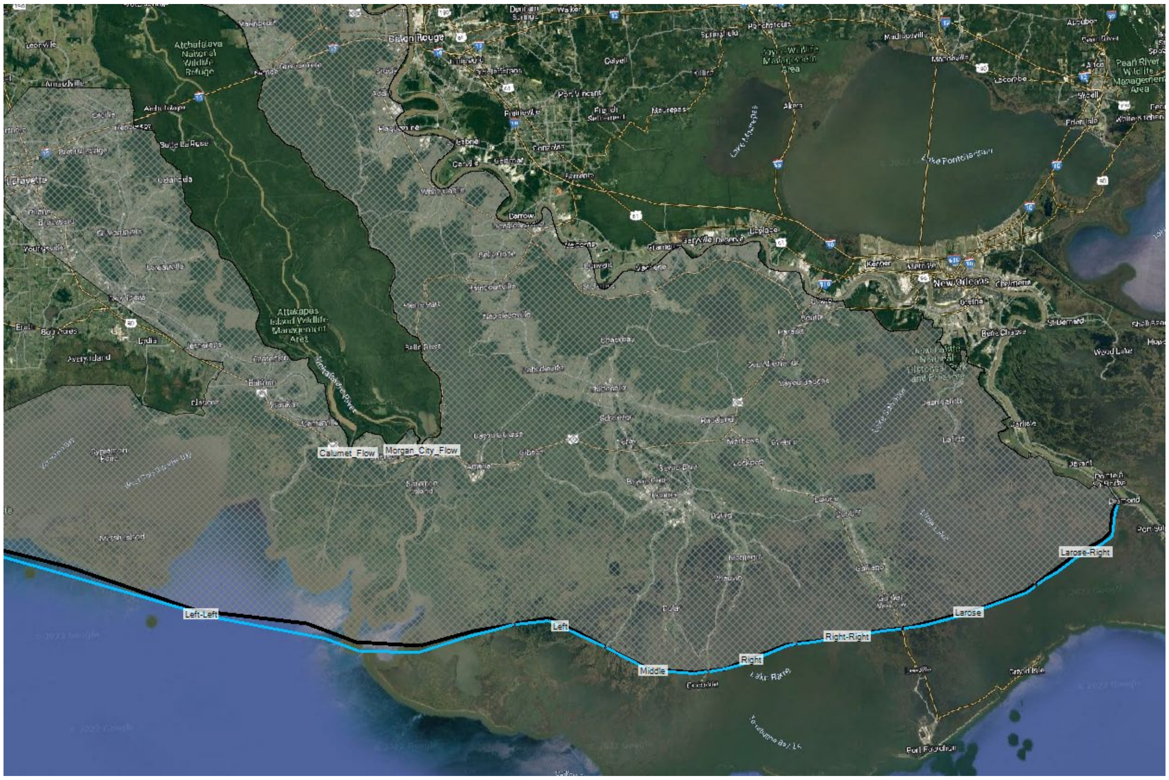

Figure 9: Boundary Condition Locations

Table 1: Base Storm Surge Boundary Hydrograph Multiplier and Peak Storm Surge Elevations

AEP	Left Peak Elevation (ft)	Multiplier	Middle Peak Elevation (ft)	Multiplier	Right Peak Elevation (ft)	Multiplier	Right-Right Peak Elevation (ft)	Multiplier	Larose Peak Elevation (ft)	Multiplier
10%	4.3	0.504	6.5	0.609	8.2	0.700	8	0.683	5.6	1.220
5%	6.1	0.715	8.2	0.769	10	0.853	10	0.853	6.7	1.460
2%	7.8	0.915	9.8	0.919	12	1.024	13	1.109	8.1	1.765
1%	9.7	1.137	12	1.125	13	1.109	14	1.195	9.6	2.092
0.5%	12	1.407	14	1.312	16	1.365	16	1.365	11	2.397
0.2%	14	1.641	17	1.594	18	1.536	19	1.621	13	2.832

Lateral Inflow Boundary

The model contains two lateral inflow boundary condition locations, Morgan City and Calumet (Wax Lake Outlet). These two boundary condition lines are shown in Figure 9 and are labeled as "Calumet_Flow" and "Morgan_City_Flow". For the calibration events, observed flow from the USGS gages (ID: 07381590, Wax Lake Outlet at Calumet, LA and ID: 07381600, Lower Atchafalaya River at Morgan City, LA) at both of these locations was used. For the precipitation and storm surge frequency events, 100 cfs of inflow was used as the boundary condition to have minimal impact on viewing the impacts of the storm surge and precipitation boundary condition variables. For the "Lateral Inflow" frequency runs, model flows from the "Atchafalaya Floodwall Prioritization Study" were used for each frequency event. It should be noted that these flows are model outputs based on frequency flows at Simmesport and are not statistically generated frequency flows at these two locations. However, the routing from Simmesport to these two locations is generally simple, and for the purpose of testing the effect of lateral inflows on the project study area, the model output hydrographs are considered appropriate. The peak Atchafalaya flows used in the lateral inflow scenarios are shown in Table 2.

Table 2: Peak Atchafalaya River Frequency Flows

AEP	Morgan City Peak Flow (cfs)	Wax Lake Peak Flow (cfs)
50%	235,709	223,762
20%	288,846	256,507
10%	318,821	278,338
5%	346,751	294,711
2%	452,344	376,575
1%	527,280	431,151
0.5%	599,492	480,269
0.2 %	689,415	551,218

Precipitation Boundary

For the calibration events, observed National Center for Environmental Prediction (NCEP) Stage IV gridded precipitation was used and overlayed over the model. The developed infiltration grid was used to account for infiltration. For the frequency events, National Oceanic and Atmospheric Administration (NOAA) Atlas-14 annual maximum point precipitation frequency depths were downloaded from the Houma, LA gage; these values are shown in Figure 10. The point frequencies were input into Hydrologic Engineering Center's Hydraulic Modeling System (HEC-HMS) to translate the precipitation data into hyetographs. The HMS model uses the alternating block method to develop the hyetographs from the precipitation depth values. The HEC-HMS model is very simple and just includes a single subbasin and a sink and does not account for infiltration. The storm duration of 24 hours was used with 15 minutes as the intensity duration, and the intensity position was set at 50% (peak precipitation intensity occurring at 12 hours). The 24-hour storm duration was chosen because it best represented historical precipitation events. The precipitation event dates that were viewed to come to this conclusion were the April 2017, May 2017, May 2020, March 2021, and May 2021 precipitation events. These precipitation events were high precipitation events, and all of which occurred primarily within a 24-hour time window around the basin of interest. The resulting frequency hyetographs from HEC-HMS are displayed in Figure 11. To overlay the hyetographs on the 2D model, the location of the precipitation was specified by creating points around the 2D area and associating the hyetographs to those points. Figure 12 shows the points that were used to overlay the precipitation over the 2D area and the resulting precipitation grid. So that the region that receives 100% of the precipitation is not unrealistically large, outlier points were drawn further away from the system. These points were input as 90% of the frequency precipitation hyetograph, and beyond those points another layer of points were added that were input as 30% of the precipitation hyetograph. Using HEC-RAS to interpolate between the 100% points and 90% points, and then 90% to 30% points, created a more realistic gridded overlay of the precipitation, but still allowed a majority of the project area to receive a 100% of the precipitation. The purpose of interpolating the precipitation grid across the basin was to better model a more realistic storm, as opposed to adding 100% of precipitation to the entire 2D area. With the variability of different paths that storms can take as they move through the basin, it was decided that the center of the storm would occur roughly at the center of the basin, and precipitation would decrease from there. Furthermore, the 100% precipitation value extends to the coastal boundary, attempting to replicate the path the storm would take if it were a tropical event. This frequency precipitation was overlayed over the 2D model for each event and used the infiltration grid to account for infiltration. It should be noted that the frequency precipitation data is pertinent to the year 2022, and it is assumed the precipitation depths per recurrence intervals will be consistent for years 2035 and 2085. The following section will discuss a qualitative look at potential climate change effects on future precipitation.

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]									
Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
5-min	**0.614** (0.487-0.757)	**0.775** (0.612-0.957)	**0.900** (0.708-1.12)	**1.07** (0.816-1.37)	**1.21** (0.898-1.56)	**1.35** (0.967-1.77)	**1.49** (1.03-2.00)	**1.68** (1.12-2.31)	**1.83** (1.18-2.55)
10-min	**0.900** (0.714-1.11)	**1.13** (0.897-1.40)	**1.32** (1.04-1.63)	**1.57** (1.20-2.00)	**1.77** (1.31-2.28)	**1.97** (1.42-2.59)	**2.18** (1.50-2.93)	**2.46** (1.63-3.38)	**2.68** (1.73-3.73)
15-min	**1.10** (0.870-1.35)	**1.38** (1.09-1.71)	**1.61** (1.26-1.99)	**1.91** (1.46-2.44)	**2.15** (1.60-2.78)	**2.40** (1.73-3.16)	**2.66** (1.83-3.57)	**3.00** (1.99-4.13)	**3.27** (2.11-4.55)
30-min	**1.65** (1.31-2.03)	**2.11** (1.67-2.61)	**2.47** (1.94-3.06)	**2.95** (2.25-3.76)	**3.33** (2.48-4.29)	**3.72** (2.67-4.88)	**4.11** (2.84-5.53)	**4.65** (3.09-6.39)	**5.06** (3.27-7.05)
60-min	**2.24** (1.78-2.76)	**2.86** (2.26-3.53)	**3.39** (2.67-4.21)	**4.18** (3.21-5.40)	**4.84** (3.62-6.30)	**5.55** (4.01-7.37)	**6.32** (4.38-8.57)	**7.42** (4.94-10.3)	**8.31** (5.37-11.6)
2-hr	**2.83** (2.27-3.45)	**3.61** (2.89-4.42)	**4.32** (3.44-5.30)	**5.41** (4.23-6.97)	**6.35** (4.83-8.22)	**7.39** (5.42-9.74)	**8.53** (6.00-11.5)	**10.2** (6.89-14.0)	**11.6** (7.56-15.9)
3-hr	**3.19** (2.58-3.88)	**4.08** (3.29-4.96)	**4.93** (3.95-6.01)	**6.27** (4.97-8.09)	**7.47** (5.73-9.66)	**8.81** (6.52-11.6)	**10.3** (7.32-13.8)	**12.5** (8.54-17.1)	**14.3** (9.46-19.6)
6-hr	**3.82** (3.13-4.59)	**4.92** (4.02-5.93)	**5.99** (4.86-7.23)	**7.71** (6.19-9.86)	**9.24** (7.19-11.8)	**11.0** (8.23-14.3)	**12.9** (9.29-17.2)	**15.8** (10.9-21.3)	**18.1** (12.1-24.5)
12-hr	**4.43** (3.67-5.27)	**5.82** (4.80-6.93)	**7.07** (5.81-8.45)	**9.00** (7.27-11.3)	**10.7** (8.38-13.5)	**12.5** (9.49-16.1)	**14.6** (10.6-19.1)	**17.5** (12.2-23.4)	**20.0** (13.5-26.6)
24-hr	**5.08** (4.26-5.98)	**6.74** (5.64-7.95)	**8.16** (6.79-9.65)	**10.2** (8.33-12.6)	**12.0** (9.50-14.9)	**13.9** (10.6-17.5)	**15.9** (11.7-20.5)	**18.8** (13.3-24.7)	**21.1** (14.5-27.9)
2-day	**5.81** (4.94-6.77)	**7.71** (6.53-9.00)	**9.30** (7.84-10.9)	**11.6** (9.55-14.1)	**13.5** (10.8-16.6)	**15.6** (12.0-19.4)	**17.7** (13.2-22.6)	**20.8** (14.9-27.0)	**23.3** (16.2-30.4)
3-day	**6.29** (5.39-7.28)	**8.34** (7.12-9.68)	**10.1** (8.55-11.7)	**12.6** (10.4-15.2)	**14.6** (11.8-17.8)	**16.8** (13.1-20.9)	**19.2** (14.4-24.3)	**22.6** (16.3-29.1)	**25.3** (17.7-32.7)
4-day	**6.66** (5.74-7.68)	**8.80** (7.56-10.2)	**10.6** (9.06-12.3)	**13.2** (11.0-15.9)	**15.4** (12.5-18.7)	**17.8** (13.9-21.9)	**20.2** (15.3-25.5)	**23.8** (17.2-30.5)	**26.7** (18.8-34.3)
7-day	**7.57** (6.59-8.65)	**9.82** (8.52-11.2)	**11.7** (10.1-13.5)	**14.5** (12.2-17.3)	**16.8** (13.8-20.2)	**19.3** (15.3-23.6)	**22.0** (16.8-27.4)	**25.8** (18.9-32.7)	**28.9** (20.5-36.8)
10-day	**8.44** (7.39-9.59)	**10.8** (9.43-12.3)	**12.8** (11.1-14.6)	**15.7** (13.3-18.5)	**18.0** (14.9-21.5)	**20.6** (16.4-25.0)	**23.3** (17.9-28.8)	**27.2** (20.0-34.2)	**30.3** (21.7-38.3)
20-day	**11.3** (10.00-12.7)	**14.1** (12.5-15.9)	**16.4** (14.4-18.5)	**19.6** (16.7-22.7)	**22.1** (18.4-25.9)	**24.7** (19.9-29.5)	**27.4** (21.3-33.4)	**31.2** (23.3-38.7)	**34.1** (24.8-42.7)
30-day	**13.8** (12.4-15.4)	**17.1** (15.3-19.2)	**19.7** (17.4-22.1)	**23.1** (19.8-26.5)	**25.7** (21.6-29.8)	**28.4** (23.1-33.5)	**31.1** (24.3-37.5)	**34.8** (26.1-42.7)	**37.6** (27.5-46.7)
45-day	**17.2** (15.5-19.1)	**21.0** (18.9-23.4)	**23.9** (21.3-26.6)	**27.6** (23.9-31.4)	**30.5** (25.8-35.0)	**33.3** (27.2-38.9)	**36.0** (28.3-43.0)	**39.7** (30.0-48.2)	**42.4** (31.3-52.2)
60-day	**20.1** (18.2-22.2)	**24.3** (22.0-27.0)	**27.5** (24.7-30.5)	**31.5** (27.4-35.6)	**34.5** (29.4-39.4)	**37.5** (30.8-43.5)	**40.3** (31.9-47.8)	**44.0** (33.5-53.2)	**46.8** (34.7-57.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of annual maxima series (AMS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and annual exceedance probability) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Figure 10: NOAA Atlas-14 Annual Maximum Point Precipitation Frequency Depths at Houma, LA

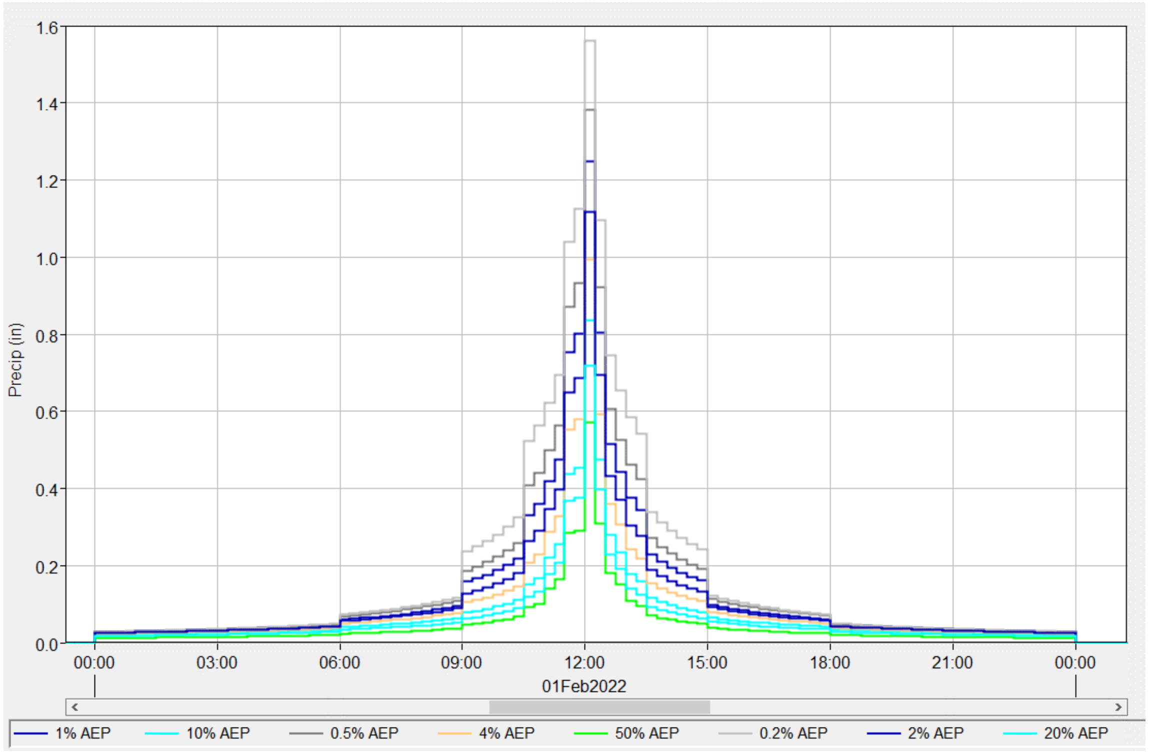

Figure 11: Frequency Hyetographs

Figure 12: Precipitation point locations for hyetograph inputs and resulting precipitation grid for the 1% AEP precipitation event

Future Precipitation Changes Considerations

Based on guidance from the Engineering and Construction Bulletin (ECB) 2018-14, an assessment of inland hydrologic changes should be performed on USACE projects early in the development process. The USACE Climate Preparedness and Resilience (CPR) Community of Practice provide an online repository for tools and information required by the ECB to assess hydrologic climate impacts. Both quantitative and qualitative methodologies are acceptable according to the ECB. Utilizing the Climate Hydrology Assessment Tool (CHAT), a simulated annual-maximum 3-day precipitation was exported, which is a simulation of historical and projected future climate-changed precipitation at the HUC8 basin encompassing Morganza to the Gulf (08090302 - West Central Louisiana Coastal). This information is displayed in Figure 13 below. Furthermore, Figure 14 displays a matrix of the results from the "Recent US Climate Change and Hydrology Literature Applicable to U.S. Army Corps of Engineers Missions – Lower Mississippi River Region 08" representing observed and projected trends.

Viewing the results from Figure 14, the results indicate an observed mild upward trend in both precipitation and hydrology/streamflow within the Lower Mississippi River Region; however, a full supporting consensus has not been reached based on the data evaluated (greater than half). The projected trends showed an increase in precipitation, but a full consensus was not established (less than half). Additionally, a decreasing trend was projected for hydrology/streamflow without a strong consensus (less than half). Observed air temperatures showed no significant change in the recent past without a strong consensus (greater than half). However, projected trend shows strong increases in air temperatures with a full consensus and citing multiple literary sources.

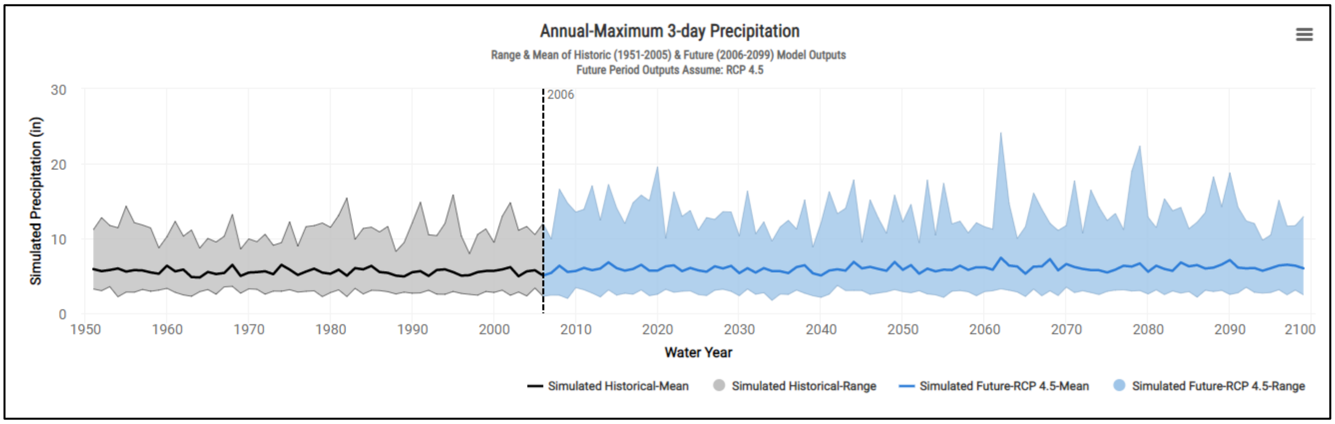

Figure 13: Annual-Maximum 3-Day Precipitation Simulation for HUC 08090302 – West Central Louisiana Coastal Basin

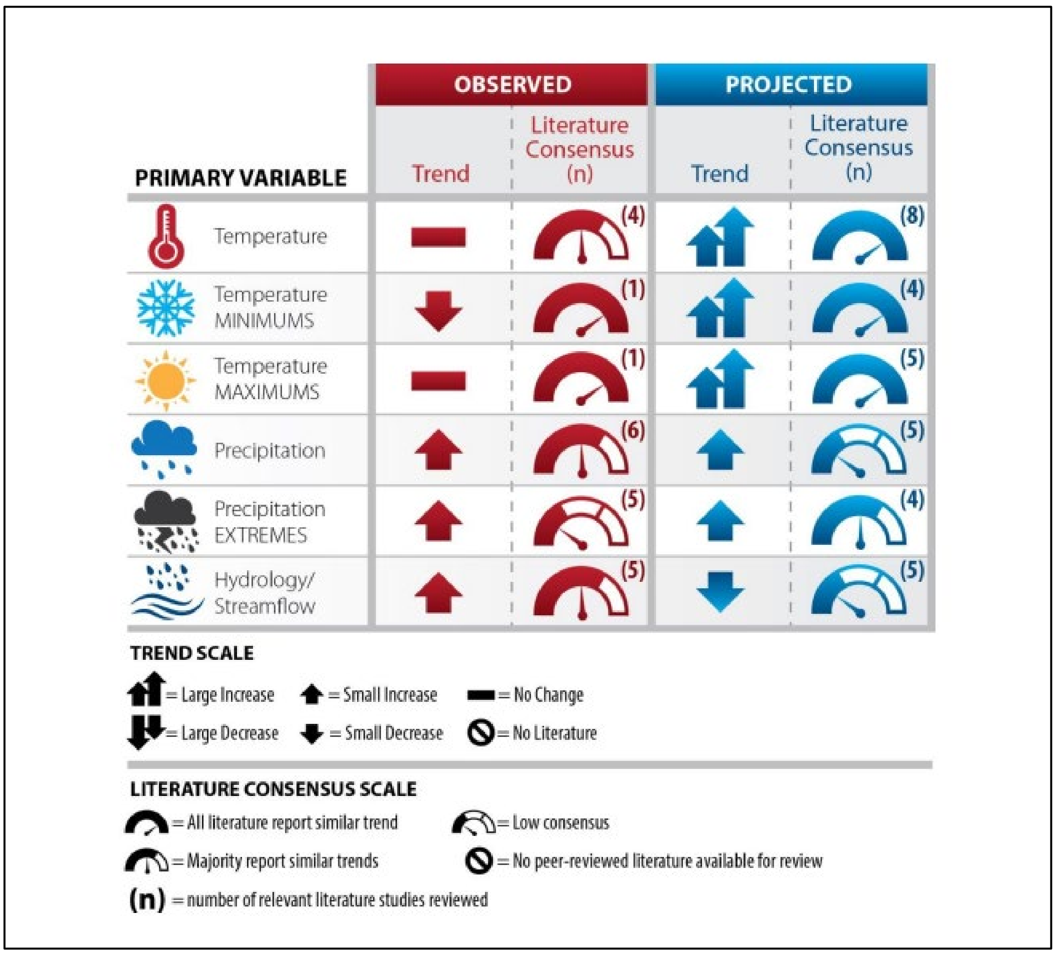

Figure 14: Summary Matrix of Observed and Projected Climate Trends and Literary Consensus Source: U.S. Army Corps of Engineers

Specifically considering future precipitation changes, both Figure 13 and Figure 14 results indicate that within the Morganza to the Gulf region there is a potential for a mild uptrend in total precipitation, but this is not conclusive. As well, there is a potential for extreme precipitation events to occur more frequently in the future. Both of these estimations are qualitative and are included in this report for informational purposes. With this in mind, Table 3 was compiled to highlight Morganza to the Gulf project specific features that could be affected by future hydrologic changes.

Table 3: Potential Hydrologic Changes on Morganza to the Gulf Project Features

Feature or Measure	Trigger	Hazard	Harm	Qualitative Likelihood
Levee	Increased precipitation from larger, slower-moving storms	Future flood volumes may be larger than present Large flood volumes may occur more frequently	Flood waters may remain on the levee for longer durations, and more frequently, potentially damaging levee	Likely
Navigation Structures	Increased precipitation from larger, slower-moving storms	Future flood volumes may be larger than present Large flood volumes may occur more frequently	High River flows may increase frequency of navigational structure closures	Likely
Pump Stations	Increased precipitation	Used more frequently, which could require more maintenance and cost.	Possible flooding as a result.	Likely

Sea Level Rise and Subsidence

Sea level rise estimates were produced from the "2015 Updated Atlas of U.S. Army Corps of Engineers Historic Daily Tide Data in Coastal Louisiana" report. The nearest gage from this analysis to the project study area was the Bayou Petit Caillou at Cocodrie gage (USACE Gage 76305), so the information at this gage was used to retrieve sea level rise information. Figure 19 shows the location of the Bayou Petit Caillou at Cocodrie gage. For this analysis, the intermediate rate of sea level rise was chosen to be used to account for the rise. The year 2035 was chosen as the "base" year condition, based on the PACR's estimated project completion date. The year 2085 was chosen as the "future" year condition, 50-years extended from 2035. From the Historic Tide Data report, the sea level rise and subsidence increase estimate at the Cocodrie gage from year 2020 to 2035 is 0.4047 feet, and from 2020 to 2085 is 2.0428 feet. These sea level rise and subsidence estimated increases were added to the 2020 frequency storm surge hydrographs to comprise the estimated 2035 and 2085 storm surge hydrographs.

Model Calibration:

Model Setup

The model is an entire 2D model built in HEC-RAS 6.3.1. Breaklines were used to refine the cell alignments by capturing high ground locations such as roadways and channel overbanks. All available levee data was downloaded from the NLD and modeled in the 2D area as 2D connections. Many levees from the NLD contained a levee centerline but no elevation data. For those locations, the elevation data was set to the terrain elevations. The structures throughout the basin were modeled as structures and culverts inside of 2D connections. Some local culverts were included that were not part of the MTG levee alignment, but the primary focus was culverts along the MTG system. Many local pump stations were added to the model based on Google Earth aerial imagery and their pump capacities were estimated based on visual size of the pump house. The pump efficiency curves based on differential head across the pump stations were unknown, and thus the pump curves were estimated with a constant head. In reality, each pump station's efficiency will be dependent on the head differential. With a constant head (as was modeled), the pump efficiency does not change based on changing head conditions and is more simplified. The pump stations within the model were turned on and off by the water surface elevation at the pump station intake. The water surface elevations that activated the pump stations depended on the terrain elevation in the area, but generally the elevation ranged from (-1 on and -1.1 off) to (-5 on and -5.1 off). The pump station features in the model have just one pump per station, with the total volume of that pump station being equivalent to the whole station. This was done for easy visualization in the model but does not affect how the model computes pump total outflow. The primary purpose of pump stations within the model was to account for the exchange of total volume of water across structures. Some pump station locations did not accurately depict the correct inlet and outlet channels dimensions within the model terrain. For these locations, the terrain was not modified due to the uncertainty of these smaller channel dimensions. It should be noted that these pump stations would only be available to pump once the water surface became greater than the terrain elevation at these locations. The model and results are in the North American Datum of 1983 horizontal datum, and the NAVD88 vertical datum.

Figure 15 shows the 2D domain for the existing conditions, with the 2D connections highlighted in yellow. The southernmost boundary of the 2D domain does not extend all the way to the gulf because the further south the 2D area extends from the system, the more the wind would have an effect on the results. The ADCIRC model outputs that were used as inputs for this model already incorporated wind. To ensure the modeled wind effects are not lesser than actual wind effects, the boundary was moved further north. Additionally, the main focus of this model is within the MTG system. Figure 16 shows an example of the 2D cell sizes and alignments. Figure 17 shows a map of the existing conditions geometry pump stations, culverts, and gates. The model used a varying timestep: a 1-minute timestep from 25-Jan-2022 to 31-Jan-2022, a 20 second timestep from 31-Jan-2022 to 03-Feb-2022, and back to a 1-minute timestep for the remainder of the run. This varying timestep allowed for a smaller timestep during the peak of the event to allow for greater model stability. Initial conditions points were used to initialize the basin to 0.7 feet elevation. Certain locations throughout the model required a lower initial elevation of -8 feet in order to not fill in storage areas inappropriately. Each event was started 6 days before the storm surge and precipitation boundary peaks, and this allowed the model to initialize to normal water levels prior to each event. Under the "Computations Options and Tolerances" options within the HEC-RAS model, the flow stability factors and submergence decay exponents were increased to 3.0 to increase stability. These values were increased due to some instabilities in the model at structure locations when releasing flows. Increasing these values improved stability but could potentially decrease accuracy. Because the model domain is so large, correcting local instabilities would require much smaller cell sizes and was beyond the scope of this analysis, and that's why the flow stability factors and decay exponents were increased.

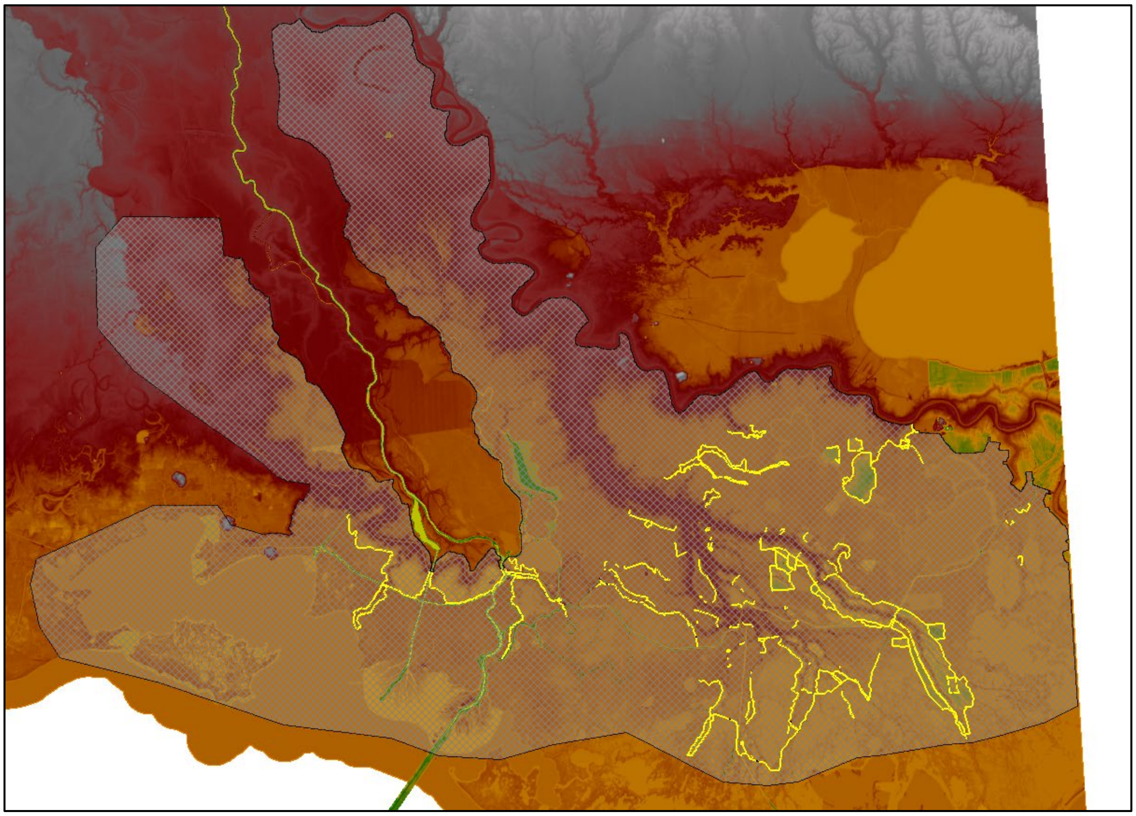

Figure 15: Existing Conditions Geometry - 2D model domain with 2D connections

Figure 16: 2D Domain with Cell Alignments

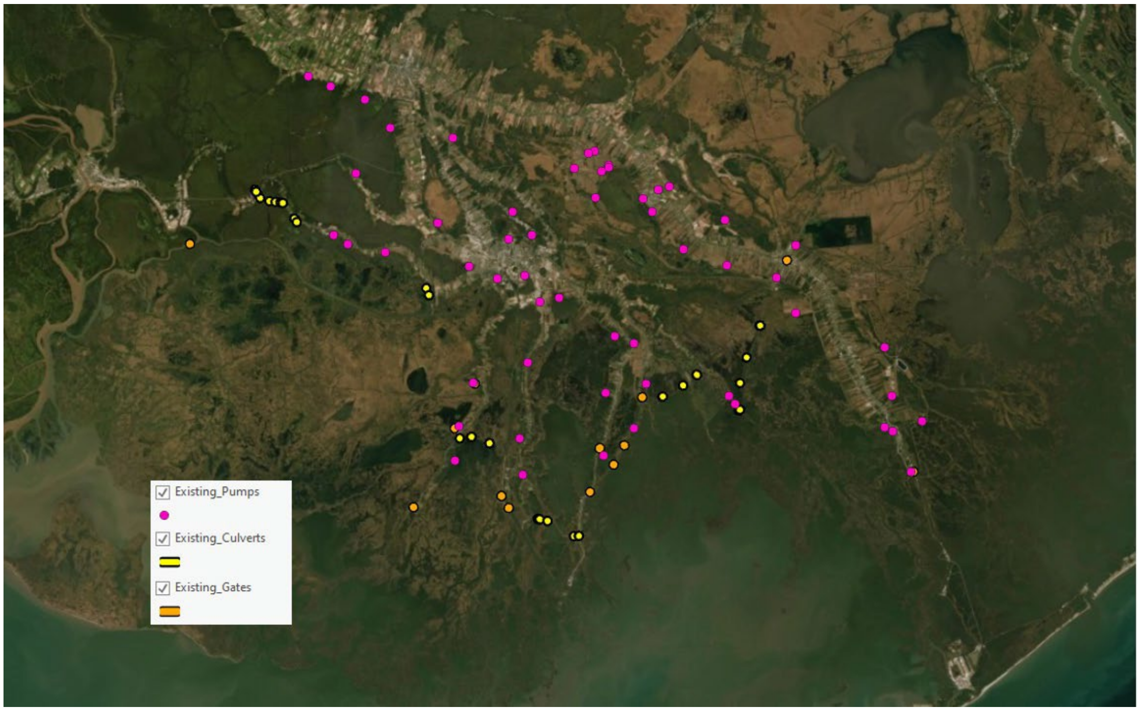

Figure 17: Existing Conditions Geometry Pumps and Structures

A minor method of calibrating this model so the computed water surface elevation better matched the observed water surface elevation was changing the Manning's N values in portions of the model. Figure 18 shows the override polygons that were used in calibration. The override polygons were used in calibration of the Atchafalaya River from a previous study and were utilized in this model. The "open water" values used in the override polygons range from .012 to .026. For the rest of the basin, a Manning's N value of .018 was utilized for "open water".

Figure 18: Manning's N Override Regions

Calibration Results

Two high water events were used to calibrate the model, the date ranges for these events are:

1. 08 July 2019 – 28 July 2019
2. 15 May 2021 – 30 May 2021

Information related to gate operation is not recorded, so definitive replication of the structure configurations for each event is impossible. However, based on the information that is available, it can be assumed that the modeled configuration is the most likely operational configuration. For the duration of the 2019 event, the Bayou Chene gate was set at closed, and the rest of the structures were set to open. The Bayou Chene structure was known to be closed during this time period, but it is unknown if or when the rest of the structures were closed throughout the event, and thus, were assumed to be open. For the May 2021 event, all structures are assumed to be open, including Bayou Chene.

A combination of USGS, USACE, and Coastwide Reference Monitoring System (CRMS) water surface elevation gage data was used to calibrate the HEC-RAS model. A map of the gages used for calibration is shown in Figure 19.

Figure 19: Map of Gages used in Calibration

Examples of computed water surface elevations compared to observed water surface elevations are shown in Figures 20-28. In the figures, the blue lines are HEC-RAS computed water surface elevations, and the black lines are observed water surface elevations. Several of the USGS gages, particularly the Houma gage, GIWW West gage, and Houma Navigational Canal gage, were removed in late 2019. These gages are located at important locations around the study area, which made it difficult to compare calibration of the model for different events. The CRMS gages are primarily located in marshland around the basin and these gages generally did not calibrate well to observed elevations. This was due to the terrain data not capturing the marshland channel bottom, but rather the water surface elevation that occurred when the DEM (digital elevation model) was surveyed. It was decided to leave the terrain data as-is in the marshland and not try and estimate a channel bottom. This was decided because estimating the channel bottom could incorrectly add too much storage in the basin and may produce an even less accurate depiction of water flow and storage. As well, the purpose of this analysis is to compare existing conditions to proposed, with the intent to observe relative differences between the conditions. Thus, model errors due to incorrect terrain data will be smoothed out in the comparison.

Two variables made it difficult to calibrate the model. Firstly, maintaining consistent vertical datums between data sources was difficult. The USGS and CRMS gages had varying geodes and unknown epochs. As well, the bathometry data used a single conversion value from Mean Low Gulf to NAVD88 due to lack of known conversions across the basin. With that, there is uncertainty in datum consistency in the terrain and gage data. This analysis did its best to maintain consistent datums, but the lack of information made it difficult. The second variable that made the model difficult to calibrate was not knowing the exact closures of the structures throughout the study area. The gates being opened or closed on some days could have a significant effect on interior elevations. Because of these uncertainties and the uncertainty in the terrain data outside of the large river channels, more emphasis was placed on the model capturing the peak water levels at the USGS Houma and USGS GIWW West gage. The unknowns surrounding the CRMS data (terrain and datum conversion) made it difficult to place much confidence in those calibration results.

In an attempt to better calibrate different gage locations, there was a focus on changing different parameters so that the model results better matched observed data. One variable that was investigated was the initial conditions of the basin. It was noticed that several gage locations throughout the model started out high for the calibration events. A sensitivity run was run for the 2019 event, in which the model was started on 10-Feb-2019 to let the basin initialize prior to the high flow event. These results showed a negligible difference in the water levels prior to the peak of the event (around 10-July-2019). Because of this, the issue with the calibration events starting high was not attributed to the model starting too high, but rather is attributed to the previously described issues in calibrating this model, such as unknowns with the datum. Another variable that was tweaked in an attempt to better calibrate the model was the Manning's N values. Manning's N override regions were added to many different areas around the basin in attempt to raise or lower water levels to better match observed data. What was noticed from these sensitivity runs was that the model was not sensitive to the Manning's N values. Changing Manning's N values showed negligible differences in water levels. Because of this, no override regions were included near the Morganza to the Gulf Levee System.

Figures 29 - 33 highlight flow and velocity comparisons for model results to gage results. These comparisons show that at Houma and GIWW West gages, the HEC-RAS model does not accurately capture the negative flow in the channel (westerly flow) during the 2019 event. Looking at the peak water surface elevations along the coastal gages for this event, the western gages at Caillou Lake and Caillou Bay show a peak elevation of 8.8 ft. NAVD88 and 6.5 ft. NAVD88, respectively; the eastern boundary gage at Little Lake shows a peak elevation of 4.0 ft. NAVD88. Because of this gradient of higher water levels on the western side of the basin compared to lower levels on the eastern side, the model results appear to be computing correctly based off the model inputs. The discrepancy between model results and the observed data may be due to the lack of wind data input into the model. The wind for this event may be the cause of easterly flows, and that was unable to be captured by the available input data.

