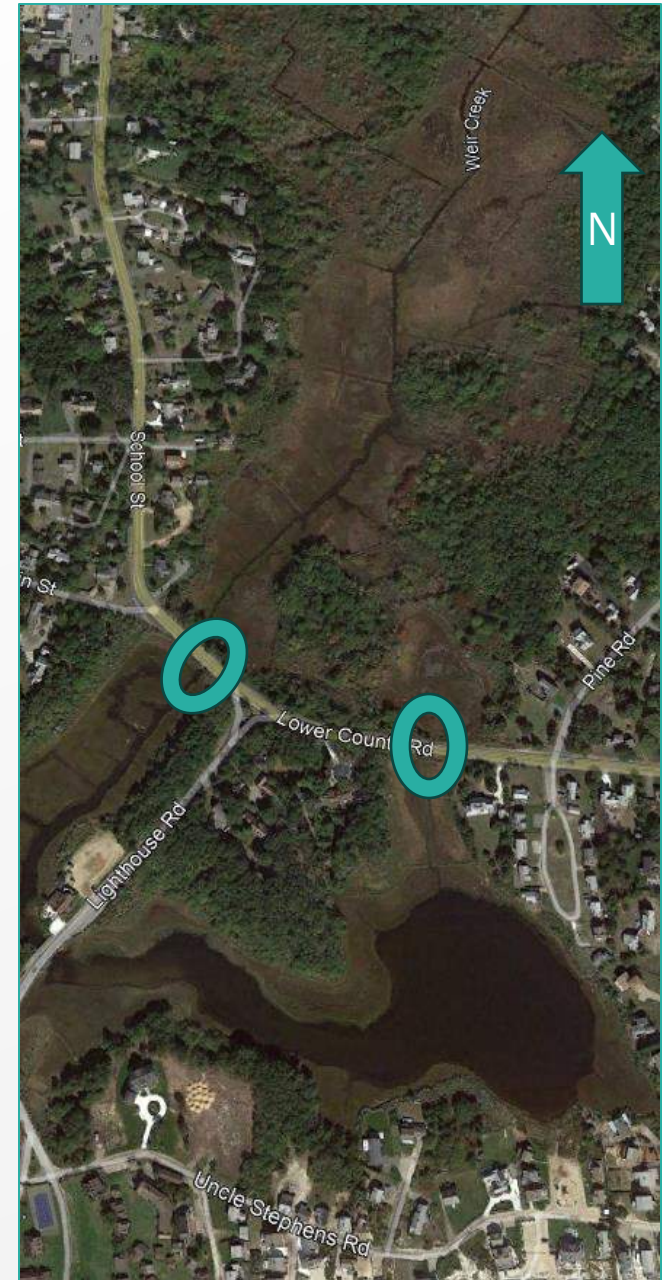


Weir Creek Restoration

Lower County Road Culvert Optimization
Dennis, MA



Arden KT Herrin Woods Hole Group

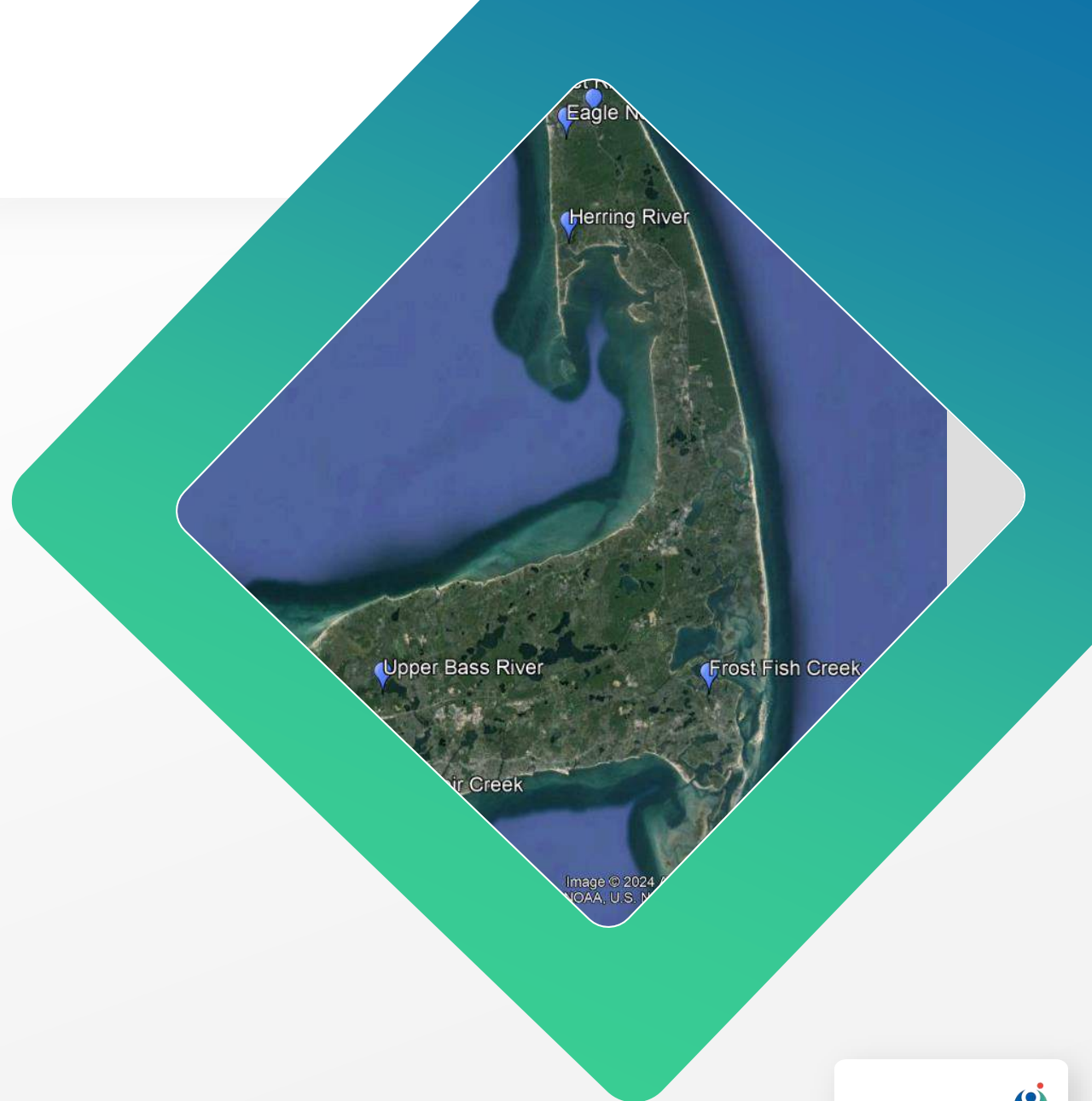
Herring River Restoration

Eagle Neck Creek Restoration

Pamet River Restoration

Upper Bass River Restoration

Frost Fish Creek Restoration

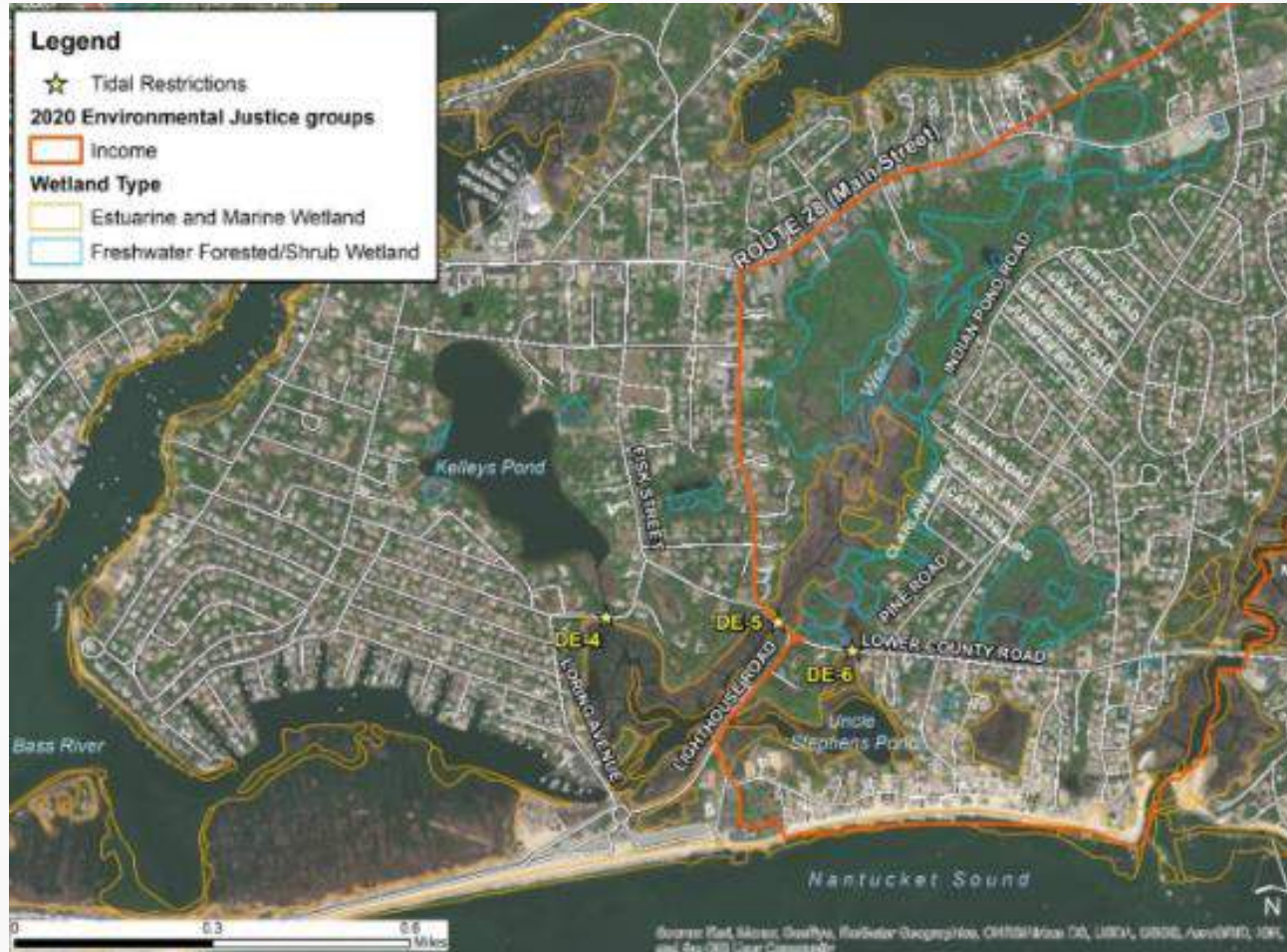


Project Timeline: Data Collection & Modeling



2023-0032-00

Weir Creek Restoration: Area of Study



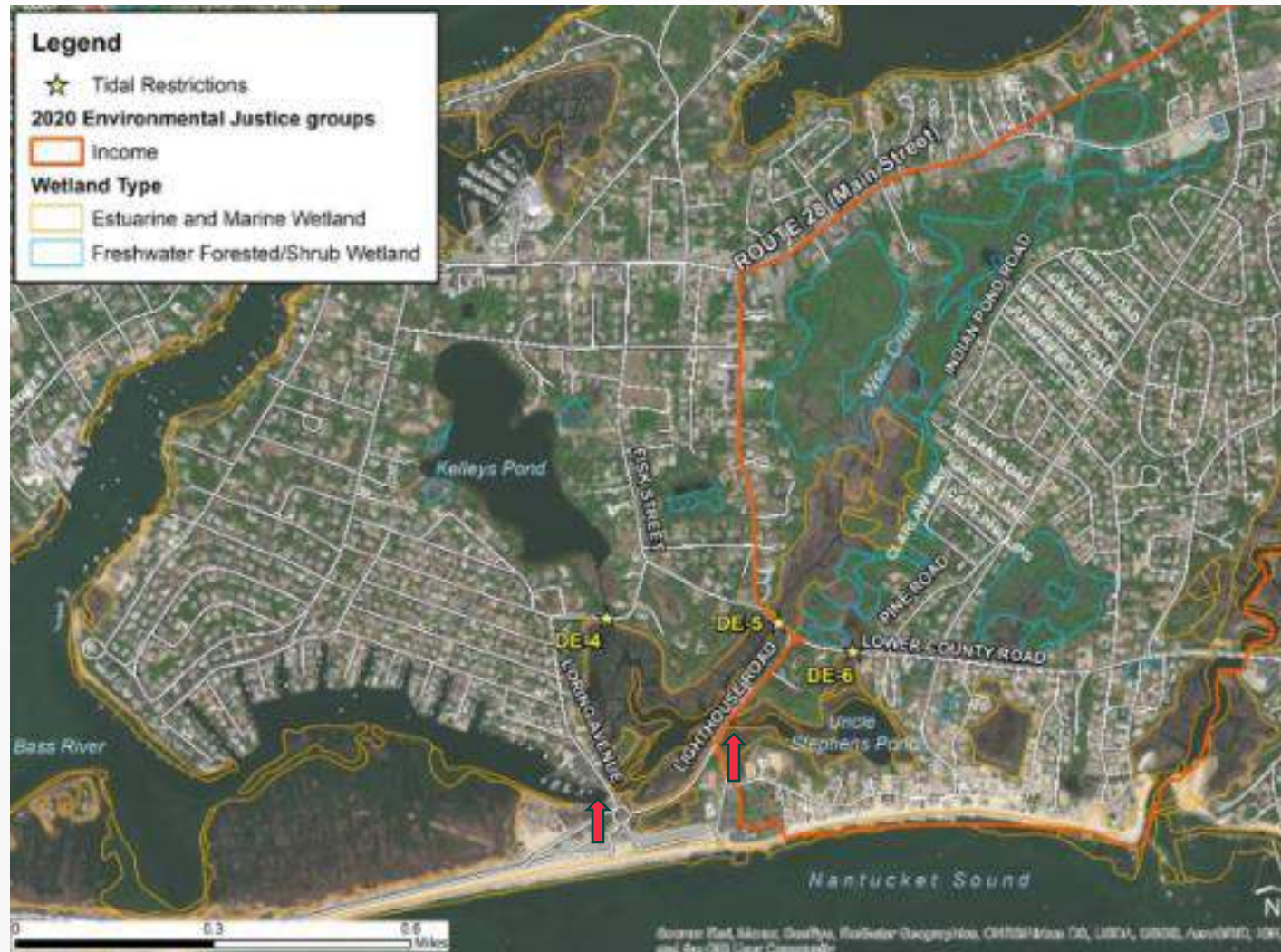
GOALS

- Increased tidal exchange
- Restore habitat
- Mitigate/minimize flooding

Methods

- Water Data Collection
- Bathymetric/Topographic Survey
- Numerical Modeling

Weir Creek Area of Study



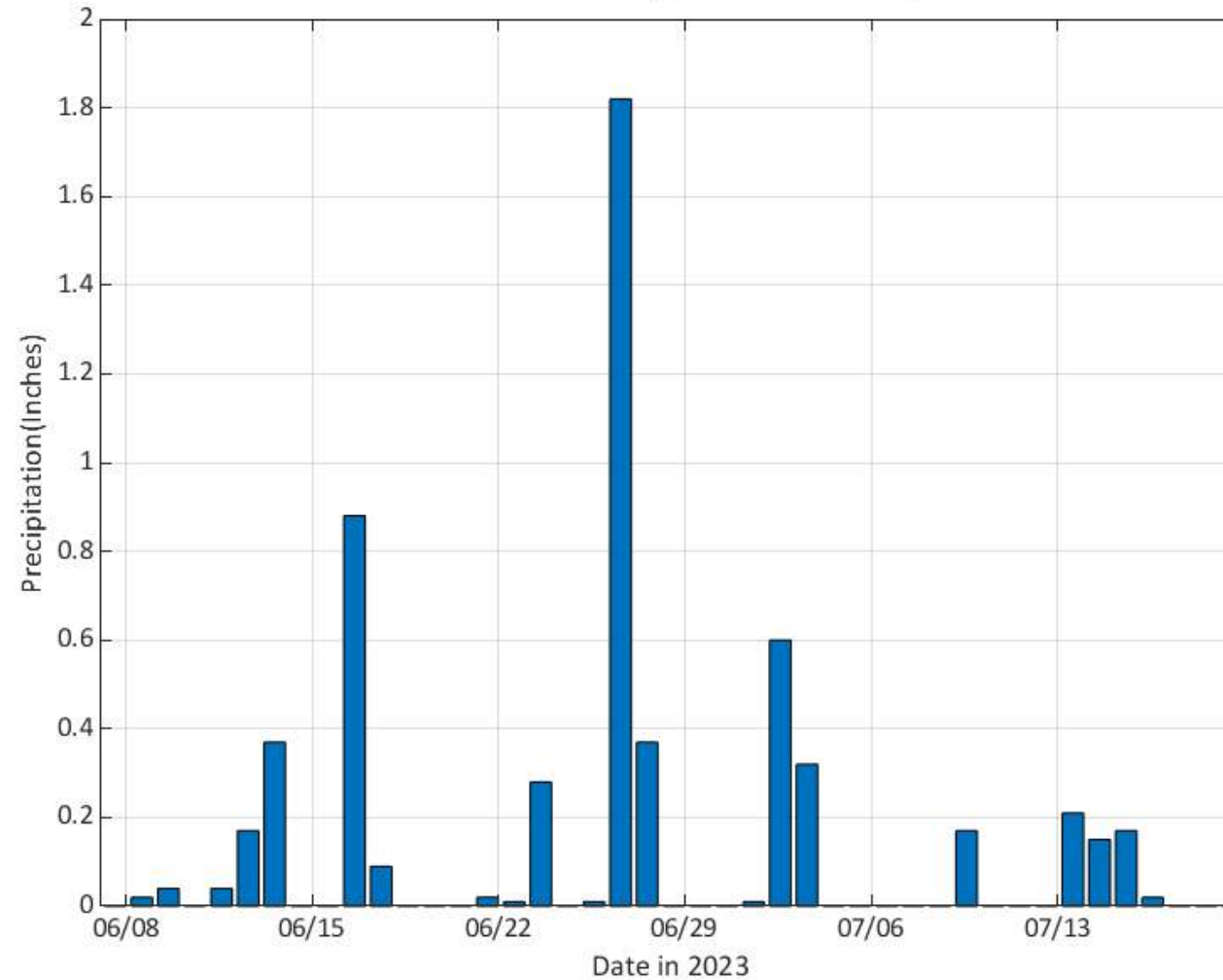
Water Column Measurements

- Ten (10) AT200 CTD measurement stations
- Stations WC1 & WC2 bracket Loring Avenue
- Stations WC8 & WC9 bracket Fisk Street
- Stations WC3 & WC7 bracket Lower County Road (East)
