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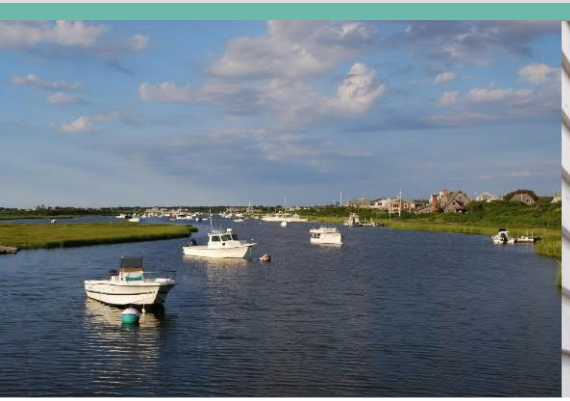
Madaket Culverts Evaluation

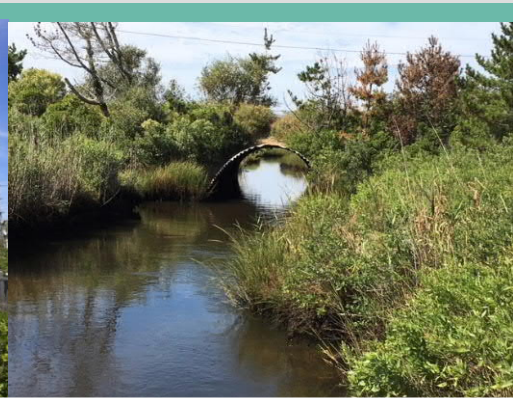
Public Meeting

Town of Nantucket

March 14, 2019

Presentation Outline





- Introductions – Project Team
- Project Background and Objectives
- Structural Condition Assessment
- Hydrologic and Hydraulic Assessment
- Alternatives Evaluation
- Recommendations
- Questions and Discussion

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Project Team

- Nantucket Department of Public Works – Rob McNeil

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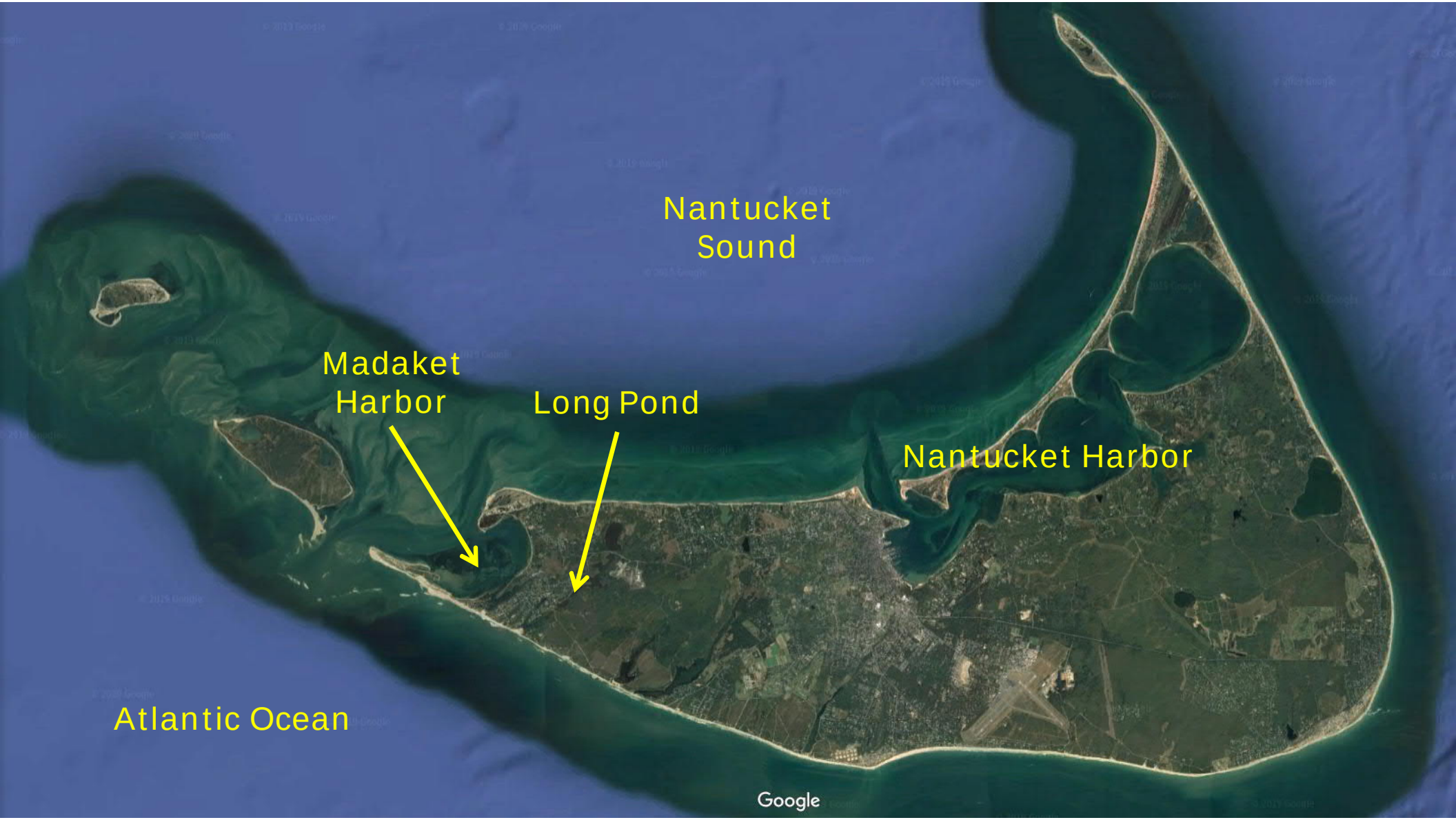
  - Project lead
  - Structural condition assessment
  - Childs Engineering – structural dive team

WOODS HOLE GROUP FOR EARTH, FROM SPACE
A CLS COMPANY

  - Hydrologic and hydraulic modeling

Madaket Harbor/Long Pond Estuary



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Madaket Harbor/Long Pond Estuary

Water Quality – Hither Creek & Long Pond

- Water Quality Issues
  - Excess nitrogen
  - Periodic extreme decreases in DO
  - Periodic algae blooms
  - Elevated bacteria/pathogens
  - Altered benthic community structure
- High nutrient loads
  - Septic systems
  - Runoff from impervious surfaces
  - Landfill
  - Fertilizers
  - Nutrient rich bottom sediments

Source: Madaket Conservation Association

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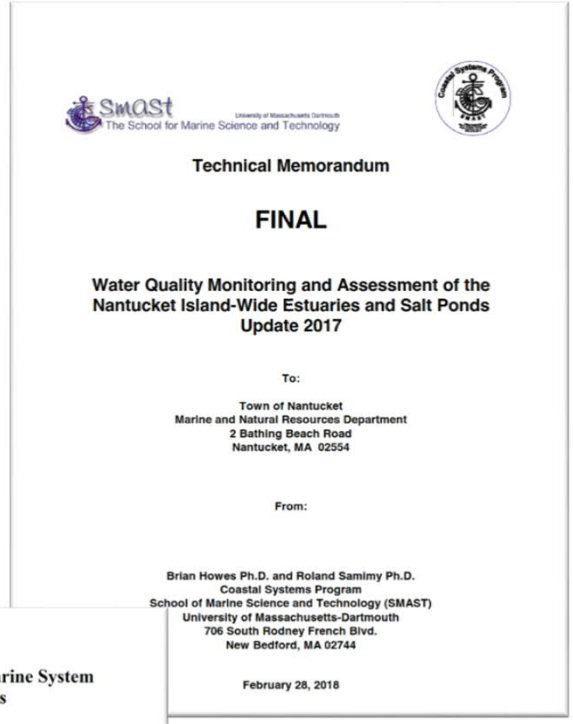
Water Quality Monitoring and Restoration

- MA Estuaries Project Watershed Embayment Model (2010)
- Madaket Harbor/Long Pond Estuary - Nitrogen TMDL (2015)
- Ongoing Water Quality Monitoring
- Management Activities within Madaket Harbor Watershed
  - Landfill improvements
  - Fertilizer management
  - Septic system management



SMAST
The School for Marine Science and Technology

Technical Memorandum

FINAL

Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds Update 2017

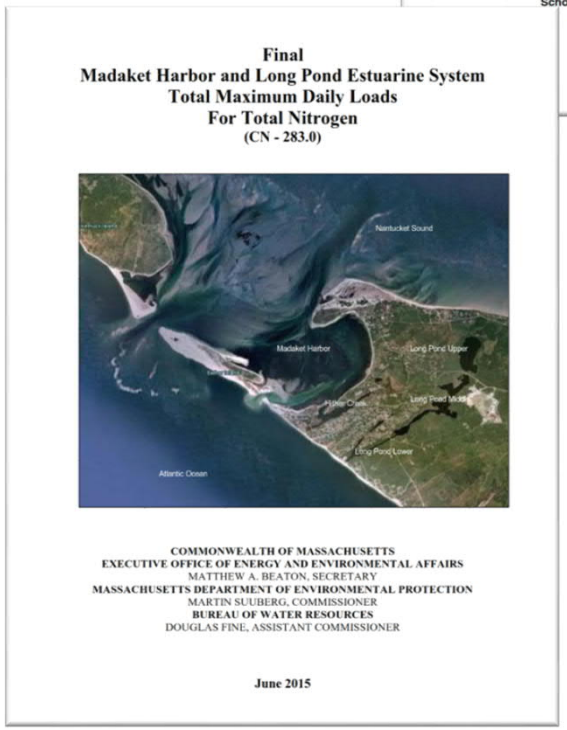
To:

Town of Nantucket
Marine and Natural Resources Department
2 Bathing Beach Road
Nantucket, MA 02554

From:

Brian Howes Ph.D. and Roland Samimy Ph.D.
Coastal Systems Program
School of Marine Science and Technology (SMAST)
University of Massachusetts-Dartmouth
706 South Rodney French Blvd.
New Bedford, MA 02744

February 28, 2018



Final
Madaket Harbor and Long Pond Estuarine System
Total Maximum Daily Loads
For Total Nitrogen
(CN - 283.0)

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
MATTHEW A. BEATON, SECRETARY
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
MARTIN SUUBERG, COMMISSIONER
BUREAU OF WATER RESOURCES
DOUGLAS FINE, ASSISTANT COMMISSIONER

June 2015

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Coastal Flooding – Storm Surge

Massachusetts Sea Level Rise and Coastal Flooding Viewer

Interactive maps of coastal flooding areas and community facilities and infrastructure based on: sea level rise scenarios, Federal Emergency Management Agency coastal flood zones, and hurricane surge models.