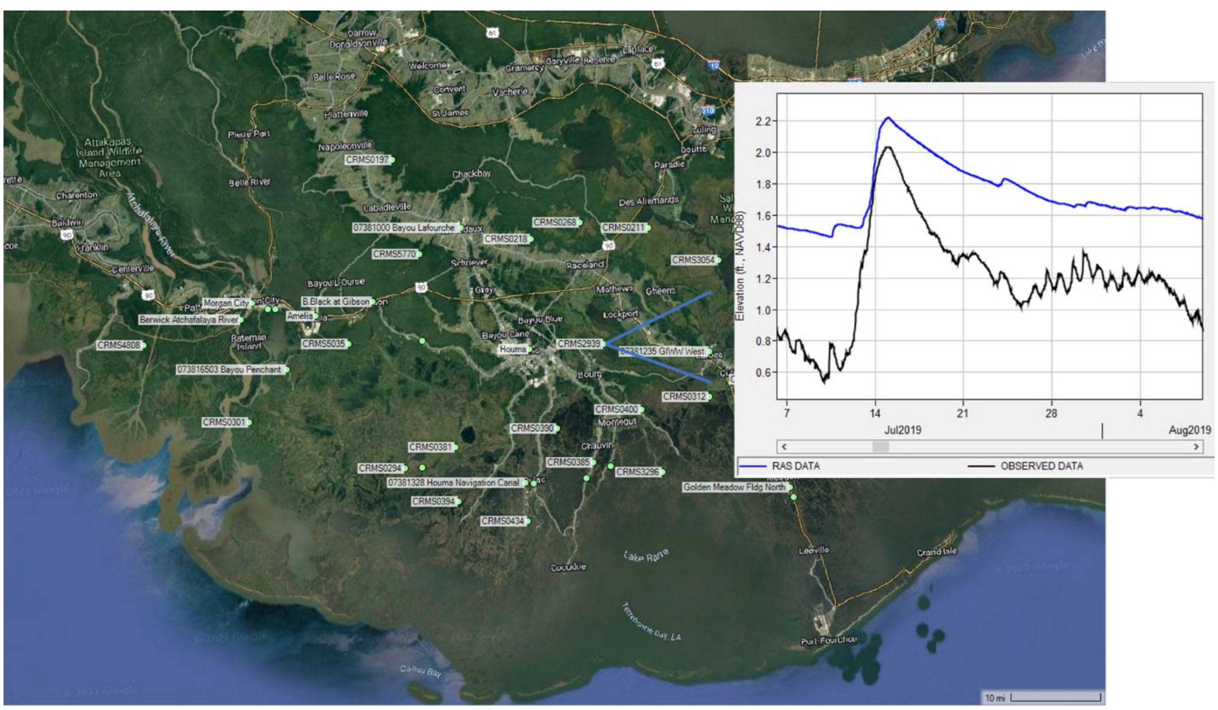

Figure 20: 2019 Calibration at CRMS Gage #2939

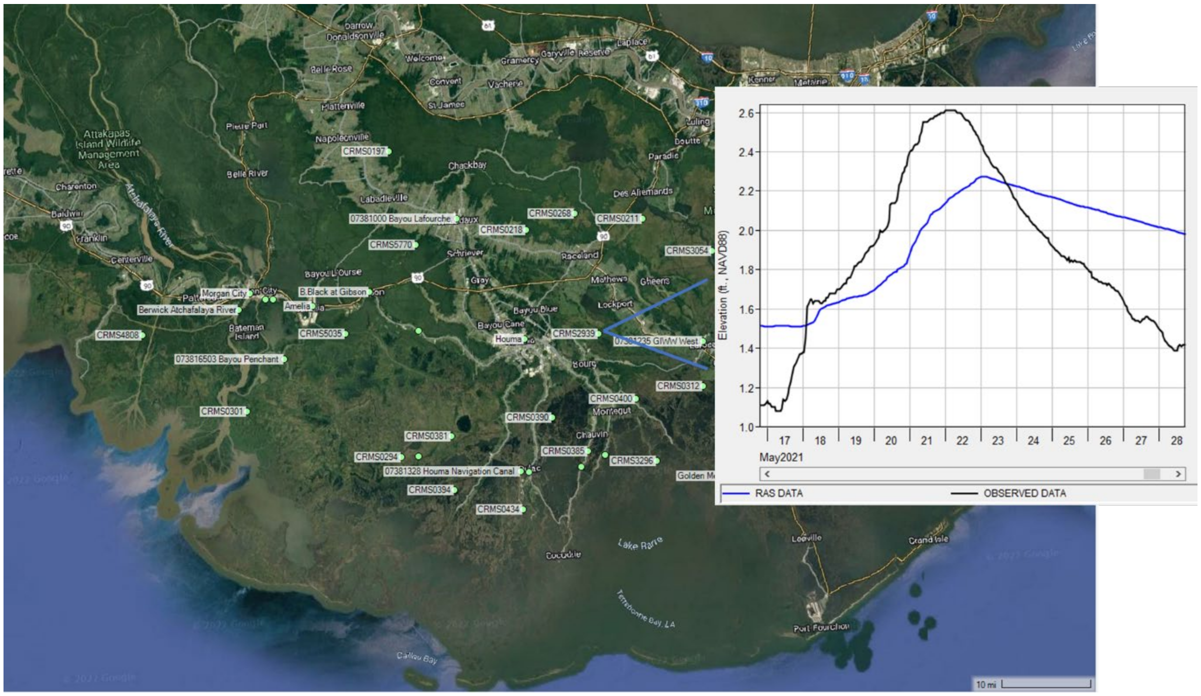

Figure 21: May 2021 Calibration at CRMS Gage #2939

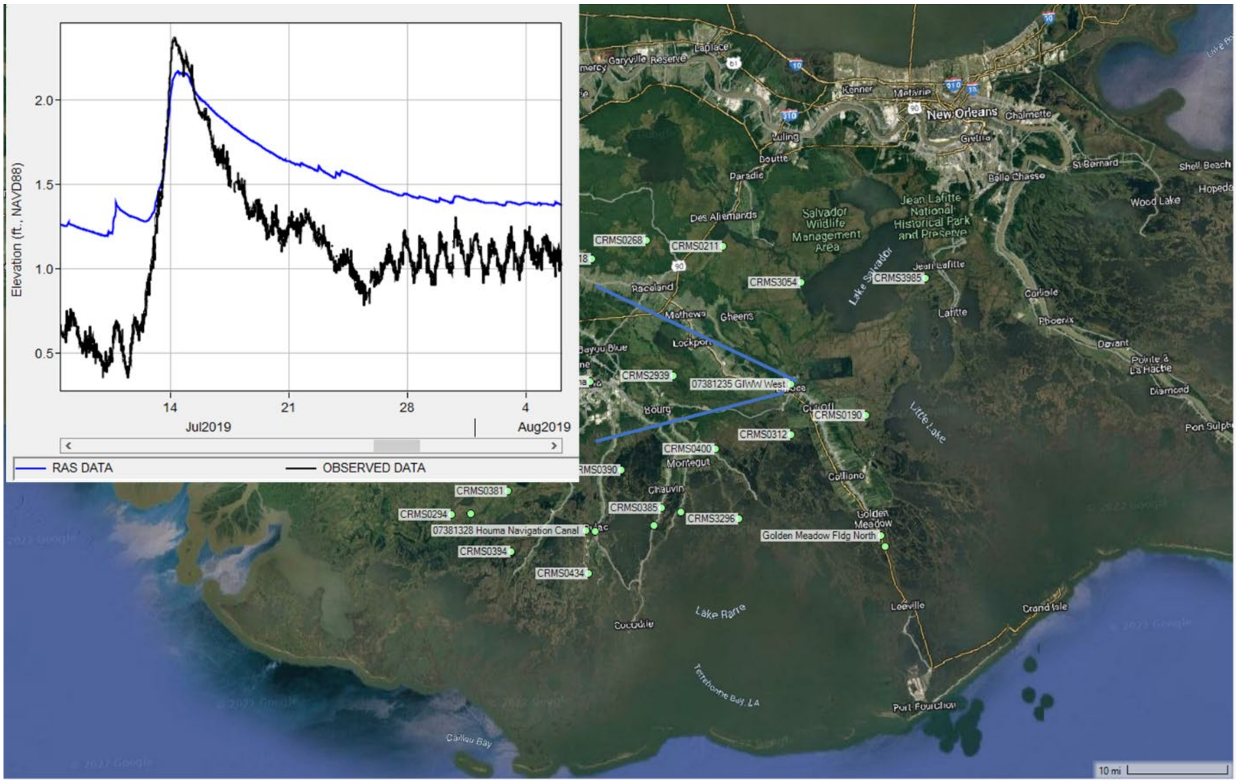

Figure 22: 2019 Calibration at USGS Gage at GIWW West

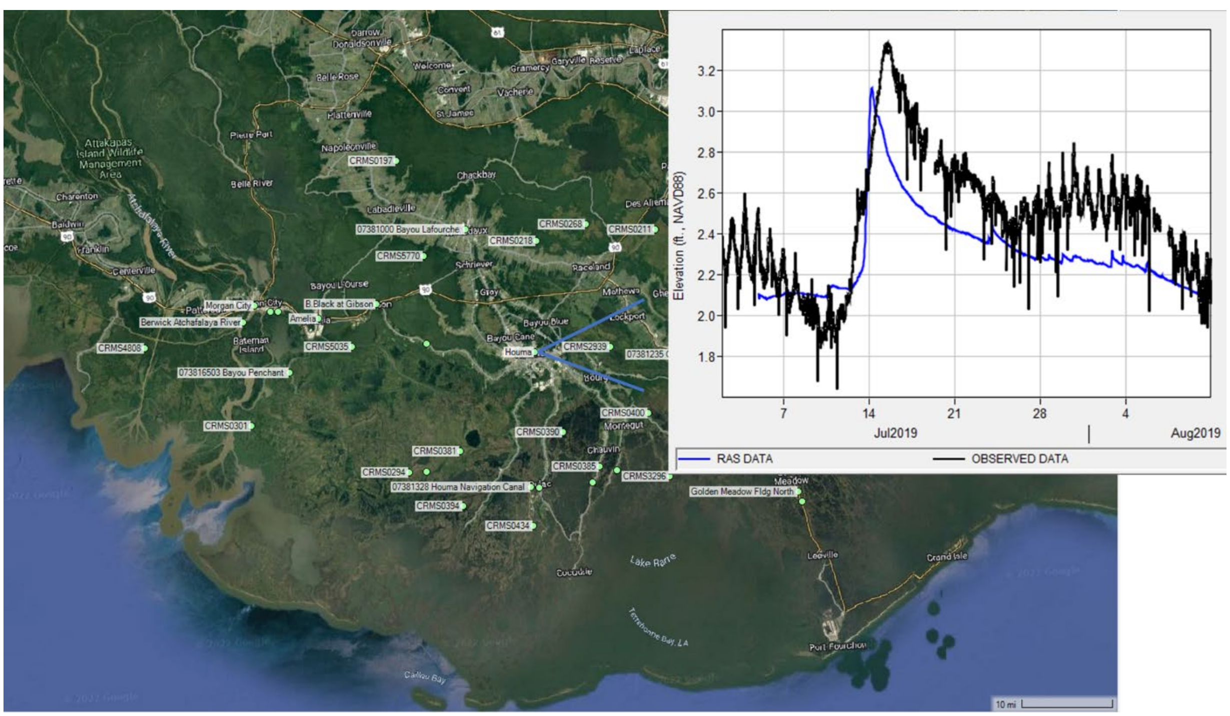

Figure 23: 2019 Calibration at USGS Gage at Houma

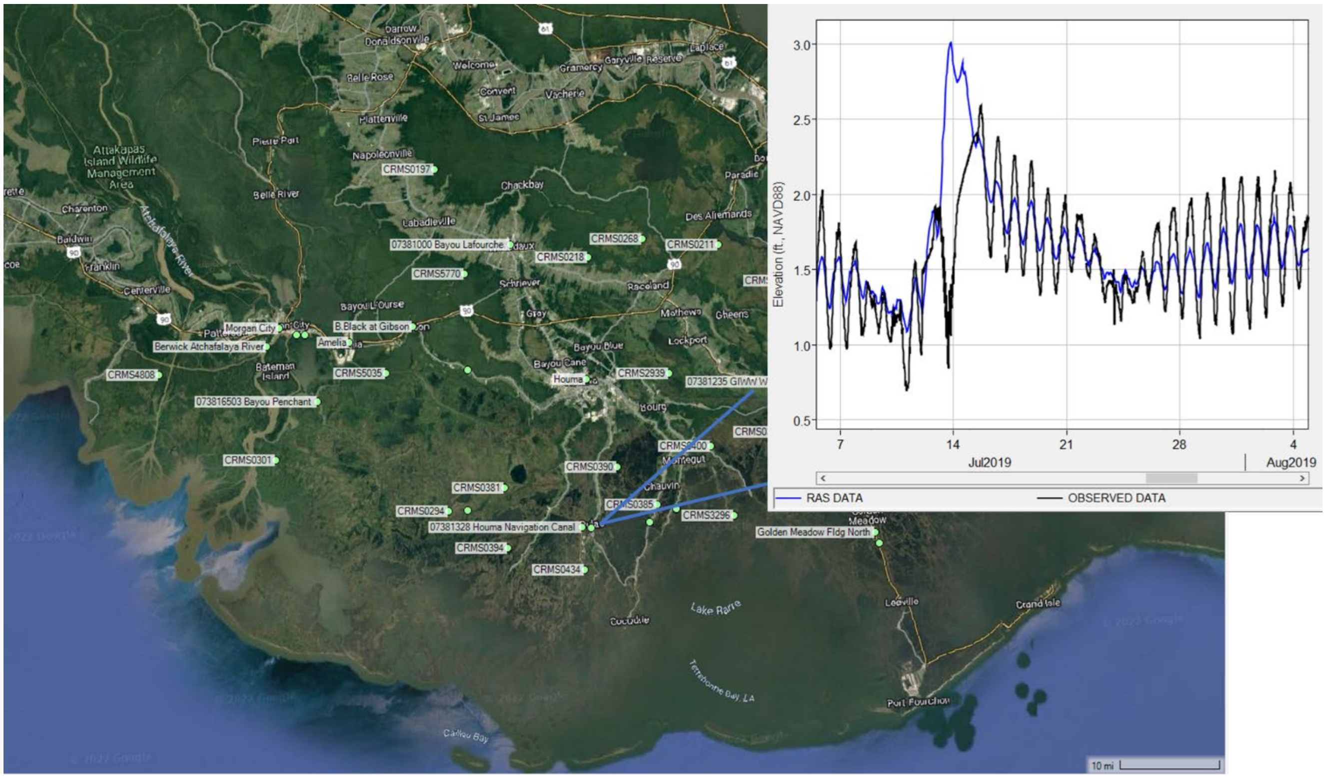

Figure 24: 2019 Calibration at USGS Gage at Houma Navigational Canal

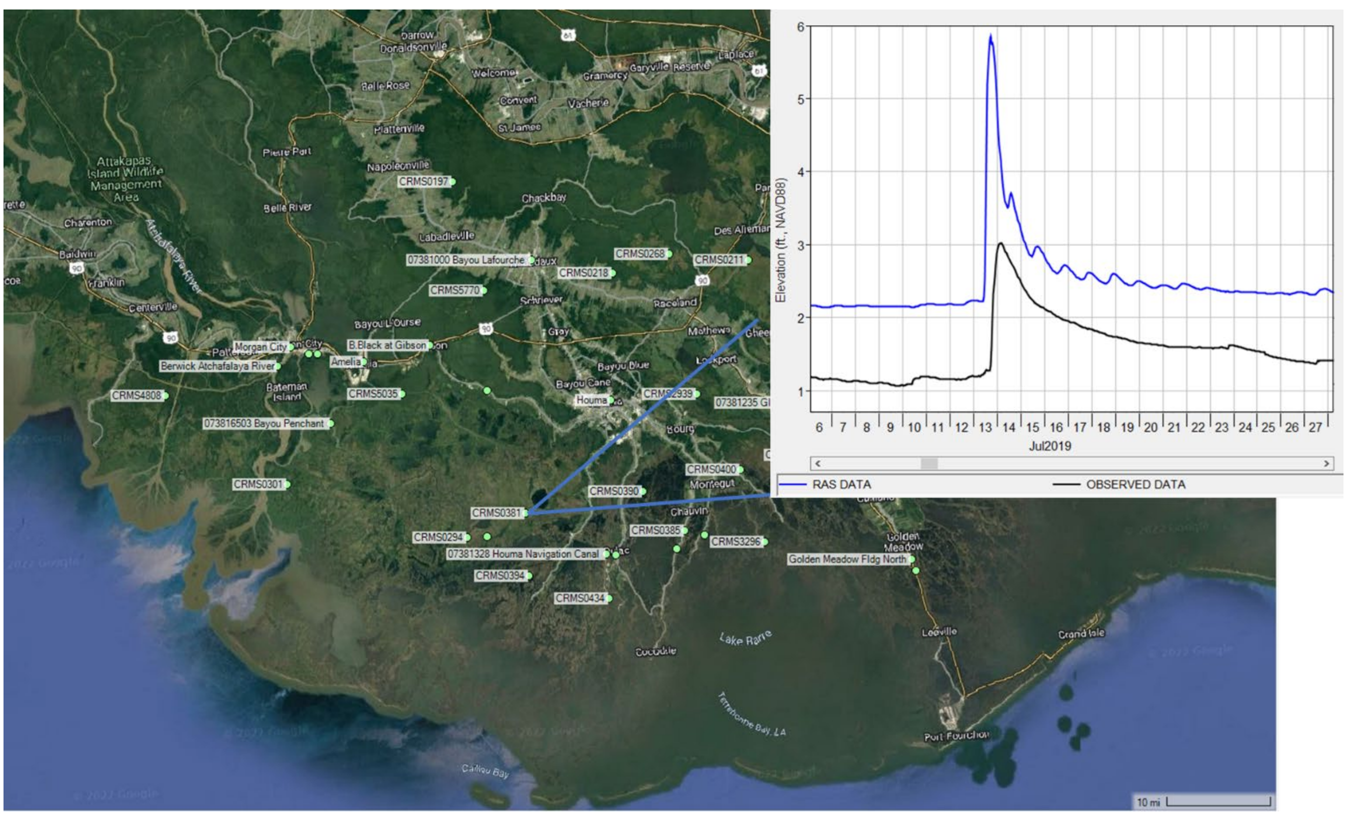

Figure 25: 2019 Calibration at CRMS Gage #0381

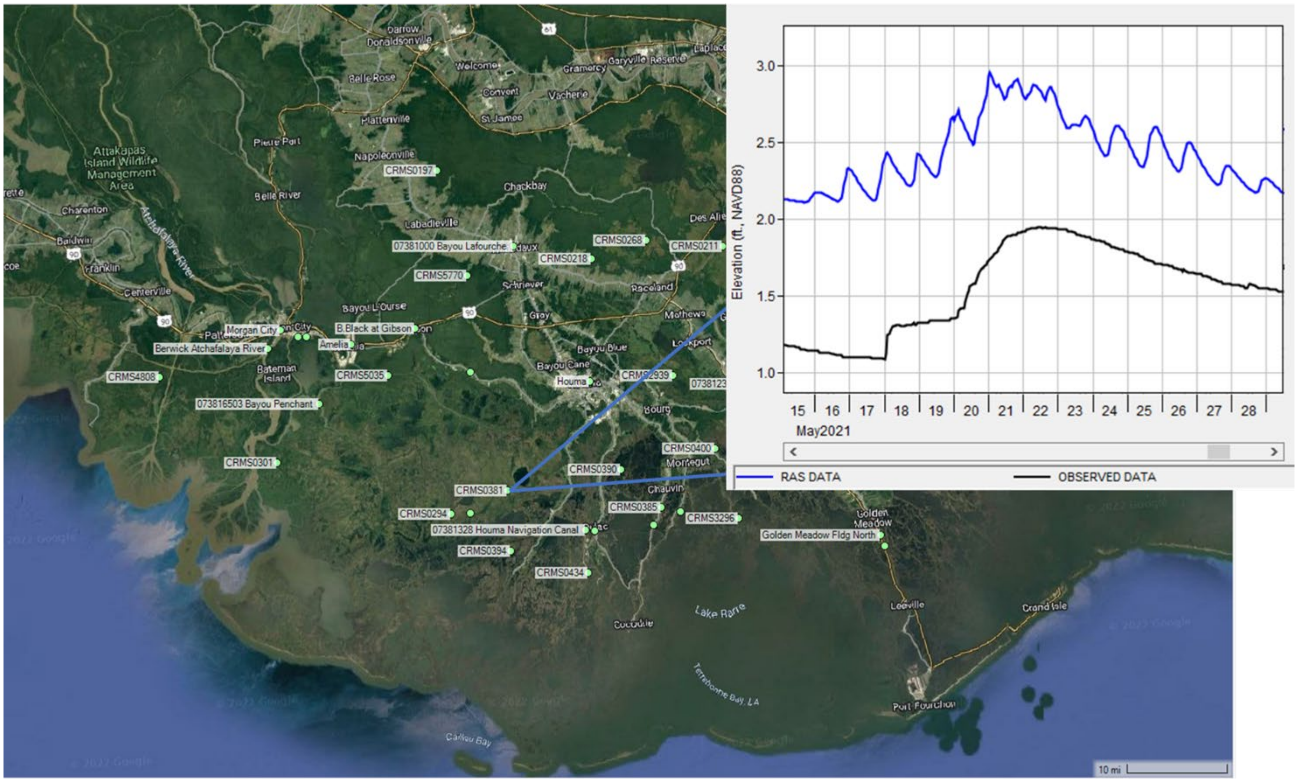

Figure 26: May 2021 Calibration at CRMS Gage #0381

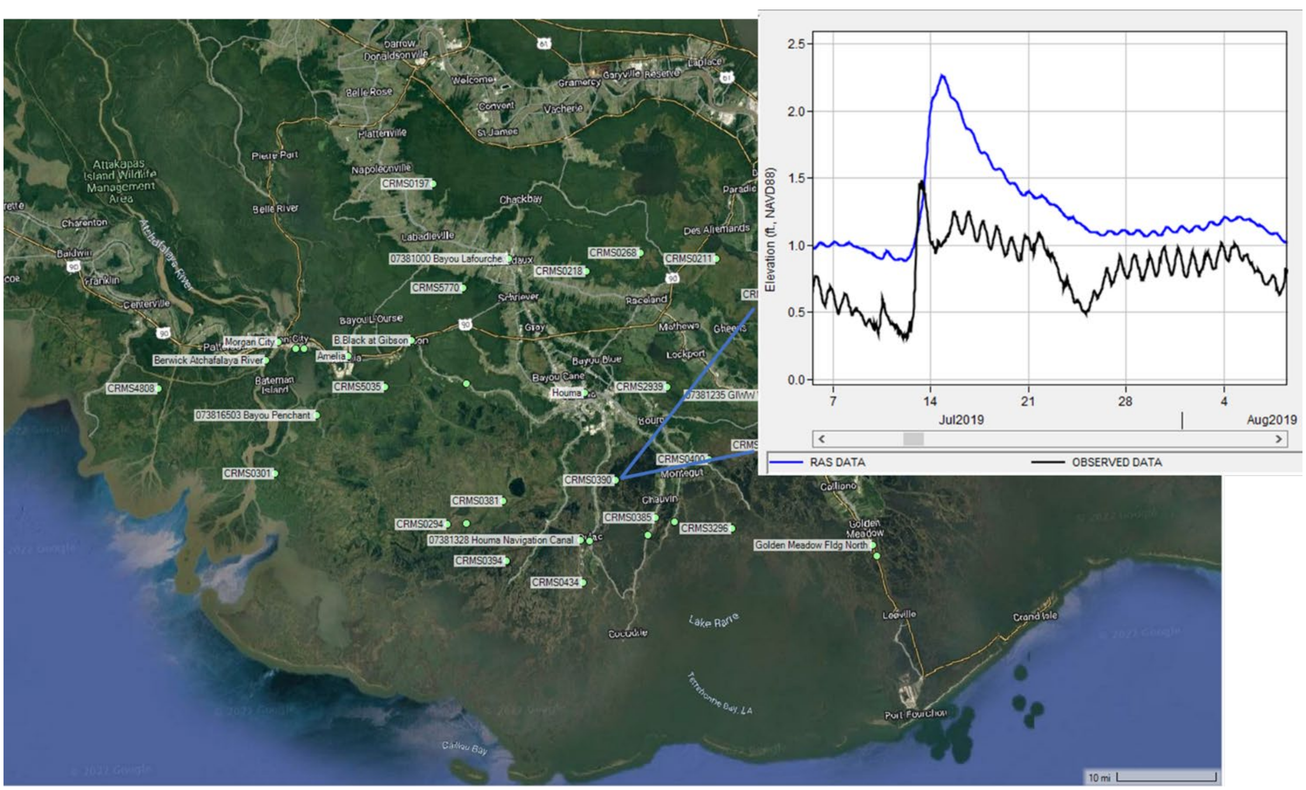

Figure 27: 2019 Calibration at CRMS Gage #0390

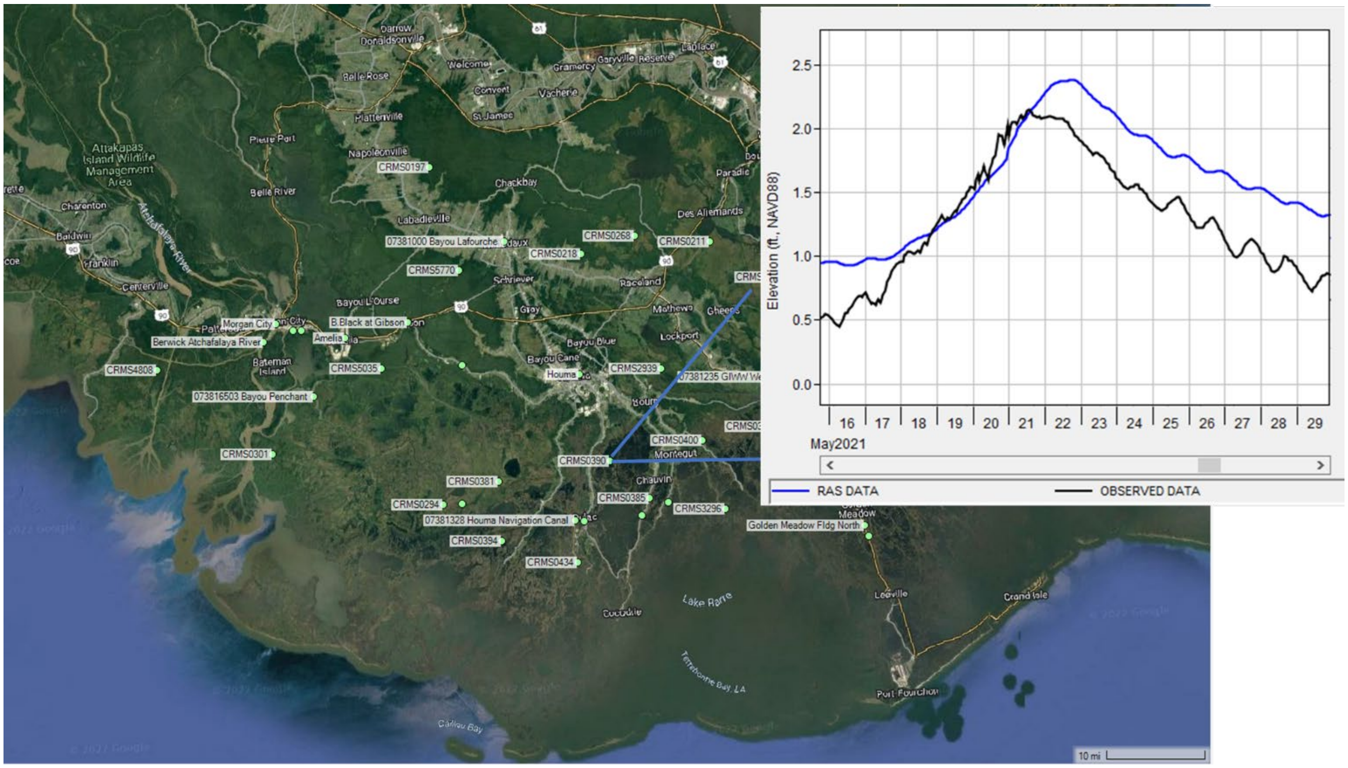

Figure 28: May 2021 Calibration at CRMS Gage #0390

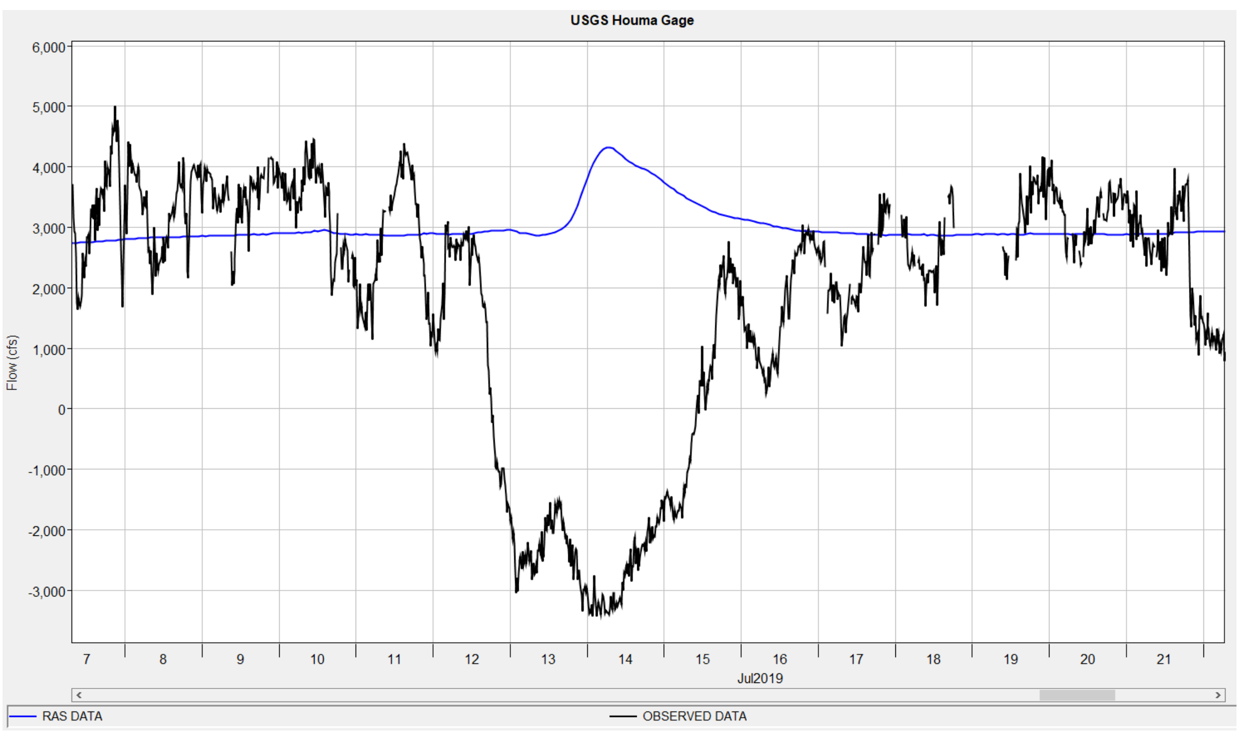

Figure 29: 2019 Calibration Comparing Flow at the USGS Houma Gage

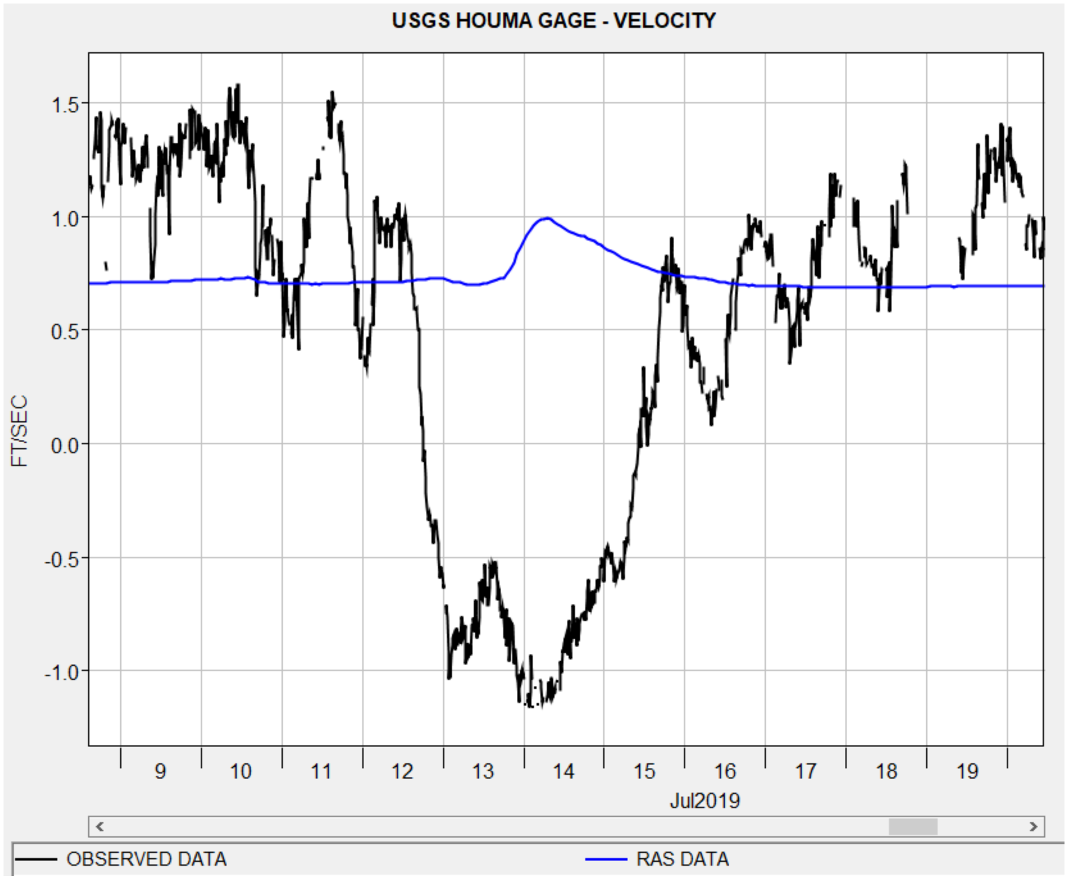

Figure 30: 2019 Calibration Comparing Velocity at the USGS Houma Gage

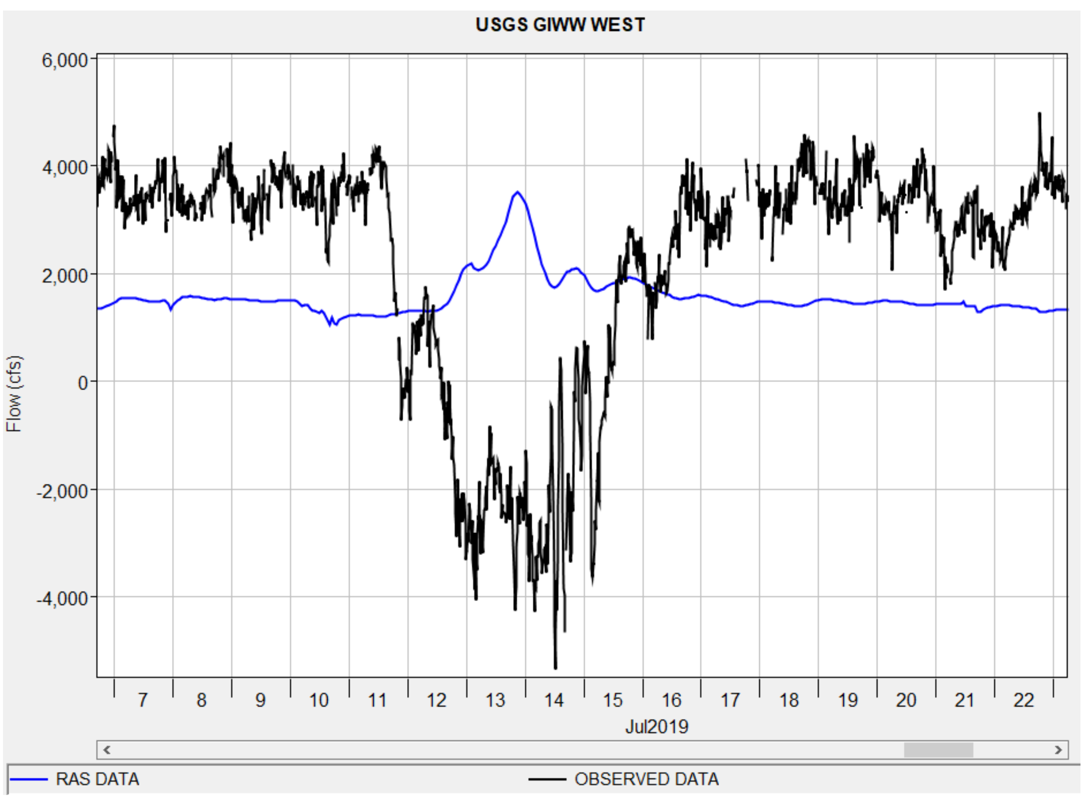

Figure 31: 2019 Calibration Comparing Flow at the USGS GIWW West Gage

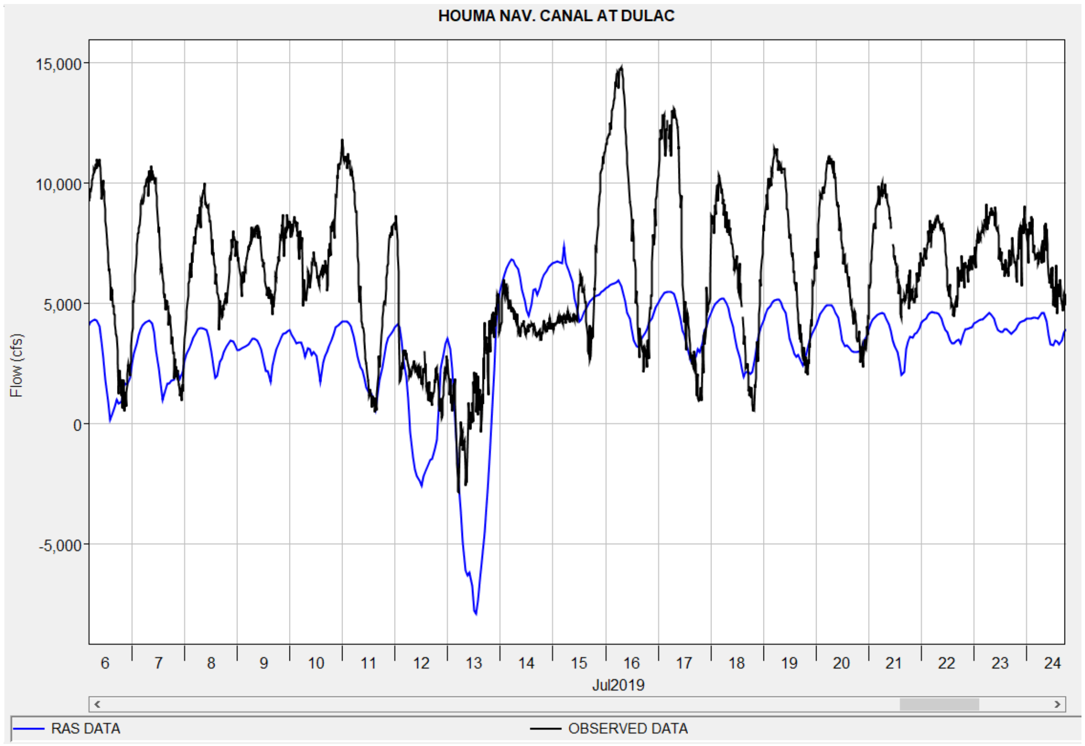

Figure 32: 2019 Calibration Comparing Flow at the USGS Houma Navigational Canal at Dulac Gage

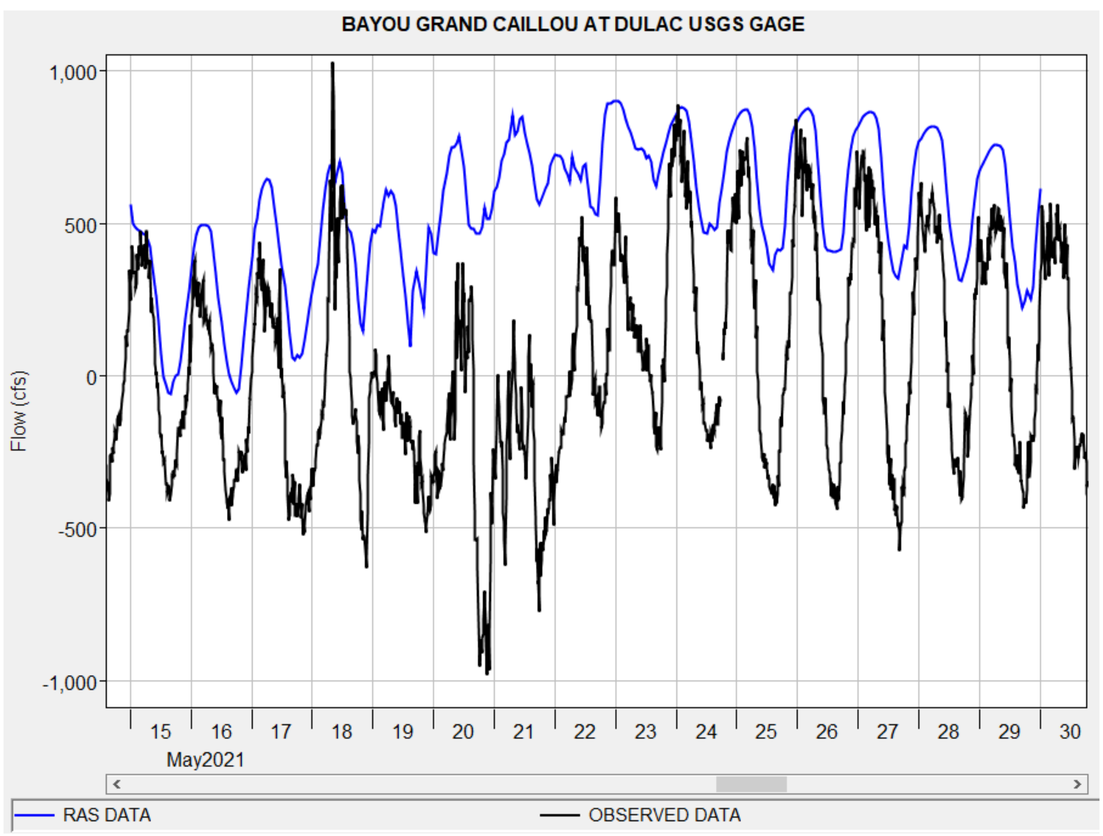

Figure 33: May 2021 Calibration Comparing Flow at the USGS Bayou Grand Caillou at Dulac Gage

Frequency Run Results:

<u>Scenarios</u>

Multiple scenarios were created and ran through the HEC-RAS model. All frequency events, for both the existing conditions and proposed conditions, were run for the year 2035. The precipitation and storm surge, and the storm surge only events were also run for the year 2085 for existing and proposed conditions. The precipitation only and lateral inflow only events were not run for the 2085 year because it was not necessary for the purpose of this model. The matrix of runs is shown in Table 4. All culverts in the model, including the environmental control structures, were modeled with flap gates which allow flow in only one direction, from inside the system to outside the system. It should be noted that the storm surge frequency data did not contain data for the 50% AEP, 20% AEP, and 4% AEP events. The 50% AEP and 20% AEP frequency events were excluded for the storm surge scenarios, and the 5% AEP was used in place of the 4% AEP. These scenarios were developed to show varying boundary conditions and the effect of the addition of proposed structures throughout the basin. The precipitation only events highlight the effects of a rainfall event over the system, and to see the efficacy of the levee system drainage structures on evacuating interior water. The precipitation and storm surge events highlight an event that would not allow the gates to be opened due to a high storm surge boundary and also receiving rainfall. The storm surge only events highlight an event with a high water surface boundary along the storm surge boundary but no rainfall occurring. Lastly, a lateral inflow event was implemented to see the effects of a high Atchafalaya River flow events on the Morganza to the Gulf study area.

Table 4: Frequency Run Scenarios

	Existing	Proposed
Precipitation Only	Gates open	
Precipitation and Storm Surge (2035 and 2085)	Gates closed	
Storm Surge Only (2035 and 2085)	Gates closed	
Lateral Inflow Only	Bayou Black, Chene, and GIWW West gates are closed; All other gates open	
Lateral Inflow Only	Bayou Black and Chene Structures are closed; All other gates open, including GIWW West	

Results

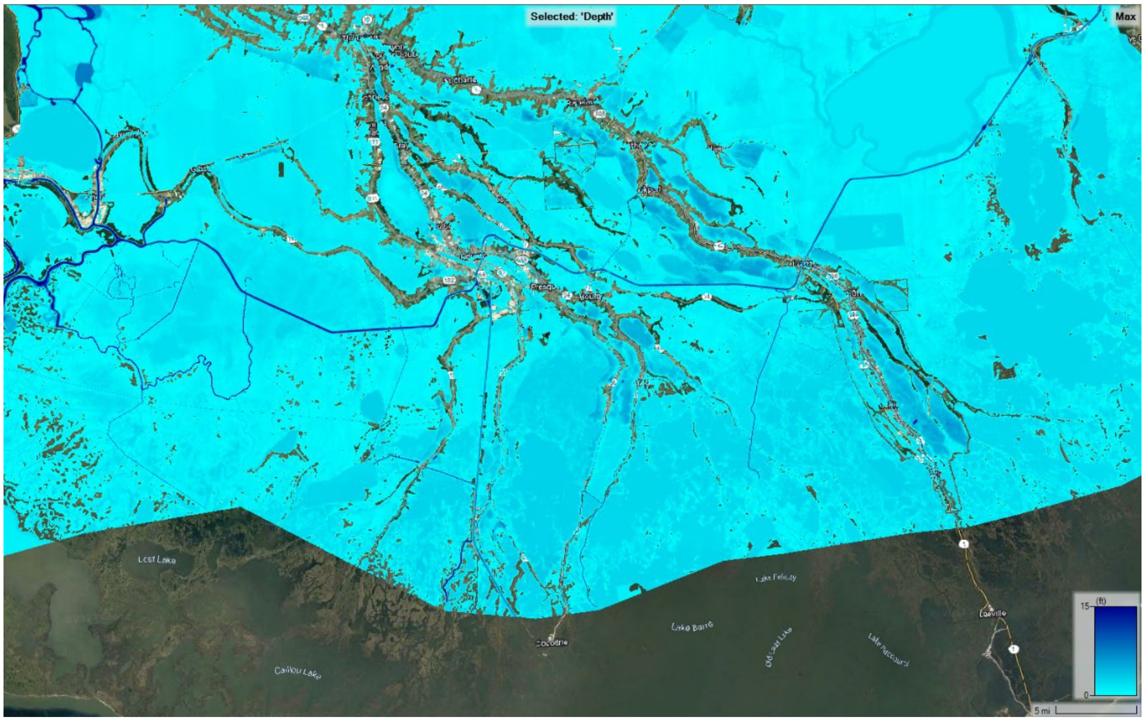

Figure 34: 1% AEP Event, Existing Conditions, Precipitation Only, 2035

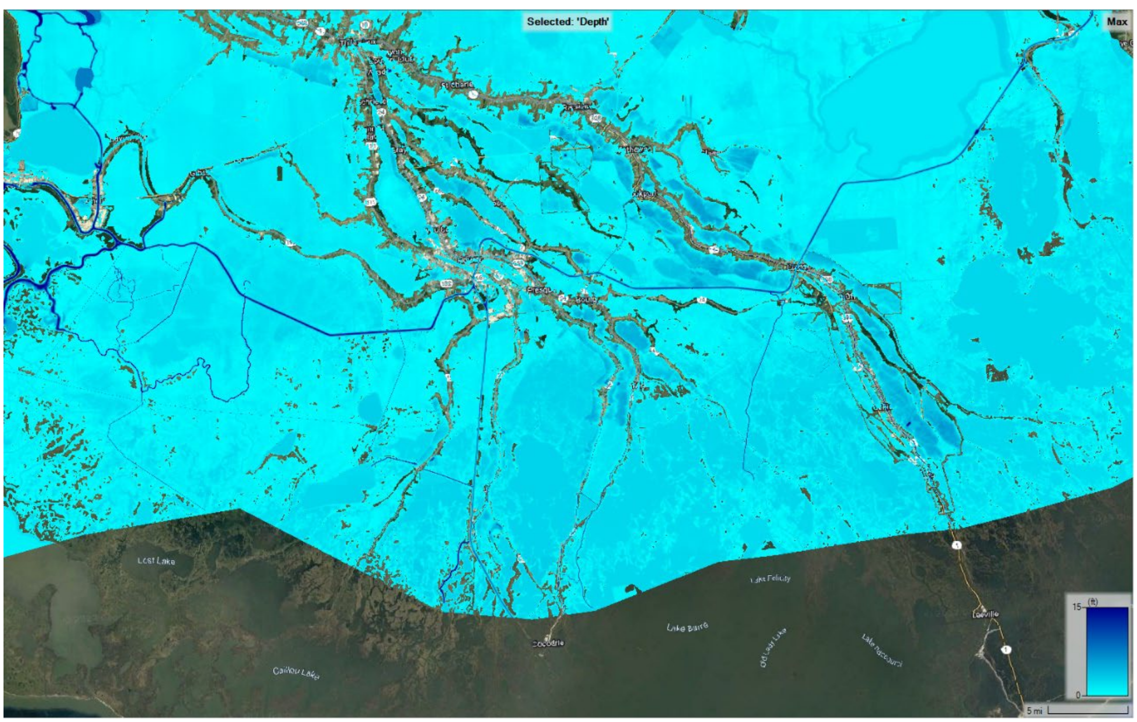

Figure 35: 1% AEP Event, Proposed Conditions, Precipitation Only, 2035

Figure 36: Difference Grid - 1% AEP Event, Existing Minus Proposed Conditions, Precipitation Only, 2035

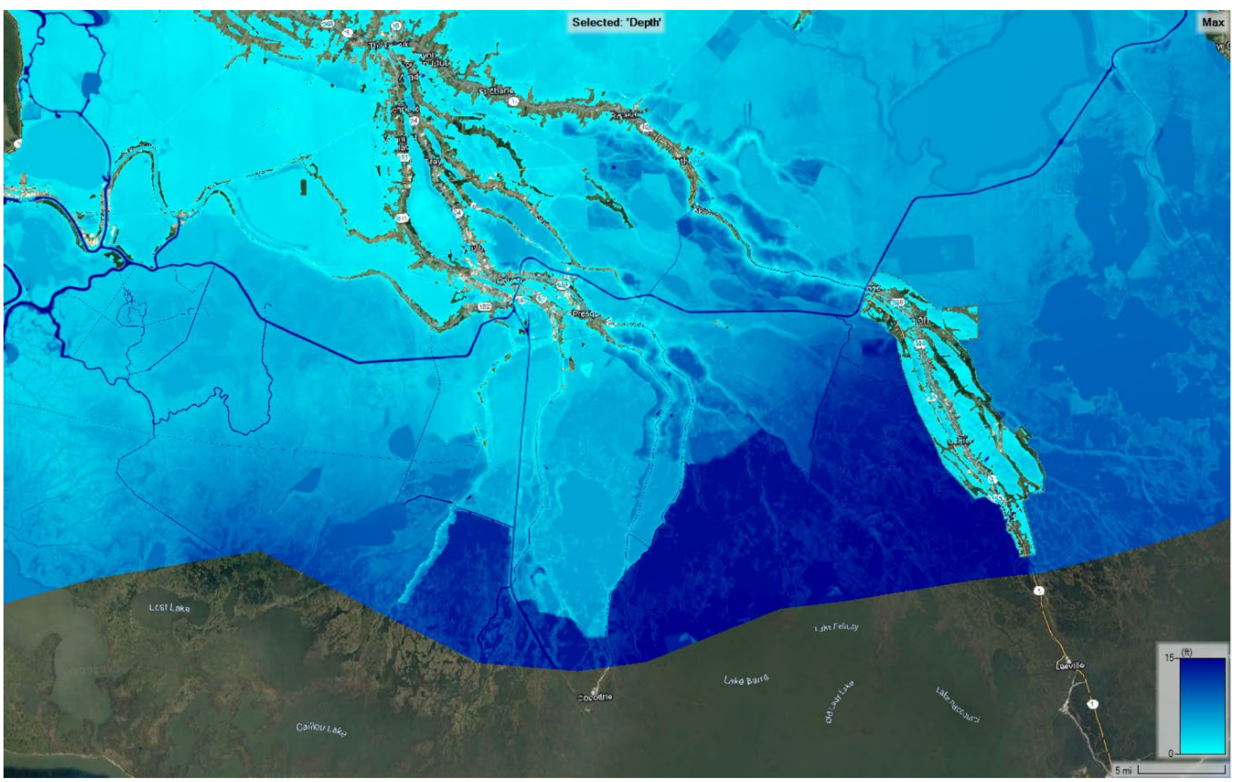

Figure 37: 1% AEP Event, Existing Conditions, Precipitation and Storm Surge, 2035

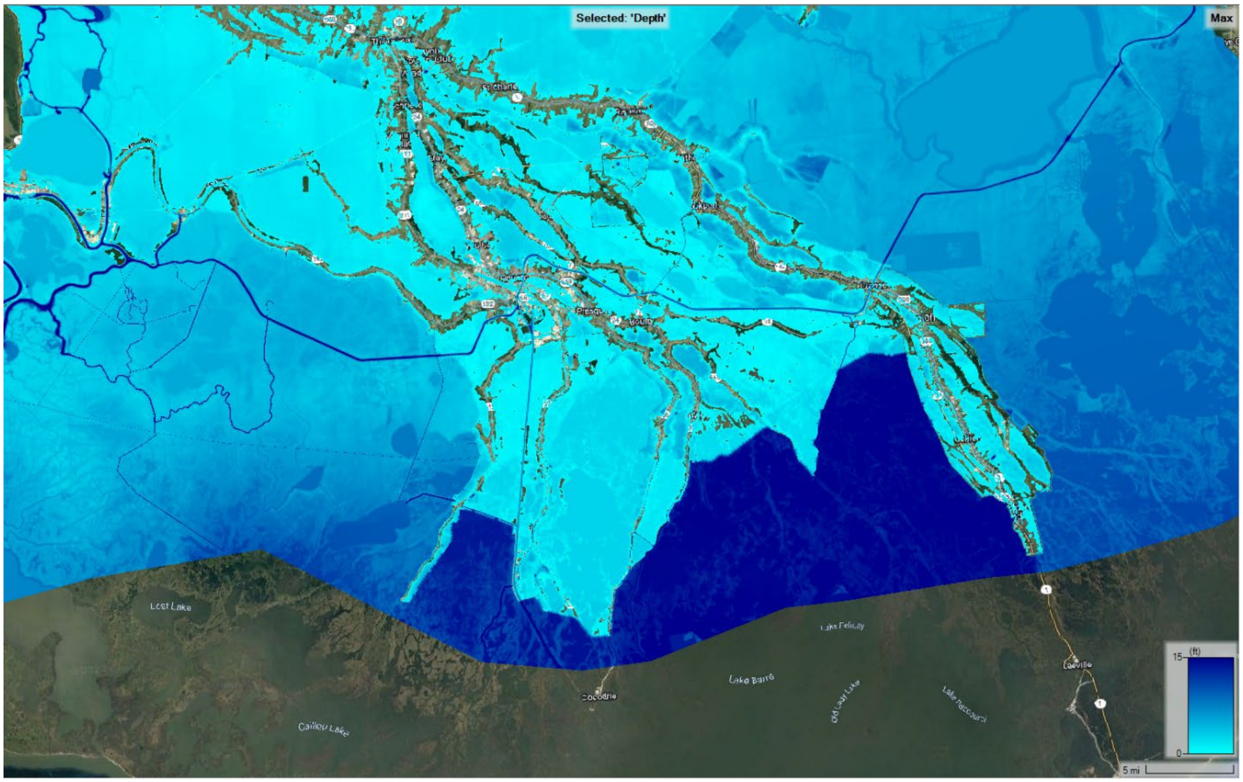

Figure 38: 1% AEP Event, Proposed Conditions, Precipitation and Storm Surge, 2035

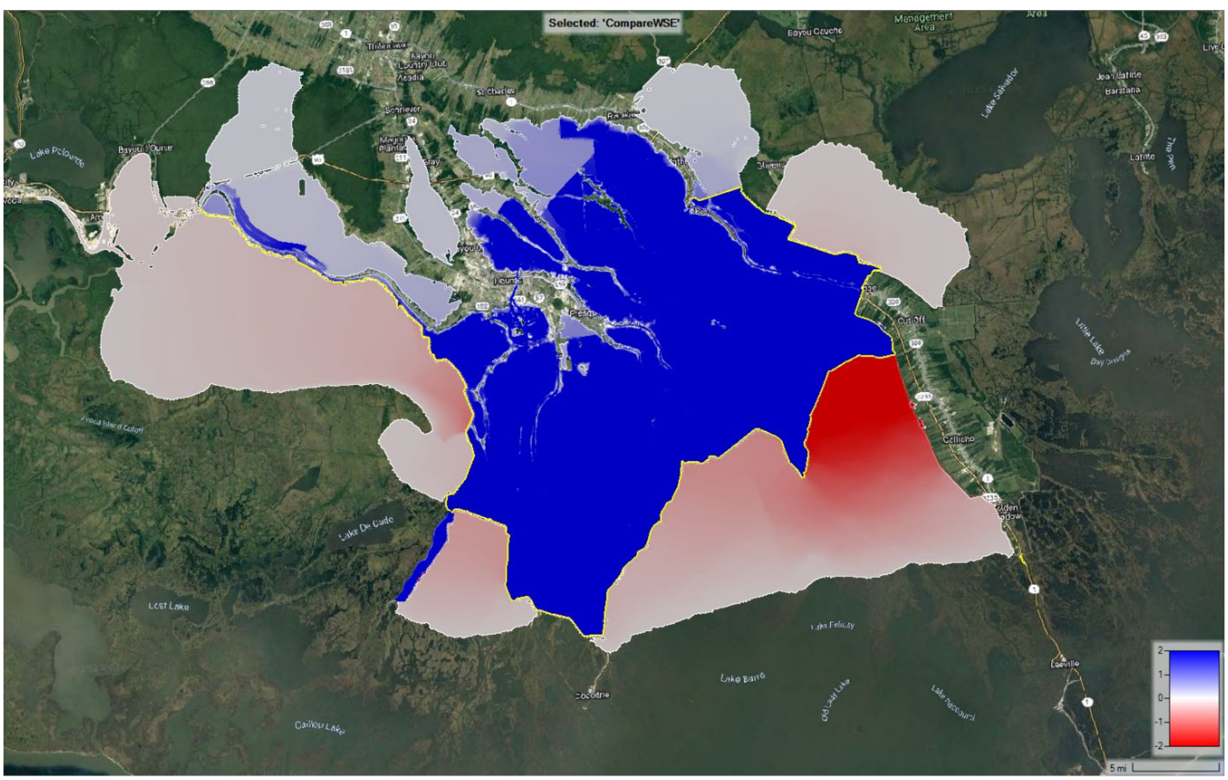

Figure 39: Difference Grid - 1% AEP Event, Existing Minus Proposed Conditions, Precipitation and Storm Surge, 2035

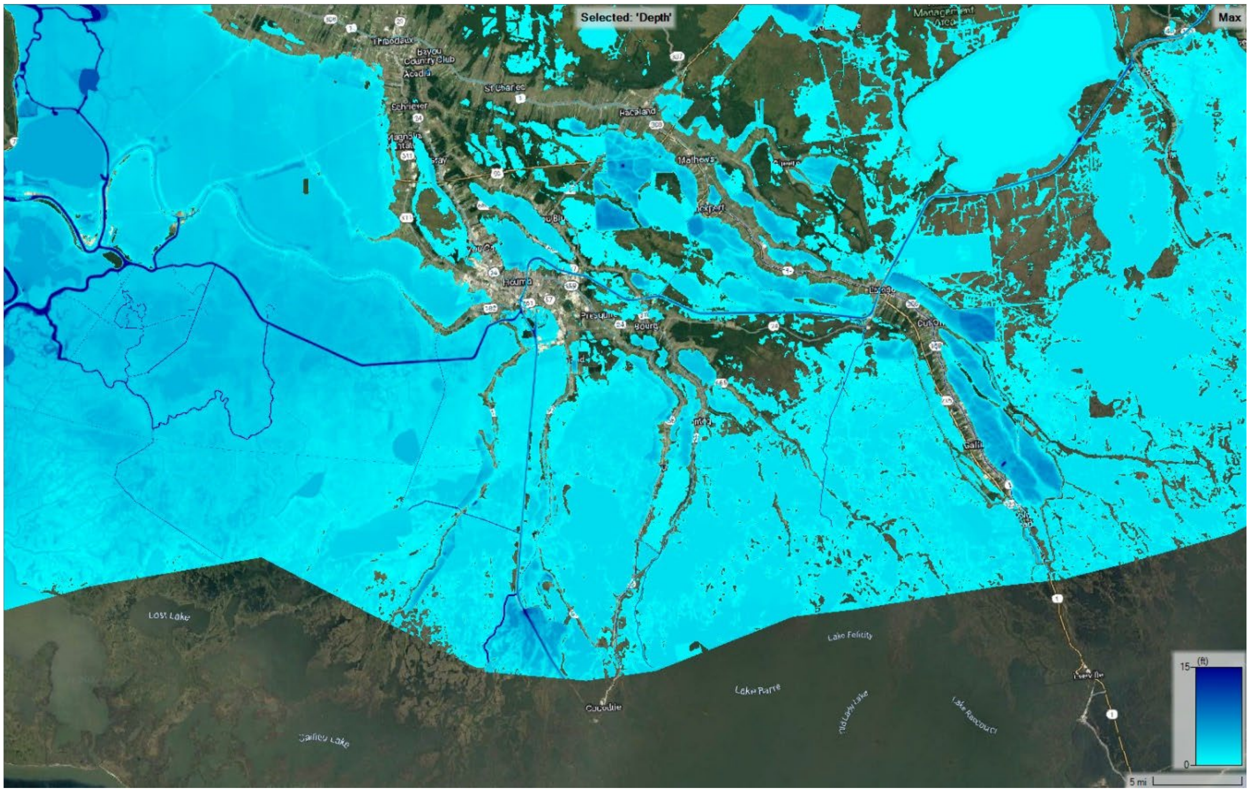

Figure 40: 1% AEP Event, Existing Conditions, Lateral Inflow Only, 2035

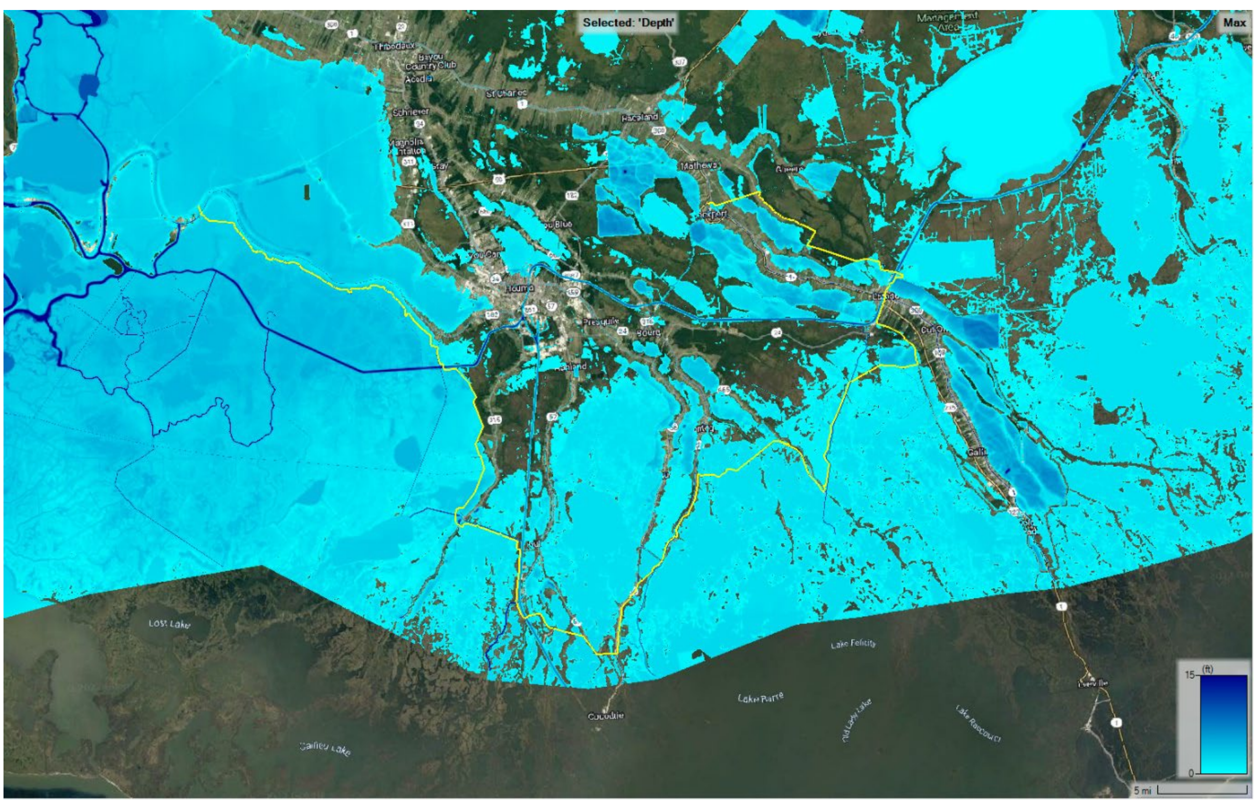

Figure 41: 1% AEP Event, Proposed Conditions, Lateral Inflow Only, GIWW West Gate Closed, 2035

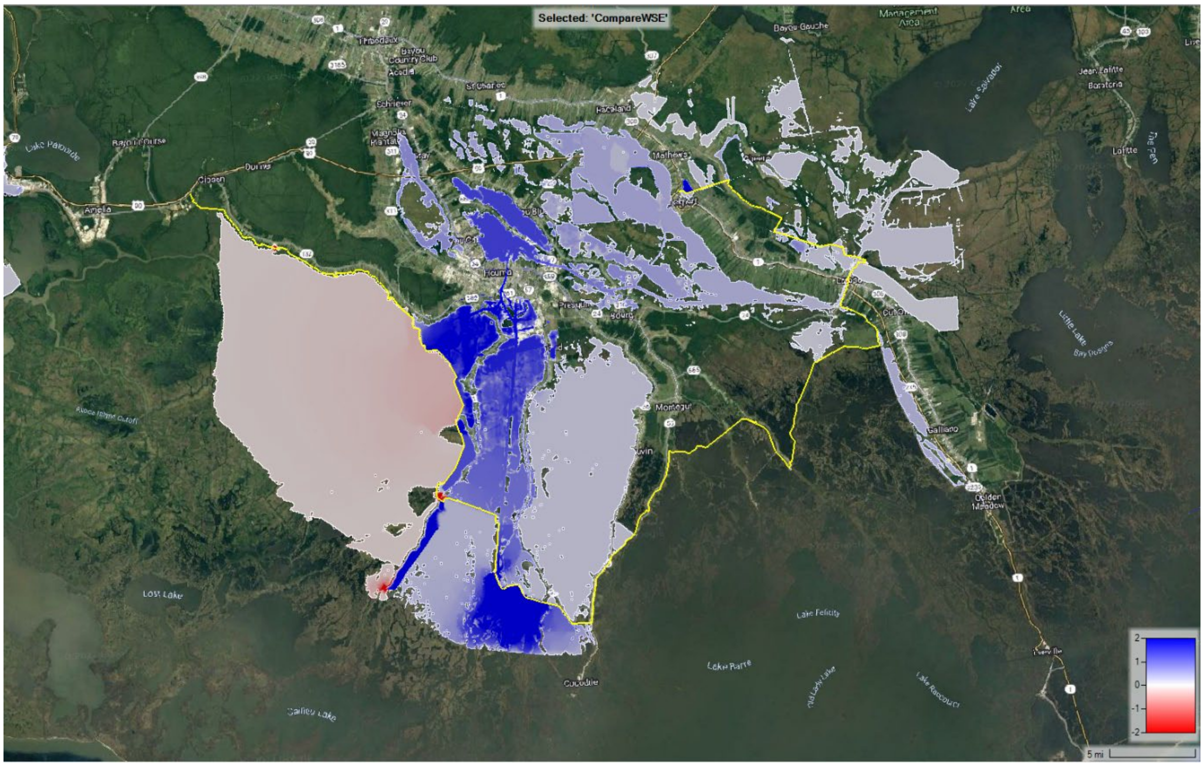

Figure 42: Difference Grid - 1% AEP Event, Existing Minus Proposed Conditions, Lateral Inflow Only, GIWW West Gate Closed, 2035

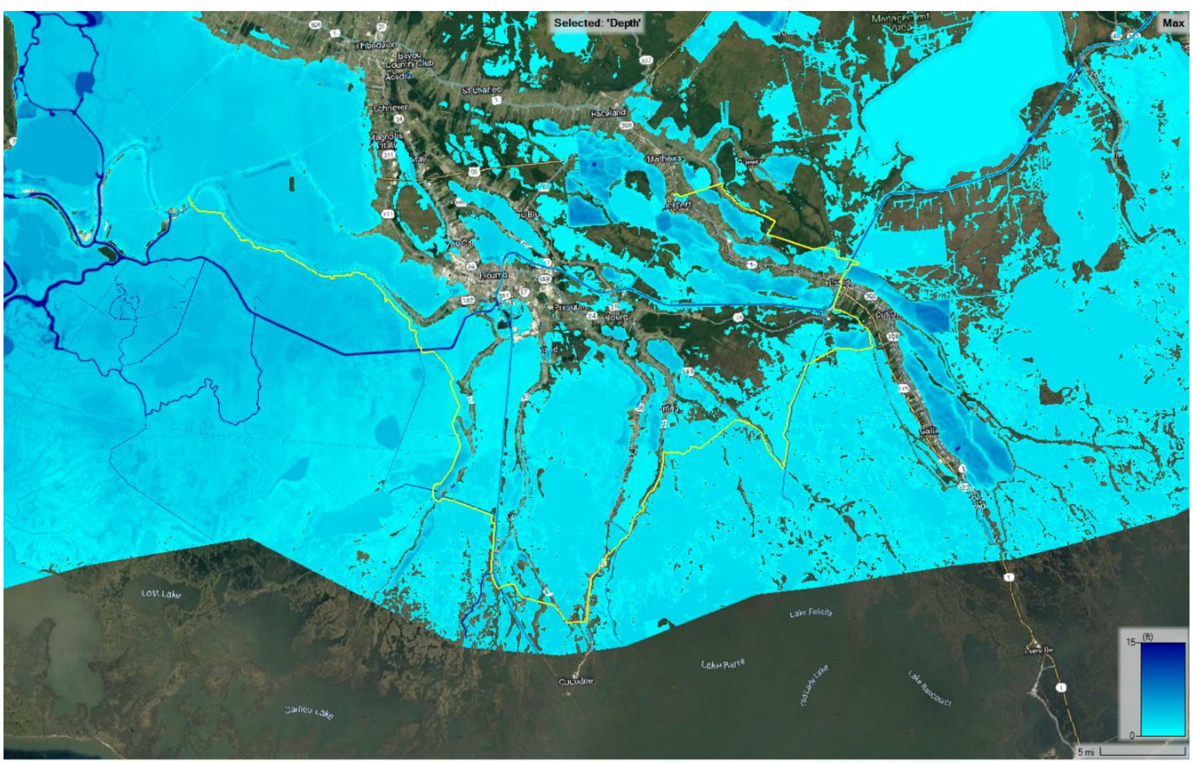

Figure 43: 1% AEP Event, Proposed Conditions, Lateral Inflow Only, GIWW West Gate Open, 2035

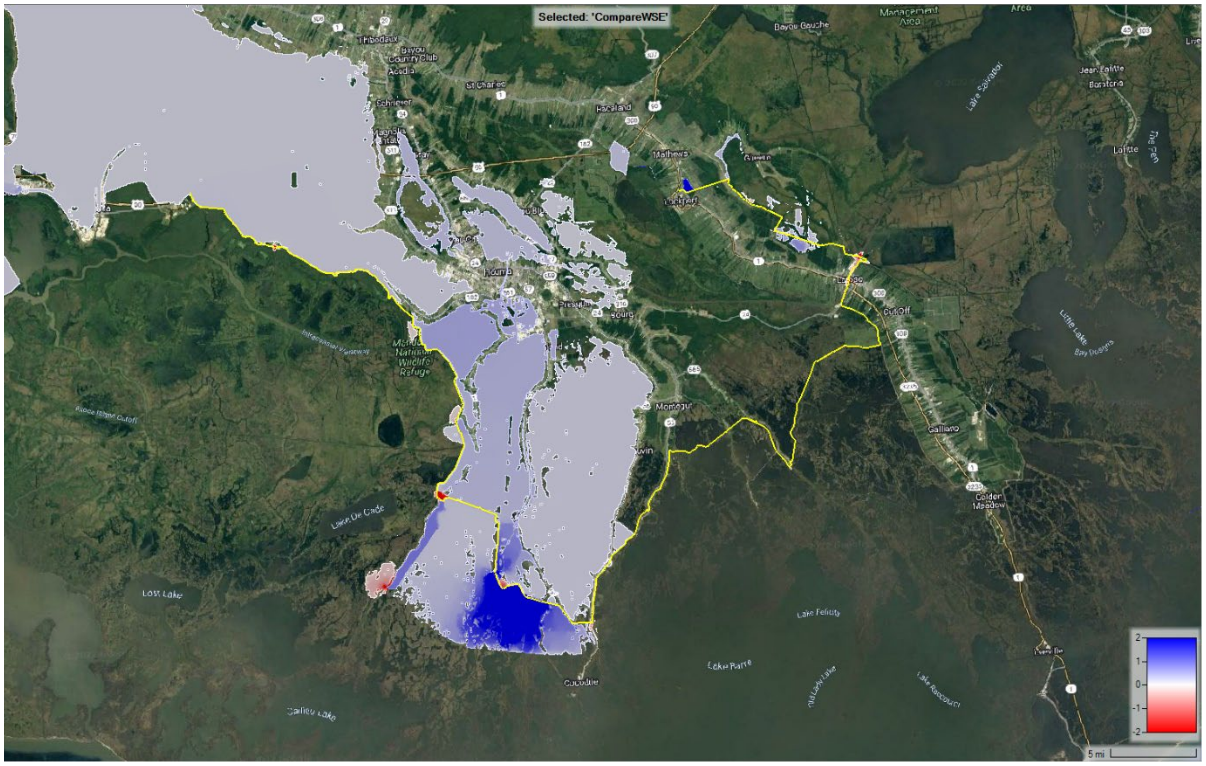

Figure 44: Difference Grid - 1% AEP Event, Existing Minus Proposed Conditions, Lateral Inflow Only, GIWW West Gate Open, 2035