- Stations WC5 & WC6 bracket Lower County Road (West)
- Station WC4 upstream side of the Lighthouse Road bridge
- Station WC10 located upstream in upper Weir Creek (near Regan Road)
- 39 days of continuous measurements (06/8 & 06/09 through 07/18 & 07/19)

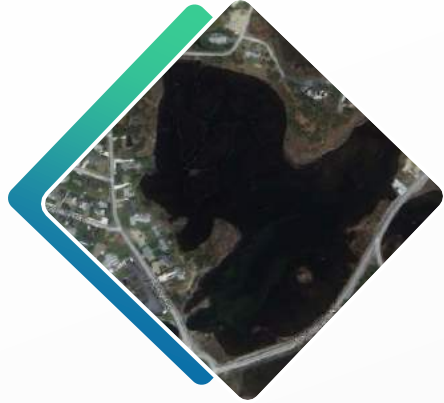


Precipitation Measurements During Deployment Period

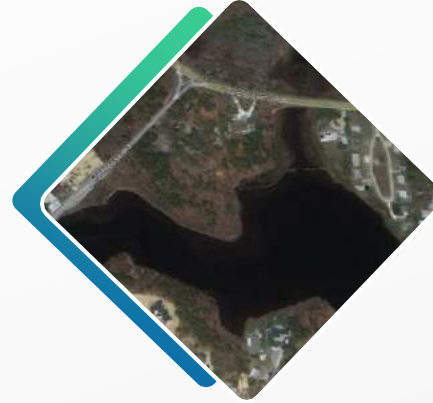
Rainfall at Hyannis Airport



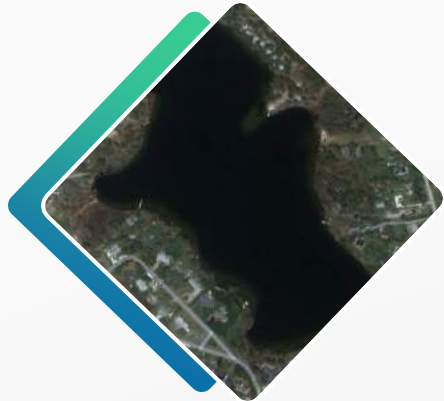
Four Subsystems for Discussion & Review



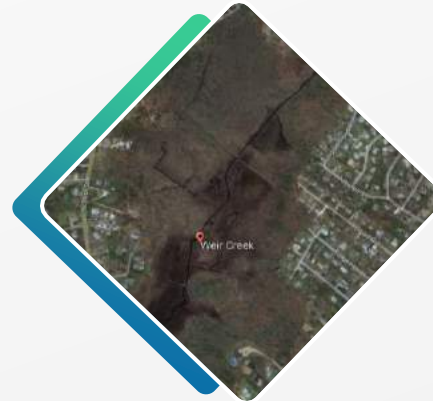
Lower Weir Creek: downstream of Lower County Road, Lighthouse Avenue, and Fisk Street



Uncle Stephen's Pond: East of Lighthouse Avenue & small marsh upstream of Lower County Road



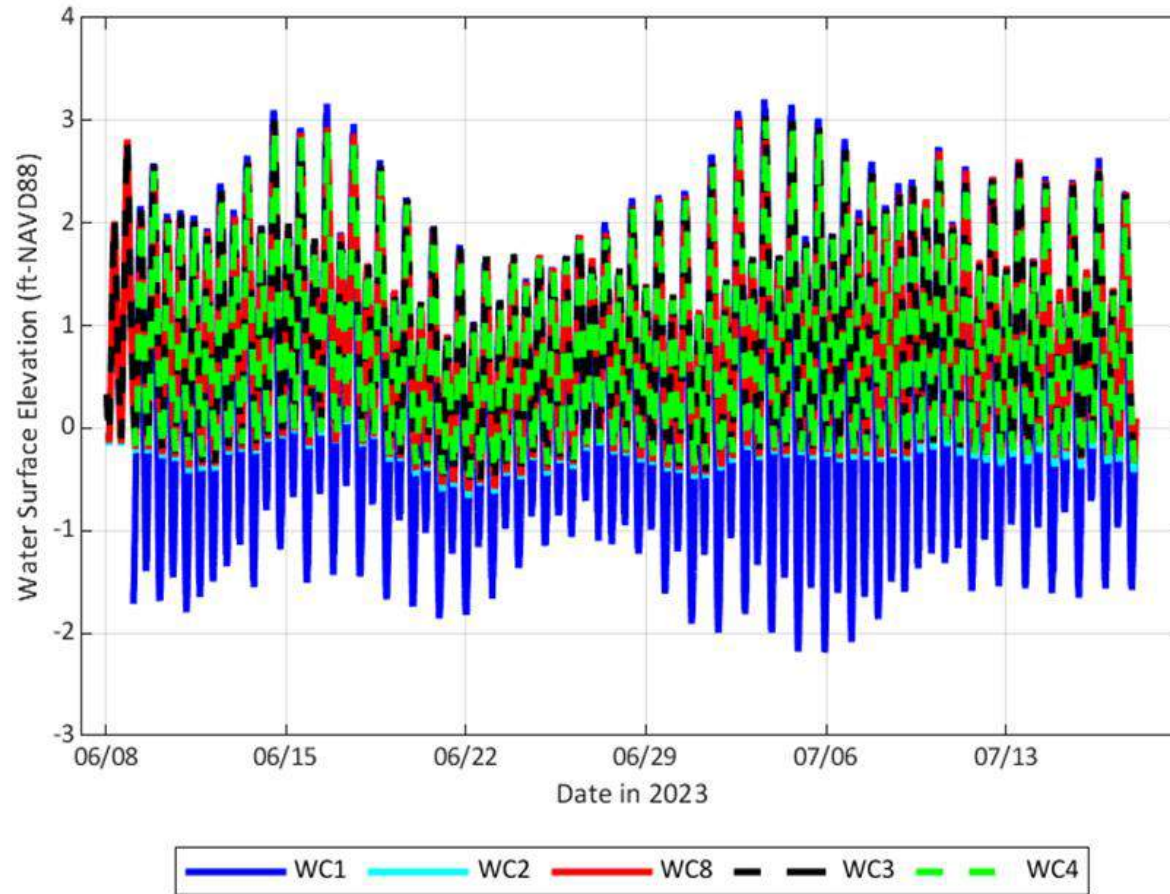
Kelley's Pond: Upstream of Fisk Street



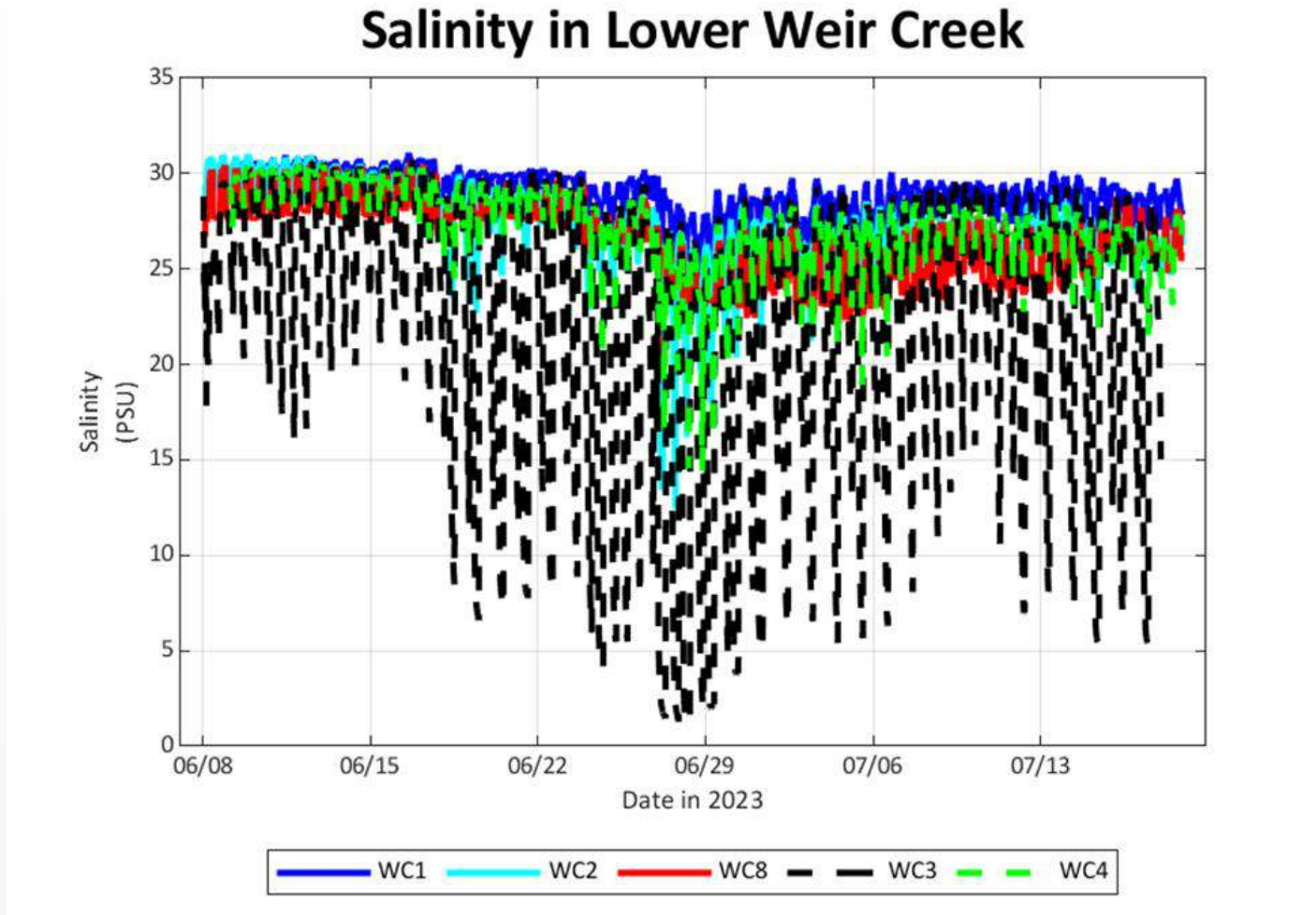
Upper Weir Creek: Large section of marsh upstream of the western Lower County Road crossing to unnamed pond in the North

