BAYSHORE COASTAL RESILIENCE DESIGN STUDY

MONMOUTH COUNTY, NEW JERSEY

NOVEMBER 2022

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1 INTRODUCTION

In 2012, Superstorm Sandy left numerous New Jersey communities with storm damage to homes and infrastructure. Naval Weapons Station (NWS) Earle incurred approximately $50M in installation damages that not only impacted mission readiness, but also impacted neighboring communities where the majority of the installation's military and civilian employee population resides. It is expected that NWS Earle and its surrounding communities will experience more frequent flooding from tidal waters and storm surge, adversely affecting ecosystems and presenting challenges to installation resilience and readiness. Nationwide, military installations rely on neighboring communities for infrastructure and support services such as electricity, roads, water, communication, and medical facilities[1]. This relationship between military installations and neighboring communities highlights the importance of community resilience in keeping installations operational and mission ready. Consequently, sea level rise (SLR) and the increasing frequency and severity of storm events along coastlines, such as Hurricane Sandy, have prompted many federal, state, and local organizations to evaluate their coastal resources and risks, and plan for future coastal conditions.

In response to these past occurrences and the increased threat of future related coastal hazards, the County of Monmouth, in cooperation with NWS Earle and the 13 municipalities that surround this military installation, published a Joint Land Use Study in 2017, which defined several goals related to adapting to SLR and improving resiliency from future storm events. In 2019 the County of Monmouth published a follow up study known as the Raritan/Sandy Hook Bay Coastal Resilience Planning Study (Bayshore Study) which identified 11 potential coastal resilience projects within the region that could improve sustainability and resiliency from current and future coastal hazards and SLR.

To advance the goals of the Bayshore Study, in 2020, the County of Monmouth selected two sites for further conceptual design. The selection process considered the importance to the NWS Earle mission, operation and/or protection of base facilities, and the need for design refinement. Ultimately the County of Monmouth selected Whale Creek in Aberdeen Township and Flat Creek in Union Beach Borough.

In 2021, the County of Monmouth contracted Princeton Hydro, LLC., Michael Baker International, and GreenVest, LLC, together known as the "Project Team" to develop coastal resilience designs for the Whale Creek and Flat Creek sites that address both current and future coastal hazards of flooding, storm surge, and SLR, which are presented in the following report.

The two sites are located on coastal wetlands, along the mouths of Whale Creek in Aberdeen Township and Flat Creek in Union Beach Borough, which are experiencing more frequent and severe coastal flooding from SLR and storm surge impacts. New Jersey's coastal wetlands provide important environmental and socioeconomic benefits, such as buffering against floodwaters by absorbing storm surge, protecting coastlines, reducing the severity of erosion and infrastructure damage, improving water quality, providing habitat for wildlife, supporting commercial fisheries, and offering recreational opportunities to the public[2]. However, increasing coastal hazards threaten the future health and function of New Jersey's coastal wetlands. A successful coastal resilience design for these sites requires a comprehensive understanding of existing site conditions as well as anticipated future conditions. The following report provides site characterizations, summarizes field assessments and data collection efforts, and presents conceptual designs for each site to ensure the longevity of the coastal wetland systems.

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[1] Government Accountability Office. (2020). *Climate Resilience: DOD Coordinates with Communities, but Needs to Assess the Performance of Related Grant Programs.* (GAO Publication No. 21-46). Washington, D.C.: U.S. Government Printing Office. Retrieved from https://www.gao.gov/products/gao-21-46

[2] Office of Habitat Conservation. (2022, February). *Coastal Wetland Habitat*. NOAA Fisheries. Retrieved from https://www.fisheries.noaa.gov/national/habitat-conservation/coastal-wetland-habitat

2 DATA COLLECTION

2.1 SITE CHARACTERIZATION AND REVIEW OF AVAILABLE MAPPING

In order to characterize existing site conditions, a site walk and desktop analysis (using GIS data) were conducted for each site to examine the local hydrology, topography, ecological communities, land use/land cover, FEMA floodplains, and threatened and endangered species. Maps of each site are provided in Appendix A, and representative aerial overviews of the sites are shown in **Figure 1** and **Figure 2**.

The sites fall on properties owned by the local municipality. The Whale Creek site in Aberdeen Township is approximately 33.4 acres. The Flat Creek site in Union Beach Borough is approximately 30.5 acres. Whale Creek and Flat Creek are both tidal channels connected to Raritan Bay that branch throughout a low-lying tidal marsh (*Figure 1 and Figure 2, Appendix A*). Narrow linear ditches appear throughout the sites and can be seen in the aerial imagery. These are indicative of historic human disturbance; grid-ditching was a common practice in the mid-20th century to control mosquitoes but resulted in unintended disturbances to marsh structure and function.

Figure 1. Whale Creek aerial overview map.

Ecological communities present on-site based on available GIS data include low marsh, high marsh, maritime scrub-shrub, and monocultures of invasive common reed (*Phragmites australis*) (*see* **Figure 3** and **Figure 4**). At both sites, the majority of land cover within the site is marsh (*Figure 3, Appendix A*). Both sites are bordered primarily by residential areas and recreational land. Additionally, vegetated dune communities, deciduous forest, and an artificial lake are located adjacent to the tidal marsh at Whale Creek.

Figure 2. Flat Creek aerial overview map.

Both sites are located within the FEMA-mapped 1% annual flood hazard chance floodplain, with the tidal marshes designated as within the VE zone (coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves greater than three feet (*Figure 4, Appendix A*). Additionally, a large portion of the Whale Creek coastal area is designated by the U.S. Fish and Wildlife Service as a Coastal Barrier Resource System (CBRS), a buffer area between coastal storms and inland areas protected under the Coastal Barrier Resources Act (CBRA) to protect inland properties and provide a protective habitat for aquatic plants and animals.

Threatened and endangered species habitats were mapped at both sites using data from the New Jersey Landscape Project, Version 3.3, from the New Jersey Division of Fish and Wildlife (*Figure 5, Appendix A*). Within the Whale Creek site three species listed as state threatened have been observed using habitat: black-crowned night-heron for foraging, osprey for nesting and foraging, and American kestrel sighted as non-breeding. The Whale Creek site is also mapped as foraging habitat for bald eagle, a state endangered species. The Flat Creek site is mapped as foraging habitat for bald eagle and least tern, also listed as a state endangered species. Additionally, Raritan Bay is considered occupied habitat for the Atlantic loggerhead turtle, listed as a state endangered and federally threatened species.

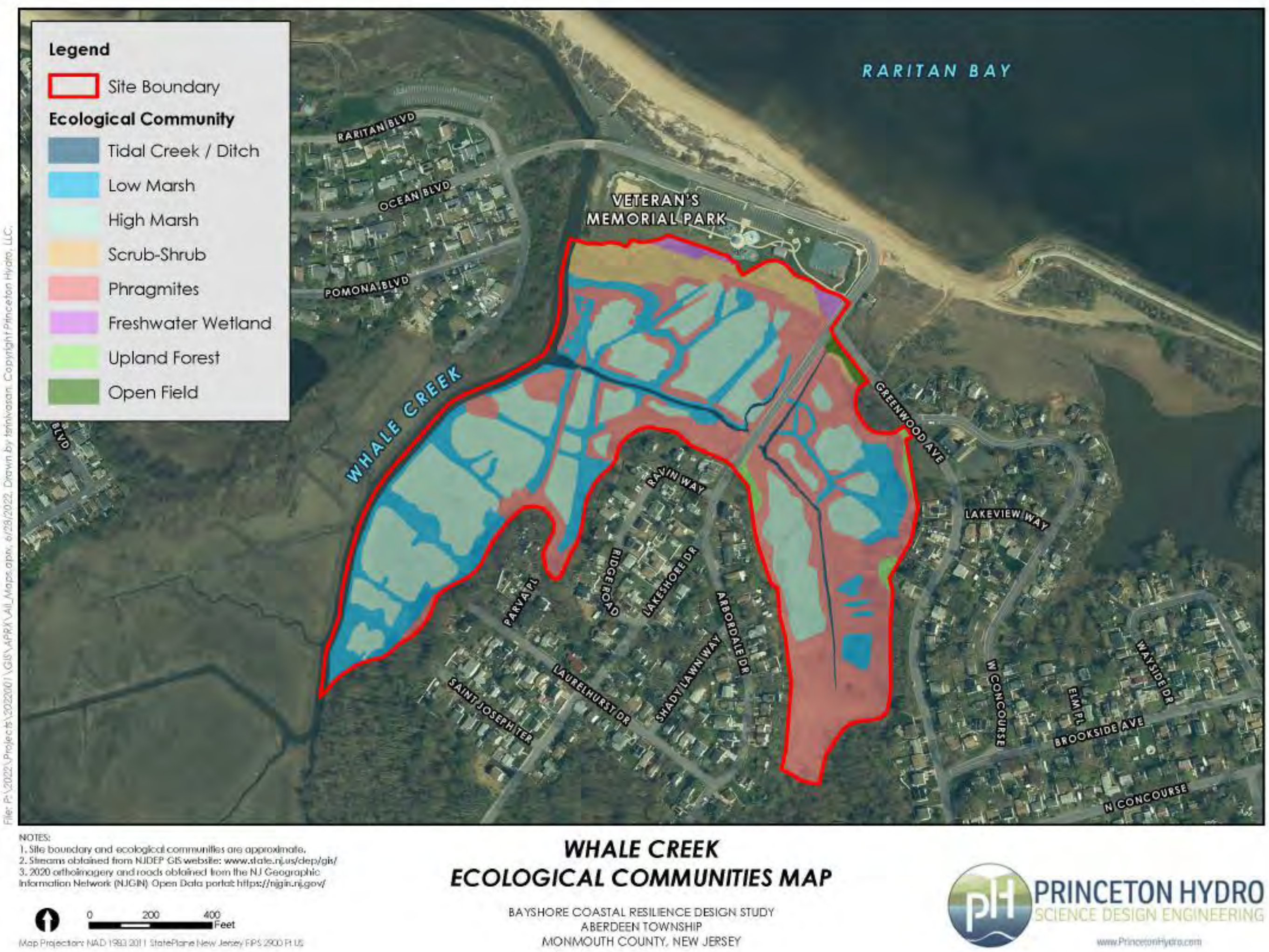


Figure 3. Whale Creek Ecological Communities Map

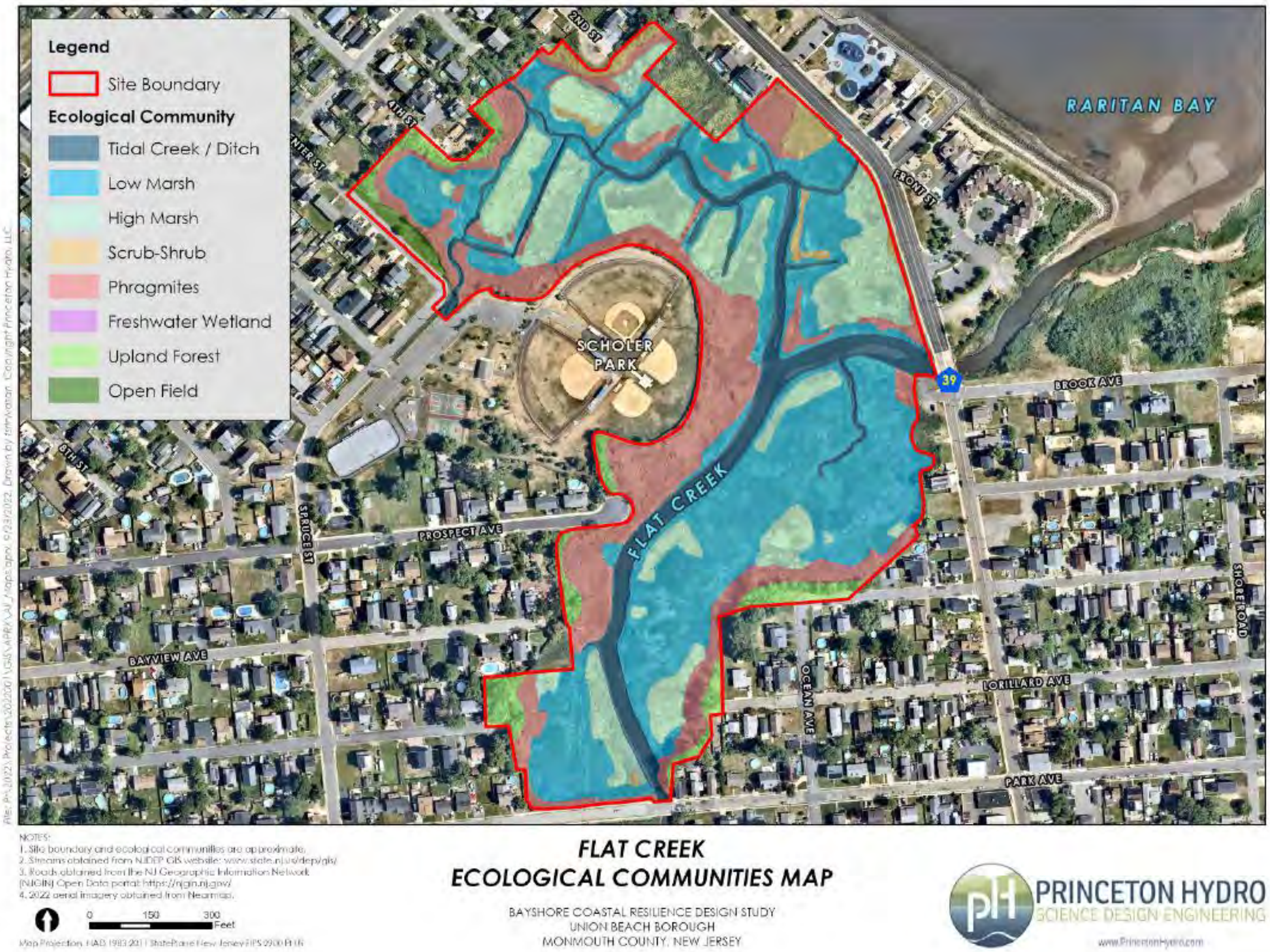


Figure 4. Flat Creek Ecological Communities Map

2.2 HYDROLOGIC MONITORING

2.2.1 HYDROLOGIC DATA COLLECTION METHODS

Tidal wetlands in New Jersey are heavily influenced by the depth, timing, and duration of inundation created by the diurnal tide, and successful restoration at these systems requires a thorough understanding of local hydrologic conditions specific to each site. Hydrologic conditions can be characterized through monitoring of water levels in tidal creeks using pressure data loggers housed in stilling wells, also referred to as monitoring wells.

Figure 5. Whale Creek monitoring well locations.

Monitoring well locations were selected to provide a comprehensive overview of tidal fluctuations and the flow regime throughout the site (**Figure 5**, **Figure 6**). Three data loggers were deployed at the Whale Creek site; MW-1 was installed in Whale Creek approximately 300 feet upstream of the bridge at Ocean Boulevard adjacent to Veteran's Memorial Park, and MW-2 and MW-3 were both installed on a tributary to Whale Creek, with MW-2 located downstream of Lakeshore Drive, and MW-3 located directly upstream of the culvert crossing at Lakeshore Drive. A barometric pressure logger was also installed at the Whale Creek site.

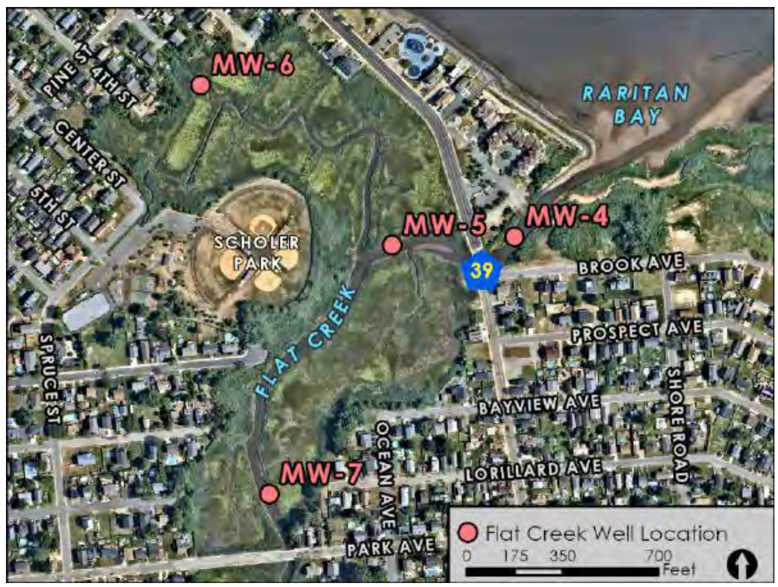


Figure 6. Flat Creek monitoring well locations.

At the Flat Creek site, four data loggers were deployed; MW-4, MW-5, and MW-7 were located on Flat Creek, while MW-6 was located on a tributary to Flat Creek. MW-4 was installed approximately 450 feet upstream of the mouth of Flat Creek where it connects to Raritan Bay. MW-5 was located approximately 500 feet upstream of MW-4, and MW-7 was located approximately 1,100 feet upstream of MW-5. Both MW-5 and MW-7 were upstream of the bridge crossing at County Route 39.

Slotted PVC monitoring wells were installed on September 7, 2021 and equipped with a HOBO unvented water level logger. Water level data was collected at 6-minute intervals, and data collection continued until November 23, 2021. The operation of the data loggers was verified on October 4-5, 2021, and the well elevations were surveyed by the Project Team using a survey-grade GPS unit. Tide gauge data was analyzed and processed to represent water surface elevations referenced to the North American Vertical Datum of 1988 (NAVD88).

2.2.2 HYDROLOGIC DATA ANALYSIS

Water level data from the three Whale Creek wells and the four Flat Creek wells were compared to each other and to the NOAA tide gauge at Sandy Hook (Station ID: 8531680), located approximately 10 miles from the sites across Raritan and Sandy Hook bays. A representative sample of the water level data for each site is presented in **Figure 7** and **Figure 8**, and a hydrograph of the full sampling period is shown in Appendix B.