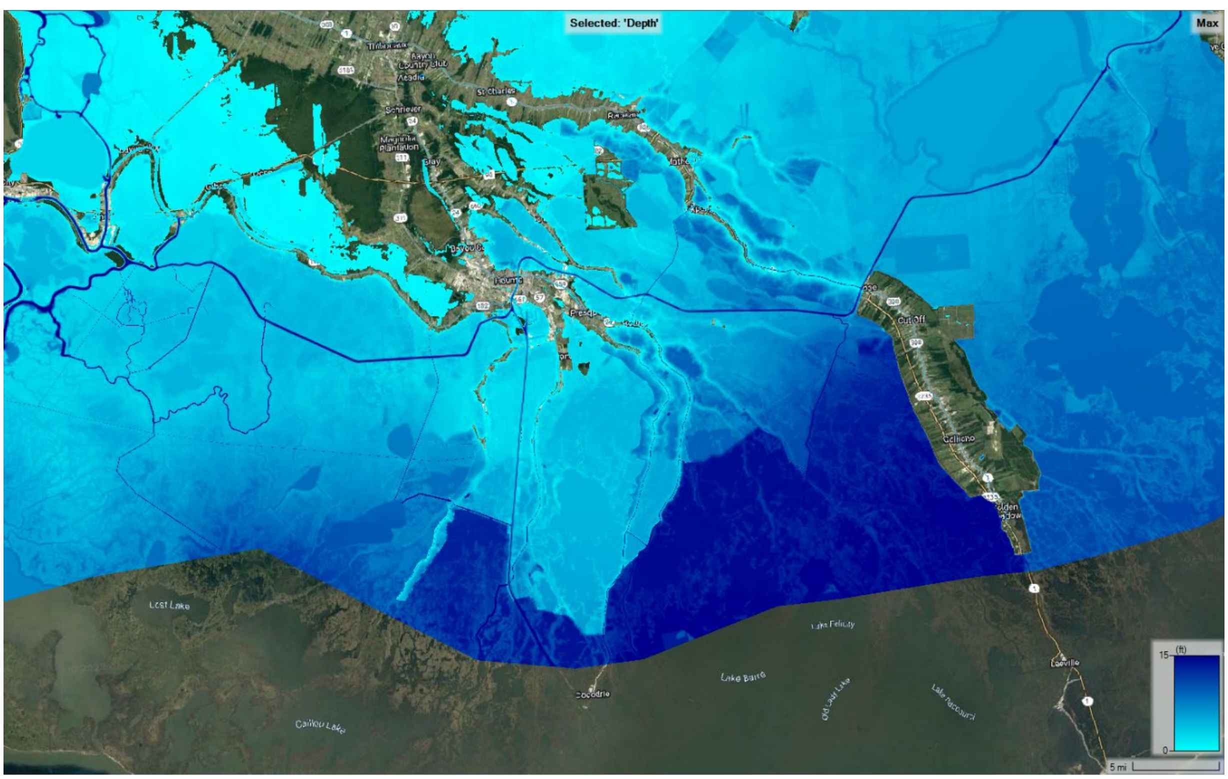

Figure 45: 1% AEP Event, Existing Conditions, Storm Surge Only, 2035

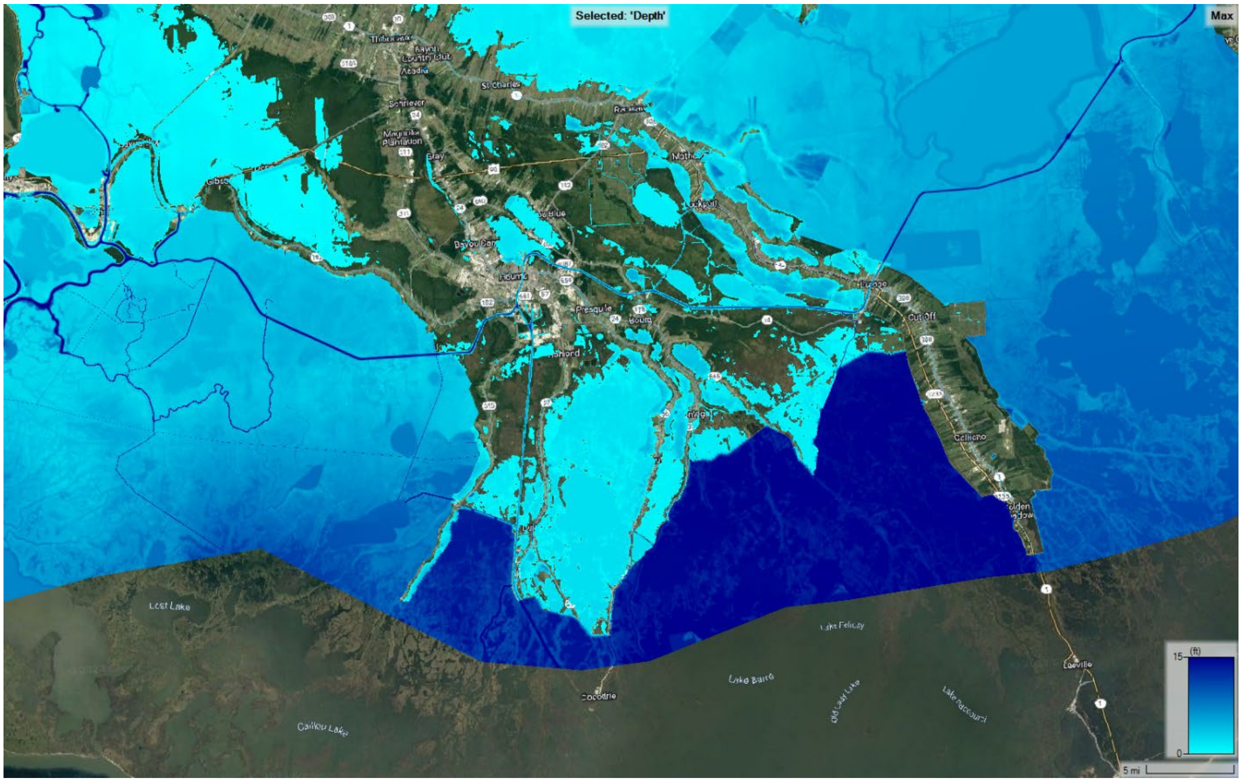

Figure 46: 1% AEP Event, Proposed Conditions, Storm Surge Only, 2035

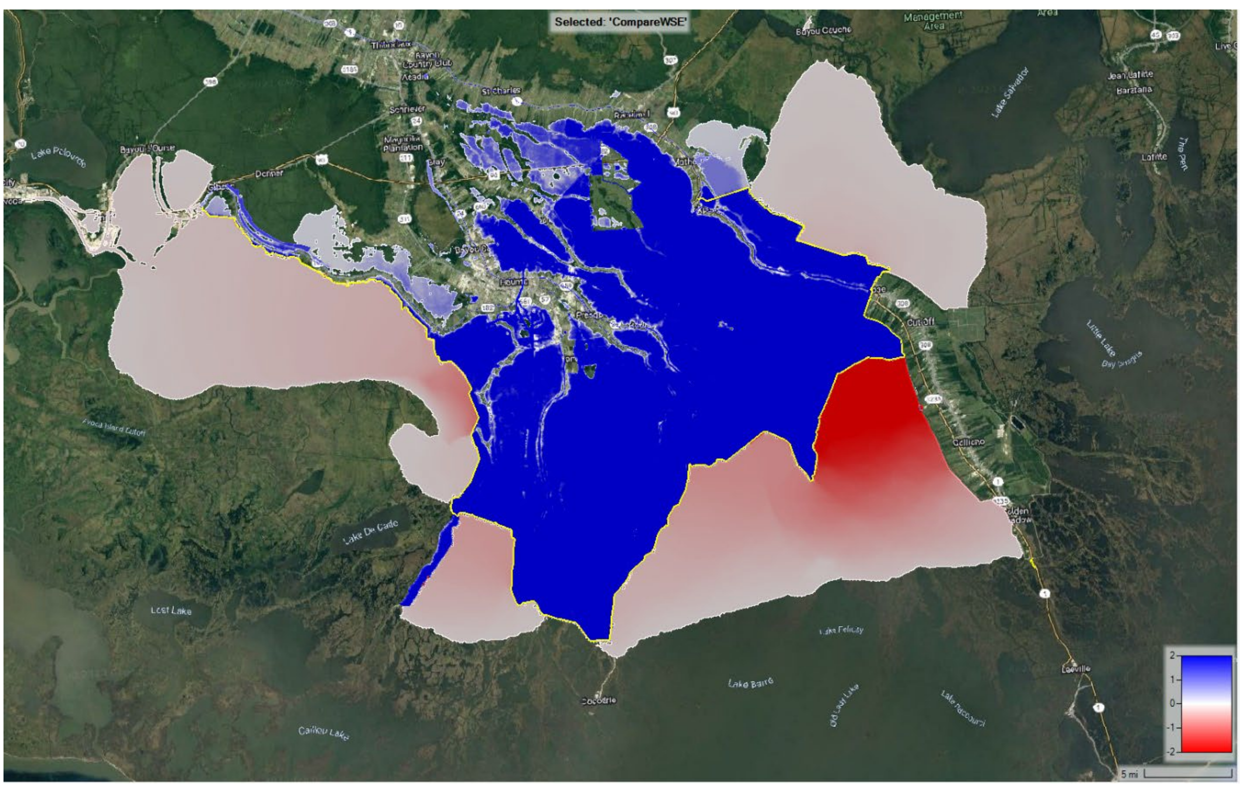

Figure 47: Difference Grid - 1% AEP Event, Existing Minus Proposed Conditions, Storm Surge Only, 2035

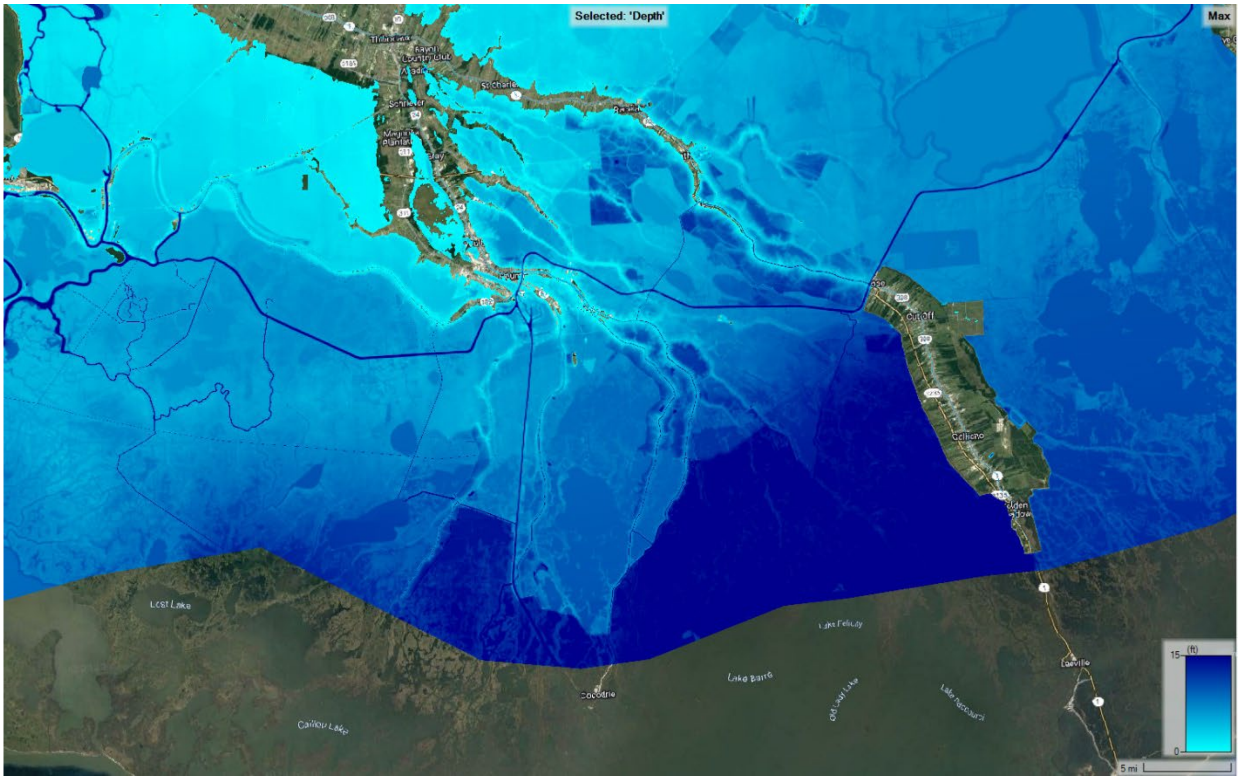

Figure 48: 1% AEP Event, Existing Conditions, Storm Surge Only, 2085

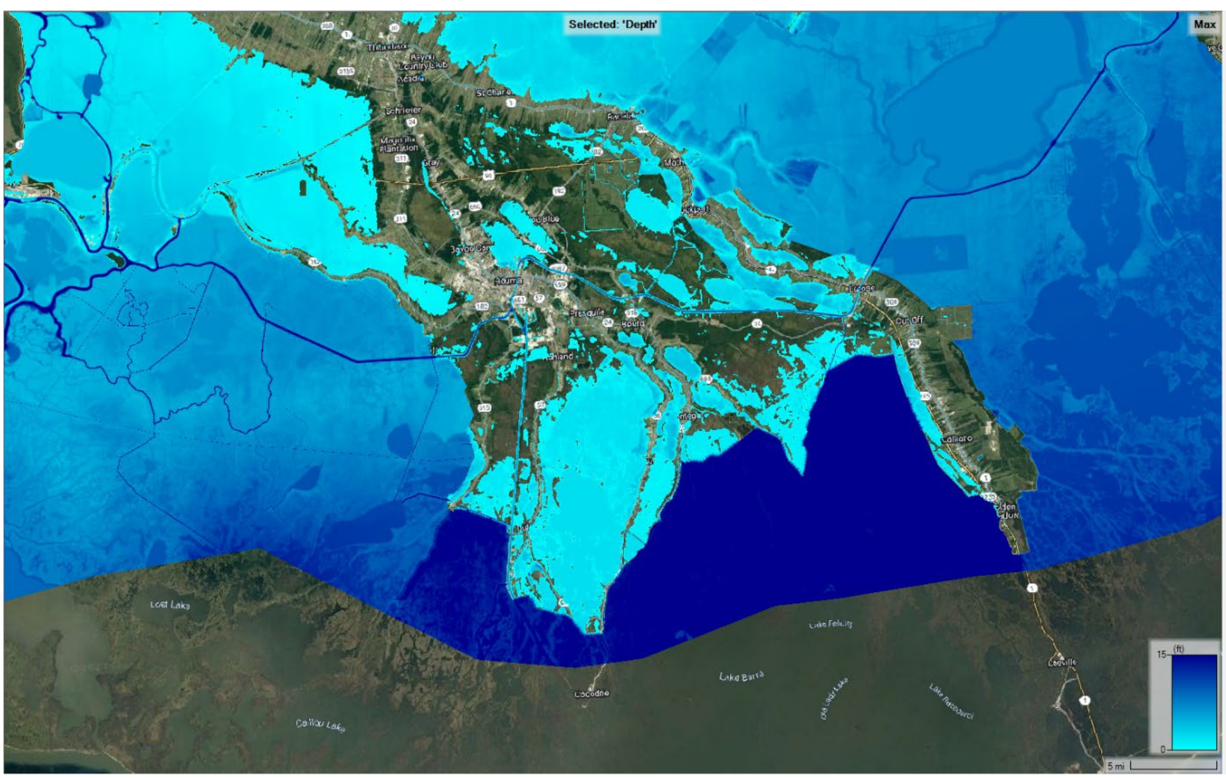

Figure 49: 1% AEP Event, Proposed Conditions, Storm Surge Only, 2085

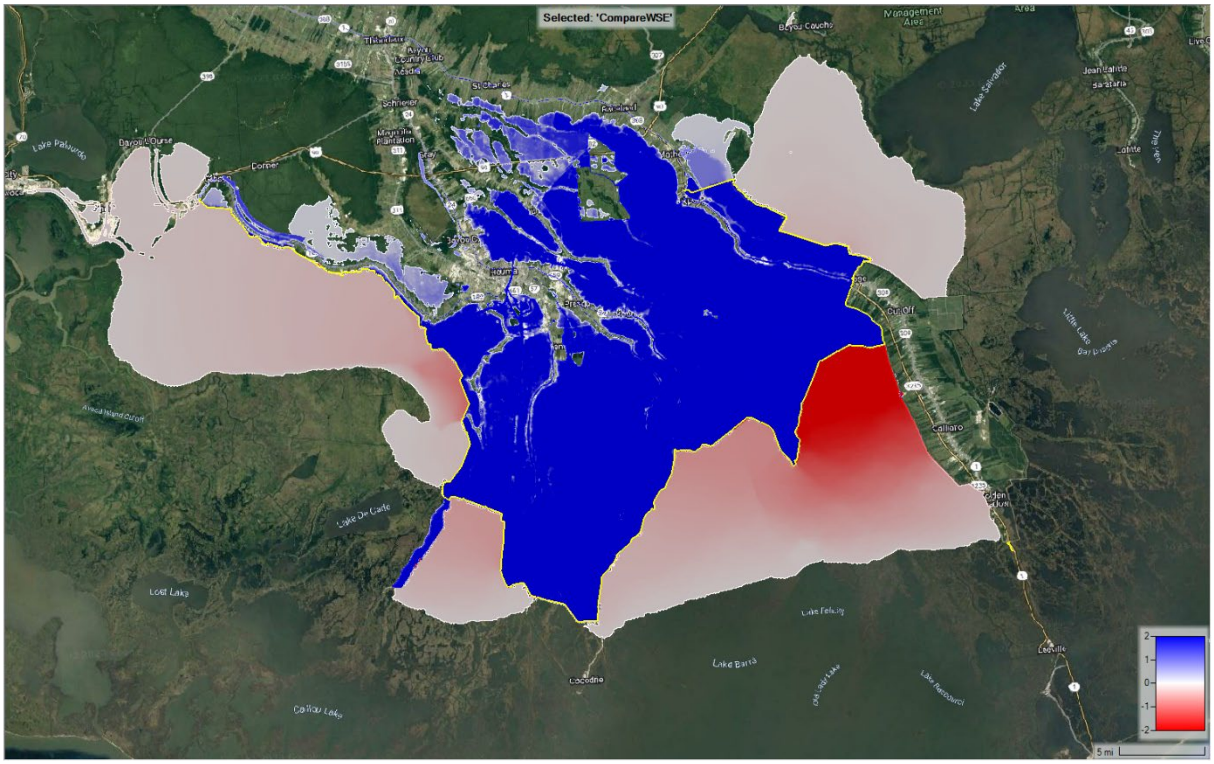

Figure 50: Difference Grid - 1% AEP Event, Existing Minus Proposed Conditions, Storm Surge Only, 2085

The frequency run results show that during high storm surge events, the interior leveed area has a large reduction in water surface elevation. This is due to the proposed levee system fully enclosing the area, not allowing storm surge to enter the system with the gates closed. For the precipitation only event, there is little to no difference between the existing conditions to proposed conditions, highlighting the efficacy of the drainage structures. More of the frequency results are displayed in Appendix C.

Reach A Alternatives

Reach A includes two alignments, the PACR alignment and the NFS alignment. The PACR report suggests the addition of the GIWW gate, the Minors Canal gate, and 6-6’x6’ box culverts with an invert of -4.5’ at a specified location. The coordinates listed in the PACR report for this environmental control structure did not align with any of the Reach A alternatives that were considered in the report, so it is unknown where the environmental control structure should be placed. As a solution, a separate analysis was performed on the Reach A alignment to determine the number and location of culverts along this Reach, and this is described in Appendix D. The number of gates, gate size, and invert depth of the gates are all greater for the manually placed gates than the environmental structures listed in the PACR report to reduce flooding along the Reach A alignment. The NFS alignment includes 10 gates that were manually added based on terrain and Google Earth imagery. The gates are 6 feet wide and 6 feet tall with an invert elevation of -4.5’. Results and an analysis comparing the PACR and NFS alignments is included in Appendix D.

Model Assumptions and Uncertainties:

The model contains sufficient terrain data throughout the basin, and bathymetry data along the larger channels such as the GIWW and Houma Navigational Canal. However, for smaller channels, especially channels near structures, channel bathymetry was estimated and incorporated into the terrain to better capture the channel bottom. For the channels that have structures in them with known invert elevations, the channel bottom was assumed to be consistent with the structure invert.

The structure sizing for the existing conditions geometry was based on information from the local sponsor. Some of this information was estimated, especially many of the culvert invert elevations. The existing and proposed pump station capacities, efficiency curves, and operations were simplified due to lack of data.

For the lateral inflow events, immediately downstream of the Calumet boundary location the water surface elevation oscillates up and down, indicating that there may be some local instability at that location. The oscillations dissipate as you get away from the boundary condition line, so for this analysis this was not looked into further, with the main focus being the volume of water exiting that river channel.

The unknowns of terrain elevation data in marshland introduces uncertainty in model calibration in these areas. Because the CRMS gages in the region are placed in marshland areas, the model calibration was only able to be emphasized in the main channels. Because of this, there is model uncertainty on how well the model replicates observed water levels outside of the main channels. Smaller channels that weren't captured by the terrain were estimated in locations shown in Figure 5. Because these channel dimensions are estimated and not measured, it allows for uncertainty in water surface elevations and channel flow results in these locations. As well, the vertical accuracy of the terrain data allows for uncertainty. The terrain cell size is 1-meter around the MTG study area, and then increases to 10-meter beyond the study area (shown in Figure 3). The 10-meter portions of the terrain data could have high levels of elevation uncertainties due to the coarseness of the survey data.

As discussed, the model contains uncertainty within the terrain data, existing structures and pump stations, and native model error. Typically, a tolerance of error is applied to HEC-RAS model results. When considering all the variables that were used in the development of the model, a model tolerance of error that should be applied to the results of this analysis should be 0.5 feet. This selected tolerance of error is consistent with tolerances that have been used in other MVN hydraulic studies that are also modeled using HEC-RAS 2D and contain terrain uncertainties due to lack of bathymetry and datum unknowns. One of the primary drivers of model result uncertainty is the surveyed terrain data. Terrain data is used in the model throughout the entire basin, and it carries a level of uncertainty that transfers over to the model and its results. Another driver for the model tolerance of error is due to the HEC-RAS modeling approach when producing a hydraulic result. HEC-RAS uses a finite difference approach to producing a solution, which is an approximation. An exact solution of the equations is not feasible for complex river systems, so HEC-RAS uses an implicit finite difference scheme. The HEC-RAS modeling approach is capable of developing a solution that is accurate but is still an approximation, especially when considering the many variables that go into developing the model.

Conclusions

With this model tolerance in mind, the model results do not show any significant increase in water surface elevation when comparing the existing condition model results to the proposed condition model results for the “1% AEP precipitation only” event. For this scenario, the results show small areas that have differences in water surface elevations between the two conditions, but the difference in water surface is less than the 0.5 ft. model tolerance and is regarded as insignificant. The conclusion for the 1% AEP precipitation scenario is then that the completion of the Morganza to the Gulf levee system and corresponding hydraulic structures will not significantly increase water surface elevations around the system for that event, when comparing the existing conditions to the proposed conditions.

For the 2035 “1% AEP storm surge only” and “1% AEP storm surge and precipitation” events, the model results show a large decrease in levee interior water levels (protected side of the levee system), and an increase in levee exterior water levels (unprotected side of the levee system), when comparing the existing conditions to the proposed conditions. The maximum increase of water surface elevation outside the levee system for this event is approximately 3.5 feet. The water surface differences occur due to the enclosing of the levee system in the proposed condition scenario, which inhibits the free flow of storm surge to enter the system; this enclosing of the levee system will then increase exterior water surface elevations due to the water stacking around the levee and being unable to freely fill the interior storage. In the existing conditions scenario, the Bayou Dularge and Larose to Golden Meadow levees do not experience any overtopping. In the proposed conditions scenario, both the Bayou Dularge and Golden Meadow levees experience overtopping for the 2035 “1% AEP storm surge only” and “1% AEP storm surge and precipitation” events. In the model, the Bayou Dularge levee is set to the design elevation of 12.0 ft. NAVD88, which is assumed to be completed by year 2035. The model results show a peak water surface elevation of approximately 11.9 ft. NAVD88 along the Bayou Dularge levee in the existing conditions scenario, and a peak of approximately 12.4 ft. NAVD88 in the proposed conditions scenario. The Larose to Golden Meadow levee system is set to the existing levee height from survey data from 2021. The lowest elevation along the West levee section of the Golden Meadow levee is approximately 13.9 ft. NAVD88. The model results show a peak water surface elevation of approximately 12.4 ft. NAVD88 at the low levee elevation location for the existing conditions scenario, and a peak of approximately 14.6 ft. NAVD88 in the proposed conditions scenario.

The 2085 “1% AEP storm surge only” and “1% AEP storm surge and precipitation” events are similar to the 2035 storm surge scenarios. The results show a large decrease in levee interior water levels, and an increase in levee exterior water levels. The maximum increase of water surface elevation outside the levee system for this event is approximately 3.5 feet.

The “1% AEP lateral inflow only” scenario was included in the model to show the possible impact of high Atchafalaya River flows on the MTG system. For the 1% AEP lateral inflow event, two scenarios were analyzed for the proposed condition. One scenario is setup with all structures within the Barrier and Reach A levee sections closed; the other scenario is setup with all structures within the Barrier and Reach A levee sections closed, except for the GIWW West structure, which is left open. The results show for the existing conditions scenario, water from the Atchafalaya River is able to find its way into the MTG system; water is able to enter the MTG system through the GIWW, west of Houma, LA. Comparing the existing conditions to the first proposed conditions scenario (all Barrier and Reach A levee gates closed), the results show a consistently higher exterior water surface elevation, and many areas on the interior of the MTG system with lower water surface elevations (shown in Figure 42). Comparing the existing conditions to the second proposed conditions scenario (all Barrier and Reach A levee gates closed, except GIWW West is open), the results show many areas on the interior of the MTG system with lower water surface elevations (shown in Figure 44). These results show that the MTG system is able to reduce the volume of water to reach the interior of the levee system during a high-flow Atchafalaya River event. The results also show that the operation of the GIWW West structure during a high-flow Atchafalaya event can affect and change the exterior and interior water surface elevations. For example, for the 1% AEP Atchafalaya flow event the model shows that a complete closure of the Barrier Reach and Reach A levee structures would result in as much as a 2.4 feet reduction in water surface elevation on the interior of the MTG levee system with a resulting ~0.3 feet increase on the exterior of the system (see Figure 42).

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Appendix A – Existing and Proposed Structure Data

Appendix A: Existing and Proposed Structure Data

Table A-1: List of Structures in the Existing Conditions Geometry

HEC_RAS Reach Name	Reach Name	Structure Name	Invert (ft)	Gate Width (ft)	Structure Type	Number	Span (ft)	Rise (ft)	Capacity (cfs)	Longitude*	Latitude*
B-Str_Section_1	B	Falgout Canal Floodgate	-10	180						-90.789	29.4158
B_Section_1	B	Local Pump 1							36	-90.7636	29.462
B_Section_1	B	Marmande Canal Floodgate	-4	30						-90.7622	29.4612
B_Section_2	B	Local Pump 2							180	-90.7842	29.4174
Barrier_1	Barrier		2.2		Circular	4	4			-90.9952	29.6629
Barrier_1	Barrier		2.2		Circular	3	4			-90.988	29.6618
Barrier_1	Barrier		2.2		Circular	1	4			-90.982	29.661
Barrier_1	Barrier		2.2		Circular	1	4			-90.9794	29.6602
Barrier_1	Barrier		2.2		Circular	1	3			-90.9667	29.6434
Barrier_1	Barrier		2.2		Circular	1	3			-90.9639	29.6396
Barrier_2	Barrier	Elliot Jones Pump Station							1000	-90.9207	29.6239
Barrier_2	Barrier	Bayou Black Pump Station							330	-90.904	29.6134
Barrier_2	Barrier	Hanson Canal Pump Station							1000	-90.8604	29.6028
Bayou_Black Gate	Barrier	Black Bayou Floodgate	-6	56						-91.0089	29.6711
E1_Section_1	E1		-4		Box	6	6	6		-90.7485	29.3982
E2_Section_1	E2		-8		Circular	2	4			-90.7835	29.4051
E2_Section_1	E2		-4		Box	6	6	6		-90.7696	29.406
F1_Section_1	F1	Bayou Grand Caillou Floodgate	-12	196						-90.7376	29.3425
F1_Section_2	F1	HNC Lock Complex	-24	250						-90.7299	29.3296
G2_Section_2	G2		-6		Circular	8	6			-90.6958	29.3166
G2_Section_2.5	G2		-6		Circular	6	6			-90.6938	29.3161
G2_Section_3	G2		-6		Circular	6	6			-90.6847	29.3137
Larose_Floodgate	GIWW	Larose Floodgate	-12	56						-90.3816	29.5711
H1_Section_2	H1		-6		Circular	4	6			-90.6542	29.2965
H1_Section_3	H1	Bayou Petit Caillou Floodgate	-6		Circular	4	6			-90.6485	29.2965
H1_Section_3	H1	Bayou Petit Caillou Floodgate	-10	110						-90.6485	29.2965
H2_Section_2	H2	Placid Canal Floodgate	-8	30						-90.6321	29.3415
I1_Section_1	I1	Bush Canal Floodgate	-8	56						-90.6022	29.3687
I2_Section_2	I2	Madison Nett Pump Station							220	-90.5749	29.4056
I2_Section_2	I2	Bayou Terrebonne Floodgate	-10	56						-90.5881	29.3881
I3_Section_1	I3	Humble Canal Floodgate	-6	56						-90.5636	29.4372
J2_Section_2	J2		-6		Box	18	5	10		-90.5394	29.4366
J2_Section_3	J2		-6		Box	10	5	10		-90.5142	29.447
J2_Section_4	J2		-6		Circular	6	6			-90.4971	29.4573
J3_Section_2	J3	Pointe Aux C Pump Station							100	-90.4541	29.4249
J3_Section_2	J3		-4		Circular	1	2			-90.4495	29.4177
J3_Section_2	J3	Bayou Pointe Aux Chenes Floodgate	-4		Circular	3	3			-90.4482	29.4183
J3_Section_2	J3	Bayou Pointe Aux Chenes Floodgate	-8	56						-90.4482	29.4183
K_Section_2	K		-2		Circular	5	4			-90.4462	29.4461
K_Section_3	K		-4		Circular	5	4			-90.4366	29.4723
L_Section_1	L	Grand Bayou Floodgate	-6.5		Circular	4	6			-90.4183	29.5048
L_Section_1	L	Grand Bayou Floodgate	-11	136						-90.4183	29.5048
A_1			3		Circular	1	3			-90.8136	29.5635
A_1			3		Circular	3	4			-90.8109	29.556
Chene_Structure		Bayou Chene Floodgate	-26.9	250						-91.0928	29.6227
Connection 22		Leon Theriot Lock	-15	56						-90.246	29.3429
Dularge_West		Lower Dularge Floodgate	-8	56						-90.8431	29.3359
Geraldine_Rd			3		Circular	1	4			-91.0062	29.6667
North Bayou Blac			3.8		Circular	2	3			-91.0118	29.6757
North Bayou Blac			3.8		Circular	2	3			-91.0105	29.6734

Notes: Blue highlight indicates gates that have culverts incorporated into them.
*XY Points are projected in WGS 1984

Table A-2: List of Structures in the Proposed Conditions Geometry

HEC_RAS Reach Name	Reach Name	Structure Name	Invert (ft)	Gate Width (ft)	Structure Type	Number	Span (ft)	Rise (ft)	Capacity (cfs)	Longitude*	Latitude *
A_North_2	A-North of GIWW		-4.5		Box	1	6	6		-90.8078	29.5643
A_North_2	A-North of GIWW		-4.5		Box	1	6	6		-90.8037	29.5532
A_North_2	A-North of GIWW		-4.5		CMP	1	48" D			-90.8003	29.5521
A_North_2	A-South of GIWW	Minors Canal Floodgate	-9	56						-90.7977	29.5512
A_North_3	A-South of GIWW		-4.5		Box	1	6	6		-90.7968	29.5500
A_South_1	A-South of GIWW		-6	56						-90.7851	29.5324
A_South_1	A-South of GIWW		-4.5		Box	2	6	6		-90.7732	29.5239
A_South_1	A-South of GIWW		-2		Box	2	6	6		-90.7677	29.5153
A_South_1	A-South of GIWW		-2		Box	1	6	6		-90.7684	29.5104
A_South_1	A-South of GIWW		-2		Box	1	6	6		-90.7688	29.5092
A_South_1	A-South of GIWW		-2		Box	1	6	6		-90.7649	29.4766
A_South_1	A-South of GIWW		-2		CMP	1	48" D			-90.7659	29.4753
GIWW_Gate	A-South of GIWW	GIWW West Structure	-16	125						-90.7930	29.5353
GIWW_Gate	A-South of GIWW	GIWW West Structure	-16		Sluice	9	16	16		-90.7930	29.5353
B_Section_1	B	Local Pump 1							36	-90.7636	29.462
B_Section_1	B	Marmande Canal Floodgate (Stoplog gate)	-4	30						-90.7622	29.4612
B_Section_2	B	Local Pump 2							180	-90.7842	29.4174
B-Str_Section_1	B	Falgout Canal Floodgate	-9	56						-90.789	29.4158
B-Str_Section_1	B	Falgout Canal Floodgate	-9		Sluice	9	16	16		-90.789	29.4158
Barrier_1	Barrier	Shell Canal West Floodgate (Stoplog gate)	-10	30						-90.9451	29.6303
Barrier_1	Barrier	Shell Canal East Floodgate	-12	56						-90.9322	29.6253
Barrier_1	Barrier		-4.5		Box	6	6	6		-91.0058	29.6665
Barrier_1	Barrier		-4.5		Box	6	6	6		-90.9839	29.6611
Barrier_1	Barrier		-4.5		Box	6	6	6		-90.9709	29.6473
Barrier_1	Barrier		2.2		Circular	4	4			-90.9952	29.6629
Barrier_1	Barrier		2.2		Circular	3	4			-90.988	29.6618
Barrier_1	Barrier		2.2		Circular	1	4			-90.982	29.661
Barrier_1	Barrier		2.2		Circular	1	4			-90.9794	29.6602
Barrier_1	Barrier		2.2		Circular	1	3			-90.9667	29.6434
Barrier_1	Barrier		2.2		Circular	1	3			-90.9639	29.6396
Barrier_2	Barrier	Elliot Jones Pump Station							1000	-90.9207	29.6239
Barrier_2	Barrier	Bayou Black Pump Station							330	-90.904	29.6134
Barrier_2	Barrier	NAFTA Canal	-12	56						-90.8758	29.5999
Barrier_2	Barrier	Hanson Canal Pump Station							1000	-90.8604	29.6028
Barrier_2	Barrier		-4.5		Box	6	6	6		-90.8989	29.6101
Barrier_2	Barrier		-4.5		Box	6	6	6		-90.8257	29.5835
Barrier_3	Barrier		-4.5		Box	5	6	6		-90.8161	29.5721
Bayou_Black Gate	Barrier	Bayou Black Floodgate	-6	56						-91.0089	29.6711
E1_Section_1	E1		-4.5		Box	6	6	6		-90.7485	29.3982
E2_Section_1	E2		-8		Circular	2	4			-90.7835	29.4051
E2_Section_1	E2		-4.5		Box	6	6	6		-90.7696	29.406
E2_Section_3	E2	Bayou Dularge Floodgate	-7	56						-90.7871	29.4075
F1_Section_1	F1	Bayou Grand Caillou Floodgate	-12	56						-90.7376	29.3425
F1_Section_1	F1	Bayou Grand Caillou Floodgate	-12		Sluice	9	16	16		-90.7376	29.3425
F1_Section_2	F1	HNC Lock Complex	-24	250						-90.7299	29.3296
G2_Section_2	G2	Four Point Bayou Floodgate (Stoplog Gate)	-6	30						-90.7048	29.3195
G2_Section_2	G2		-6		Circular	8	6			-90.6958	29.3166
G2_Section_2.5	G2		-6		Circular	6	6			-90.6938	29.3161
G2_Section_3	G2		-6		Circular	6	6			-90.6847	29.3137
Larose_Floodgate	GIWW	Larose Floodgate	-12	56						-90.3816	29.5711
H1_Section_2	H1		-4.6		Box	1	6	6		-90.6704	29.302
H1_Section_2	H1		-6		Box	6	6	6		-90.6542	29.2965
H1_Section_3	H1	Bayou Petit Caillou Floodgate	-10	56						-90.6485	29.2965
H1_Section_3	H1	Bayou Petit Caillou Floodgate	-8		Sluice	6	16	16		-90.6485	29.2965
H2_Section_2	H2	Placid Canal Floodgate	-8	56						-90.6321	29.3415
H2_Section_2	H2	Placid Canal Floodgate	-8		Sluice	6	16	16		-90.6321	29.3415
I1_Section_1	I1	Bush Canal Floodgate	-12	56						-90.6022	29.3687
I1_Section_1	I1	Bush Canal Floodgate	-12		Sluice	9	16	16		-90.6022	29.3687
I2_Section_2	I2	Bayou Terrebonne Floodgate	-10	56						-90.5881	29.3881
I2_Section_2	I2	Madison Nett Pump Station							220	-90.5749	29.4056
I3_Section_1	I3	Humble Canal Floodgate	-9	56						-90.5636	29.4372
J2_Section_2	J2		-6		Box	18	5	10		-90.5394	29.4366
J2_Section_3	J2		-6		Box	10	5	10		-90.5142	29.447
J2_Section_4	J2		-6		Box	5	5	10		-90.4971	29.4573
J3_Section_2	J3	Pointe Aux C Pump Station							100	-90.4541	29.4249
J3_Section_2	J3		-4		Circular	1	2			-90.4495	29.4177
J3_Section_2	J3	Bayou Pointe Aux Chenes Floodgate	-8	56						-90.4482	29.4183
J3_Section_2	J3	Bayou Pointe Aux Chenes Floodgate	-4		Circular	3	3			-90.4482	29.4183
K_Section_2	K		-4.5		Box	2	6	6		-90.439	29.4647
K_Section_2	K		-4.5		Box	2	6	6		-90.4462	29.4461
K_Section_3	K		-4		Circular	5	4			-90.4366	29.4723
L_Section_1	L	Grand Bayou Floodgate	-11	56						-90.4183	29.5048
L_Section_1	L	Grand Bayou Floodgate	-11		Sluice	9	16	16		-90.4183	29.5048
L_Section_2	L	Proposed Structure at Bayou Blue	-4.5	56						-90.402	29.5117
Lock_Larose_A	Lockport A	GIWW East Structure	-16	125						-90.3708	29.5907
Lock_Larose_A	Lockport A	GIWW East Structure	-10		Sluice	6	12	16		-90.3708	29.5907
Lock_Larose_B	Lockport B		-2.9	20						-90.5045	29.66
Lock_Larose_B	Lockport B		-3	30						-90.4923	29.6616
Lock_Larose_A	Lockport to Larose	Proposed Larose Pump Station							50	-90.4431	29.6278
Barrier_Ext			3		Circular	1	3			-90.8136	29.5635
Barrier_Ext			3		Circular	3	4			-90.811	29.556
Chene_Structure		Bayou Chene Floodgate	-26.9	250						-91.0928	29.6227
Connection 22		Leon Theriot Lock	-15	56						-90.246	29.3429
Dulage_West		Lower Dularge Floodgate	-8	56						-90.8431	29.3359
Geraldine_Rd			3		Circular	1	4			-91.0062	29.6667
North Bayou Blac			3.8		Circular	2	3			-91.0118	29.6757
North Bayou Blac			3.8		Circular	2	3			-91.0105	29.6734

Notes: Orange highlight indicates gates that have culverts incorporated into them.

*XY Points are projected in WGS 1984

Table A-3: Proposed Levee and Structure Design Elevations

Morganza to the Gulf Proposed Design Elevations			
Hydraulic Reach	Levee Elevation (ft) NAVD88	Hydraulic Reach	Structure Elevation (ft) NAVD88
A-North of GIWW	10	A-North of GIWW	16.5
A-South of GIWW	11	A-South of GIWW	16.5
B	13	B	18.5
E2	17.5	E2	21
E1	17	E1	20
F2	16	F2	19
F1	15.5	F1	18.5
G1	17	G1	19.5
G2	17.5	G2	20.5
G3	18	G3	20.5
H1	17	H1	20
H2	18	H2	22
H3	20	H3	24
I1	20	I1	24
I2	21	I2	25
I3	20	I3	24.5
J2	21.5	J2	25
J1	20.5	J1	24
J3	20	J3	23.5
K	20.5	K	26
L	20.5	L	24.5
C-North	8.5	C-North	16.5
GIWW	8.5	GIWW	15.5
Lockport -A	9.5	Lockport -A	13
Lockport-B	7.5	Lockport-B	11
Barrier	10.5	Barrier	17

Figure A-4: Morganza to the Gulf Levee Reaches

Appendix B – Boundary Condition Hydrographs

Appendix B: Boundary Condition Hydrographs

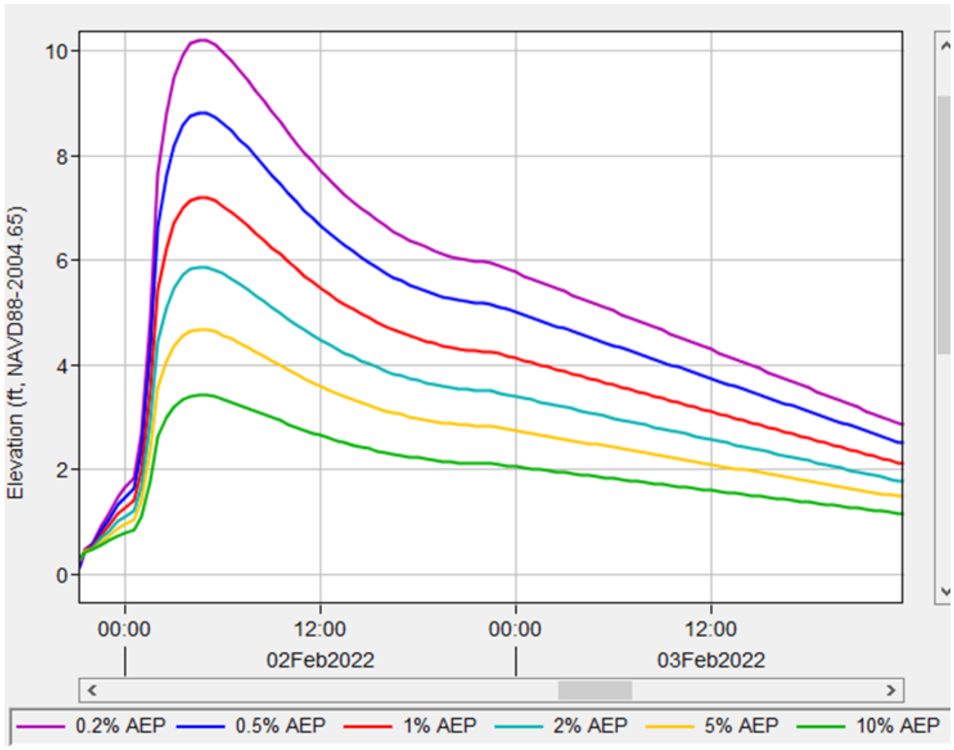

Figure B-1: "Left-Left" 2035 Boundary Condition Frequency Storm Surge Hydrographs

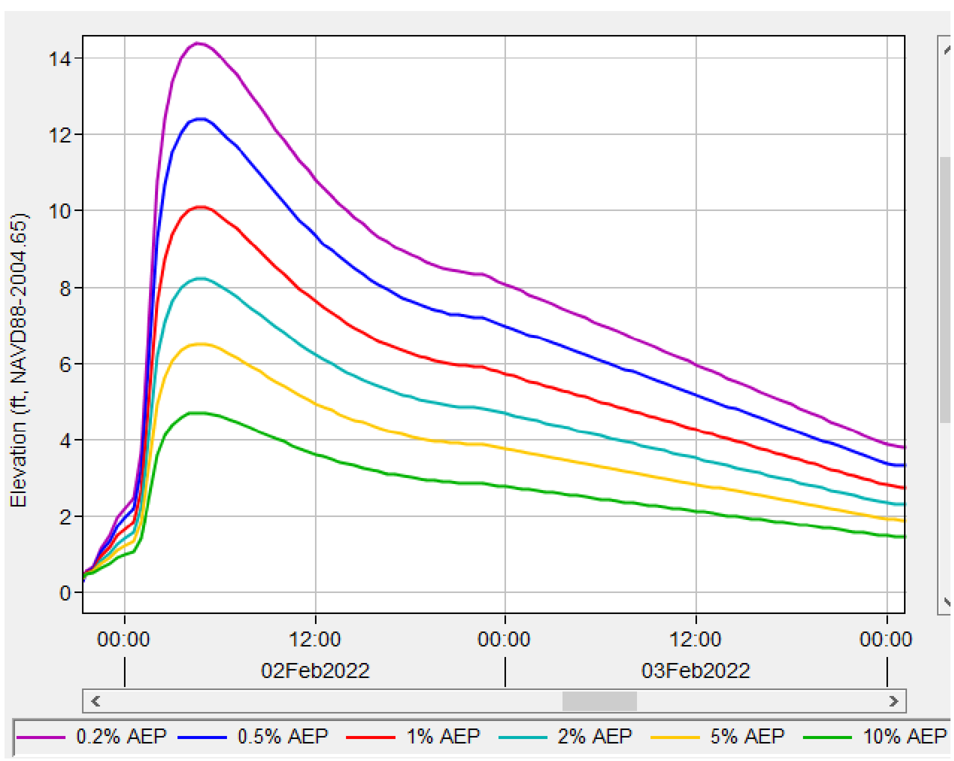

Figure B-2:"Left" 2035 Boundary Condition Frequency Storm Surge Hydrographs

Figure B-3: "Middle" 2035 Boundary Condition Frequency Storm Surge Hydrographs

Figure B-4: "Right" 2035 Boundary Condition Frequency Storm Surge Hydrographs

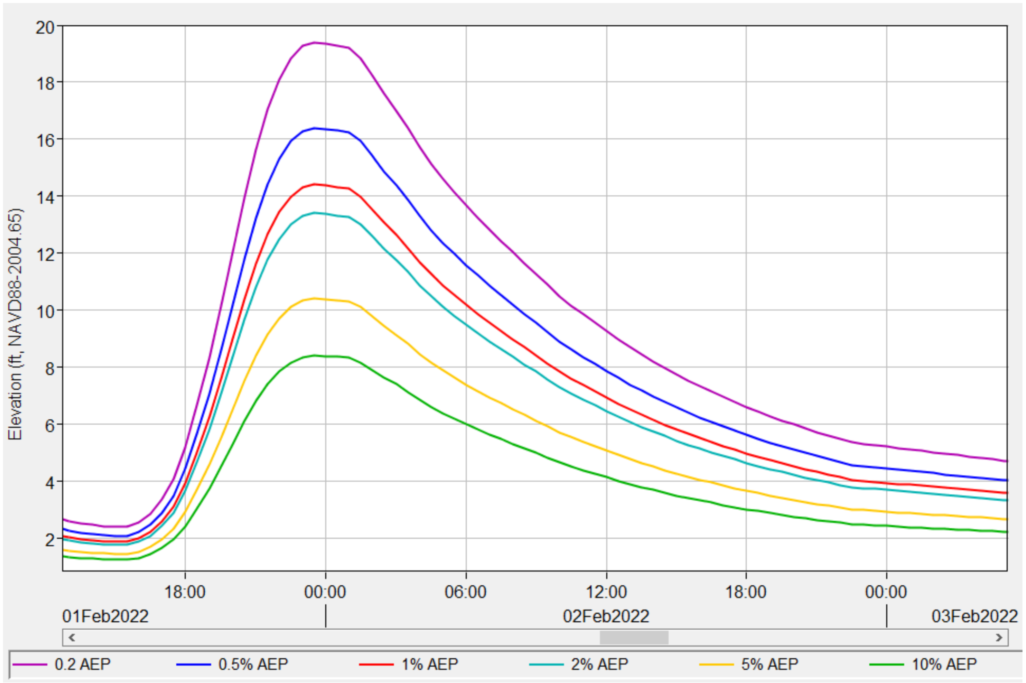

Figure B-5: "Right-Right" 2035 Boundary Condition Frequency Storm Surge Hydrographs

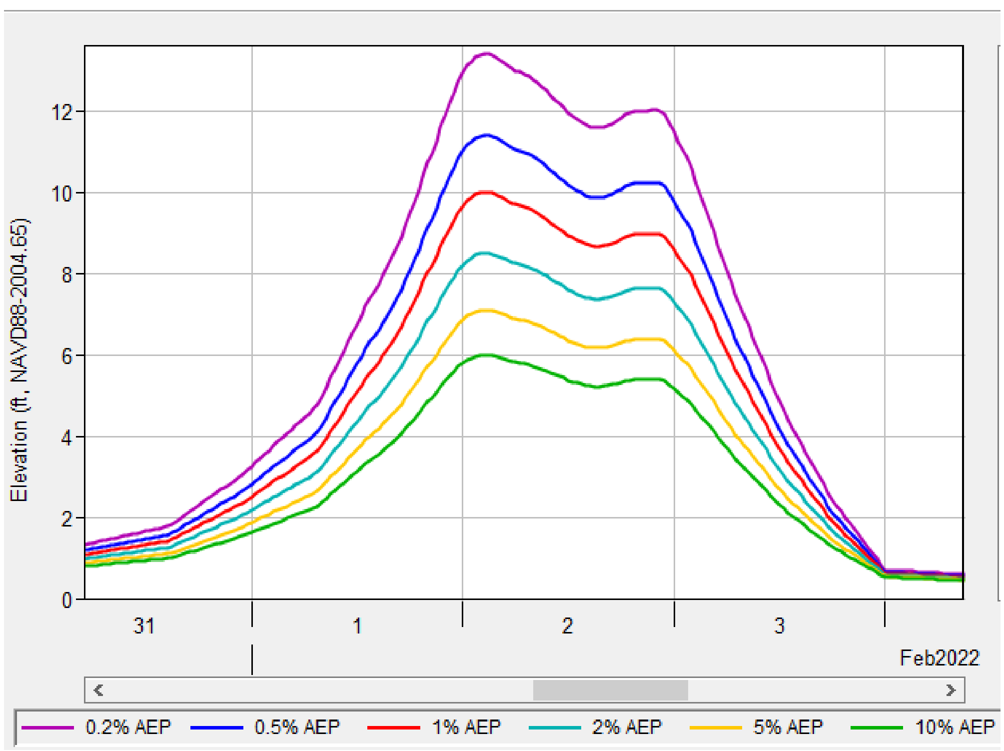

Figure B-6: "Larose" 2035 Boundary Condition Frequency Storm Surge Hydrographs

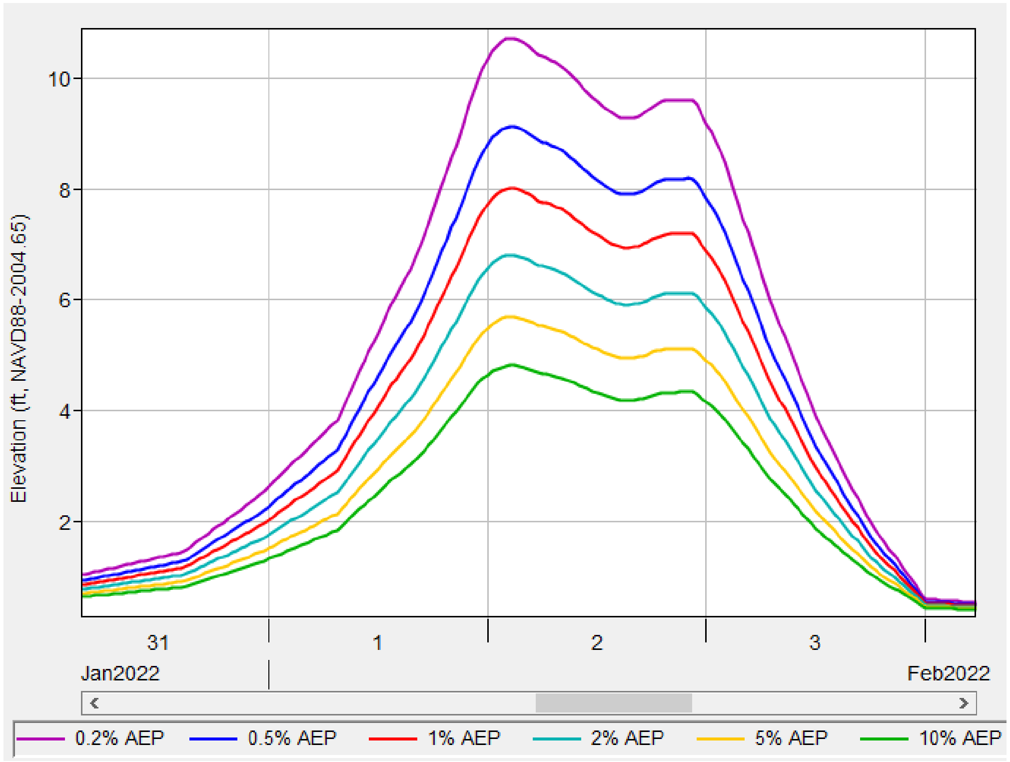

Figure B-7: "Larose-Right" 2035 Boundary Condition Frequency Storm Surge Hydrographs

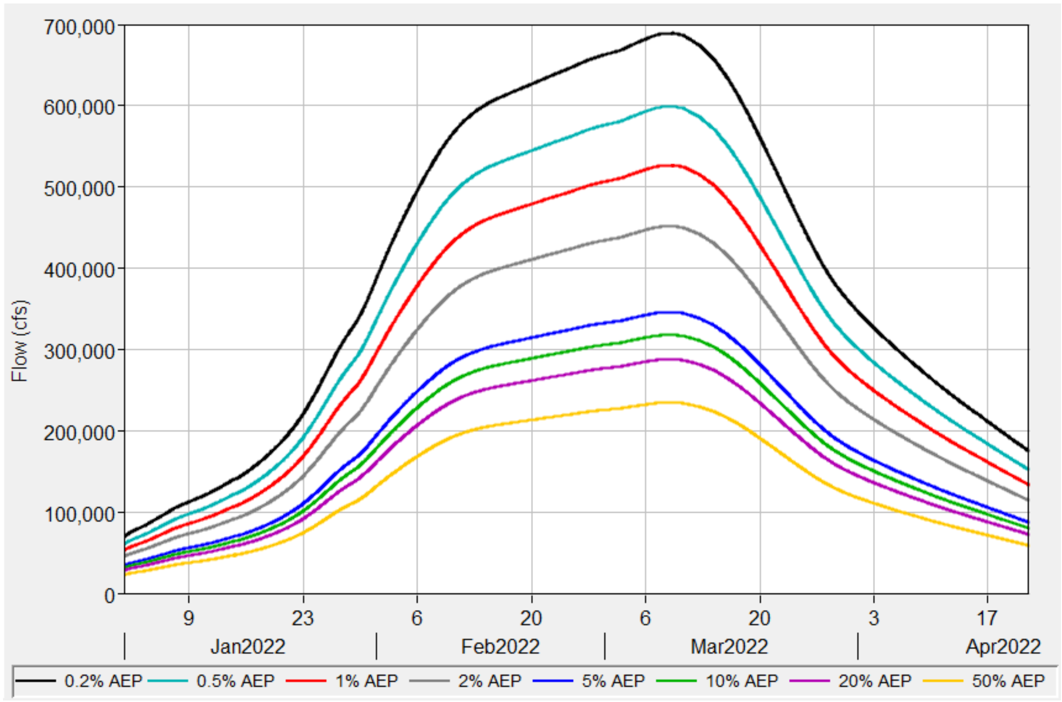

Figure B-8: Morgan City Boundary Condition Frequency Flows

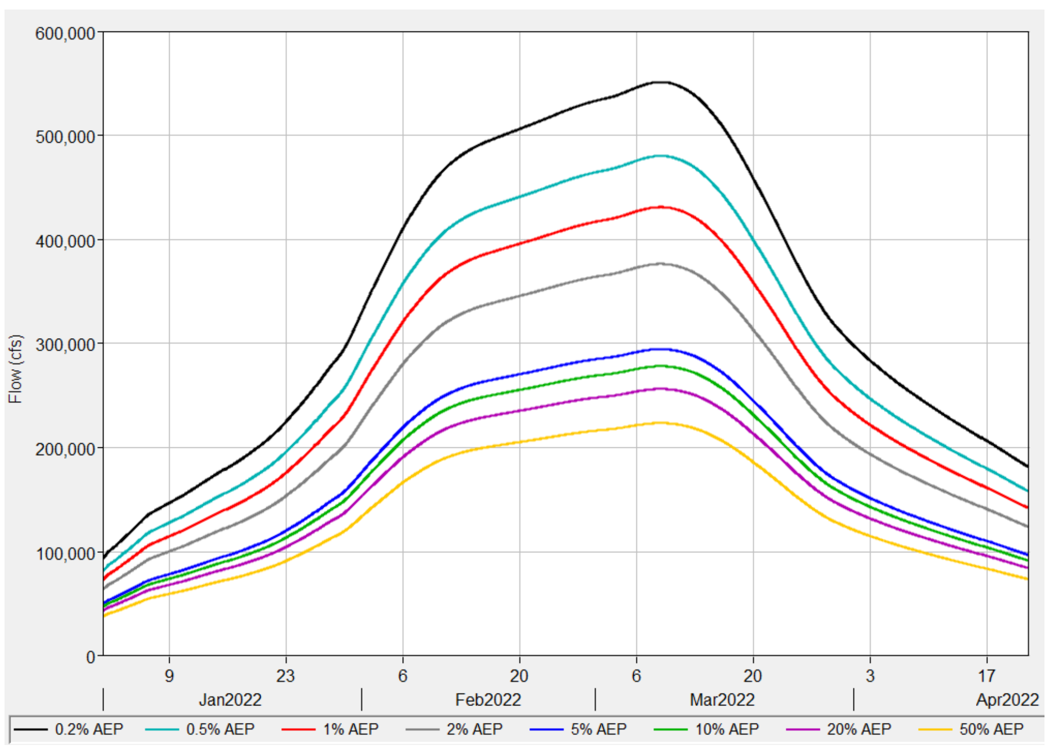

Figure B-9: Calumet Boundary Condition Frequency Flows

Appendix C – Frequency Model Results

Appendix C: Frequency Model Results

This appendix highlights more frequency events model results. Figures C-1 through C-18 highlight hydrograph results for various frequency events. The results for events that contain storm surge consistently show a decrease in interior (within the Morganza to the Gulf leveed area) water levels when compared to existing conditions. This is an intuitive response when considering that the proposed conditions encloses the system and thus protects the interior from storm surge water levels. The precipitation only events were included to highlight the drainage response and capability of hydraulic structures within the proposed levee alignment. The design event for hydraulic structures is the 10% AEP precipitation event. The 10% AEP precipitation only difference grid when comparing proposed conditions to existing conditions, as shown in Figure C-19 and Figure C-20, shows that there is only one area within the basin that has an increase in water levels for this event, around the Lockport to Larose section of levee. The difference grid results are consistent for all precipitation only events, with only increases to interior water levels occurring around the Lockport to Larose levee section. The hydraulic design for the Lockport to Larose levee was estimated in this model analysis and further analysis will be done in a separate analysis to minimize any interior water surface elevation increases from the 10% AEP precipitation only event.