Lower Weir Creek: Loring, Lighthouse, Fisk, & Lower County Road

Water Levels in Lower Weir Creek

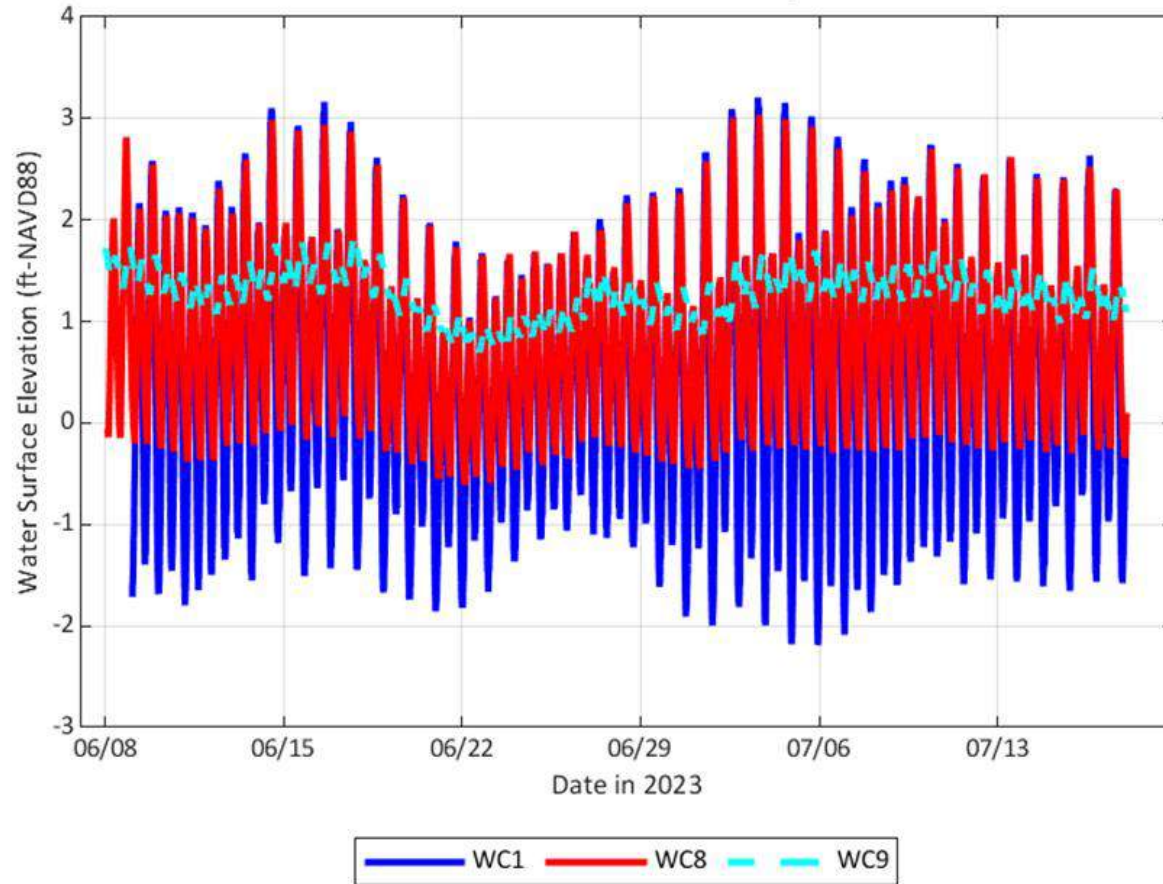


Lower Weir Creek: Loring, Lighthouse, Fisk, & Lower County Road

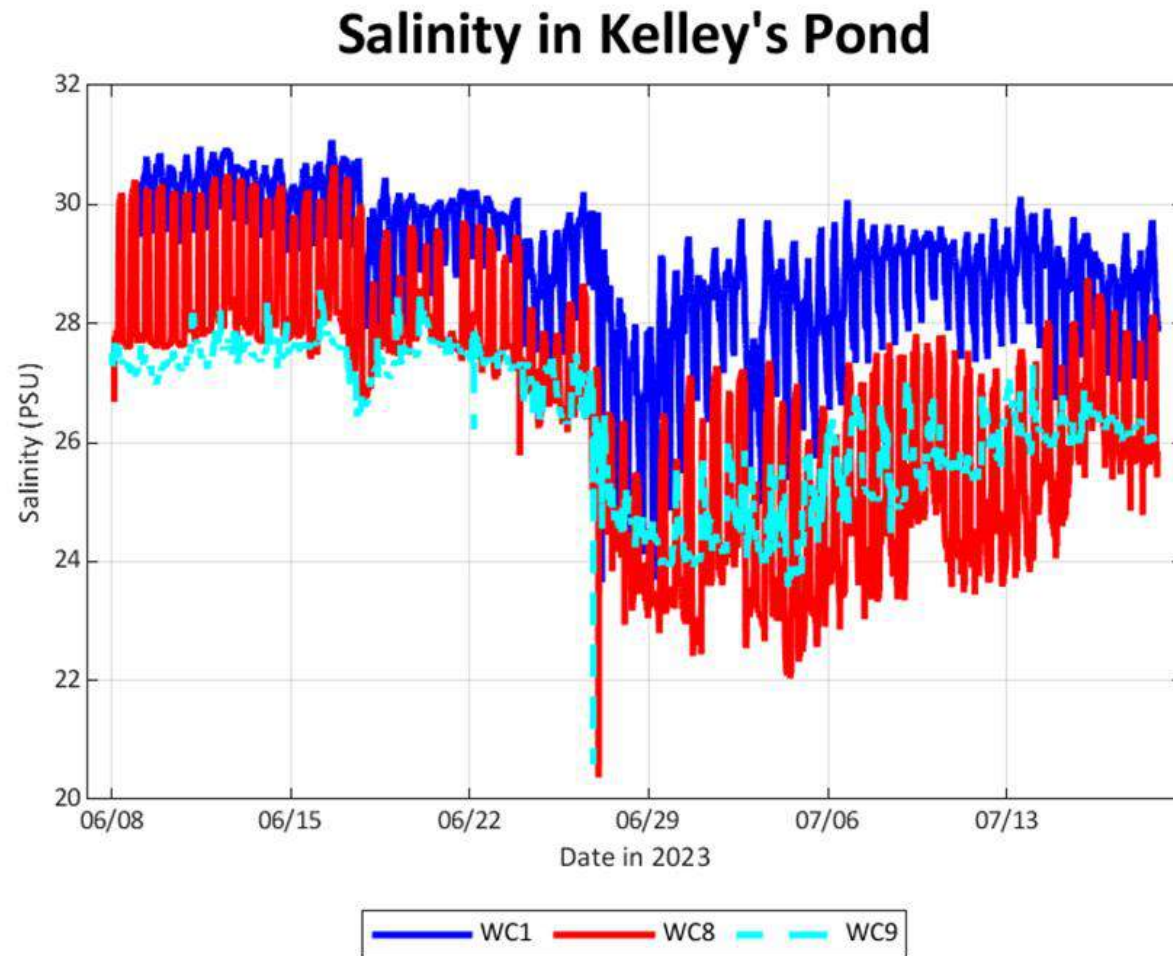


Kelley's Pond: Fisk Street Crossing

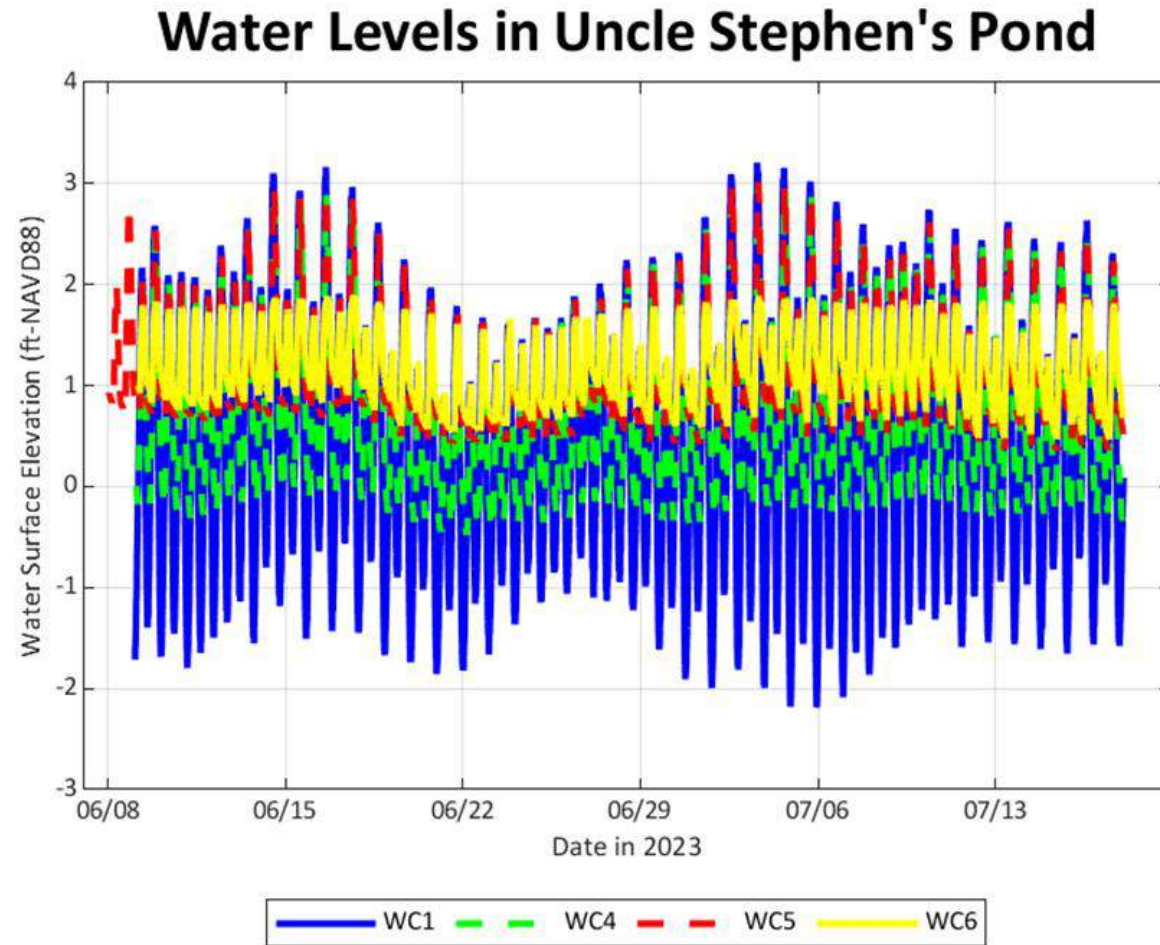
Water Levels in Kelley's Pond



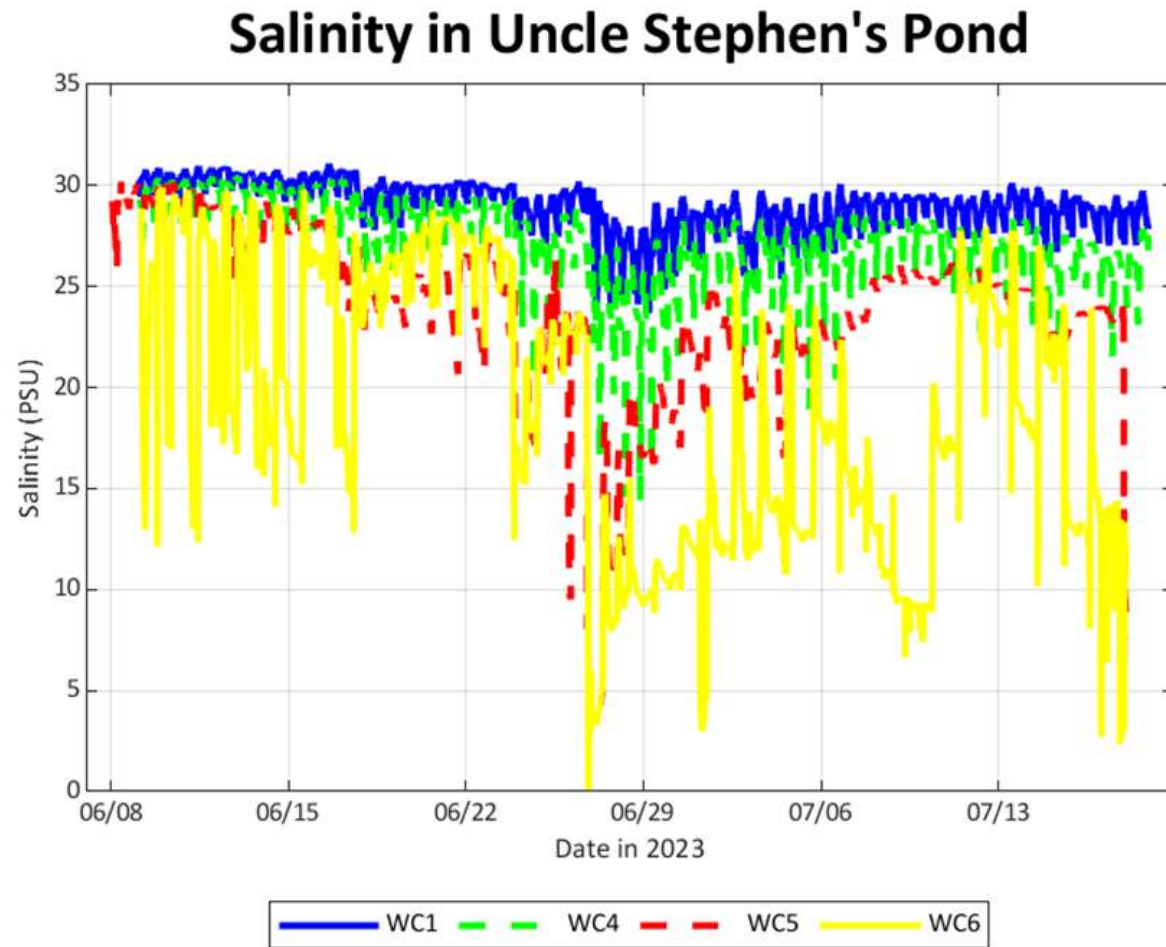
Kelley's Pond: Fisk Street Crossing



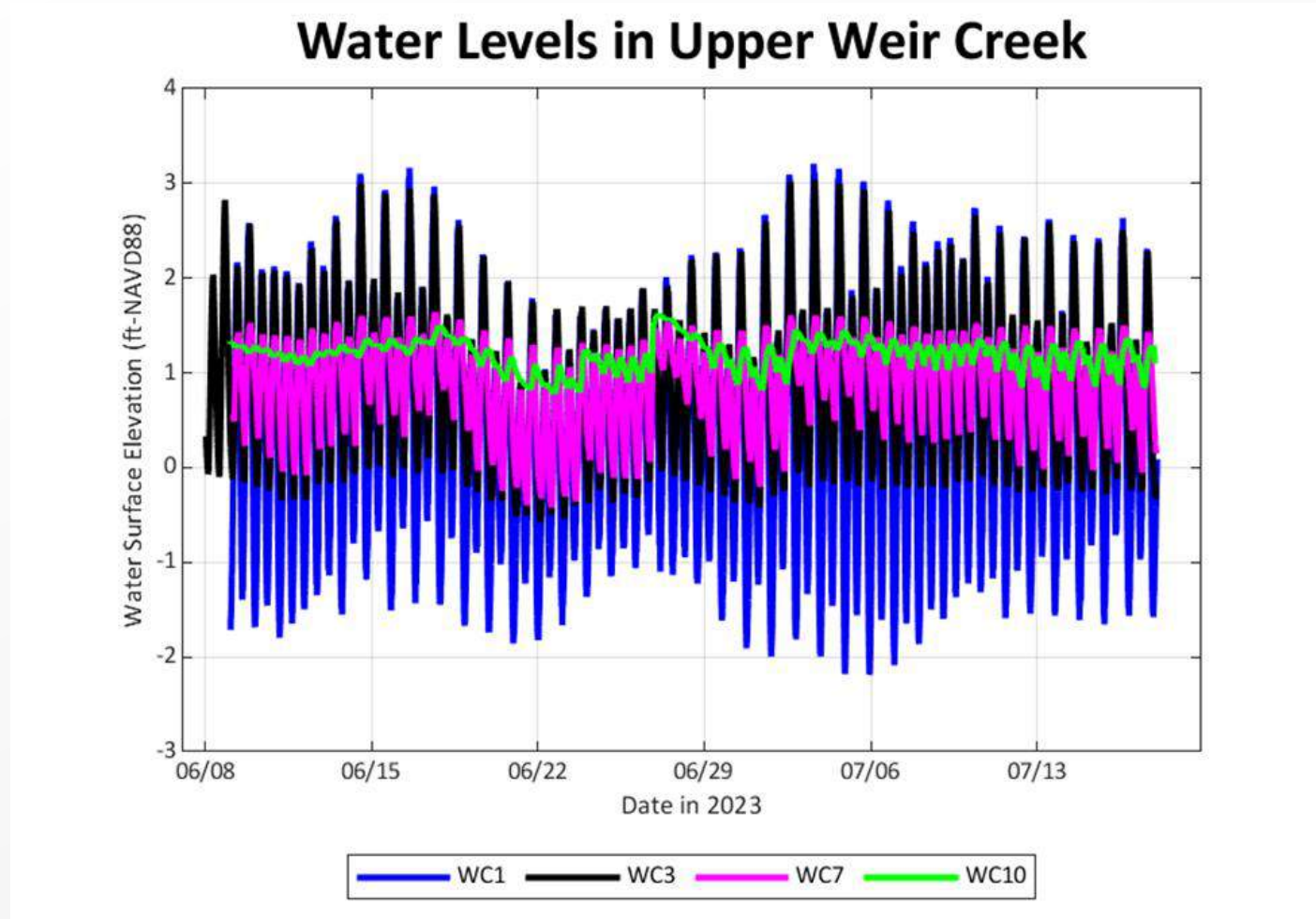
Uncle Stephen's Pond: Lighthouse Avenue & Lower County Road (East)



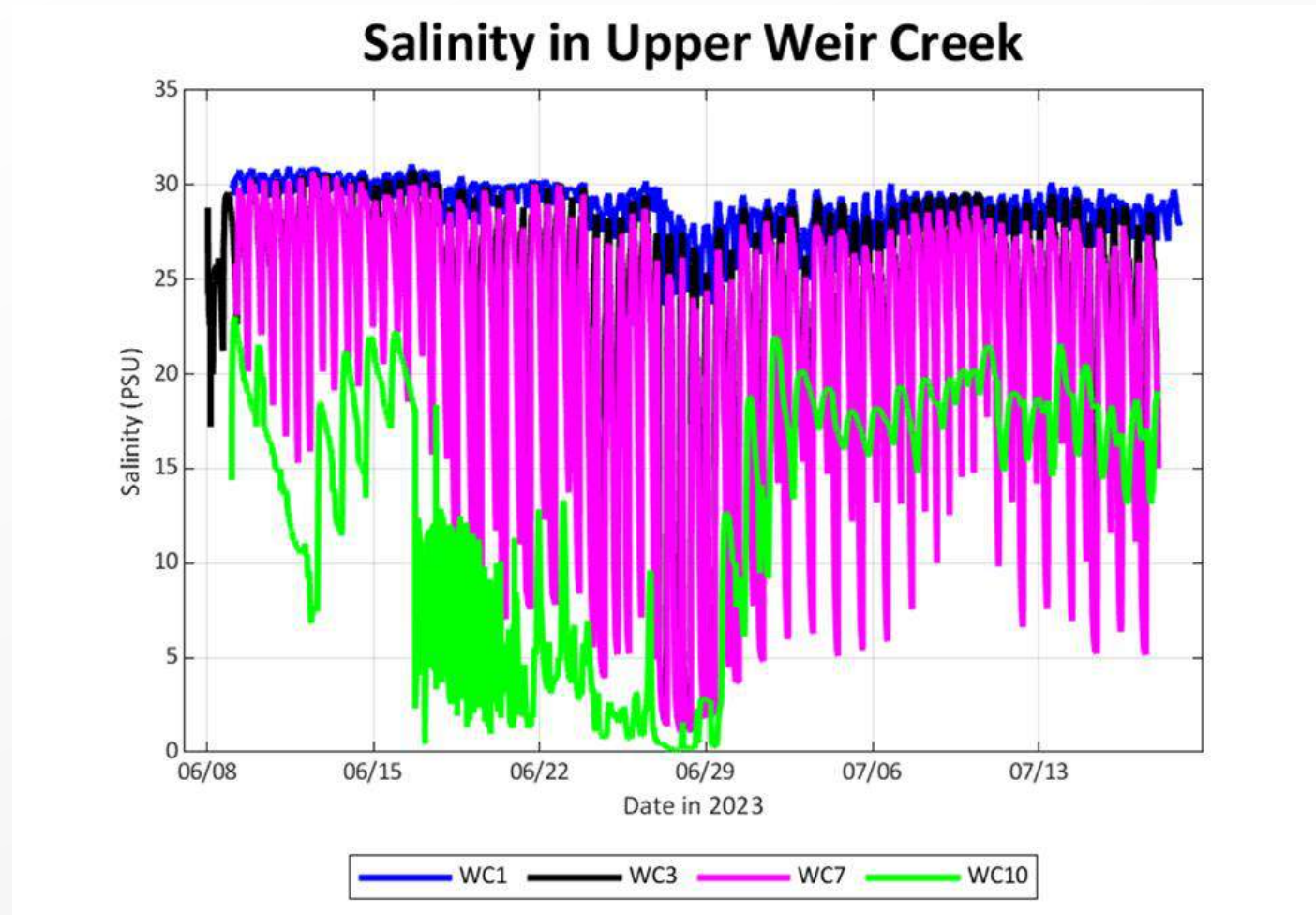
Uncle Stephen's Pond: Lighthouse Avenue & Lower County Road (East)



Upper Weir Creek: Lower County Road (west) to Unnamed Pond



Upper Weir Creek: Lower County Road (west) to Unnamed Pond



Tidal Benchmarks and Salinity Variability by Station

	WC1	WC2	WC3	WC4	WC5	WC6	WC7	WC8	WC9	WC10
MHHW	2.4	2.4	2.4	2.4	2.4	1.8	1.5	2.4	1.5	1.3
MHW	2.0	2.0	2.0	2.0	2.0	1.7	1.4	2.0	1.4	1.3
TDL	0.4	0.8	0.9	0.9	1.3	1.2	0.8	0.9	1.3	1.2
