

North Padre Island Flow Study Peer Review

Presented by:

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Agenda

- Introduction
- Coastal Engineering Analysis
- Peer Review of LJA's Study
- Anchor QEA Model Setup
- Anchor QEA Model Calibration and Validation
- Anchor QEA Modeling
- Recommendations

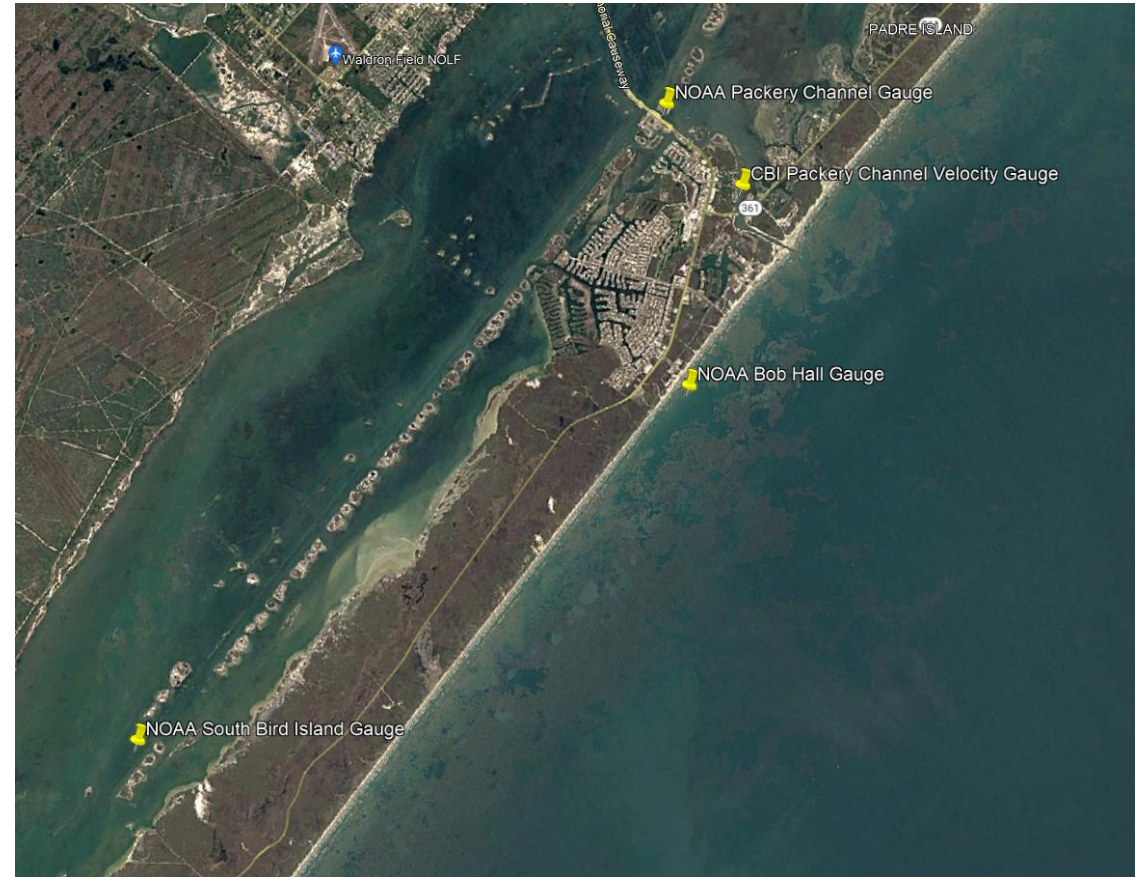
Introduction

- Project Manager/Principal Engineer
 - Aaron Horine, PE (Corpus Christi)
- Senior Project Engineer/Technical Lead
 - Ryan Burke, PE (Austin)
- Study Purpose
 - Review LJA's circulation study for the Whitecap Development
 - Conduct similar study
 - Compare results
 - Provide additional information and recommendations

Coastal Engineering Analysis

Gauges Used

- Three NOAA gauges are utilized in both LJA and Anchor QEA's study
 - These gauges provide boundary conditions for model runs
- An additional gauge monitored by CBI provided historical velocity data for model calibration and validation



Water Surface Elevation Extremal Results

- An extremal analysis is a generalized extreme value (GEV) analysis in which gauge data is statistically analyzed to determine return period events

| | Bob Hall | Packery Channel | South Bird Island |
|----------------------|------------------------|------------------------|--------------------------|
| Return Period | WSE (ft NAVD88) | WSE (ft NAVD88) | WSE (ft NAVD88) |
| 1 | 1.6 | 1.0 | 1.2 |
| 2 | 2.9 | 2.1 | 2.0 |
| 5 | 3.6 | 2.8 | 2.5 |
| 10 | 4.1 | 3.4 | 2.7 |
| 15 | 4.4 | 3.8 | 2.9 |
| 20 | 4.7 | 4.1 | 2.9 |
| 25 | 4.8 | 4.4 | 3.0 |
| 50 | 5.4 | 5.3 | 3.2 |
| 75 | 5.7 | 5.9 | 3.3 |
| 100 | 6.0 | 6.4 | 3.4 |

Peer Review of LJA's Circulation Study

Field Data Collection Initiatives

- LJA conducted a probing survey to characterize channel cross sections across the existing canals
- LJA investigated each of the proposed and existing structures for characteristic dimensions and depths

| Location | Width (feet) | Depth (ft, NAVD88) | | | |
|----------|--------------|--------------------|--------|-------|-------|
| | | left | Center | Right | Ave |
| A | 274 | -5.6 | -5.9 | -6.1 | -5.9 |
| B | 122 | -7.1 | -7 | -5.8 | -6.6 |
| C | 189 | -7.8 | -5.8 | -5.8 | -6.5 |
| D | 233 | -9.8 | -10.3 | -6.8 | -9.0 |
| E | 342 | -5.8 | -10.8 | -5.7 | -7.4 |
| F | 216 | -11.3 | -11.8 | -12.1 | -11.7 |
| G | 313 | -11.8 | -13.1 | -11.8 | -12.2 |
| H | 301 | -11.8 | -11.9 | -9.8 | -11.2 |
| I | 365 | -11.8 | -14.8 | -13.3 | -13.3 |
| J | 108 | -8.8 | -10.3 | -8.8 | -9.3 |



**Figure and Table provided by LJA Engineering

Other Bathymetric Data Sources

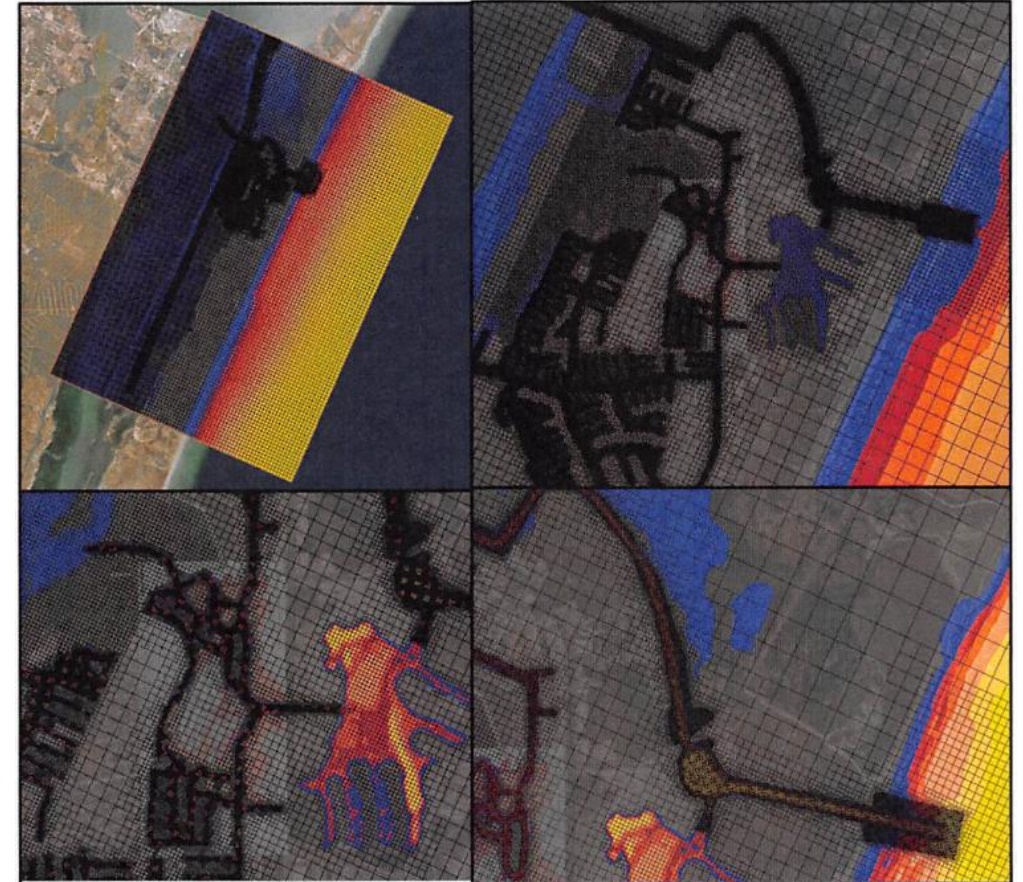
- Hydrodynamic model conducted by Hamilton et. Al 2018
 - Composed of data from the following studies
 - Kraus et. al 2006, Maynard et al. 2001, Lambert et al. 2013, and Wood et al. 2017
 - Data used covers the land, bays, rivers, waterways, nearshore, and offshore area
- Bathymetry along the Gulf Coast is from NOAA Nautical Charts
- Bathymetry for the bays and land were based on NOAA Digital Elevation Models (DEMs) and Lidar

Model Surface Development

- LJA utilized online data or previous study data for all areas outside the project region
- Within the existing canals
 - LJA used survey cross-section data collected at each location and then used the average depth between the cross sections
- Existing culvert structures
 - Existing culvert pipe invert elevations were not determined but were input into the model so that the elevation stayed fully submerged with the correct geometry
- Other structures
 - Information from the data collection provided depths and dimensions for existing structures and design plans were used for the proposed structures