WHALE CREEK

For the Whale Creek site, MW-1 and MW-2 typically had similar water levels to each other, and high tide levels were generally comparable to the Sandy Hook observed water levels in elevation, though with a slight lag, peaking on average of 12 minutes after Sandy Hook. The minimum low tide for both MW-1 and MW-2 was typically over an hour after the Sandy Hook minimum low tide. Also, at times the low tide level at MW-2 was slightly higher than MW-1. Overall, low tide water levels for both MW-1 and MW-2 did not drop below an elevation of -1 feet.

Water levels in MW-3 behaved differently than MW-1 and MW-2 in several ways, and patterns were inconsistent throughout the monitoring period. At times, the MW-3 high tide water elevation and timing was similar to MW-1 and MW-2, while at other tide cycles, the peak high tide was both lower and delayed by an average of 20 minutes relative to MW-1 and MW-2. The low tide levels were significantly higher than MW-1 and MW-2 and appeared to be truncated at the approximate elevation of 0 feet, even though the logger was located at -0.8 feet. This lag in peak tide and truncation at low tide is likely due to a tidal constriction caused by the culvert under Lakeshore Drive located immediately downstream. Additionally, during some tide cycles, water levels rose and fell in a similar pattern to the other wells, but during other time periods the falling tide is significantly delayed, such as from 10/10/21-10/12/21 (**Figure 7**). During this time period, precipitation occurred on some but not all of the days; stormwater runoff may therefore contribute to this uneven tidal pattern. Another potential explanation may be temporary obstructions at the culvert from vegetation or other debris that impact its ability to drain the channel.

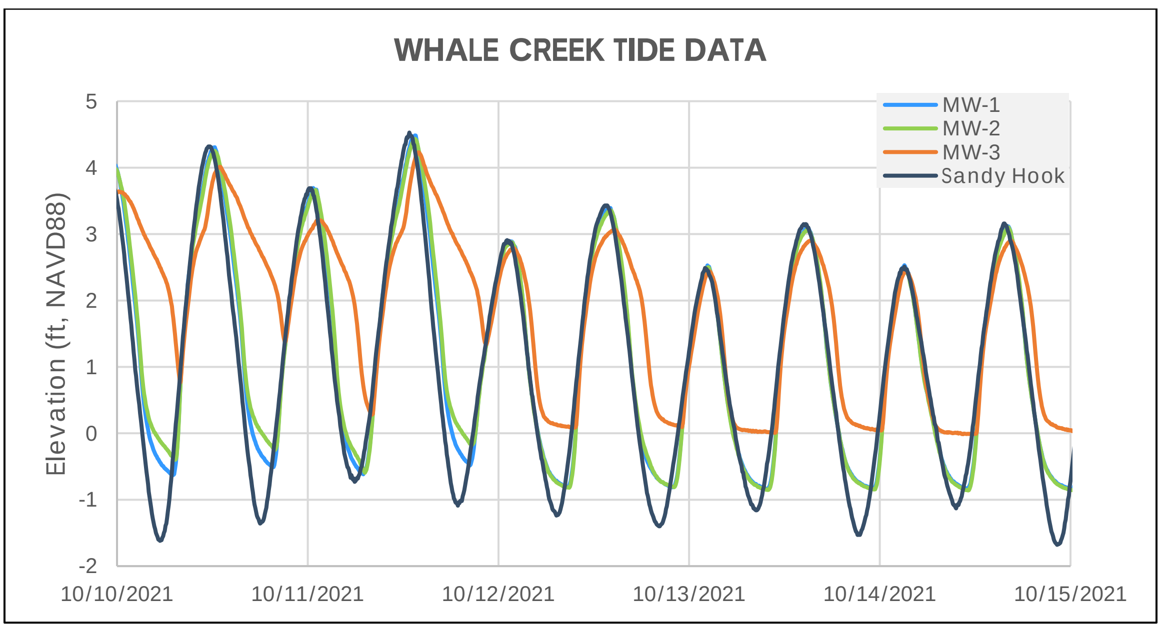


Figure 7. Representative sample of Whale Creek tide elevations.

FLAT CREEK

At the Flat Creek site, MW-4, MW-5, and MW-7, all located on Flat Creek, had consistently similar water levels throughout the tide cycle and throughout the monitoring period (**Figure 8**). Water levels at MW-6, located on a tributary to Flat Creek, were similar to the other wells and Sandy Hook at high tide, but had a truncated low tide that did not fall below 0 feet elevation. This was due to the channel invert elevation being approximately 0 feet at that location; lower elevations could therefore not be recorded, yet based on field observations, the channel was typically dry at low tide. The similar tide cycle patterns between MW-4 and other monitoring wells indicates that the Route 39 crossing over the tidal channel does not constrict tidal flows during the daily tidal cycle.

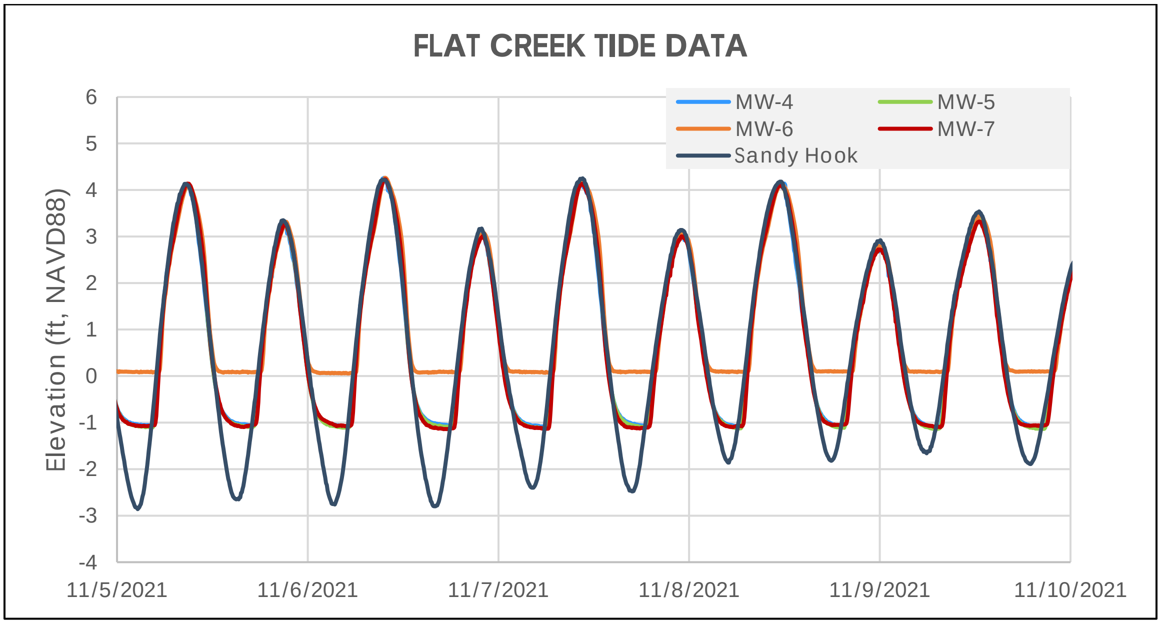


Figure 8. Representative sample of Flat Creek tide elevations.

2.2.3 TIDAL DATUM CALCULATIONS

Tidal datums for the Whale Creek and Flat Creek sites were calculated using the *NOAA Center for Operational Oceanographic Products and Services (CO-OPS) Tidal Analysis Datum Calculator*[3], in accordance with the methods described in the 2003 NOAA publication, *Computational Techniques for Tidal Datums Handbook*[4]. This tool uses an automated algorithm which identifies high and low tide peak levels from the provided data, as well as the higher-high, lower-high, higher-low, and lower-low tide within each daily cycle. As three months is an insufficient time period to independently determine tidal datums, observed water levels are then compared to a nearby long-term gauge and corrected to account for long term tidal cycles. Corrected tidal datum values were calculated for mean higher-high water (MHHW), mean high water (MHW), mean tide level (MTL), mean low water (MLW), and mean lower-low water (MLLW). Data from MW-1 were used to compute tidal datums for Whale Creek, and data from MW-4 were used to calculate tidal datums for Flat Creek. The long-term gage used was the NOAA water level station at Sandy Hook. Results are shown in **Table 1** with the tidal datums for the Sandy Hook station reported for comparison.

[3] NOAA Center for Operational Oceanographic Products and Services (CO-OPS). (2021, December). *Tidal Analysis Datum Calculator*. Retrieved from CO-OPS Tides & Currents Web Site: https://access.co-ops.nos.noaa.gov/datumcalc/

[4] NOAA Center for Operational Oceanographic Products and Services (CO-OPS). (2003). *Computational Techniques for Tidal Datums Handbook*. Silver Spring, MD: NOAA.

Table 1. Tidal datums calculated at Whale Creek and Flat Creek.

Tidal Datum	Water Surface Elevation (ft, NAVD88)		
	Whale Creek (MW-1)	Flat Creek (MW-4)	Sandy Hook
MHHW	2.27	2.27	2.41
MHW	1.99	1.99	2.08
MTL	0.13	-0.03	-0.27
MLW	-1.73	-2.05	-2.62
MLLW	-1.82	-2.13	-2.82

2.3 BIOLOGICAL BENCHMARK SURVEY

The success of tidal marsh restoration is dependent on establishing appropriate wetland hydrology to support targeted tidal marsh plant communities. More specifically, tidal inundation frequency and duration are the primary determinants of tidal marsh zonation (low marsh and high marsh). The combination of these factors – inundation duration and frequency – dictate tidal marsh zones along an elevation gradient (**Figure 9**)[5]. For example, low marsh species, such as smooth cordgrass (*Spartina alterniflora*), typically occur at lower elevations in the intertidal zone below the MHW level where tidal flushing occurs twice daily. High marsh species, such as *Spartina patens*, tend to occur at higher elevations, which are inundated less frequently and for shorter durations. Transition areas between high marsh and uplands, while located outside of the average daily tidal range, are also typically influenced by coastal effects, such as high winds, salt spray, and occasional coastal surge, and generally form a marsh border, also referred to as the maritime scrub-shrub zone, containing species such as *Baccharis halimifolia* and *Iva frutescens*. Additionally, non-native invasive species such as *Phragmites australis* commonly invade and outcompete native species in transitional zones and adjacent coastal uplands but lack a competitive advantage at lower elevations when exposed to salt water on a regular basis.

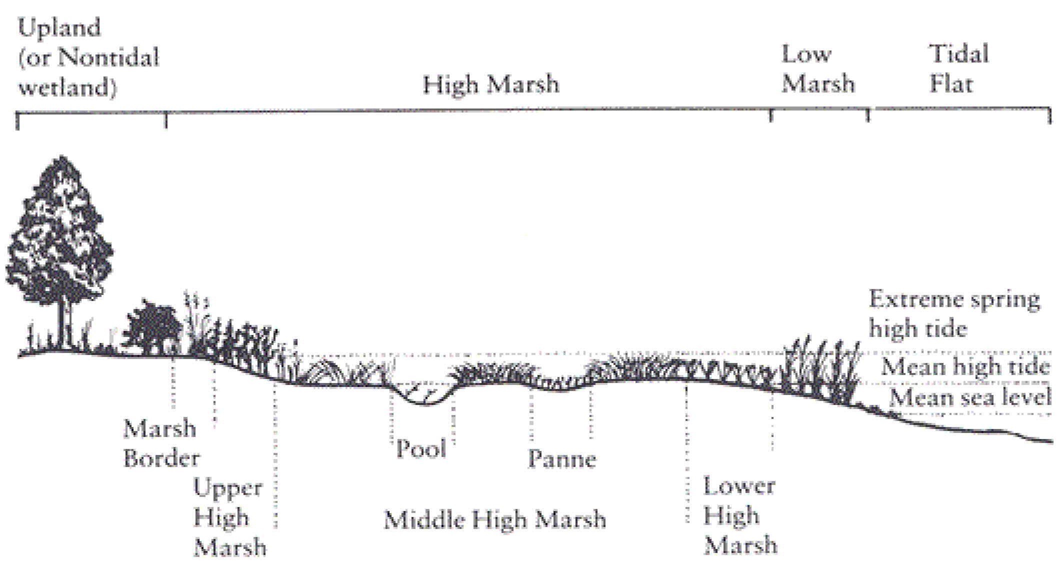


Figure 9. Generalized plant community zonation in northeastern salt marshes. Adapted from Tiner, 2009.

Characterizing the relationship among ground elevation, tidal inundation frequency and duration, and marsh zonation is vital to the success of tidal marsh restoration. Biological benchmarks, or bio-benchmarks, are surveyed

[5] Tiner, R. W. (2009). *Field guide to tidal wetland plants of the northeastern United States and neighboring Canada: Vegetation of beaches, tidal flats, rocky shores, marshes, swamps, and coastal ponds.* Amherst, MA: University of Massachusetts Press.

locations along a shoreline's elevation gradient which document the presence of a specific marsh zone or boundary between marsh zones. Bio-benchmarks, in conjunction with tidal elevation data, serve as reference points, which relate ground elevations to marsh vegetation zones in order to inform optimal elevation ranges for the establishment of tidal marsh plant communities.

2.3.1 BIO-BENCHMARK SURVEY METHODS

The bio-benchmark survey was conducted at Whale Creek on October 4, 2021, and at Flat Creek on October 5, 2021. Twenty-four bio-benchmarks were established at Whale Creek and 30 bio-benchmarks were established at Flat Creek across the site within each habitat zone, as determined by the presence of key indicator species identified in **Table 2** (**Figure 10** and **Figure 11**). Plant community zones were categorized as low marsh, high marsh, or marsh border (maritime scrub-shrub). *Phragmites australis* was also identified as a unique category due to its status as a non-native, invasive species, and its tendency to form dense monocultured stands.

At each bio-benchmark location a wooden stake was installed marking the bio-benchmark point, observed species were recorded, the site was photo documented, and the bio-benchmark elevation was recorded using a survey-grade, Leica Viva GS14 GNSS RTK Rover unit.

Figure 10. Whale Creek bio-benchmark locations.

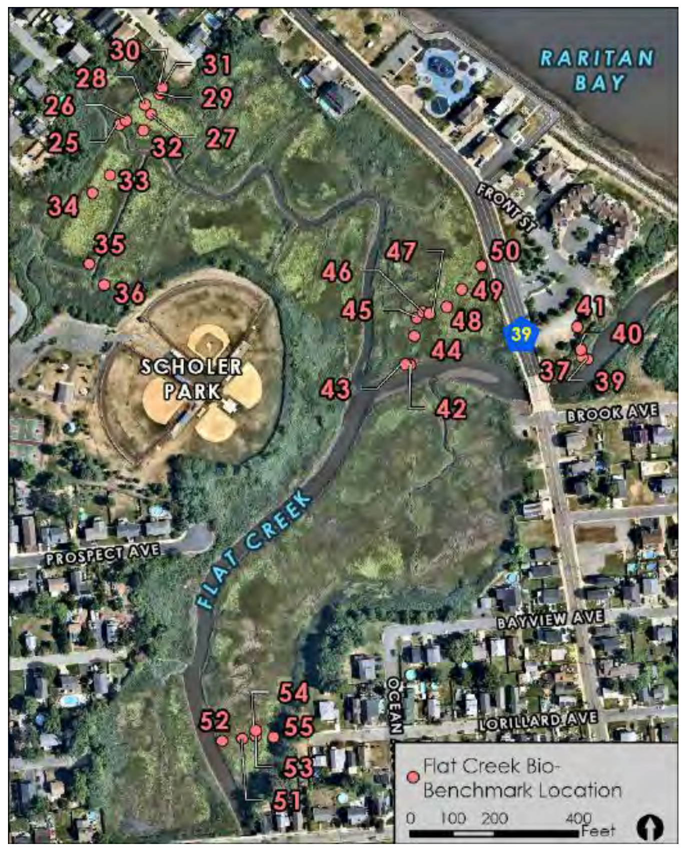


Figure 11. Flat Creek bio-benchmark locations.

Table 2. Key indicator species by plant community zone. Adapted from Tiner, 2009.

Plant Community Zone	Dominant Plants	Common Associates
Low Marsh	• Smooth Cordgrass (*Spartina alterniflora)* [tall form*]	• Smooth Cordgrass (*Spartina alterniflora*) [intermediate form*] • Rockweed (*Fucus vesiculosus*)
High Marsh	• Smooth Cordgrass (*Spartina alterniflora*) [short form*] • Saltmeadow Cordgrass (*Spartina patens*) • Blackgrass (*Juncus gerardii*) • Seaside Plantain (*Plantago maritima*) • Widgeon grass (*Ruppia cirrhosa*) • Saltgrass *(Distichlis spicata)*	• Glassworts (*Salicornia* sp.) • Sea Lavender (*Limonium carolinianum*) • Marsh Orach (*Atriplex* patula) • Seaside Gerardia (*Agalinis maritima*) • Seaside Arrowgrass (*Triglochin maritima*) • Salt Marsh Bulrush (*Schoenoplectus robustus*) • Goldenrod (*Solidago* sp.)
Marsh Border (Maritime Scrub-Shrub)	• Switchgrass (*Panicum virgatum*) • High-Tide Bush (*Iva frutescens*) • Groundsel Bush (*Baccharis halimifolia*) *In seepage areas:* • Narrow-Leaved Cattail (*Typha angustifolia*) • Three-Square (*Schoenoplectus pungens*)	• Northern Bayberry (*Myrica pensylvanica*) • Goldenrod (*Solidago* sp.) • Blackgrass (*Juncus gerardii*)
**Spartina alterniflora* form: *Short form = <1.5 feet, Intermediate form = 1.5 – 3.0 feet; Tall form = >3.0 feet.		

2.3.2 BIO-BENCHMARK DATA ANALYSIS

A full summary of the bio-benchmark data and site photos are presented in Appendix C. The study areas' plant community zonation, detailed in **Table 3** and **Table 4** and plotted in **Figure 12** and **Figure 13**, largely followed the prototypical elevation gradient and species assemblage of other New Jersey coastal ecosystems (**Figure 9**). Ecological community maps for both sites are presented in **Figure 3** and **Figure 4**.

Low marsh was most abundant below the MHW level (1.99 ft NAVD88). High marsh was most abundant between the MHW level and slightly above the MHHW level (2.27 ft NAVD88). The marsh border (maritime scrub-shrub) occurred up-gradient of the high marsh zone. *Phragmites australis* was observed at elevation ranges overlapping the high marsh zones.