MLW	-1.3	-0.3	-0.2	-0.2	0.6	0.7	0.2	-0.3	1.2	1.1
MLLW	-1.6	-0.4	-0.3	-0.3	0.5	0.7	0.1	-0.3	1.1	1.1
Range	3.3	2.3	2.3	2.2	1.4	0.9	1.2	2.3	0.3	0.1
Avg. Sal	29.0	27.4	22.4	27.4	23.7	18.9	21.1	26.6	26.3	12.8
Max Sal	23.7	12.4	1.1	14.4	2.8	0.1	1.0	20.4	20.6	0.1
Min Sal	31.1	31.0	30.7	30.6	30.2	29.9	30.7	30.7	28.6	23.0
Sal Range	7.4	18.6	29.6	16.2	27.4	29.8	29.7	10.3	8.0	22.8

Topographic & Bathymetric Survey

Vessel Mounted Acoustic Sounder used for Kelley's Pond, Uncle Stephen's Pond, and portions of Weir Creek below Lower County Road

RTK GPS survey in Weir Creek upstream of Lower County Road, flood shoal upstream of Loring Avenue & channel upstream of Fisk Street

Vessel survey with RTK & GPS for western section of Weir Creek

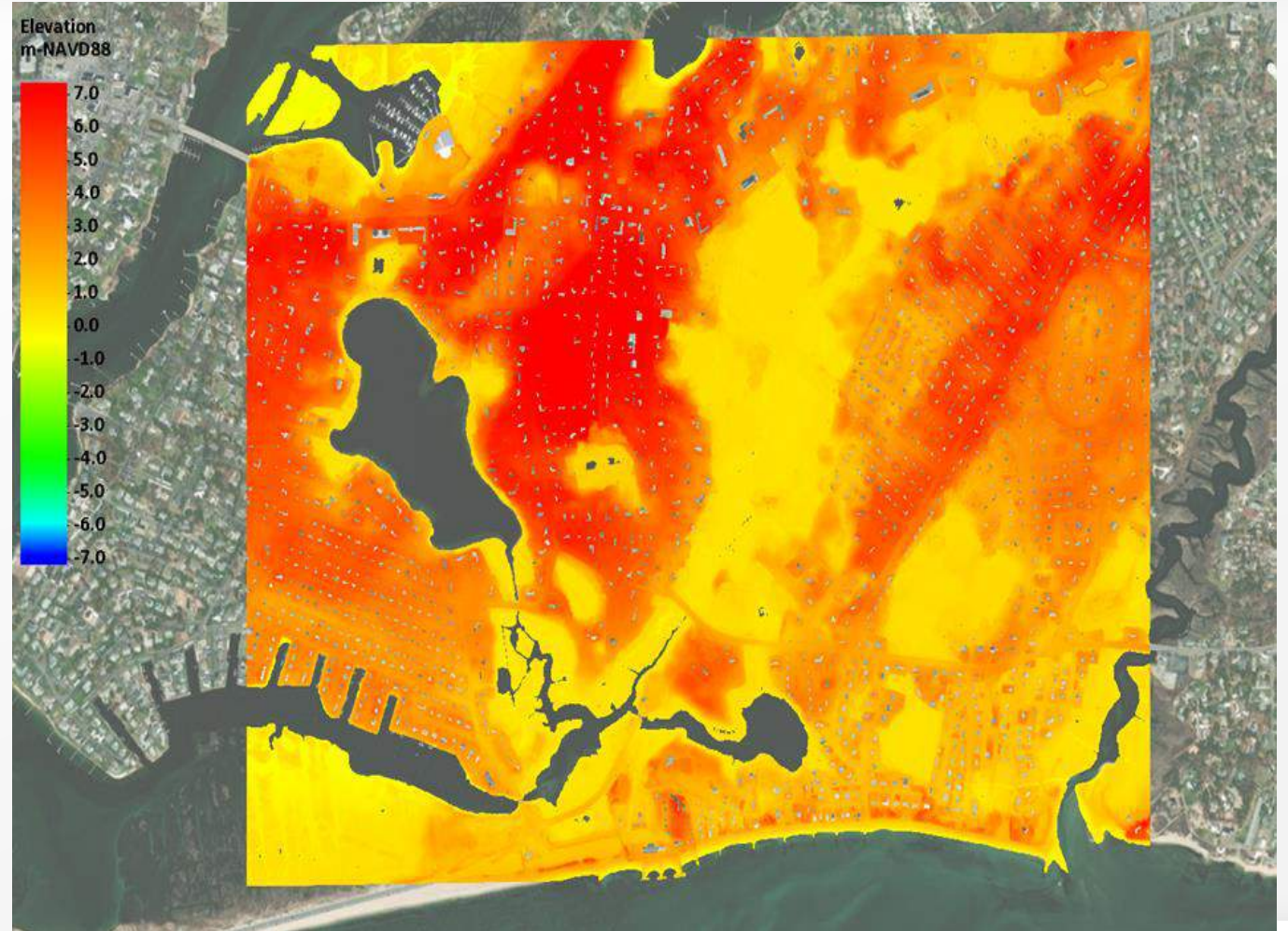


LiDAR Elevation Data

2021 USGS Elevation dataset

Uses light reflection & return time to measure elevation

Dense point coverage over land, but typically does not provide usable data for wetted areas.