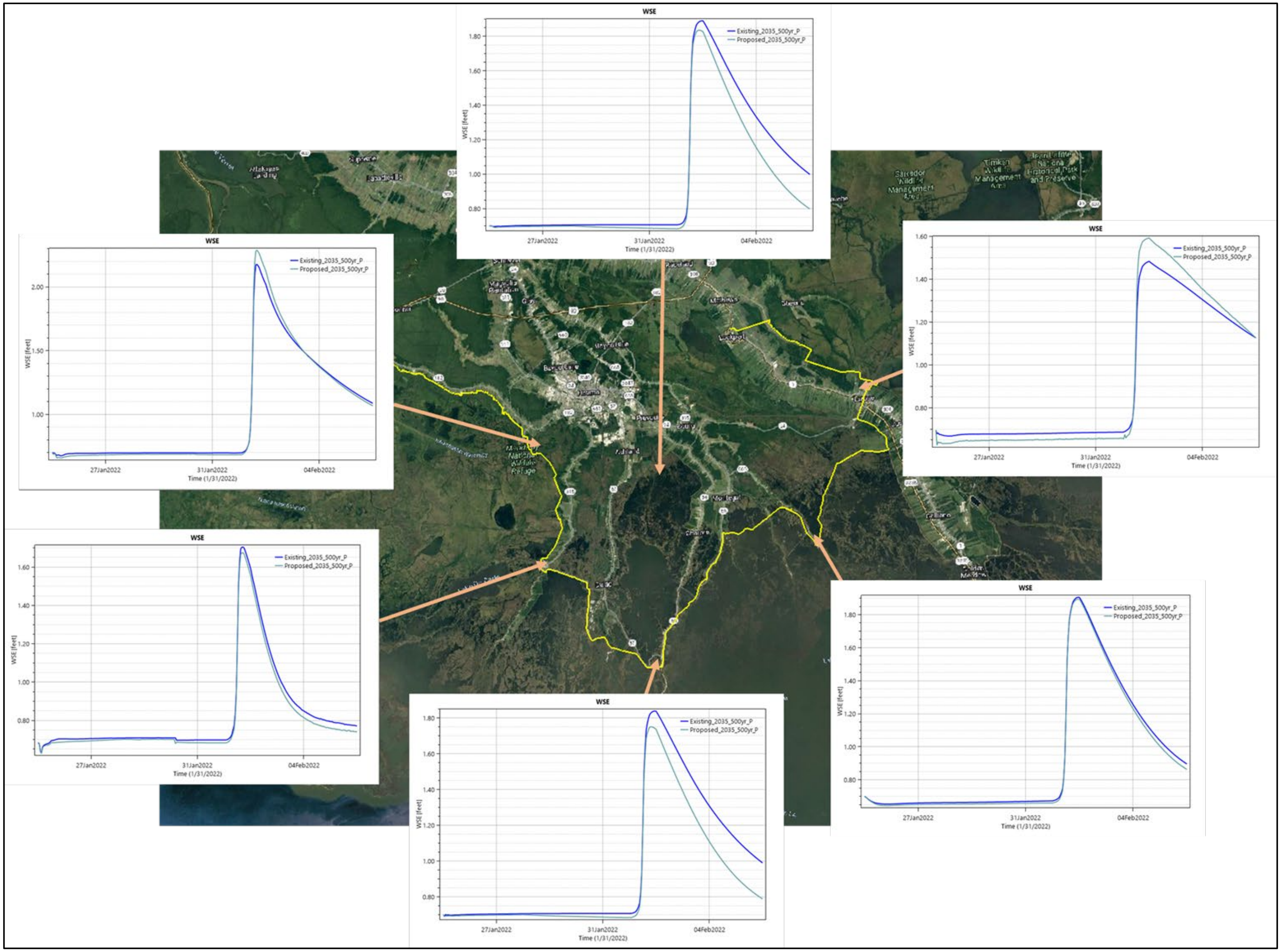

Figure C-1: 0.2% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

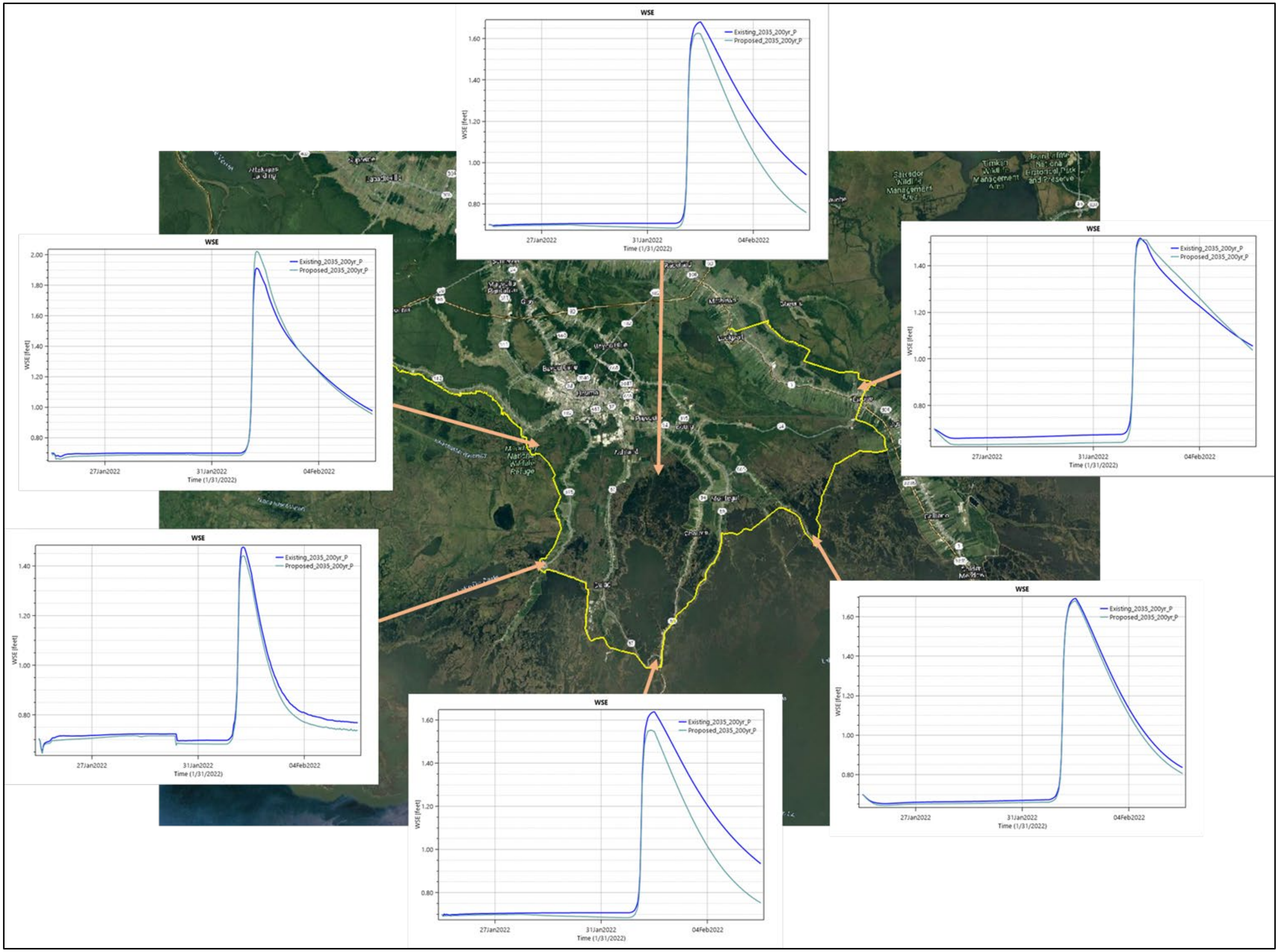

Figure C-2: 0.5% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

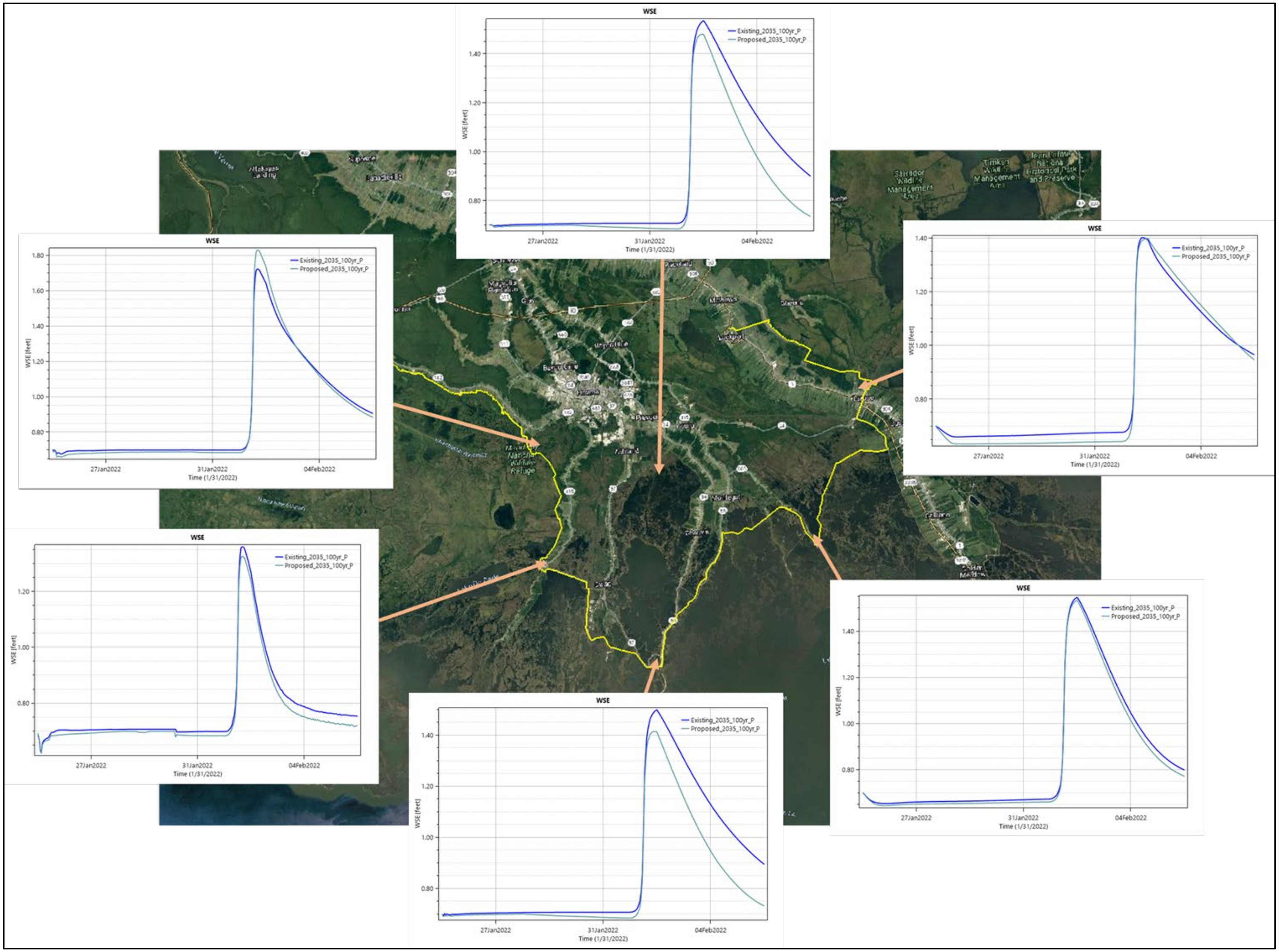

Figure C-3: 1% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

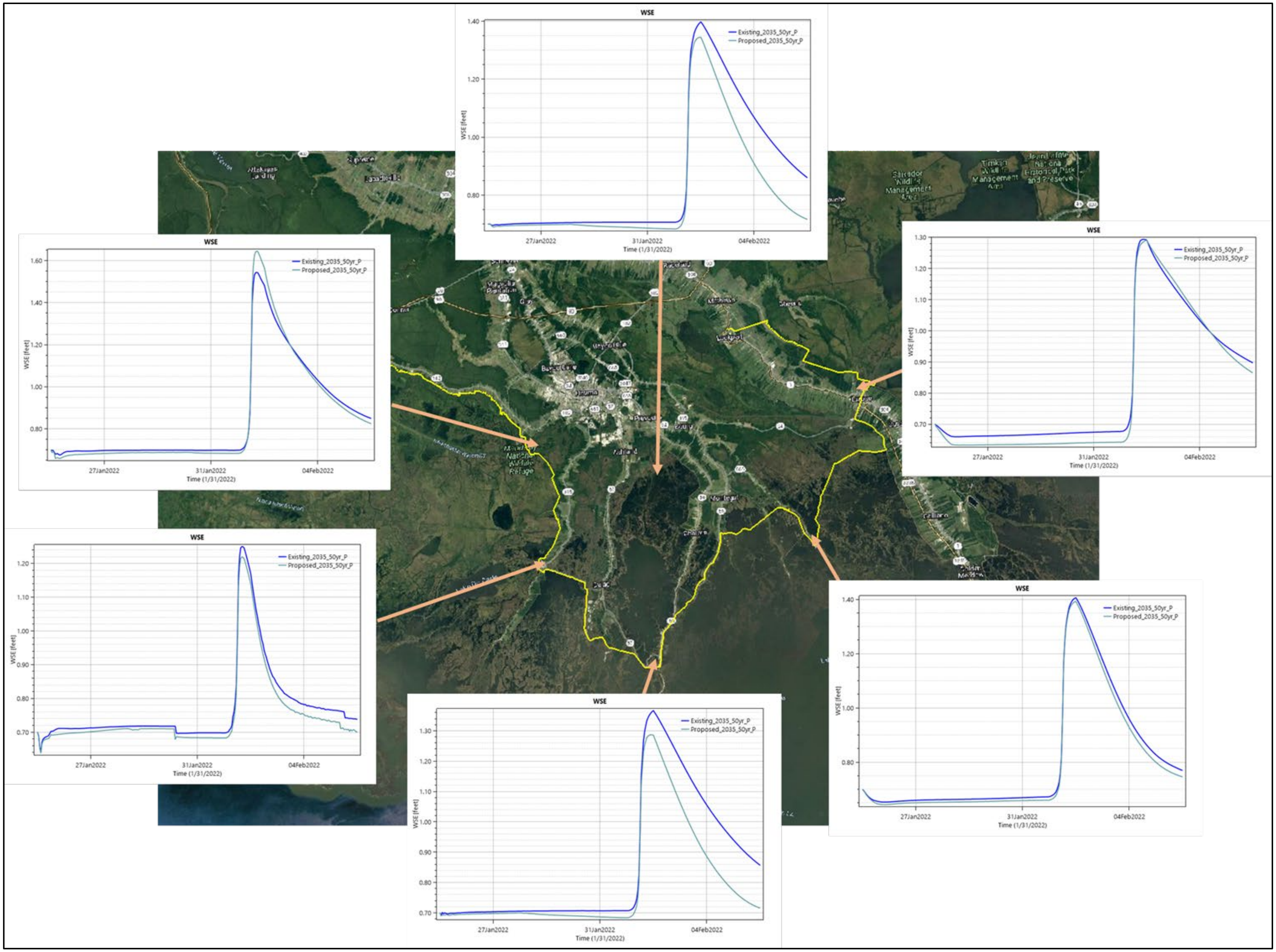

Figure C-4: 2% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

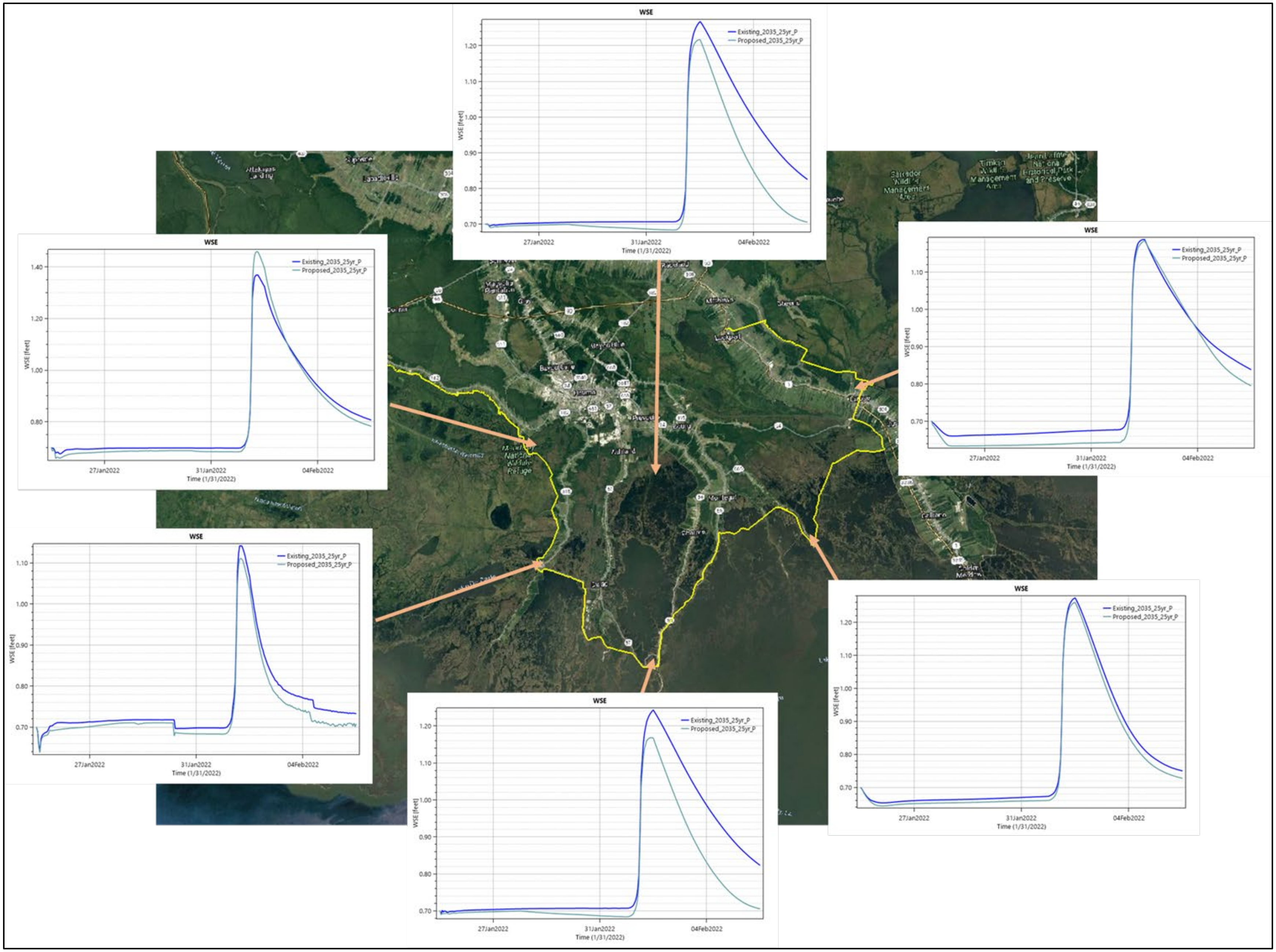

Figure C-5: 4% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

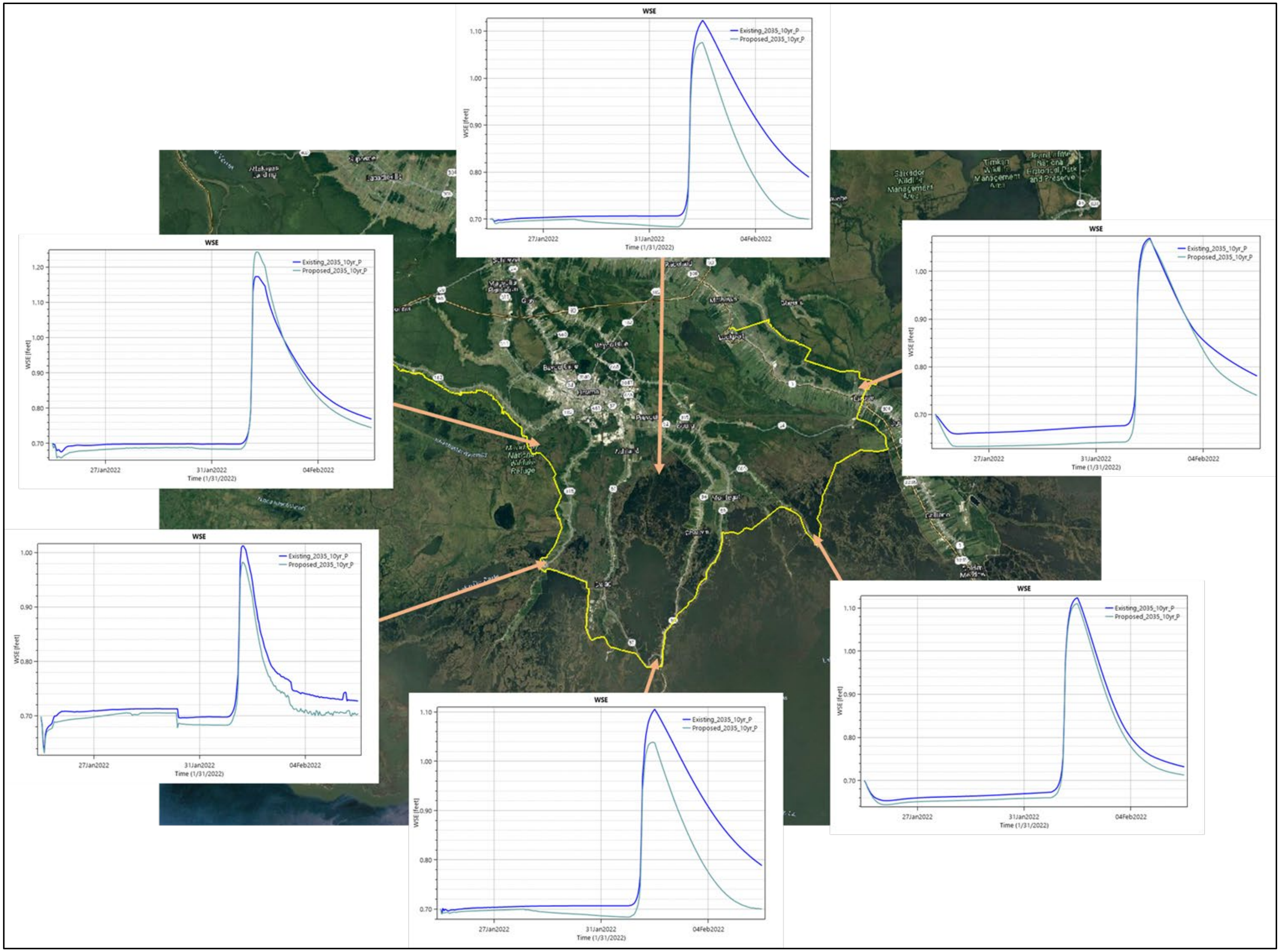

Figure C-6: 10% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

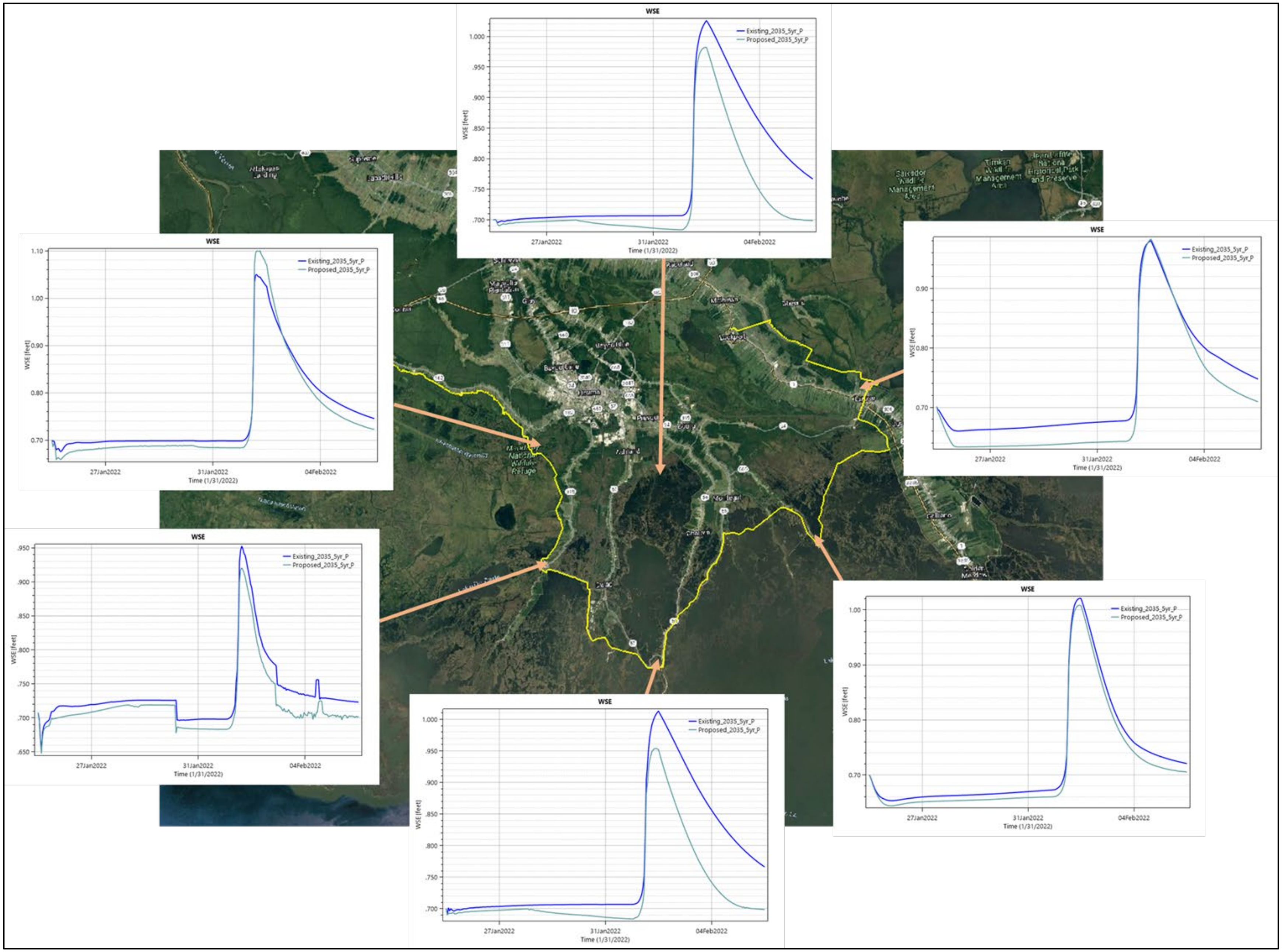

Figure C-7: 20% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

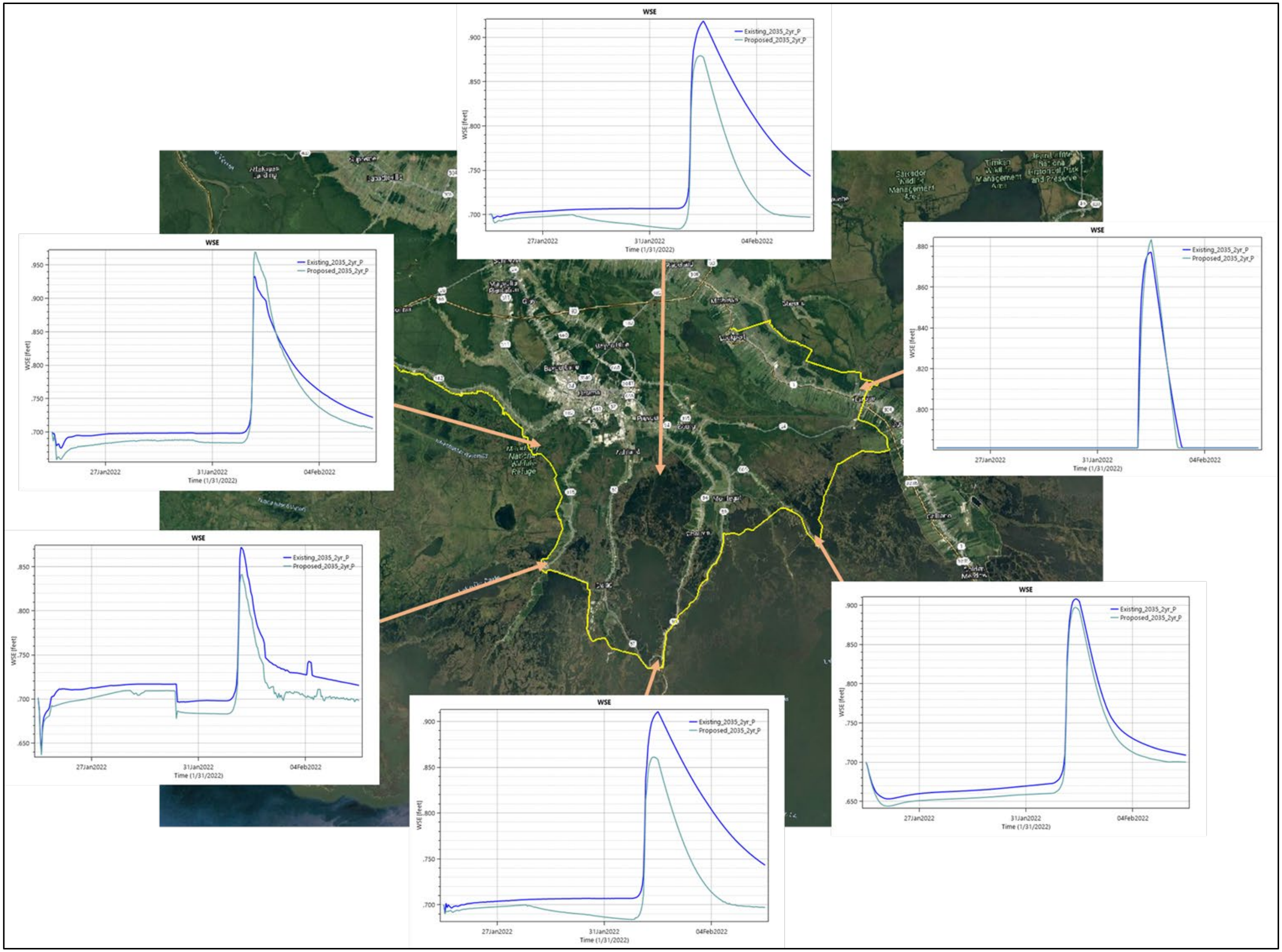

Figure C-8: 50% AEP Event, Existing and Proposed Conditions, Precipitation Only, 2035

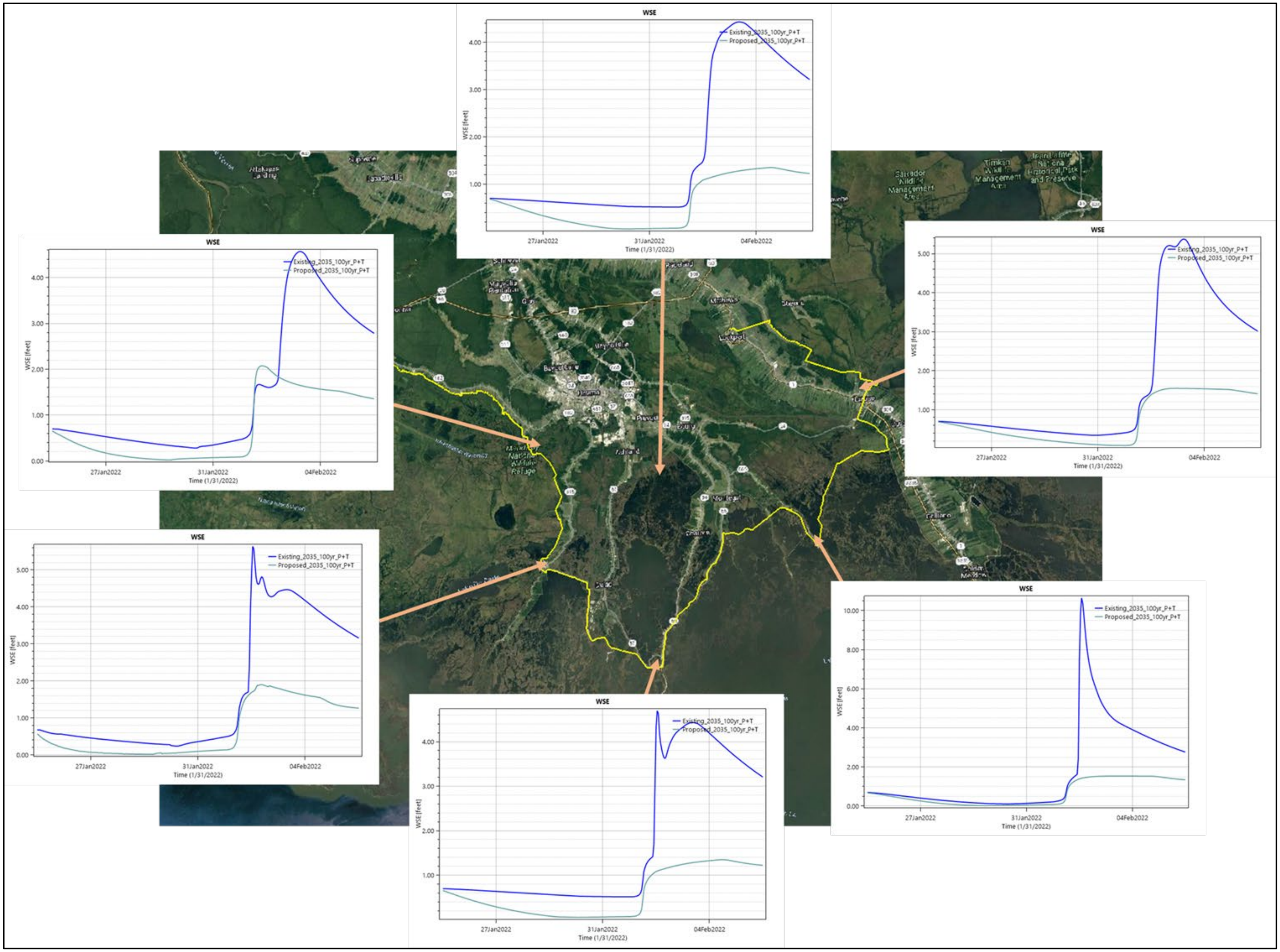

Figure C-9: 1% AEP Event, Existing and Proposed Conditions, Precipitation and Storm Surge, 2035

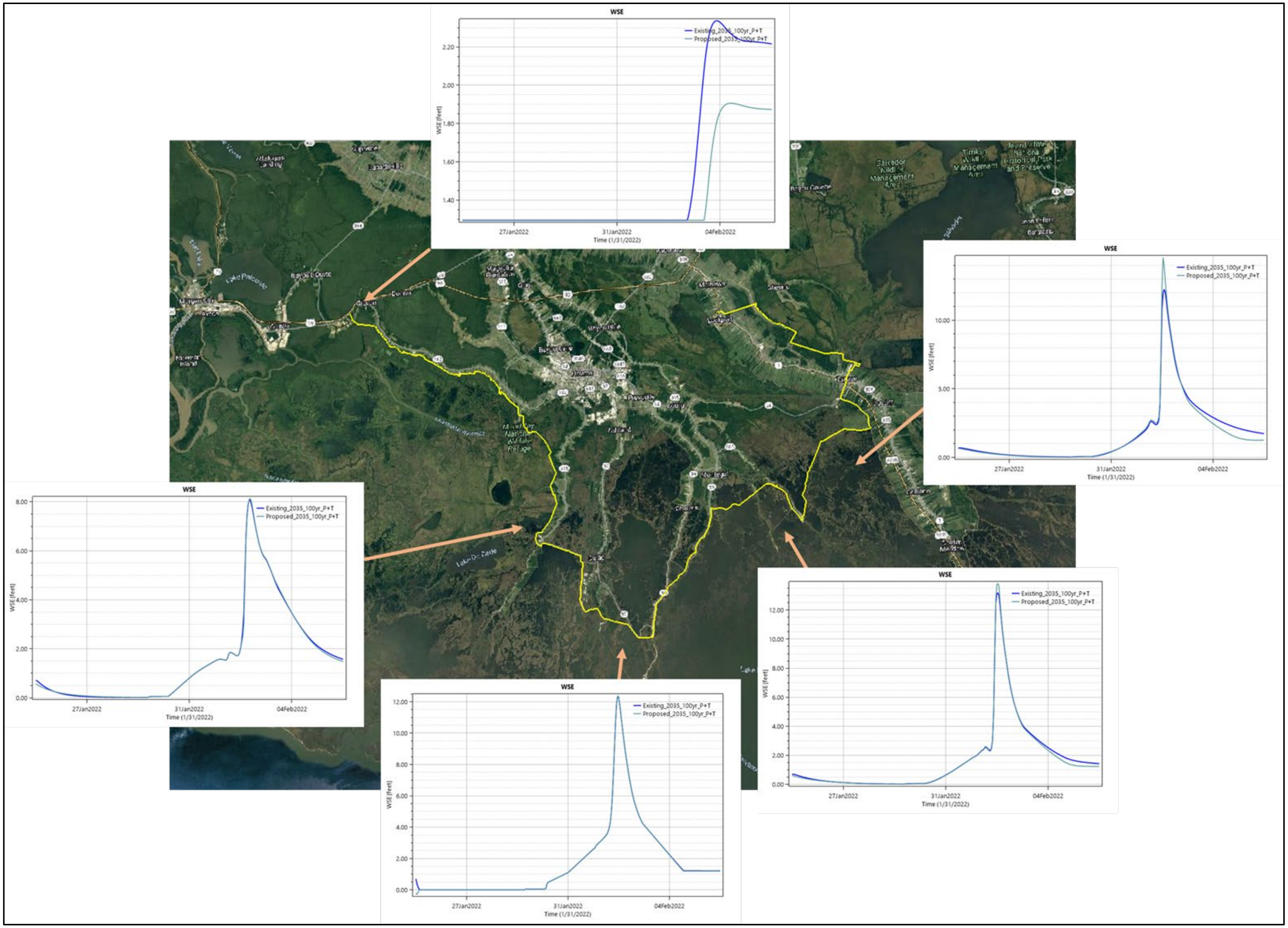

Figure C-10: 1% AEP Event, Existing and Proposed Conditions, Precipitation and Storm Surge, 2035

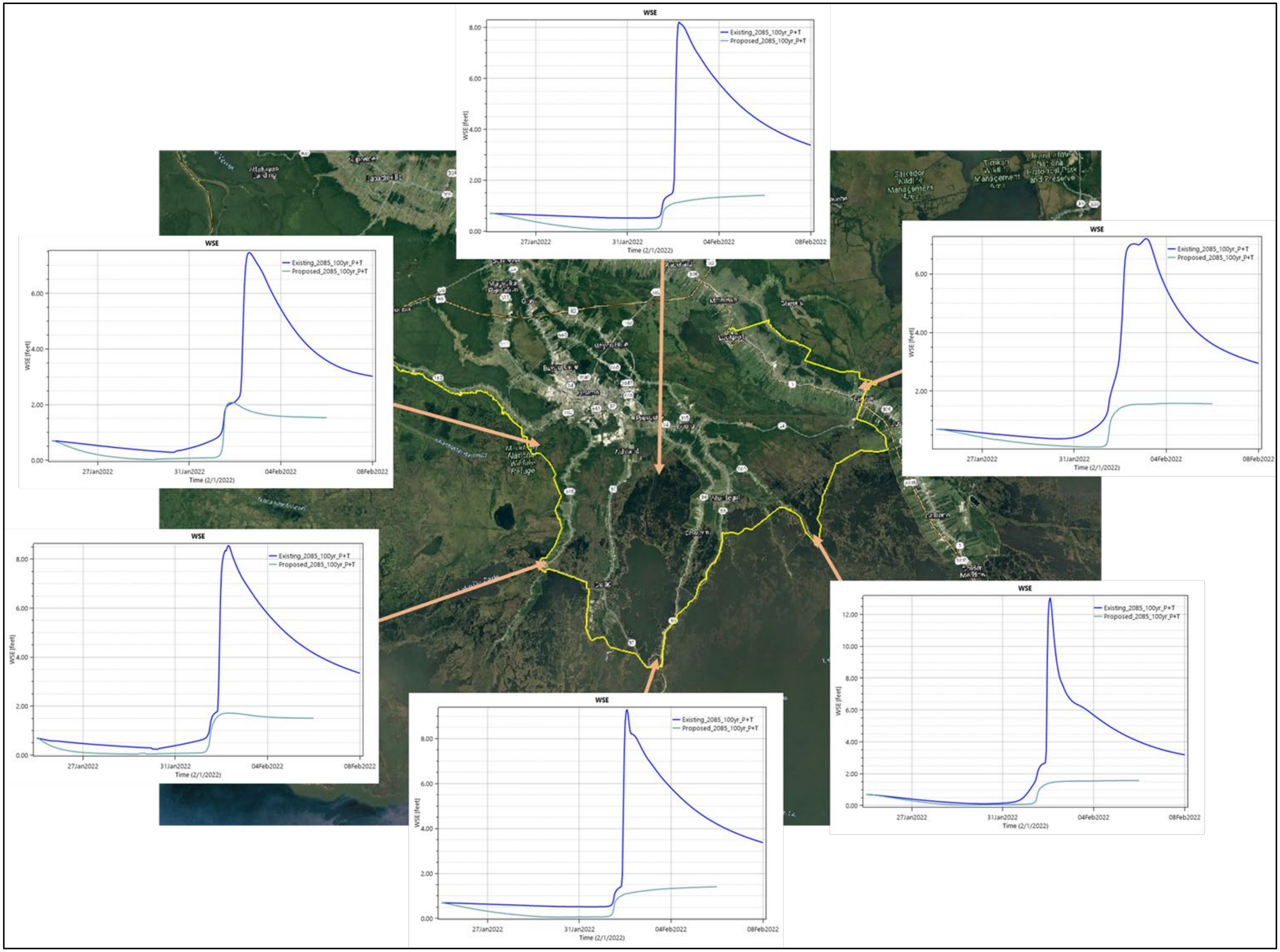

Figure C-11: 1% AEP Event, Existing and Proposed Conditions, Precipitation and Storm Surge, 2085

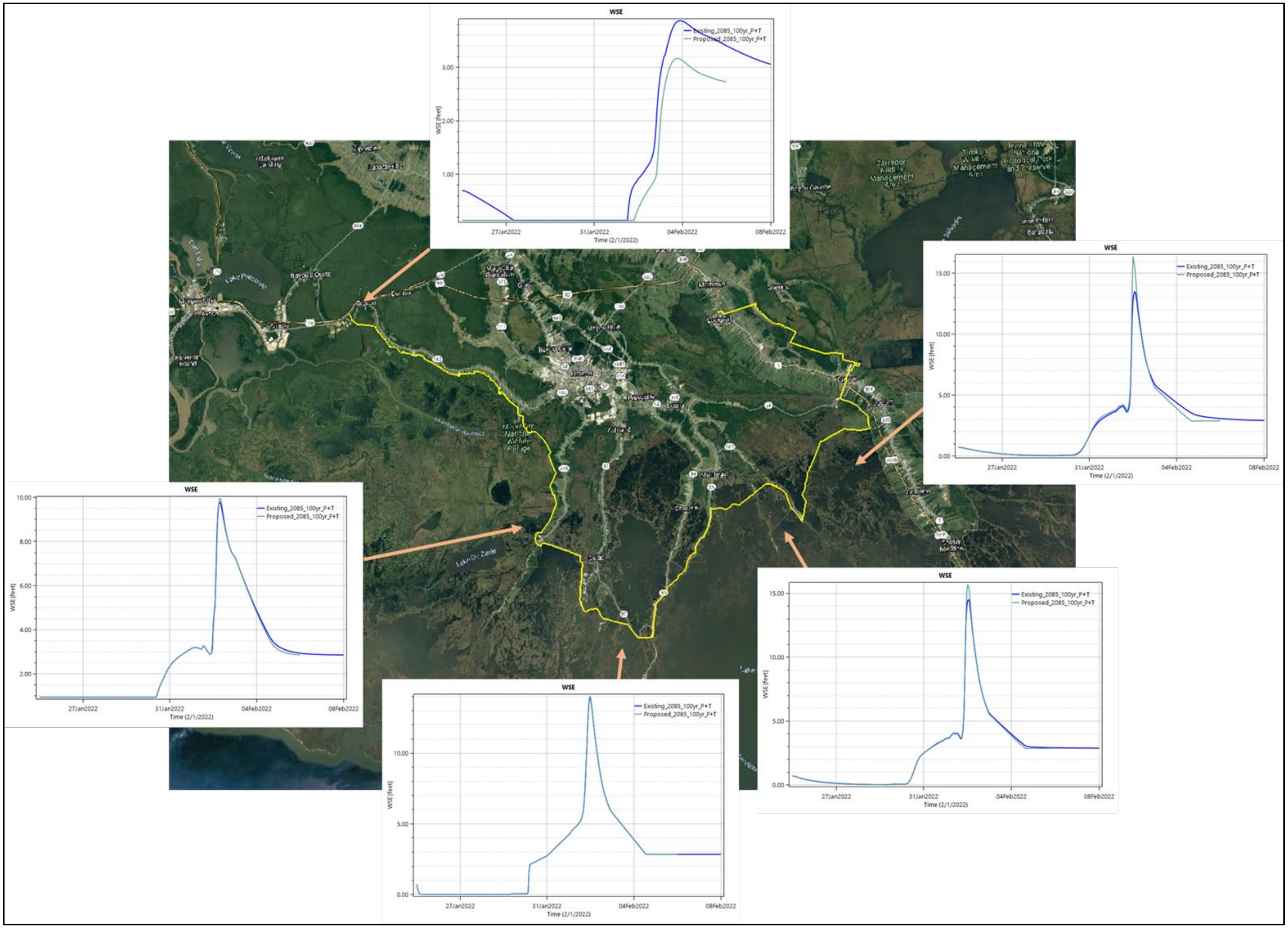

Figure C-12: 1% AEP Event, Existing and Proposed Conditions, Precipitation and Storm Surge, 2085