MASSACHUSETTS OFFICE OF COASTAL ZONE MANAGEMENT

Intro | Sea Level Rise | FEMA Coastal Flood Zones | Hurricane Surge

This map includes four worst-case scenarios of storm surge based on thousands of modeled combinations of hurricane intensity (Category 1-4), forward speed, track or direction, and other factors not including sea level rise. The National Oceanic and Atmospheric Administration (NOAA) National Hurricane Center, in partnership with the U.S. Army Corps of Engineers (USACE), uses the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to calculate the storm surge heights and map coastal areas with the highest degree of exposure.

Zoom in until the hurricane surge scenarios come into view. Community facilities and infrastructure are identified with an icon and facility outline. Click the icon for a pop-up box displaying the facility name, type, town or city, and the water level associated with the hurricane surge scenarios. Flood levels represent water depth in feet above 0 NAVD 88, rather than above the ground surface. Coastal flood data can be directly compared for each facility by switching viewer tabs.

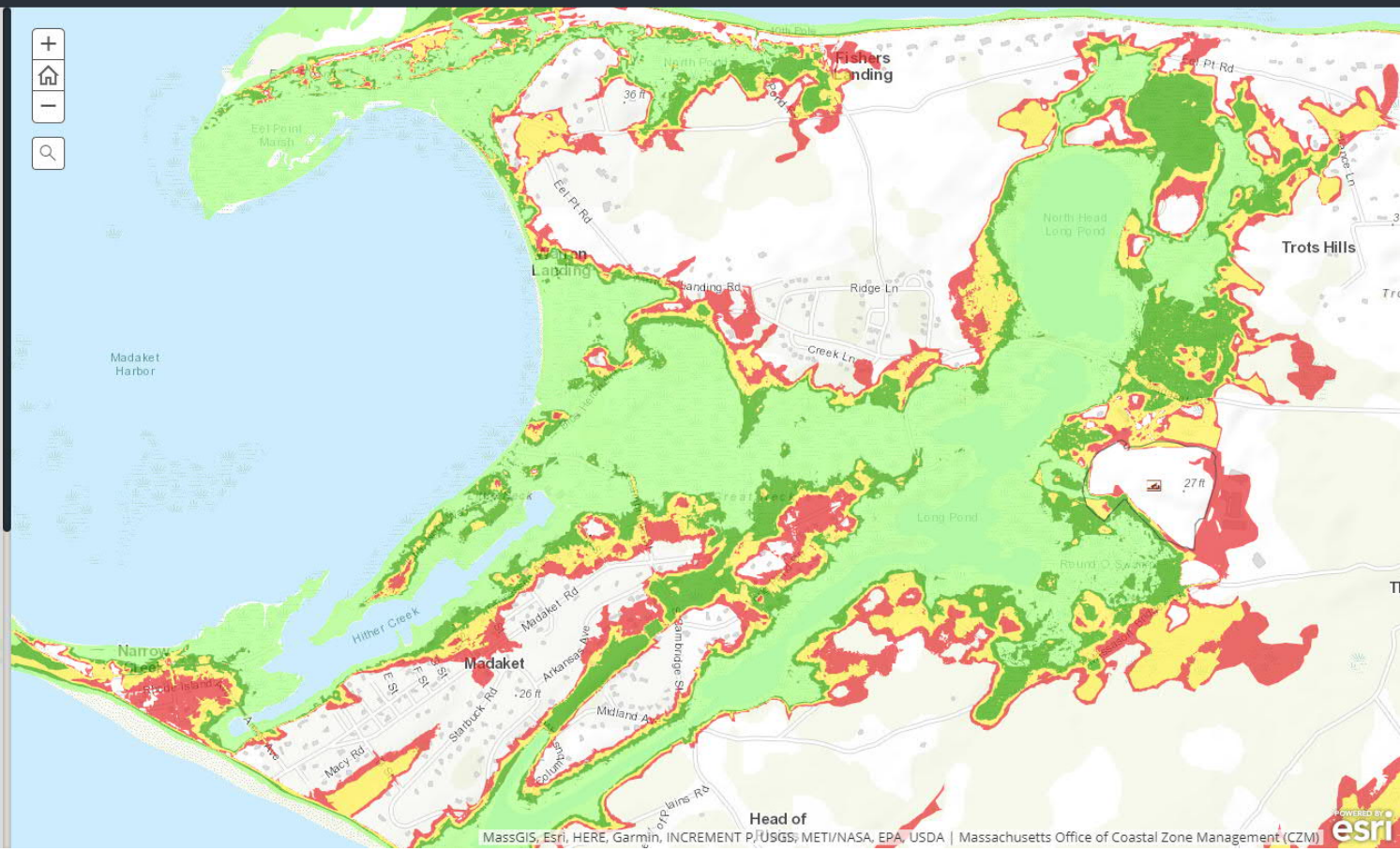
For planning purposes only. Hurricane surge data courtesy of USACE, October 2013. These data were mapped using current sea level. Please see the technical report (PDF, 272 KB) for data sources and processing steps.

Hurricane Surge Scenarios

- Category 1
- Category 2
- Category 3
- Category 4

Public Facilities and Infrastructure

- Airport
- Community Health Center
- Electrical Generation Facility
- Fire Station
- Harbormaster
- Hospital
- Landfill
- Library
- Long-Term Care Residence



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Sea Level Rise

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Interactive maps of coastal flooding areas and community facilities and infrastructure based on: sea level rise scenarios, Federal Emergency Management Agency coastal flood zones, and hurricane surge models.

MASSACHUSETTS OFFICE OF COASTAL ZONE MANAGEMENT

Intro | Sea Level Rise | FEMA Coastal Flood Zones | Hurricane Surge

This map shows the National Oceanic and Atmospheric Administration (NOAA) modeling of coastal flooding above Mean Higher High Water (MHHW, the average height of daily highest tide) with six increasing levels of sea level rise (1-foot increments up to six feet). This map does not account for storm surge, waves, erosion, and other dynamic factors. Future updates to the viewer will include maps that depict water levels from storm-driven flooding under sea level rise scenarios. See CZM's Sea Level Rise Guidance (PDF, 3.0 MB) for more information on sea level rise rates and projections, as well as general advice in the selection and application of scenarios for coastal vulnerability assessments.

Zoom in until the mapped extents of the sea level rise scenarios come into view. Community facilities and infrastructure are identified with an icon and facility outline. Click the icon for a pop-up box displaying the facility name, type, town or city, and water levels under the sea level rise scenarios. Flood levels represent water depth in feet above 0 NAVD 88, rather than above the ground surface. See the Sea Level Rise Scenario figure (PDF, 155 KB) for a visual representation of the information depicted on the map. Coastal flood data can be directly compared for each facility by switching viewer tabs.

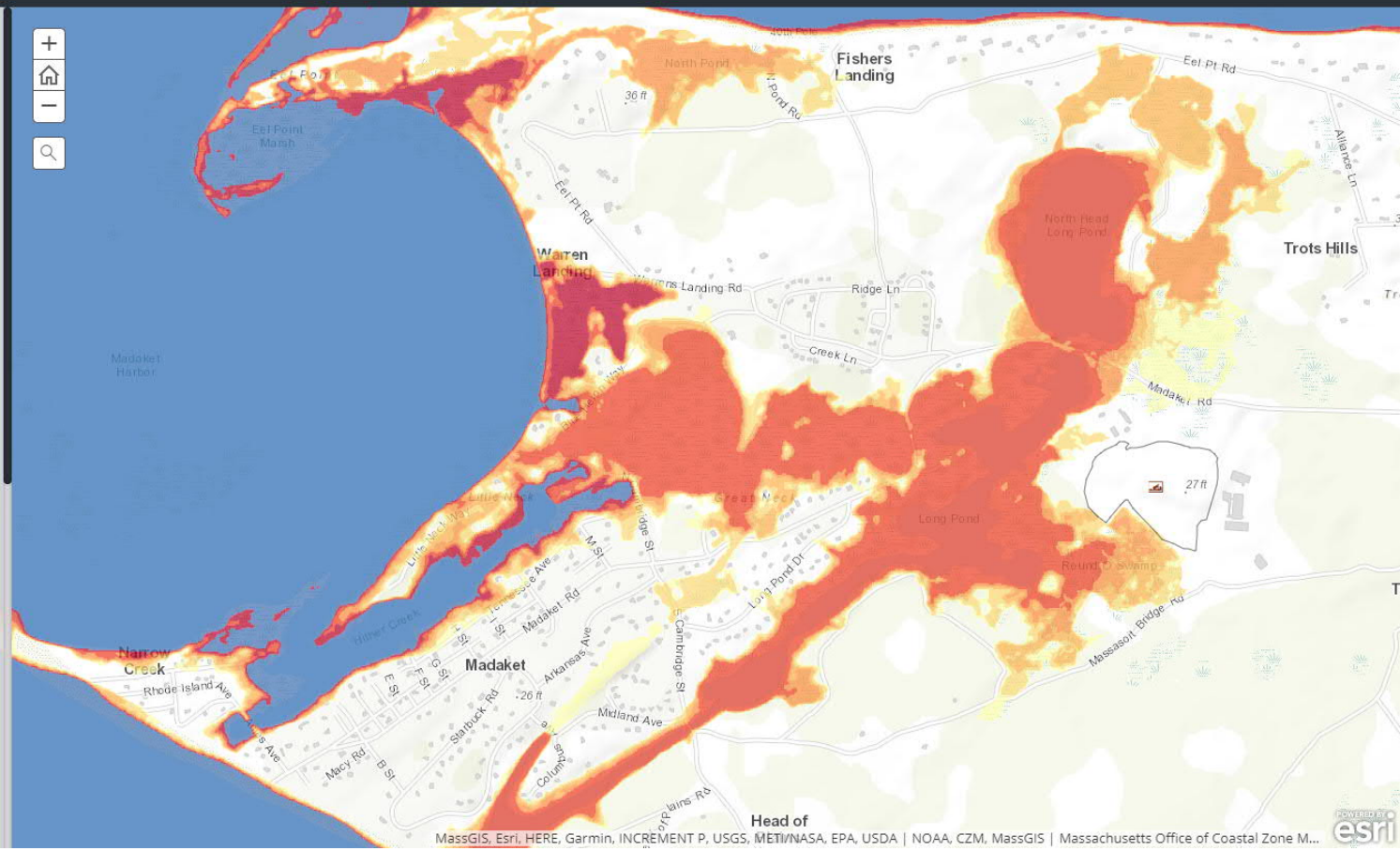
For planning purposes only. Sea level rise data courtesy of NOAA, January 2013. Please see the technical report (PDF, 272 KB) for data sources and processing steps.