EFDC Model Description & Domain

Environmental Fluid Dynamics Code (EFDC)

Developed at VIMS for application afor2D or 3D systems

Solves the equations of motion for variable density fluids

Capable of simulating water quality constituents & sediment transport



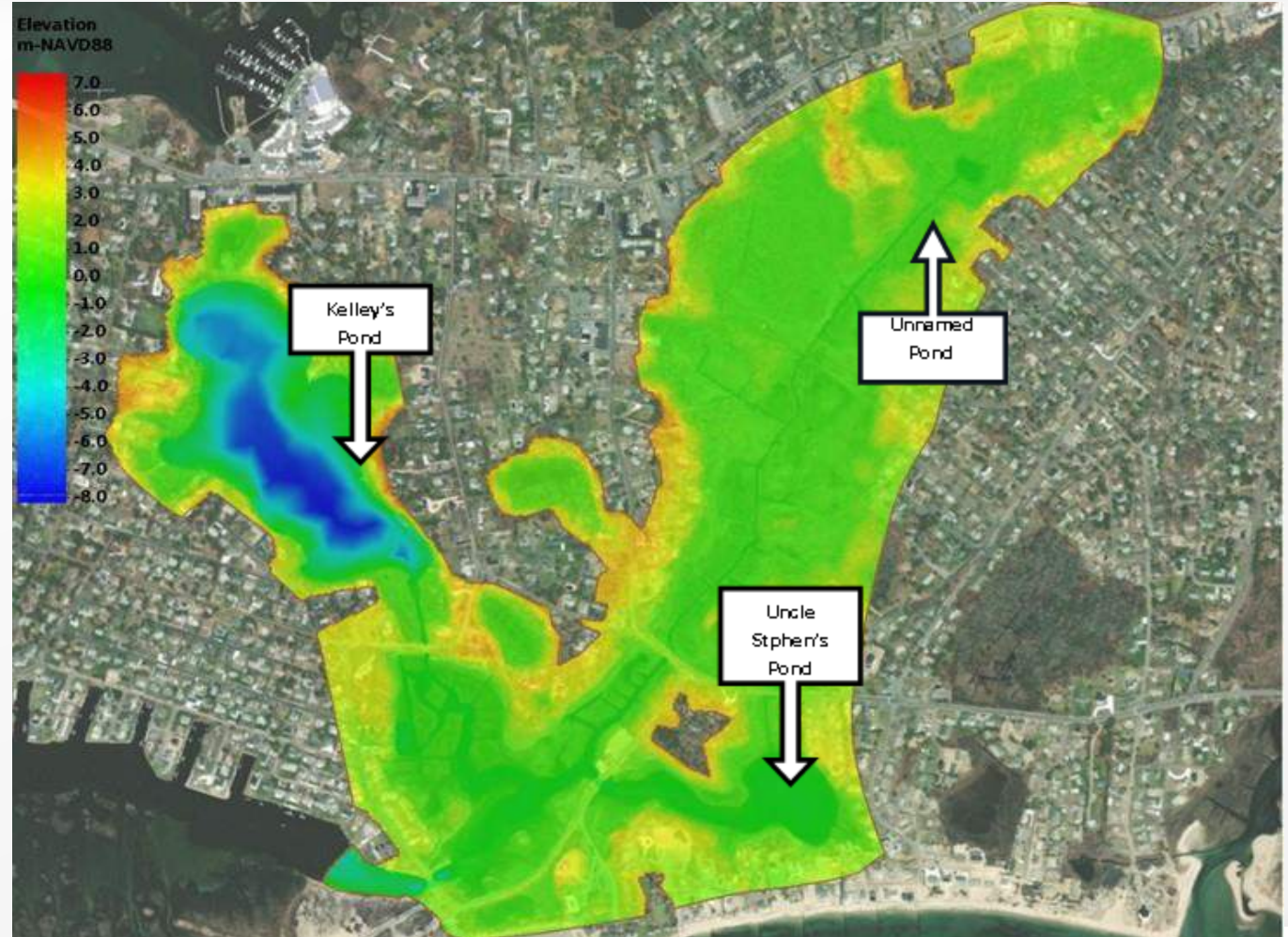
EFDC Model Description & Domain

Environmental Fluid Dynamics Code (EFDC)

Developed at VIMS for application in 2D or 3D systems

Solves the equations of motion for variable density fluids

Capable of simulating water quality constituents & sediment transport



Model Calibration:Tides

Model Grid

Existing topography from survey & LiDAR

Surface roughness varied by depth & increased in Upper Weir Creek

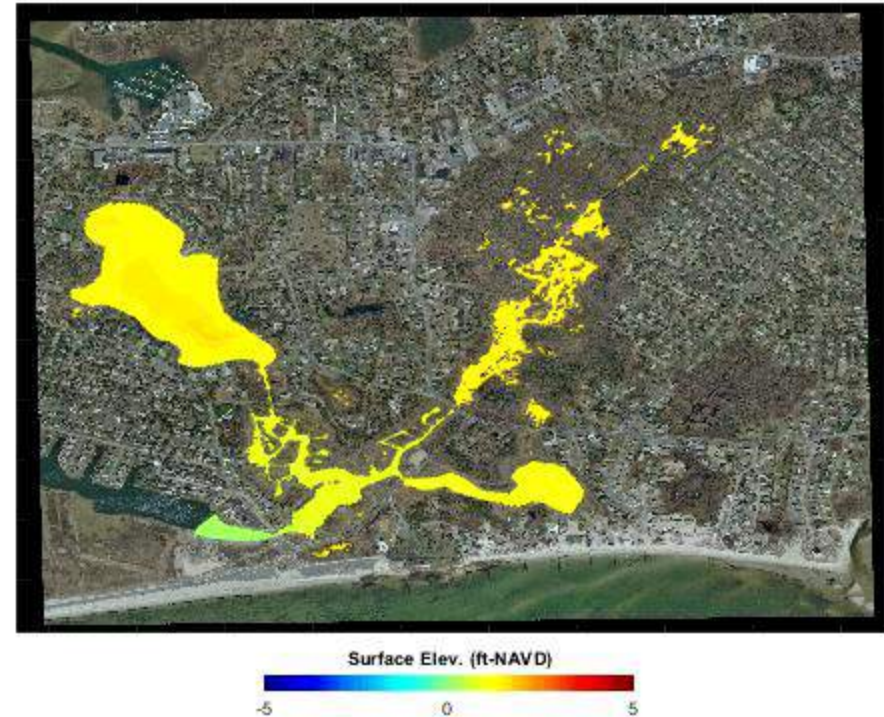
Model Boundaries

Tidal signal forcing from WC1 (Yacht Club)

Precipitation as measured at Hyannis Airport

Freshwater inflows at Kelley's Pond, Unnamed Pond, and marsh upstream of Uncle Stephen's Pond

Existing Culverts:Tide
2.0104 Days



Potential Alternatives for Evaluation



Three Variations Investigated

1. Status quo or unchanged
2. Maximum Restoration: Dredging, bridges, channel widening
3. Culvert replacement: varying width of box culverts



Maximized Restoration

Replaced all existing bridges with wider openings

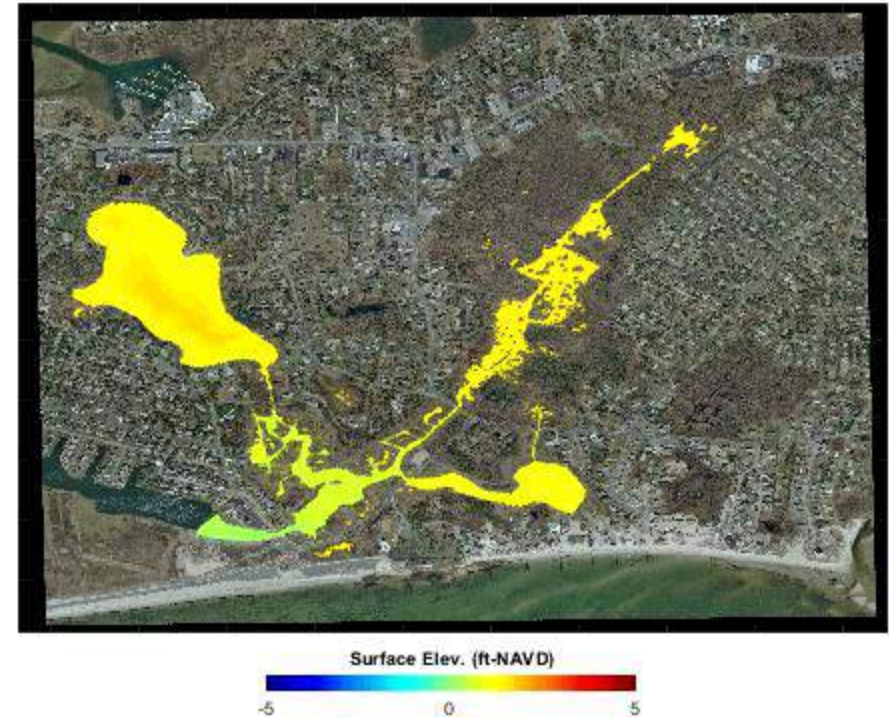
Dredged the flood shoal upstream of Loring Avenue

Lowered the channel bottoms approaching both Lower County Road crossings

Replaced both culverts with 20-ft single span bridges

Channel widening and grading upstream of the western Lower County Road crossing

Maximized Restoration:Tide
2.0104 Days



Tide Range

Increased from 0.2 ft to
1 ft (increased by 5X)

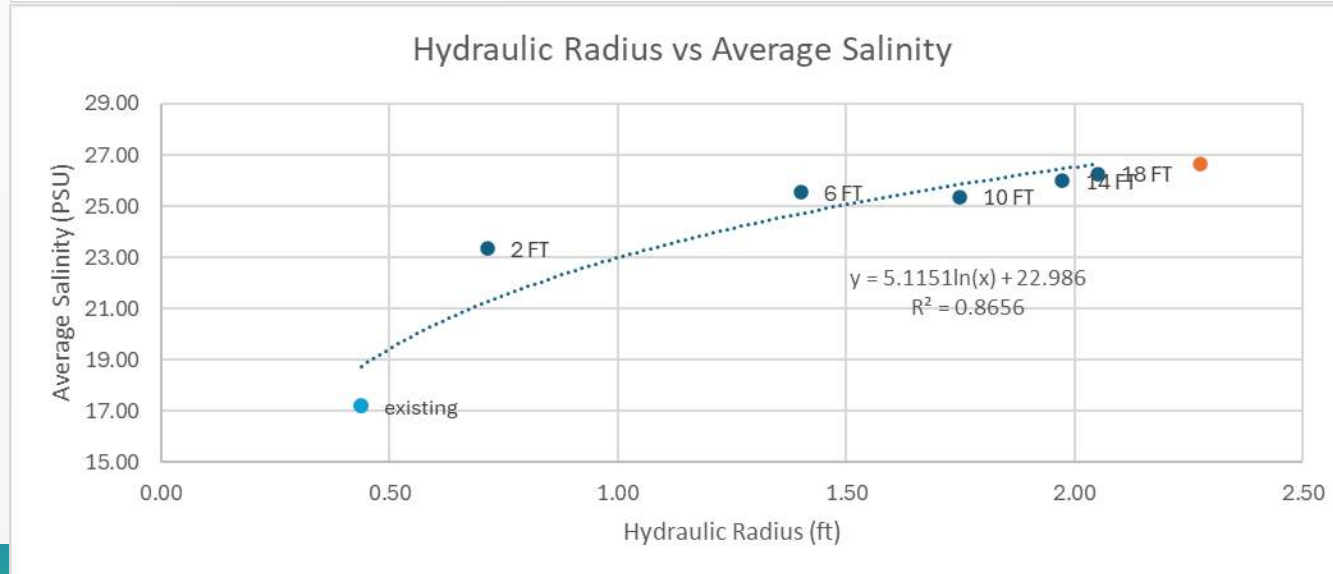
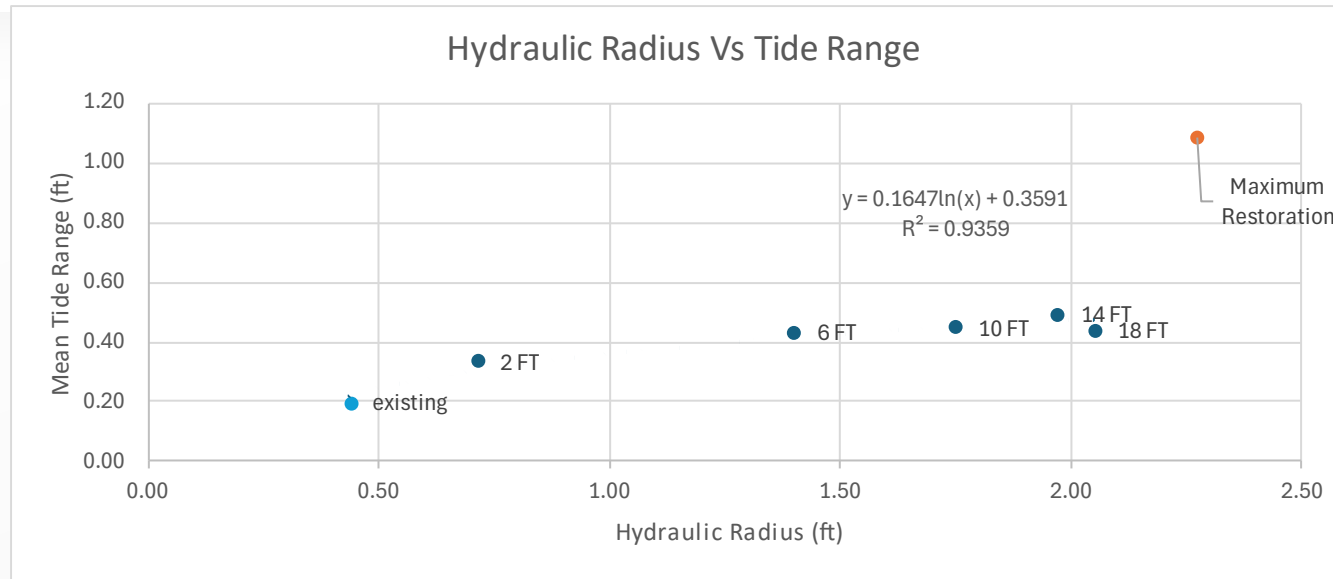
Salinity

Increased from an
average salinity of 17
PSU to 27 PSU

Restoration Selection Metrics from Initial Screening

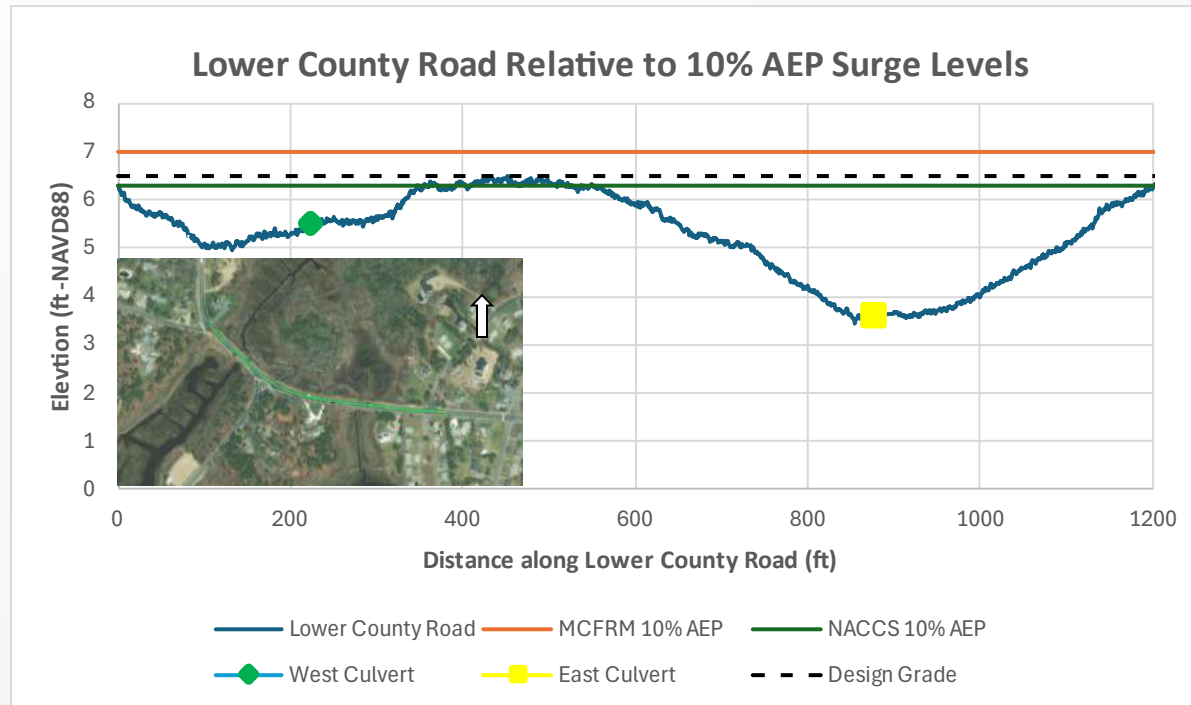
Opening	R_H (ft)	MHW (ft- NAVD88)	MLW (ft- NAVD88)	MTR (ft)	S_{max} (PSU)	S_{min} (PSU)	S_{ave} (PSU)
Existing	0.44	1.36	1.17	0.19	22.48	16.00	19.18
2 FT	0.71	1.50	1.20	0.30	29.39	21.86	23.82
6 FT	1.40	1.61	1.18	0.43	30.19	23.13	24.89
10 FT	1.73	1.65	1.22	0.44	29.72	23.10	24.93
14 FT	1.94	1.68	1.22	0.46	30.32	23.09	25.28
18 FT	2.00	1.57	1.20	0.36	30.33	23.40	25.50
Maximum	2.23	1.87	0.89	0.99	30.43	16.36	25.69