Coastal Modeling System (CMS) Model Grid

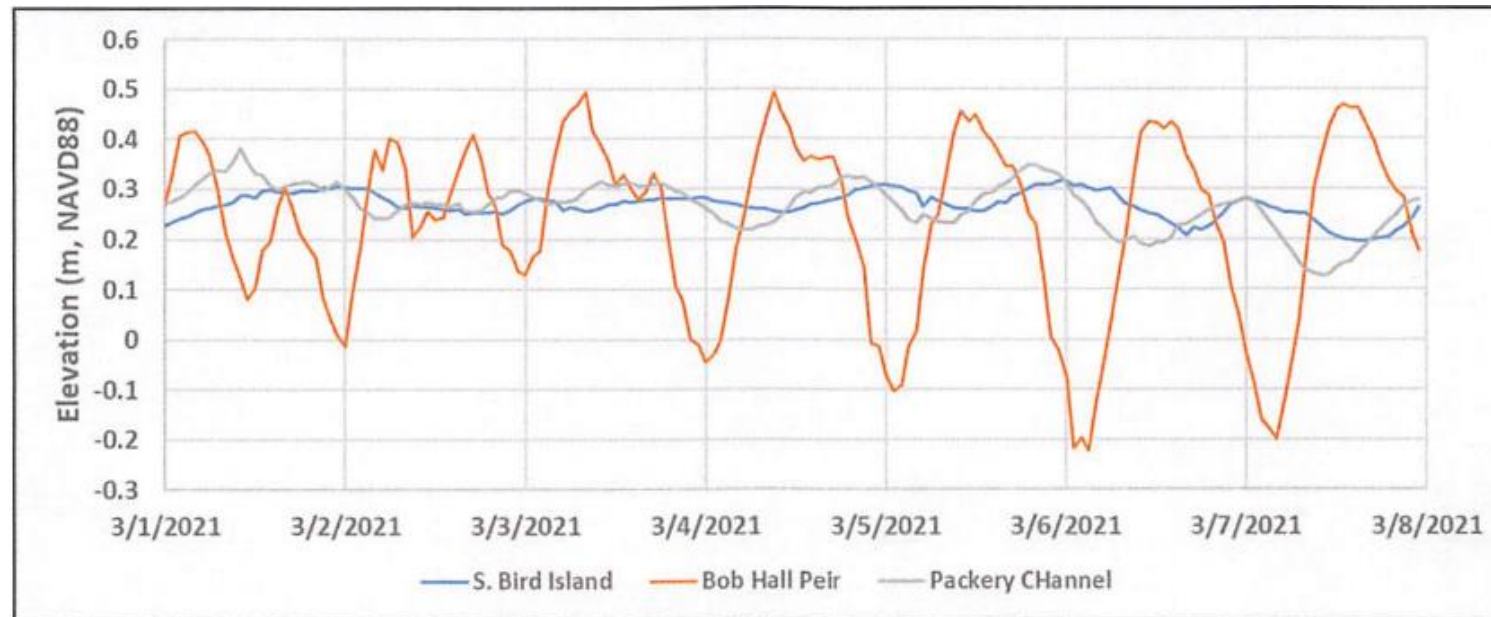
- Variable grid resolution
 - Cell size ranges from 6 to 200 meters
- Grid extent aligned with South Bird Island gauge to assure that the boundaries were not in proximity to the study area



**Figure provided by LJA Engineering

Model Calibration and Validation

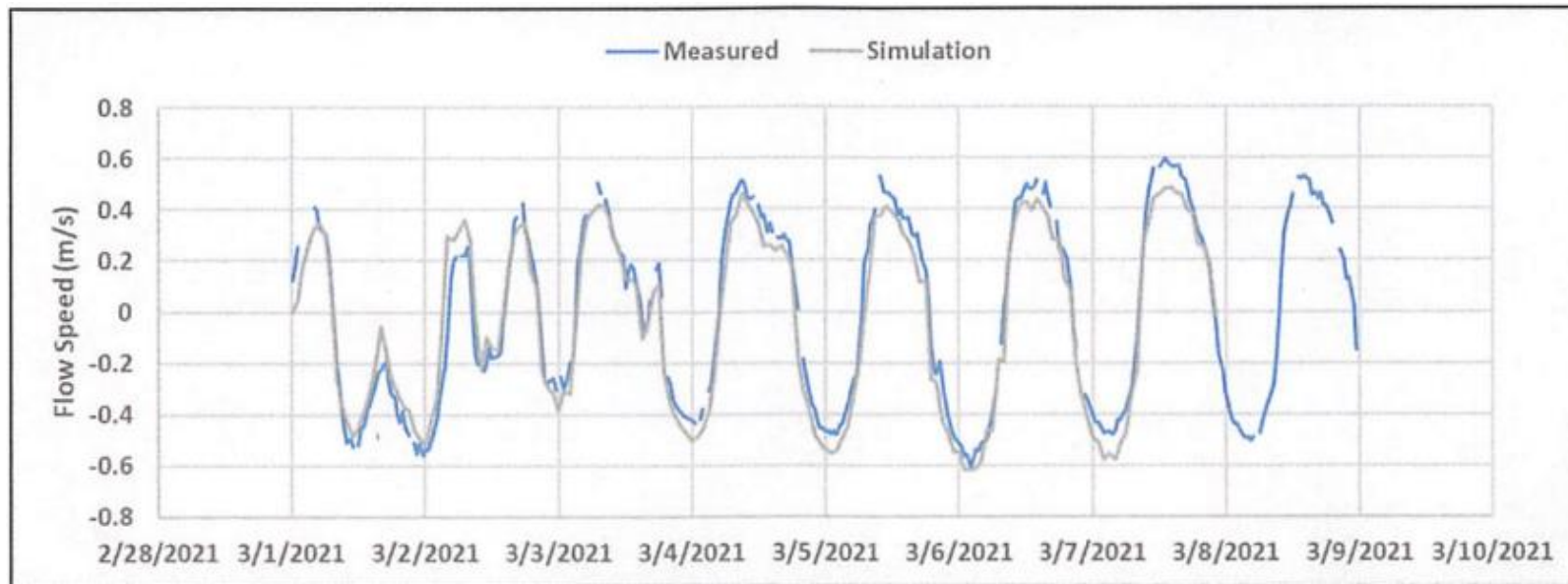
- Calibration and Validation: 3/1/2021 to 3/8/2021
- Water Surface Elevations were extracted from the three gauges and used as boundary conditions



**Figure provided by LJA Engineering

Model Calibration and Validation Results

- Calibration and validation consisted of altering Manning's n value
- The calibration and validation resulted in a Manning's n value of 0.02, which provided an agreement index (R^2) of 0.94

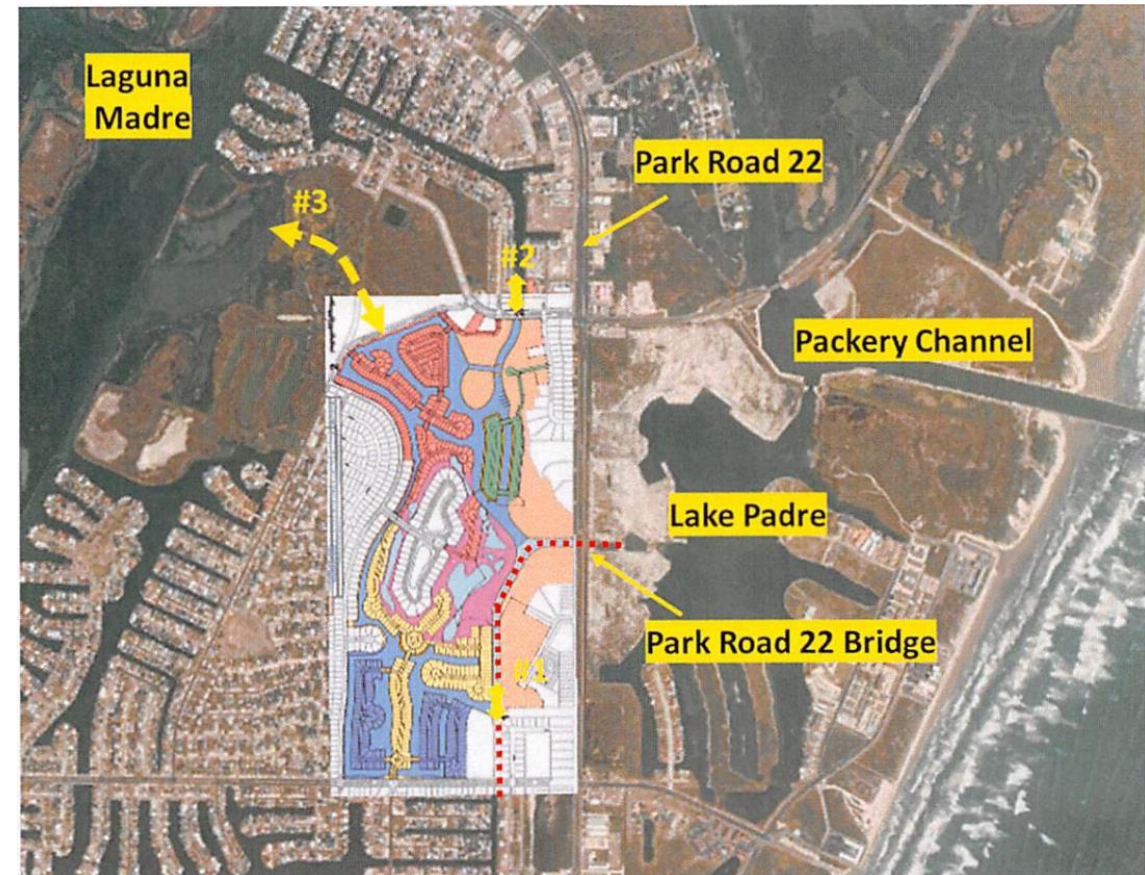


**Figure provided by LJA Engineering

Model Scenarios

- Existing Conditions
 - Bathymetric and structural configurations prior to the start of development
- Tide Gate
 - The narrowing of the connection between Packery Channel and Padre Lake
- Phase 1
 - Connection 1 is open and operational
- Phase 2
 - Connection 1, 2, and 3 are all open and operational