Potential Extent of Mean Higher High Water (MHHW) with Sea Level Rise

- MHHW
- MHHW + 1 ft Sea Level Rise
- MHHW + 2 ft Sea Level Rise
- MHHW + 3 ft Sea Level Rise
- MHHW + 4 ft Sea Level Rise
- MHHW + 5 ft Sea Level Rise
- MHHW + 6 ft Sea Level Rise

Public Facilities and Infrastructure

- Airport
- Community Health Center
- Electrical Generation Facility
- Fire Station



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Long Pond

- Brackish 70-acre pond
- 6 feet deep
- Tidally restricted
- Long Pond water quality improving but still “impaired”

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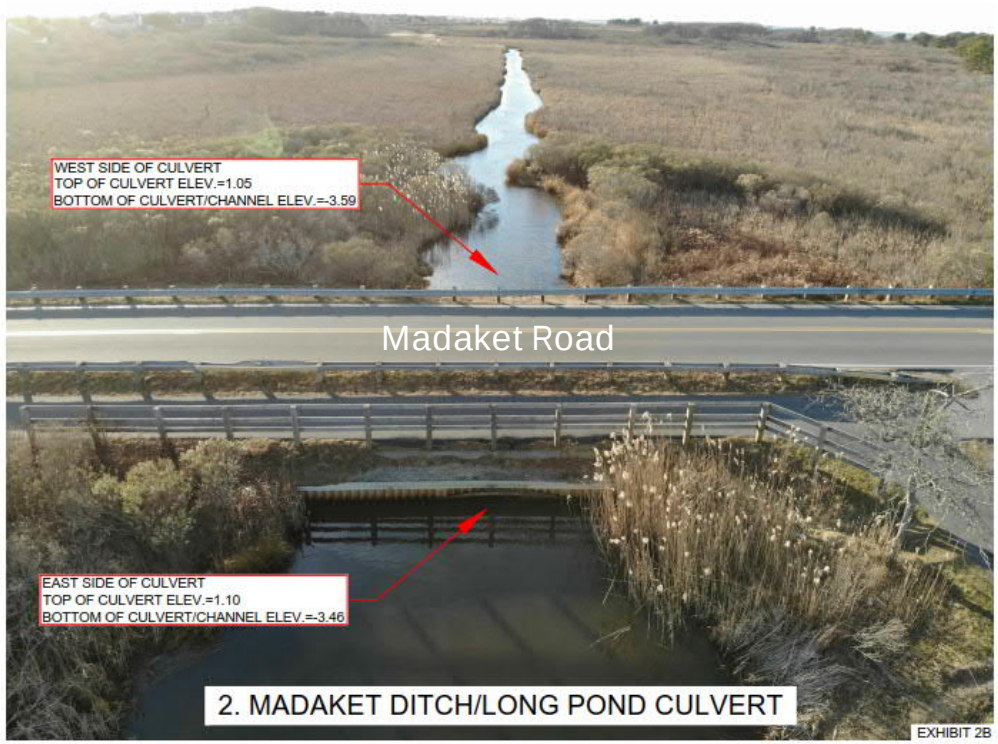
Madaket Ditch

- Artificial connection between Madaket Harbor and Long Pond (approx. 3,500 feet long)
- Originally dug in 1665 by island's early European settlers and Wampanoag Indians
- Tidal restriction



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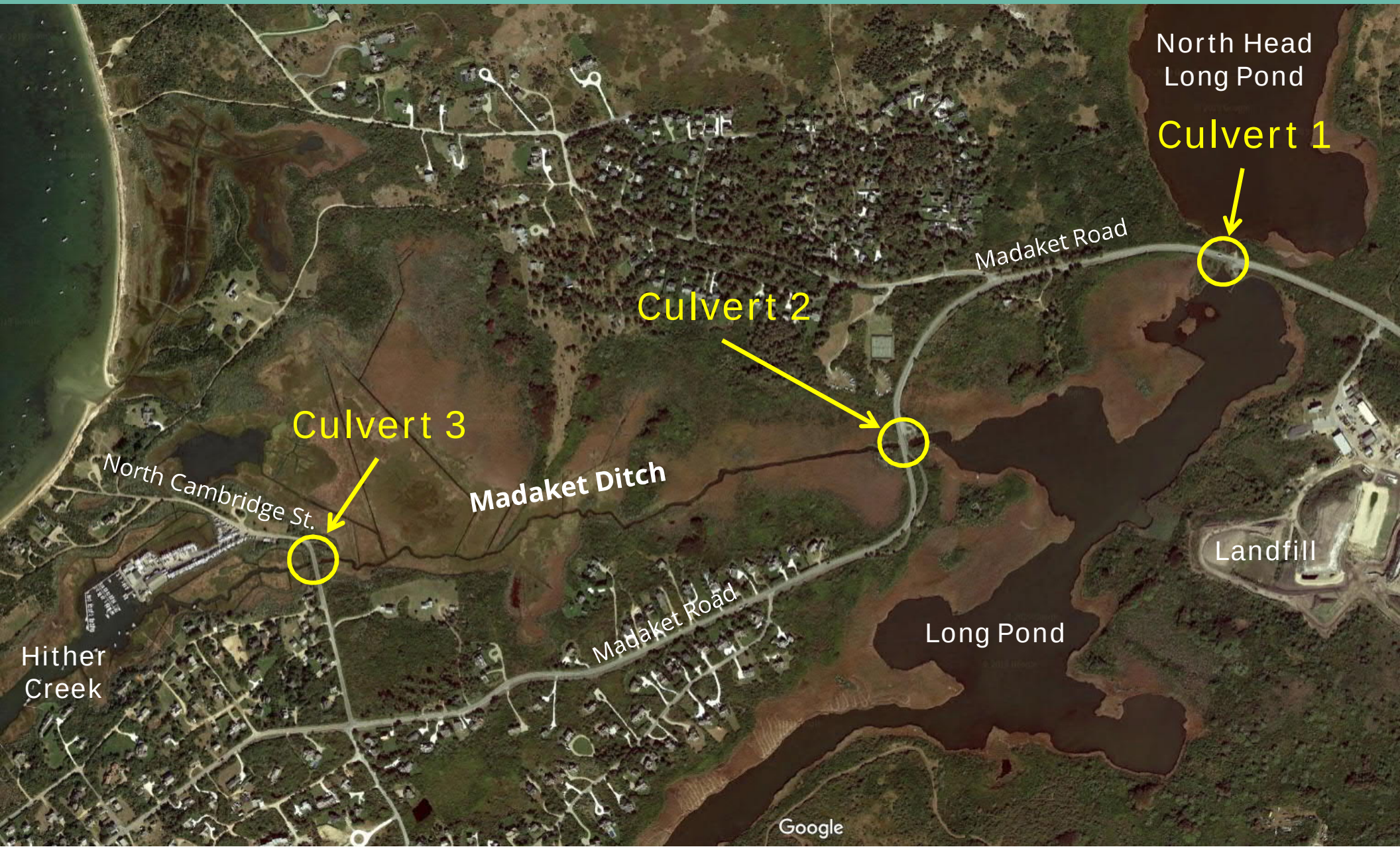
Study Culverts



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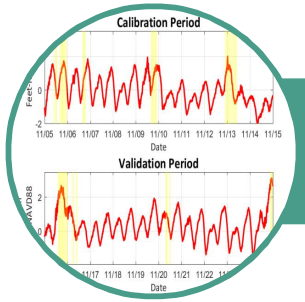
Study Objectives and Scope

- Evaluate the need to replace the study culverts:
  - Structural condition
  - Potential water quality improvements
  - Flood resilience
- Scope of Work