Restoration Selection Metrics from Initial Screening



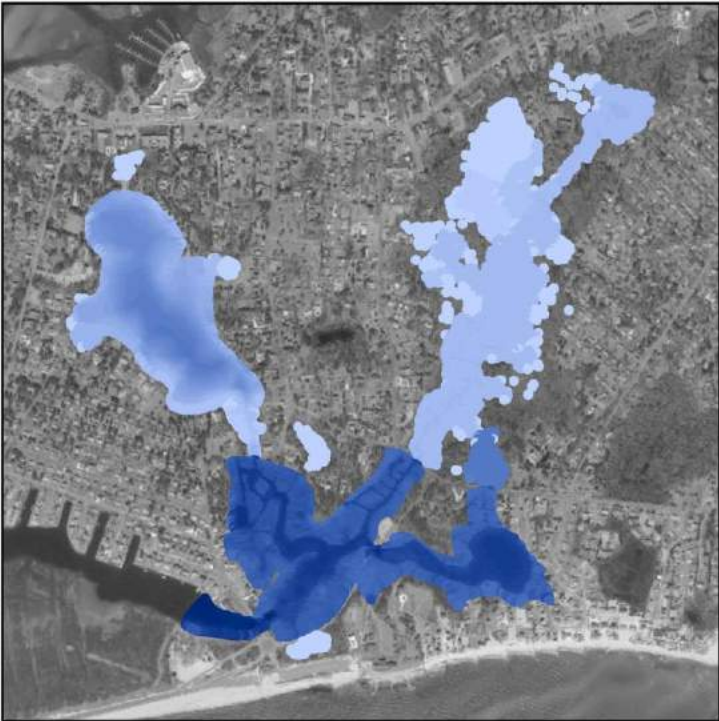
Preferred Design for Additional Analyses: Criteria

- Maximize Tidal Exchange to restore marsh to pre-development habitat
- Minimize or decrease potential flooding
 - Low frequency storm events (10% AEP, 2% AEP, 1%AEP)
 - Potential Sea Level Rise: 2070 high emissions scenario
- Minimize impacts to surrounding wetlands and infrastructure



Preferred Design: Increases in Water Levels

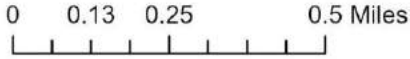
Existing Conditions



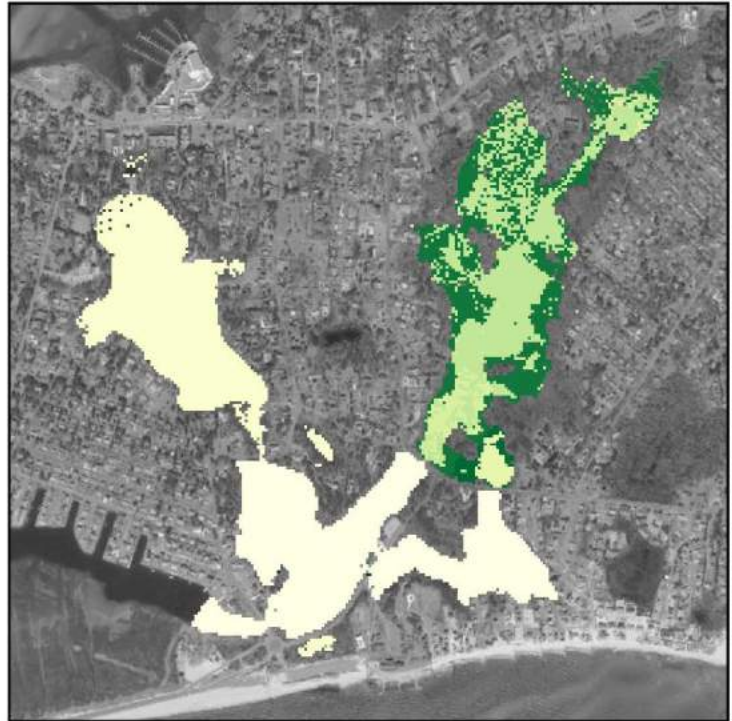
Maximum Tidal Water Surface Elevation (FT, NAVD88)



Design Conditions



Difference in Maximum Tidal WSE

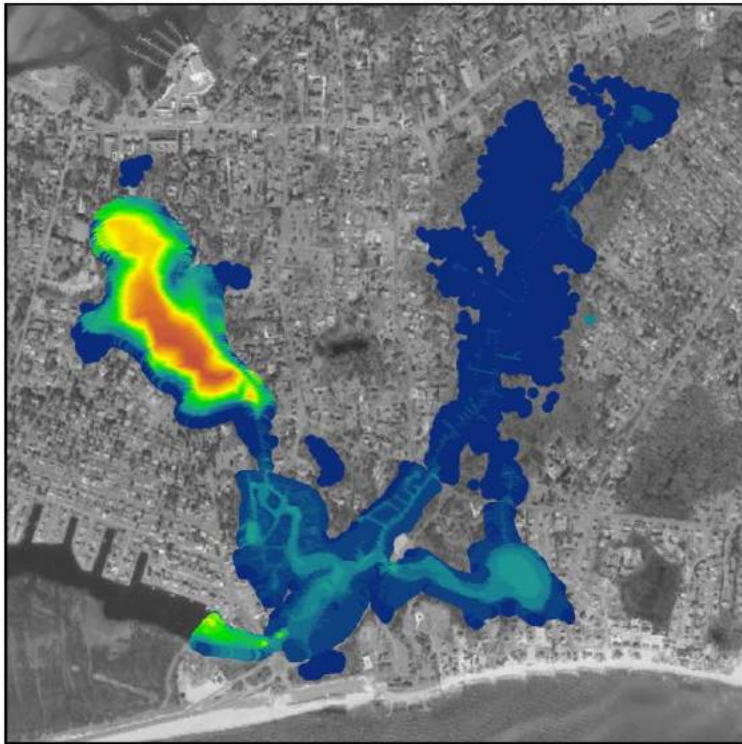


Maximum Tidal WSE Difference (FT, NAVD88)

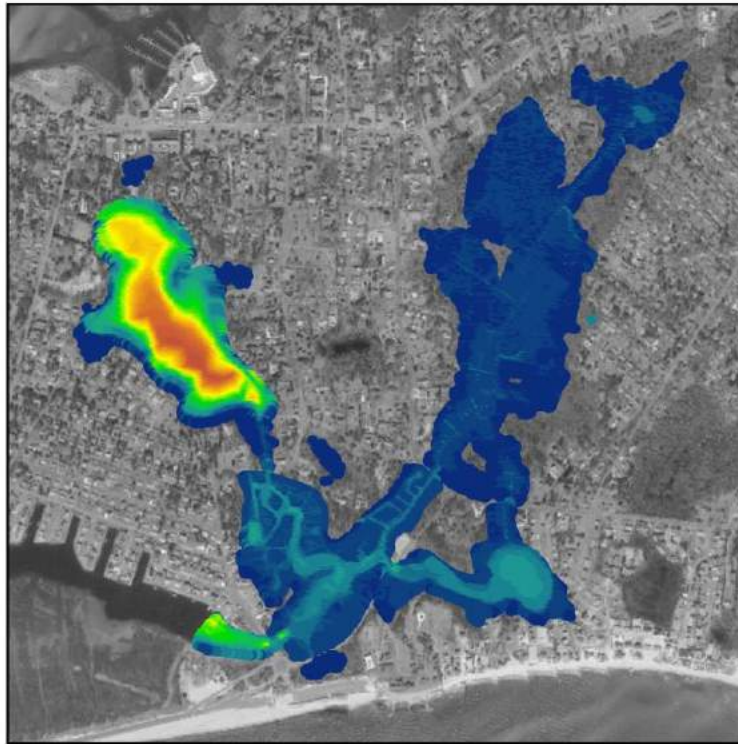


Preferred Design: Criteria increase in tidal exchange

Existing Conditions



Design Conditions



Difference in Maximum Depth



Maximum Depth (FT, NAVD88)



0 0.13 0.25 0.5 Miles

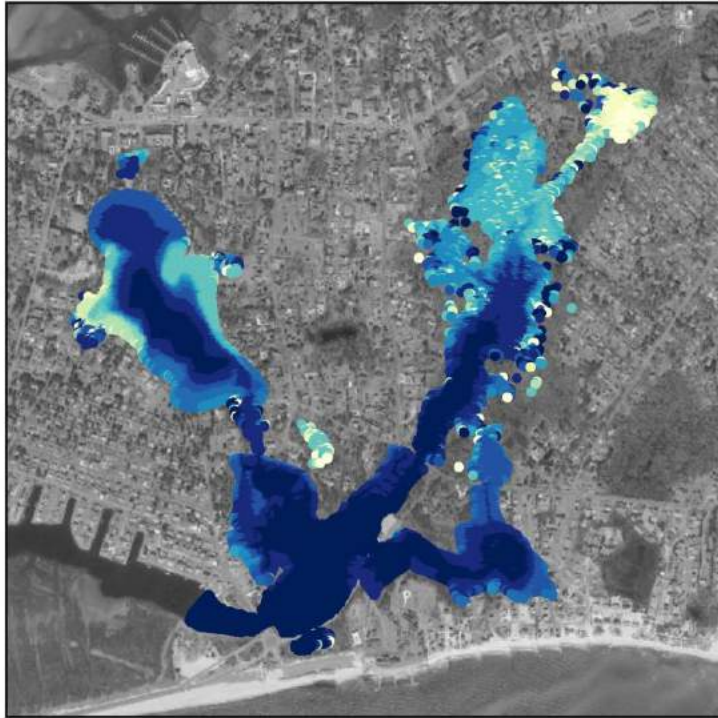


Design Depth - Existing Depth (FT NAVD88)



Preferred Design: Changes in Salinity

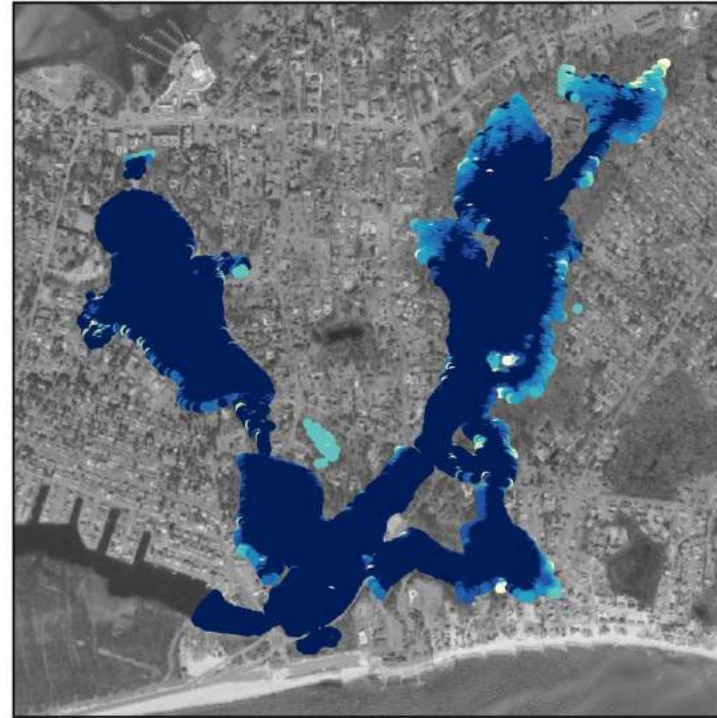
Existing Conditions



Maximum Salinity (PSU)