Table 3. Whale Creek bio-benchmark summary statistics.

Plant Community Zone	Bio-benchmark Elevations (Feet, NAVD88)				Species Observed
	n	min.	max.	avg.	
Low Marsh	6	1.35	2.14	1.73	*Spartina alterniflora* (intermediate & tall)
High Marsh	11	2.21	2.96	2.60	*Spartina alterniflora* (short), *Spartina patens*, *Distichlis spicata*, *Juncus gerardii*, *Atriplex* sp., *Salicornia* sp., *Phragmites australis*
Marsh Border (Maritime Scrub-Shrub)	5	2.66	4.01	3.39	*Spartina alterniflora* (intermediate & short), *Distichlis spicata*, *Juncus gerardii*, *Atriplex* sp., *Salicornia* sp., *Phragmites australis*, *Spartina patens*
Phragmites australis	2	2.19	2.59	2.39	*Spartina patens*, *Distichlis spicata*, *Juncus gerardii*, *Atriplex* sp., *Salicornia* sp., *Phragmites australis*

Table 4. Flat Creek bio-benchmark summary statistics.

Plant Community Zone	Bio-benchmark Elevations (Feet, NAVD88)				Species Observed
	n	min.	max.	avg.	
Mudflat	1	-1.04	-1.04	-1.04	No vegetation
Low Marsh	4	0.22	2.09	1.50	*Spartina alterniflora* (intermediate & tall)
High Marsh	17	1.97	2.76	2.30	*Spartina alterniflora* (short), *Spartina patens*, *Distichlis spicata*, *Juncus gerardii*, *Atriplex* sp., *Salicornia* sp., *Phragmites australis*
Marsh Border (Maritime Scrub-Shrub)	4	2.53	3.22	2.94	*Distichlis spicata*, *Juncus gerardii*, *Atriplex* sp., *Salicornia* sp., *Phragmites australis*, *Spartina patens*.
Phragmites australis	3	2.32	2.75	2.47	*Spartina patens*, *Distichlis spicata*, *Juncus gerardii*, *Atriplex* sp., *Salicornia* sp., *Phragmites australis*
Freshwater/Brackish Adjacent Wetland	1	4.79	4.79	4.79	*Typha angustifolia*, *Bolboschoenus robustus*

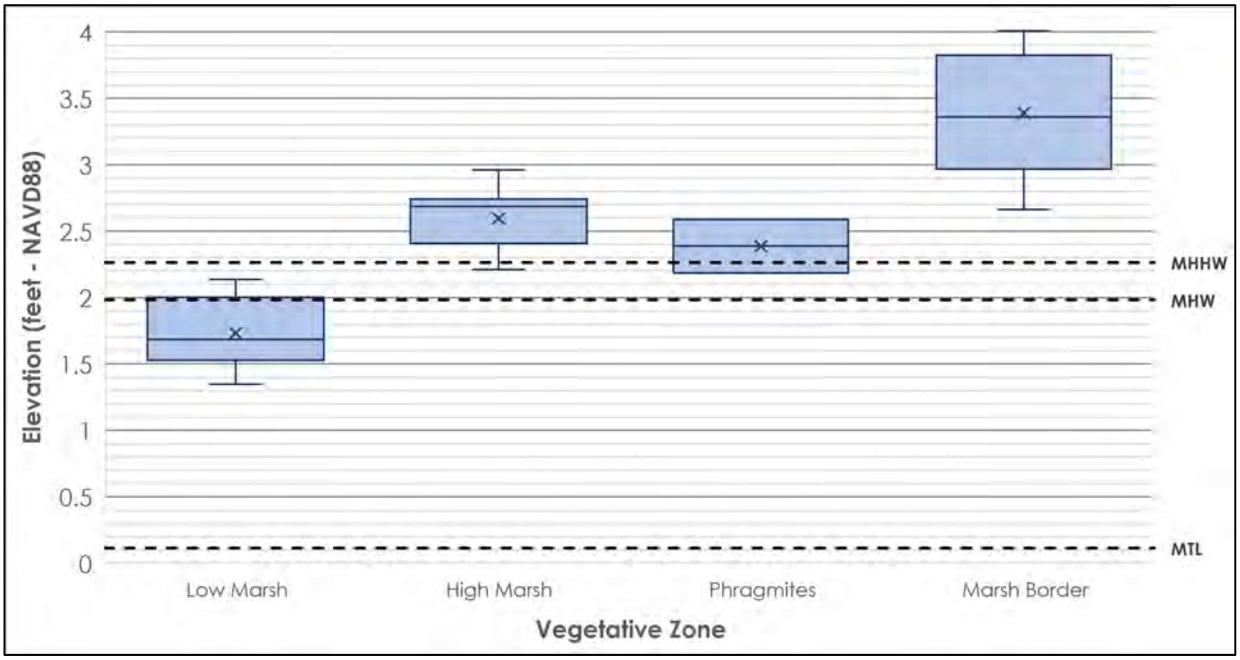


Figure 12. Whale Creek bio-benchmark elevation box plot.

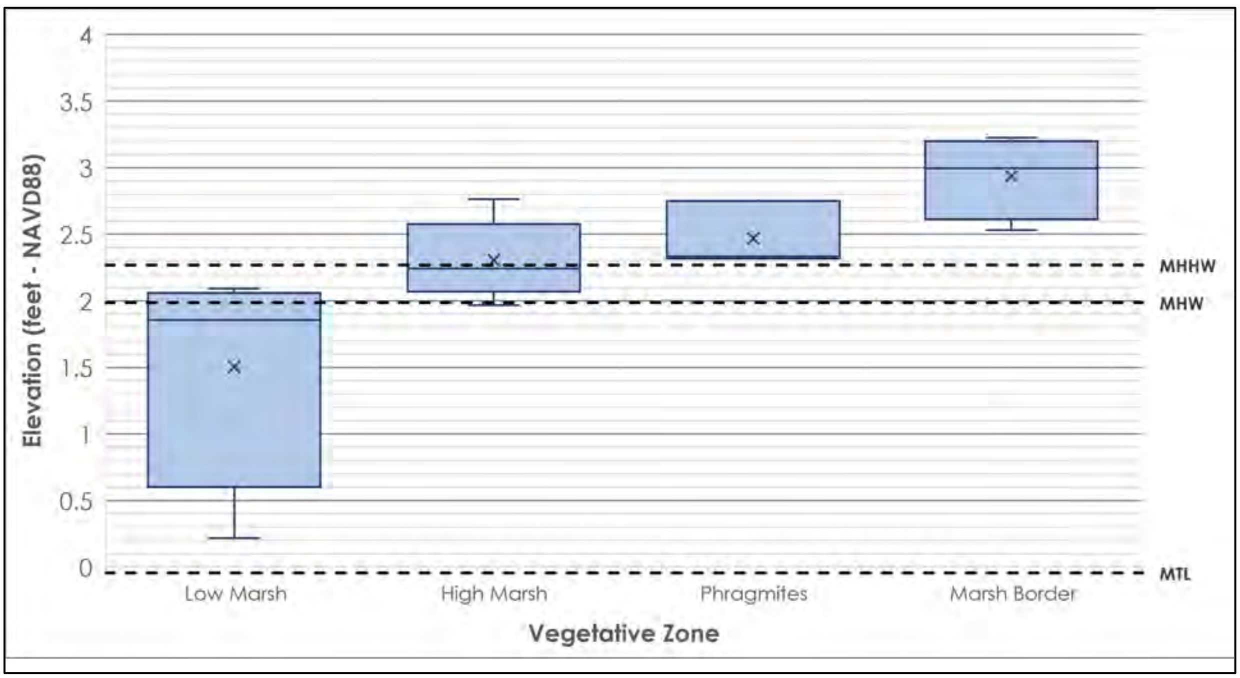


Figure 13. Flat Creek bio-benchmark elevation box plot.

Note: For each vegetation zone, the associated rectangular "box" contains all elevation values between the upper and lower quartiles. The horizontal line within each box indicates the median value, and the "X" indicates the mean value. The vertical lines outside the box indicate variability outside the upper and lower quartiles and extend to the maximum and minimum values.

2.4 HYDRODYNAMIC MODELING

To assess the potential impacts of the proposed conceptual design, it is important to understand flow dynamics and storm surge inundation for long-term scenarios. Thus, a site-specific hydrodynamic model was created to simulate tidal flood events of concern, and two Hydrologic Engineering Center's River Analysis System (HEC-RAS) 2D models were run to assess impacts of these flood events at both sites, namely the potential for hydraulic constriction at the Ocean Blvd. Bridge over Whale Creek and the Union Ave. Bridge over Flat Creek. Data gathered to simulate the terrain included combined recent LiDAR data obtained from NOAA National Centers for Environmental Information, and New Jersey Geographic Information Network. The model was validated using a historical flood event (Hurricane Sandy). Comparison of model results with historical results indicated inaccuracy of exact values but confirmed the ability of the model to evaluate relative water elevations for inputted events.

The model performed analyses for two types of events (the 10-year storm, and Sunny Day flooding events) based on a SLR scenario from the *New Jersey's Rising Seas and Changing Coastal Storms*[6] report by the 2019 Science and Technical Advisory Panel (STAP), which simulated current, 2050 (1.4 ft above MSL) and 2070 (2.2 ft above MSL) water levels. Results of the model concluded that neither bridge is overtopped by floodwaters or constricts flow under any scenario during the 10-year storm and Sunny Day flooding event. In the 10-year flood event, waters flow around the bridges and through approach roads. A more comprehensive analysis is needed to understand the timing (duration) and water surface elevation (depth) resulting from SLR; the next step is to refine the model to evaluate SLR impacts at a granular scale that may directly impact the health of the wetlands (e.g., lags in timing of tidal cycles, incomplete drainage).

A full summary of the hydrodynamic model development and assessment is presented in Appendix D.

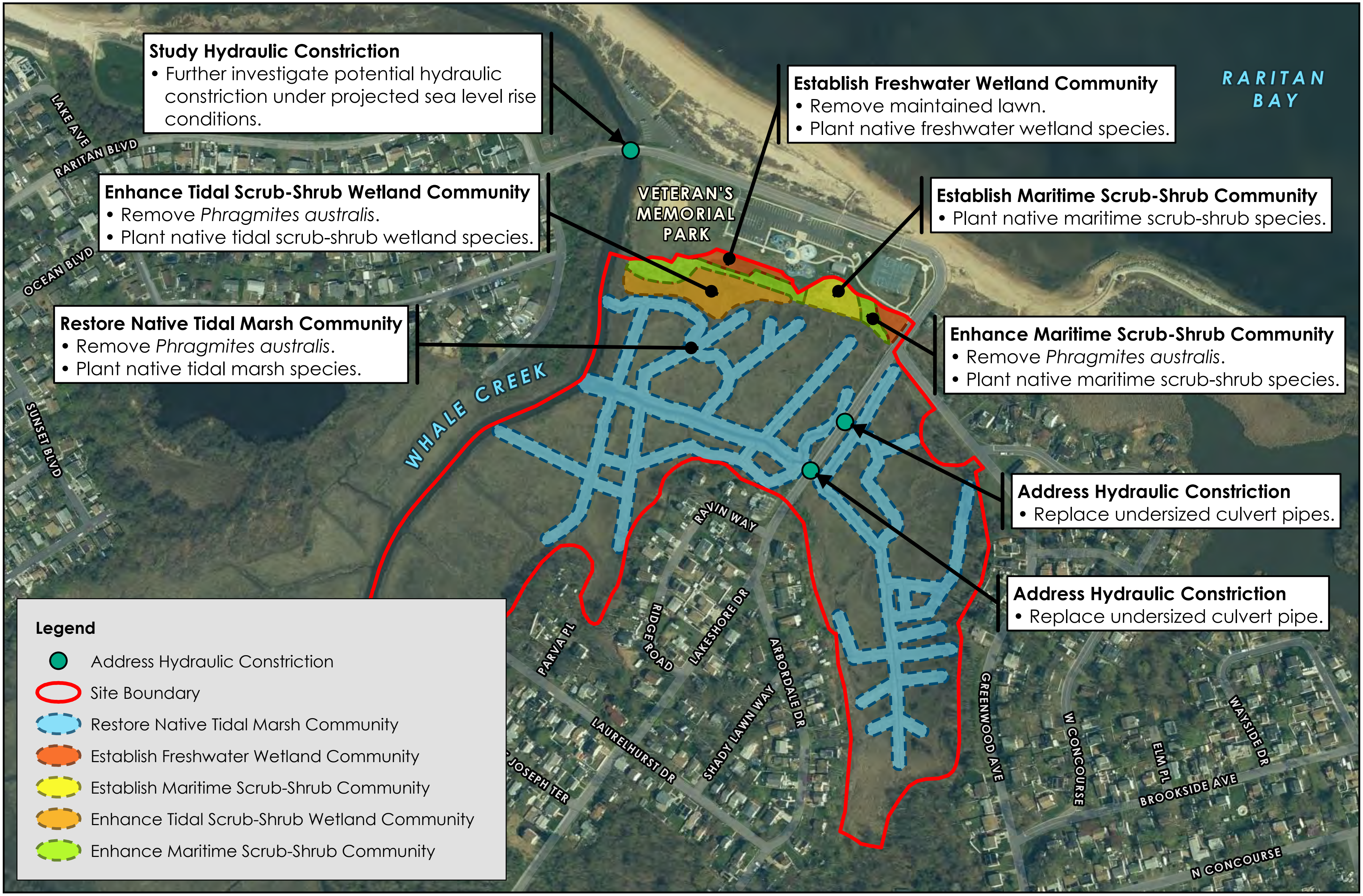
3 CONCEPTUAL DESIGNS

Conceptual designs for both study areas are provided in **Figure 14** and **Figure 15**. For the purposes of this report proposed design features fall into one of three categories: establishment, restoration, and enhancement. Establishment is defined as the creation of a new native plant community where it is largely absent or sparse; restoration is defined as the re-establishment of a native plant community where it is largely absent or sparse but is inferred to have thrived in the past; and enhancement is defined as the revitalization of the health of the existing native plant community.

The success of coastal wetland restoration projects is dependent on implementing a suite of strategies that support short-term and long-term ecological health and sustainability.

The strategies relevant to the goals of this project include removing invasive species, planting native species, enhancing hydrology, and fostering marsh migration. This section discusses each strategy in detail and proposes design features specific to each site based on existing site conditions. A discussion of regulatory permits that may be required for implementation of the conceptual designs is also included.

[6] Kopp, RE, CJ Andrews, A Broccoli, and 20 others. (2019). New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Rutgers, The State University of New Jersey. DOI: https://doi.org/10.7282/t3-eeqr-mq48



NOTES:
1. Concept design and site boundaries are approximate.
2. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 200 400 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

WHALE CREEK CONCEPTUAL DESIGN

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
ABERDEEN TOWNSHIP
MONMOUTH COUNTY, NEW JERSEY

PRINCETON HYDRO
SCIENCE DESIGN ENGINEERING
www.PrincetonHydro.com

NOTES:
1. Concept design and site boundaries are approximate.
2. Pump station and sluice gate proposed by the United States Army Corps of Engineers, "Hurricane Sandy Limited Reevaluation Report", June 2017.
3. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/
4. 2022 aerial imagery obtained from Nearmap.

0 200 400 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FLAT CREEK CONCEPTUAL DESIGN

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
UNION BEACH BOROUGH
MONMOUTH COUNTY, NEW JERSEY

PRINCETON HYDRO
SCIENCE DESIGN ENGINEERING
www.PrincetonHydro.com

3.1 SUITE OF STRATEGIES

3.1.1 REMOVE INVASIVE SPECIES

Coastal vegetation communities provide important services, such as stabilizing soil and reducing erosion, filtering and cycling nutrients, and intercepting and slowing the rate of floodwaters. *Phragmites australis* is a common invasive species in coastal vegetation communities. While *Phragmites australis* provides similar structural services as native coastal vegetation communities, it also tends to outcompete native communities and form dense monocultures. This interrupts the food web and overall ecological health of coastal systems, reducing their capacity to support native biodiversity. Ensuring a diverse suite of native ecological communities is critical to continued success of native wildlife populations which depend on those communities. Thus, design features were selected to target the removal of invasive species, primarily *Phragmites australis*. At both sites, *Phragmites australis* grows as a monoculture or poses a significant risk of becoming one.

Phragmites australis can be treated through a variety of methods that include mechanical and chemical controls[7]. Cutting and pulling to remove shoots is effective, but temporary and labor-intensive (especially when done by hand) and usually needs to be repeated annually. Spraying of herbicides such as glyphosate and imazapyr is effective in killing existing stands as well as targeting the rhizome layer to prevent future spreading. Herbicide should be applied properly to avoid harming native flora and fauna. In general, successful management plans often involve pairing multiple treatment methods, such as herbicide treatment followed by mechanical cutting and rolling over one or two growing seasons. Additionally, depending on the thickness of the existing *Phragmites australis* root mat and duff layer (decomposing organic matter), it may be necessary to remove these layers to re-establish tidal marsh platform elevations and to expose the native seed bank. Reintroducing tidal flow with salinities greater than 18 parts-per-thousand will also inhibit *Phragmites australis* establishment and cause existing stands to decline.

3.1.2 PLANT NATIVE SPECIES

Following the removal of invasive vegetation, native vegetation would be planted to encourage transition of site areas to healthier ecological communities. Tidal plant community composition would be determined by ground elevations and tidal hydrology (depth, duration, and frequency). Preliminary planting elevation ranges for a tidal marsh are shown in **Table 5**. These ranges are based on the local tidal datums and bio-benchmark survey results presented above. Refer to **Table 2** for a list of plant species specific to each plant community zone.

Table 5. Preliminary tidal marsh planting elevation ranges.