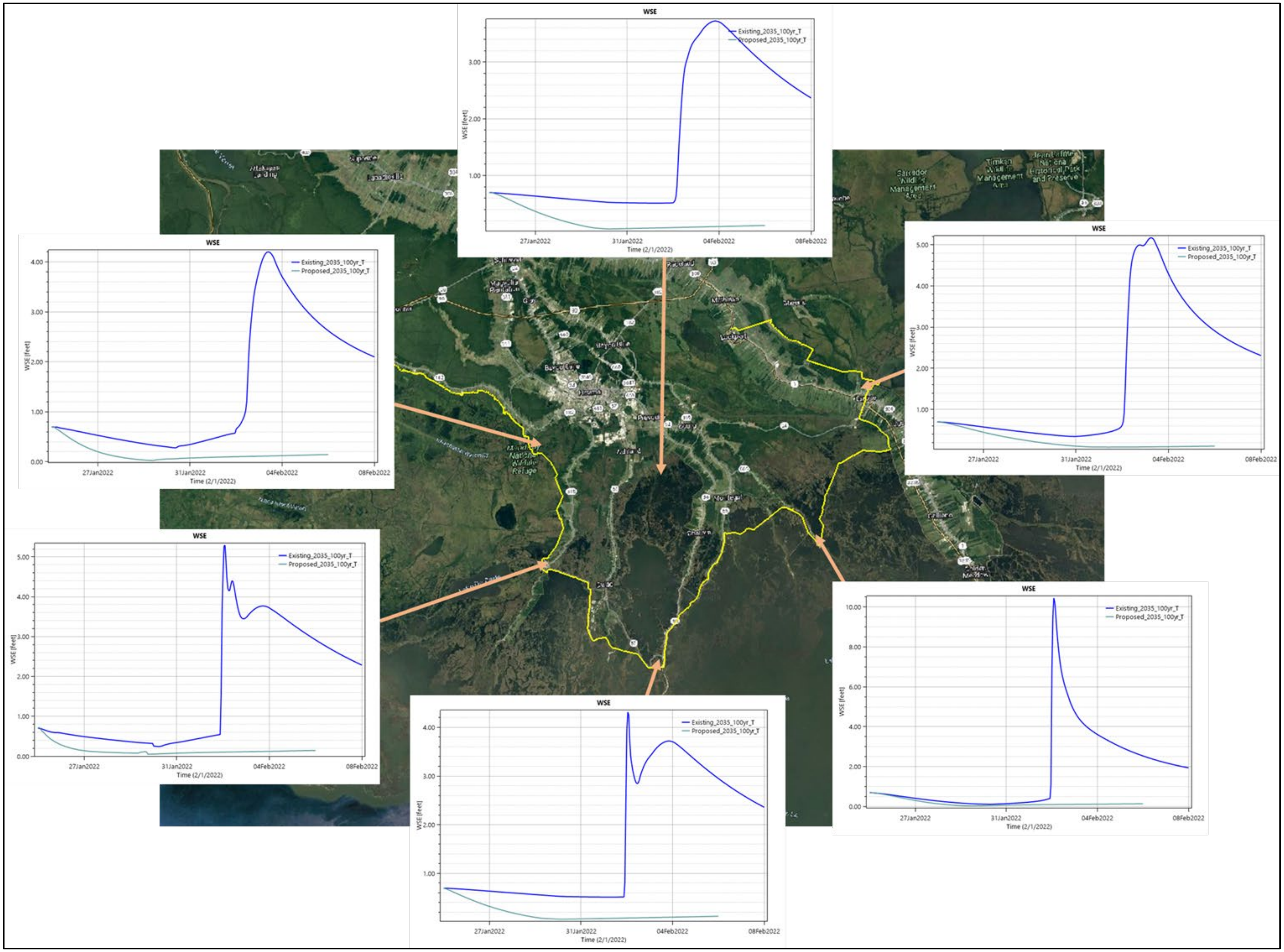

Figure C-13: 1% AEP Event, Existing and Proposed Conditions, Storm Surge, 2035

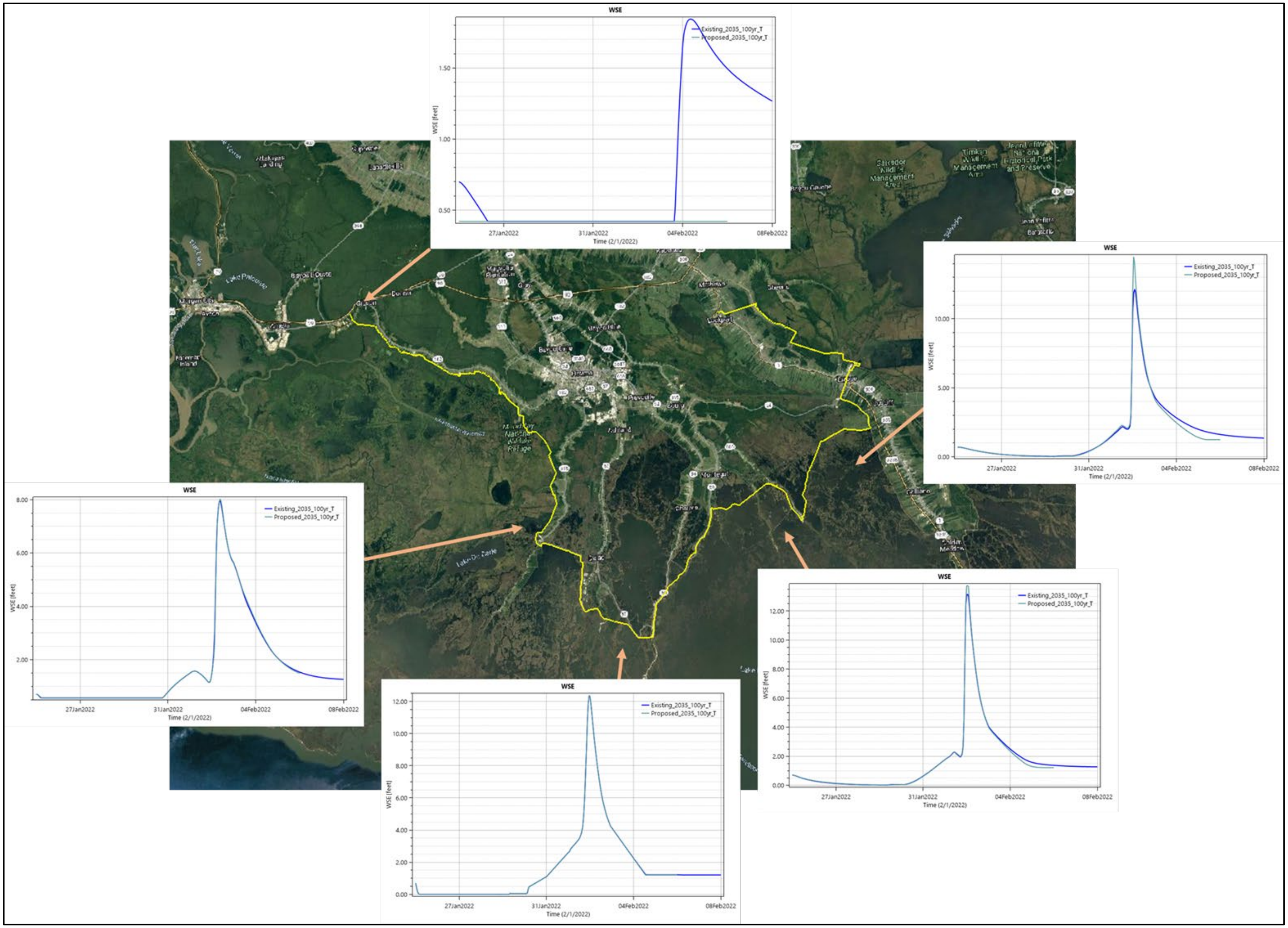

Figure C-14: 1% AEP Event, Existing and Proposed Conditions, Storm Surge, 2035

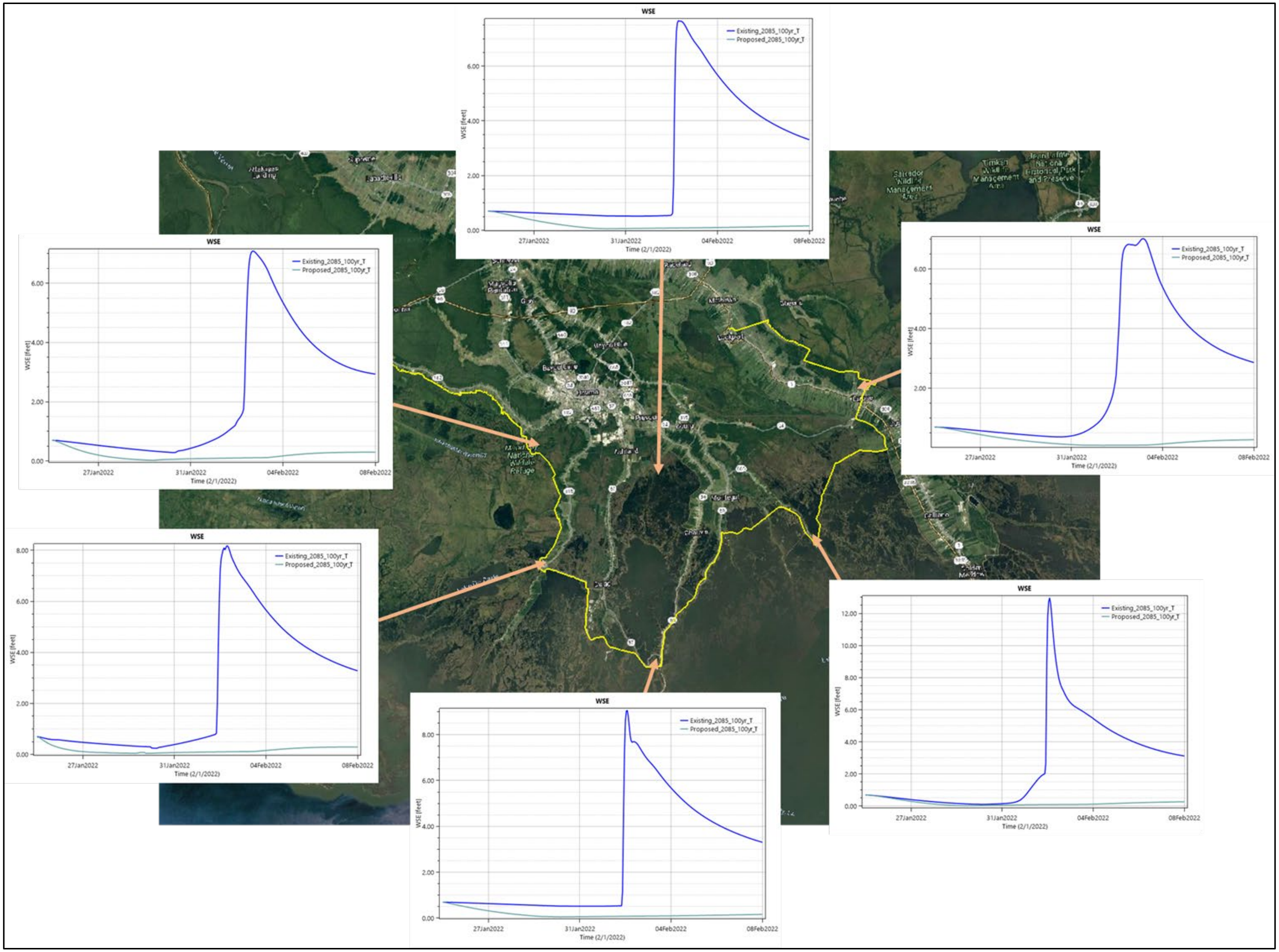

Figure C-15: 1% AEP Event, Existing and Proposed Conditions, Storm Surge, 2085

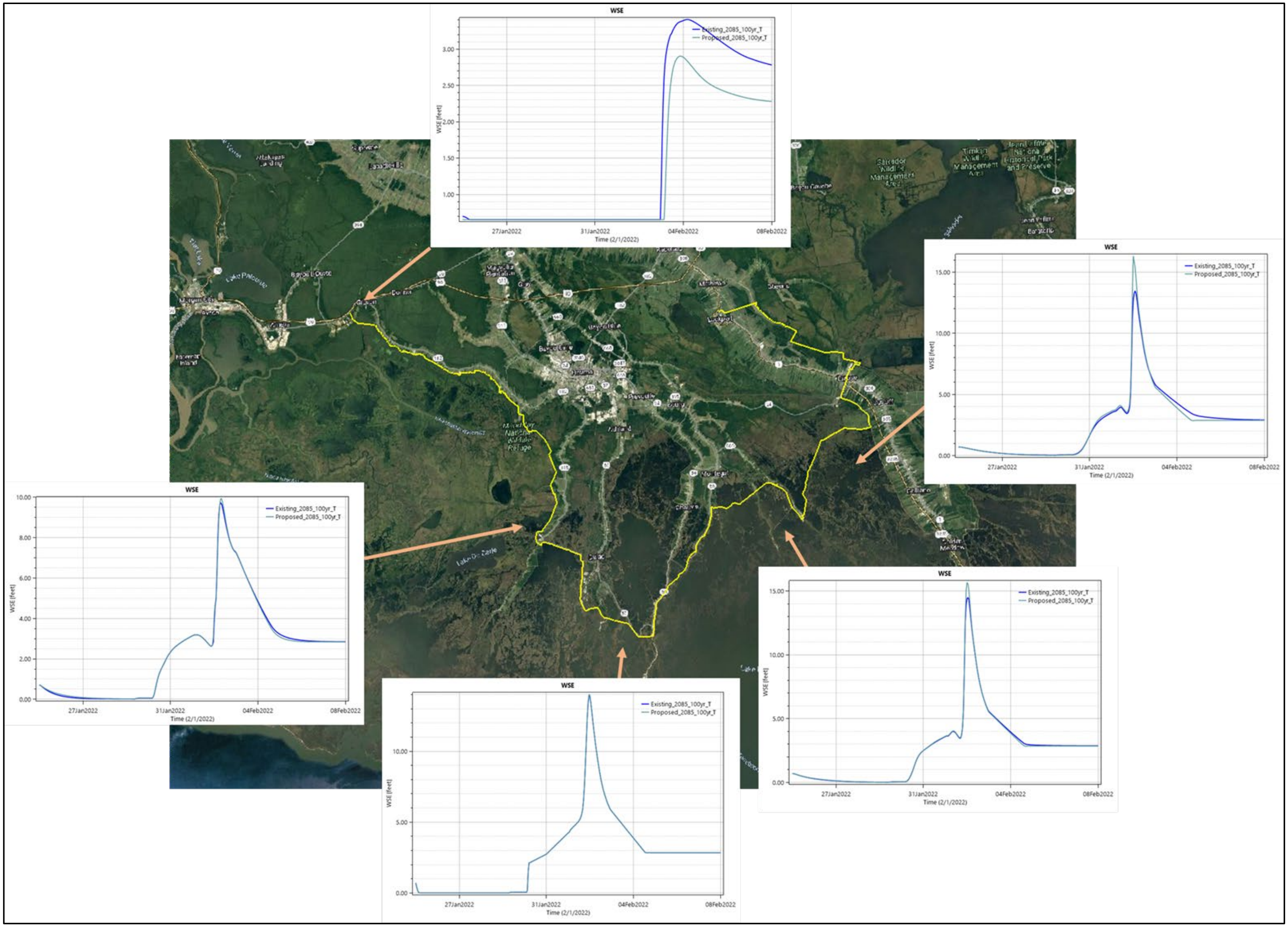

Figure C-16: 1% AEP Event, Existing and Proposed Conditions, Storm Surge, 2085

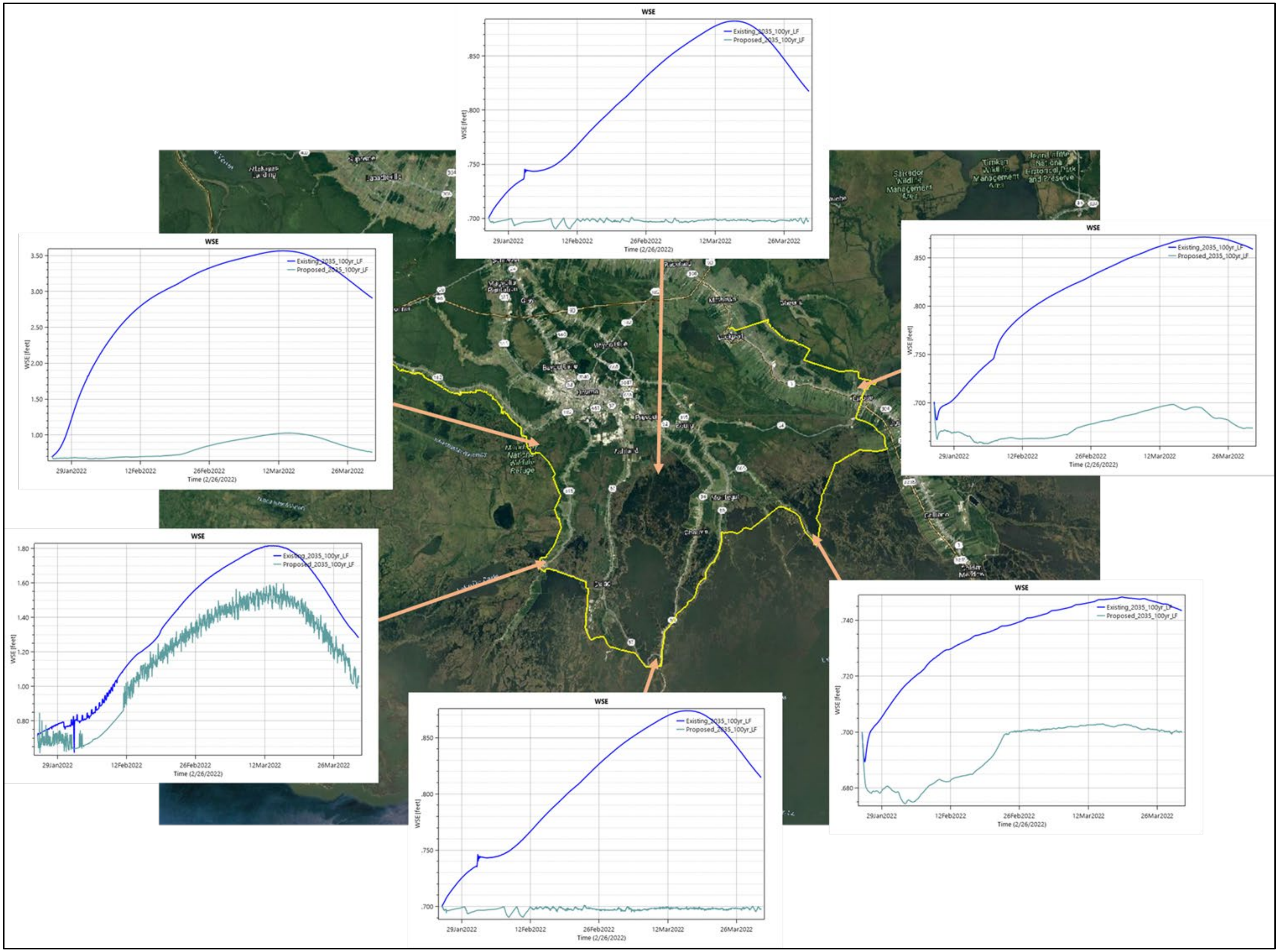

Figure C-17: 1% AEP Event, Existing and Proposed Conditions, Lateral Inflow Only, GIWW Gate Closed, 2035

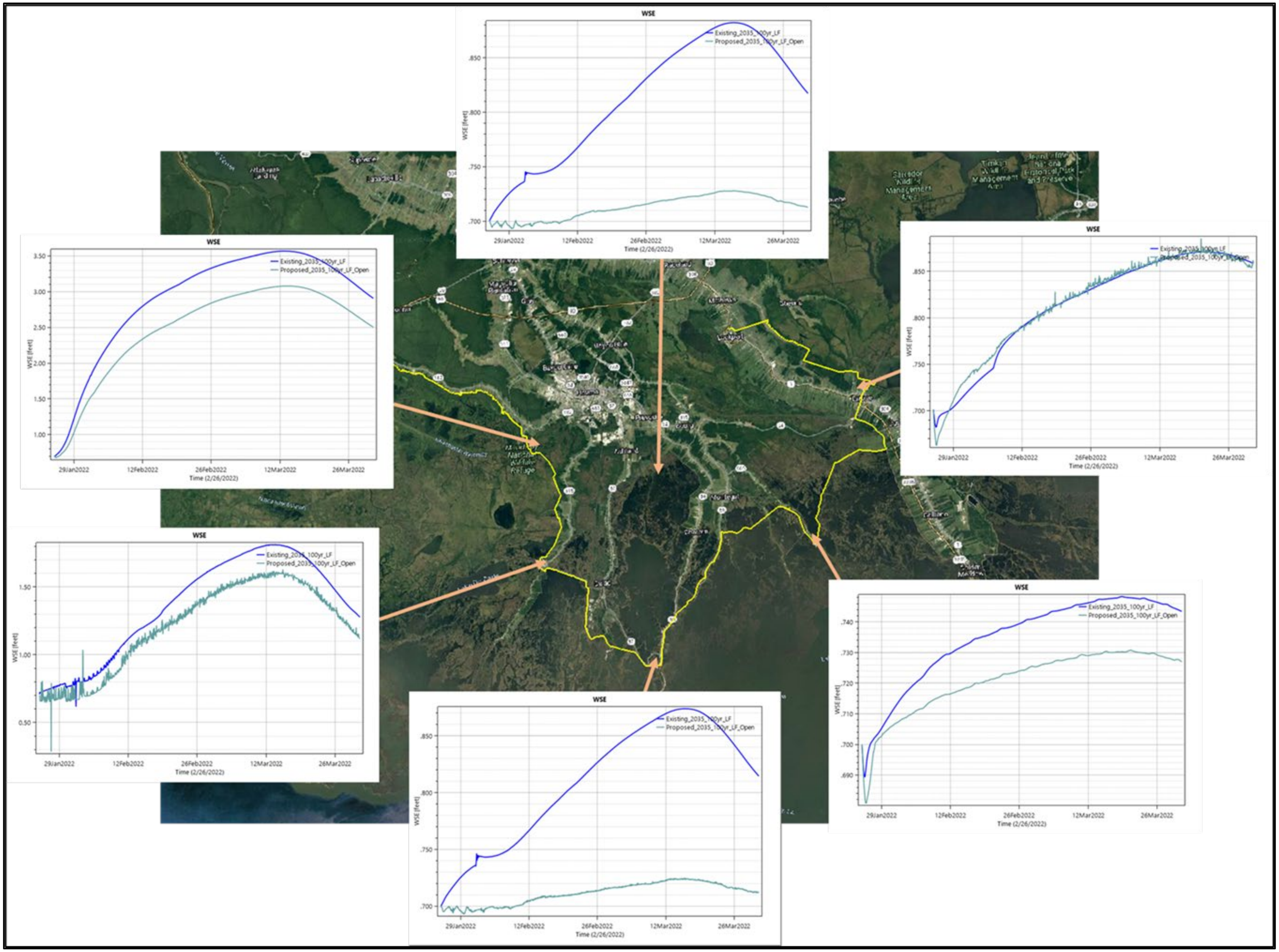

Figure C-18: 1% AEP Event, Existing and Proposed Conditions, Lateral Inflow Only, GIWW Gate Open, 2035

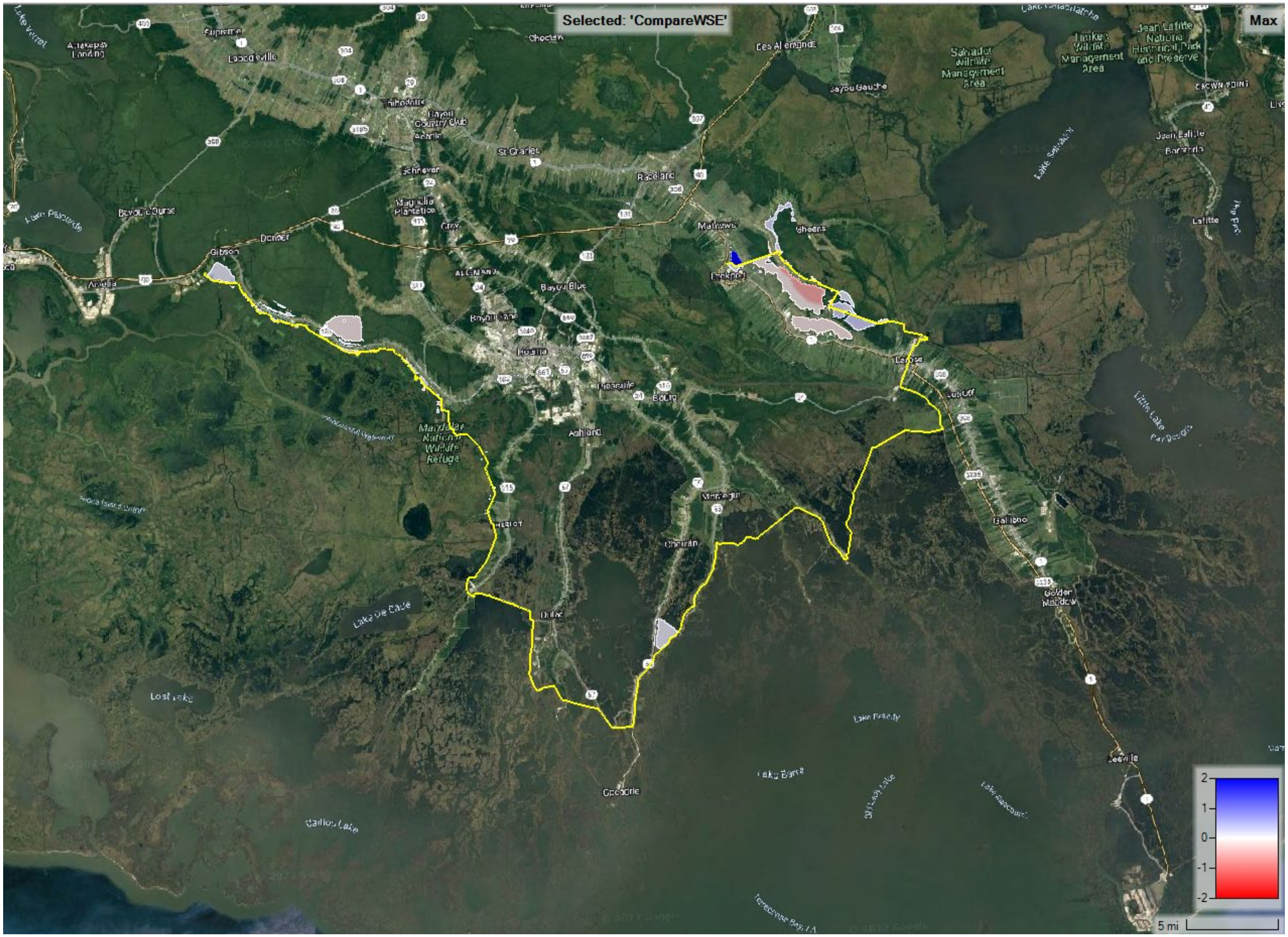

Figure C-19: Difference Grid - 10% AEP Event, Existing Minus Proposed Conditions, Precipitation Only, Max Extent, 2035

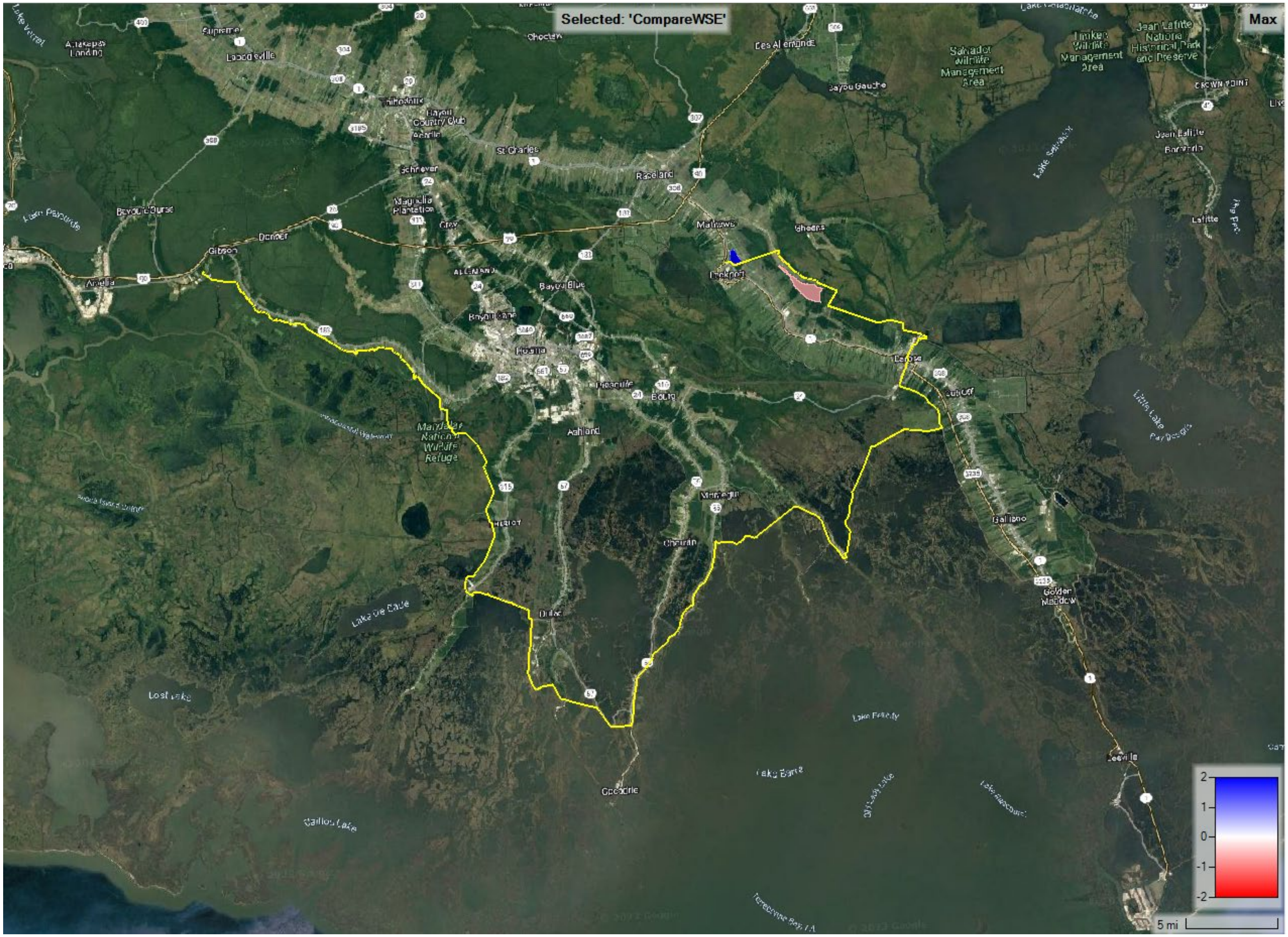

Figure C-20: Difference Grid - 10% AEP Event, Existing Minus Proposed Conditions, Precipitation Only, Max Extent, 2035, 0.5 ft. Difference Threshold Applied

Appendix D – Reach A Alternative Comparison

Appendix D: Reach A Alternative Comparison

The Reach A levee segment has two proposed levee centerline locations. The two alternatives are referred to in this Appendix as NFS and PACR alignments. The NFS alignment (Non-Federal Sponsor) is shown in green in Figure D-1 below. The NFS alignment is an alternate alignment to Reach A from the PACR (Post Authorization Change Report) proposed alignment. The PACR alignment is shown in red in Figure D-1. This Appendix highlights the two alternative alignment location results from the HEC-RAS model for varying boundary conditions. The results highlight differences in water surface elevation in the surrounding area based on the differing levee alignments. The proposed levee alignments include environmental control structures which are primarily intended to allow tidal exchange to occur in the marshland, but also double as drainage structures during precipitation events.

Figure D-1: NFS and PACR Levee Alignments for Reach A

The estimated hydraulic structures that were used for both proposed condition scenarios are shown in Figure D-2 below. The locations of the proposed structures were estimated by looking at existing channel crossings and placing hydraulic structures to adequately allow tidal exchange to occur. South of the GIWW, the PACR alternative includes a 56 ft. wide gated navigational structure and 9-6x6 ft. box culverts; the NFS alternative includes 7-6x6 box culverts south of the GIWW. North of the GIWW, the PACR alternative includes 7-6x6 ft. box culverts; the NFS alternative includes 3-6x6 box culverts North of the GIWW. Both alternatives include structures at the GIWW crossing and Miners Canal.

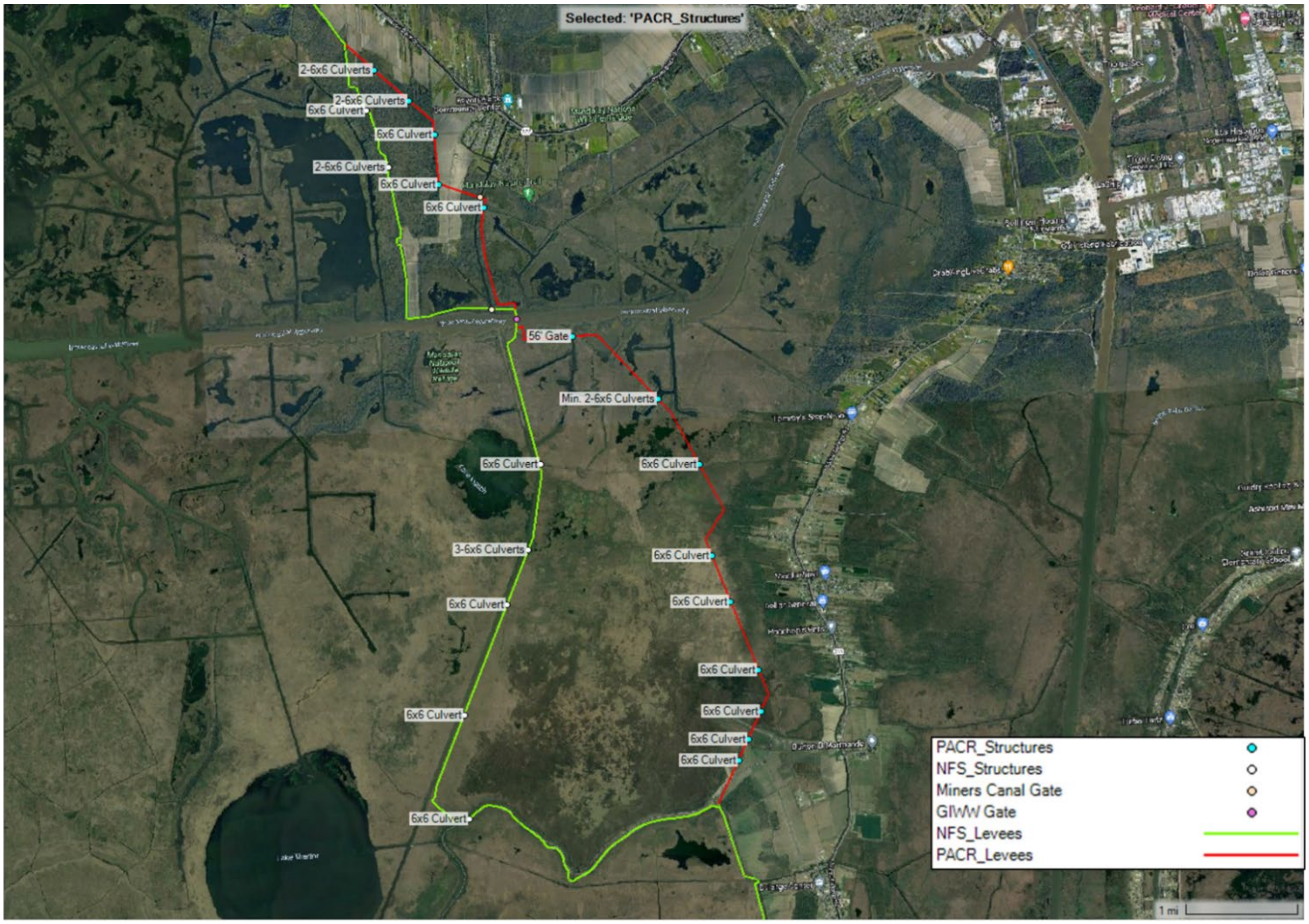

Figure D-2: Proposed Hydraulic Structures for both Reach A Alternatives

To best estimate the required number of box culverts for the PACR alternative, the “10% AEP precipitation only” event was run with varying structure counts and locations and these results were compared to the existing conditions. A profile line was drawn in HEC-RAS across the PACR alternative levee location south of the GIWW and the model total flow was retrieved for the “10% AEP precipitation only” event, the location of this total flow is shown in Figure D-3. Figure D-4 displays the flow results of each PACR structure count alternative (9, 11, and 13 – 6x6 Box Culverts) across that flow path, and Figure D-5 displays the total volume accumulation across the profile line. It can be seen that the existing condition total outflow peaks at a much greater total flow, and faster than the PACR alternatives. It can also be seen that the differences between the structure count alternatives are minor with regard to outflow and total volume. To further compare these results, the water surface elevation hydrograph was retrieved on the protected side of the Reach A levee; the location is shown in Figure D-6 and the Hydrograph is Figure D-7. When looking at the water surface elevation comparison, it can be seen that although the peak elevation is greater for the PACR alternatives, that the water quickly is able to recede to normal levels through the drainage structures, and there is only a minor difference between structure count alternatives. Based on these results, the structure count used for this analysis (South of the GIWW) is the 9-6x6 box culverts. It should be noted that the structure count and locations for the PACR alignment are estimates and should be further analyzed when considering the final design for this levee reach. The NFS alignment structure count and locations were retrieved from an initial estimate put together from the MTG PDT; this structure count was not refined from the initial estimate for this analysis.

Figure D-3: HEC-RAS Profile Line (in Green) to Retrieve Total Flow across the area South of the GIWW

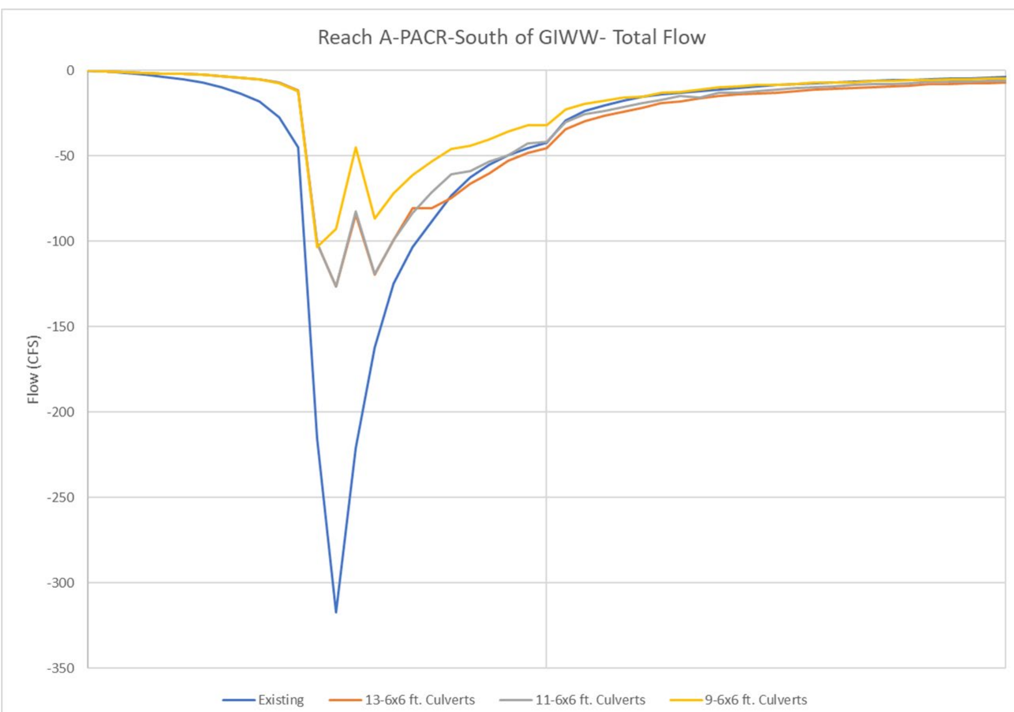

Figure D-4: HEC-RAS Profile Line Total Flow Hydrograph - PACR Alternative Structure Count Comparison – 10% AEP Precipitation Only Event

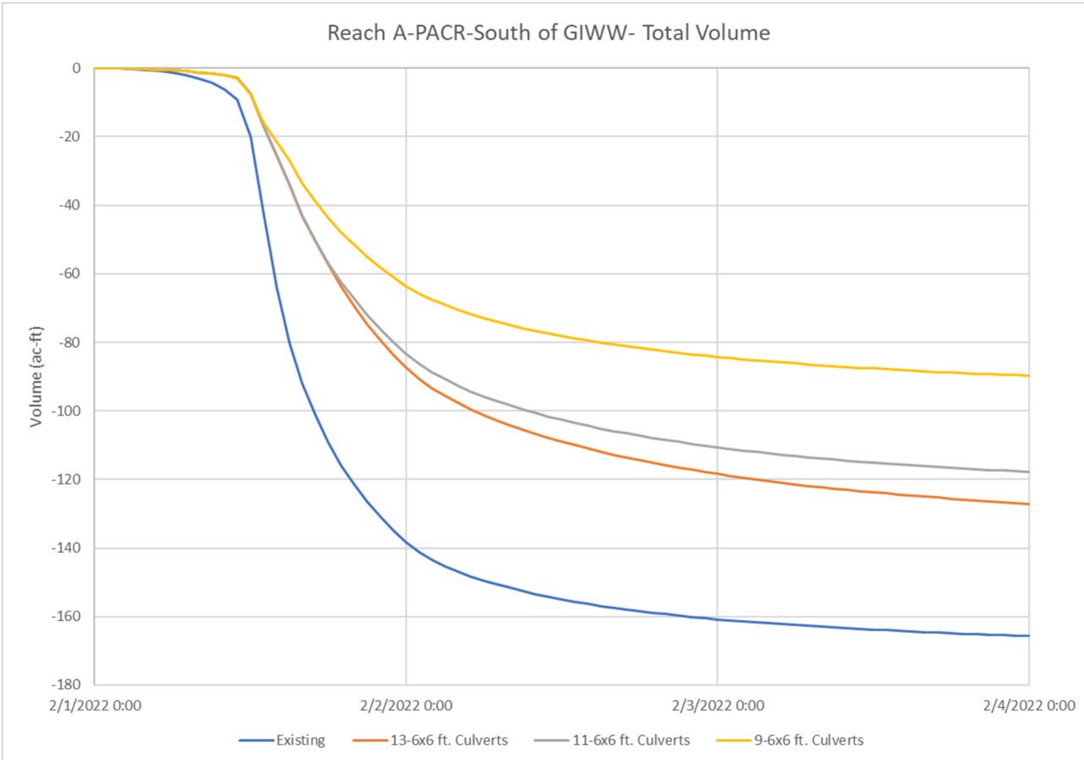

Figure D-5: HEC-RAS Profile Line Total Volume Accumulation Hydrograph - PACR Alternative Structure Count Comparison – 10% AEP Precipitation Only Event

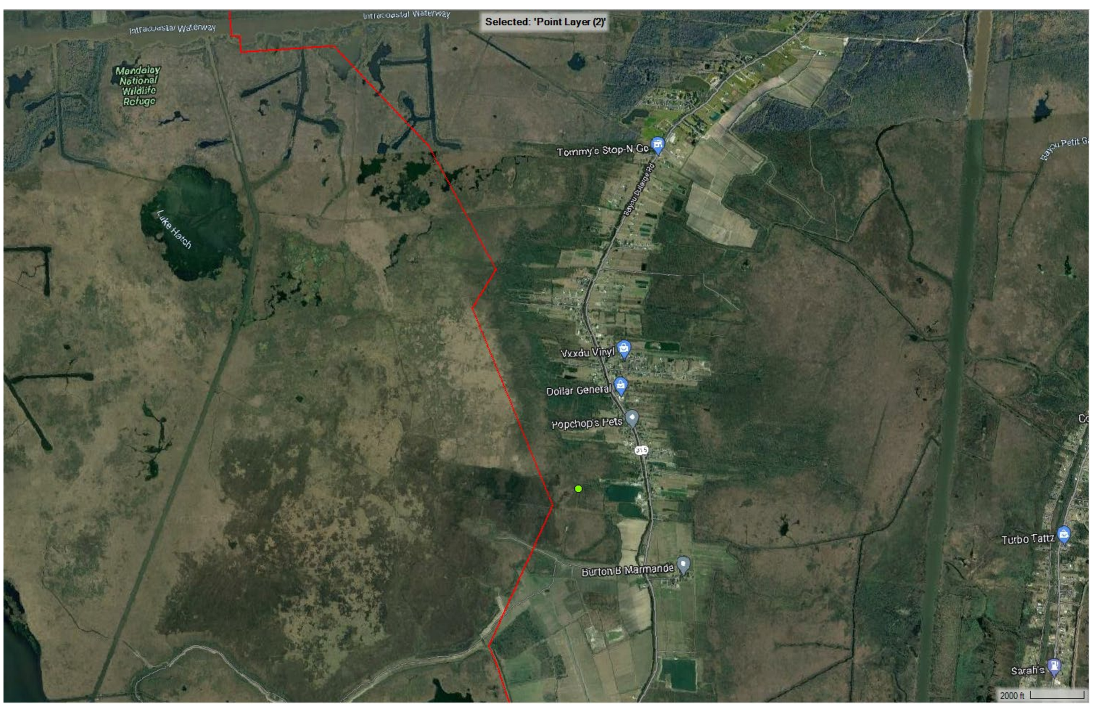

Figure D-6: Hydrograph Output Location - PACR Alternative Structure Count Comparison – 10% AEP Precipitation Only Event

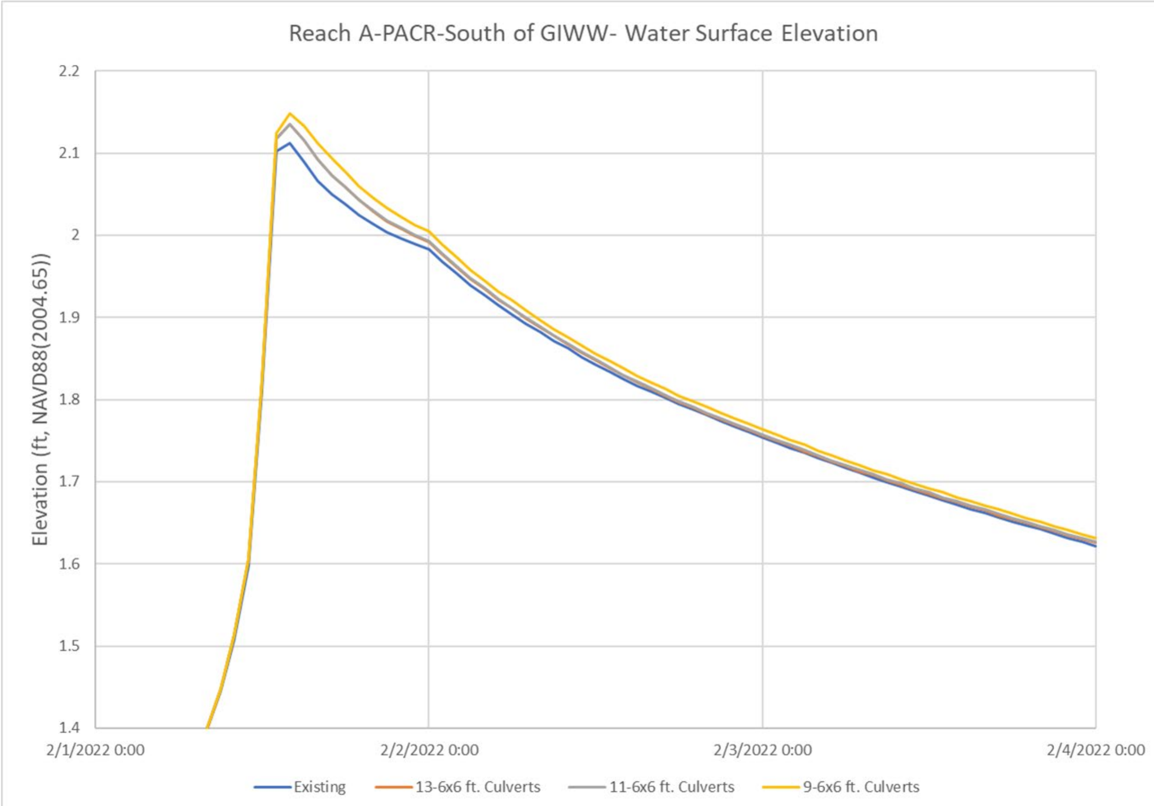

Figure D-7: Water Surface Elevation - PACR Alternative Structure Count Comparison – 10% AEP Precipitation Only Event

The following scenarios were analyzed using the HEC-RAS model to compare the resulting water surface elevations. The results are compiled in this Appendix.

Table D-1: Reach A Comparison Scenarios

Scenario 1	10% AEP Precipitation and Low Storm Surge (0.7 ft. Boundary) - Existing Conditions VS. Proposed (PACR and NFS Alternatives)
Scenario 2	10% AEP Precipitation and 10% AEP Storm Surge - Existing Conditions VS. Proposed (PACR and NFS Alternatives)
Scenario 3	1% AEP Precipitation and 10% AEP Storm Surge – Existing Conditions VS. Proposed (PACR and NFS Alternatives)
Scenario 4	10% AEP Precipitation and 10% AEP Storm Surge and 10% AEP Atchafalaya River Flow – Existing Conditions VS. Proposed (PACR and NFS Alternatives)

For the scenarios with a high storm surge boundary, the gates along the MTG system are closed for two simulation days. The storm surge hydrographs and precipitation both peak during the first 24 hours; furthermore, precipitation occurs for a duration of 24 hours. Once the storm surge boundary recedes to approximately 2.0 feet NAVD88, the gates are opened, and water can be released out of the system. The boundary conditions for the “10% AEP precipitation and 10% AEP storm surge” event are displayed in Figure D-8. The “Left” and “Middle” Storm Surge hydrographs correspond to the location around the full MTG levee system; these are explained in Figure 9 in the main report.

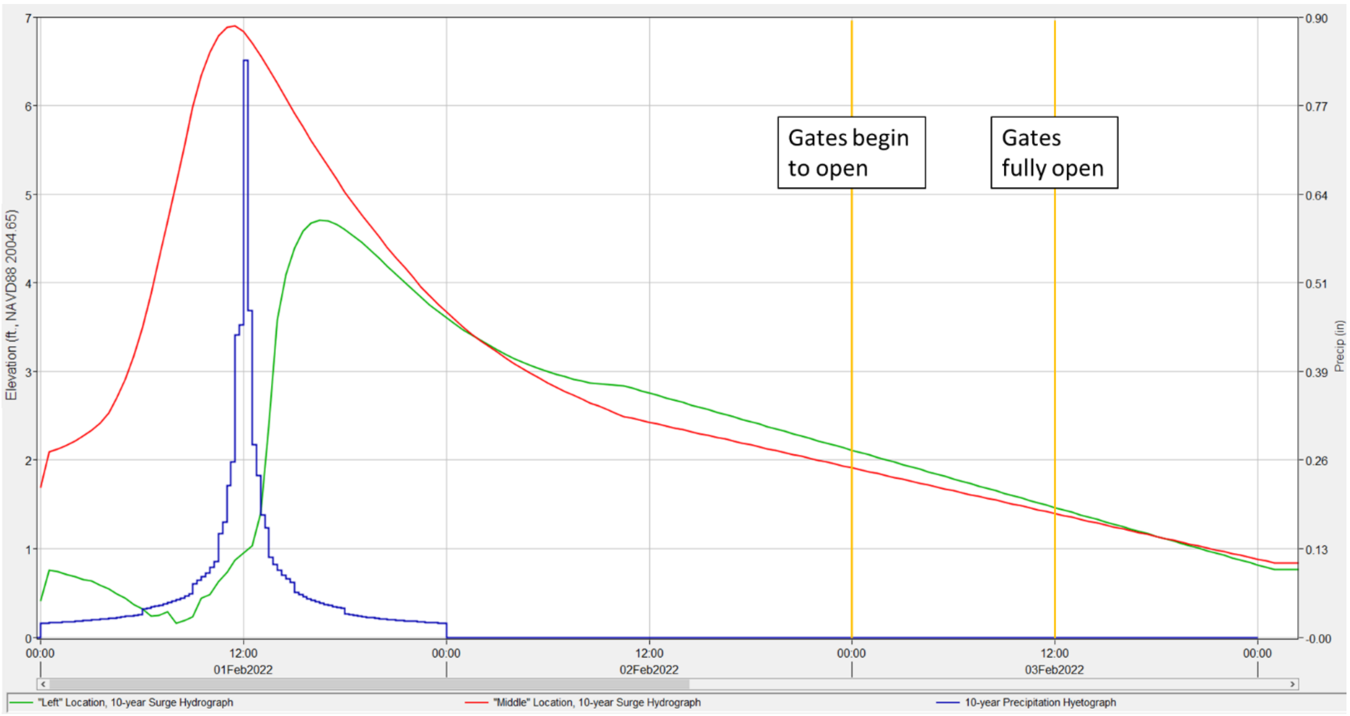

Figure D-8: 10% AEP Precipitation Hyetograph and 10% AEP Storm Surge Hydrograph

SCENARIO 1: 10% AEP Precipitation and Low Storm Surge Event

The three geometry conditions (Existing Levee, NFS, and PACR Alignments) were run in the 2D HEC-RAS model for the 10% AEP precipitation and low storm surge event (0.7 ft. constant boundary elevation), and the results are compiled below. The gates for this scenario are open for this entire event.

The results for each water depth plot are at simulation time 02FEB2022 0200. This time was chosen because HEC-RAS overlays precipitation over each 2D cell, and thus during the precipitation event occurring, the depth layer shows water in each cell; its only after the precipitation ends that the depth layer shows the true extent of inundation. The simulation time that was chosen is immediately after the precipitation event occurs and precipitation values are at 0 inches.

The first set of results, shown in Figures D-9 and D-10, display the water depths for each alternative. These results are intended to show the extent of inundation after the storm surge and precipitation event. The water levels for each condition are very similar, indicating that the location of the Reach A levee does not greatly affect the total inundation area coverage during the 10% AEP precipitation and low storm surge event, based on the two designs.

The second set of Figures, Figures D-11 through D-13, show the difference in maximum water surface elevation between each scenario, with accompanying hydrographs at locations of interest. The difference grids are set to only display differences levels greater than .07 feet. For these results, highlighted in red are areas that increase in water surface elevation, and blue that decrease in water surface elevation. The largest water surface elevation increase when comparing the PACR alternative to the Existing Conditions is approximately 0.3 ft. The largest water surface elevation increase when comparing the NFS alternative to the Existing Conditions is approximately 0.5 ft. These results show the maximum water level differences are relatively low between scenarios, and the hydrographs highlight that both alternatives are able to evacuate water out of the system effectively with the gates open.

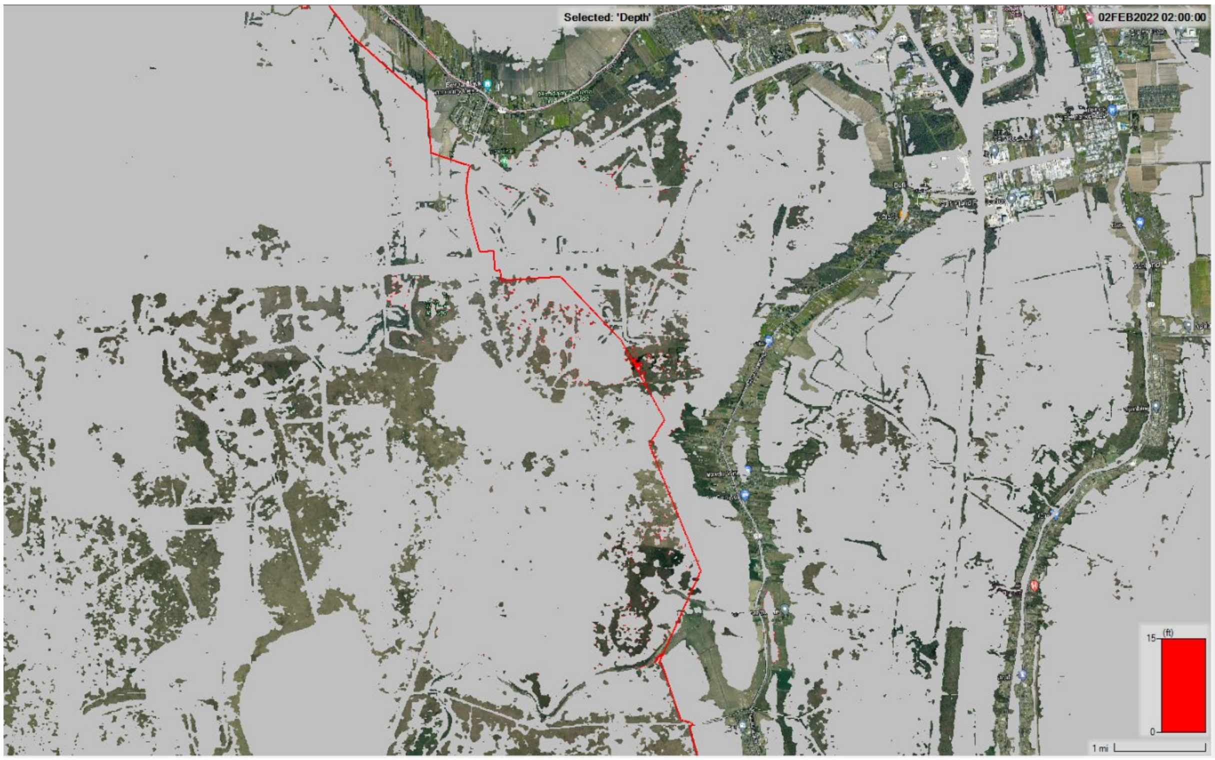

Figure D-9: 10% AEP Precipitation and Low Storm Surge Event – Existing Conditions (Gray) and PACR Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

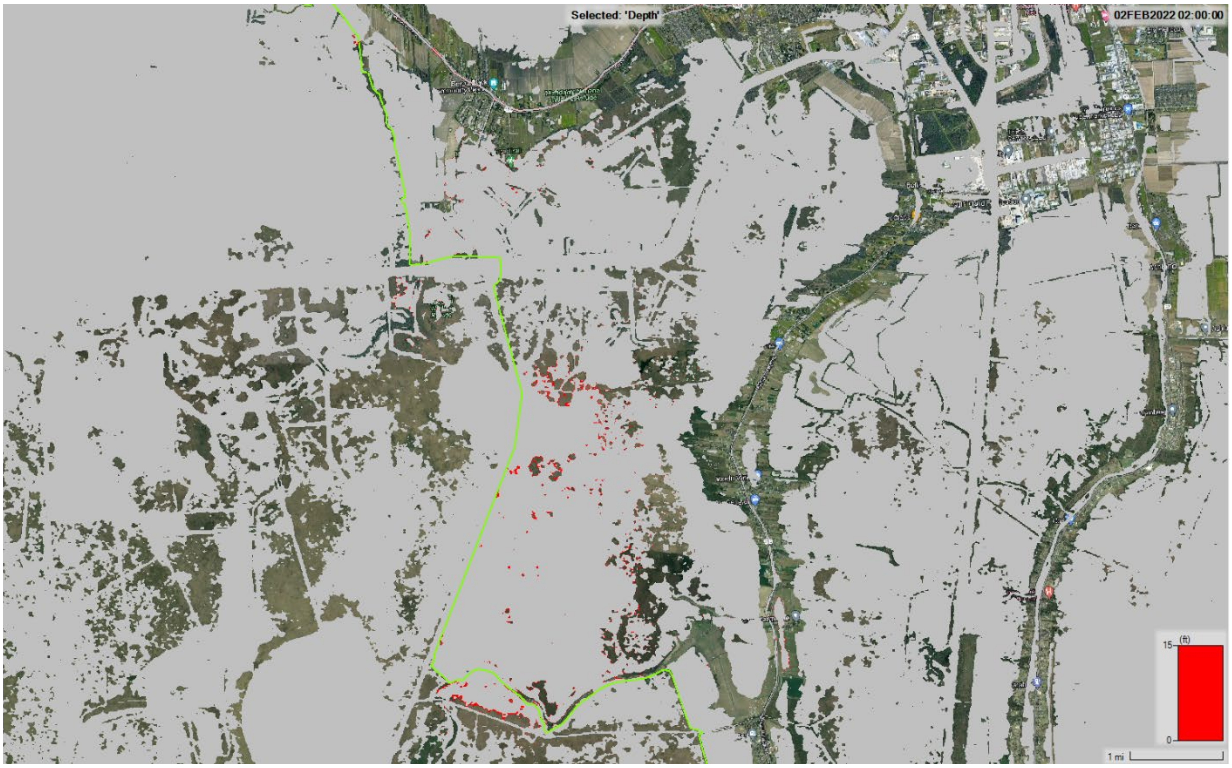

Figure D-10: 10% AEP Precipitation and Low Storm Surge Event – Existing Conditions (Gray) and NFS Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

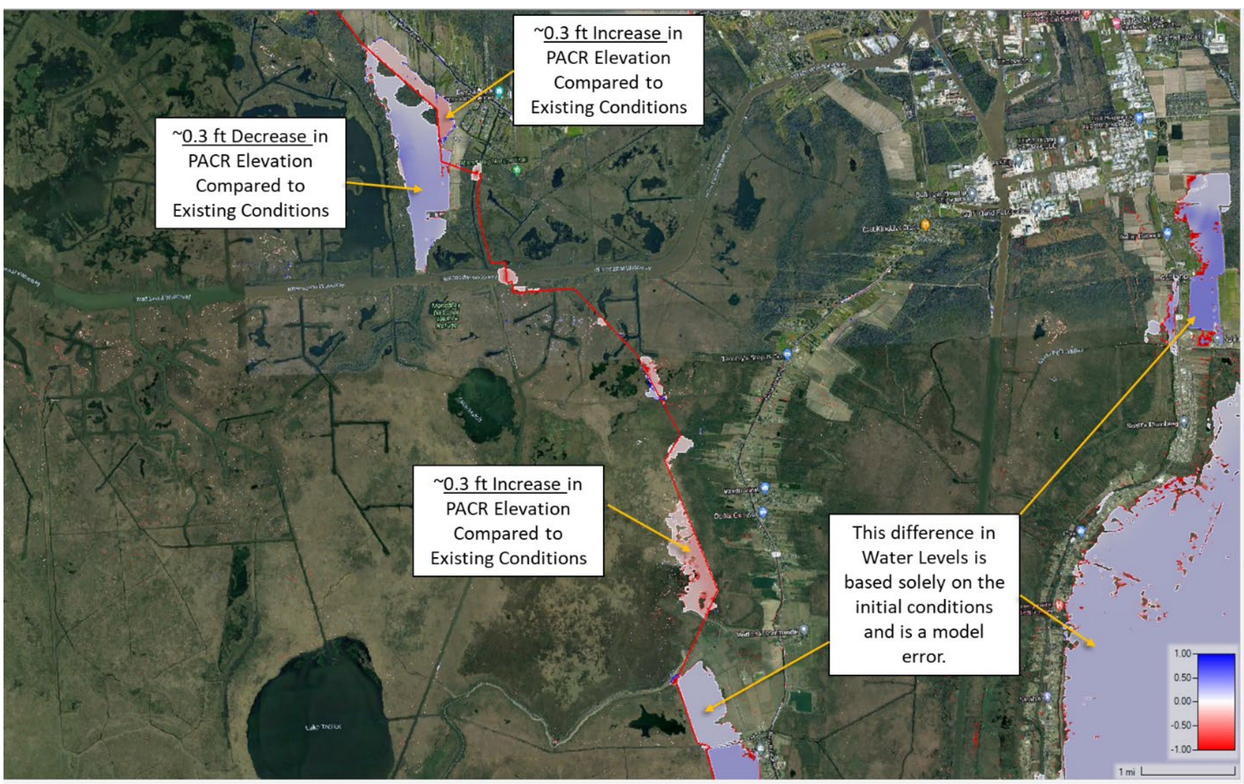

Figure D-11: 10% AEP Precipitation and Low Storm Surge Event – Difference in water surface elevation – Existing Conditions minus Proposed (PACR) Conditions at maximum water surface elevation

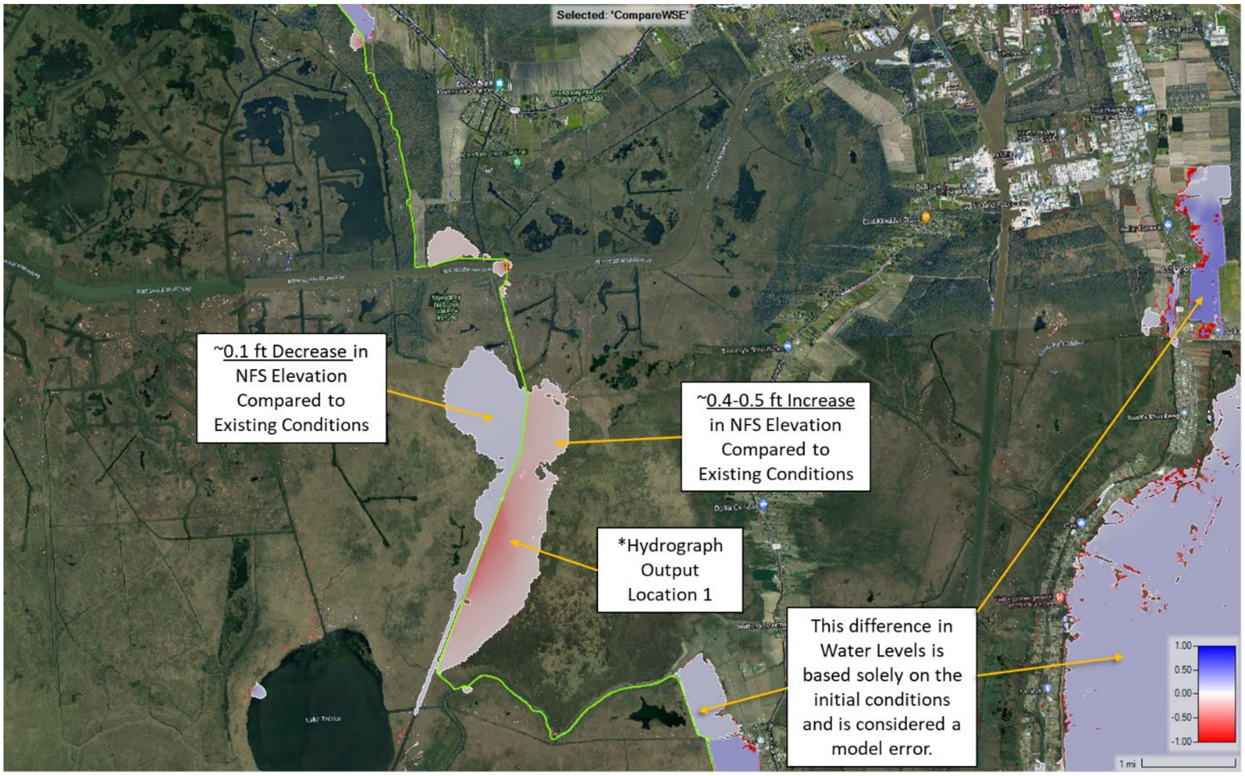

Figure D-12: 10% AEP Precipitation and Low Storm Surge Event – Difference in water surface elevation – Existing Conditions minus Proposed (NFS) Conditions at maximum water surface elevation

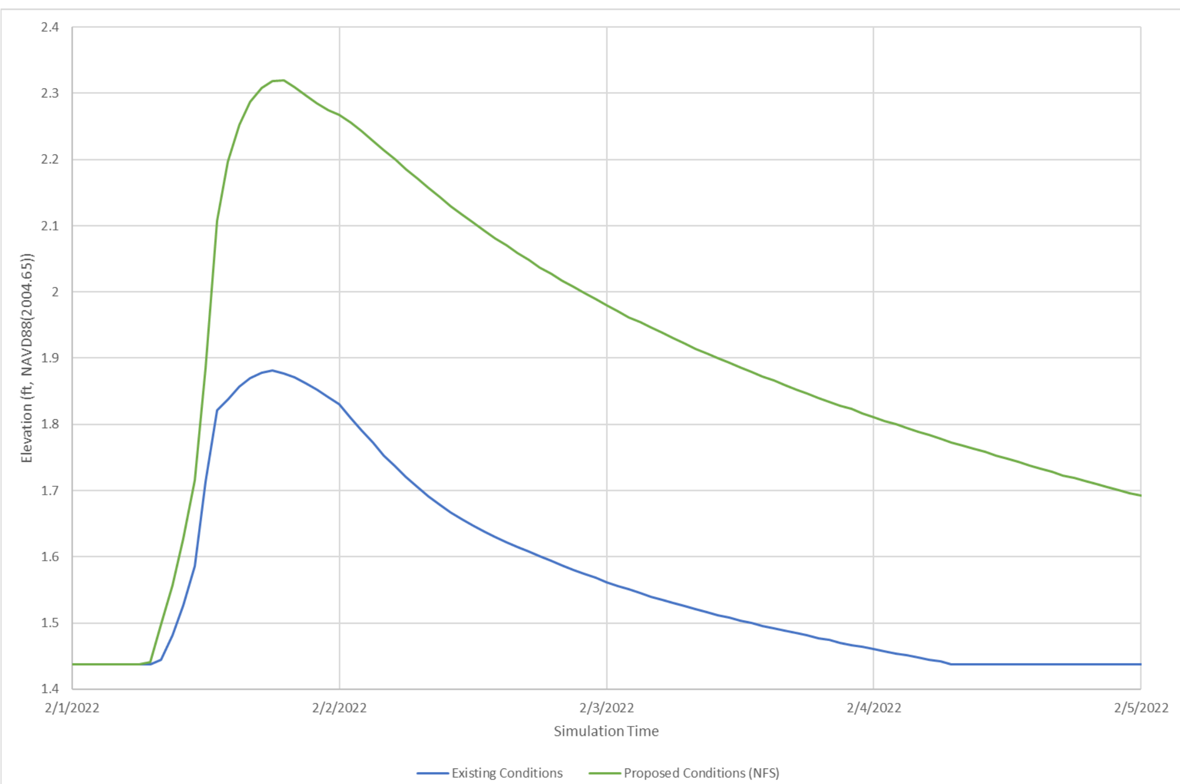

Figure D-13: 10% AEP Precipitation and Low Storm Surge Event –Existing Conditions and Proposed (NFS) at Hydrograph Location 1

SCENARIO 2: 10% AEP Precipitation and 10% AEP Storm Surge Event

The three geometry conditions (Existing Levee, NFS, and PACR Alignments) were run in the 2D HEC-RAS model for the 10% AEP precipitation and 10% AEP storm surge event, and the results are compiled below. The gates for this scenario are closed until simulation time 03FEB2022 00:00, and they become fully opened at 03FEB2022 12:00. The 12-hour lag time to get the gates fully open is implemented to estimate the time that it takes the maintenance staff to get all gates open around the levee system.