1. Structural Condition Assessment



2. Hydrologic & Hydraulic Modeling

3. Alternatives Evaluation

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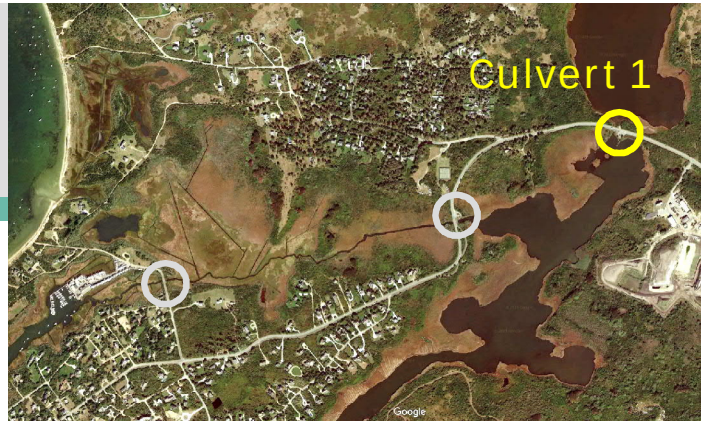
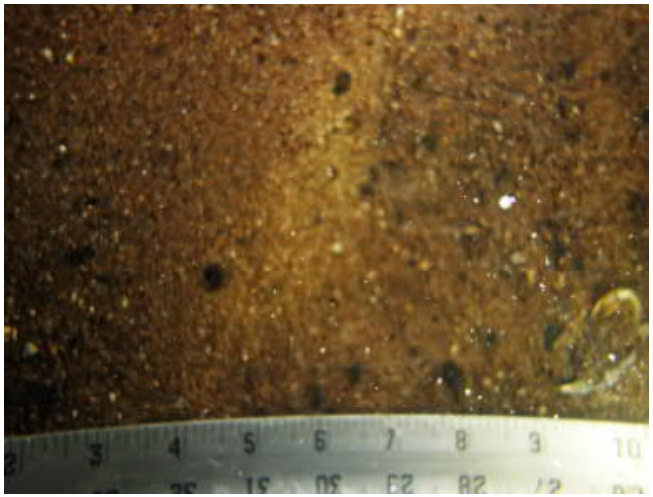
Structural Condition Assessment

- Structural condition inspections – September 17, 2018
  - Study culverts and Massasoit Bridge
- MassDOT and FHWA National Bridge Inspection Standards
- Underwater inspections by dive team
- Dates of last culvert replacements uncertain
  - Reconstructed in 1900 according to MassDOT records
  - Local accounts indicate Madaket Road culverts were installed as a temporary measure decades ago to allow for bridge repairs, but the bridges were never rebuilt

Culvert 1 – Madaket Road



- Corrugated aluminum box culvert
- 50 inches high, 9 feet wide, 50 feet long
- Connects North Head Long Pond to Long Pond
- Good condition, some buildup of sand and marine growth (2 to 5 inches), minor sinkhole



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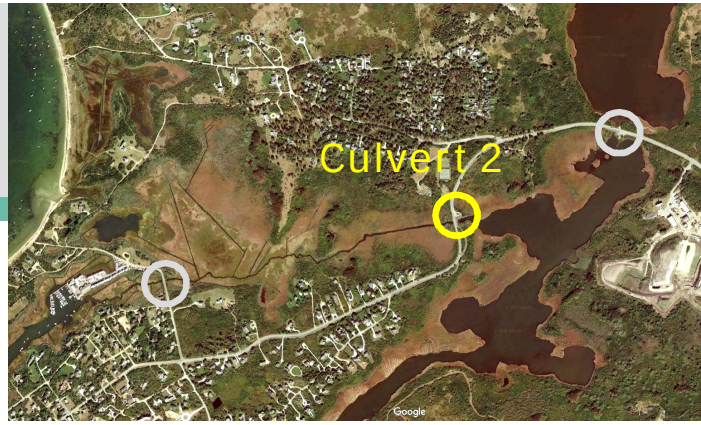
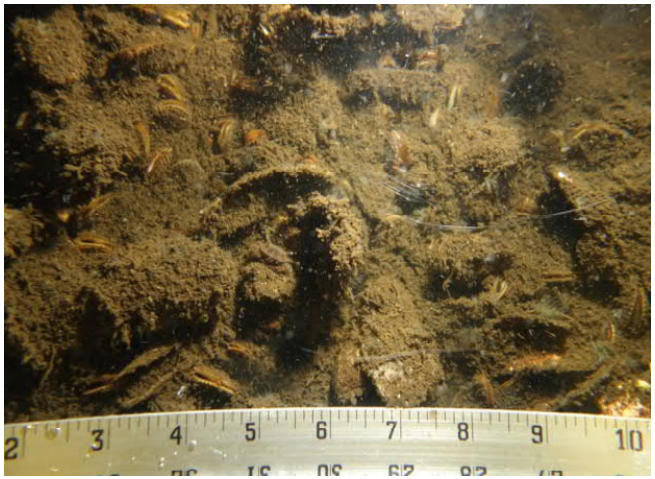
Culvert 2 – Madaket Road

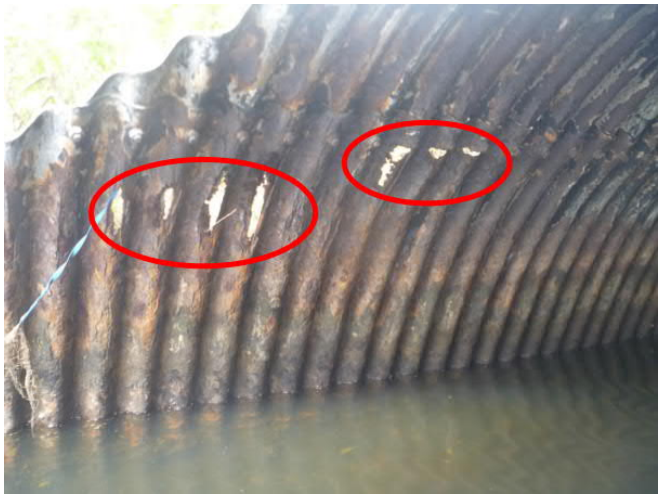


- Corrugated aluminum culvert
- 60 inches high, 16 ft wide, 60 ft long
- Connects upstream end of Madaket Ditch to Long Pond
- Satisfactory condition, minor deformation of eastern headwall, some buildup of sand and marine growth (2 inches or less)



Culvert 3 – North Cambridge St.

- Multi-plate steel corrugated culvert
- 7 feet tall, 50 feet long, tapered ends
- Connects downstream end of Madaket Ditch to Hither Creek
- Satisfactory condition, minor corrosion of plate walls and connections, original protective coating in poor condition



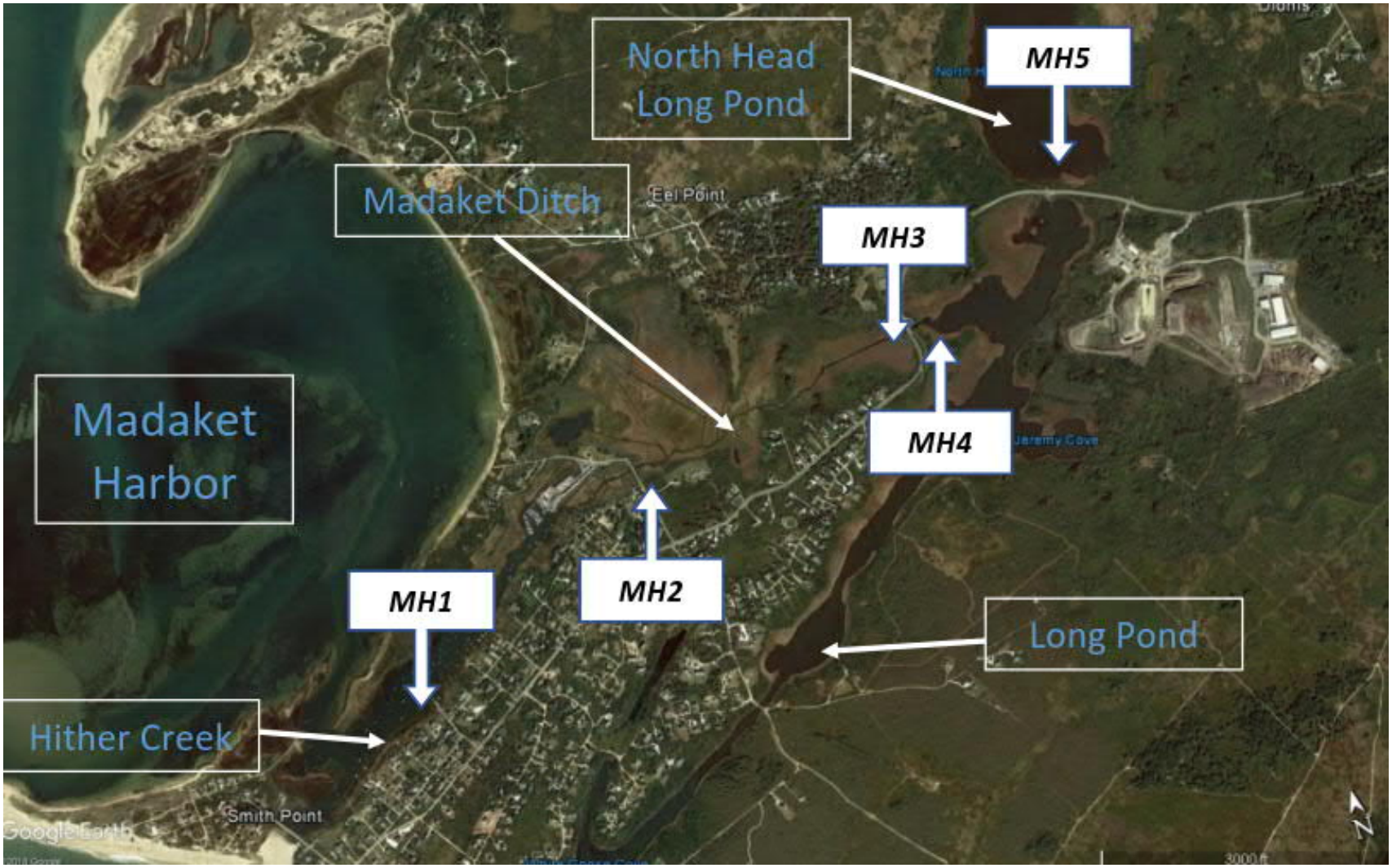
Hydrologic & Hydraulic Assessment

- Evaluate existing tidal exchange
- Determine optimal culvert sizing and elevations
  - Allow for increased tidal flushing
  - Limit adverse flooding impacts