Plant Community Zone	Lower Elevation (Feet, NAVD88)	Upper Elevation (Feet, NAVD88)
Low Marsh	1.3	2.0
High Marsh	2.0	2.6
Scrub-Shrub	2.6	4.0

[7] Natural Resources Conservation Service (NRCS). *Common Reed – Phragmites australis*. Pest management – Invasive Plant Control. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1081651.pdf

3.1.3 ENHANCE HYDROLOGY

Tidal wetland plant communities are an expression of their hydrology – depth, duration, and frequency of tidal flooding, as discussed above. For example, low marsh plant communities are supported by semidiurnal tidal flooding and duration and depth of saturation. If there is a long-term disruption to the hydrology caused by land subsidence, sea level rise, or channel hydraulic constrictions, for example, plants will become stressed and degraded over time due to a change in inundation and salinity levels. This degradation can affect the function of wetlands and may result in the following impacts[8]:

- An increase in invasive species such as Phragmites australis;
- A decrease in the ability of tidal wetlands to remove pollutants;
- Loss of habitat and/or barriers to movement for marsh dependent species;
- A decrease in carbon storage potential and greater methane emissions; and
- A reduction in marsh elevations that can impact wave attenuation and shoreline stabilization.

The site observations and hydrological monitoring performed as part of this study do not suggest there are significant hydrologic impairments. In general, the marsh platform was drained during low tide and flooded during high tide which indicates the marsh platform is not sustaining prolonged periods of inundation that could be caused by sea level rise or subsidence. The health of the plants was also favorable and did not indicate signs of stress. However, the hydrological monitoring indicated a channel constriction at MW-3 at Whale Creek. The constriction is likely caused by undersized culverts that cross under Lakeshore Drive. As sea levels rise, this constriction will become more pronounced and will likely cause prolonged marsh inundation upstream of the culvert. A detailed hydrologic and hydraulic analysis is needed to further understand the impacts associated with this channel crossing; however, it is recommended that the hydrology should be enhanced by increasing the tidal flow exchange under Lakeshore Drive. Lastly, hydrological monitoring and analysis of current conditions, as well as hydrodynamic modeling under SLR projections, did not indicate hydraulic constriction at the creek inlets (i.e., bridges; Appendix D). However, as noted above, a more comprehensive analysis is needed to understand how SLR impacts will directly impact the health of the wetlands.

3.1.4 FOSTER MARSH MIGRATION

Tidal marshes are dynamic ecosystems that are located at the nexus of land and water, and are intrinsically dependent on sea levels. Given this dependency, they are one of the most vulnerable ecosystems to a changing climate and associated SLR. Marshes can adapt to a shift in sea level through a process known as marsh migration, which is the gradual inland shift of marshes into formerly dry and upland transition areas. An accelerating rise in sea level may cause marshes to migrate inland, as described, if suitable land is available, or not keep pace in gaining elevation, resulting in marsh loss, slumping, and conversion of marshland to mudflat or open water.

The project sites are surrounded by hard infrastructure, such as roads and residential development, which limits the potential for marsh migration. However, it's important to preserve and optimize the land where suitable areas exist. The slope of the adjacent undeveloped upland areas is one of the primary factors that determines the likelihood of marsh migration. Marshes are more likely to migrate on slopes of 1% or less. As such, in addition to preserving undeveloped land adjacent to marshes, recontouring the land to slopes of 1% will foster marsh migration as sea levels rise. This strategy would allow for the continued survival of the marsh, compensating for losses that may occur at lower elevations that transition to mud flat and open water due to SLR.

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[8] U.S. Environmental Protection Agency. (2020). Tidal Restriction Synthesis Review: An Analysis of U.S. Tidal Restrictions and Opportunities for their Avoidance and Removal. Washington D.C., Document No. EPA-842-R-20001.

3.2 PROPOSED DESIGN FEATURES

3.2.1 WHALE CREEK

Restoration strategies at the Whale Creek site would include removal of invasive *Phragmites australis*, planting of native species, and hydrologic enhancement. Two main areas were identified as restoration targets: the scrub-shrub upland area south of Veteran's Memorial Park, and the network of linear tidal marsh ditches on the northern section of the site. The scrub-shrub upland area was further divided into design feature sections based on existing conditions of invasive and native vegetation.

ESTABLISH MARITIME SCRUB-SHRUB COMMUNITY

The conceptual design proposes the planting of native maritime scrub-shrub species on the upland area south of Veteran's Memorial Park, where a native plant community is largely absent or sparse.

ESTABLISH FRESHWATER WETLAND COMMUNITY

Portions of maintained lawn adjacent to the marsh were observed to be visibly saturated, inhibiting lawn establishment. Taking into account this characteristic as well as its low-lying landscape position, we propose converting this portion of lawn into a freshwater wetland community with native plantings. It is not anticipated that earthwork is required to establish a freshwater wetland community.

RESTORE NATIVE TIDAL MARSH COMMUNITY

The conceptual design proposes the removal of *Phragmites australis* adjacent to the ditches within the marsh system. A native marsh community is largely absent or sparse but is assumed to have thrived here in the past prior to the ditching and placement of sidecast material. Native tidal marsh species would be planted in place of the removed vegetation.

ENHANCE TIDAL SCRUB-SHRUB WETLAND COMMUNITY

The conceptual design proposes the removal of *Phragmites australis* in the wetland area. While a healthy tidal scrub-shrub wetland community was identified on-site and was determined to be the dominant plant community in this location, areas of invasive *Phragmites australis* exist among the vegetation. Native tidal scrub-shrub wetland species would be planted in its place.

ENHANCE MARITIME SCRUB-SHRUB COMMUNITY

The conceptual design proposes the removal of *Phragmites australis* in the upland area. While a maritime scrub-shrub community was identified in this area, *Phragmites australis* was also prevalent. Removal of *Phragmites australis* and planting of native maritime scrub-shrub species would enhance the ecological function in this area.

STUDY/ADDRESS HYDRAULIC CONSTRICTION

The conceptual design proposes the replacement of undersized culvert pipes connecting the tidal channels under Lakeshore Drive. The hydrological analysis of MW-3, which is located upstream of the culverts (**Figure 3**), indicated hydraulic constriction at this location. Larger culvert pipes would accommodate flow and reduce potential obstructions from vegetation or other debris that impact their ability to drain the channel.

3.2.2 FLAT CREEK

Restoration strategies at the Flat Creek site would include removal of invasive *Phragmites australis*, recontouring the land to foster marsh migration, and planting of native species. Two main sections were identified as restoration targets: the sloped *Phragmites*-dominant upland area flanking Scholer Park and extending east to the main Flat Creek channel, and the network of linear tidal marsh ditches on the northern section of the site. We also recommend additional modeling to better understand the impact of the bridge on ecologically important tidal characteristics.

ESTABLISH NATIVE PLANT COMMUNITIES

The conceptual design proposes the removal of *Phragmites australis* and its root mat adjacent to Scholer Park. A native plant community is largely absent or sparse due to a monoculture of *Phragmites australis*. Grades would be recontoured to establish a maximum slope of 1% to foster marsh migration and one foot of sandy substrate would be placed before planting. The sandy substrate would support a maritime plant community while preventing establishment of *Phragmites australis* due to having a low organic matter and nutrient content. Native plant communities would be planted along the elevation gradient consistent with their hydrologic requirements.

RESTORE NATIVE TIDAL MARSH COMMUNITY

The conceptual design proposes the removal of *Phragmites australis* adjacent to the ditches within the marsh system. A native marsh community is largely absent or sparse but is assumed to have thrived here in the past prior to the ditching and placement of sidecast material. Native tidal marsh species would be planted in place of the removed vegetation.

STUDY HYDRAULIC CONSTRICTION

USACE's Hurricane Sandy Limited Reevaluation Report, published in 2017, planned to establish a sluice gate with box culvert, connected to a larger levee system, and a pump station at Flat Creek[9]. The conceptual design recommends that impacts associated with these features be evaluated to ensure that operations do not adversely impact the marsh ecosystem via changes to duration and depth of inundation.

As part of this study, the Project Team developed a hydraulic model to assess the potential for hydraulic constriction at the bridge over Flat Creek. While modeling indicates that the bridge is not a hydraulic constriction under high flows, further modeling for sea level rise scenarios is recommended for future phases of design. A more refined analysis will lead to an improved understanding of how SLR will affect tidal characteristics (e.g., duration, depth) that directly impact the ecology of the wetlands.

3.3 APPLICABLE REGULATORY PERMITS

A pre-application meeting with the New Jersey Department of Environmental Protection (NJDEP) was held on May 19, 2022 to discuss the conceptual designs and help identify local, state, and federal permits that are expected to be necessary to implement the designs (Appendix E). The following is a preliminary list of permits which are directly associated with the conceptual designs. More details, including other required permits and actions related to possible secondary impacts of the design features, as well as additional data needs, are noted

[9] U.S. Army Corps of Engineers. (2017). *Hurricane Sandy Limited Reevaluation Report for Coastal Storm Risk Management*. Union Beach, NJ: Retrieved from https://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-Jersey/Raritan-Bay-Sandy-Hook-Union-Beach/

in the post-meeting email from NJDEP (Appendix E). The information provided here is not comprehensive; additional discussions with NJDEP and USACE are recommended.

3.3.1 NJDEP DIVISION OF LAND RESOURCE PROTECTION

The NJDEP-LRP regulates the use and development of coastal resources via several coastal permits under the Wetlands Act of 1970, N.J.S.A. 13:9A-1 et seq. (coastal wetlands permits), the Coastal Area Facility Review Act, N.J.S.A. 13:19-1 et seq. (CAFRA permits), and the Waterfront Development Law, N.J.S.A. 12:5-3 (waterfront development permits). Coastal wetlands permits are required for all activities in coastal wetlands delineated and mapped pursuant to the Wetlands Act of 1970. As most of the proposed restoration areas are mapped coastal wetlands, Coastal Zone Management Permits, in compliance with the Coastal Zone Management Rules at N.J.A.C. 7:7, would be required. The Sites at Aberdeen and Union Beach are also within the CAFRA zone as established by the Coastal Area Facility Review Act of 1973 (CAFRA) and therefore within the bounds of CAFRA regulation. Finally, Waterfront Development permits are needed for activities within the regulated waterfront area, which includes "any tidal waterway of this State and all lands lying thereunder, up to and including the mean high-water line" (N.J.A.C. 7:7-2.4(a)2). More information will be needed to determine which specific permits will be necessary, including, analysis of where the mean-high-water and promulgated coastal wetlands lines are in relation to design features.

Implementation of design features in mapped freshwater wetlands areas would require additional permits. Habitat establishment, restoration, and enhancement design features are authorized by General Permit No. 16 (N.J.A.C. 7:7A-16) and culvert replacement at Whale Creek would require General Permit No. 10 for Minor Road Crossings (N.J.A.C. 7:7a-10A/B). The restoration efforts included in the conceptual design would also likely require a Flood Hazard Area Permit (N.J.A.C. 7:13).

Additional detail related to NJDEP-LRP permitting is available in Appendix E. Further discussions with NJDEP-LRP are recommended to determine which permits will be required.

3.3.2 NJDEP GREEN ACRES PROGRAM

While the proposed restoration efforts constitute a park improvement and are therefore consistent with Green Acres (GA) Regulations, more information is required to determine whether further GA review is necessary for construction. Because the sites are mostly located on parcels encumbered by GA, if there are easements or restrictions placed on property, the public should be provided with the opportunity to comment on the proposed changes (Change in Use process, N.J.A.C. 7:36-25.6).

3.3.3 NJDEP COMPLIANCE AND ENFORCEMENT

Phragmites australis treatment, which uses pesticides, would require an Aquatic Pesticide Permit.

3.3.4 U.S. ARMY CORPS OF ENGINEERS

Habitat establishment, restoration, and enhancement design features, which would promote a net increase in aquatic resource function, would require Nationwide Permit 27. Culvert replacement (classified as maintenance of a service structure) at Whale Creek would require Nationwide Permit 3. The Clean Water Act Section 401: Water Quality Certification would also be necessary for all actions (such as construction) that may result in any discharge into navigable waters.

3.3.5 SOIL EROSION AND SEDIMENT CONTROL AND NEW JERSEY POLLUTANT DISCHARGE ELIMINATION

New Jersey requires the management of soil erosion and stormwater from all non-agriculture, construction-based soil disturbances via the NJ Soil Erosion and Sediment Control Act (N.J.S.A. 4:24-39 et seq). The Act requires that all construction activities greater than 5,000 square feet, including earth moving for restoration purposes, include a plan to control erosion during and immediately after construction. For projects with more than 5,000 square feet of soil disturbances, approval from the Freehold Soil Conservation District (SCD) will be required.

In addition, a New Jersey Pollutant Discharge Elimination System (NJPDES) Request for Authorization to Discharge Stormwater During Construction Activities 5G3 Construction Activity Stormwater General Permit is required for projects that disturb one or more acres of land, including clearing, grading, and excavation. To apply for authorization under the construction general permit an SCD certification code is required as proof that there is an approved soil erosion and sediment control plan for the project.

3.3.6 MUNICIPAL PERMITS

Construction associated with the restoration of Whale Creek and Flat Creek may require municipal construction permits, depending on the specific activities proposed. For example, Union Beach requires a development permit "upon a change in the use of a structure or land; or prior to any use of or alteration of the natural condition of a parcel of land" (Union Beach, NJ Ordinances, § 13-3.6(a)1). The appropriate municipal offices (e.g., construction, land use planning) should be contacted to assure that the appropriate municipal permits are secured prior to initiating construction.

4 EVALUATION OF CONCEPTUAL DESIGNS

4.1 TECHNICAL ADVISORY COMMITTEE ENGAGEMENT

The Project Team met with the Technical Advisory Committee for the Monmouth County Bayshore Design Study on May 10, 2022. The goals of the meeting were to provide a project overview, present the conceptual designs, and solicit feedback on the designs. The meeting agenda, participants list, presentation slides, and meeting notes are included in Appendix F.

The TAC meeting included answering questions about various aspects of the conceptual designs and discussion of potential site constraints and project-specific concerns. The TAC offered suggestions for future stages of design and implementation such as incorporating interpretive signage, further coordination with the US Army Corps of Engineers at Flat Creek, and investigating opportunities for wetland mitigation credits at Flat Creek.

4.2 FURTHER RESEARCH

Additional data is necessary to advance the conceptual designs to bid-ready engineering plans. At a minimum, the following information is recommended to support engineering plan development and regulatory approvals.

- Topographic and utility survey – the survey should include site features, representative cross sections in the tidal channels, half-foot elevation contours site wide, and underground and overhead utilities.

- Wetland delineation – delineate tidal and freshwater wetlands in accordance with the *1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands*[10], and the *United States Army Corps of Engineers Regional Supplement to the Corps of Engineers Wetland Delineation Manual*[11].
- *Phragmites australis* vegetation survey – document the boundary and areal coverage of *Phragmites australis*, and the average thickness of the root mat and duff layer.
- Supplemental bio-benchmark data, if desired and dependent on the time lapse between this report and implementation.
- Hydrological monitoring, if desired and dependent on the time lapse between this report and implementation.
- Hydrologic and hydraulic modeling of proposed culvert replacements.

While not required, it would be beneficial to understand the long-term trajectory of the marsh with respect to physical processes that may act towards or against the goals of the resiliency effort. For example, steps could be taken to understand the rates of subsidence and/or accretion of the wetlands, so that this can be compared with SLR projections. This information can be used to further determine what magnitude of restoration work, such as vertical enhancement (e.g., thin layer sand placement), is necessary to support the sites' abilities to maintain the desired level of resiliency in the future.

4.3 COST ESTIMATE / RELATIVE COST COMPARISON

Table 6. Relative cost comparison for Whale Creek.
Costs of restoration activities are ranked by number of dollar signs from $ (least expensive) to $$$ (most expensive) *

Design Feature	Approximate Area (acres)	Action	Relative Cost Rating
Establish Maritime Scrub-Shrub Community	0.3	Plant native maritime scrub-shrub species.	$
Establish Freshwater Wetland Community	0.3	Remove maintained lawn. Plant native freshwater wetland species.	$
Restore Native Marsh Community	8.1	Remove *Phragmites australis.* Plant native tidal marsh species.	$$
Enhance Tidal Scrub-Shrub Wetland Community	0.8	Remove *Phragmites australis.* Plant native tidal scrub-shrub wetland species.	$$
Enhance Maritime Scrub-Shrub Community	0.6	Remove *Phragmites australis.* Plant native maritime scrub-shrub species.	$$
Study/Address Hydraulic Constriction	N/A	Investigate hydraulic constriction potential under SLR (Initial study completed).	---
		Replace undersized culvert pipes (x5).	$$$

*Relative costs are based on conceptual designs and may not reflect actual costs of design, construction, and permitting.

Table 7. Relative cost comparison for Flat Creek.
Costs of restoration activities are ranked by number of dollar signs from $ (least expensive) to $$$ (most expensive) *

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[10] U.S. Federal Interagency Committee for Wetland Delineation. (1989). Federal manual for identifying and delineating jurisdictional wetlands.
[11] U.S. Army Corps of Engineers. Regional Supplement to the Corps of Engineers Wetland Delineation Manual. Available: https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/

Design Feature	Approximate Area (acres)	Action	Relative Cost Rating
Establish Native Plant Communities	3.6	Remove *Phragmites australis* and root mat.	$$$
		Recontour grades to establish a gentle slope.	
		Place one foot of sandy substrate.	
		Plant native maritime scrub-shrub and tidal marsh species.	
Restore Native Marsh Community	3.7	Remove *Phragmites australis.*	$
		Plant native tidal marsh species.	
Study/Address Hydraulic Constriction	N/A	Investigate hydraulic constriction potential under SLR (Initial study completed).	---
		Evaluate USACE-proposed pump station and sluice gate.	---

*Relative costs are based on conceptual designs and may not reflect actual costs of design, construction, and permitting.

Note: Approximate Area is calculated from spaces highlighted in attached conceptual design maps, which provide a general layout of ecological communities relative to each other. Proposed actions, such as spot-removal and planting of species within these spaces, will likely impact a significantly lesser land area than provided.