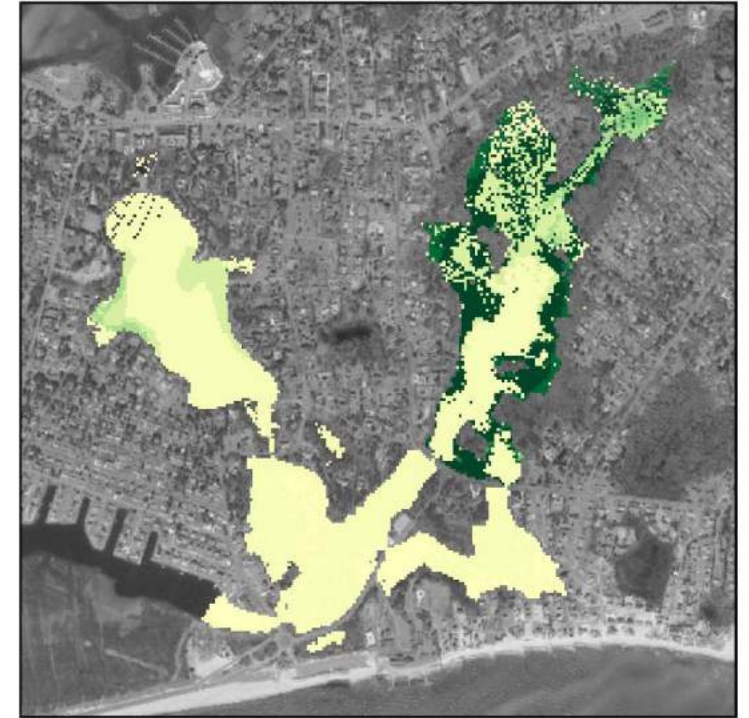
Design Conditions



0 0.13 0.25 0.5 Miles



Difference in Maximum Salinity

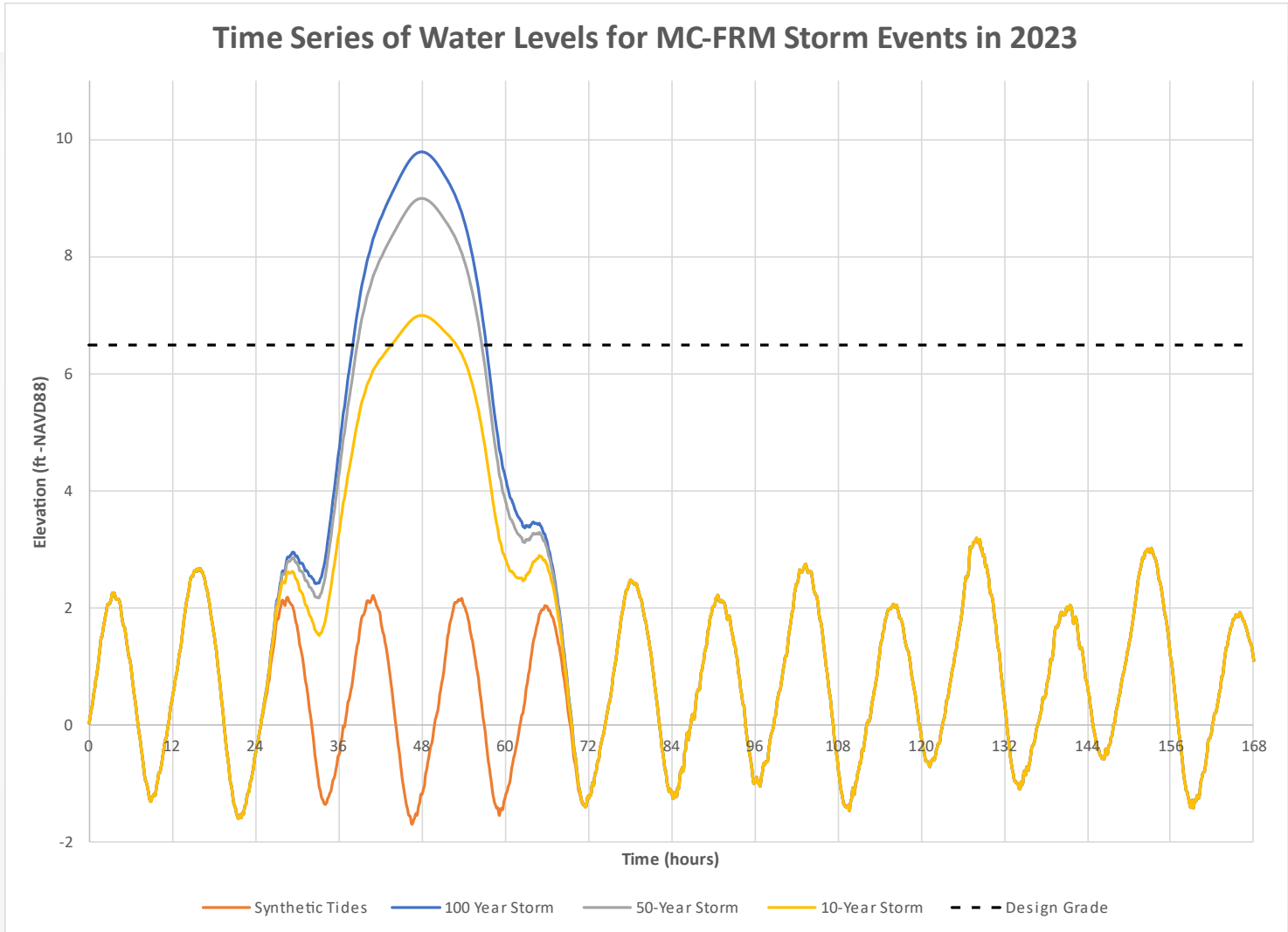


Difference in Salinity (Design - Existing, PSU)



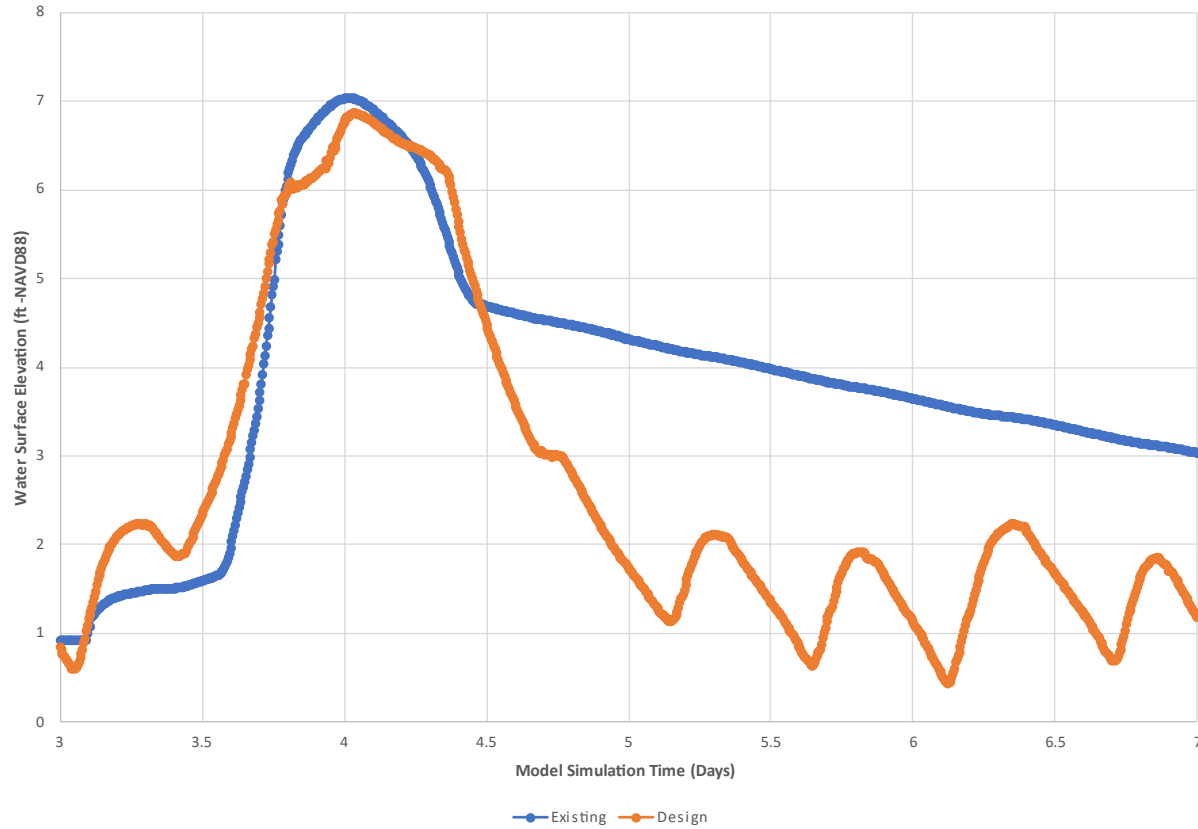
Low Frequency Storm Events

- 10 % AEP (10-Year) peak elevation=7.0 ft-NAVD88
- 2 % AEP (50Year) peak elevation=9.0 ft-NAVD88
- 1 % AEP (100-Year) peak elevation=9.8 ft-NAVD88

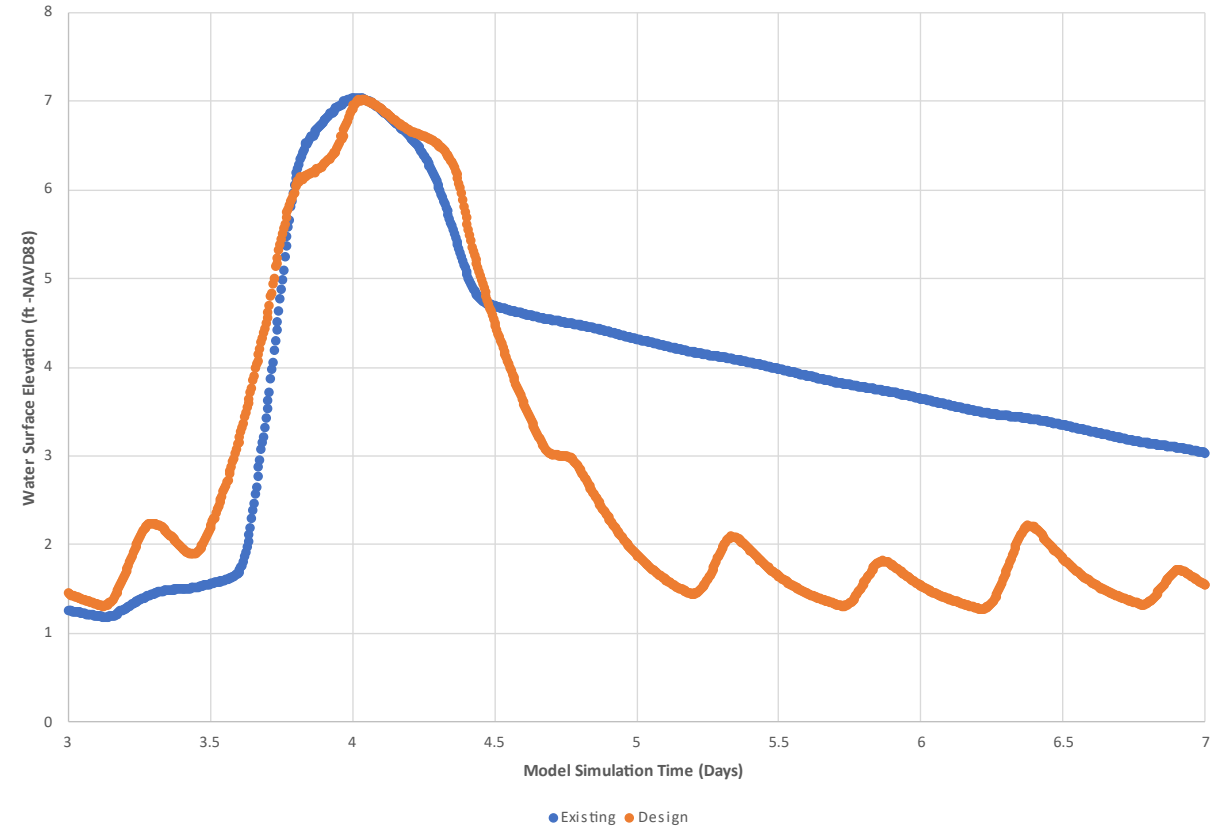


Low Frequency Storm Events: 10% AEP Storm

EFDC-WC Model Results at Station WC7



EFDC-WC Model Results at Station WC10



Low Frequency Storm Events: 10% AEP (10-year) Storm

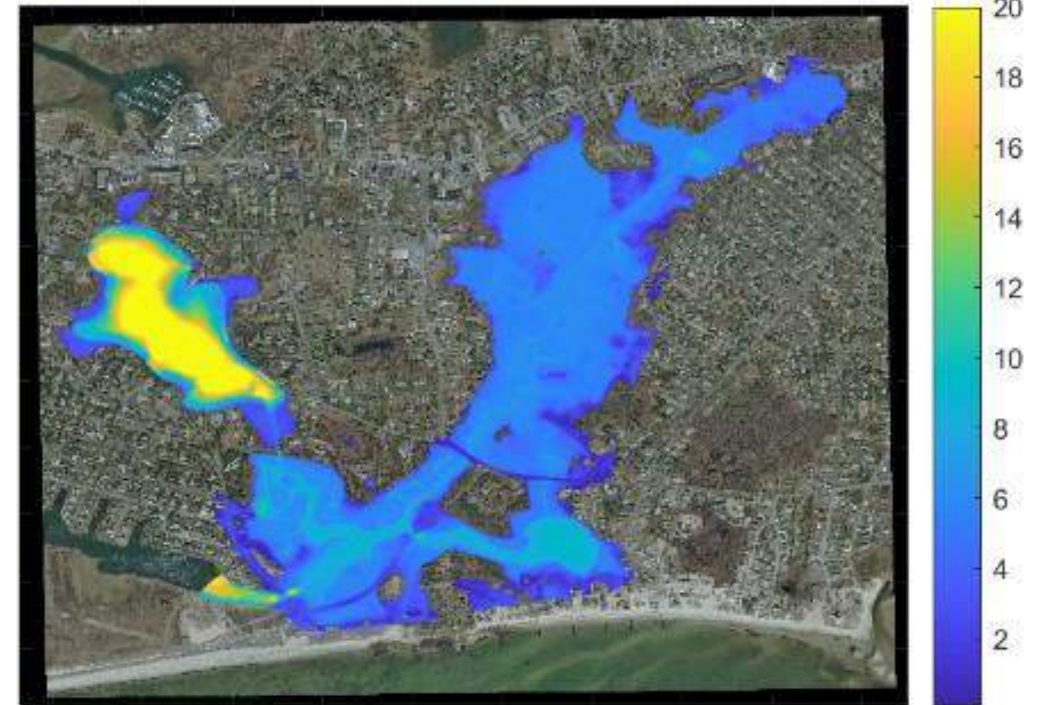
Maximum Depth (ft)

Existing Conditions: 10% AEP Storm



Maximum Depth (ft)

8ft x 6ft Box Culverts: 10% AEP Storm



Low Frequency Storm Events: 10% AEP (10-year) Storm

Maximum Depth (ft)

Existing Conditions: 10% AEP Storm



Maximum Depth (ft)