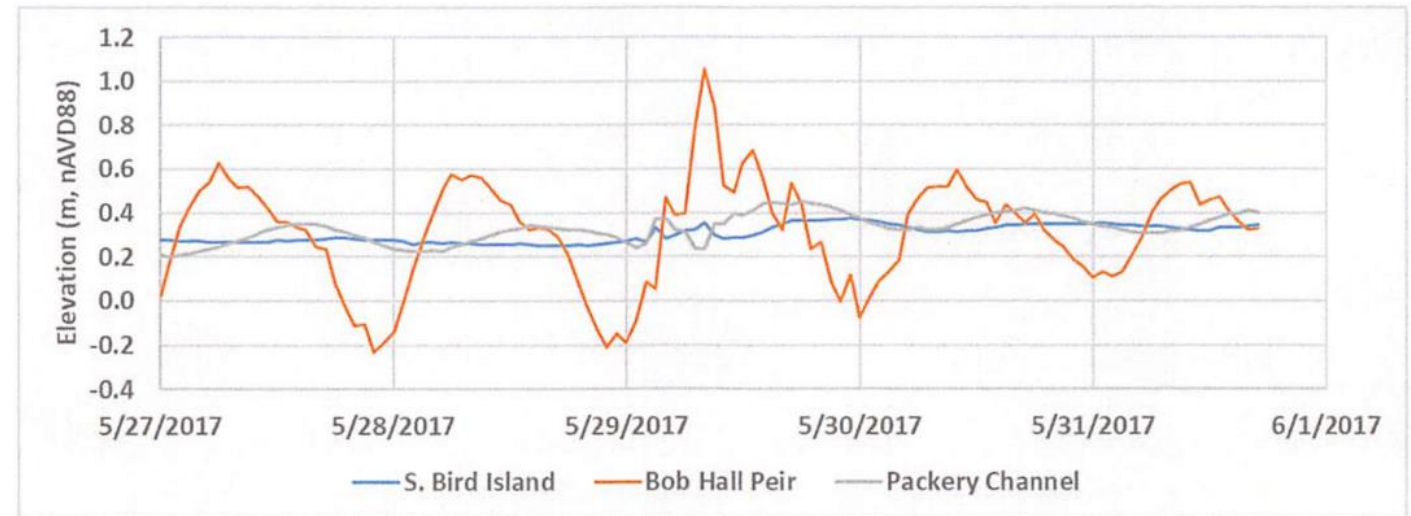
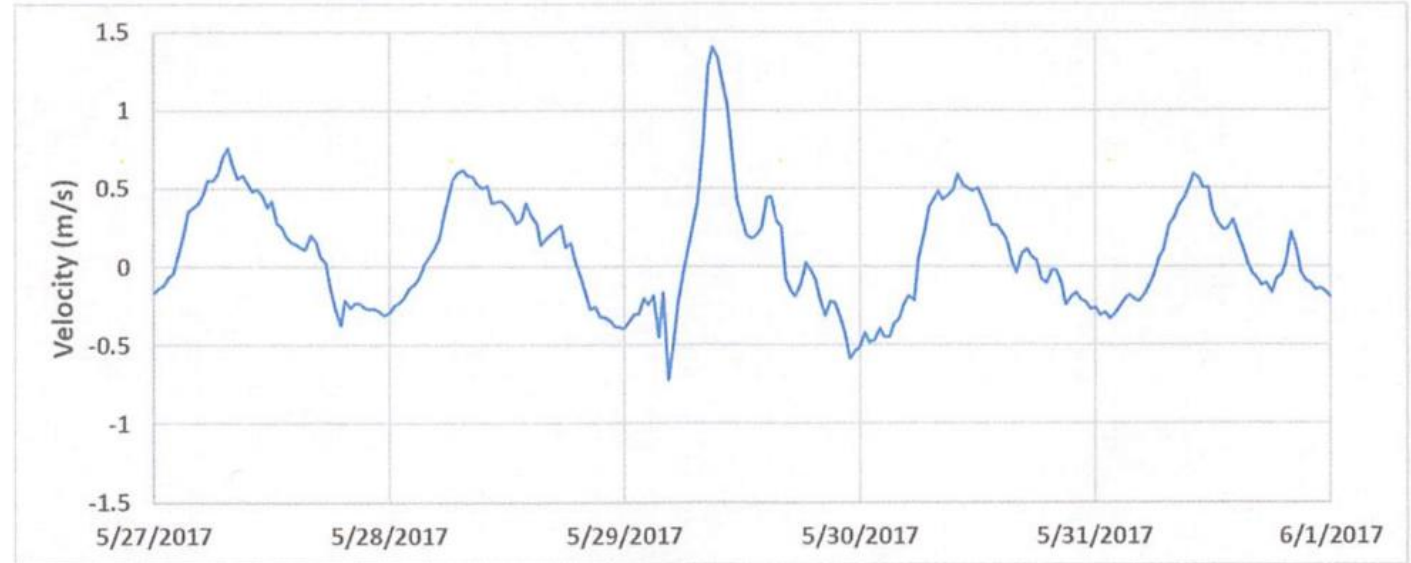
| Scenario | Description |
|----------|----------------------------------|
| EC | Existing Conditions |
| 1 | Phase I with existing tide gate |
| 2 | Phase I with tide gate removed |
| 3 | Phase II with existing tide gate |
| 4 | Phase II with tide gate removed |



**Figure and Table provided by LJA Engineering

High-Flow Event

- CBI Packery Channel Data LJA noted a high velocity event from 5/27/2017 to 6/1/2017
 - Associated with severe thunderstorms and high winds at the time
- LJA pulled the WSE from the gauges and used them as boundary conditions for the “High Flow Event” runs



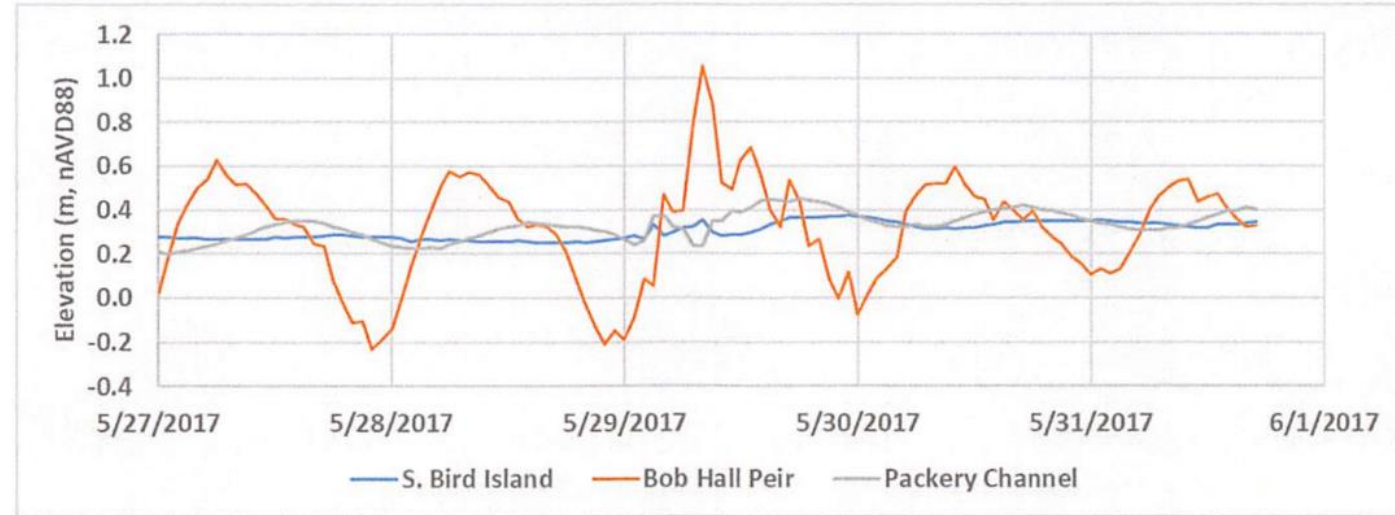
**Figures and Table provided by LJA Engineering

Anchor QEA High Flow Event Characterization

- From the extremal analysis Anchor QEA determined the Peak WSE for each gauge area associated as

| | WSE Max HF Event (m) | Return Period |
|-----------------|----------------------|---------------|
| Bob Hall Max | 1.1 | 5 |
| Packery Max | 0.5 | 1.4 |
| Bird Island Max | 0.4 | 1 |

- The high-flow event is approximately a 5-year event



**Figure provided by LJA Engineering

| | Bob Hall | Packery Channel | South Bird Island |
|---------------|----------------|-----------------|-------------------|
| Return Period | WSE (m NAVD88) | WSE (m NAVD88) | WSE (m NAVD88) |
| 1 | 0.5 | 0.3 | 0.4 |
| 2 | 0.9 | 0.6 | 0.6 |
| 5 | 1.1 | 0.9 | 0.8 |
| 10 | 1.3 | 1.0 | 0.8 |
| 15 | 1.4 | 1.2 | 0.9 |
| 20 | 1.4 | 1.3 | 0.9 |
| 25 | 1.5 | 1.3 | 0.9 |
| 50 | 1.6 | 1.6 | 1.0 |
| 75 | 1.8 | 1.8 | 1.0 |
| 100 | 1.8 | 1.9 | 1.0 |

High-Flow Event Results

- LJA provides maximum velocity results at three locations
 - Park Road 22 Bridge Crossing
 - CBI Gauge Location
 - Packery Channel
 - Tide Gate
 - Between Lake Padre and Packery Channel

| Scenario | Park Road 22 Crossing | Packery Channel | Flood Gate |
|-----------------------|-----------------------|-----------------|------------|
| EC | - | 5.2 | 3.28 |
| Phase 1 with gates | 3.1 | 5.0 | 4.69 |
| Phase 1 without gates | 3.7 | 4.9 | 2.32 |
| Phase 2 with gates | 3.5 | 5.0 | 4.82 |
| Phase 2 without gates | 4.3 | 4.8 | 2.42 |