4.4 EFFECTIVENESS IN FULFILLING PROJECT GOALS

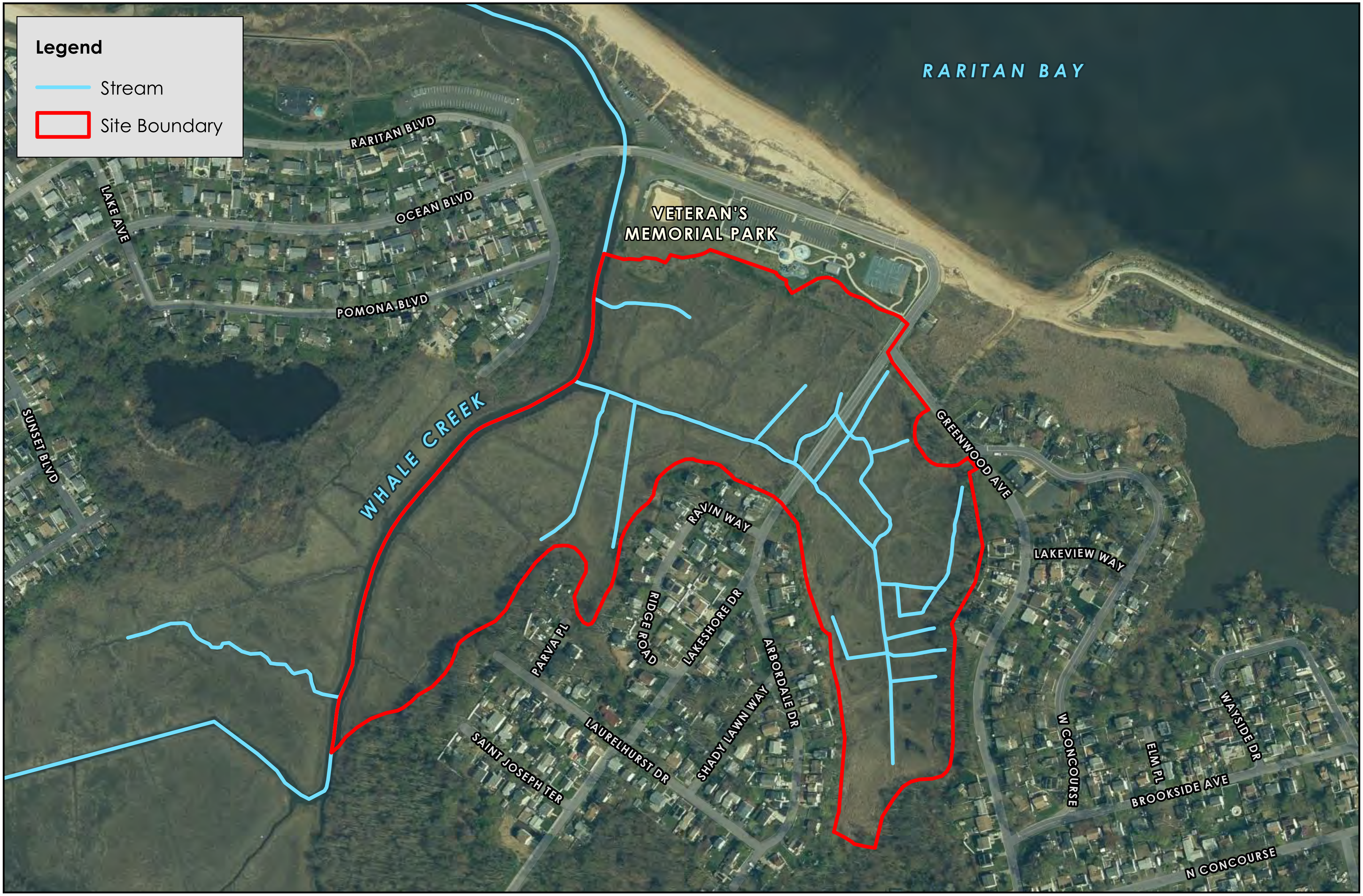
The goal of the Bayshore Coastal Resilience Design Study was to develop coastal resilience designs for the Whale Creek and Flat Creek sites that address both current and future coastal hazards of flooding, storm surge, and SLR. The presented conceptual designs are based on a thorough review of the data collected (site characterization and inventory of ecological communities, bio-benchmarks, hydrological monitoring, and hydrodynamic model findings for future conditions), and recognition of specific site constraints and data gaps. They are recommended as the best practical approach to fulfill the Study goals with respect to the site constraints discussed.

All conceptual designs were chosen with the intent of bringing the site habitats closer to a natural state of existence and production, with attention to conditions considered optimal and favorable for native vegetation communities and site hydrology. Implementation of these conceptual designs would enable Whale Creek and Flat Creek to naturally achieve a heightened level of resiliency against current flooding and storm surge, as well as allow the habitats to further develop their long-term resilience capability; in other words, the sites would be more equipped to adapt to future changes in storm and tidal patterns resulting from climate change and SLR.

As resources become more available and new information becomes known, approaches may need to be adapted to better ensure the long-term survival and resilience of Whale Creek and Flat Creek. The Bayshore Coastal Design Resilience Study offers a manageable starting point that can inform future projects.

APPENDIX A

SITE CHARACTERIZATION MAPS



File: P:\2022\Projects\2022001\GIS\APRX\All_Maps.aprx, 6/22/2022, Drawn by tsrinivasan, Copyright Princeton Hydro, LLC.

NOTES:
1. Site boundary is approximate.
2. Streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 200 400 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 1-A. WHALE CREEK AERIAL OVERVIEW MAP

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
ABERDEEN TOWNSHIP
MONMOUTH COUNTY, NEW JERSEY

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File: P:\2022\Projects\2022001\GIS\APRX\All_Maps.aprx, 9/23/2022, Drawn by tsrinivasan, Copyright Princeton Hydro, LLC.

NOTES:
1. Site boundary is approximate.
2. Streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/
4. 2022 aerial imagery obtained from Nearmap.

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 1-B. FLAT CREEK AERIAL OVERVIEW MAP

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
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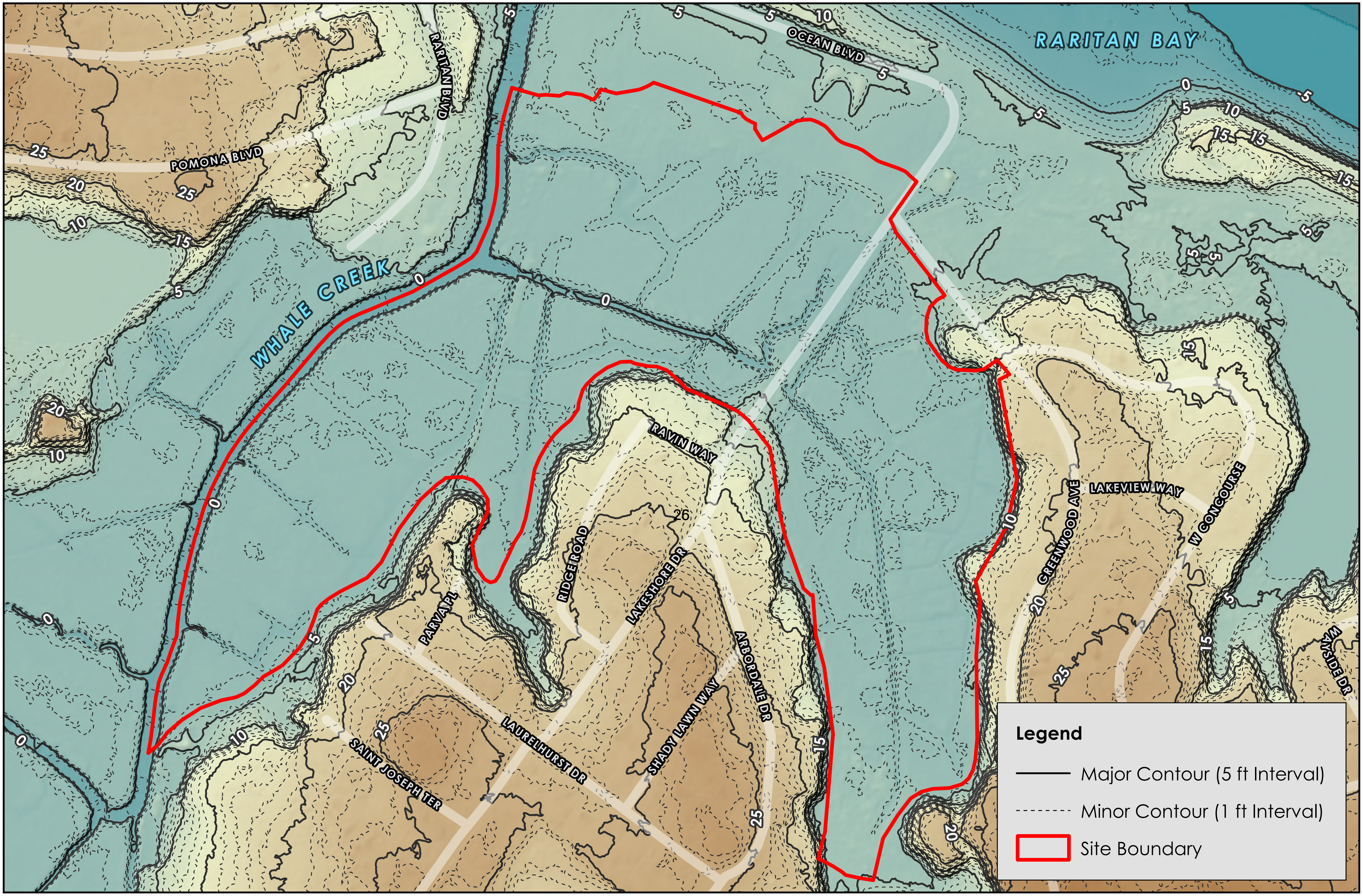

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NOTES:
1. Site boundary is approximate.
2. 2014 LiDAR data obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems.
3. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 2-A. WHALE CREEK TOPOGRAPHY MAP

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MONMOUTH COUNTY, NEW JERSEY

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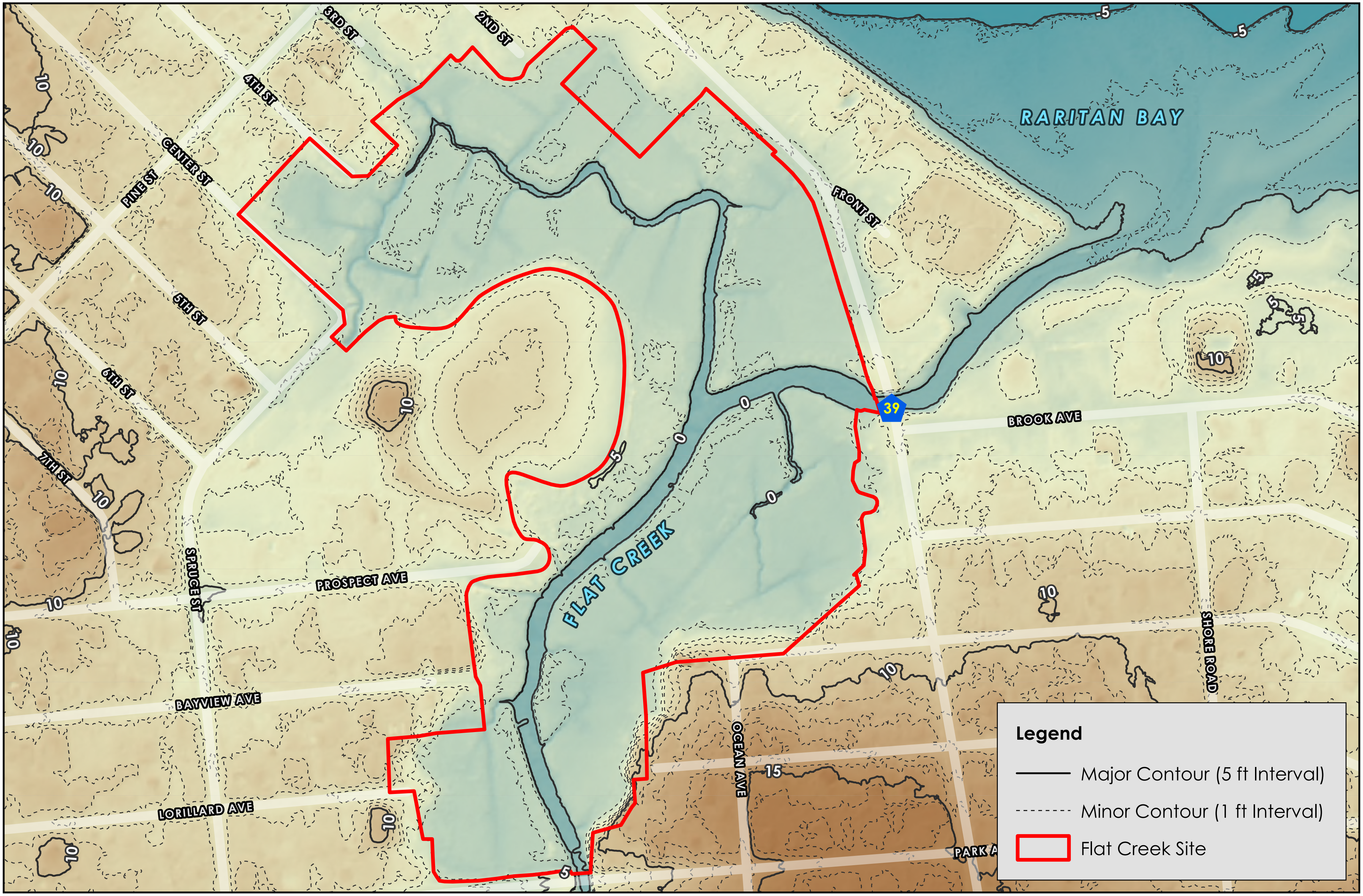

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NOTES:
1. Site boundary is approximate.
2. 2014 LiDAR data obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems.
3. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 2-B. FLAT CREEK TOPOGRAPHY MAP

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File: P:\2022\Projects\2022001\GIS\APRX\All_Maps.aprx, 6/22/2022, Drawn by tsrinivasan, Copyright Princeton Hydro, LLC.

NOTES
1. Site boundary is approximate.
2. 2015 land use/land cover obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 3-A. WHALE CREEK LAND USE/LAND COVER MAP

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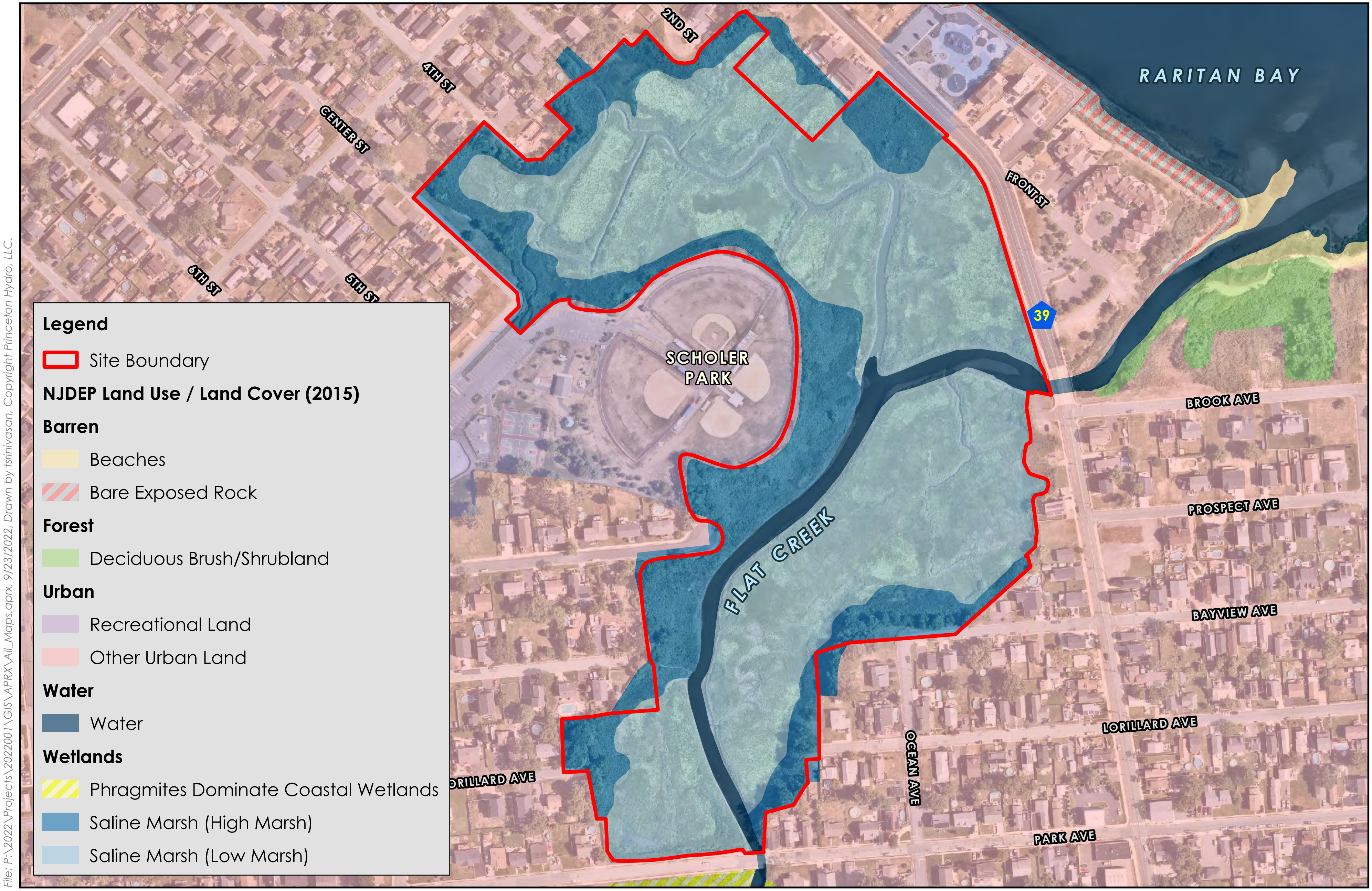

NOTES
1. Site boundary is approximate.
2. 2015 land use/land cover obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/
4. 2022 aerial imagery obtained from Nearmap.