The first set of results, shown in Figures D-14 through D-18, display the water depths for each alternative. These results are intended to show the extent of inundation after the storm surge and precipitation event. The water levels for each condition are very similar, indicating that the location of the Reach A levee does not greatly affect the total inundation area coverage during the 10% AEP precipitation and storm surge event, based on the two designs.

The second set of Figures, Figures D-17 through D-25, show the difference in maximum water surface elevation between each scenario, with accompanying hydrographs at locations of interest. For these results, highlighted in red are areas that increase in water surface elevation, and blue that decrease in water surface elevation. The largest water surface elevation increase when comparing the PACR alternative to the Existing Conditions is approximately 0.3 ft. The largest water surface elevation increase when comparing the NFS alternative to the Existing Conditions is approximately 0.1 ft. These results show the maximum water level differences are relatively low between scenarios, and the hydrographs highlight that both alternatives are able to evacuate water out of the system effectively once the storm surge recedes and the gates are opened. The interior of the levee system around Reach A benefits from being able to have the gates closed and not allow the storm surge to push into the system. For this reason, both Reach A alternatives show locations with lower water levels when compared to existing conditions for this scenario.

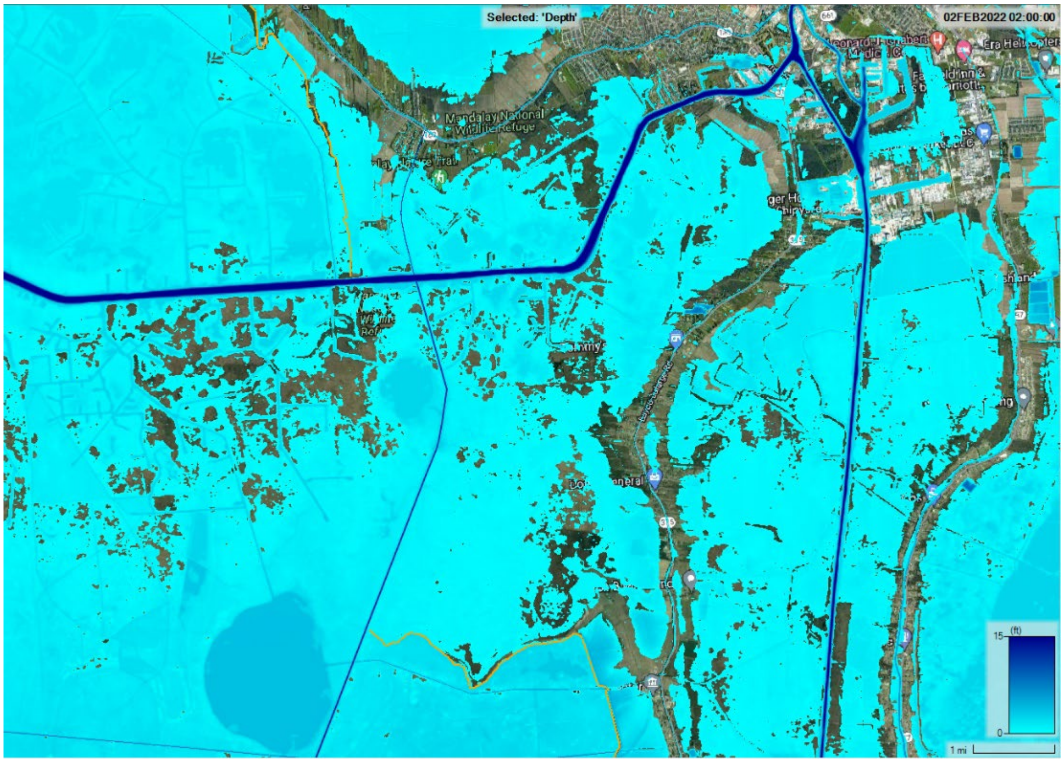

Figure D-14: 10% AEP Precipitation and 10% AEP Storm Surge Event - Existing Conditions – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

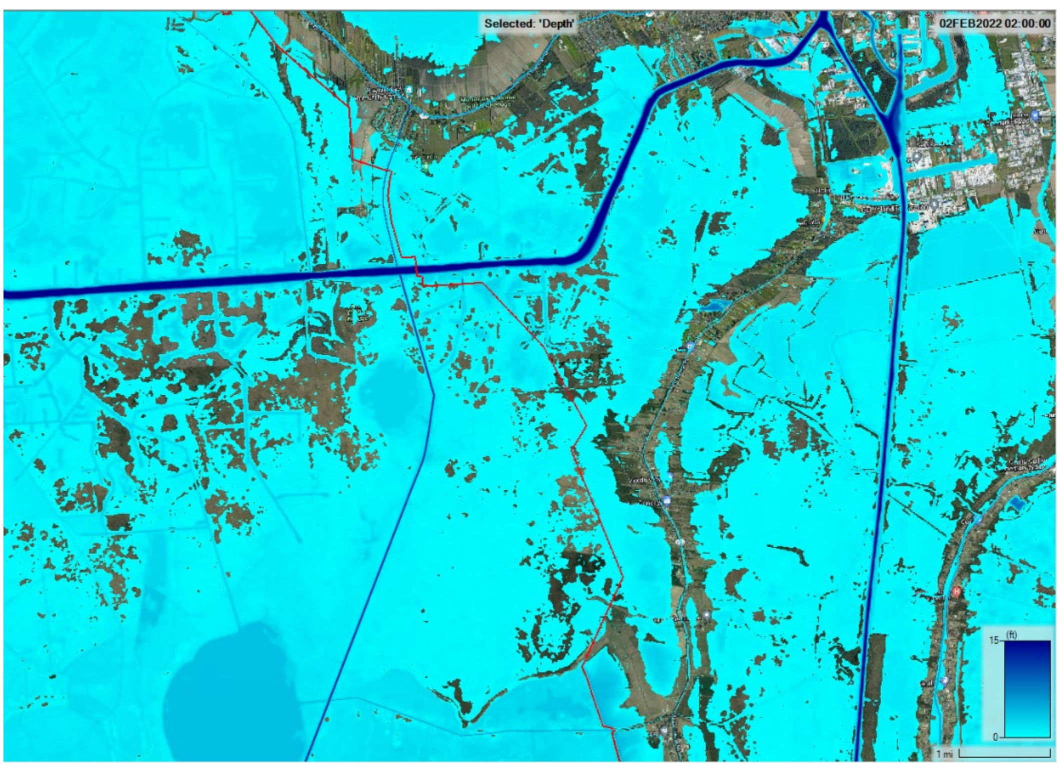

Figure D-15: 10% AEP Precipitation and 10% AEP Storm Surge Event – PACR Alignment Conditions – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

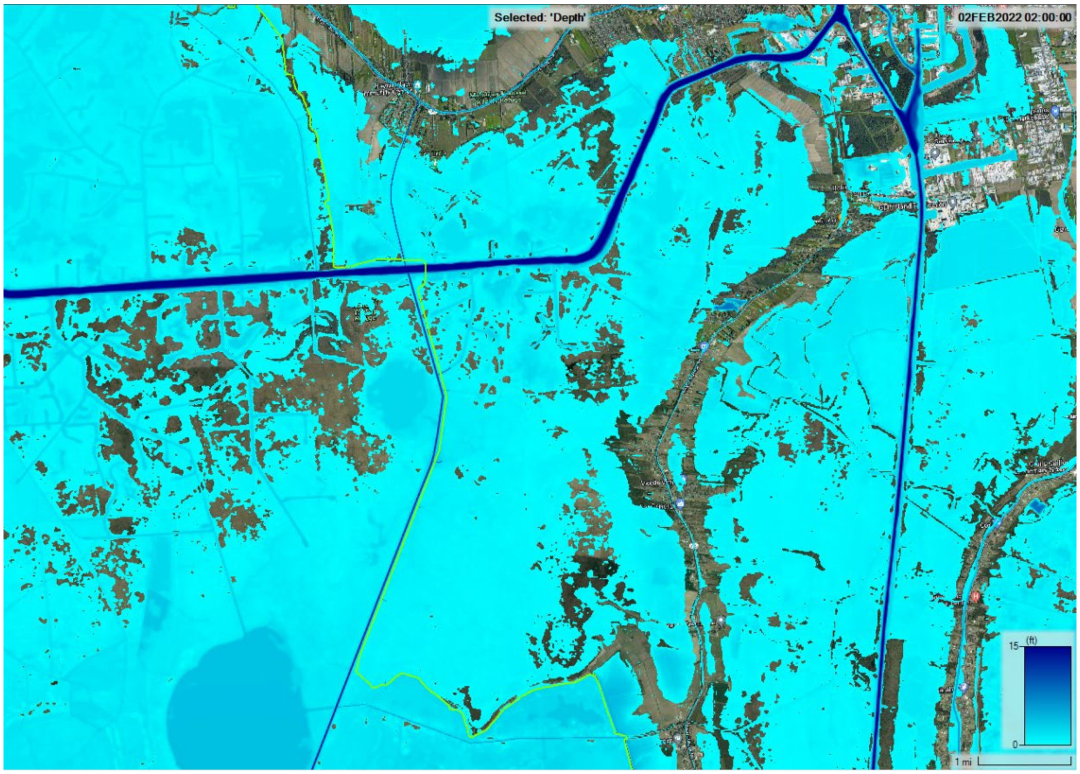

Figure D-16: 10% AEP Precipitation and 10% AEP Storm Surge Event – NFS Alignment Conditions – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

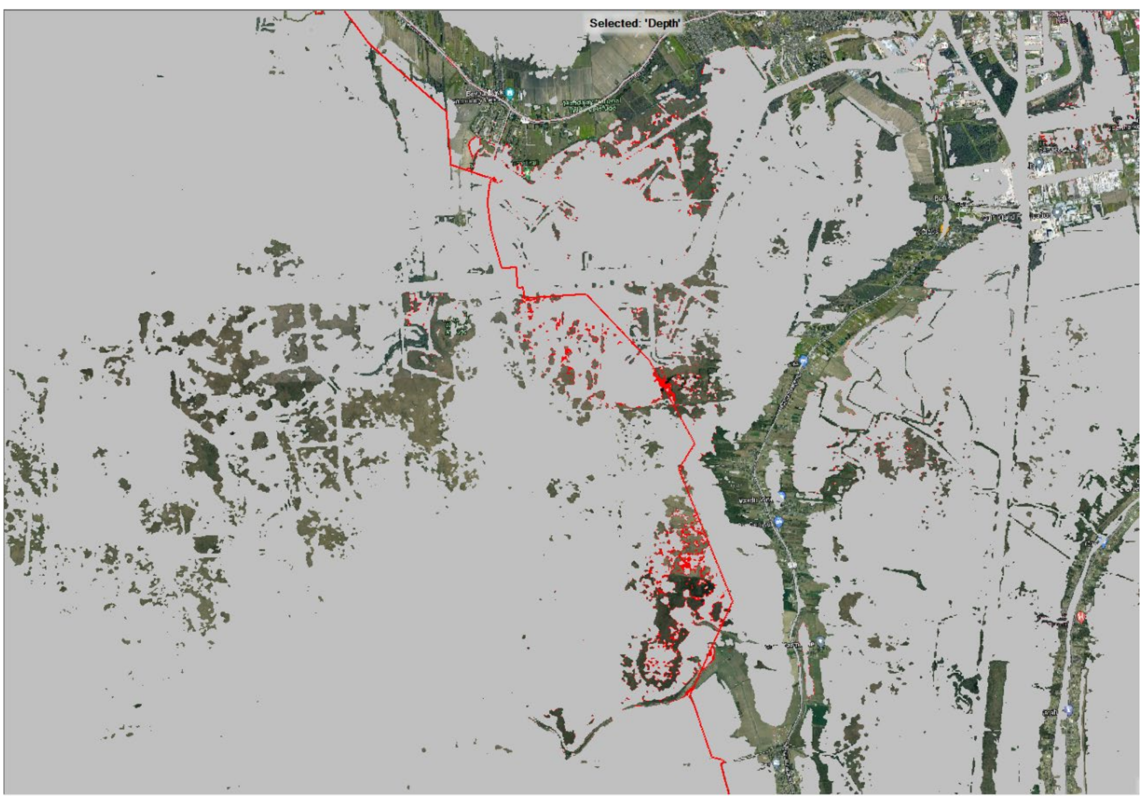

Figure D-17: 10% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions (Gray) and PACR Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

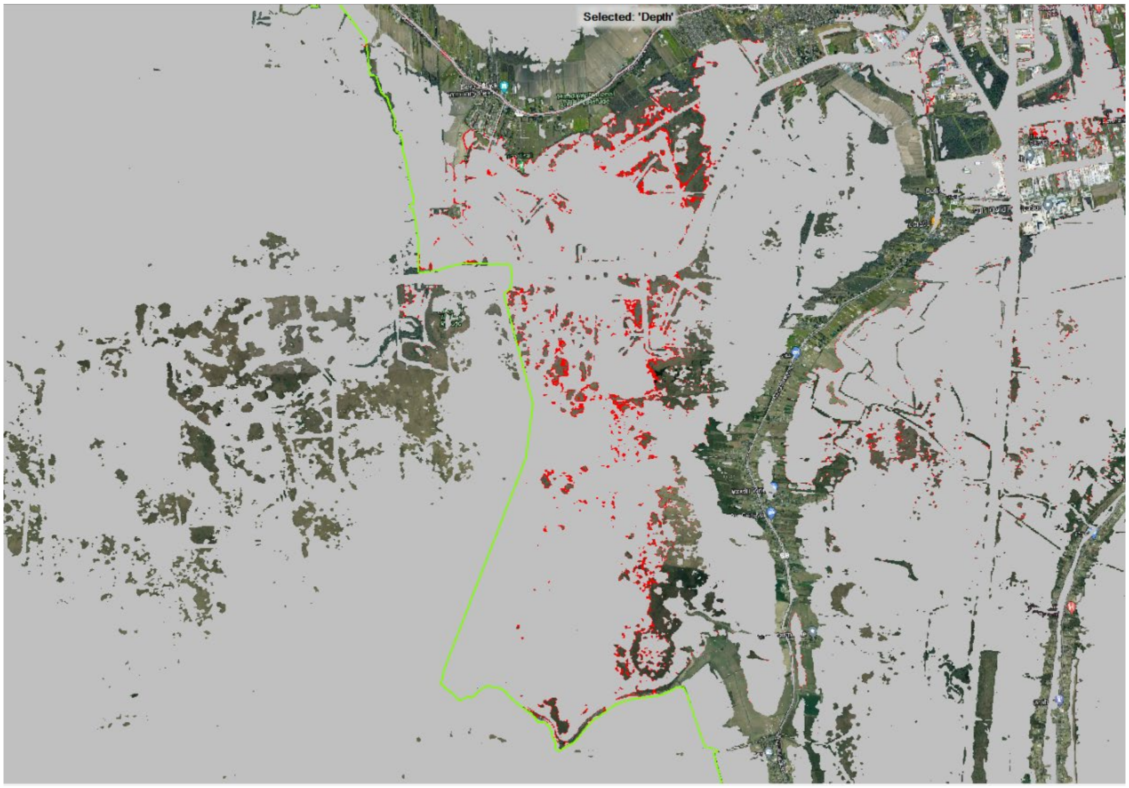

Figure D-18: 10% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions (Gray) and NFS Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

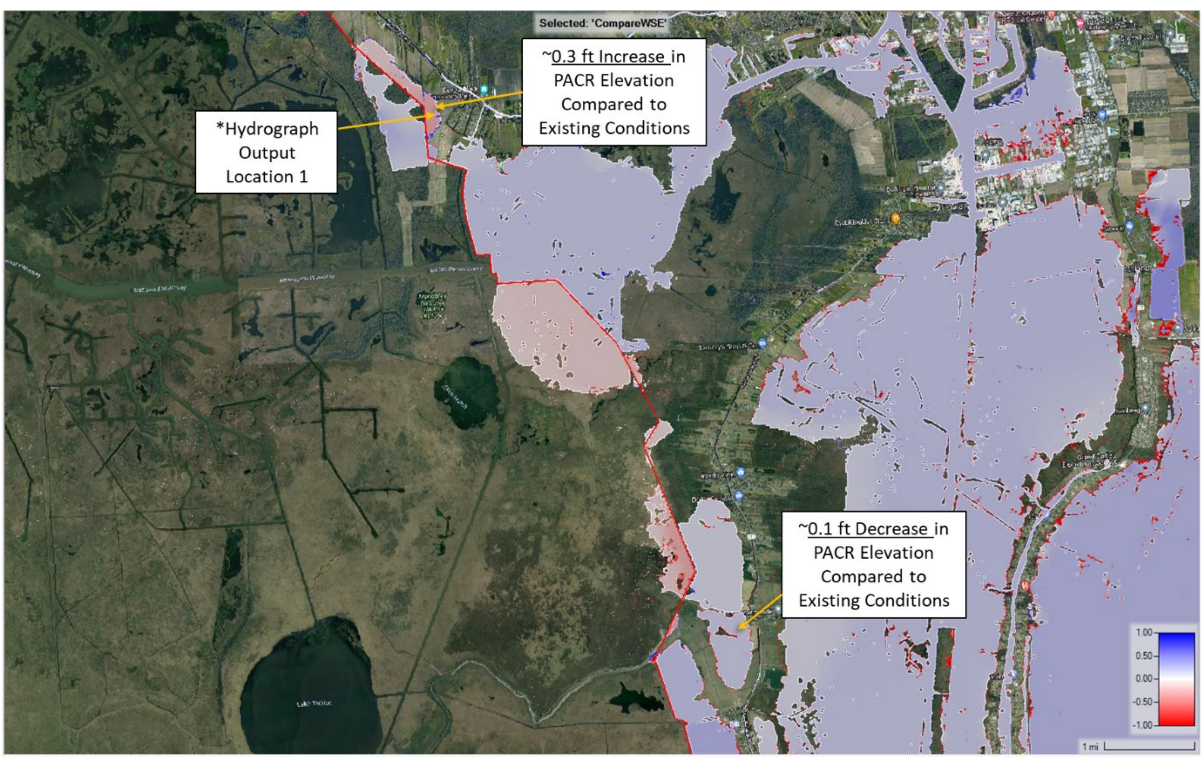

Figure D-19: 10% AEP Precipitation and 10% AEP Storm Surge Event – Difference in water surface elevation – Existing Conditions minus Proposed (PACR) Conditions at maximum water surface elevation

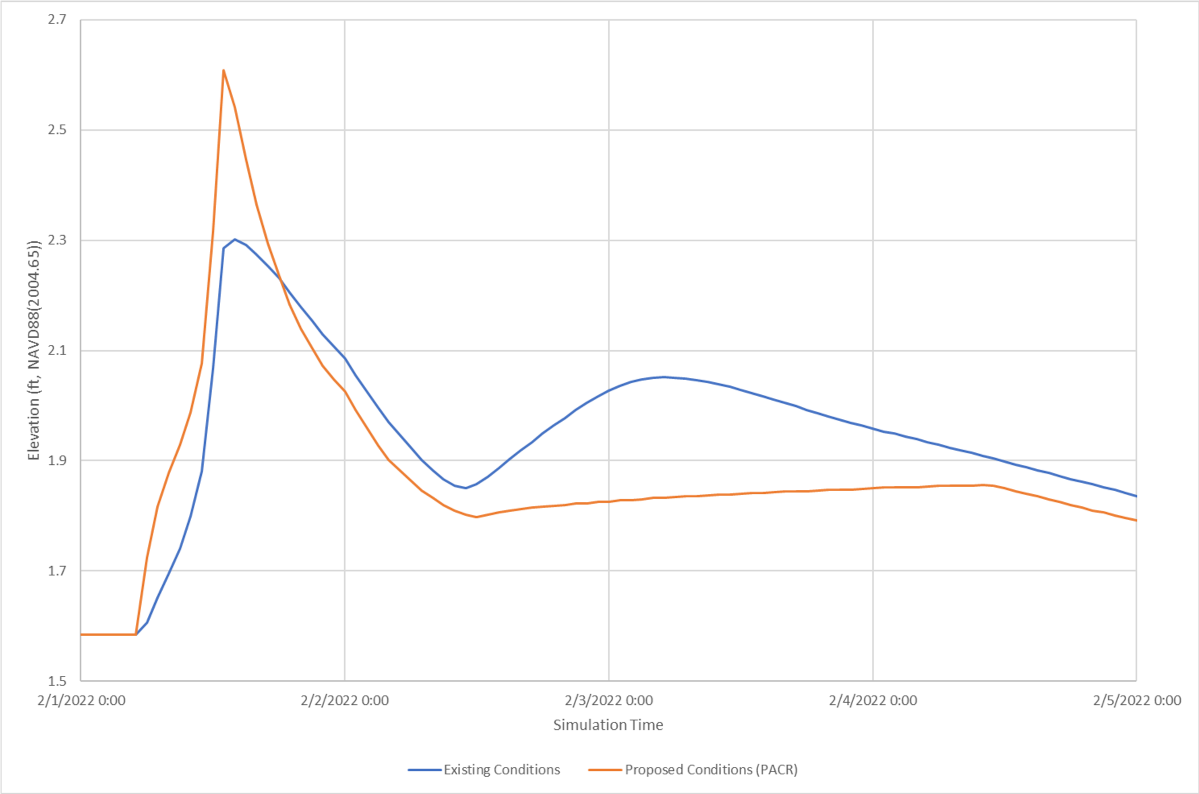

Figure D-20: 10% AEP Precipitation and 10% AEP Storm Surge Event –Existing Conditions and Proposed (PACR) at Hydrograph Location 1

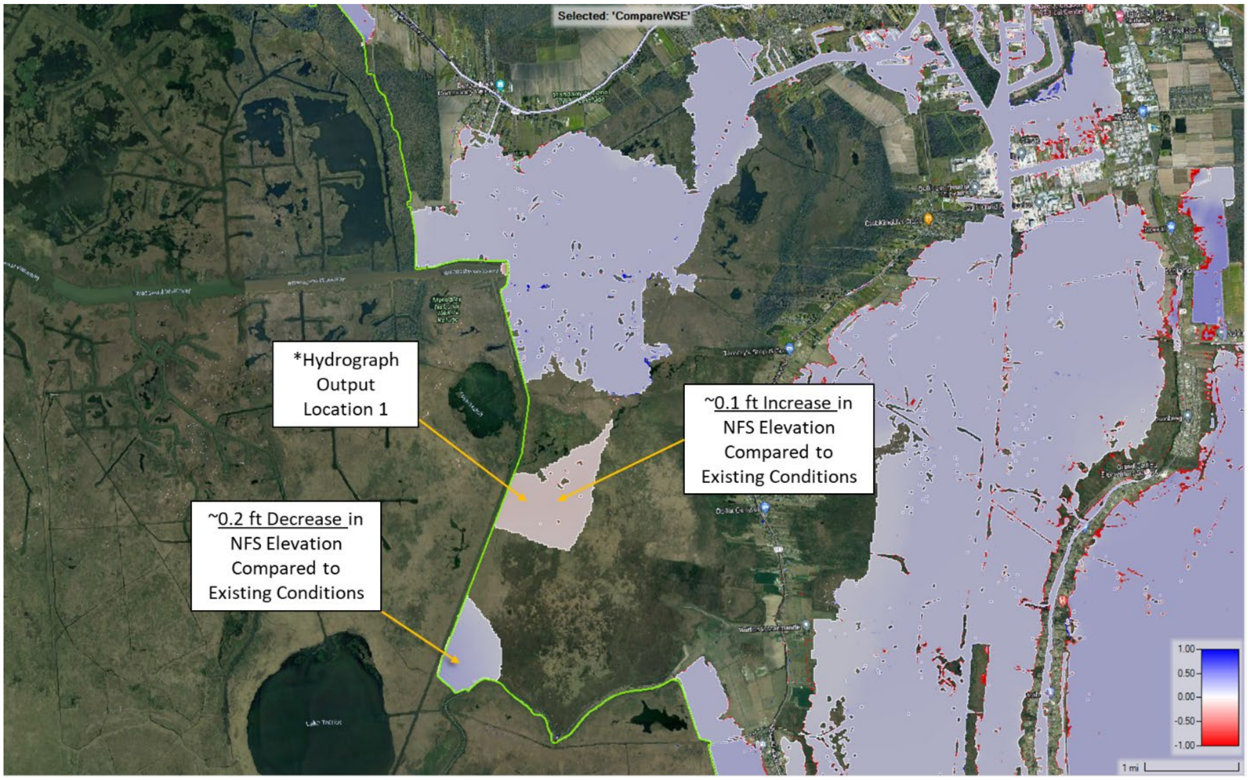

Figure D-21: 10% AEP Precipitation and 10% AEP Storm Surge Event – Difference in water surface elevation – Existing Conditions minus Proposed (NFS) Conditions at maximum water surface elevation

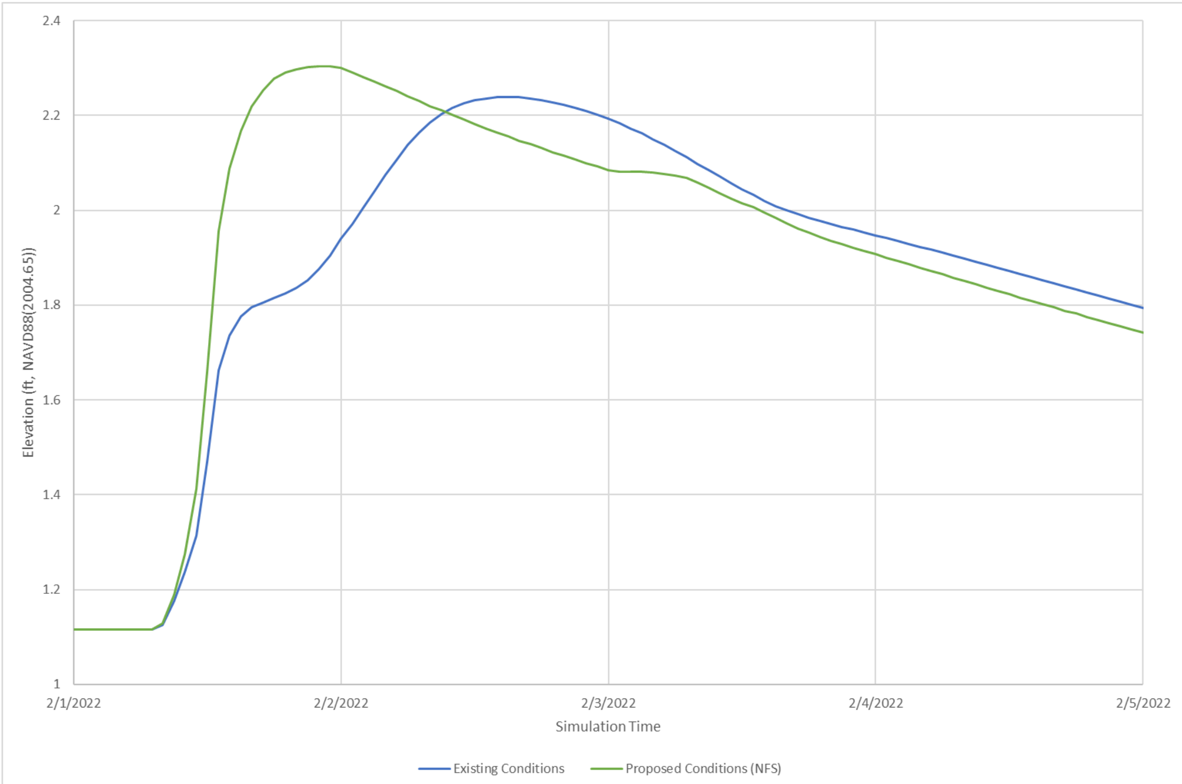

Figure D-22: 10% AEP Precipitation and 10% AEP Storm Surge Event –Existing Conditions and Proposed (NFS) at Hydrograph Location 1

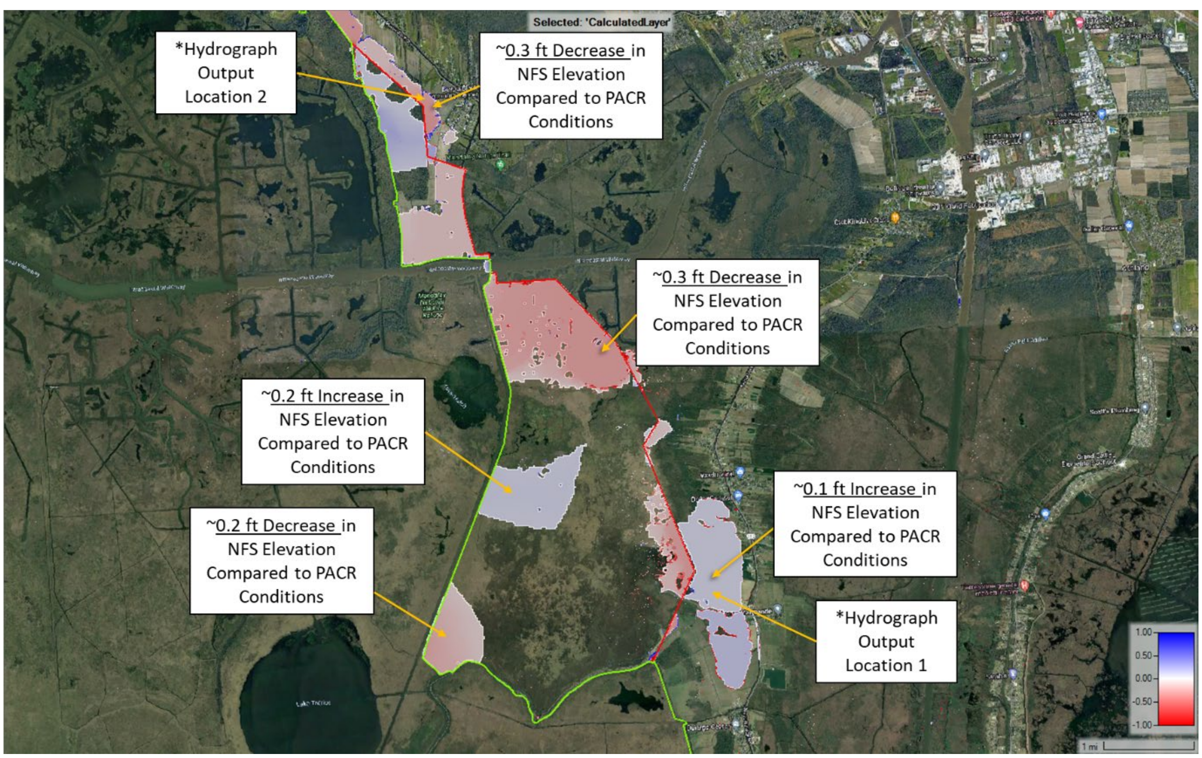

Figure D-23: 10% AEP Precipitation and 10% AEP Storm Surge Event – Difference in water surface elevation – Proposed (NFS) minus Proposed (PACR) Conditions at maximum water surface elevation

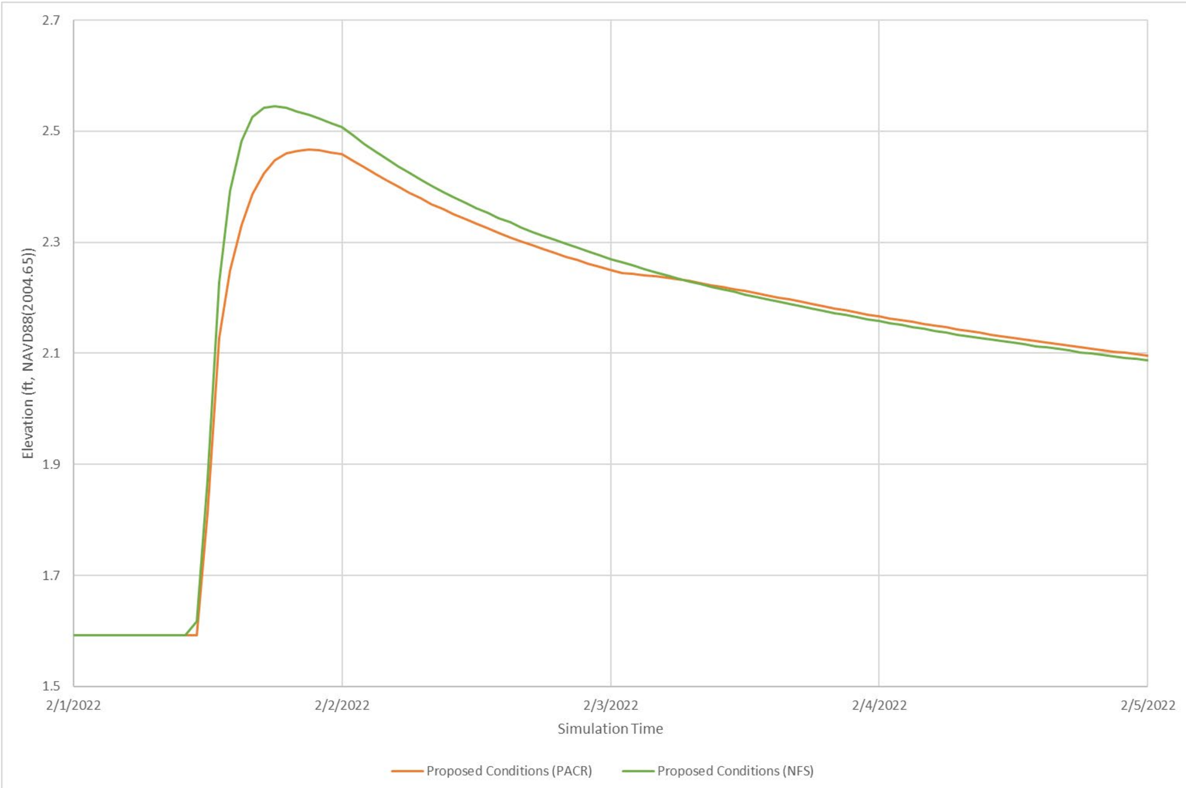

Figure D-24: 10% AEP Precipitation and 10% AEP Storm Surge Event –Proposed (PACR) and Proposed (NFS) at Hydrograph Location 1

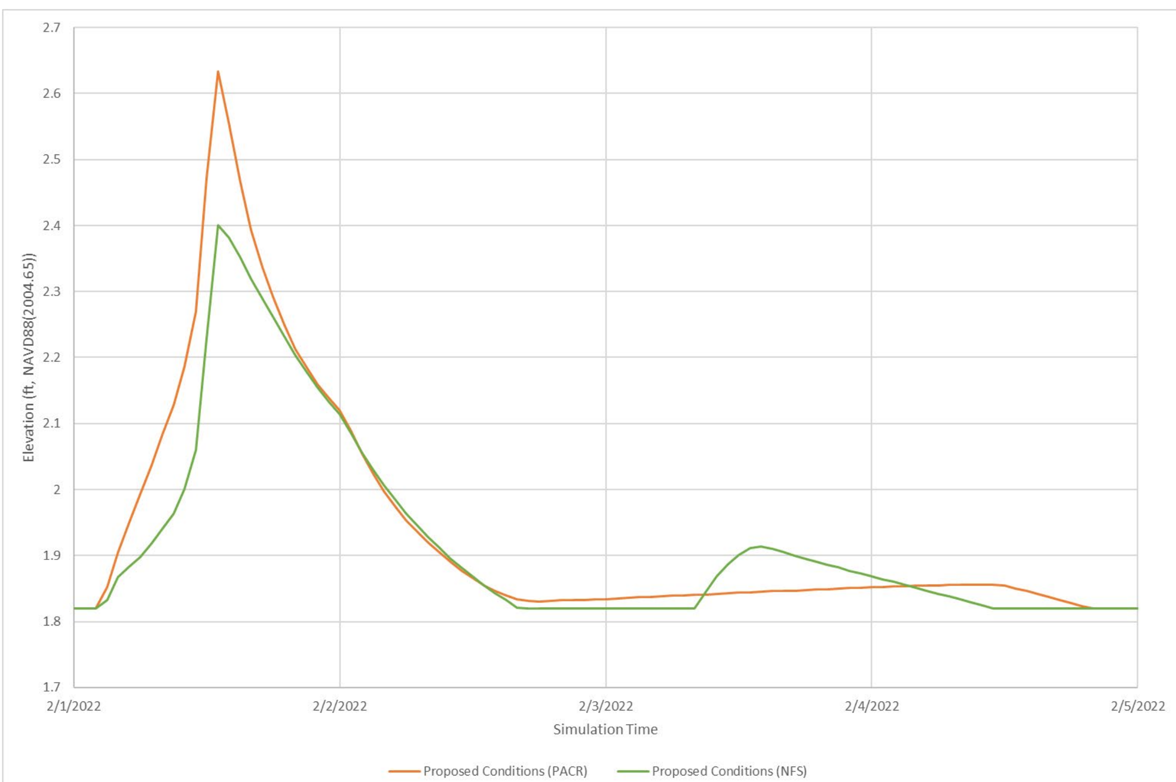

Figure D-25: 10% AEP Precipitation and 10% AEP Storm Surge Event – Proposed (PACR) and Proposed (NFS) at Hydrograph Location 2

SCENARIO 3: 1% AEP Precipitation and 10% AEP Storm Surge Event

The three geometry conditions (Existing Levee, NFS, and PACR Alignments) were run in the 2D HEC-RAS model for the 1% AEP precipitation and 10% AEP storm surge event, and the results are compiled below. The gates for this scenario are closed until simulation time 03FEB2022 00:00, and they become fully opened at 03FEB2022 12:00. The gates were closed for this scenario to achieve the most conservative result. In reality some of the hydraulic structures may have the ability to be opened if the headwater is greater than the tailwater, but for conservativity sake the gates remained closed until the storm surge receded.

The results for this scenario are similar to the “10% AEP precipitation and 10% AEP storm surge” event, but with a larger water surface elevation difference and coverage. From Figures D-26 through D-32, the inundation coverage for both the PACR and NFS alternatives are very similar to the existing conditions event, and do not show a significant increase in coverage.

The second set of Figures, Figures D-33 through D-40, show the difference in maximum water surface elevation between each scenario, with accompanying hydrographs at locations of interest. For these results, highlighted in red are areas that increase in water surface elevation, and blue that decrease in water surface elevation. The largest water surface elevation increase when comparing the PACR alternative to the Existing Conditions is approximately 0.2 ft. The largest water surface elevation increase when comparing the NFS alternative to the Existing Conditions is approximately 0.2 ft.

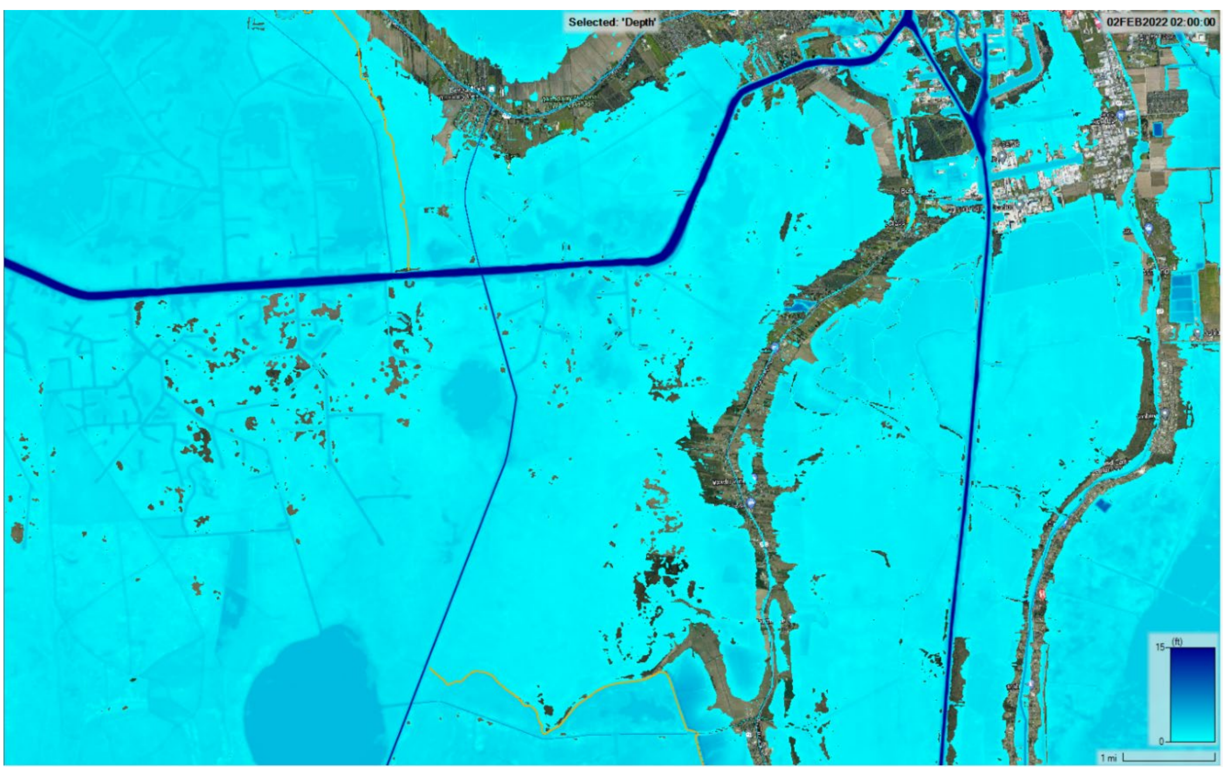

Figure D-26: 1% AEP Precipitation and 10% AEP Storm Surge Event - Existing Conditions – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

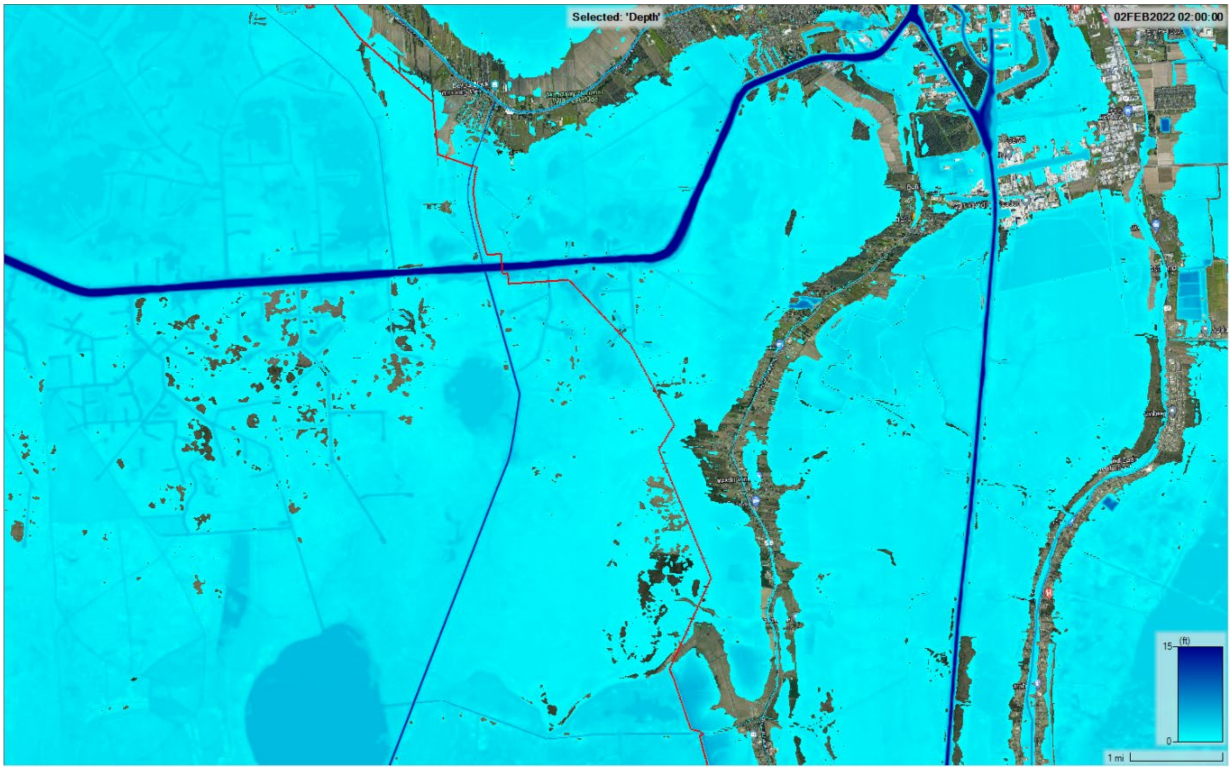

Figure D-27: 1% AEP Precipitation and 10% AEP Storm Surge Event – PACR Alignment Conditions – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

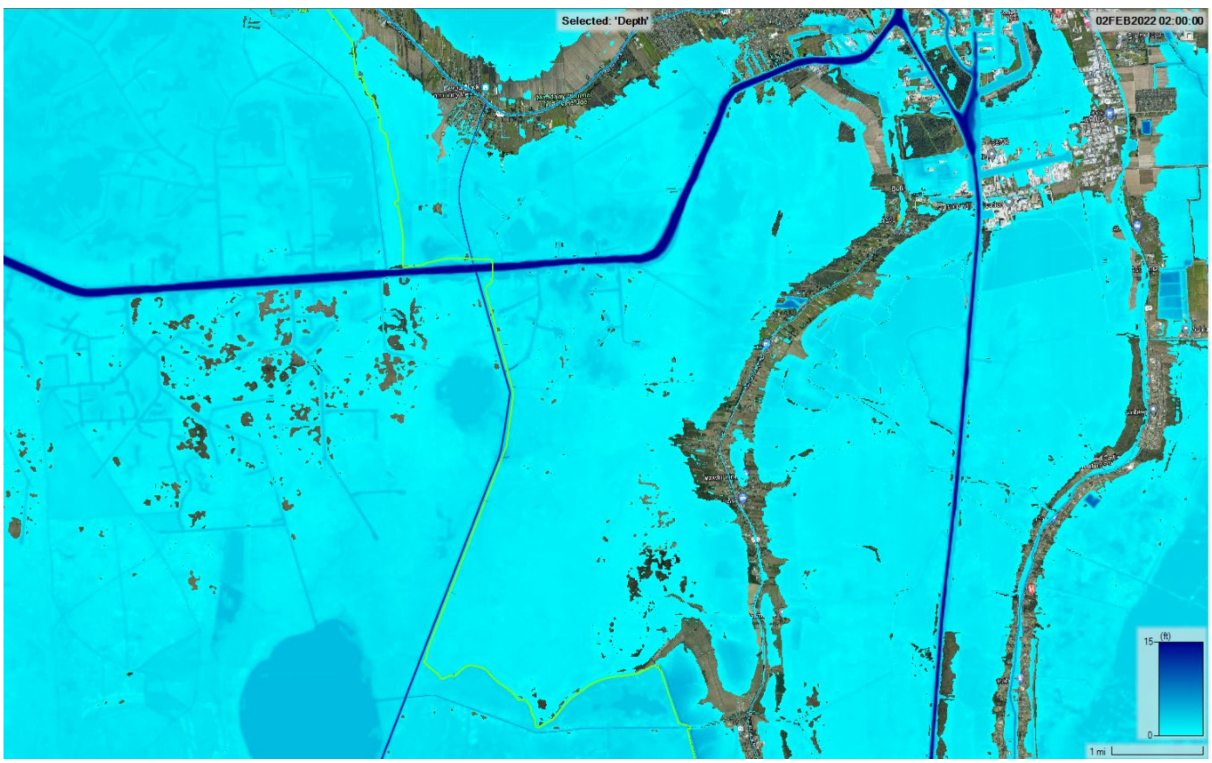

Figure D-28: 1% AEP Precipitation and 10% AEP Storm Surge Event – NFS Alignment Conditions – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

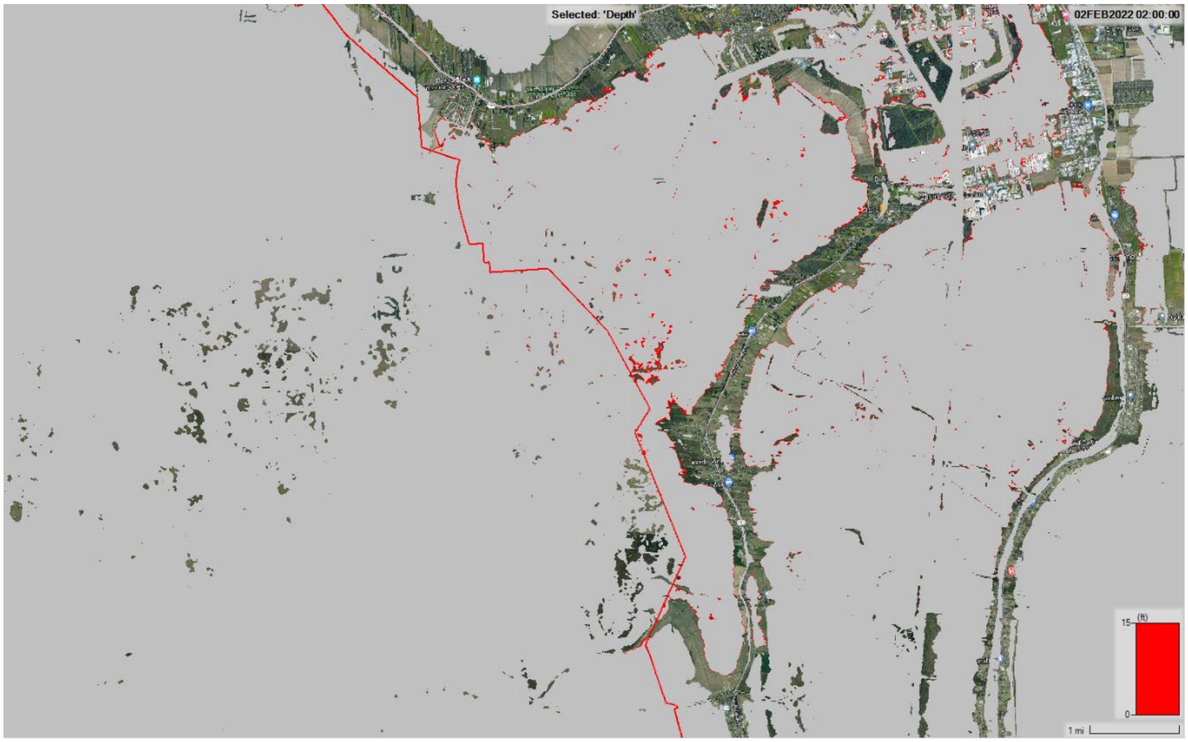

Figure D-29: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions (Gray) and PACR Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

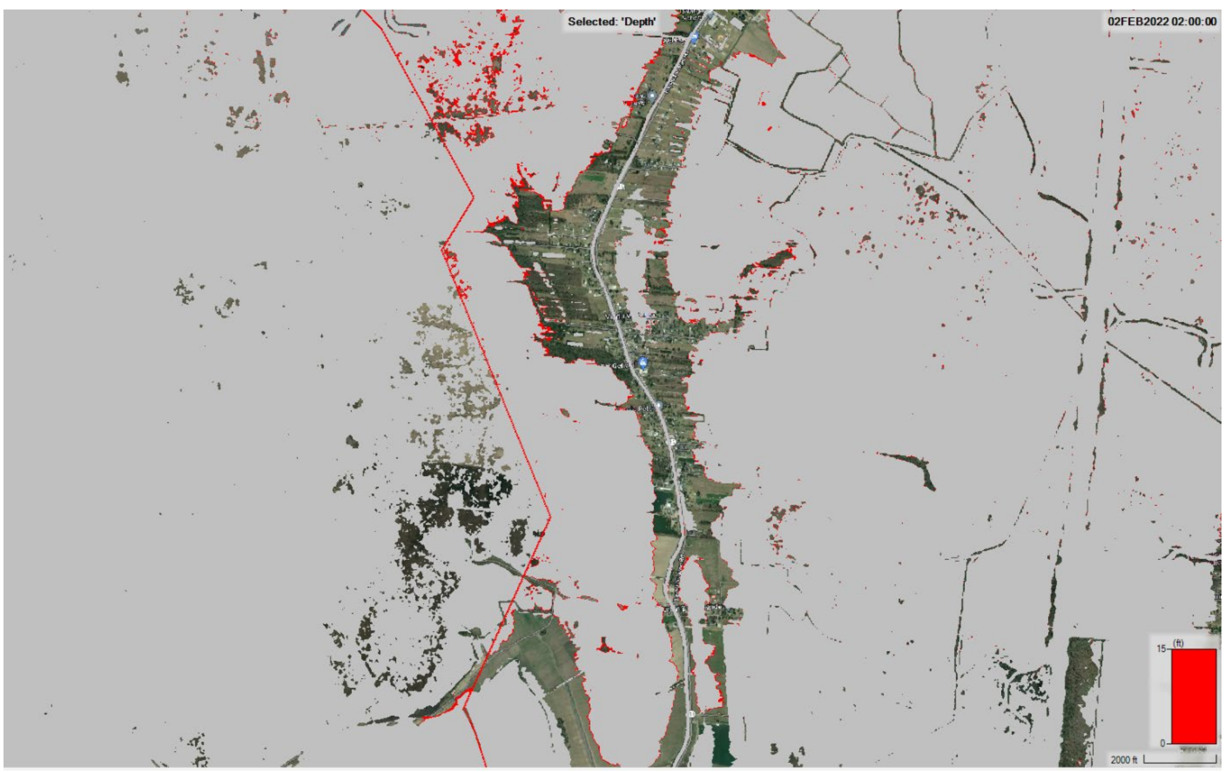

Figure D-30: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions (Gray) and PACR Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time) – South of GIWW