Field Data Collection → Model Development → Alternatives Evaluation

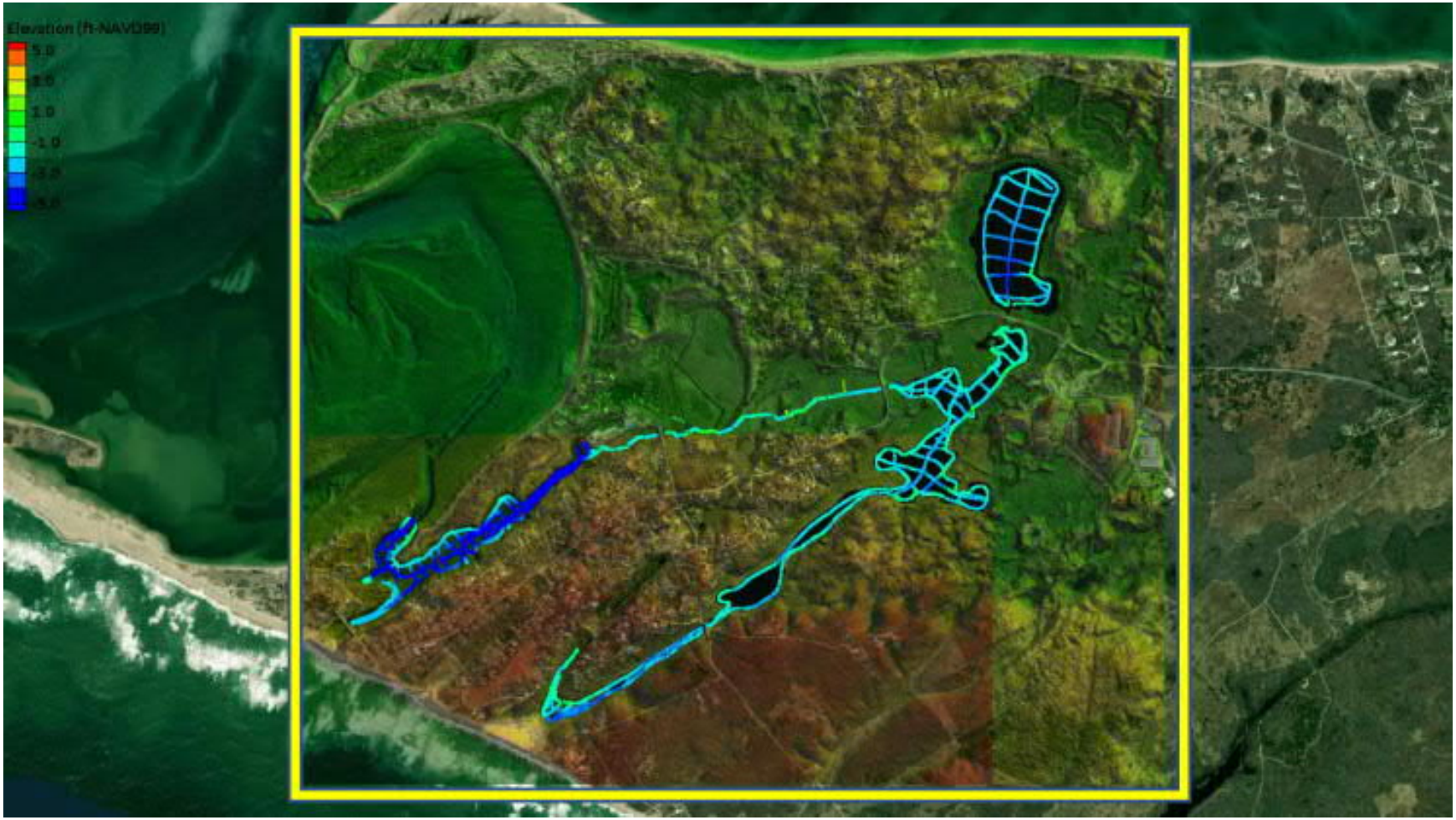
Field Data Collection

- Continuous measurement of water level, temperature, and salinity at 5 locations (October 24 – November 28, 2018)



Elevation Survey

- Bathymetry survey (RTK GPS) combined with LiDAR
- Survey of culvert elevations



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Water Level Data

- Culvert at N. Cambridge Street not restricting tidal flow
- Madaket Ditch channel is the primary tidal restriction

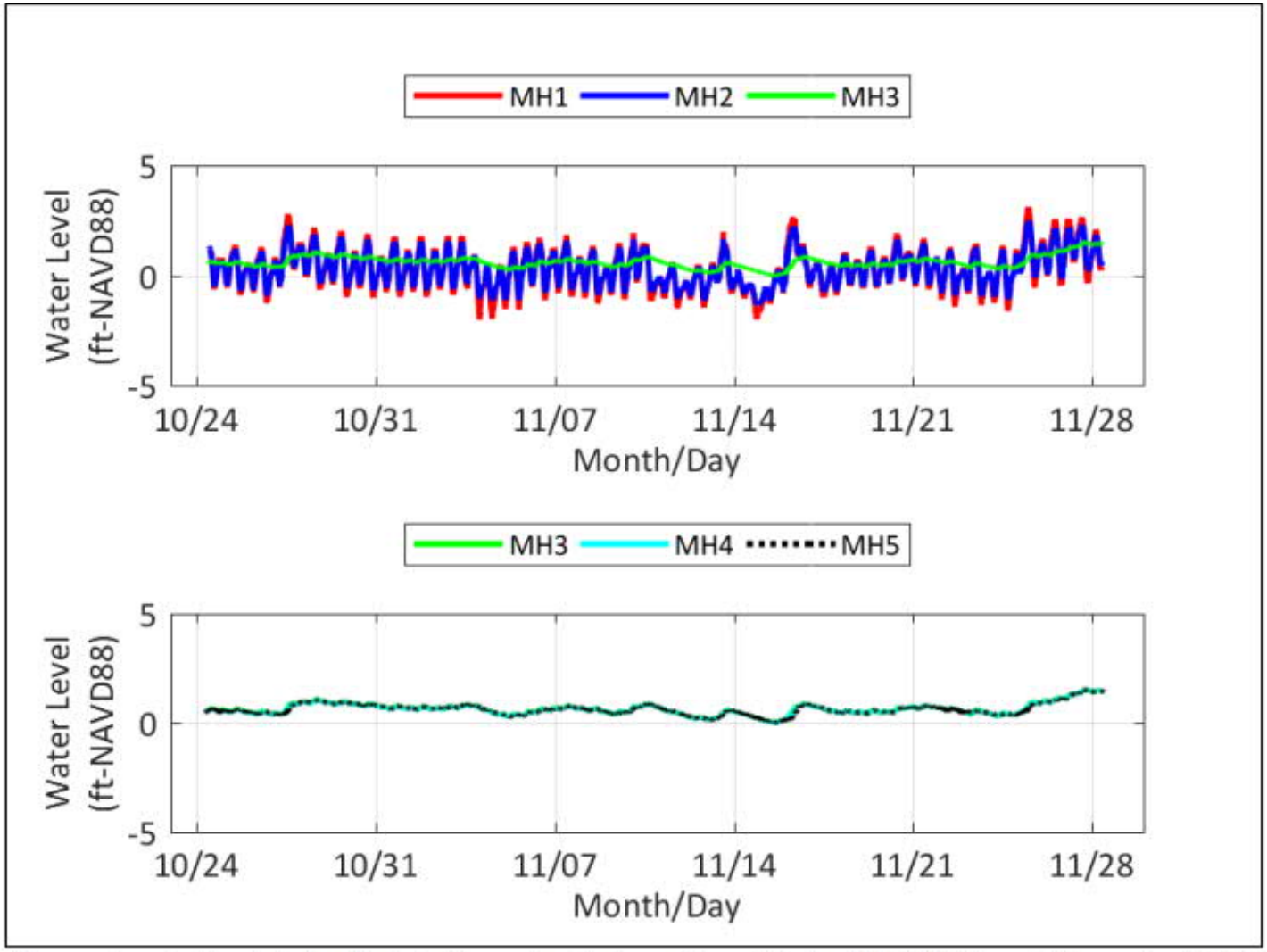

Figure 2. Observed water levels in the Madaket-Long Pond estuary from October 24, 2018 through November 28, 2018.