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 3-B. FLAT CREEK LAND USE/LAND COVER MAP

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
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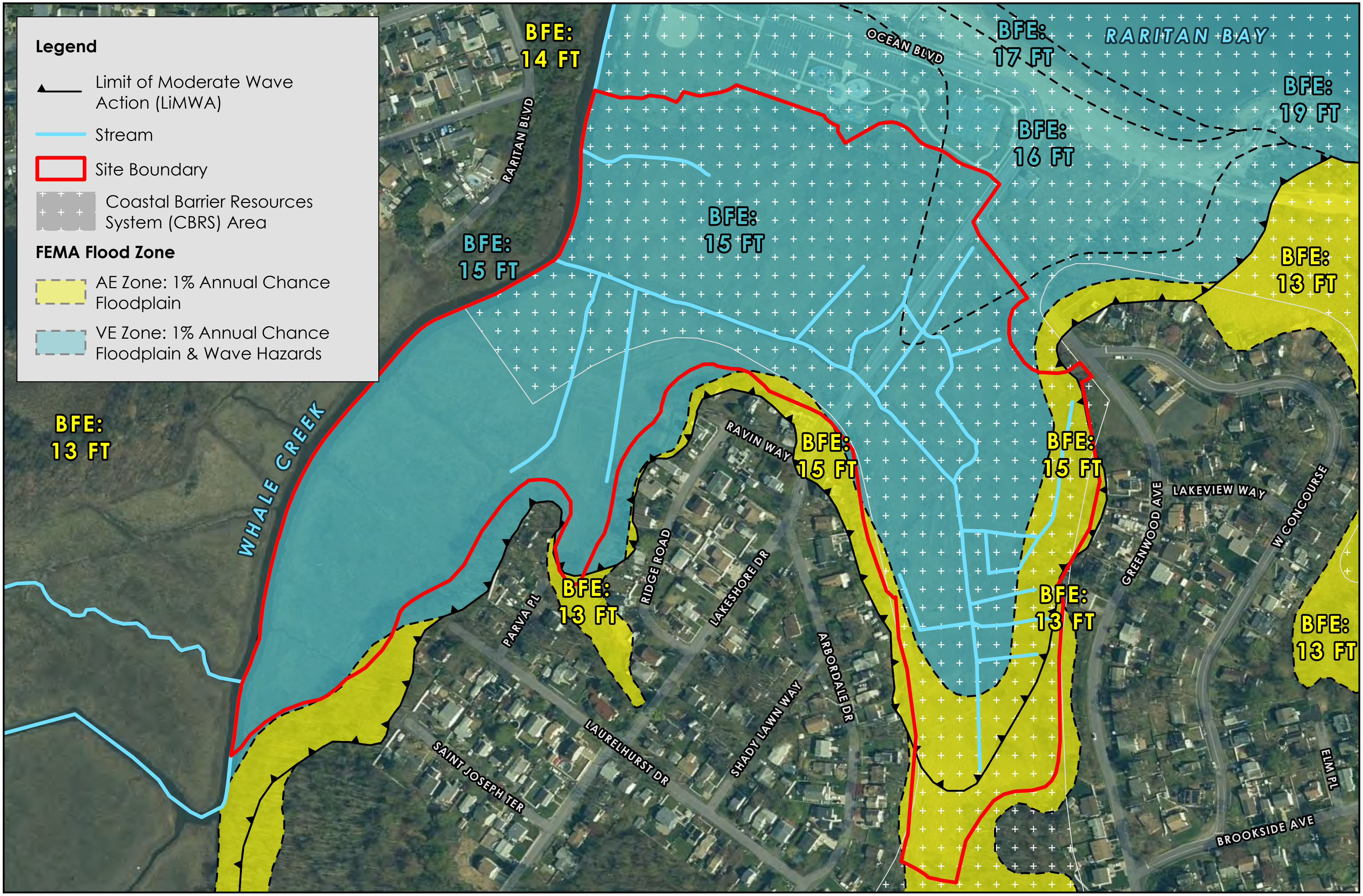

File: P:\2022\Projects\2022001\GIS\APRX\All_Maps.aprx, 6/22/2022, Drawn by tsrinivasan, Copyright Princeton Hydro, LLC.

NOTES:
1. Site boundary is approximate.
2. Preliminary flood insurance rate map for Monmouth County, issued January 30, 2015, and Middlesex County, issued January 31, 2014, obtained from FEMA Flood Map Service Center: https://msc.fema.gov/portal/
3. Streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
4. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 4-A. WHALE CREEK FEMA FLOODPLAIN MAP

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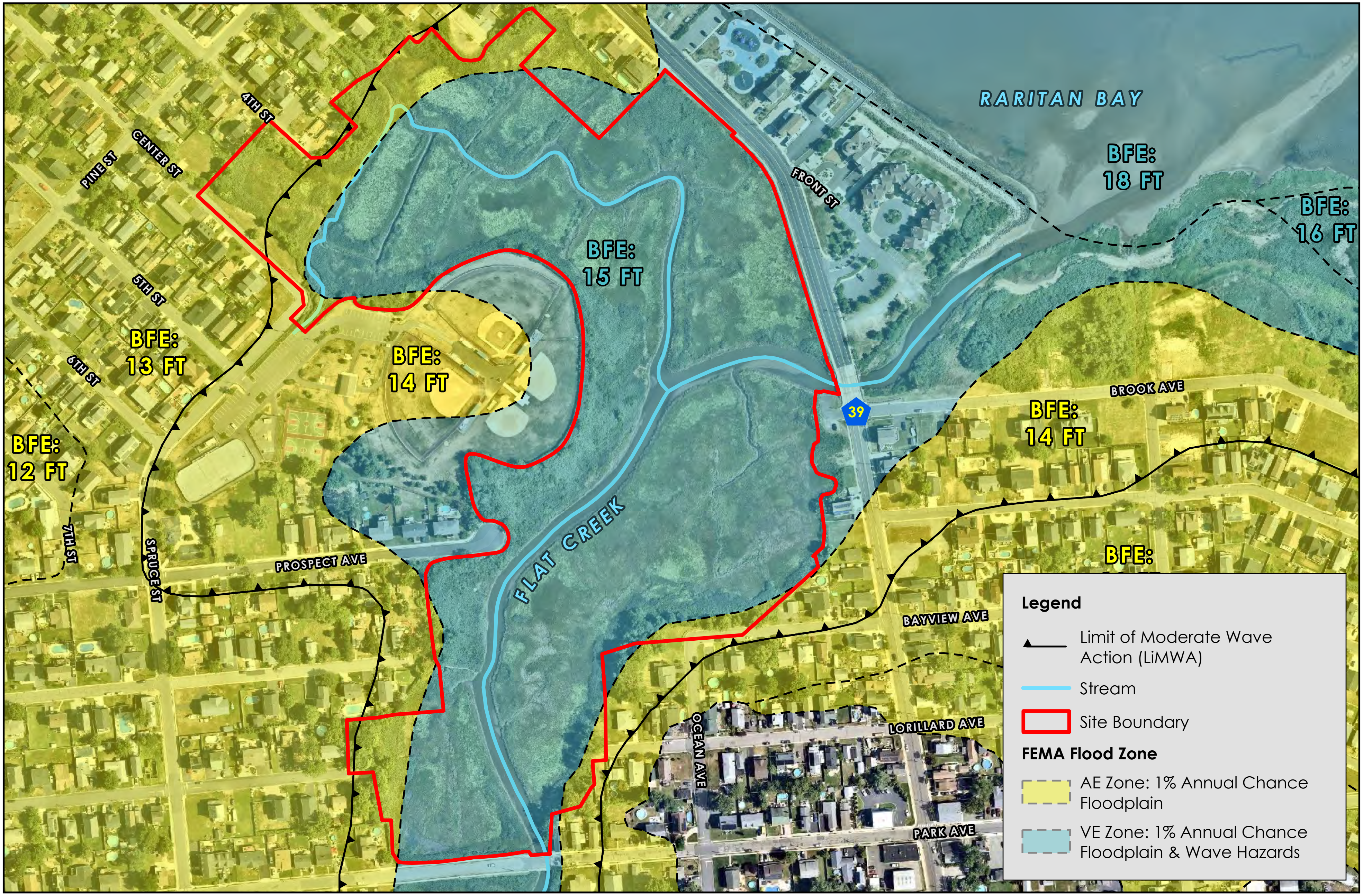

File: P:\2022\Projects\2022001\GIS\APRX\All_Maps.aprx, 9/23/2022, Drawn by tsrinivasan, Copyright Princeton Hydro, LLC.

NOTES:
1. Site boundary is approximate.
2. Preliminary flood insurance rate map for Monmouth County, issued January 30, 2015, and Middlesex County, issued January 31, 2014, obtained from FEMA Flood Map Service Center: https://msc.fema.gov/portal/
3. Streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
4. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/
5. 2022 aerial imagery obtained from Nearmap.

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 4-B. FLAT CREEK FEMA FLOODPLAIN MAP

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
UNION BEACH BOROUGH
MONMOUTH COUNTY, NEW JERSEY

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Threatened and Endangered Species Observations at Whale Creek

COMMON NAME	SCIENTIFIC NAME	SPECIES CLASS	OBSERVED HABITAT USE	SPECIES RANK	FEDERAL STATUS	NEW JERSEY STATUS
Glossy Ibis	Plegadis falcinellus	Aves	Foraging	2	NA	Special Concern
Little Blue Heron	Egretta caerulea	Aves	Foraging	2	NA	Special Concern
Snowy Egret	Egretta thula	Aves	Foraging	2	NA	Special Concern
American Kestrel	Falco sparverius	Aves	Non-breeding Sighting	3	NA	State Threatened
Black-crowned Night-heron	Nycticorax nycticorax	Aves	Foraging	3	NA	State Threatened
Osprey	Pandion haliaetus	Aves	Nest and Foraging	3	NA	State Threatened
Bald Eagle	Haliaeetus leucocephalus	Aves	Foraging	4	NA	State Endangered
Atlantic Loggerhead	Caretta caretta	Reptilia	Occupied Habitat	5	Federally Listed Threatened	State Endangered

NOTES:
1. Site boundary is approximate.
2. Landscape Project v3.3 data and streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 5-A. WHALE CREEK T&E SPECIES MAP

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
ABERDEEN TOWNSHIP
MONMOUTH COUNTY, NEW JERSEY

PRINCETON HYDRO
SCIENCE DESIGN ENGINEERING
www.PrincetonHydro.com

Threatened and Endangered Species Observations at Flat Creek

COMMON NAME	SCIENTIFIC NAME	SPECIES CLASS	OBSERVED HABITAT USE	SPECIES RANK	FEDERAL STATUS	NEW JERSEY STATUS
Glossy Ibis	Plegadis falcinellus	Aves	Foraging	2	NA	Special Concern
Snowy Egret	Egretta thula	Aves	Foraging	2	NA	Special Concern
Black-crowned Night-heron	Nycticorax nycticorax	Aves	Foraging	3	NA	State Threatened
Osprey	Pandion haliaetus	Aves	Nest and Foraging	3	NA	State Threatened
Yellow-crowned Night-heron	Nyctanassa violacea	Aves	Foraging	3	NA	State Threatened
Bald Eagle	Haliaeetus leucocephalus	Aves	Foraging	4	NA	State Endangered
Least Tern	Sternula antillarum	Aves	Foraging	4	NA	State Endangered
Atlantic Loggerhead	Caretta caretta	Reptilia	Occupied Habitat	5	Federally Listed Threatened	State Endangered

NOTES:
1. Site boundary is approximate.
2. Landscape Project v3.3 data and streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FIGURE 5-B. FLAT CREEK T&E SPECIES MAP

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
UNION BEACH BOROUGH
MONMOUTH COUNTY, NEW JERSEY

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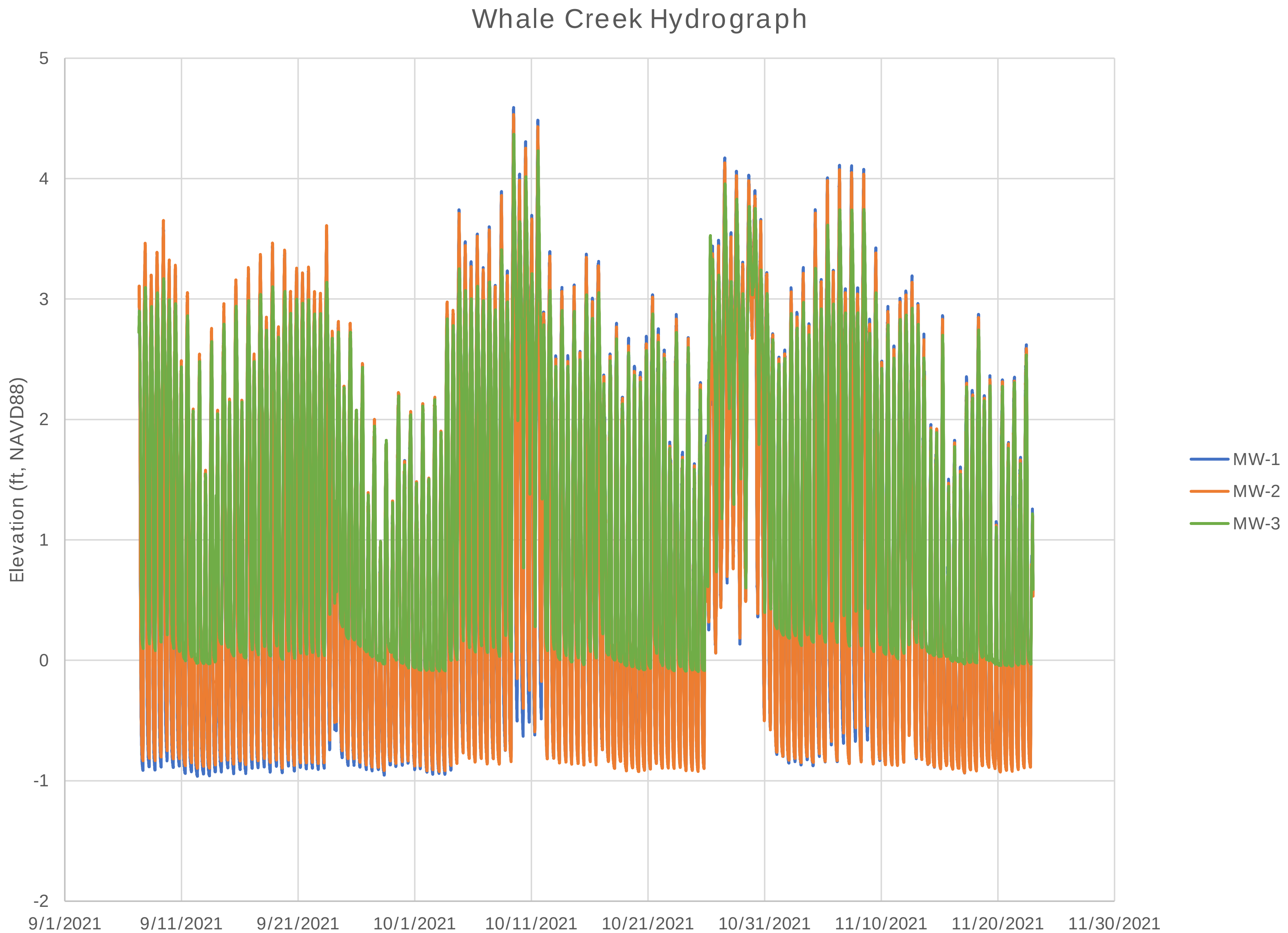
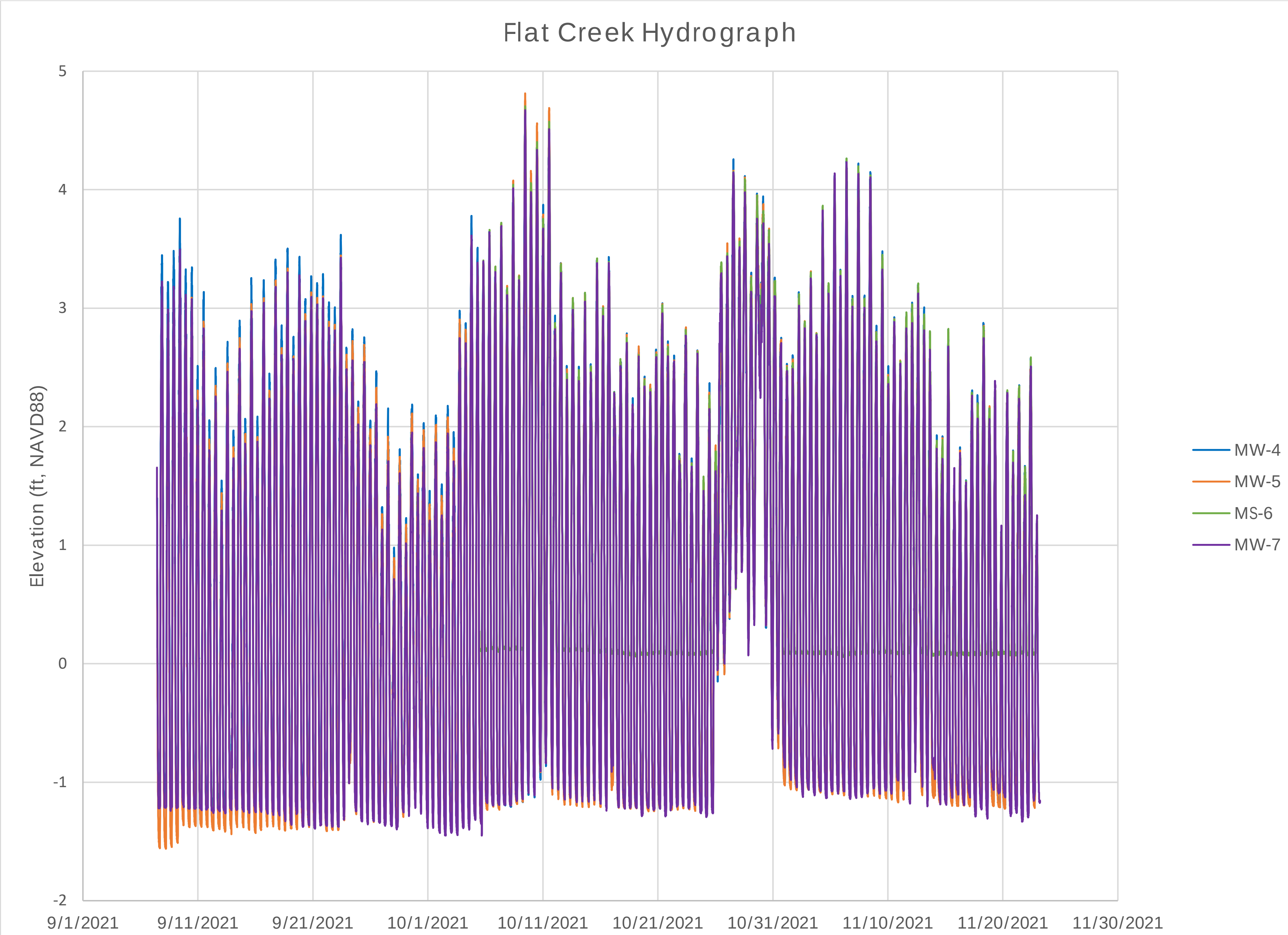
APPENDIX B