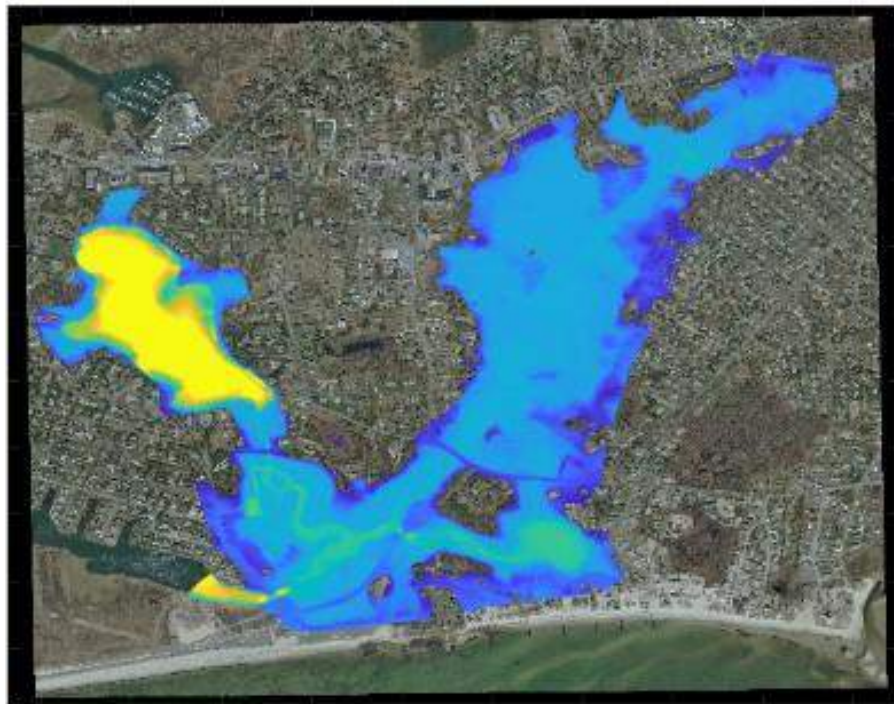
8ft x 6ft Box Culverts: 10% AEP Storm



Low Frequency Storm Events: 2% AEP (50-year) Storm

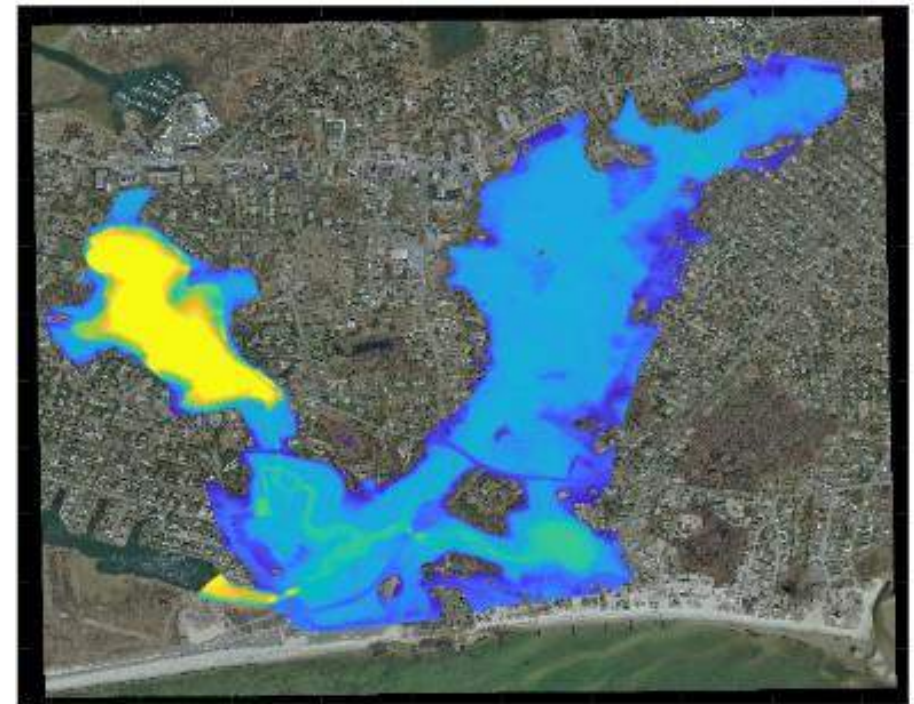
Maximum Depth (ft)

Existing Conditions: 2% AEP Storm



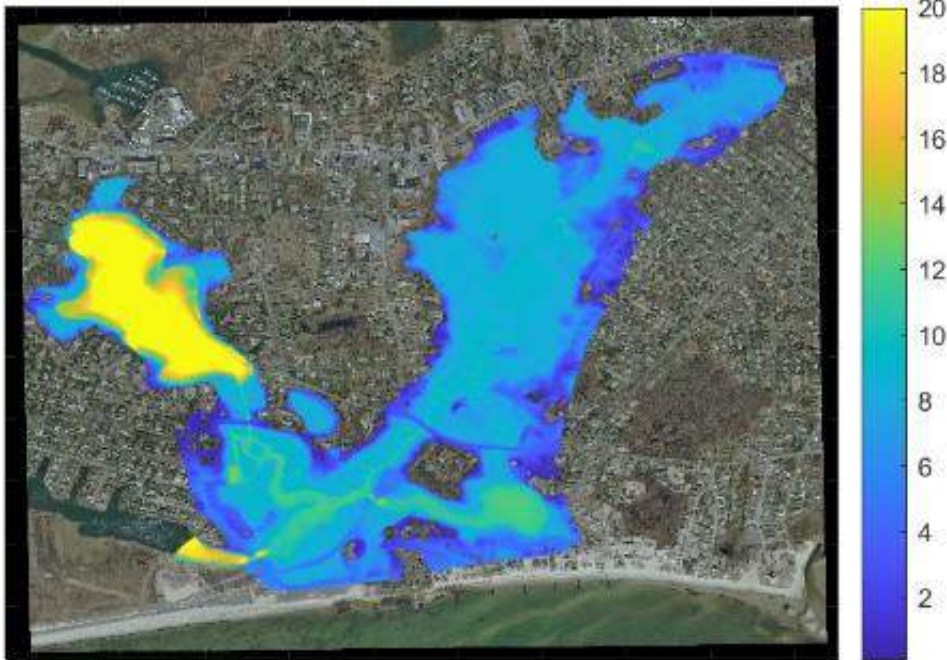
Maximum Depth (ft)

8ft x 6ft Box Culverts: 2% AEP Storm

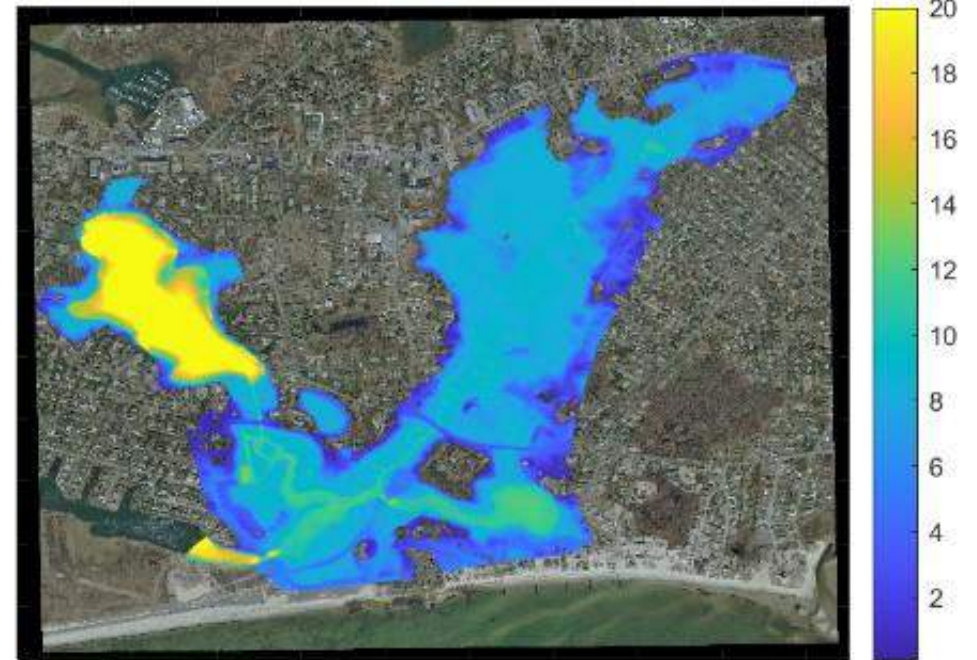


Low Frequency Storm Events: 1% AEP (100-year) Storm

Maximum Depth (ft)
Existing Conditions: 1% AEP Storm

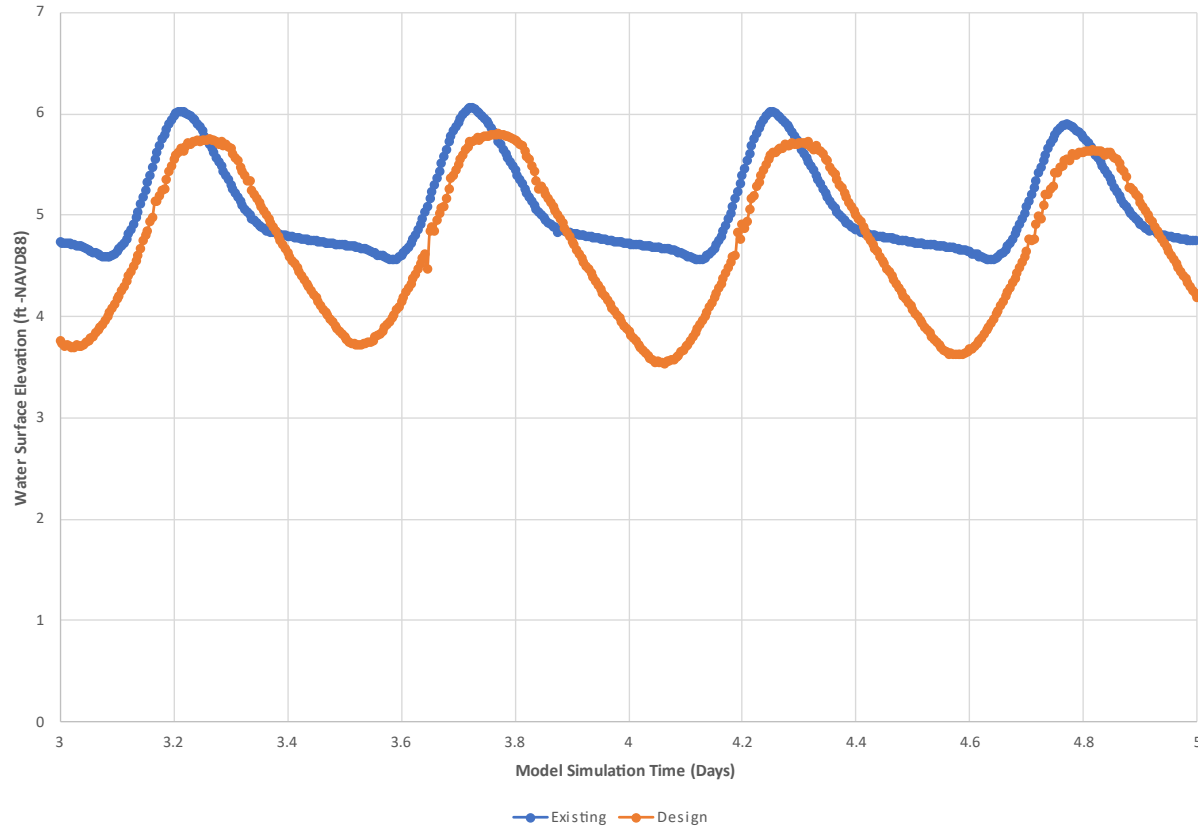


Maximum Depth (ft)
8ft x 6ft Box Culverts: 1% AEP Storm

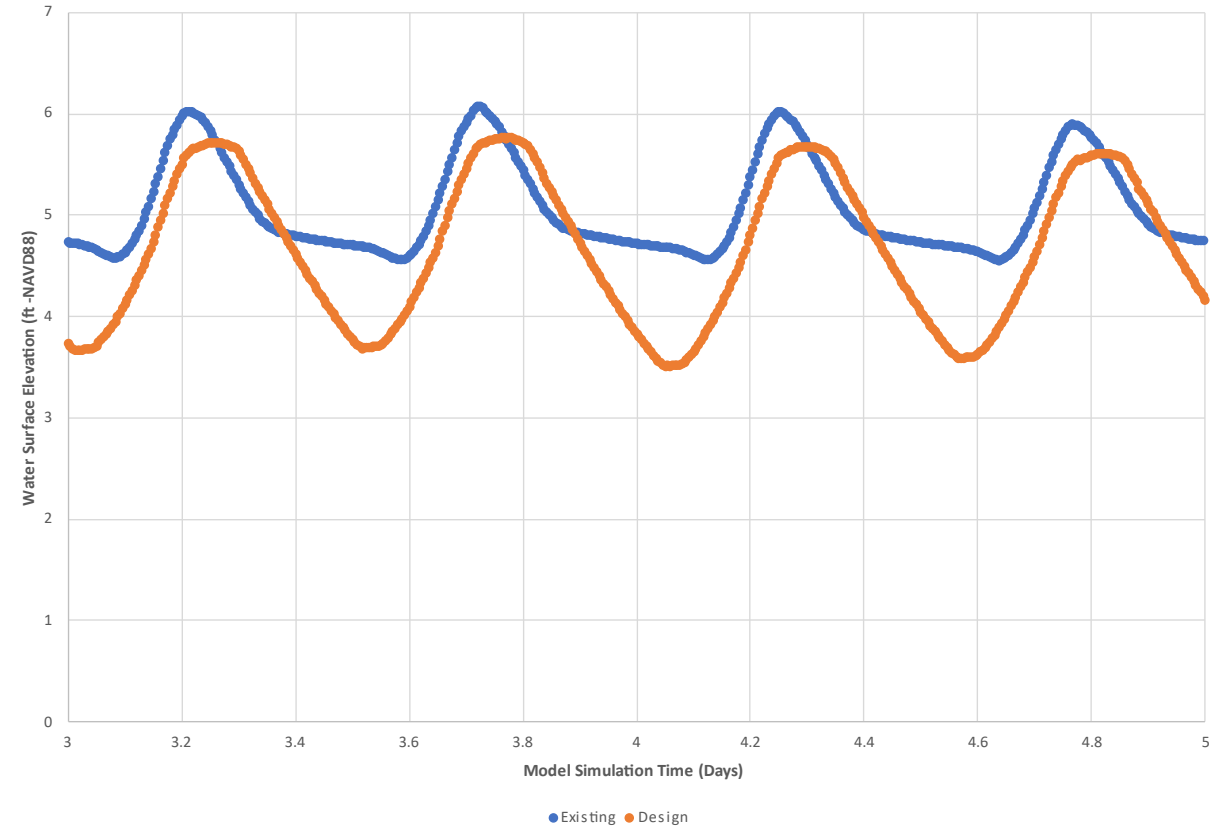


2070 Tides: 4.1 feet of Sea Level Rise

EFDC-WC Model Results at Station WC7



EFDC-WC Model Results at Station WC10



Conclusions & Recommendations

- The bridge crossing at Loring Avenue restricts flows during ebb tides as a result of the large flood shoal created by high velocity flows depositing sediments upstream of the bridge crossing. Dredging of the flood shoal will allow for greater tidal exchange.
- The low roadway elevations at Lower County Road allow for surge events to propagate over the roadway at approximately the 10% AEP (10-year) storm level, increasing to 6.5 ft-NAVD88 will help mitigate future flooding.
- Replacement of the existing pipe culverts at both the eastern and western crossings of Lower County Road will allow additional saltwater to enter the upper reaches of the system increasing the average salinity thereby encouraging salt marsh habitat and eliminating invasive vegetation.
- Following storm events, the larger 8'x6' culverts will provide additional drainage capacity allowing the system to return to pre-surge water levels more quickly than the undersized culverts currently in place.