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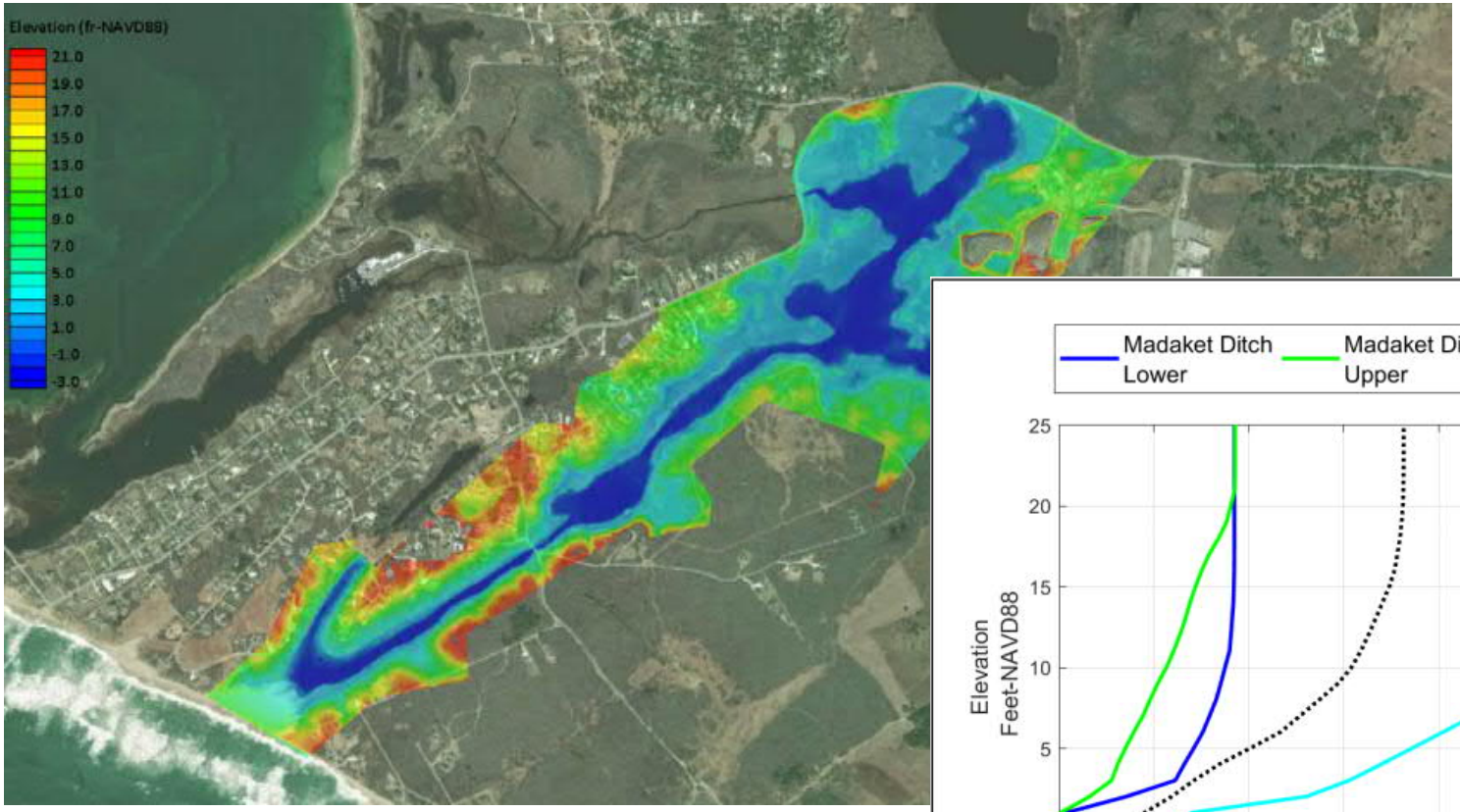
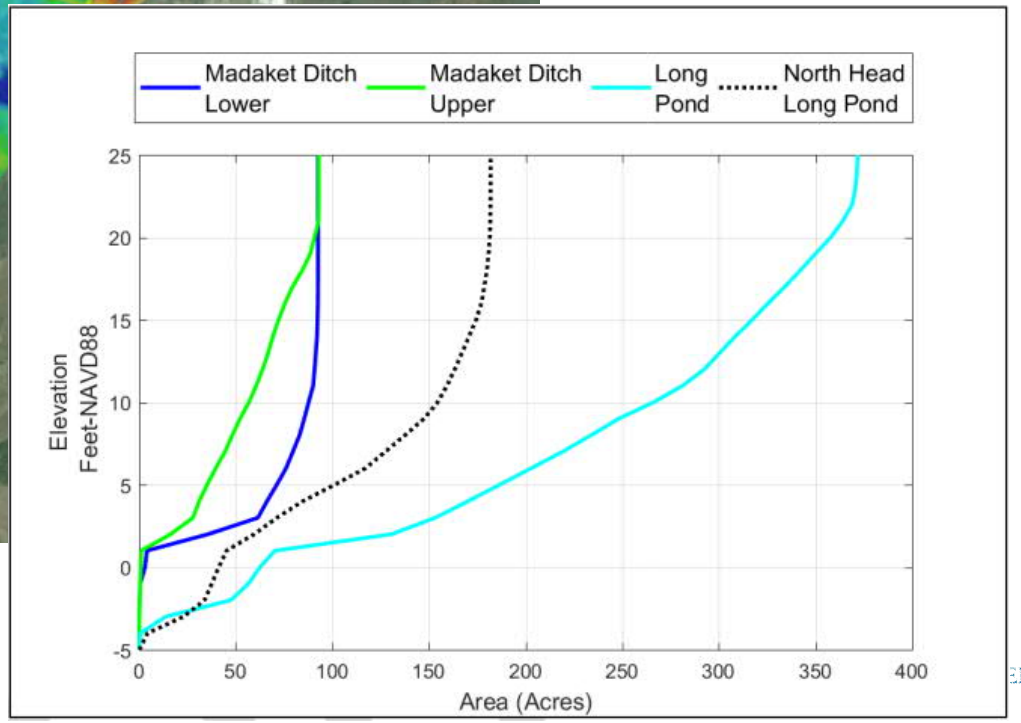
Estuarine Culvert Model

- Topography and bathymetry of basins
- Culvert geometry
- Tidal boundary conditions at Madaket Harbor