**Table provided by LJA Engineering



Design Change

- Following the completion of LJA's study, canal configurations were changed
- Model results from LJA for the final configuration have not been provided or reviewed

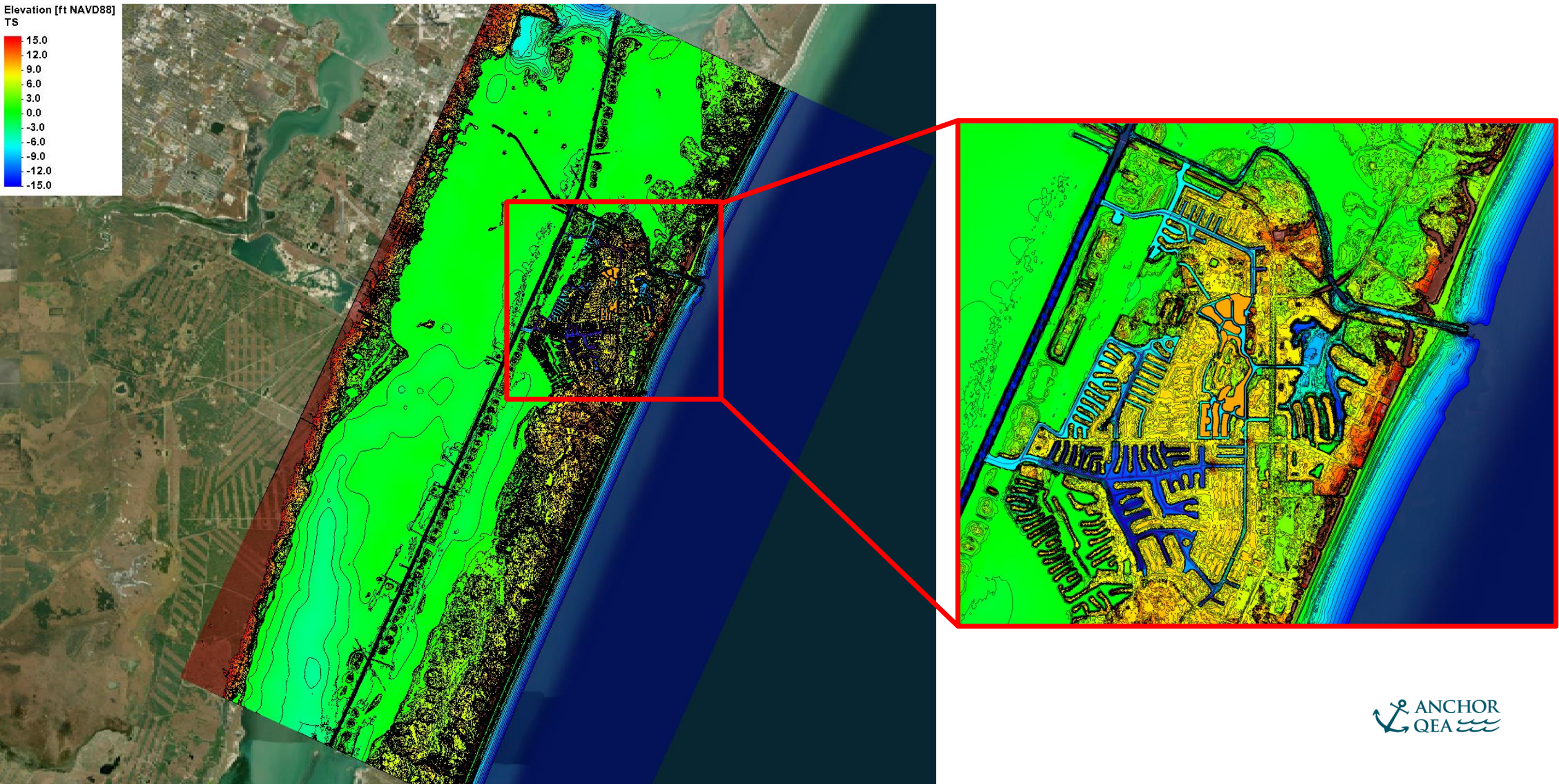


Anchor QEA Model Setup

Anchor QEA Model Surface Development

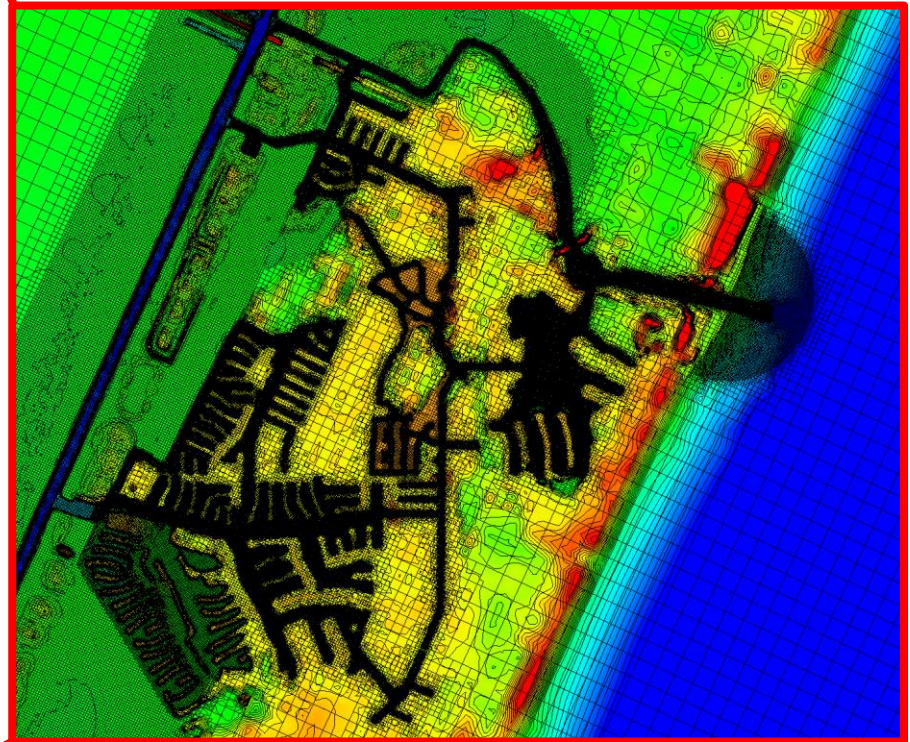
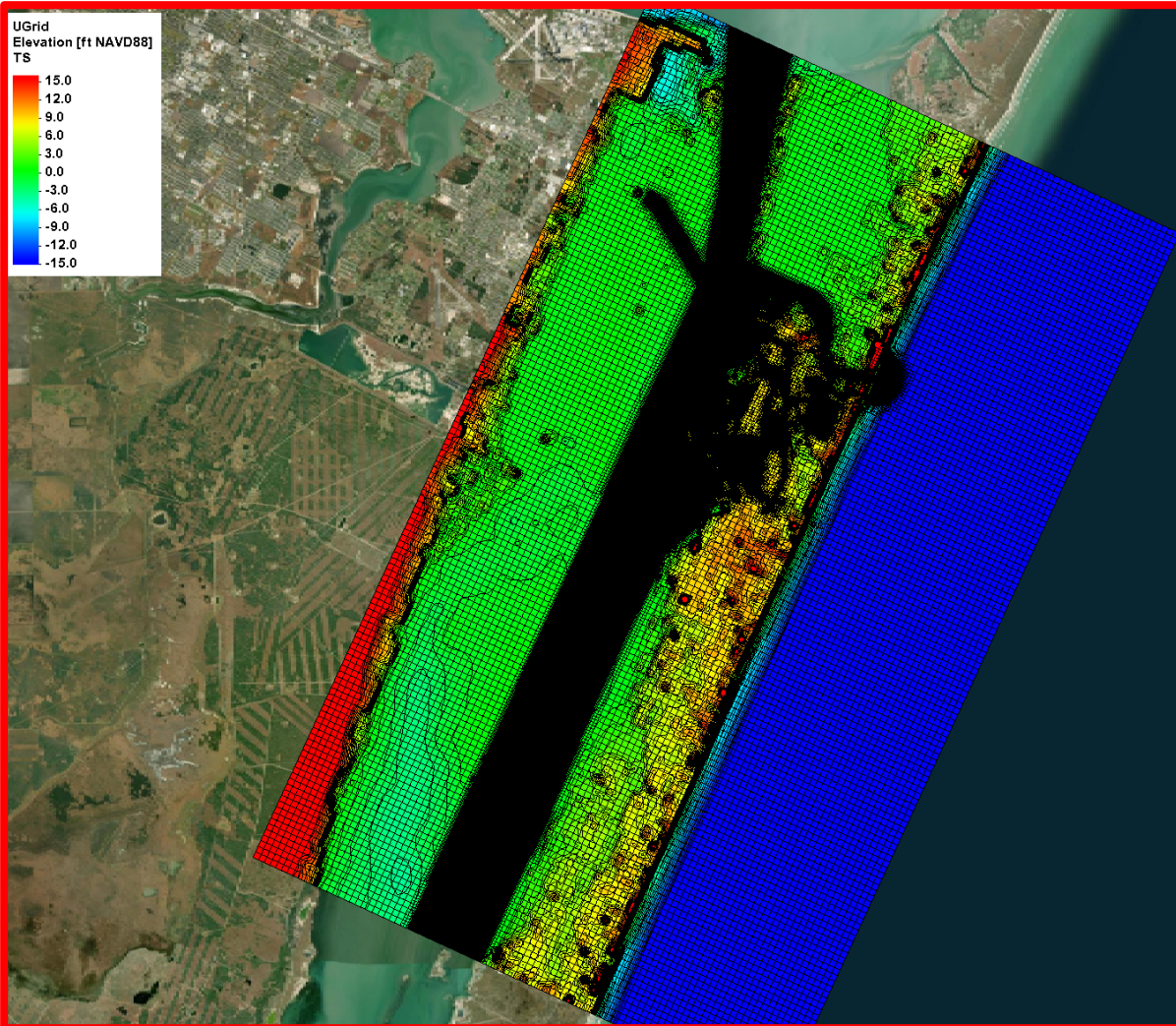
- Anchor QEA used the same data sources for surface development
- Within the existing canals
 - Anchor QEA implemented the cross-section data collected and then linearly interpolated the corresponding slope between for depths between cross sections
- Existing culvert structures
 - CMS does not allow for the inclusion of culverts
 - Anchor QEA implemented culverts as open channels
 - Culverts within the proposed development are never fully submerged
 - Follow open channel flow phenomenon
- Other structures
 - Information from the data collection provided depths and dimensions for existing structures, and design plans were used for the proposed structures