Figure D-31: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions (Gray) and PACR Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time) – North of GIWW

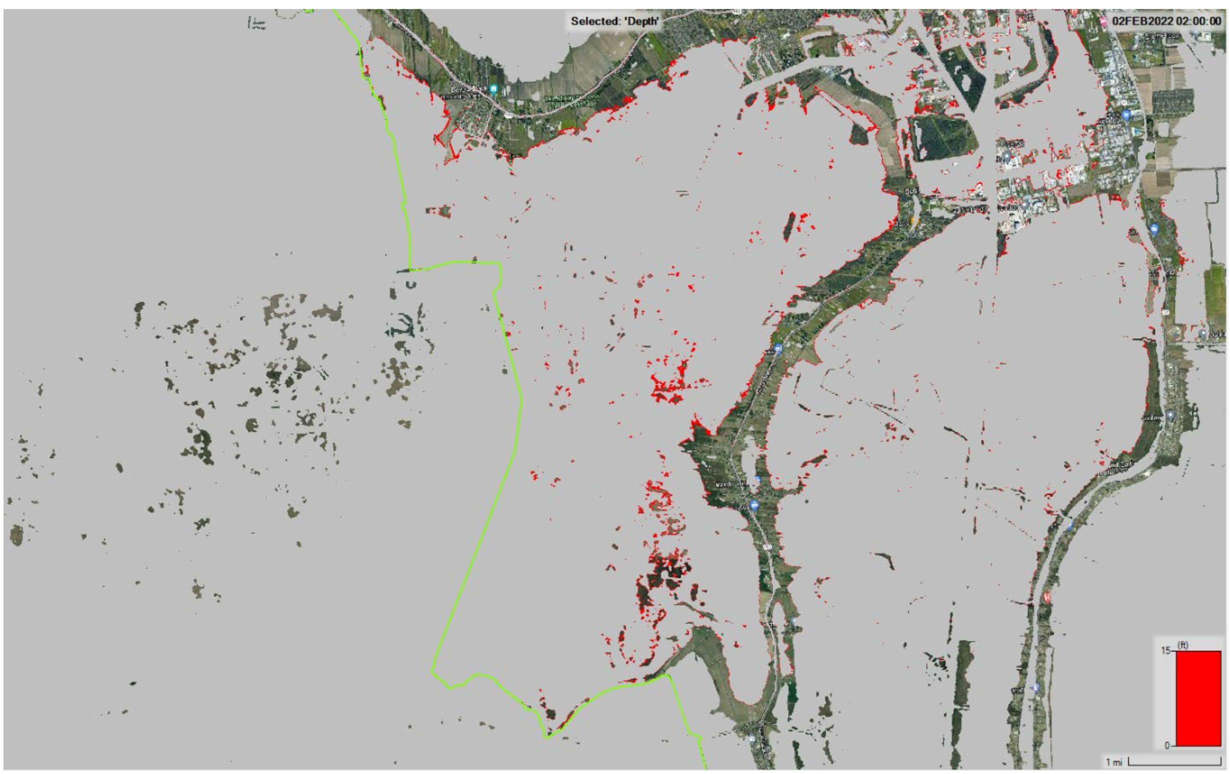

Figure D-32: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions (Gray) and NFS Alignment Conditions (red) – Water Depth Boundary at 02FEB2022 0200 (Simulation Time)

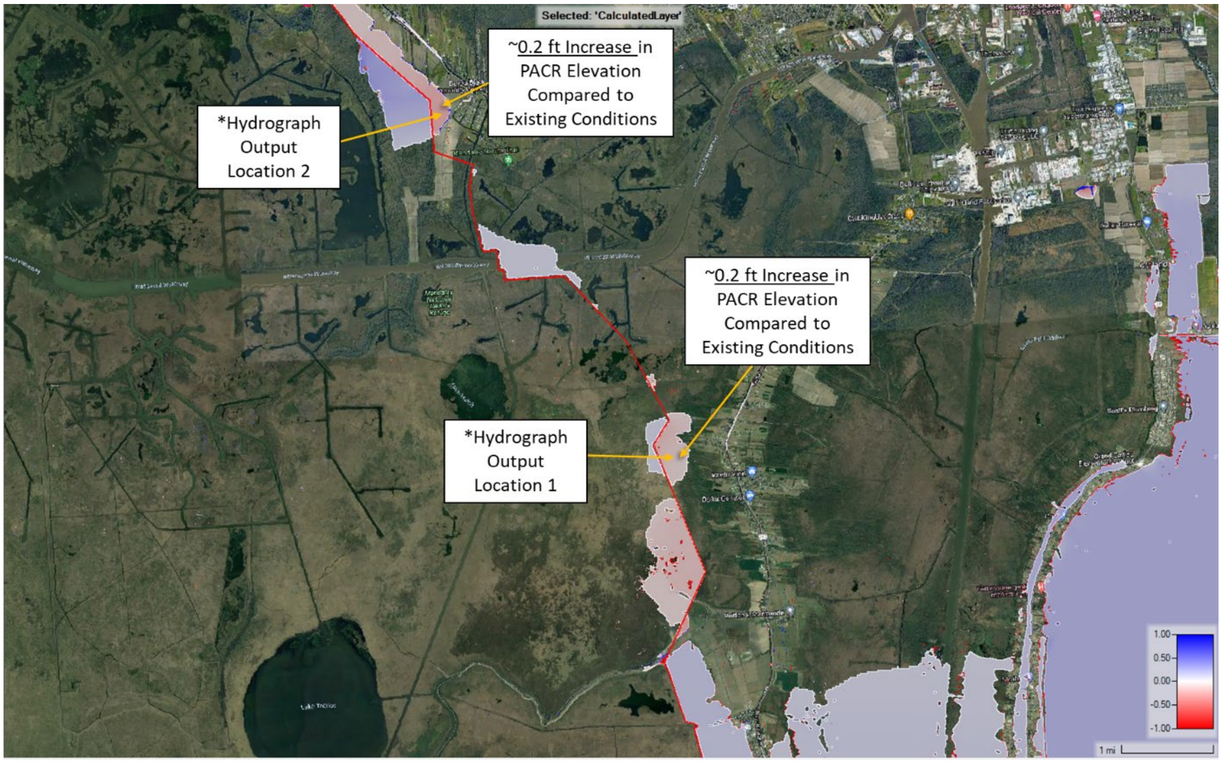

Figure D-33: 1% AEP Precipitation and 10% AEP Storm Surge Event – Difference in water surface elevation – Existing Conditions minus Proposed (PACR) Conditions at maximum water surface elevation

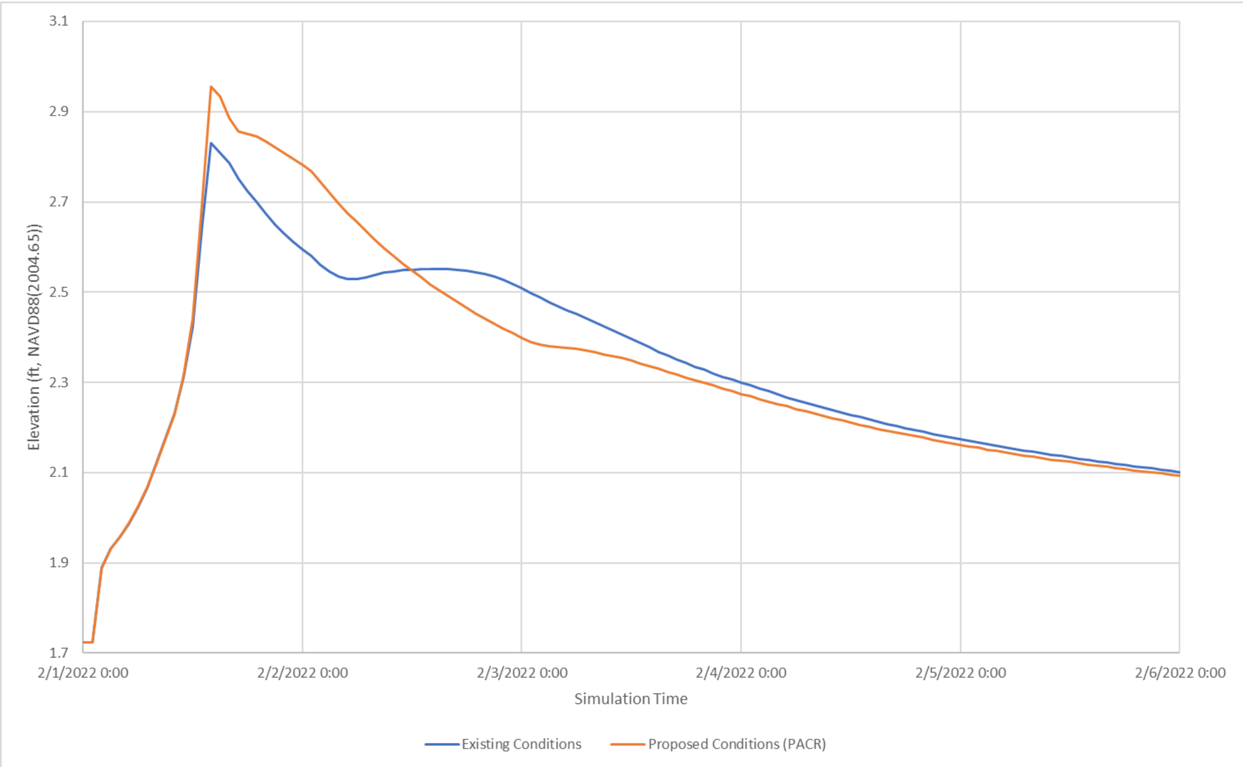

Figure D-34: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions and Proposed (PACR) at Hydrograph Location 1

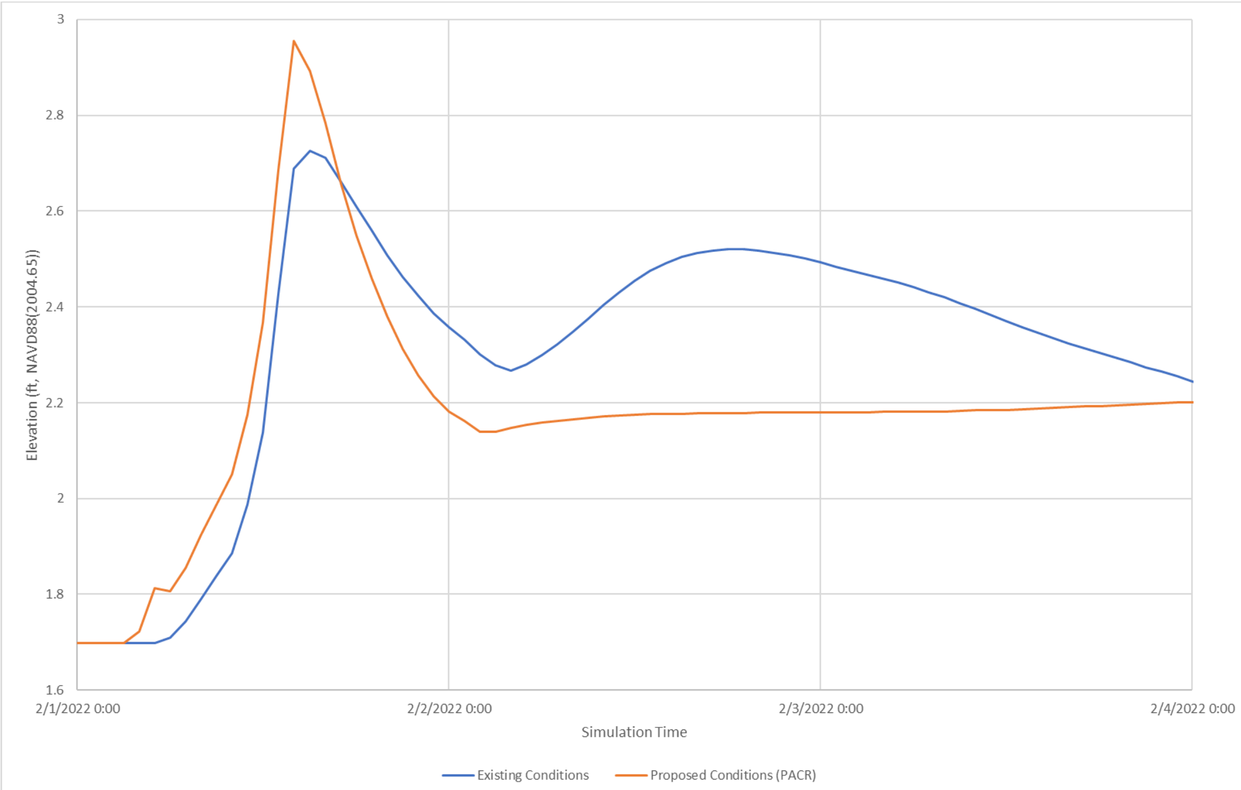

Figure D-35: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions and Proposed (PACR) at Hydrograph Location 2

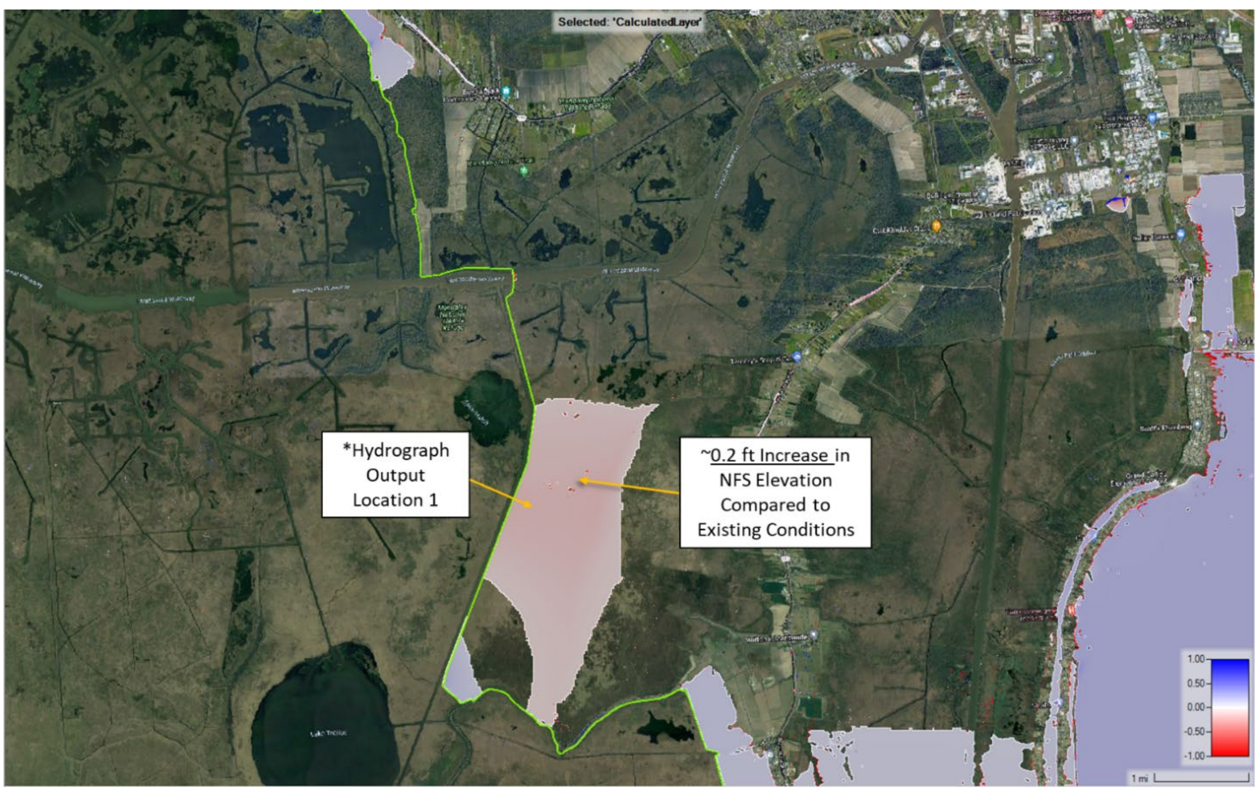

Figure D-36: 1% AEP Precipitation and 10% AEP Storm Surge Event – Difference in water surface elevation – Existing Conditions minus Proposed (NFS) Conditions at maximum water surface elevation

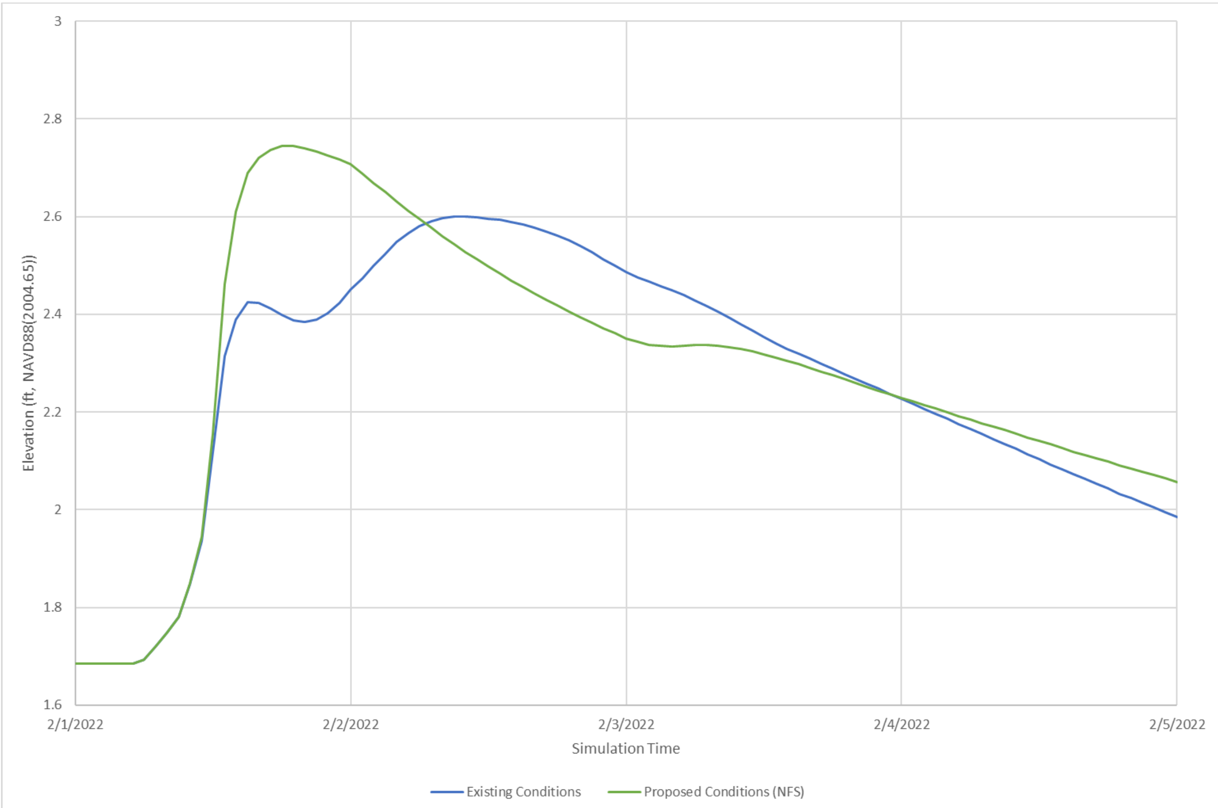

Figure D-37: 1% AEP Precipitation and 10% AEP Storm Surge Event – Existing Conditions and Proposed (NFS) at Hydrograph Location 1

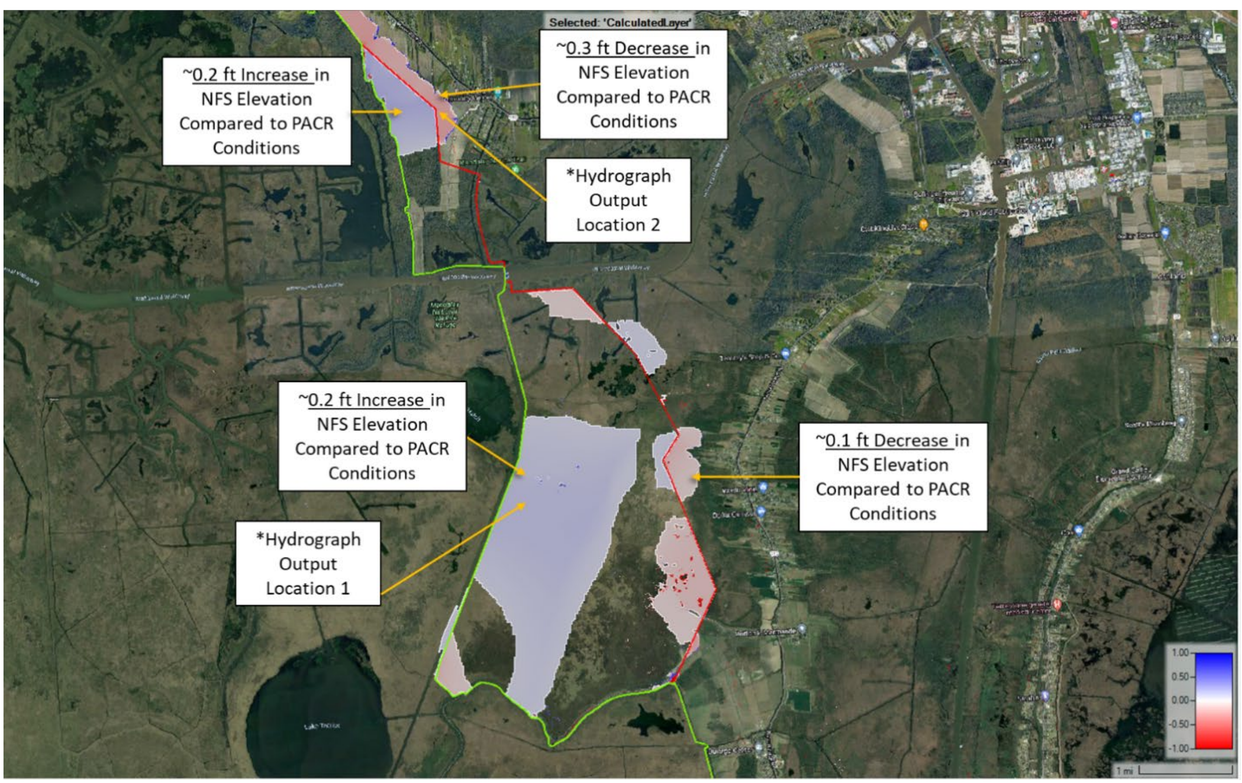

Figure D-38: 1% AEP Precipitation and 10% AEP Storm Surge Event – Difference in water surface elevation – Proposed (NFS) minus Proposed (PACR) Conditions at maximum water surface elevation

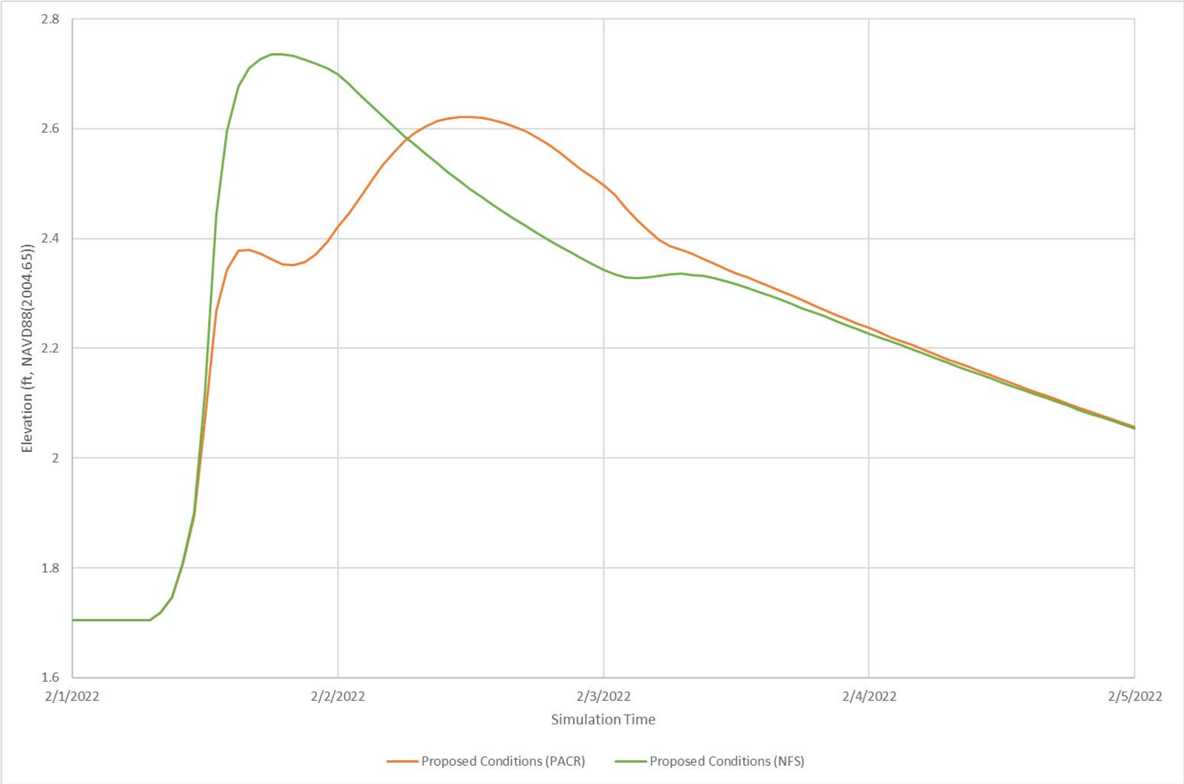

Figure D-39: 1% AEP Precipitation and 10% AEP Storm Surge Event – Proposed Conditions (PACR) and Proposed (NFS) at Hydrograph Location 1

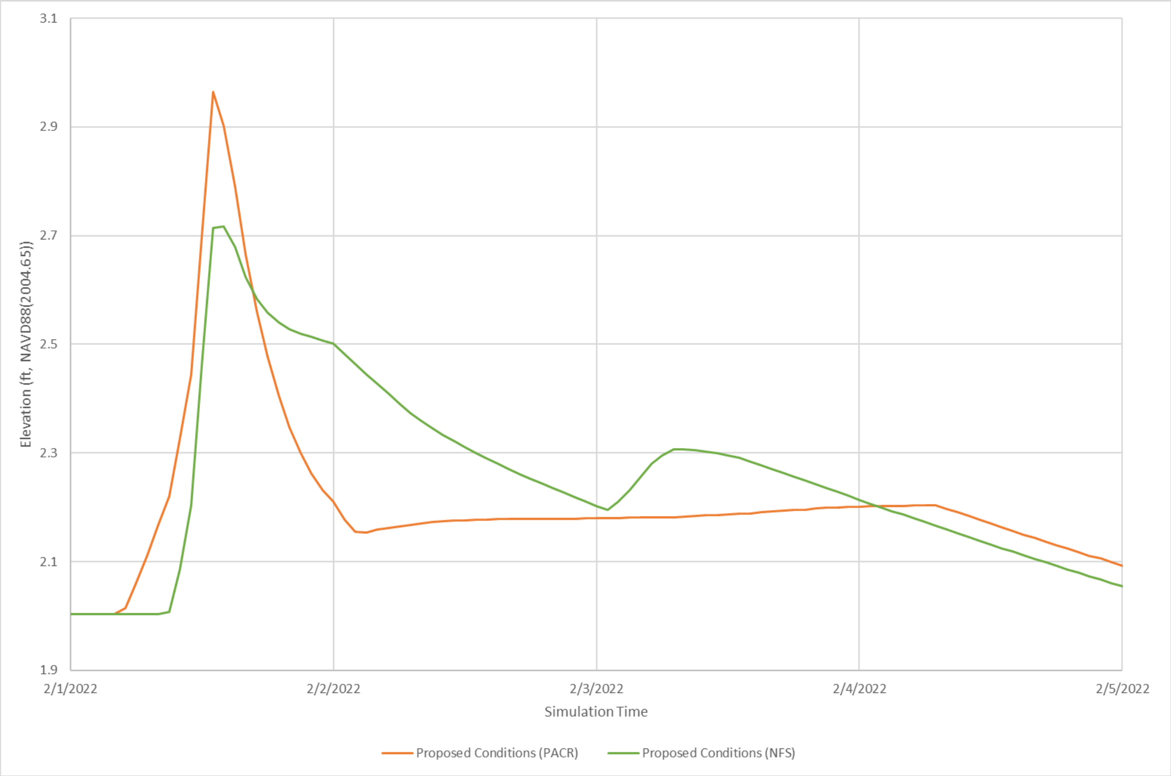

Figure D-40: 1% AEP Precipitation and 10% AEP Storm Surge Event – Proposed Conditions (PACR) and Proposed (NFS) at Hydrograph Location 2

SCENARIO 4: 10% AEP Precipitation and 10% AEP Storm Surge and 10% AEP Atchafalaya Flow Event

The three geometry conditions (Existing Levee, NFS, and PACR Alignments) were run in the 2D HEC-RAS model for the 10% AEP precipitation, 10% AEP storm surge event, and 10% AEP Atchafalaya River Flow event and the results are compiled below. All gates are open for the full duration of this event. The model starting time for this event was stepped back to 25JAN2022 11:00 to allow the Atchafalaya River Flow to make its way through the MTG system and fill in storage areas prior to the storm surge and precipitation event starting at 01FEB2022 00:00. The peak of the Atchafalaya River flow hydrograph occurs at approximately 01FEB2022 00:00. It should be noted that no coincidental statistics were analyzed to approximate the probability of the 3 boundary condition events (Flow, Precipitation, and storm surge) occurring and peaking at the same time. This event was included to show a very conservative event and compare the proposed levee alignments to existing conditions.

The results for this event highlight the benefit of adding levees to the Reach A area. The interior of the system for both Reach A conditions show a reduction of approximately 0.1-0.2 ft. when compared to the existing conditions. The addition of the levee allows the interior of the system to experience less inflow, even with the gates open.

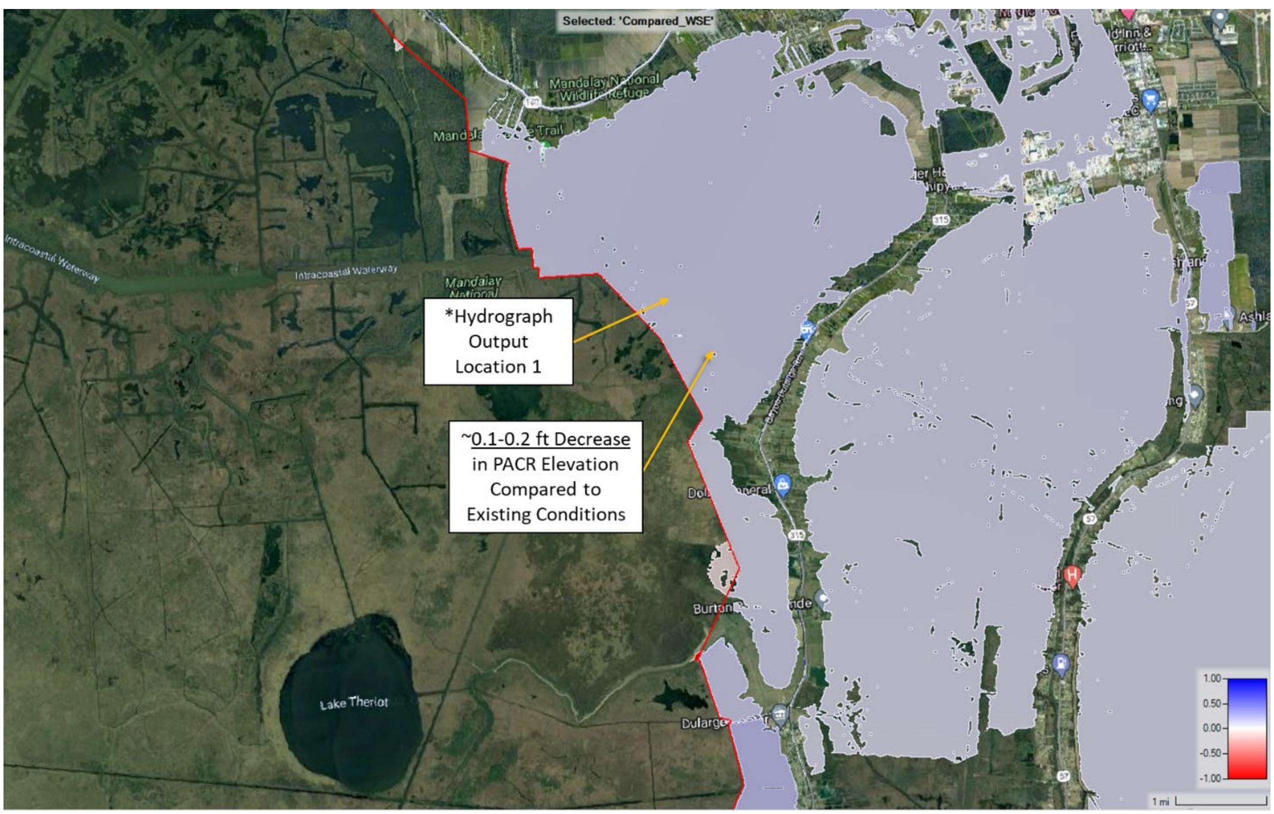

Figure D-41: 10% AEP Precipitation and 10% AEP Storm Surge Event and 10% AEP Atchafalaya River Flow Event – Difference in water surface elevation – Existing Conditions minus Proposed (PACR) Conditions at maximum water surface elevation

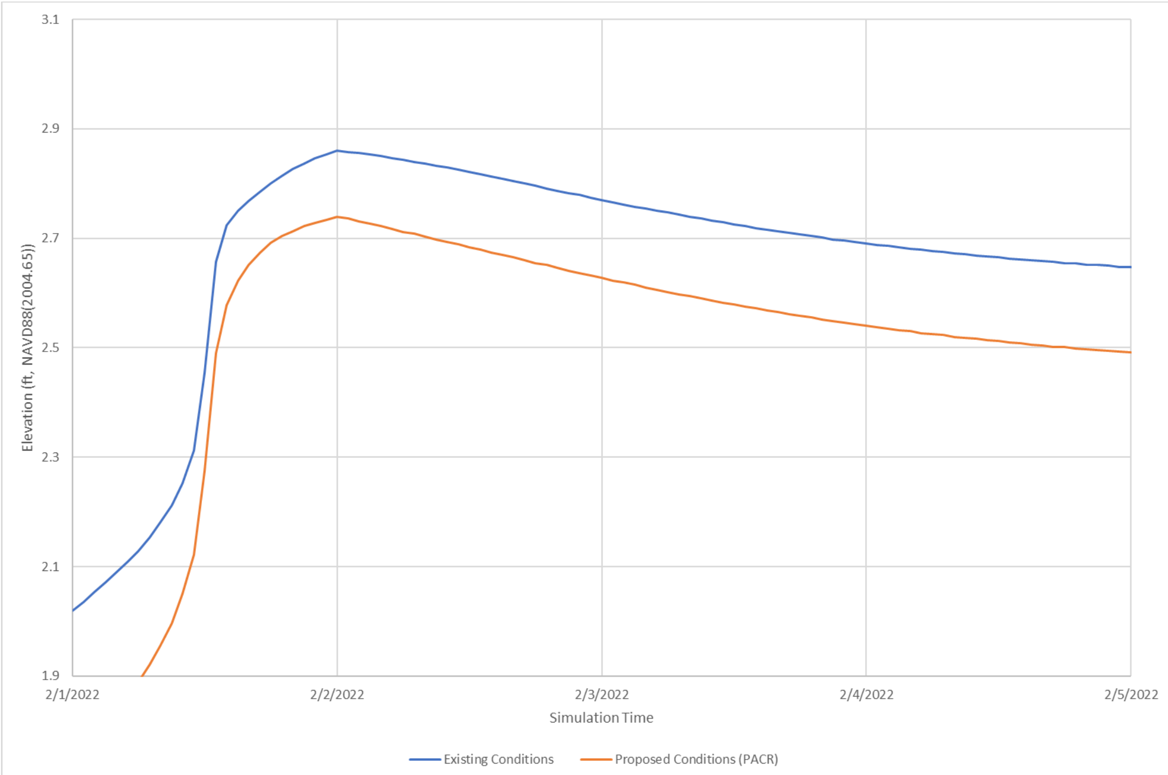

Figure D-42: 10% AEP Precipitation and 10% AEP Storm Surge Event and 10% AEP Atchafalaya River Flow Event – Existing Conditions and Proposed (PACR) at Hydrograph Location 1

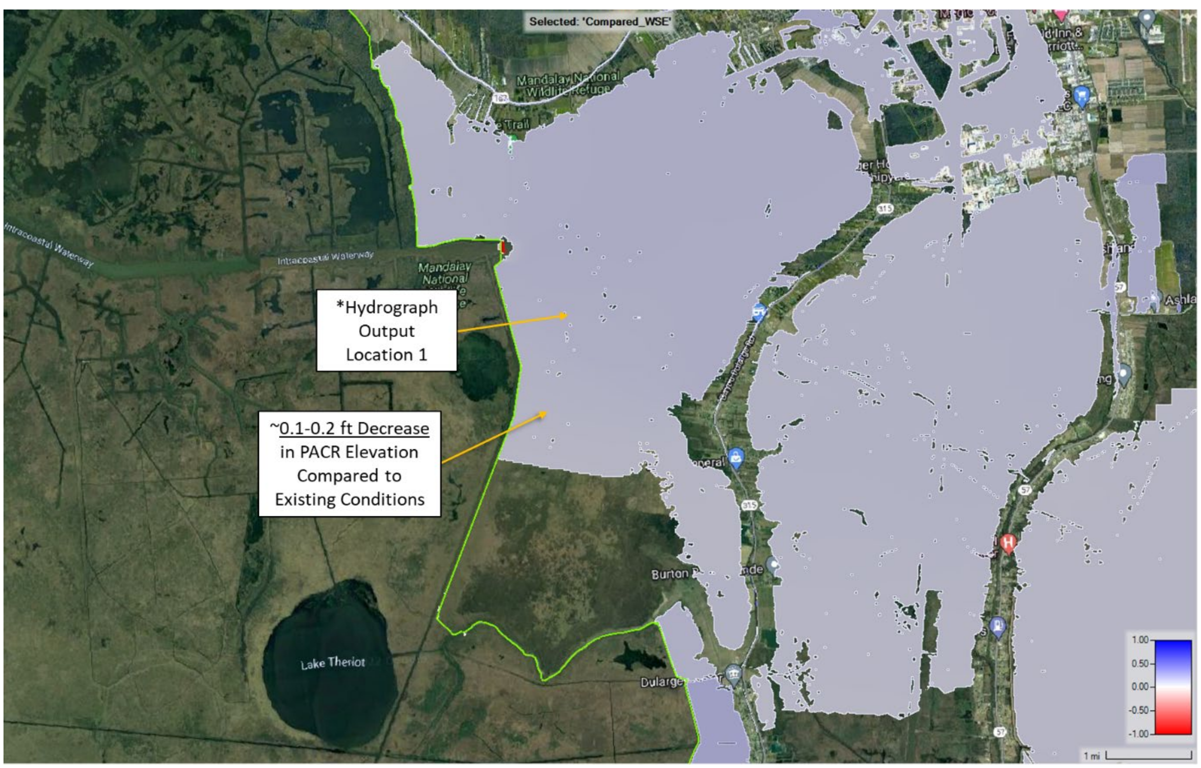

Figure D-43: 10% AEP Precipitation and 10% AEP Storm Surge Event and 10% AEP Atchafalaya River Flow Event – Difference in water surface elevation – Existing Conditions minus Proposed (NFS) Conditions at maximum water surface elevation

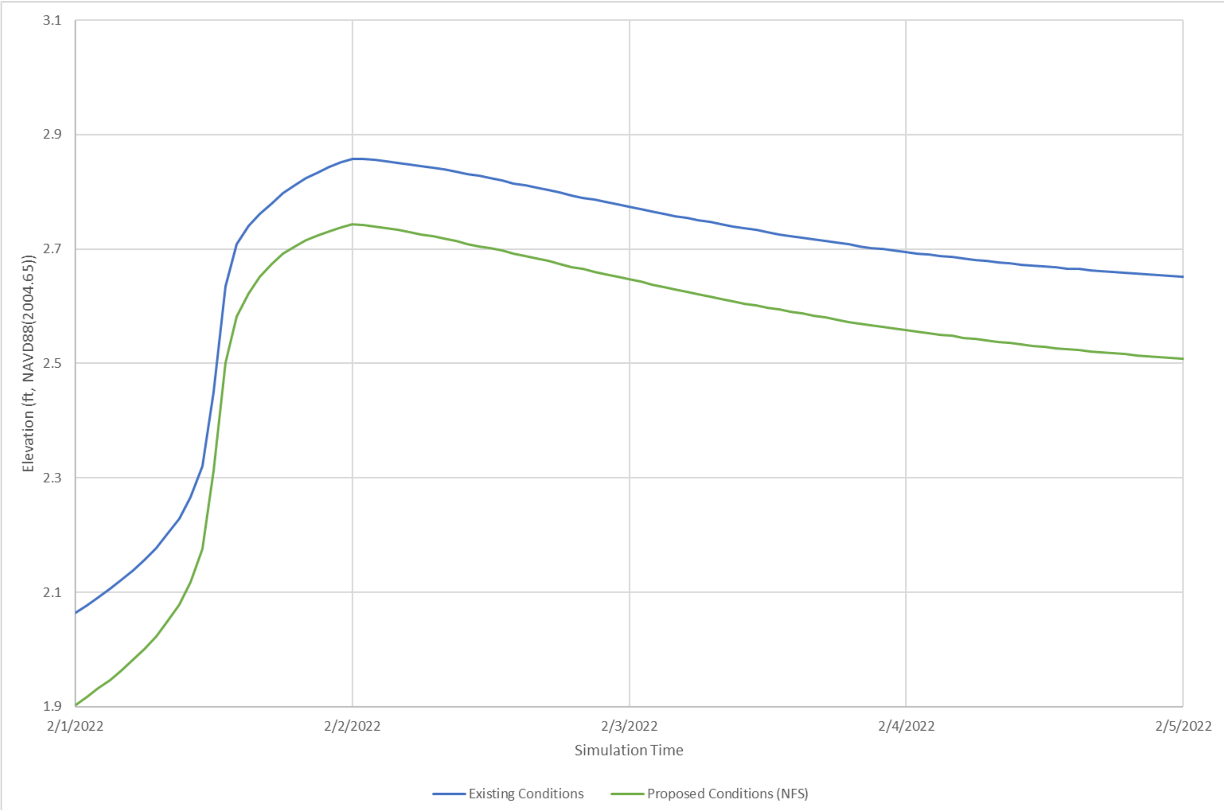

Figure D-44: 10% AEP Precipitation and 10% AEP Storm Surge Event and 10% AEP Atchafalaya River Flow Event – Existing Conditions and Proposed (NFS) at Hydrograph Location 1

Recommendations

This analysis highlights the differences of the Reach A alternative alignments (NFS and PACR) compared to the existing conditions. The 1% AEP precipitation and 10% AEP storm surge event was run to produce the most conservative results, i.e. the results that would produce the greatest water surface elevations in the study area. Because the gates were closed for the first two simulation days, the results show the impact of water in the system that is unable to evacuate through the drainage structures, and thus begins to fill in storage. Furthermore, the HEC-RAS precipitation setup for this Reach A alternative analysis did not include infiltration; in other words, the precipitation overlayed over the 2D area developed into 100% runoff. This was once again done to simulate the most conservative scenario, replicating an event where the soil would be fully saturated and wouldn't allow any infiltration.

As discussed in the "Model Assumptions and Uncertainties" section in the main Morganza to the Gulf Hydraulic Analysis Report, a model tolerance of error that should be applied to the results of this analysis is 0.5 feet. The results comparing the proposed conditions (for both the NFS and PACR alignments) to the existing conditions show a small difference in water surface elevation. There is approximately 0.5 feet or less of difference, depending on the location, around the vicinity of Reach A. Because these differences are less than the determined 0.5 feet of model tolerance of error, the differences shown between the alternatives should be considered insignificant. Furthermore, the difference grid results comparing the proposed conditions to the existing conditions show the proposed conditions having higher water surface elevations in locations that typically contain water in both conditions (i.e. marshland). In other words, the model results show the proposed conditions increasing the water levels in areas that will be underwater for both the existing and proposed scenarios, but do not show water inducing flooding on areas that wouldn't typically be underwater.

The results of this analysis indicate that the layout of proposed drainage structures for the PACR alternative are sufficient in evacuating water from the system and would not require a forced drainage system. Both Reach A alternatives, the PACR and NFS alignments, do not significantly induce flooding around the Reach A Levee area when compared to the existing conditions for the 1% AEP precipitation event, and the difference between the scenarios are within the accepted model tolerance of error. Furthermore, both Reach A alternative designs provide adequate drainage to protect the interior of the Reach A levee system from the 1% AEP precipitation event. However, due to the closeness of inundation to infrastructure (primarily the area shown in Figure D-30), when going into design for Reach A (if the PACR alternative is chosen for design), updated survey data should be gathered near the infrastructure in that area to confirm the elevations.

Mississippi Valley Division, Regional Planning and Environment Division South

Appendix E – Reach A Construction Conditions, Independent Utility, and Structure Sizing

CEMVN-EDH

MEMORANDUN FOR Project Management Division (CEMVN-PMR/Lacy Shaw)

SUBJECT: 2023 Morganza to the Gulf Hydraulic Analysis Final Report

1. Enclosed is Appendix E - Reach A Construction Conditions, Structure Optimization, and Independent Utility for the 2023 Morganza to the Gulf Hydraulic Analysis Final Report.

2. Hydrology, Hydraulics & Coastal Branch used HEC-RAS 6.3.1 to model water levels surrounding Reach A of the Morganza to the Gulf system to compare existing to proposed conditions for evaluation of construction conditions, structure optimization, and independent utility. The model results are displayed in the enclosed appendix.

3. The EDH point of contact for this effort are Cameron Broussard x2275 and Stacey Frost, P.E., x2993. The ED POC for this effort is Charles Brandstetter P.E., x2501. The Project Manager is Lacy Shaw (CEMVN-PMR), x1200.

Encl

CHRISTOPHER L. DUNN, Ph.D., P.E.
Chief, Engineering Division

Frost EDH	FROST.STACEY.ULM.1230838085	Digitally signed by FROST.STACEY.ULM.1230838085 Date: 2023.05.25 14:52:14 -05'00'
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Henville ED	HENVILLE.AMENA.MALENE.1247757690	Digitally signed by HENVILLE.AMENA.MALENE.1247757690 Date: 2023.06.02 15:28:26 -05'00'
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Appendix E: Reach A Construction Conditions, Independent Utility, and Structure Sizing

For this appendix, Reach A levee was divided into two segments, north of the Gulf Intracoastal Water Way (GIWW) and south of the GIWW. These two segments are referred to as Reach A North and Reach A South, respectively. Figure E-1, below, shows the separation between Reach A North, in red, and Reach A South, in green.

Figure E-1: Reach A North (red) and Reach A South (green)

For this assessment, the existing conditions Morganza to the Gulf (MTG) levee system was used to identify the construction conditions for Reach A, an optimization of the structures along Reach A, and the independent utility of Reach A. The HEC-RAS precipitation setup for this Reach A analysis did not include infiltration; in other words, the precipitation overlayed over the 2D area developed into 100% runoff. This was done to simulate the most conservative scenario, replicating an event where the soil would be fully saturated and wouldn't allow any infiltration.

Construction Conditions

The construction conditions for the Reach A levee alignment includes a 6-foot-high embankment and 25-foot-wide gaps in the levee embankment, instead of structures. The elevation of the bottom of each gap is equal to the ground elevation in existing conditions. To best determine the locations for the gaps in the alignment, particle tracing in HEC-RAS was used. Particle tracing provides a visual representation of how water is flowing in the model. Below, in Figure E-2, are the depth results at the hydrograph peak for the existing conditions with particle tracing. The Reach A alignment is overlayed for orientation purposes. The gaps in the levee were then placed to best allow the natural flow of water.

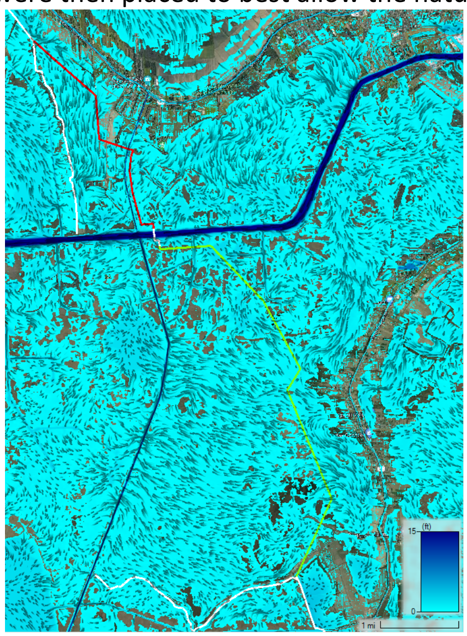

Figure E-2: Existing conditions depth grid with Reach A alignment overlayed

Where the Reach A alignment crosses Minors Canal and the GIWW, gates were input into the model instead of gaps. It is assumed in this analysis that these gates will be constructed along with the Reach A levee embankment. The optimum number of gaps in both the Reach A North (Figure E-3) and Reach A South (Figure E-4) alignment to best replicate the flow of water in the existing conditions is 5 openings. To determine the optimum number of gaps in the alignment, the model was run until the areas with the greatest difference in the depth of water between existing conditions and construction conditions was below 0.5 feet. This value was set as the difference criteria for negligible change in water surface elevation based on the hydraulic model level of certainty.

Figure E-3: Gap locations in the Reach A North levee embankment during construction

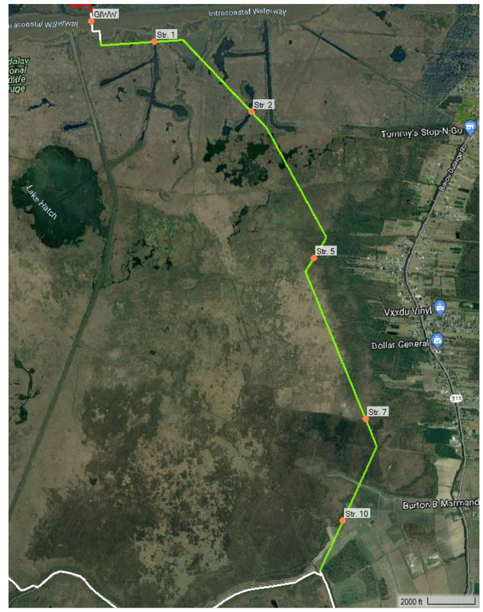

Figure E-4: Gap locations in the Reach A South levee embankment during construction

Two channel modifications are necessary along the Reach A South alignment to allow flow to reach a gap in the levee embankment, shown in Figure E-5. The Structure 5 Channel intercepts the northerly flow on the interior (east side) of the levee embankment and directs it through Structure 5 to exit the system. The Structure 10 channel allows for connectivity of low-lying areas that become hydraulically disconnected when the levee embankment is put in place.

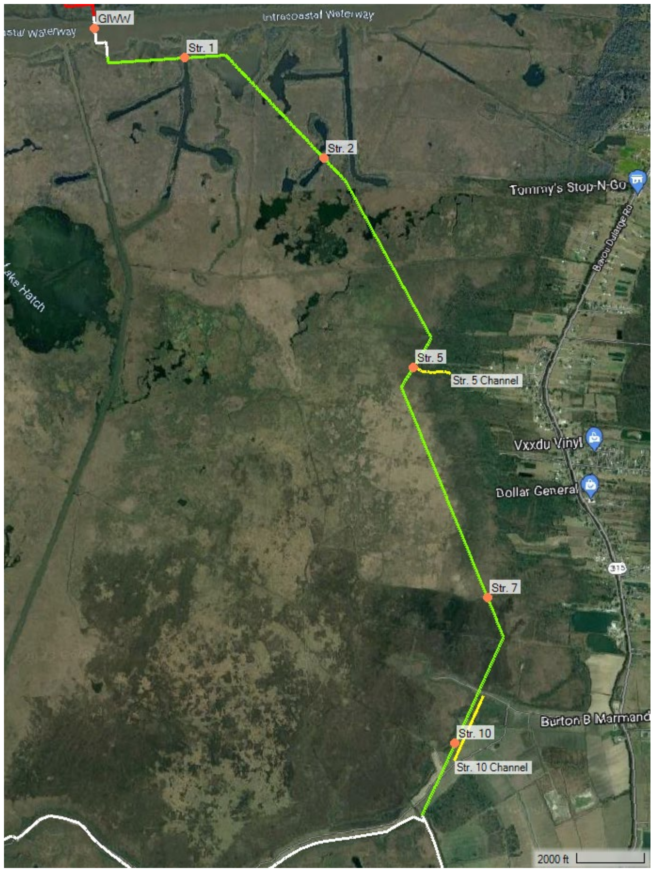

Figure E-5: Location of channel modifications along the Reach A South levee alignment

The below figure, Figure E-6, shows the difference in maximum water surface elevation between the existing conditions and the construction conditions, with accompanying hydrographs at locations of interest. For these results, the red areas indicate an increase in water surface elevation for the construction conditions and blue areas indicate a decrease in water surface elevation for the construction conditions. The largest increase in water surface elevation, when comparing the existing conditions to the construction conditions, is approximately 0.48 feet along Reach A North between Structure 2 and Structure 3. It is expected that water would collect more in this area because the existing conditions show the flow moving south. When the levee embankment is constructed, the flow is directed along the levee in an east/west direction until it finds a gap in the embankment.

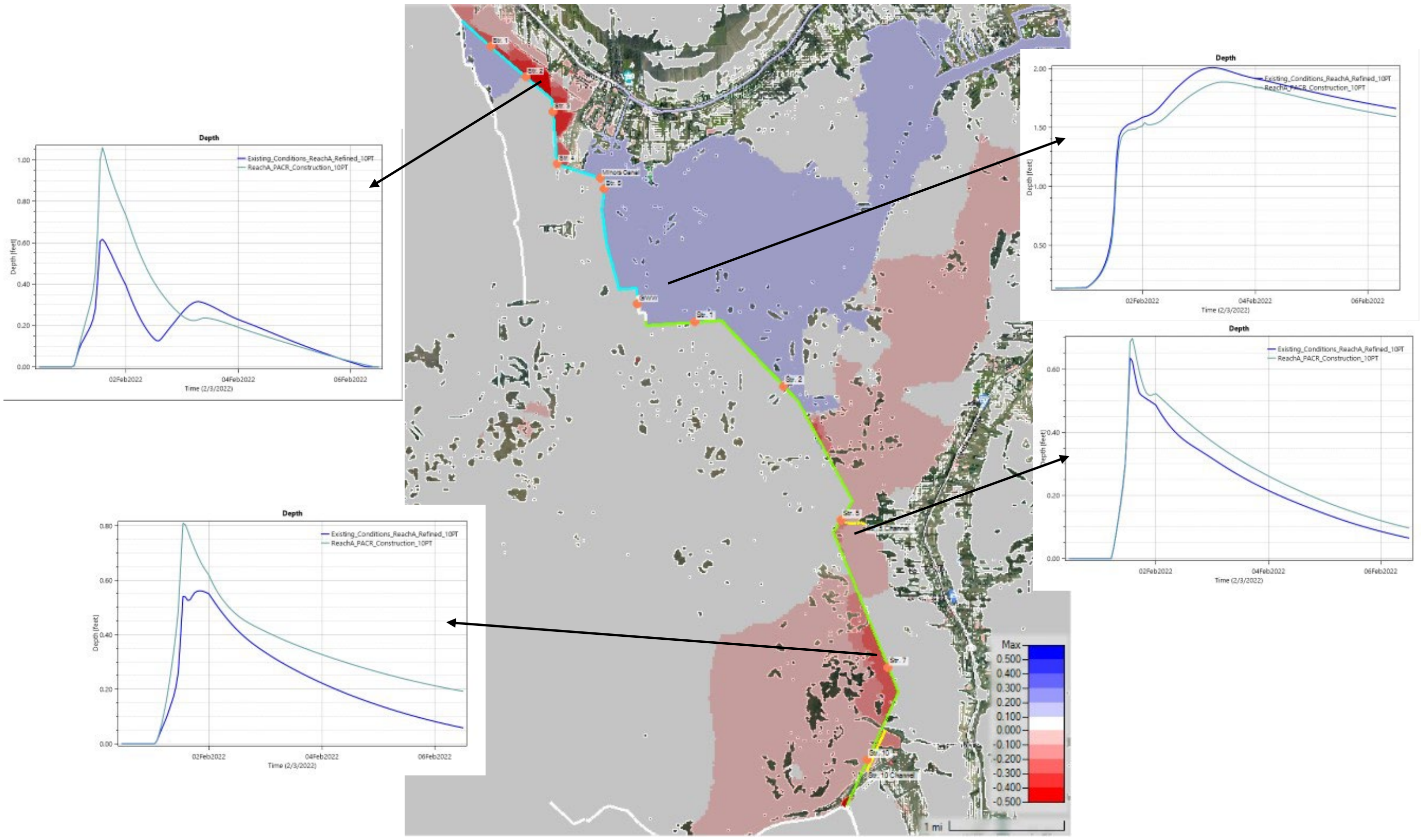

Figure E-6: Existing Conditions minus Construction Conditions (gaps in levee embankment and gates at Minors Canal and GIWW) for a 10-year precipitation and 10-year tidal surge event

Reach A Independent Utility

The Reach A PACR alignment was assessed to determine the water level reduction for the 10-year precipitation and 10-year tidal surge, 50-year precipitation and 50-year tidal surge, 100-year precipitation and 100-year tidal surge, and10-year precipitation and 100-year tidal surge event. Maps showing the difference in water surface elevation, outside of the model tolerance of 0.5 feet, between the existing conditions and the condition being assessed were generated for each event. The water surface difference grids show an *increase* in water levels (compared to the existing conditions) with a red color (and a negative value). The water surface difference grids show a *decrease* in water levels (compared to the existing conditions) with a blue color (and a positive value). The difference maps are set to only show water surface elevation differences greater than 0.5 feet or less than -0.5 feet. This was done to be consistent with the main report's (Morganza to the Gulf Hydraulic Analysis Report) model tolerance of 0.5 feet. For results that show differences less than the model tolerance, these results are considered insignificant.