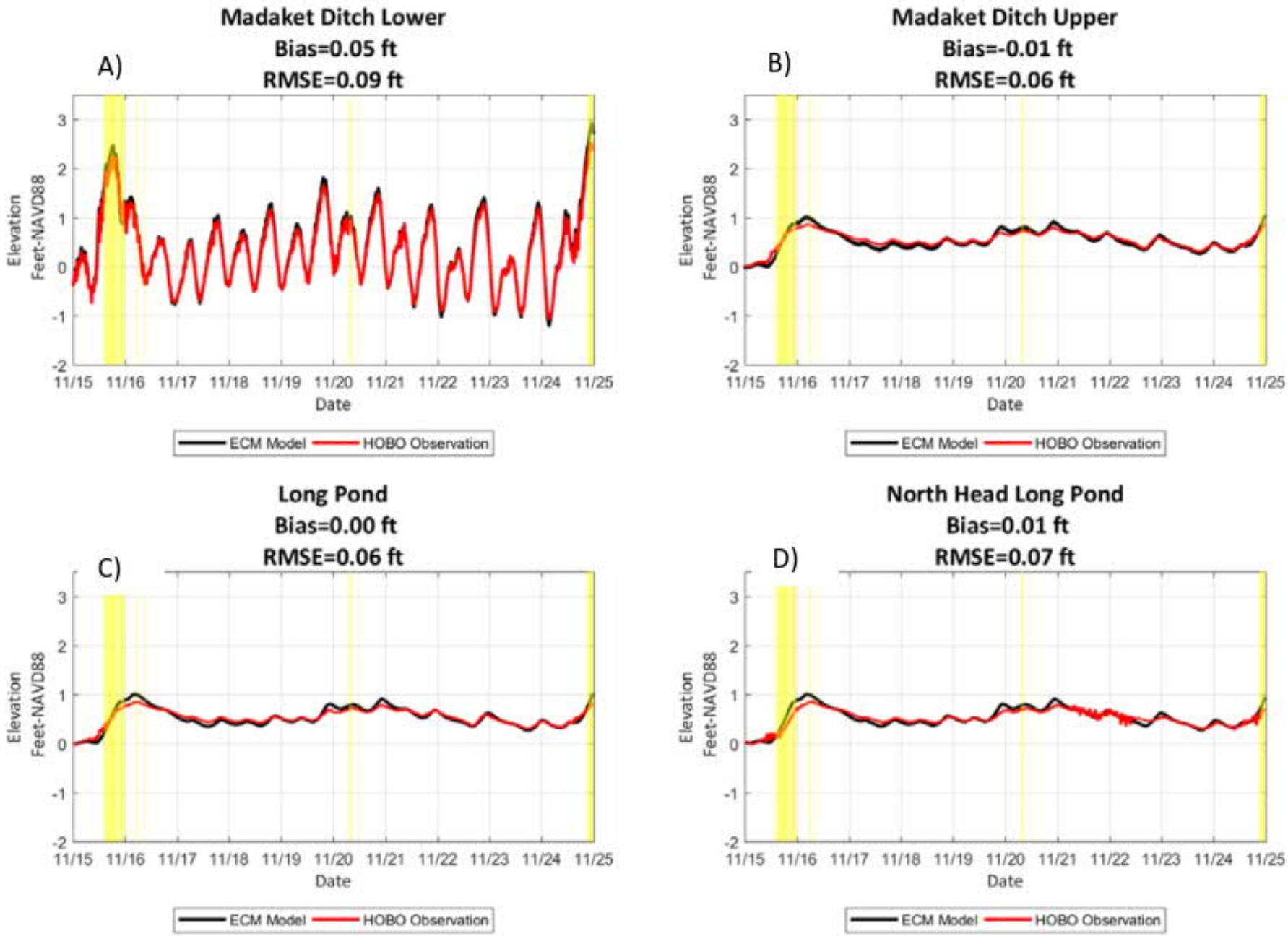
<u>Model Simulations</u>

Typical Tides
Typical Tides w/SLR
100-yr Storm Surge
100-yr Rainfall





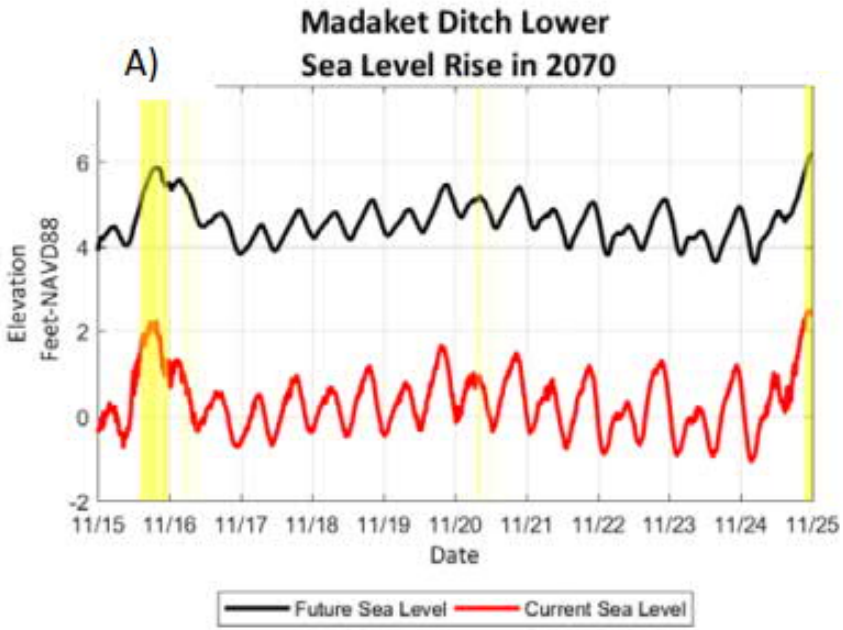
Model Results – Existing Conditions

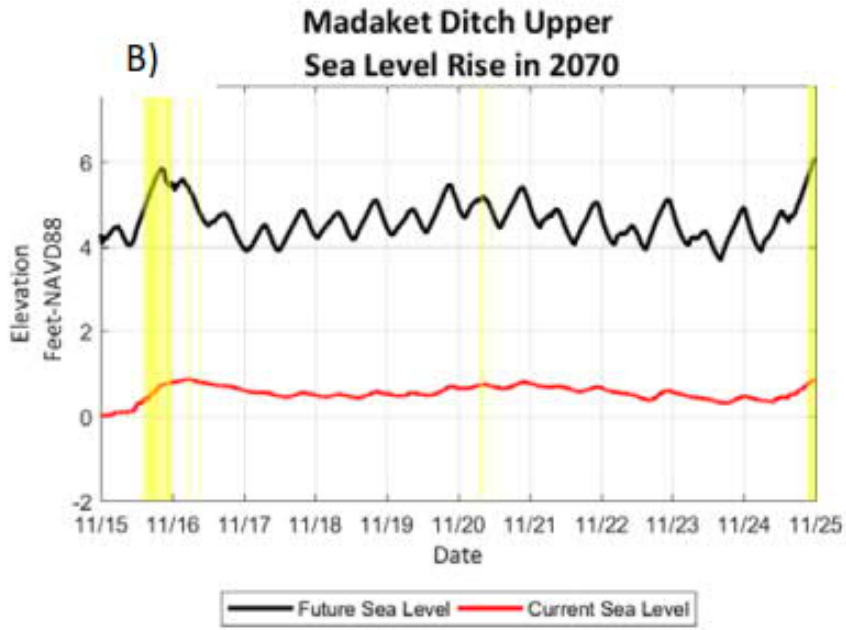


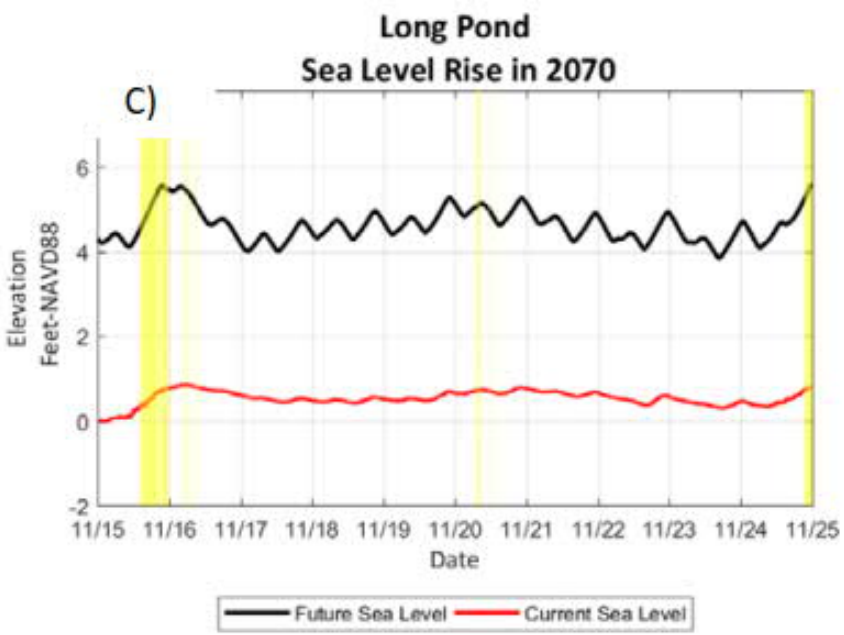
Model Results – Existing Conditions

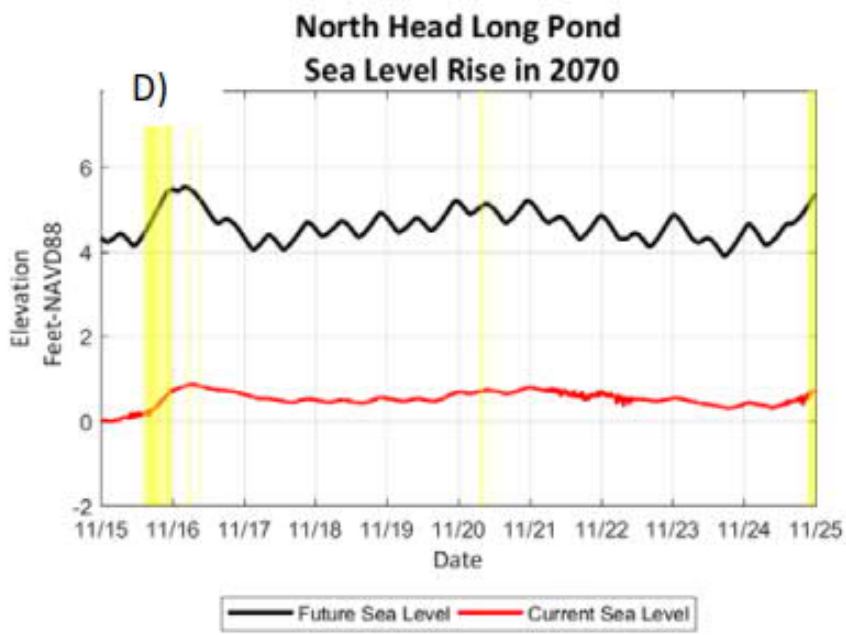
- Madaket Ditch channel is the primary tidal restriction
  - Natural sinuosity of channel and shoaling at channel bends
- All three study culverts <u>are not restrictive</u> and <u>are sufficiently sized</u>, with the existing channel and current-day tides
- In 100-year storm, Madaket Ditch channel attenuates surge peak from 7.4 feet in harbor to 4.7 feet in Long Pond
- 4-day drainage period following the storm

Model Results – 2070 Sea Level Rise (4.3 feet)









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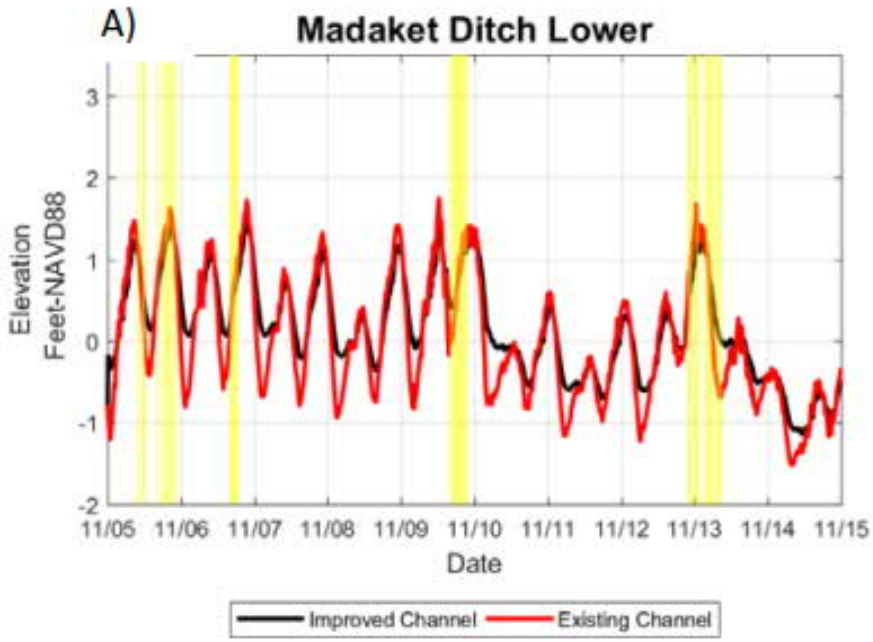
Model Results – 2070 Sea Level Rise (4.3 feet)

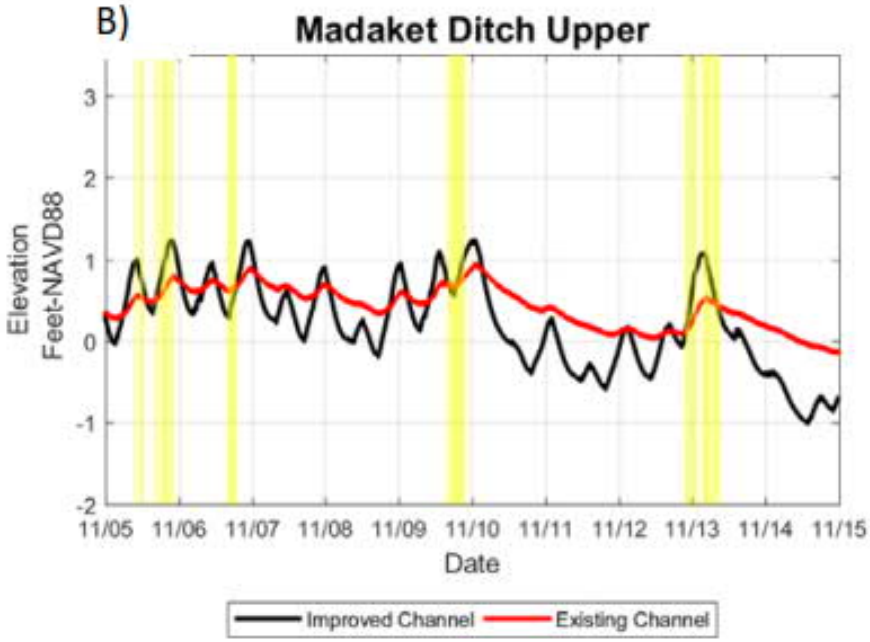
- Culvert at N. Cambridge Street starts to restrict tidal flow to Madaket Ditch
- Culvert under Madaket Road connecting Madaket Ditch to Long Pond slightly restricts tides in Long Pond
- N. Cambridge Street and Madaket Road crossings (or roadway approaches) predicted to be inundated in a 100-year coastal storm event and in typical tides