Topographic and Bathymetric Surface



Coastal Modeling System Model Grid

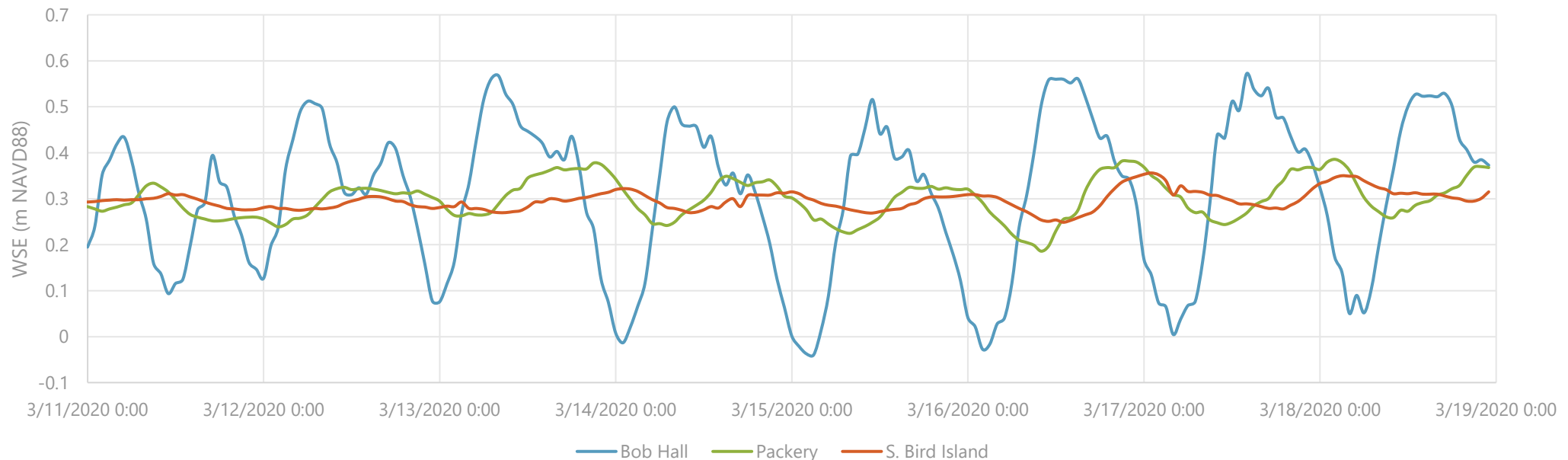
- Variable grid resolution
 - Cell size ranges from 5 to 160 meters
- Grid extent was selected to match LJA's model domain



Anchor QEA Model Calibration and Validation

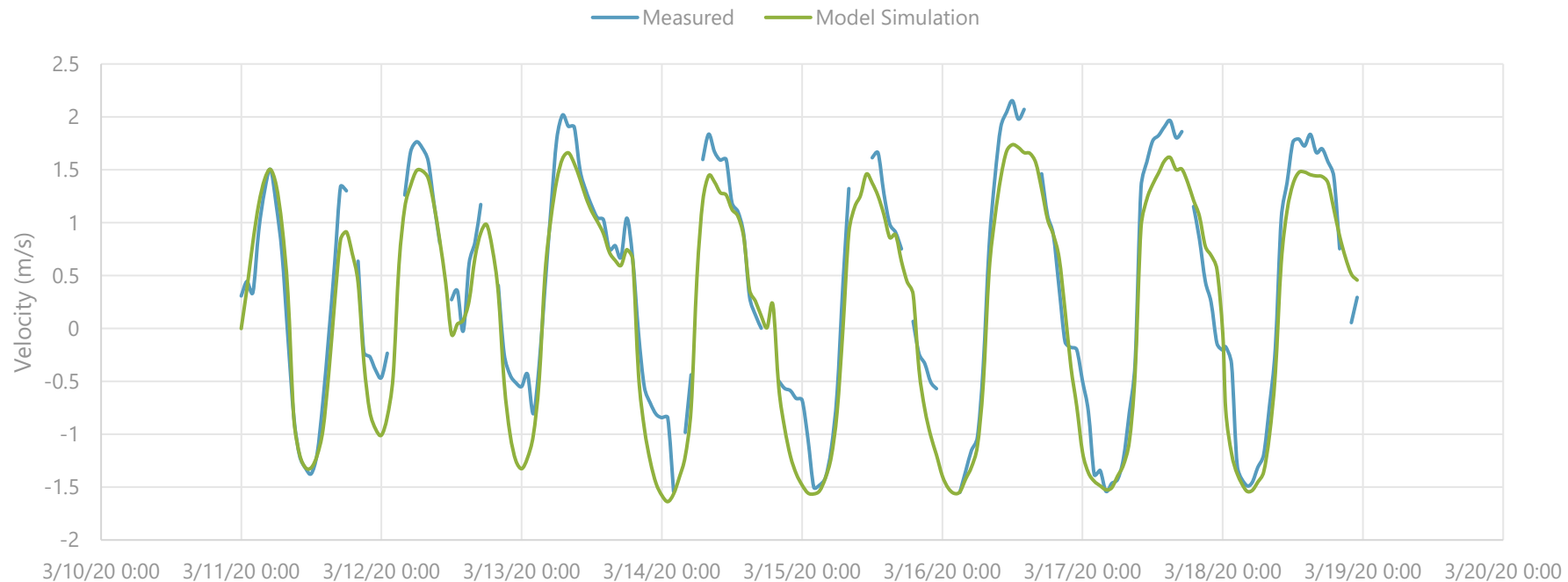
Model Calibration and Validation

- Calibration and Validation: 3/11/20 to 3/18/20
- Water Surface Elevations were extracted from the three gauges and used as boundary conditions



Model Calibration and Validation Results

- Calibration and validation consisted of altering Manning's n
- The calibration and validation resulted in a Manning's n value of 0.02, which provided an index agreement index (R^2) of 0.91



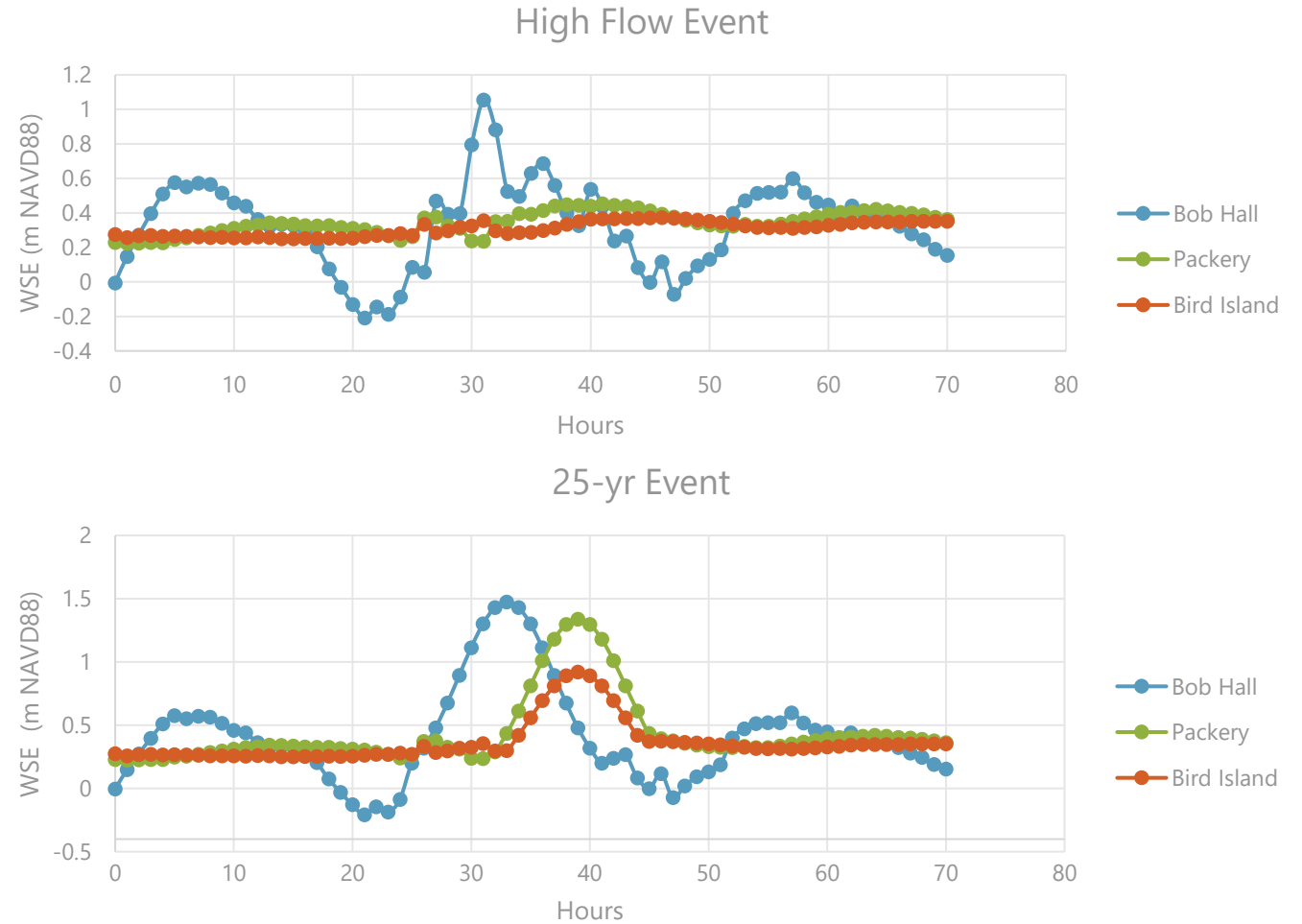
Anchor QEA Modeling

Model Scenarios and Simulations

- Existing Conditions
 - Park Road 22 Open
 - Park Road 22 and School District Open
 - Park Road 22, School District, and Commodores Bridge Open
 - All Open
- Four Simulations for each scenario were ran:
 - Daily Conditions
 - High-Flow Event
 - 25-yr Event
 - 100-yr Event