The first condition analyzed is a fully constructed condition where the levee embankment height is equal to the PACR design height, optimum culverts are in place, and gates are in place at the GIWW and Minors Canal. For this condition, a set of simulations were run with the GIWW and Minors Canal gates completely open for the duration of event and another set of simulations with the gates completely closed for the duration of the event. The 10-year precipitation and tidal surge event was not evaluated with the gates closed because the tidal surge does not reach an elevation great enough to be equal to the elevation of the levee toe, so effects of the tidal surge on the alignment are not seen for this event. Figure E-7, Figure E-8, Figure E-10, and Figure E-12 show the difference in water surface elevation between existing conditions and the fully constructed PACR condition with the gates and culverts completely open for the entirety of the simulation. Figure E-9, Figure E-11, and Figure E-13 show the difference in water surface elevation between existing conditions and the fully constructed condition with the culverts open and gates closed for the entirety of the simulation.

For the fully constructed PACR alignment condition, the greatest reduction of inundation within the interior of the system (on the east side of Reach A) is seen for the 100-year tidal surge events because the tidal surge effects are reduced by the blockage created by the levee and structures. Additionally, there is an even greater reduction in water surface elevation for the proposed conditions when the GIWW and Minors Canal gates are closed because less water is able to enter the system through the gate openings.

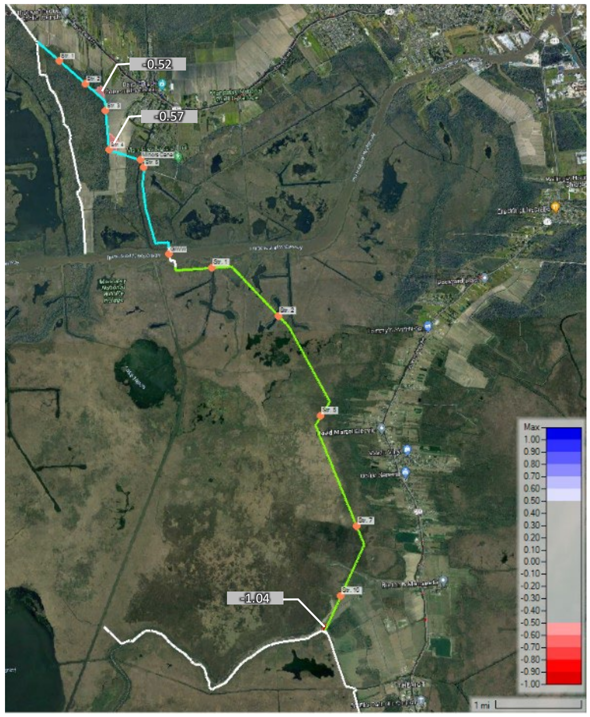

Figure E-7: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates open for the 10-year precipitation and 10-year tidal surge event

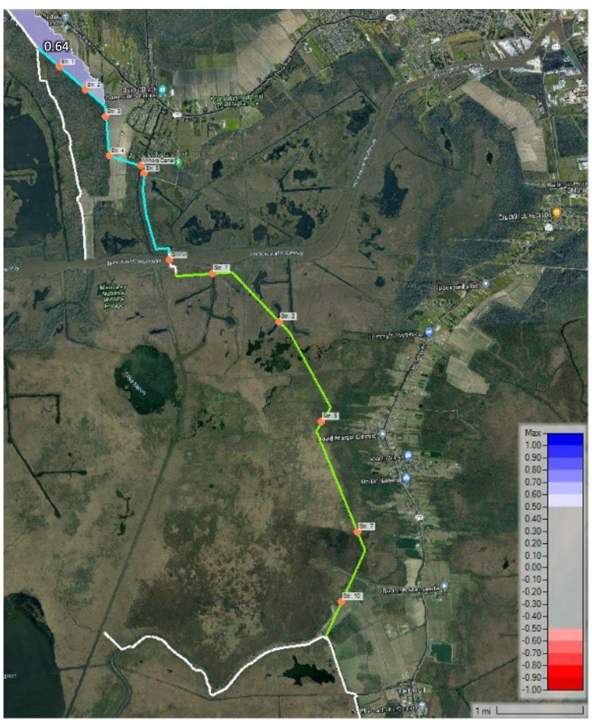

Figure E-8: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates open for the 50-year precipitation and 50-year tidal surge event

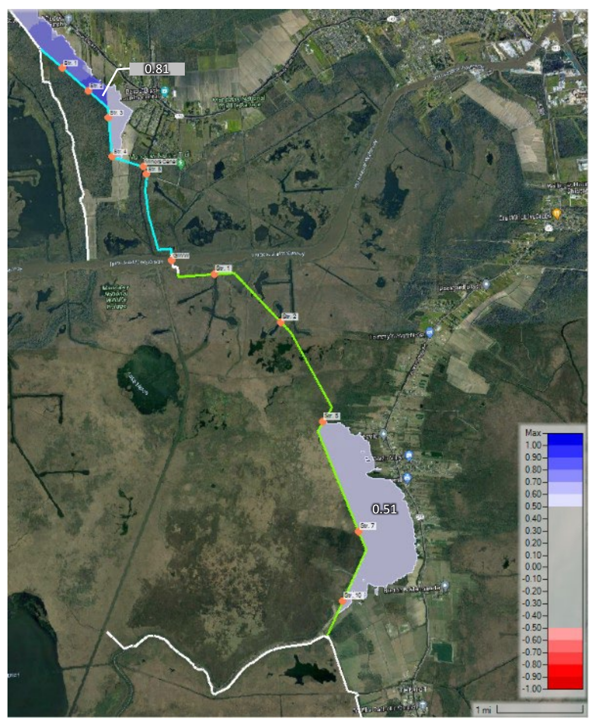

Figure E-9: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates closed for the 50-year precipitation and 50-year tidal surge event

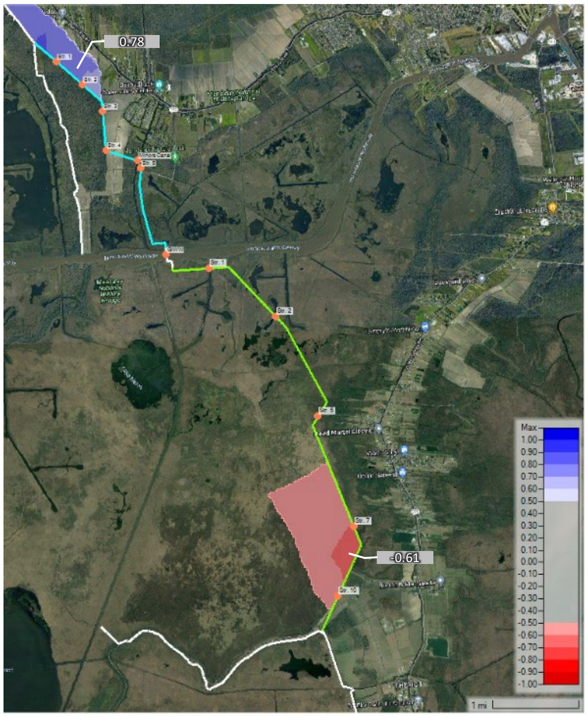

Figure E-10: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates open for the 100-year precipitation and 100-year tidal surge event

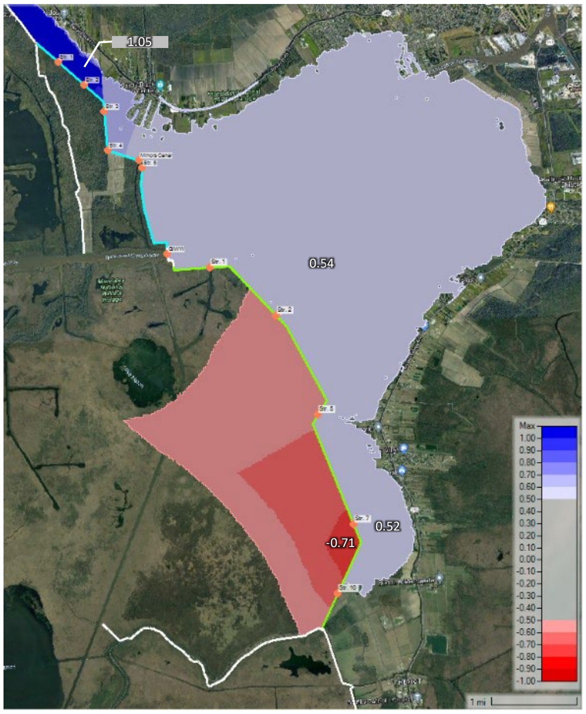

Figure E-11: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates closed for the 100-year precipitation and 100-year tidal surge event

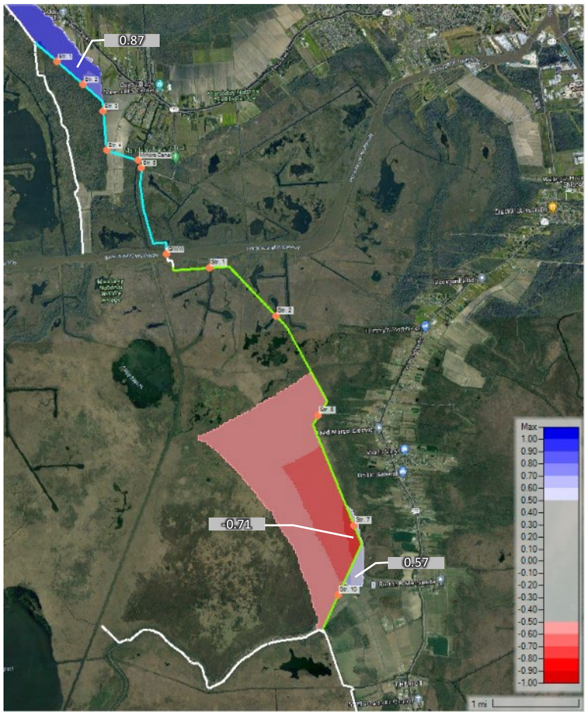

Figure E-12: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates open for the 10-year precipitation and 100-year tidal surge event

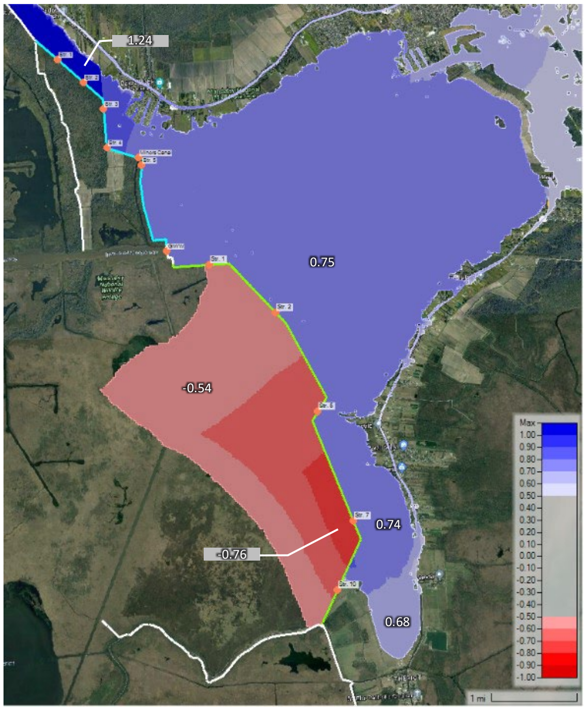

Figure E-13: Existing conditions minus fully constructed conditions with the GIWW and Minors Canal gates closed for the 10-year precipitation and 100-year tidal surge event

The second condition analyzed is a construction condition where the Reach A levee embankment is 6 feet high throughout, gaps are placed in the levee embankment where the culverts will be located at the completion of construction, and gates are in place at the GIWW and Minors Canal. For this condition, a set of simulations were run with the GIWW and Minors Canal gates completely open for the duration of the event and another set of simulations with the gates completely closed for the duration of the event. The 10-year precipitation and tidal surge event was not evaluated with the gates closed because the tidal surge does not reach an elevation great enough to be equal to the elevation of the levee toe, so the effects of the tidal surge on the alignment are not seen for this event. Additionally, no differences were seen in the 50-year precipitation and tidal surge event when compared to existing conditions, so a difference map is not displayed for this event.

Figure E-14, Figure E-15, and Figure E-17 show the difference in water surface elevation between the existing conditions and the construction conditions with gaps and gates at the GIWW and Minors Canal open. Figure E-16 and Figure E-18 show the difference in water surface elevation between the existing conditions and the construction condition with gaps and gates at the GIWW and Minors Canal closed. For the construction condition with gaps and gates, only the 100-year tidal surge events have a reduction of inundation within the interior of the system (on the east side of Reach A) when the GIWW and Minors Canal gates are closed because the tidal surge is not able to enter the system through those gate openings.

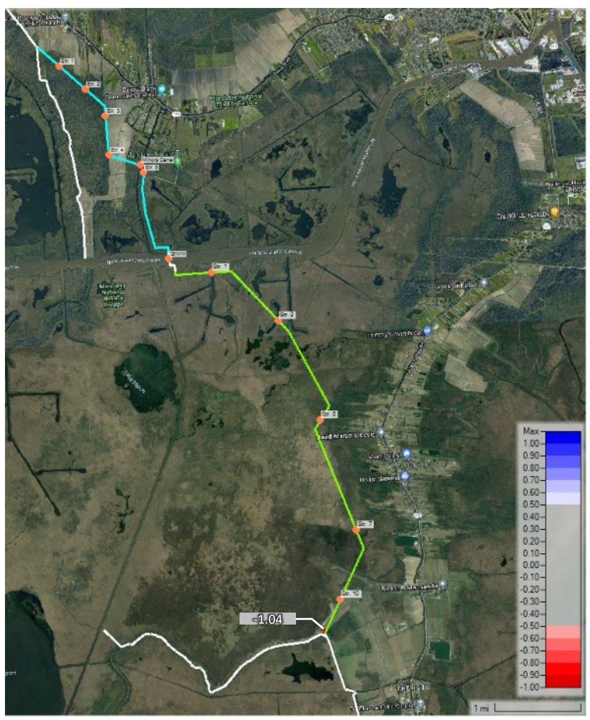

Figure E-14: Existing conditions minus construction conditions with gaps and the GIWW and Minors Canal gates open for the 10-year precipitation and 10-year tidal surge event

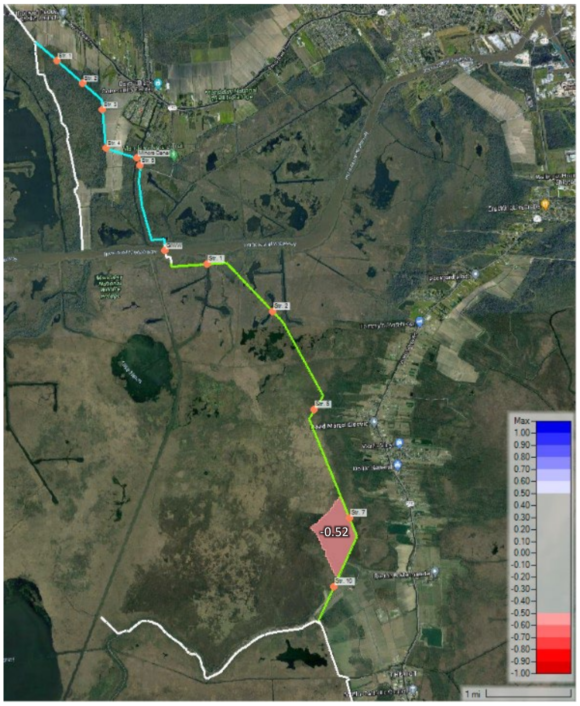

Figure E-15: Existing conditions minus construction conditions with gaps and the GIWW and Minors Canal gates open for the 100-year precipitation and 100-year tidal surge event

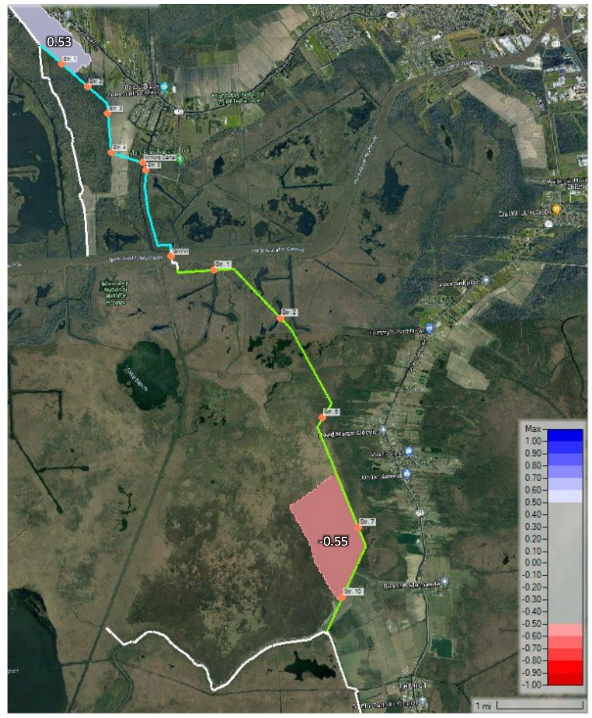

Figure E-16: Existing conditions minus construction conditions with gaps and the GIWW and Minors Canal gates closed for the 100-year precipitation and 100-year tidal surge event

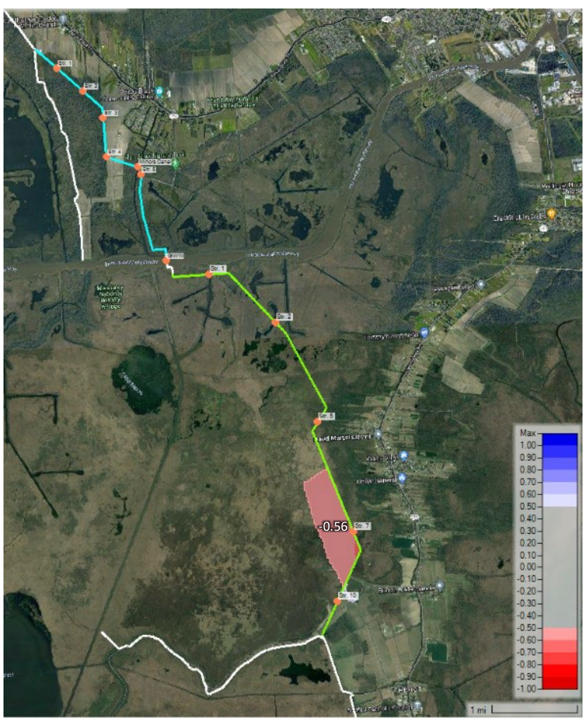

Figure E-17: Existing conditions minus construction conditions with gaps and the GIWW and Minors Canal gates open for the 10-year precipitation and 100-year tidal surge event

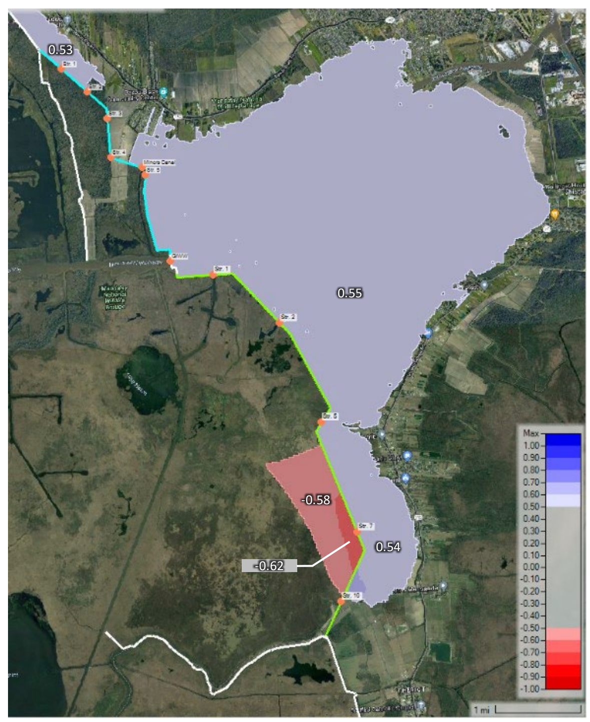

Figure E-18: Existing conditions minus construction conditions with gaps and the GIWW and Minors Canal gates closed for the 10-year precipitation and 100-year tidal surge event

The final condition analyzed is a construction condition where the Reach A levee embankment is 6 feet high, and gaps are placed in the embankment where the culverts and gates will be located at the completion of construction, and no gates are included at the GIWW and Minors Canal. Figure E-19 through Figure E-21 show the difference in water surface elevation between the existing conditions and the construction conditions with gaps. No differences were seen in the 50-year precipitation and tidal surge event when compared to existing conditions, so a difference map is not displayed for this event. For the construction condition with gaps, there is no reduction seen on the interior of the system (on the east side of Reach A) for any of the events.

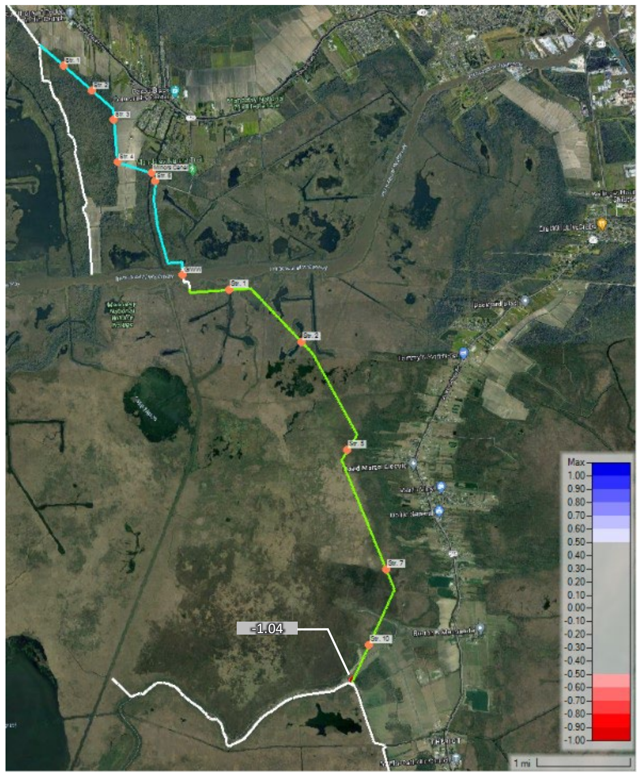

Figure E-19: Existing conditions minus construction conditions with gaps for the 10-year precipitation and 10-year tidal surge event

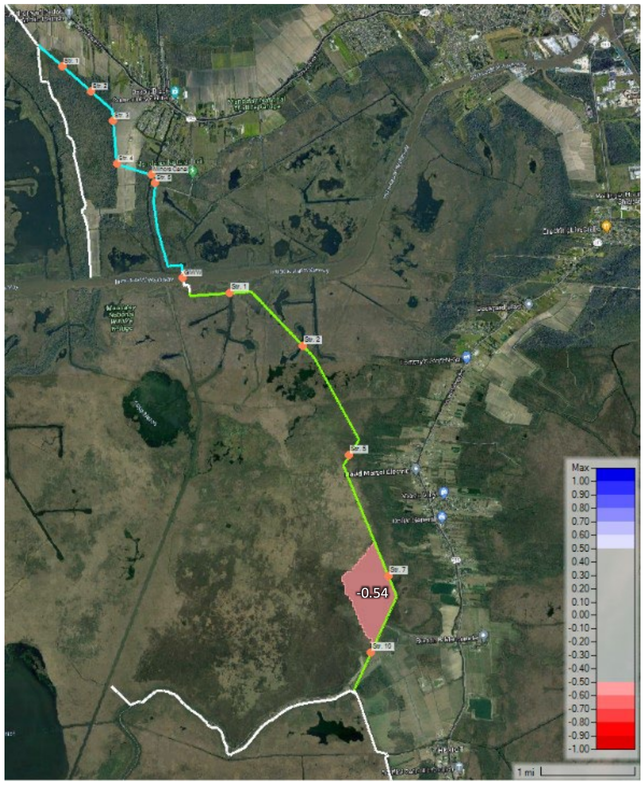

Figure E-20: Existing conditions minus construction conditions with gaps for the 100-year precipitation and tidal surge event

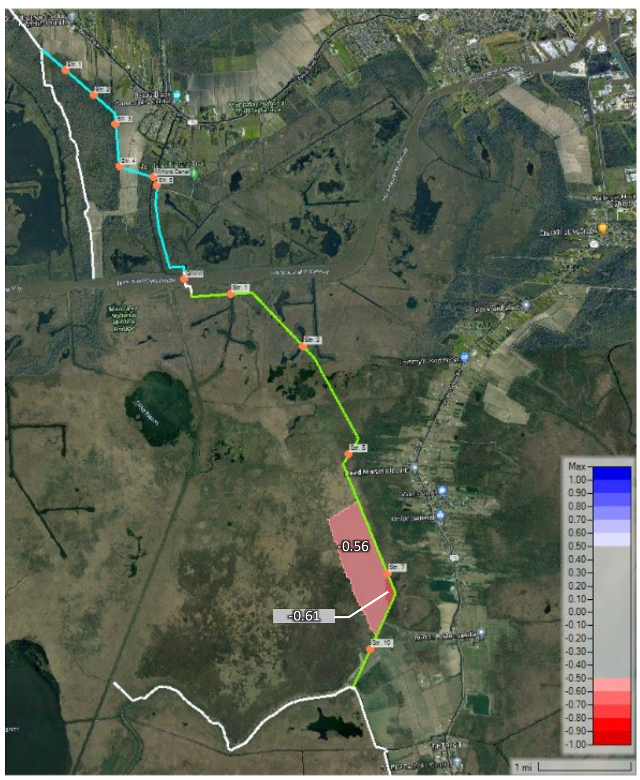

Figure E-21: Existing conditions minus construction conditions with gaps for the 10-year precipitation and 100-year tidal surge event

Reach A Independent Utility Conclusion

For the first condition analyzed, the fully constructed Reach A scenario, the model results show that the Reach A Levee will reduce interior water levels compared to the existing conditions for the 50-year and 100-year storm surge events. The 10-year event did not show a significant reduction in interior water levels. The second condition analyzed, the construction conditions with Minor's Canal and GIWW Floodgates closed, did not show a significant reduction in water levels for the 10-year or 50-year storm surge events. The results showed a reduction of interior water level of approximately 0.6 ft. for the 10-year precipitation plus 100-year storm surge event for the construction conditions with the Minor's Canal Floodgate and GIWW-West Floodgate closed. The third condition analyzed, the construction conditions without Minor's Canal and GIWW Floodgates, did not show a significant reduction in water levels for the 10-year, 50-year, or 100-year storm surge events. Table E-3 and Table E-4 highlight the water differences; the water levels are negative when the proposed conditions are higher than the existing conditions (Inducement) and the water levels are positive when the proposed conditions are lower than the existing conditions (Reduction).

Table E-3: Fully Constructed Reach A Water Level Differences

Fully Constructed Reach A Water Level Differences				
Location	Storm Event (Storm Surge Values - Year 2035)			
	10-year Precipitation and 10-year Storm Surge	50-year Precipitation and 50-year Storm Surge	10-year Precipitation and 100-year Storm Surge	100-year Precipitation and 100-year Storm Surge
	Water Level Differences in Feet (Existing Minus Reach A Fully Constructed)			
North of the GIWW (Interior)	-0.6	0.8	1.2	1.0
South of the GIWW (Interior)	NA*	NA*	0.8	NA*
South of the GIWW (Exterior)	NA*	NA*	-0.8	-0.7

*Water level differences are considered insignificant (Below the 0.5 ft. model tolerance)

Table E-4: Construction Conditions with Minor's Canal Floodgate and GIWW-West Floodgate Closed - Reach A Water Level Differences

Construction Conditions with Minor's Canal Floodgate and GIWW-West Floodgate Closed - Reach A Water Level Differences				
Location	Event (Storm Surge Values - Year 2035)			
	10-year Precipitation and 10-year Storm Surge	50-year Precipitation and 50-year Storm Surge	10-year Precipitation and 100-year Storm Surge	100-year Precipitation and 100-year Storm Surge
	Water Level Differences in Feet (Existing Minus Reach A Fully Constructed)			
North of the GIWW (Interior)	NA*	NA*	NA*	NA*
South of the GIWW (Interior)	NA*	NA*	0.6	NA*
South of the GIWW (Exterior)	NA*	NA*	-0.6	-0.6

*Water level differences are considered insignificant (Below the 0.5 ft. model tolerance)

Final Culvert Locations and Sizing

The hydraulic structure design (count, location, and sizing) has gone through an iterative process as the levee alignment has changed and as survey data was provided. The final structure design is shown in Figure E-22 and Figure E-23 and Table E-5 shows the structure sizing and locations, starting from southern-most end of Reach A south and going North. The structures were designed to pass the 10-year precipitation event without increasing the interior water levels compared to existing conditions above the 0.5 ft. model tolerance and to allow the interior water levels to return to normal water levels within a reasonable amount of time (5-10 days).

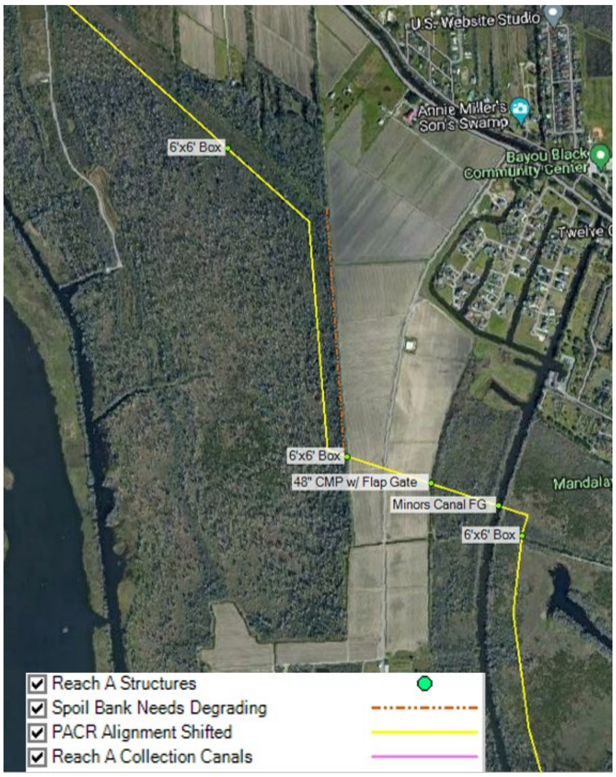

Figure E-22: Culvert and gate locations in the Reach A North alignment

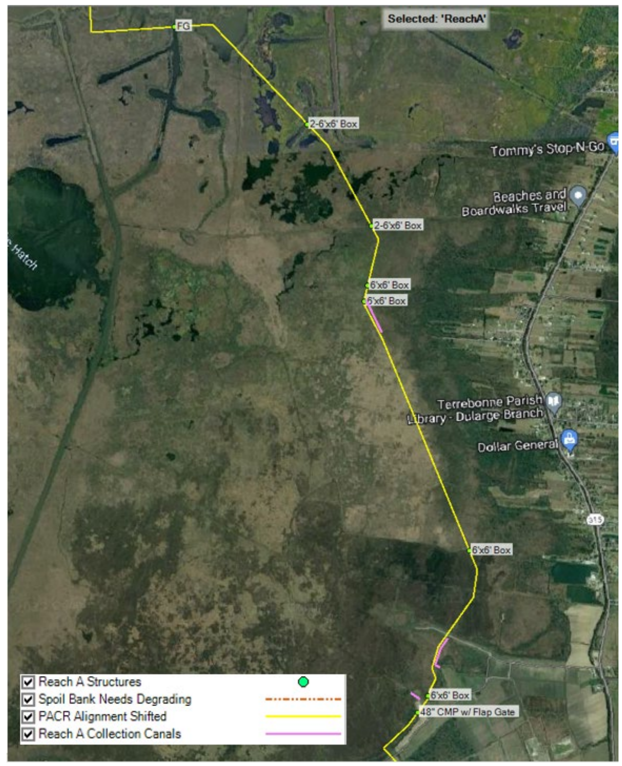

Figure E-23: Culvert, gate, and channel locations in the Reach A South alignment

Table E-5: Summary of structures and gates for Reach A Levee Reach

Structure Name	Size (ft)	X Coordinate*	Y Coordinate*
Structure 1	48" CMP w/ Flap Gate	-90.7659	29.4753
Structure 2	1, 6x6 Box Culvert	-90.7649	29.4766
Structure 3	1, 6x6 Box Culvert	-90.7688	29.5092
Structure 4	1, 6x6 Box Culvert	-90.7684	29.5104
Structure 5	2, 6x6 Box Culvert	-90.7677	29.5153
Structure 6	2, 6x6 Box Culvert	-90.7732	29.5239
Structure 7	Barge Floodgate	-90.7851	29.5324
Structure 8	GIWW West Structure	-90.793	29.5353
Structure 9	1, 6x6 Box Culvert	-90.7968	29.55
Structure 10	Minors Canal Floodgate	-90.7977	29.5512
Structure 11	48" CMP w/ Flap Gate	-90.8003	29.5521

Structure 12	1, 6x6 Box Culvert	-90.8037	29.5532
Structure 13	1, 6x6 Box Culvert	-90.8078	29.5643

Notes: *in decimal degrees and coordinate system GCS_WGS_1984

A difference map with hydrographs at locations of interest for the existing conditions minus proposed conditions for the 10-year precipitation event is shown in Figure E-24 and Figure E-25. The largest difference in depth is seen along the Reach A North alignment. In existing conditions, the water was able to sheet flow, but with the levee alignment in place, it must be directed to a culvert before exiting the system. The difference in the depth of water in the area is generally at or below 0.5 feet, which is within the model tolerance. Along the entire stretch of the Reach A levee, water levels on the interior of the system are able to return to normal levels shortly after the rainfall event (1-2 days for this highlighted hypothetical 10-year precipitation event).

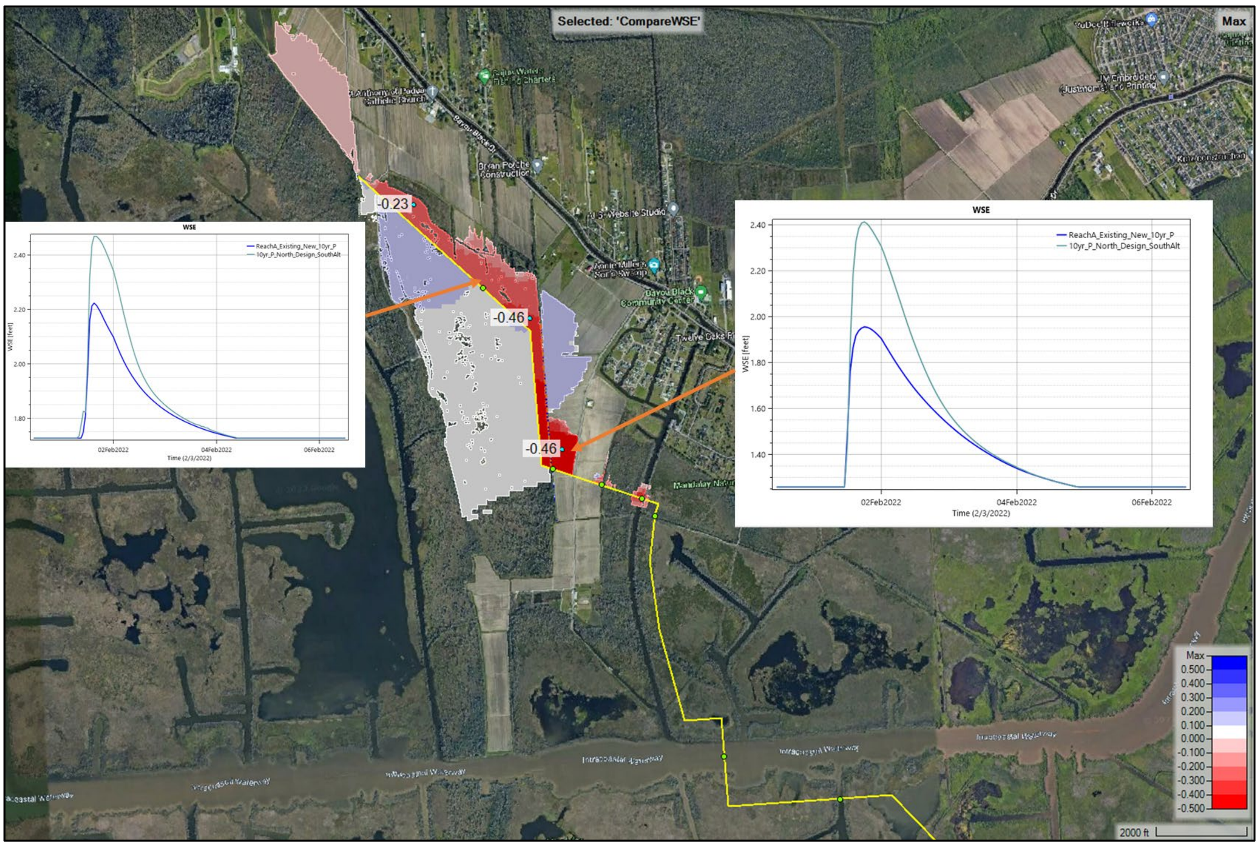

Figure E-24: Existing Conditions minus Proposed Conditions – Reach A North - 10-year precipitation Event.

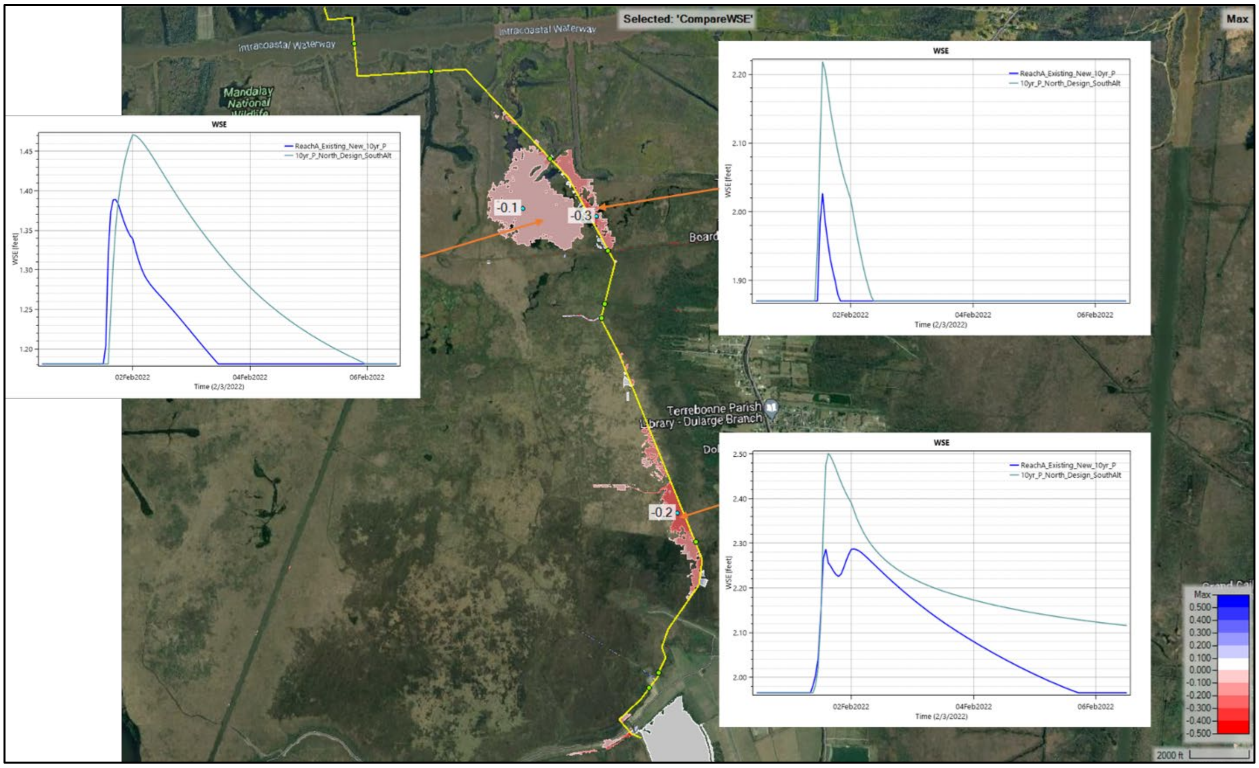

Figure E-25: Existing Conditions minus Proposed Conditions – Reach A South - 10-year precipitation Event.

It is recommended prior to finalizing Reach A structure design, to acquire real-world water level data during varying water conditions at the locations of interest around Reach A to better gage the model's accuracy in replicating real-world events. If real-world water data can be acquired, it will allow a higher degree of confidence in the model results and the final hydraulic design.

Mississippi Valley Division, Regional Planning and Environment Division South

Appendix F – Morganza to the Gulf Project, Reach A Levee Reach – Hydraulic Analysis of Shifted Levee Alignment from the PACR Levee Alignment

Appendix F: Morganza to the Gulf Project, Reach A Levee Reach – Hydraulic Analysis of Shifted Levee Alignment from the PACR Levee Alignment

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW ORLEANS DISTRICT

CEMVN-ED-HH&C 30 August 2023

MEMORANDUM FOR RECORD

SUBJECT: Morganza to the Gulf Project, Reach A Levee Reach – Hydraulic Analysis of Shifted Levee Alignment from the PACR Levee Alignment

1. Introduction:
   The purpose of this document is to analyze the shift in Morganza to the Gulf Reach A levee alignment from the PACR (Post Authorization Change Report) proposed alignment. The emphasis of this analysis is to assess if the change in levee alignment produces any negative effect on the hydraulics of the leveed area.

   The HEC-RAS model, terrain, and input data is the same data used in the main report and Appendix E. Please refer to those sections for model and data information.

   Figure 26 highlights in red the newly shifted Reach A alignment compared to the PACR proposed alignment in blue. The shifted alignment has 2 primary areas of deviation from the PACR alignment, the middle of Reach A south in which the shifted alignment is drawn further to the west, and the southernmost part of Reach A South in which the shifted alignment goes more to the east.

Figure 26: Reach A Levee Alignments

2. <u>Analysis:</u>
   The two Reach A alignments are very similar in design and the shifted Reach A alignment does not appear qualitatively to negatively affect the interior drainage or hydraulics of the system, compared to that of the original PACR alignment. The shifted alignment still allows for adequate drainage design. For the shift in the middle of Reach A South, the shifted alignment is still able to utilize existing channels to drain local rainfall, see Figure 27 for the culvert locations for each alignment.

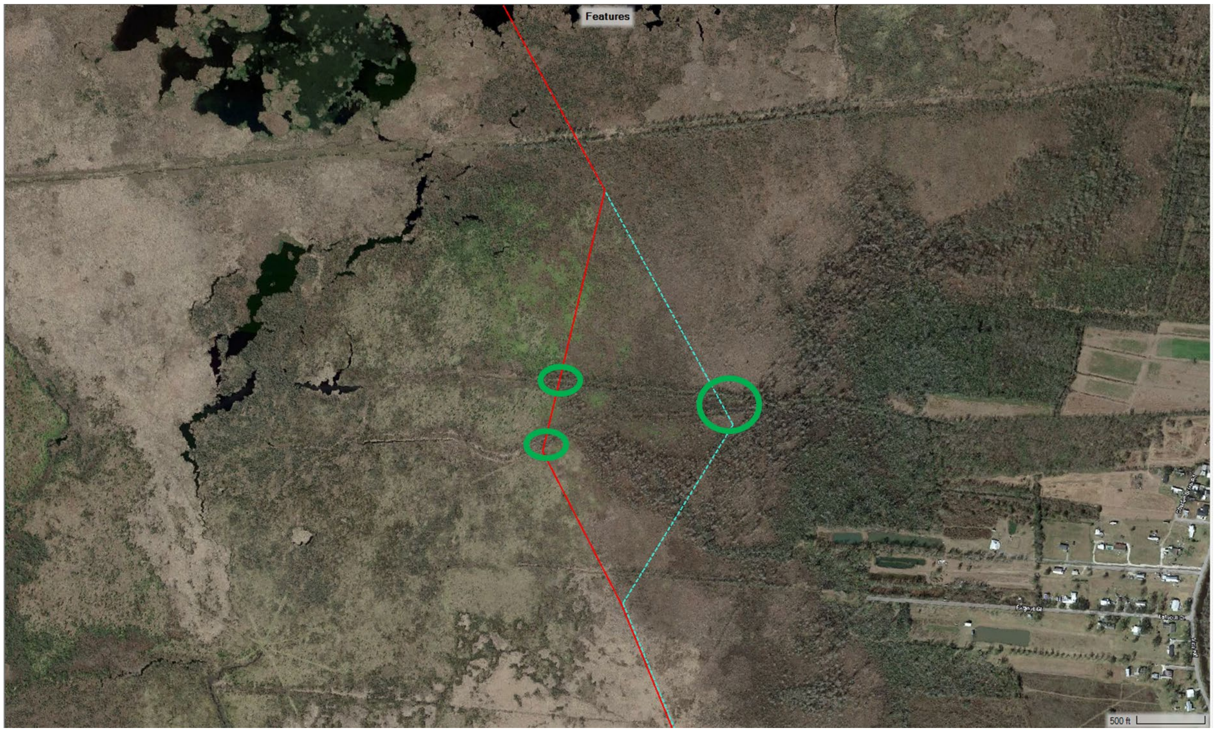

Figure 27: Culvert Design Locations in the Middle of Reach A South

The southern most point of Reach A is shown in Figure 28. The drainage design for this section of levee is not finalized at this point and is awaiting survey information. Visually comparing the two alignments at this location, there appears to be no major difference hydraulically to altering the alignment to the proposed shifted alignment. This location does not have any natural canals large enough to be utilized for drainage, and thus either alignment would have to design the drainage system in this area without an existing canal.

Figure 28: Levee Alignments along southernmost point of Reach A South

Because a hydraulic model is available for this leveed area domain, the HEC-RAS model from the 2022 Morganza to the Gulf Hydraulic Analysis was utilized to compare water level differences for the 10-year precipitation event. This model and event are being used to design the drainage structures for Reach A. Subtracting the PACR alignment maximum water surface elevation results from the shifted alignment results, the differences between water levels is displayed; this is shown in Figure 29. Viewing the results, there is only very minor differences between the resulting interior water levels when comparing the two Reach A Alignments. The water level difference results indicate that the interior drainage of the Reach A system is not significantly changed when the alignment is shifted.

Figure 29: Maximum Water Surface Elevation Difference Grid – PACR Reach A Alignment Minus PACR Shifted Alignment, 10-year precipitation only event

3. <u>Conclusion:</u>
   Comparing the proposed PACR Reach A alignment with the proposed shifted alignment, it is clear that the shifted alignment will not significantly change the hydraulics of the system, nor will it inhibit the drainage design of the levee system. This conclusion is backed up by the HEC-RAS model results comparing both alignments resulting water levels for the 10-year precipitation event.

Mississippi Valley Division, Regional Planning
and Environment Division South

Draft Proposed Water Control Structure Operations Plan (December 2023)

December 5, 2023

Morganza to the Gulf of Mexico, Louisiana

Water Control Structure Operations Plan

The following is an operation plan for the navigation gates, flood gates, and environmental control structures that are incorporated into the Morganza to the Gulf (MTG) Levee System. The following plan must be routinely reevaluated, at least every 5 years, by USACE New Orleans District. Updates may include, but are not limited to, increasing trigger water surface elevations to account for sea level rise, updating closure/reopening procedure for specific environmental conditions such as salinity or sedimentation, and updating instantaneous gages that are acceptable for use in determining closure or reopening of structures and gates.

Acceptable Use

All real-time water surface elevations used to determine closure or reopening should be read at the location of the structure or gate. If there is not a gage at the structure or gate location, the following gages are acceptable to use to retrieve instantaneous stages in and around the MTG Levee System. It is imperative that the stages obtained from the USGS website are converted to water surface elevations in NAVD88 (if necessary) using the conversion published on the gage's page, which is also listed below. Gages both internal of and external to the MTG Levee System may be used to determine a closure, but only gages external of the MTG Levee System may be used to determine reopening. No structure or gate can be closed or reopened when the pressure head differential exceeds the design capability. Additionally, no structure or gate can be reopened until the storm force winds have dropped to a level which is safe for personnel to access the area and operate the machinery.

Gages internal of the MTG Levee System:

USGS 07381150 Bayou Lafourche at Lockport, LA

- Subtract 3.9 feet from the stage to get elevation in NAVD88

USGS 07381350 Company Canal at Hwy 1 at Lockport, LA

- Subtract 0.7 feet from the stage to get elevation in NAVD88

USGS 07381355 Company Canal at Salt Barrier near Lockport, LA

- Subtract 1.18 feet from the stage to get elevation in NAVD88

Gages external to the MTG Levee System:

USGS 073813498 Caillou Bay SW of Cocodrie, LA

- Subtract 0.41 feet from the stage to get elevation in NAVD88

USGS 292952090565300 CRMS 0411-H01-RT

- Subtract 0.91 feet from the stage to get elevation in NAVD88

USGS 07381349 – Caillou Lake (Sister Lake) SW of Dulac, LA

- Subtract 1.03 feet from the stage to get elevation in NAVD88

USGS 07380330 Bayou Perot at Point Legard near Cutoff, LA

- Add 1.67 feet to the stage to get elevation in NAVD88

USGS 2951190901217 L. Cataouatche at Whiskey Canal S of Waggaman, LA

- Subtract 3.5 feet from the stage to get elevation in NAVD88

Operating Plan

Table 1, includes operation guidance for the structures located within each levee reach shown in Figure 1. The trigger water surface elevations are highlighted in Table 1. Historic gage data from the USGS, USACE, and CRMS was utilized to approximate appropriate water surface elevation triggers. For each group of levee reaches, the selected trigger water surface elevations corresponded to approximately the 0.2% annual exceedance probability (AEP) value, using October 2013 to November 2023 for the statistical analysis period. The trigger elevations were chosen to be consistent with the existing levee system operation plan. The statistical analysis allowed more clarity to the frequency of these values occurring.

Figure 1: Morganza to the Gulf Levee Reaches

Table 1: Morganza to the Gulf Structure Operation Guidance

Reach Name	Structures/Gates	Closure Conditions[3]	Reopening Conditions
Barrier Reach	Bayou Black Floodgate Shell Canal West Floodgate (Stoplog Gate) Shell Canal East Floodgate NAFTA Canal Environmental Control Structures	1. A named storm is in the Gulf of Mexico that is threating the Louisiana coast, OR 2. The water surface elevation measured at the gate/structure location reaches **+3.0 ft NAVD88**	1. The water surface elevation on the outside of the gate/environmental control structure drops below **+3.0 ft NAVD88**, AND (for ONLY Navigation Gates) 1. The NHC small craft advisory no longer applies to the area, 2. The channel has been cleared of debris or obstructions so that navigation can safely resume.
Reach A North of GIWW	Environmental Control Structures		
Reach A South of GIWW	Minors Canal Floodgate GIWW West[1] Environmental Control Structures		
Reach B	Marmande Canal Floodgate (Stoplog Gate) Falgout Canal Floodgate[1]	1. A named storm is in the Gulf of Mexico that is threating the Louisiana coast, OR (for ONLY Navigation Gates) 2. The water surface elevation measured at the gate location reaches **+2.5 ft NAVD88**, OR (for ONLY Environmental Control Structures) 2. The water surface elevation measured at the structure location (or nearest approved instantaneous gage) reaches **+3.0 ft NAVD88**.	1. The water surface elevation measured on the exterior of the System at the gate location drops below **+2.5 ft NAVD88**, OR 1. The water surface elevation measured on the exterior of the System at the environmental control structure location drops below **+3.0 ft NAVD88**, AND (for ONLY Navigation Gates) 1. The NHC small craft advisory no longer applies to the area, 2. The channel has been cleared of debris or obstructions so that navigation can safely resume.
Reach E (1&2)	Bayou Dularge Floodgate Environmental Control Structures		
Reach F (1&2)	Bayou Grand Caillou Floodgate[1] HNC Lock Complex[2]		
Reach G (1-3)	Four Point Bayou Floodgate (Stoplog Gate) Environmental Control Structures		
Reach H (1-3)	Bayou Petit Caillou Floodgate[1] Placid Canal Floodgate[1] Environmental Control Structures		
Reach I (1-3)	Bush Canal Floodgate[1] Bayou Terrebonne Floodgate Humble Canal Floodgate		
Reach J (1-3)	Bayou Pointe Aux Chenes Floodgate[1] Environmental Control Structures		
Reach K	Environmental Control Structures		
Reach L	Grand Bayou Floodgate[1] Proposed Structure at Bayou Blue		
GIWW Reach	Larose Floodgate	1. A named storm is in the Gulf of Mexico that is threating the Louisiana coast, OR 2. The water surface elevation measured at the gate/structure location reaches **+3.0 ft NAVD88**	1. The water surface elevation on the outside of the gate/environmental control structure drops below **+3.0 ft NAVD88**, AND (for ONLY Navigation Gates) 1. The NHC small craft advisory no longer applies to the area, 2. The channel has been cleared of debris or obstructions so that navigation can safely resume.
Lockport Reach A	GIWW East[1]		
Lockport Reach B	Environmental Control Structures		
Reach J	Environmental Control Structure #1 and #2	Managed according to current LA Wildlife and Fisheries Permit.	Managed according to current LA Wildlife and Fisheries Permit.

Notes:

1. Structure contains culverts within or adjacent to the floodgate for continued flow passage when the gate is closed. Most culverts include a flap gate and/or sluice gate that can also be closed if the closure conditions are reached.
2. HNC Lock Complex has additional criteria for acceptable closure, see "**HNC Lock Complex**" section.
3. All water surface elevations should be read at the gate or structure location to satisfy closure conditions. If the gate or structure does not have a gage on location, the water surface elevation must be taken from an approved gage. See "**Acceptable Use**" section, above, for approved gages.
4. NHC = National Hurricane Center

HNC Lock Complex
The HNC Lock Complex will be closed for salinity control only if: THIS IS ALL INFO FROM OLD WATER CONTROL PLAN

1. Flows in the Atchafalaya River flows are below 100,000 cfs as measured on the Simmesport gage (USGS 07381490 Atchafalaya River at Simmesport, LA)

OR

2. A gage on the outside of the HNC Lock complex exceeds a salinity value that has been correlated with preventing exceedance of the maximum allowable chloride level of 250 ppm as defined in EPA's secondary drinking water standard at the Houma Treatment Plant. The structure should be closed for at least 12 hours and fluctuations in chloride levels should be monitored and recorded hourly. This to be determined salinity value at the new gage should correlate with the value of 7.5 ppt measured at the HNC at Dulac monitoring station. The 7.5 ppt trigger will be used to perform the indirect impact analysis in this document. Once the new trigger is established, the impact analysis will be redone to verify the assumptions made.

The HNC Lock Complex may be reopened when:

1. The NHC small craft advisory no longer applies to the area, and the channel has been cleared of obstructions,

OR

2. The differential between the interior water level and exterior water level is equal to or less than +1.0 foot, as measured on the upstream and downstream staff gage, respectively.

AND

3. After monitoring chloride levels over the 12-hour period at the new gage on the outside of the HNC Lock complex drops below the salinity closure trigger described above. For the analysis of indirect impacts, a salinity level of 13 ppt as measured near Cocodrie (LUMCON Station) will be used. The LUMCON station replaces the Bayou Grand Caillou USACE 76305 from the 2002 feasibility report because it has a more robust dataset. If the USACE re-evaluates the salinity trigger at the LUMCON station and comes up with a trigger different than 13ppt, this trigger may change. Once the new trigger is established the impact analysis will be redone to verify the assumptions made. LUMCON STATION DOES NOT EXIST ANYMORE.