HYDROLOGIC DATA


Whale Creek Hydrograph
Elevation (ft, NAVD88)
5
4
3
2
1
0
-1
-2
9/1/2021
9/11/2021
9/21/2021
10/1/2021
10/11/2021
10/21/2021
10/31/2021
11/10/2021
11/20/2021
11/30/2021
MW-1
MW-2
MW-3



Flat Creek Hydrograph
Elevation (ft, NAVD88)
5
4
3
2
1
0
-1
-2
9/1/2021
9/11/2021
9/21/2021
10/1/2021
10/11/2021
10/21/2021
10/31/2021
11/10/2021
11/20/2021
11/30/2021
MW-4
MW-5
MS-6
MW-7

APPENDIX C

BIO-BENCHMARK DATA SUMMARY, LOCATION MAPS AND PHOTOGRAPHIC LOG

BB ID	Site Name	Elevation (ft - NAVD88)	Marsh Zone	Bio-Benchmark Description
1	Whale Creek	4.009	Marsh Border	*B. halimifolia*, *I. frutescens*, *J. gerardii* codominant. Sparse *M. pensylvanica*.
2	Whale Creek	3.272	Marsh Border	*I. frutescens* and *P. australis* codominant. Sparse *B. halimifolia*.
3	Whale Creek	1.711	Low Marsh	*S. alterniflora* (intermediate and tall) dominant, adjacent to narrow linear creek/ditch.
4	Whale Creek	2.685	High Marsh	*S. alterniflora* (short and intermediate). Sparse *P. australis* and *Salicornia sp*.
5	Whale Creek	2.743	High Marsh	*S. alterniflora* (short). Trace *D. spicata* and *P. australis*.
6	Whale Creek	2.732	High Marsh	*D. spicata* monoculture.
7	Whale Creek	2.274	High Marsh	*S. alterniflora* (intermediate) and *D. spicata* codominant. Trace *Salicornia sp*. and *P. australis*.
8	Whale Creek	2.589	Phragmites	*P. australis* dominant with sparse *D. spicata*.
9	Whale Creek	2.962	High Marsh	*I. frutescens* and *D. spicata* codominant.
10	Whale Creek	1.655	Low Marsh	*S. alterniflora* (tall) monoculture.
11	Whale Creek	2.698	High Marsh	*D. spicata* monoculture.
12	Whale Creek	1.347	Low Marsh	*S. alterniflora* (tall) monoculture. Top of bank along major tributary.
13	Whale Creek	2.766	High Marsh	*D. spicata* dominant. Trace *Salicornia sp*..
14	Whale Creek	2.185	Phragmites	*P. australis* monoculture.
15	Whale Creek	2.504	High Marsh	*D. spicata* monoculture.
16	Whale Creek	2.21	High Marsh	*S. patens* and *D. spicata* codominant.
17	Whale Creek	1.959	Low Marsh	*S. alterniflora* (tall) dominant. Sparse *Salicornia sp*..
18	Whale Creek	2.57	High Marsh	*D. spicata* dominant. Sparse *S. alterniflora* (short and intermediate), *S. patens*, *D. spicata*, and *Salicornia sp*..
19	Whale Creek	2.409	High Marsh	*D. spicata* dominant. Sparse *S. patens*.
20	Whale Creek	2.135	Low Marsh	*S. alterniflora* (intermediate and tall) monoculture.
21	Whale Creek	3.361	Marsh Border	*I. frutescens* and *B. halimifolia* codominant. Moderate *P. australis* and trace *Solidago sp*..
22	Whale Creek	1.589	Low Marsh	*S. alterniflora* (tall) monoculture.
23	Whale Creek	2.663	Marsh Border	*I. frutescens* dominant. Sparse *P. australis.*
24	Whale Creek	3.638	Marsh Border	*J. gerardii* dominant, *I. frutescens* secondary. Sparse *B. halimifolia* and trace *Solidago sp*..
25	Flat Creek	1.753	Low Marsh	*S. patens* dominant, *D. spicata* secondary. Trace Atriplex sp..
26	Flat Creek	1.955	Low Marsh	*S. alterniflora* (tall) monoculture.
27	Flat Creek	2.538	High Marsh	*S. alterniflora* (intermediate) dominant. Sparse *D. spicata*.
28	Flat Creek	2.622	High Marsh	*D. spicata* dominant. Trace *Salicornia sp*., *Asteraceae sp*. and *Atriplex sp*..
29	Flat Creek	2.615	High Marsh	*J. gerardii* dominant, *S. alterniflora* (intermediate) secondary. Sparse *D. spicata*. Trace *Salicornia sp*. and *Atriplex sp*..
30	Flat Creek	2.335	Phragmites	*P. australis* monoculture with shallow ditch and standing water.
31	Flat Creek	3.224	Marsh Border	*B. halimifolia* and *P. australis* codominant. Sparse *I. frutescens* and trace *Polygonum sp*..
32	Flat Creek	2.862	Marsh Border	*I. frutescens* and *D. spicata* codominant. Moderate *P. australis*.

BB ID	Site Name	Elevation (ft - NAVD88)	Marsh Zone	Bio-Benchmark Description
33	Flat Creek	2.506	High Marsh	*D. spicata* dominant. Trace *Salicornia sp*. and *Atriplex sp*..
34	Flat Creek	2.647	High Marsh	*S. patens* dominant. Moderate *D. spicata*.
35	Flat Creek	2.087	High Marsh	*S. alterniflora* (intermediate) dominant. Trace *P. australis* and *Atriplex sp*..
36	Flat Creek	2.373	High Marsh	*S. alterniflora* (short) dominant. Sparse *D. spicata*. Trace *P. australis* and *Salicornia sp*..
37	Flat Creek	-1.04	Mudflat	Intertidal mudflat along main creek, no vegetation.
39	Flat Creek	0.218	Low Marsh	*S. alterniflora* (intermediate and tall) monoculture. Mostly tall.
40	Flat Creek	2.53	Marsh Border	*P. australis* dominant. Moderate *I. frutescens*.
41	Flat Creek	4.789	Freshwater/ Brackish Adjacent Wetland	*T. angustifolia* dominant. Sparse *B. robustus*. Small Freshwater/brackish depression in the upland immediately adjacent to main tidal creek. Possibly in floodplain and affected by occasional storm surges based on presence of saltmarsh bulrush.
42	Flat Creek	2.243	High Marsh	*S. alterniflora* (intermediate) dominant. Trace *Atriplex sp*..
43	Flat Creek	2.317	Phragmites	*P. australis* patch surrounded by *S. alterniflora* matrix.
44	Flat Creek	2.264	High Marsh	*D. spicata* dominant. Sparse *S. patens* and trace *Salicornia sp*..
45	Flat Creek	1.985	High Marsh	*Salicornia Sp*. and *D. Spicata* codominant. Trace *S. alterniflora* (short).
46	Flat Creek	1.968	High Marsh	*S. alterniflora* (intermediate) monoculture.
47	Flat Creek	2.204	High Marsh	*S. alterniflora* (short) monoculture.
48	Flat Creek	2.051	High Marsh	Pooled water in high marsh at low tide. *D. spicata* dominant.
49	Flat Creek	2.763	High Marsh	*D. spicata* dominant. Sparse *P. australis* and *I. frutescens*. Trace Asteraceae sp. and Limonium sp..
50	Flat Creek	3.126	Marsh Border	*I. frutescens* dominant, *D. spicata* secondary. Sparse *P. australis*, *Asteraceae sp*., and *Limonium sp*..
51	Flat Creek	2.092	Low Marsh	*S. alterniflora* (intermediate and tall) monoculture.
52	Flat Creek	2.123	High Marsh	*D. spicata* dominant, sparse *Salicornia sp*..
53	Flat Creek	2.188	High Marsh	*S. patens* and *D. spicata* codominant.
54	Flat Creek	2.007	High Marsh	*S. alterniflora* (short and intermediate), *S. patens*, and *D. spicata* codominant.
55	Flat Creek	2.751	Phragmites	*P. australis* and *D. spicata* codominant. Trace *I. frutescens*, *Atriplex sp*., and *Asteraceae sp*..

NOTES:
1. Bio-benchmark locations collected by Princeton Hydro on October 4, 2021 using survey-grade GPS unit.
2. Streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. 2020 orthoimagery and roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/

0 100 200 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

WHALE CREEK BIO-BENCHMARK LOCATION MAP

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File: P:\2022\Projects\2022001\GIS\APRX\All_Maps.aprx, 9/23/2022, Drawn by tsrinivasan, Copyright Princeton Hydro, LLC.

NOTES:
1. Bio-benchmark locations collected by Princeton Hydro on October 5, 2021 using survey-grade GPS unit.
2. Streams obtained from NJDEP GIS website: www.state.nj.us/dep/gis/
3. Roads obtained from the NJ Geographic Information Network (NJGIN) Open Data portal: https://njgin.nj.gov/
4. 2022 aerial imagery obtained from Nearmap.

0 150 300 Feet

Map Projection: NAD 1983 2011 StatePlane New Jersey FIPS 2900 Ft US

FLAT CREEK BIO-BENCHMARK LOCATION MAP

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Photograph 1: Bio-benchmark No.: BB-1	**Photograph 2:** Bio-benchmark No.: BB-2
	

Photograph 3: Bio-benchmark No.: BB-3	**Photograph 4:** Bio-benchmark No.: BB-4
	

Photograph 5: Bio-benchmark No.: BB-5	**Photograph 6:** Bio-benchmark No.: BB-6
	

Photograph 7: Bio-benchmark No.: BB-7	**Photograph 8:** Bio-benchmark No.: BB-8
	

Photograph 9: Bio-benchmark No.: BB-9	**Photograph 10:** Bio-benchmark No.: BB-10
	

Photograph 11: Bio-benchmark No.: BB-11	**Photograph 12:** Bio-benchmark No.: BB-12
	

Photograph 13: Bio-benchmark No.: BB-13	**Photograph 14:** Bio-benchmark No.: BB-14
	

Photograph 15: Bio-benchmark No.: BB-15	**Photograph 16:** Bio-benchmark No.: BB-16
	

Photograph 17: Bio-benchmark No.: BB-17	**Photograph 18:** Bio-benchmark No.: BB-18
	

Photograph 19: Bio-benchmark No.: BB-19	**Photograph 20:** Bio-benchmark No.: BB-20
	

Photograph 21: Bio-benchmark No.: BB-21	**Photograph 22:** Bio-benchmark No.: BB-22
	

Photograph 23: Bio-benchmark No.: BB-23	**Photograph 24:** Bio-benchmark No.: BB-24
	

Photograph 25: Bio-benchmark No.: BB-25	**Photograph 26:** Bio-benchmark No.: BB-26
	

Photograph 27: Bio-benchmark No.: BB-27	**Photograph 28:** Bio-benchmark No.: BB-28
	

Photograph 29: Bio-benchmark No.: BB-29	**Photograph 30:** Bio-benchmark No.: BB-30
	

Photograph 31: Bio-benchmark No.: BB-31	**Photograph 32:** Bio-benchmark No.: BB-32
	

Photograph 33: Bio-benchmark No.: BB-33	**Photograph 34:** Bio-benchmark No.: BB-34
	

Photograph 35: Bio-benchmark No.: BB-35	**Photograph 36:** Bio-benchmark No.: BB-36
	

Photograph 37: Bio-benchmark No.: BB-37	**Photograph 39:** Bio-benchmark No.: BB-39
	

Photograph 40: Bio-benchmark No.: BB-40	**Photograph 41:** Bio-benchmark No.: BB-41
	

Photograph 42: Bio-benchmark No.: BB-42	Photograph 43: Bio-benchmark No.: BB-43
	

Photograph 44: Bio-benchmark No.: BB-44	**Photograph 45:** Bio-benchmark No.: BB-45
	

Photograph 46: Bio-benchmark No.: BB-46	**Photograph 47:** Bio-benchmark No.: BB-47
	

Photograph 48: Bio-benchmark No.: BB-48	**Photograph 49:** Bio-benchmark No.: BB-49
	

Photograph 50: Bio-benchmark No.: BB-50	**Photograph 51:** Bio-benchmark No.: BB-51
	

Photograph 52: Bio-benchmark No.: BB-52	**Photograph 53:** Bio-benchmark No.: BB-53
	

Photograph 54: Bio-benchmark No.: BB-54	**Photograph 55:** Bio-benchmark No.: BB-55
	

APPENDIX D

HYDRODYNAMIC MODELING MEMORANDA

Memorandum

TO:	Rebecca Lyne	**DATE:**	11/18/2021
FROM:	Xiaohai Liu, Arslaan Khalid, Muthu Narayanaswamy	**SUBJECT:**	Hydrodynamic Model Validation Memo

Introduction

The Raritan/Sandy Hook Bay Coastal Resilience Planning Study (Michael Baker International, 2019) identified 11 potential coastal resilience projects to improve the sustainability and resiliency of the Bayshore municipalities from current and future coastal hazards. Based on this study, Monmouth County proposes to advance design for two of these projects. The projects include the Whale Creek Restoration/Cliffwood Beach, Aberdeen, marsh restoration and maritime forest berm, and Flat Creek Restoration, Union Beach, marsh restoration. Project locations (site 1 and 3) are shown in the Figure 1. To aid the concept design, a hydrodynamic model was developed to assess the potential impacts of proposed projects in the study area. This memo provides a summary of the model development and validation.

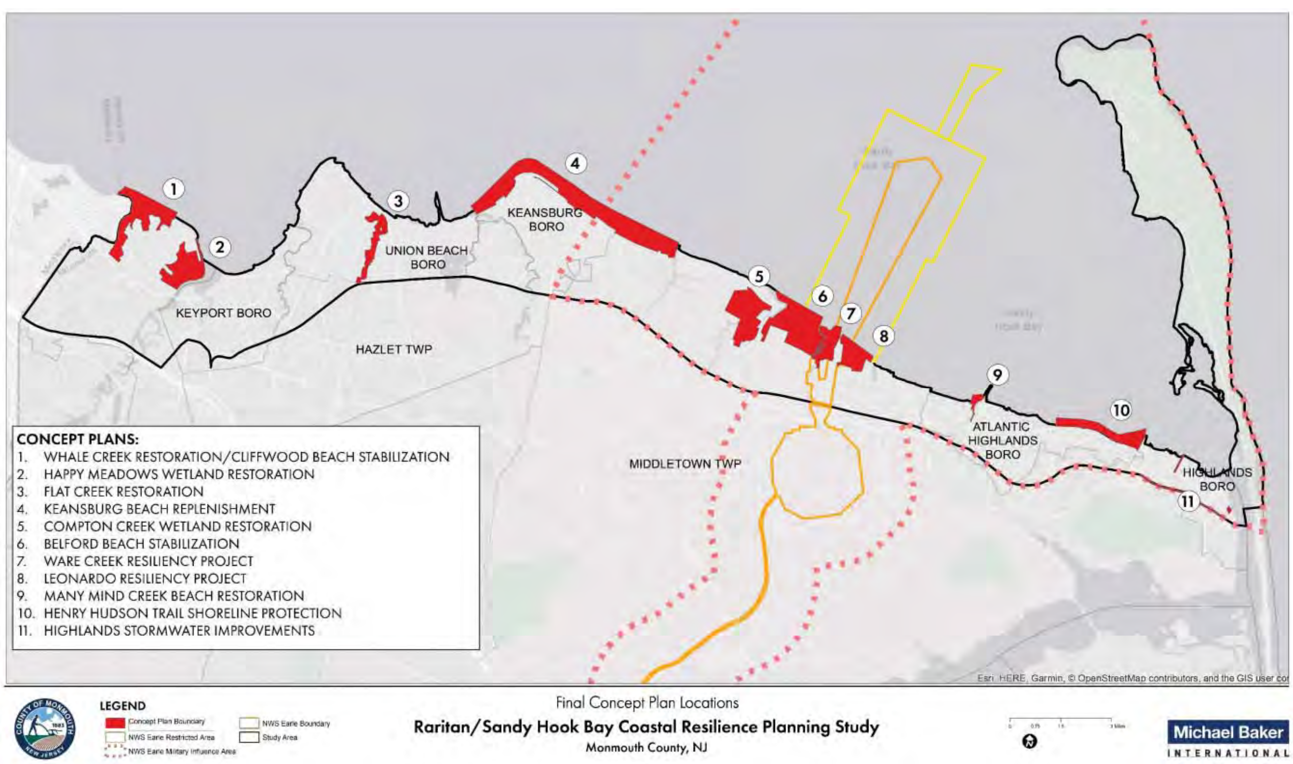


Figure1 Proposed project locations

Model Development

The modeling framework suited to the project area is ADCIRC, which has been used for the FEMA Region II Coastal Surge Study (FEMA (2014)) and the USACE North Atlantic Costal Comprehensive Study (NACCS (2015)).