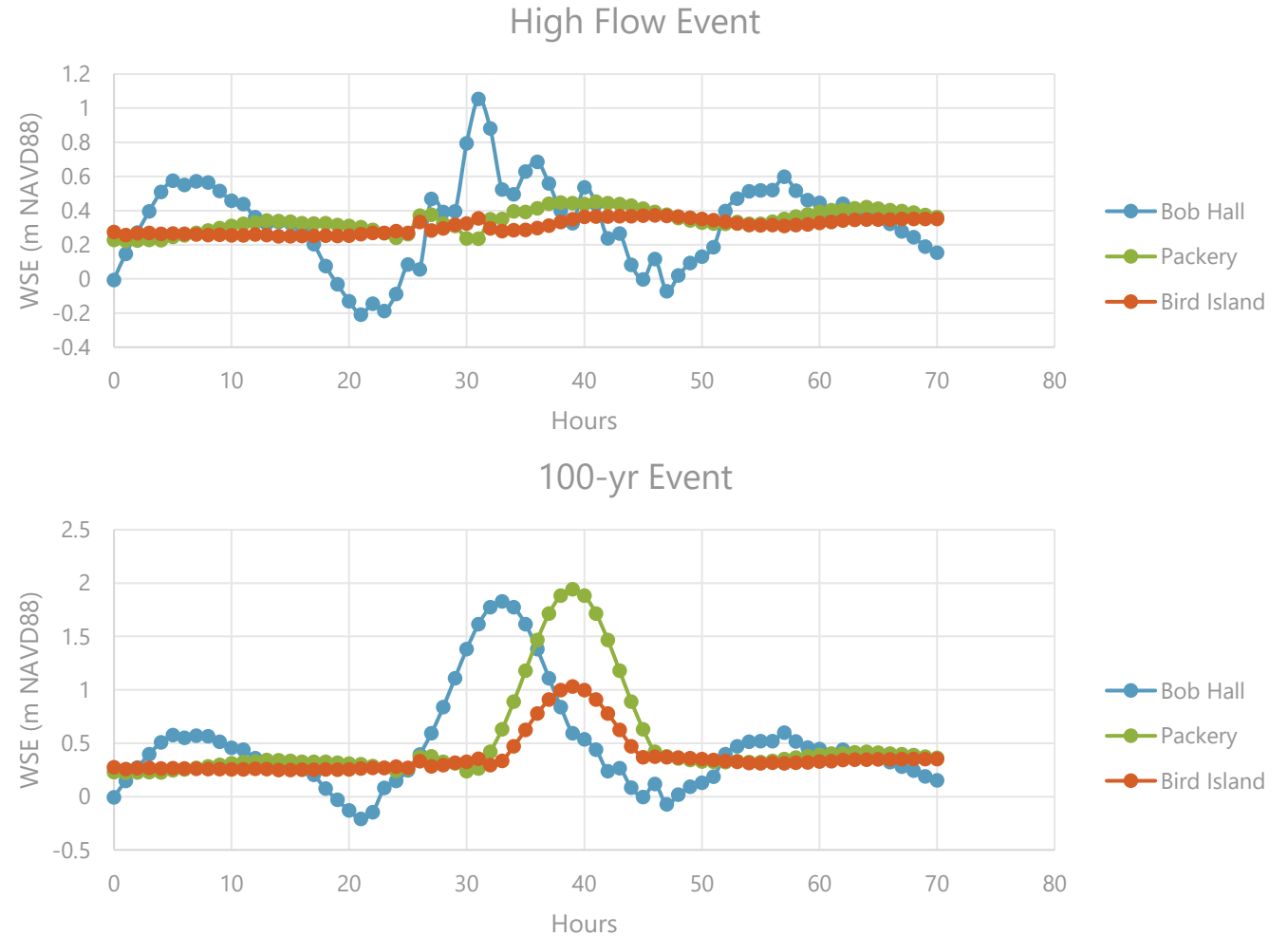
Development of 25-Year Event

- Synthetic 25-year Gulf forcing surge event
- Idealized bell curve distribution developed for each gauge's 25-year water level
- Bell curve hydrograph was supplemented into the high-flow event time series