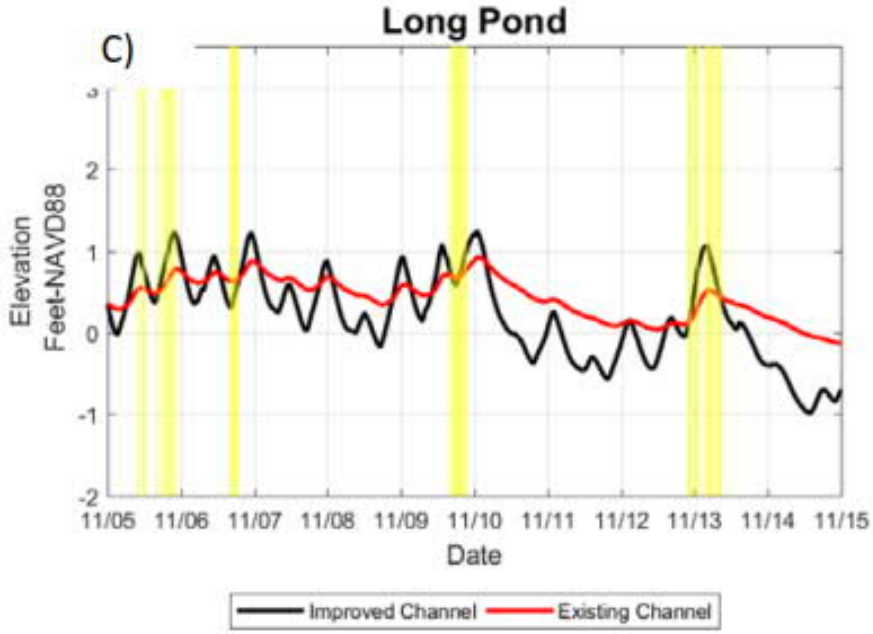
Alternatives Evaluation – Channel Dredging

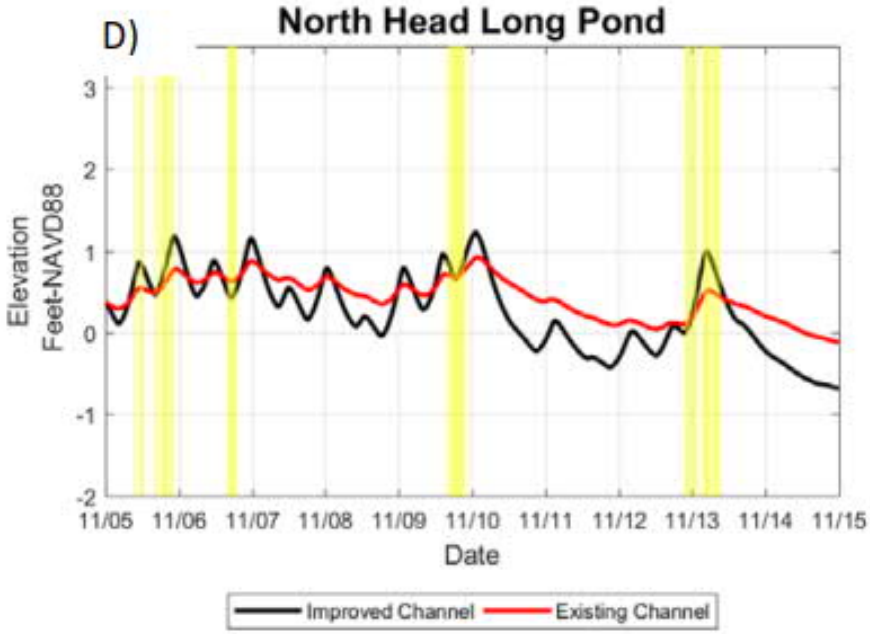
- Dredging of Madaket Ditch channel
  - 465 foot channel reach between upper and lower portions of Madaket Ditch
  - Increase cross-sectional flow area
  - Reduced channel friction
- Model simulations for typical tides, with and without extreme storm events and sea level rise

Channel Dredging – Model Results









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Channel Dredging – Model Results

- Typical Tides
  - Enhanced tidal exchange
  - Increased tidal range in Long Pond
  - Would not completely alleviate the restriction to tidal exchange
  - Culvert to North Head Long Pond would become slightly restrictive (15-foot wide by 5-foot high box culvert required)
  - Reduced time required for upper reaches of system to drain following storms
  - Reduced local residence time (30-40% reduction) in Long Pond (water quality benefits)

Channel Dredging – Model Results

- 100-year Coastal Storm
  - Surge elevations in upper reach of Madaket Ditch predicted to be higher, overtopping Madaket Road
  - Reduced drainage period of upstream Long Pond basins from 4 days to 2 days
- Sea Level Rise (4.3 feet by 2070)
  - Both Madaket Road culverts shown to restrict tidal exchange with an improved Madaket Ditch channel
  - To not restrict typical tides in 2070, larger culvert openings are required:

20'w x 10'h concrete box at N. Cambridge Street
16'w x 10'h concrete box at Madaket Rd. to Long Pond (Culvert 2)
15'w x 5'h concrete box at Madaket Rd. to North Head Long Pond (Culvert 1)

Recommendations

- Sediment removal (dredging) at channel bends and areas of shoaling in Madaket Ditch (approx. 850 feet)
  - Dredging feasibility study
- Continued monitoring of water levels in Madaket Ditch
- Consider culvert replacement and elevating roadways to address future SLR and coastal storms

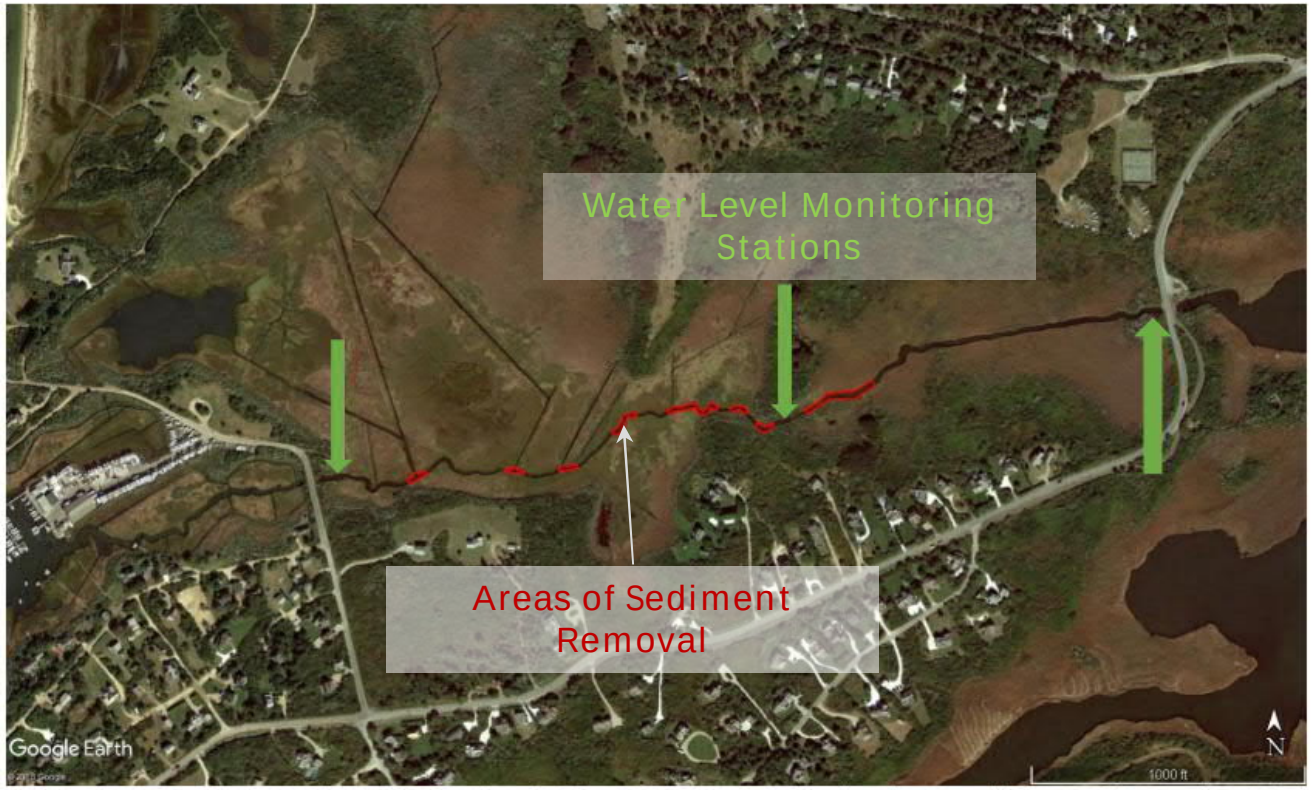

Figure 29. Locus map showing areas identified for sediment removal (red) and potential locations for post-channel-improvement monitoring stations. Green arrows point to provisional gauge locations.

Questions & Discussion

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