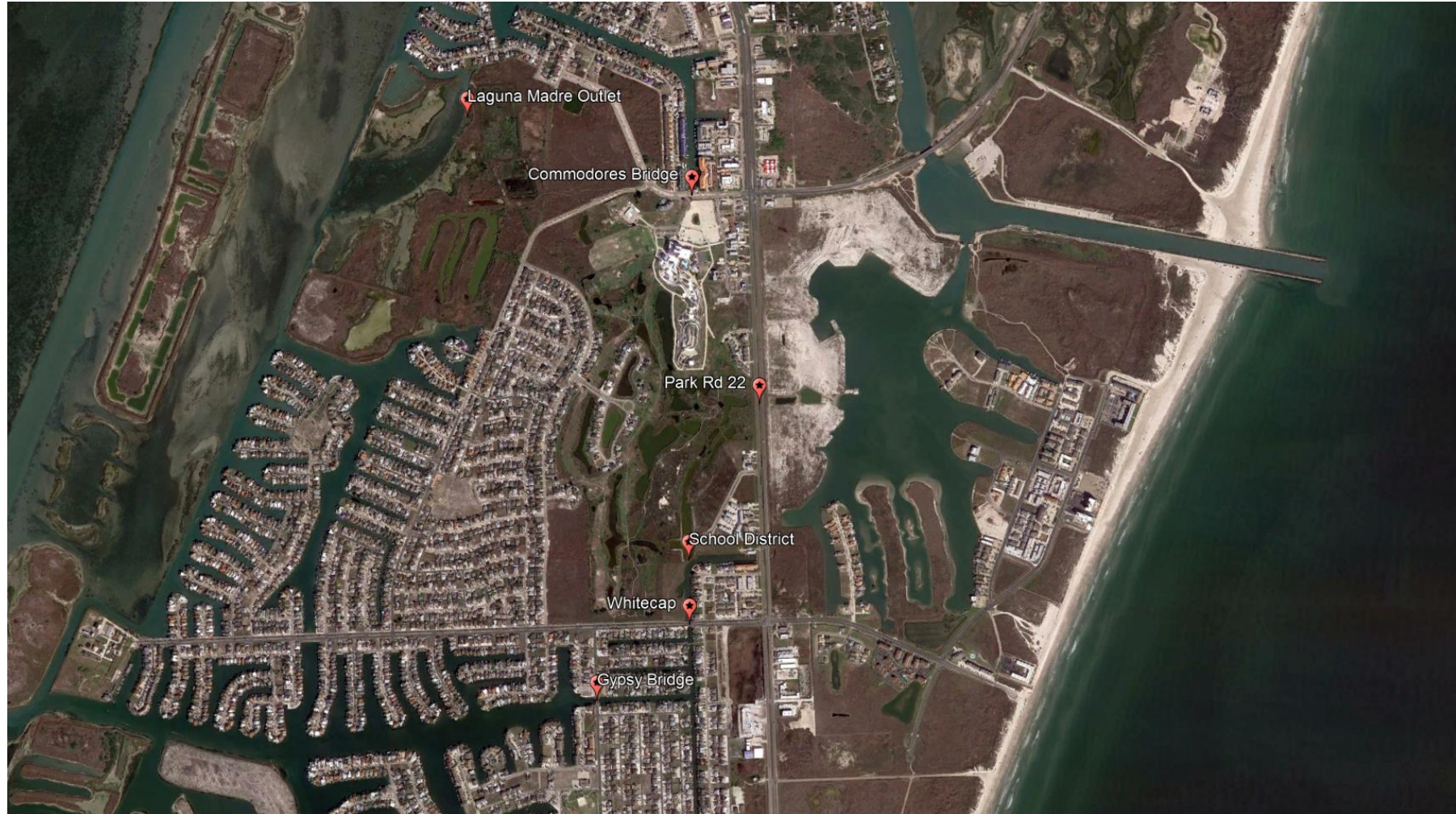


Development of 100-Year Event

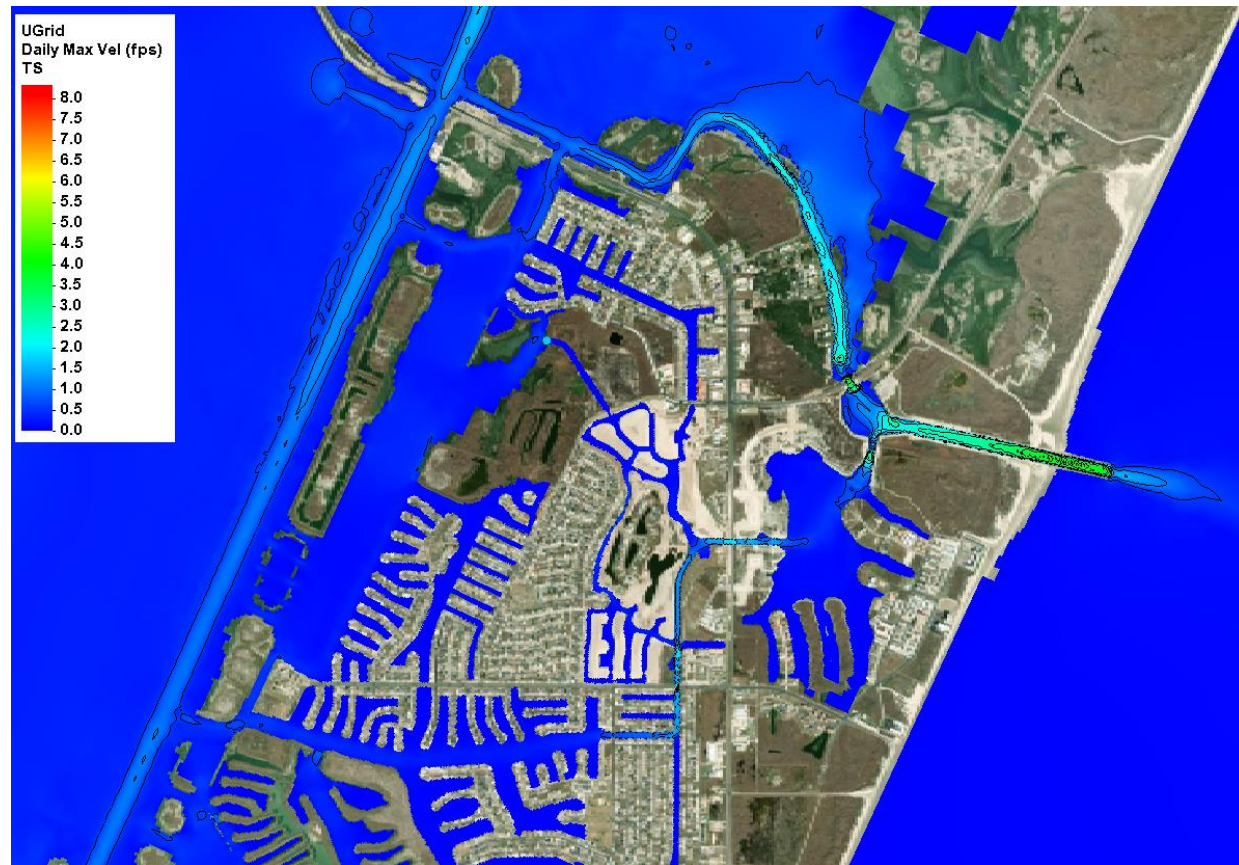
- Synthetic 100-year Gulf forcing surge event
- Idealized bell curve distribution developed for each gauge's 100-year water level
- Bell curve hydrograph was supplemented into the high-flow event time series



Model Extraction Locations



Daily Tide Model Results

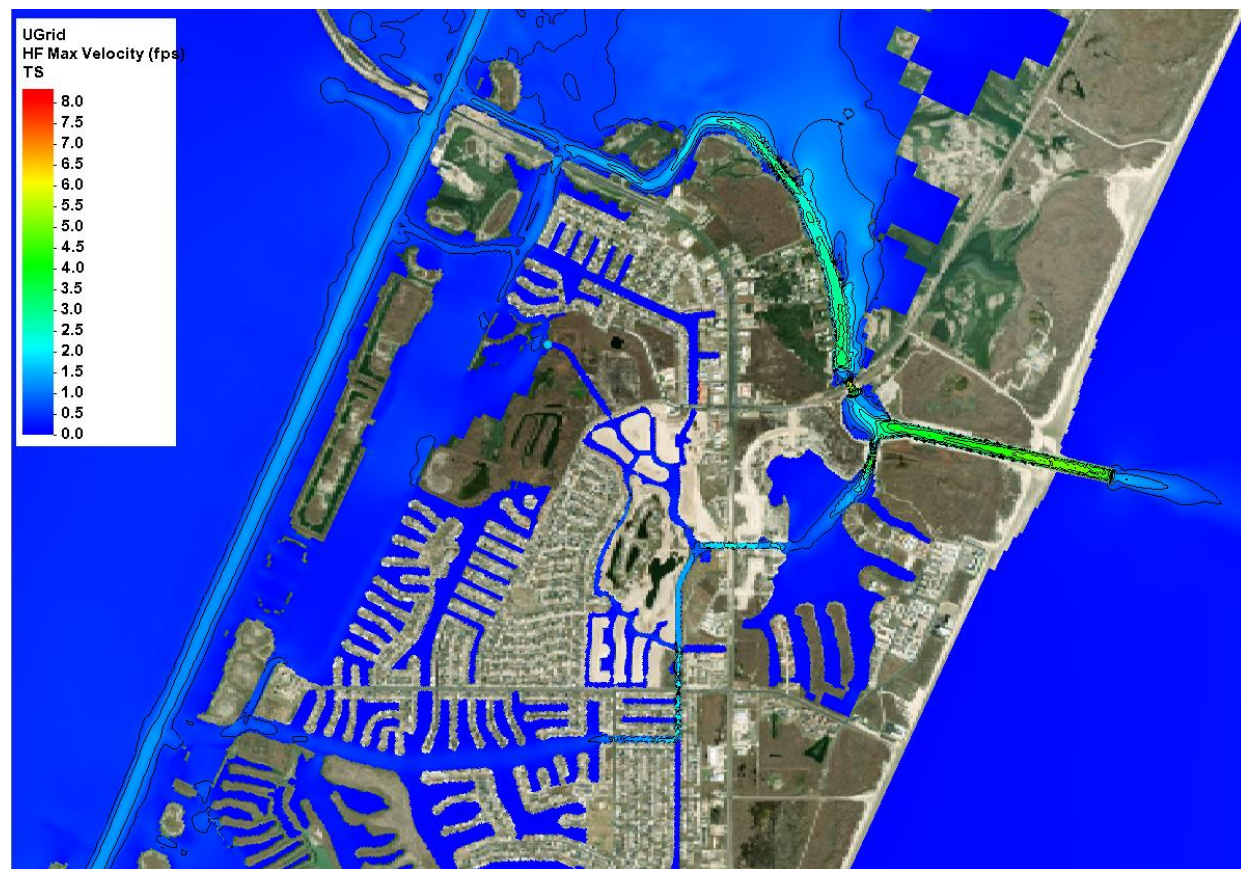


Daily Event: Park Road 22 and School District Open

| | | Whitecap | Gypsy | Park Rd 22 | School District | Commodores Bridge | Laguna Madre Outlet |
|-------|---|----------|-------|------------|-----------------|-------------------|---------------------|
| Daily | Park Rd 22 Open | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 |
| | Park Rd 22 and School District Open | 3.0 | 1.0 | 1.8 | 1.4 | 0.0 | 0.0 |
| | Park Rd 22, School District, and Commodores Bridge Open | 2.1 | 0.7 | 2.4 | 1.0 | 1.9 | 0.0 |
| | All Open | 1.8 | 0.6 | 2.5 | 0.8 | 1.6 | 0.4 |



High-Flow Event Model Results



| | Whitecap | Gypsy | Park Rd 22 | School District | Commodores Bridge | Laguna Madre Outlet |
|---|----------|-------|------------|-----------------|-------------------|---------------------|
| Park Rd 22 Open | 0.0 | 0.1 | 1.0 | 0.0 | 0.0 | 0.0 |
| Park Rd 22 and School District Open | 4.8 | 1.6 | 2.4 | 1.9 | 0.0 | 0.0 |
| Park Rd 22, School District, and Commodores Bridge Open | 3.4 | 1.1 | 3.7 | 1.4 | 3.6 | 0.0 |
| All Open | 2.9 | 1.0 | 4.0 | 1.2 | 3.0 | 0.8 |



High Flow Event: Park Road 22 and School District Open

25-Year Event Model Results

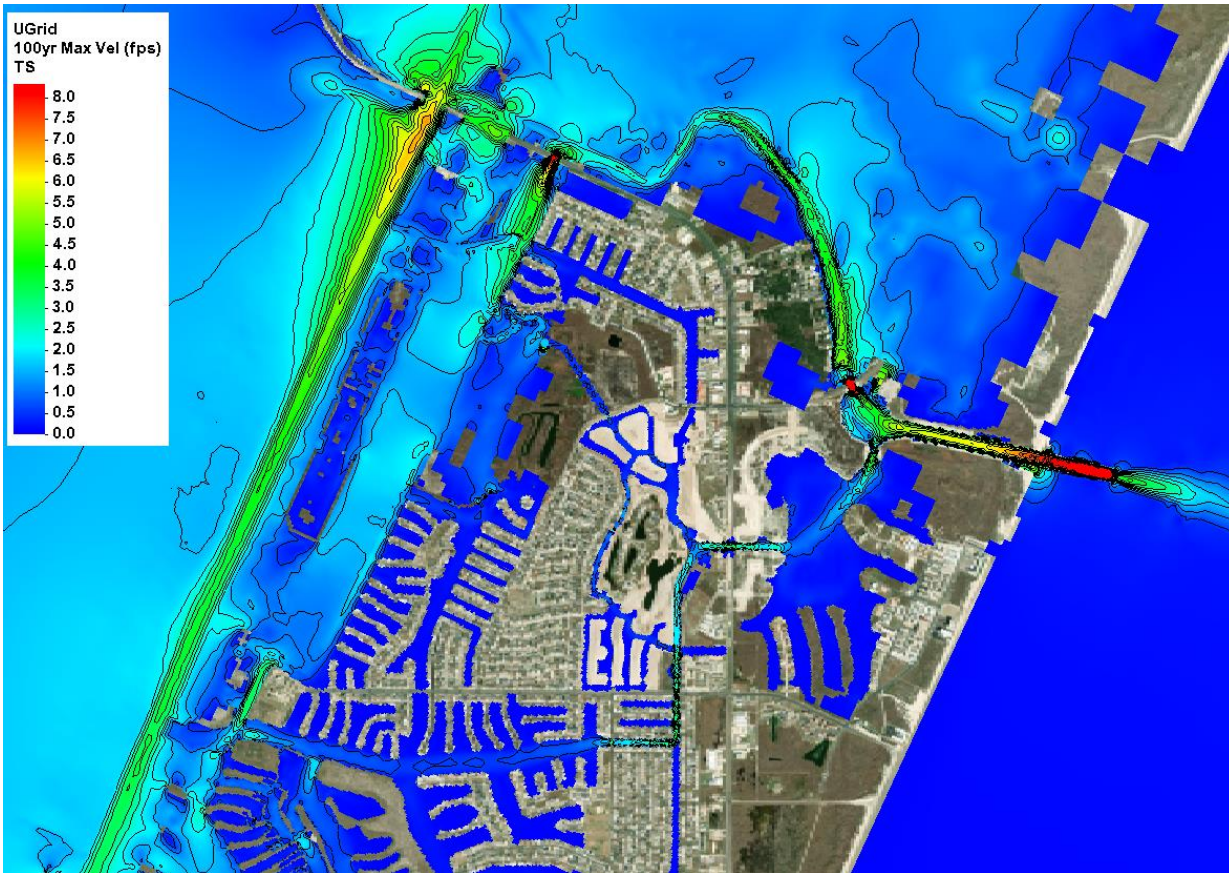


25-Year Event: Park Road 22 and School District Open

| | Whitecap | Gypsy | Park Rd 22 | School District | Commodores Bridge | Laguna Madre Outlet |
|--|----------|-------|------------|-----------------|-------------------|---------------------|
| Park Rd 22 Open | 0.1 | 0.2 | 0.9 | 0.0 | 0.0 | 0.0 |
| Park Rd 22 and School District Open | 6.8 | 2.4 | 2.9 | 2.3 | 0.0 | 0.0 |
| 25-year Event Park Rd 22, School District, and Commodores Bridge Open | 5.1 | 1.7 | 4.8 | 1.9 | 4.9 | 0.0 |
| All Open | 4.4 | 1.5 | 5.3 | 1.8 | 4.0 | 1.1 |

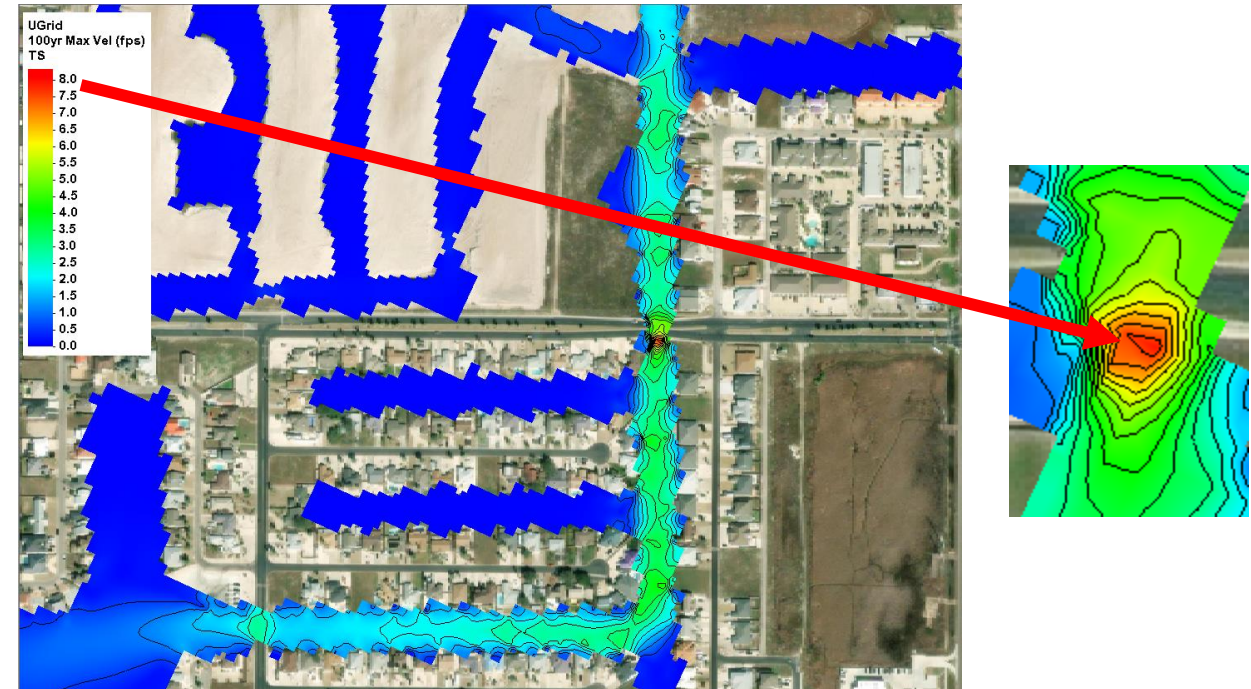


100-Year Event Model Results



100-Year Event: Park Road 22 and School District Open

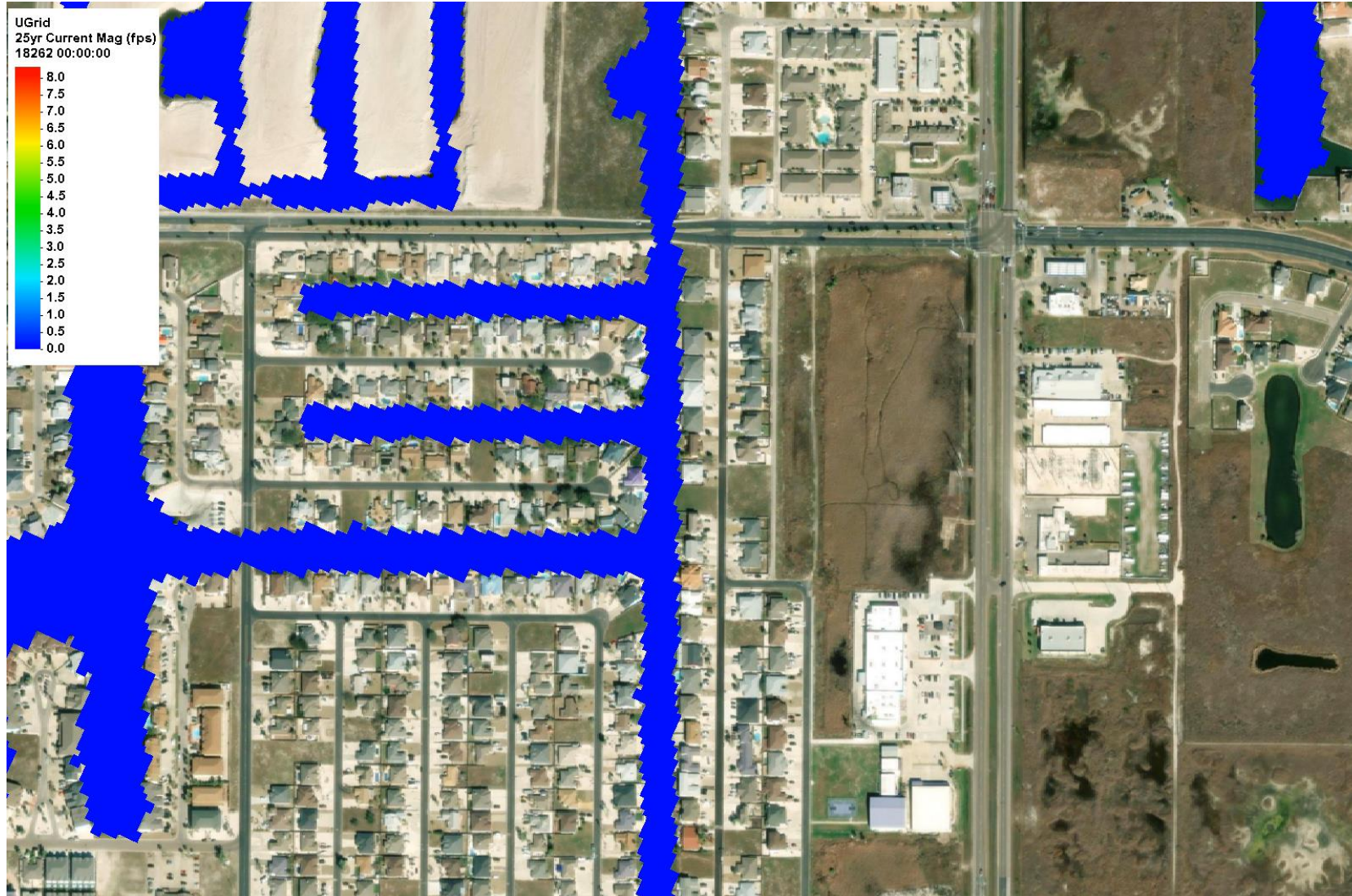
| | | Whitecap | Gypsy | Park Rd 22 | School District | Commodores Bridge | Laguna Madre Outlet |
|-----------------------|---|----------|-------|------------|-----------------|-------------------|---------------------|
| 100-year Event | Park Rd 22 Open | 0.1 | 0.3 | 1.4 | 0.0 | 0.0 | 0.0 |
| | Park Rd 22 and School District Open | 7.9 | 2.8 | 3.3 | 2.6 | 0.0 | 0.0 |
| | Park Rd 22, School District, and Commodores Bridge Open | 6.1 | 2.1 | 5.4 | 2.2 | 5.6 | 0.0 |
| | All Open | 5.3 | 1.8 | 6.1 | 2.0 | 4.6 | 1.3 |



25-Year Event Park Road 22 and School District Open



25-Year Event Park Road 22 and School District Open



Recommendations

Recommendations

- Suggest further analysis for the need of scour protection at Whitecap Bridge
 - Results for Park Road 22 and School District Open
 - Daily event: 3.0 ft/s
 - High-flow event: 4.8 ft/s
 - Higher return period flow events: 6.8 to 7.9 ft/s
- Suggest further analysis for the need of scour protection at Gypsy Bridge
 - Results for Park Road 22 and School District Open
 - Daily event: 1.0 ft/s
 - High-flow event: 1.6 ft/s
 - Higher return period flow events: 2.4 to 2.8 ft/s

Additional Recommendations

- Bathymetric multibeam survey of existing bridges prior to any potentially incorporated scour protection installation
 - Provides details for design and implementation of new scour protection
- Bathymetric multibeam survey of existing bridges post scour protection
 - Provides baseline conditions that can be compared to in the future if additional survey is conducted after a storm event