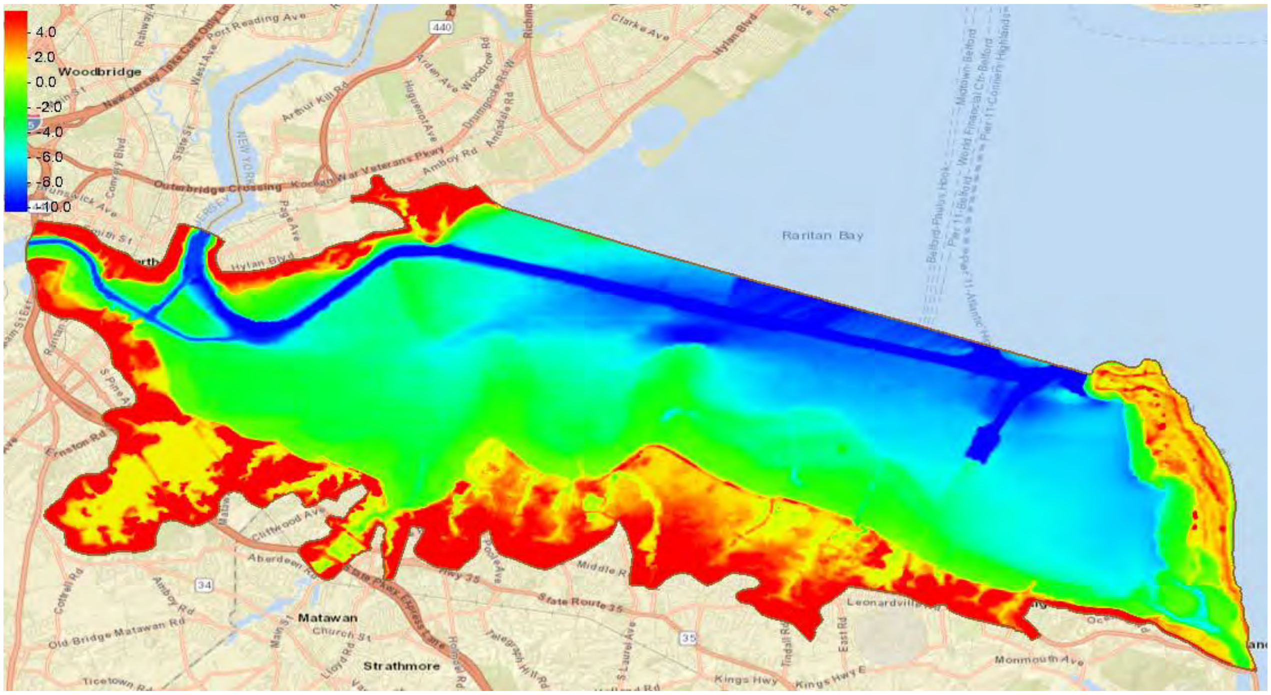


Figure 2 Bayshore coastal resilience study ADCIRC model mesh

As part of the data gathering effort, both the NACCS (2015) mesh and the FEMA (2014) mesh were obtained and reviewed. Based on the review, the NACCS (2015) mesh was determined to have good coverage of the overall study area. Consequently, The ADCIRC grid from the NACCS (2015) was used as a base to develop a high-resolution mesh for the study area. The mesh development and refinement were performed with Aquaveo SMS 13.1 software.

The domain of the Bayshore project model is within the Raritan/Sandy Hook Bay and bounded at the mouth of three main tributaries (Arthur Kill Strait, Raritan River and Highlands Reach) to the bays system (Figure 2). To accurately simulate the hydrodynamics in the project areas, the local mesh resolution was decreased from 60 meters to 20 meters to capture the details of important hydraulic features such as flow paths, ridges, etc. in the Digital Elevation Model (DEM). The model offshore boundary was placed within Raritan Bay to optimize computational time while maintaining model accuracy. The final mesh has 30,300 nodes and 59,500 elements. As part of the data collection efforts the most recent and best available topo-bathymetric data (2015 USGS CoNED topo-bathymetric Model) was obtained and used for this effort. To reflect the current existing conditions within the project area, this 2015 DEM was interpolated onto the refined mesh to ensure the hydrodynamic model reflects the most updated conditions of the project sites. Figure 3 and figure 4 show the improvement of Bayshore project mesh over NACCS (2015) mesh at the project areas.

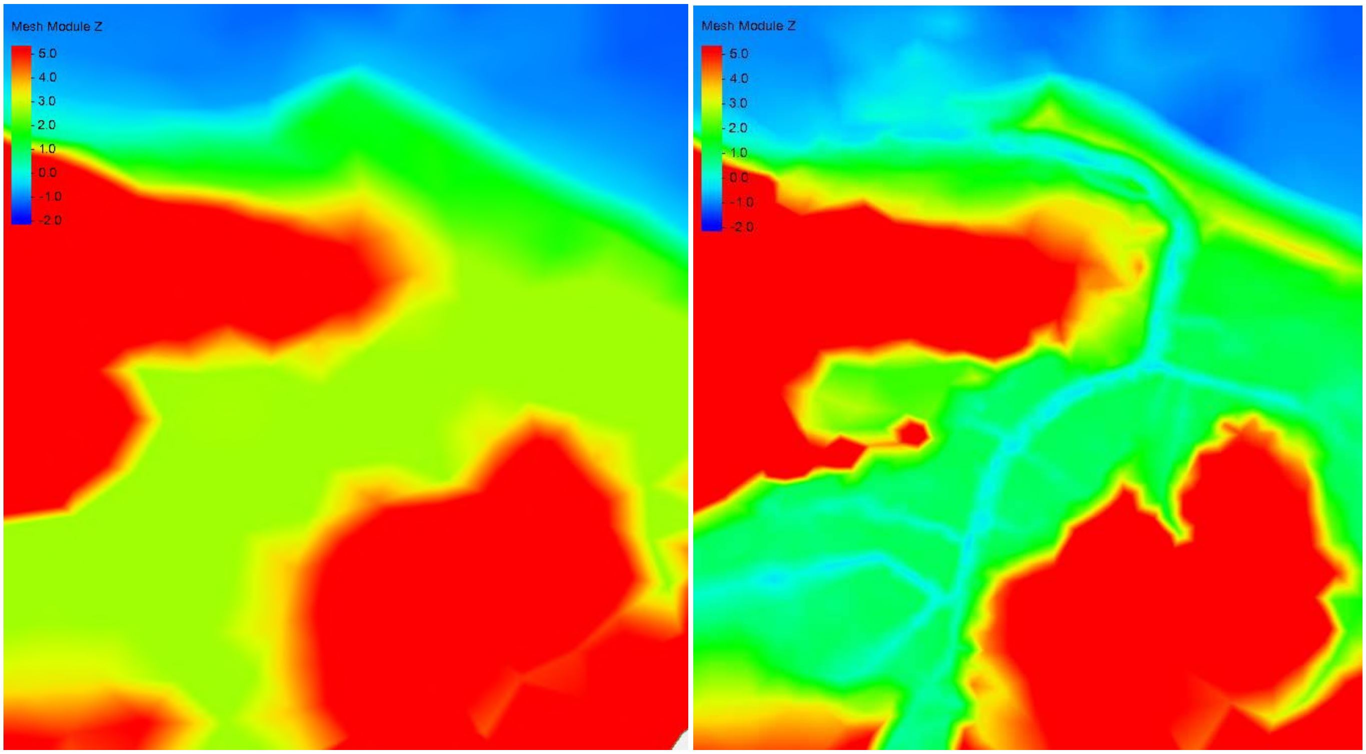


Figure 3 NACCS (2015) (left) and Bayshore project (right) mesh contours at Cliffwood Beach project area. The project model resolves Whale Creek that cannot be seen in the NACCS (2015) and FEMA (2014) models.

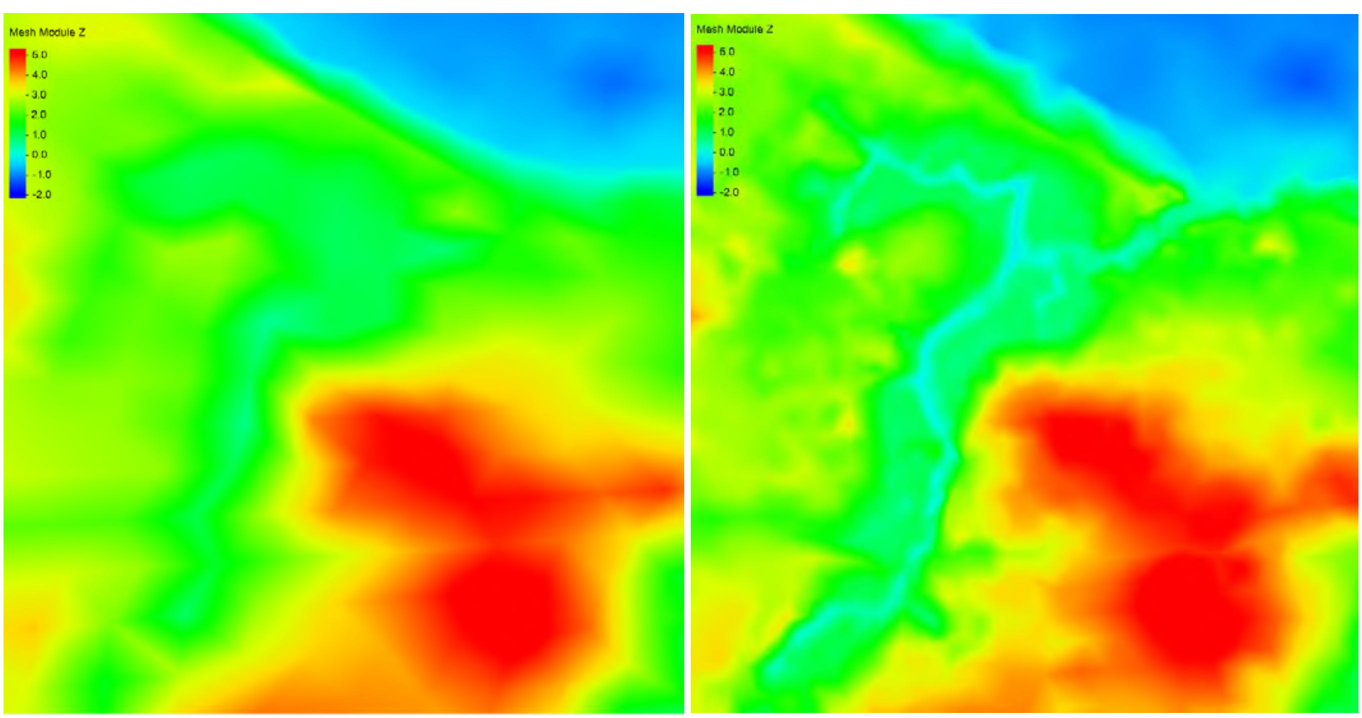


Figure 4 NACCS (2015) (left) and Bayshore project (right) mesh contour at Union Beach project area. The project model resolves Flat Creek that cannot be seen in the NACCS (2015) and FEMA (2014) models.

ADCIRC Nodal Attributes

The ADCIRC numerical model includes parameterization for land use features that influence the storm surge generation and the propagation of storm surges from the open coast to inland areas. The Manning's n, nodal attribute indicates the bottom roughness, which is used in ADCIRC computations to calculate the energy dissipation in the nearshore coastal areas. For this model validation, manning's N from the original NACCS study was used and interpolated to the refined mesh. Figure 5 below shows the spatial distribution of manning's N across the modeling domain.

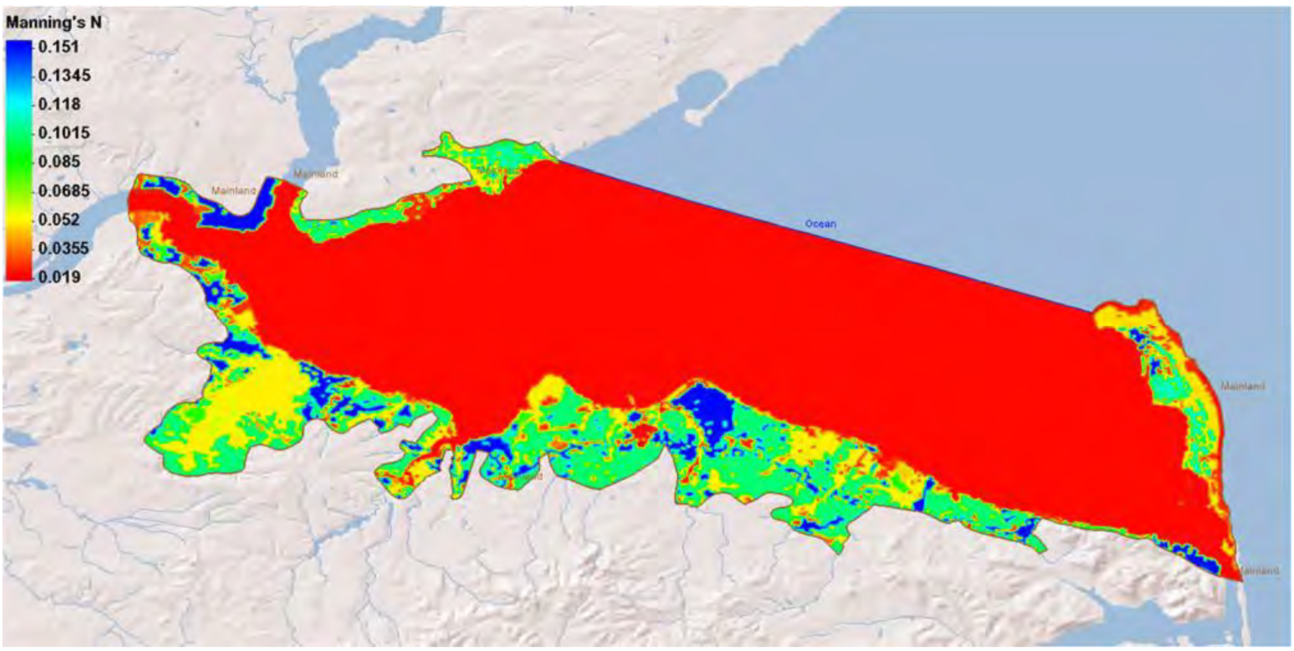


Figure 5 The Manning's n coefficient distribution within the project domain.

Water Level Model Validation

To accurately assess the potential impacts of proposed projects, the Bayshore project ADCIRC model need to be validated first.

In project area, we decided to further leverage NACCS (2015) synthetic storm data set that is composed of more than 1000 synthetic tropical and extra-tropical storms. These storms were chosen to be reflective of the coastal storm climatology including along the project locations. The results from the NACCS (2015) study were analyzed using the approach described below to identify a 100-year storm event in the project model domain. Based on the Annual Exceedance Probability (AEP) at save points proximal to the project areas from NACCS (2015), the 100-year water level was determined to be 3.65 m above Mean Sea Level (MSL) near the Cliffwood Beach project area, and 3.55 m MSL near Union Beach project area. Then the peak water level from all the synthetic tropical storms at these two save points were scanned to find a storm that generates surge close to the 100-year value at both locations. Peak water level from NACCS (2015) Storm ID 470 is 3.63 m MSL near Cliffwood Beach site and 3.58 m near Union Beach site. Consequently, this storm is selected as the representative 100-year event used for model water level validation. Water level time series from NACCS (2015) Storm ID 470 were extracted at a save point near the mesh ocean boundary and used as model open boundary condition. The water level time series were also extracted at two save points close to the project areas used as validation sites. The locations of these save points are shown in Figure 6 and AEP curve at the ocean boundary is shown in Figure 7.

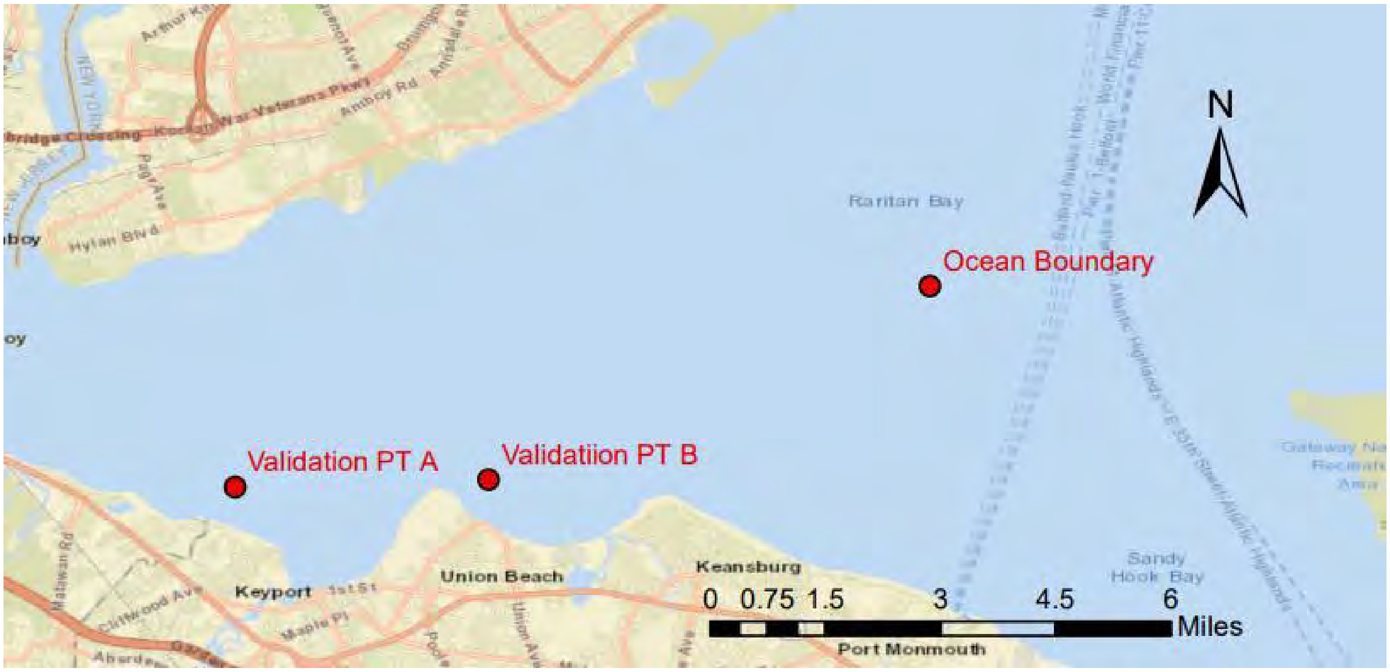


Figure 6 Locations of NACCS (2015) save points data used for Bayshore model validation

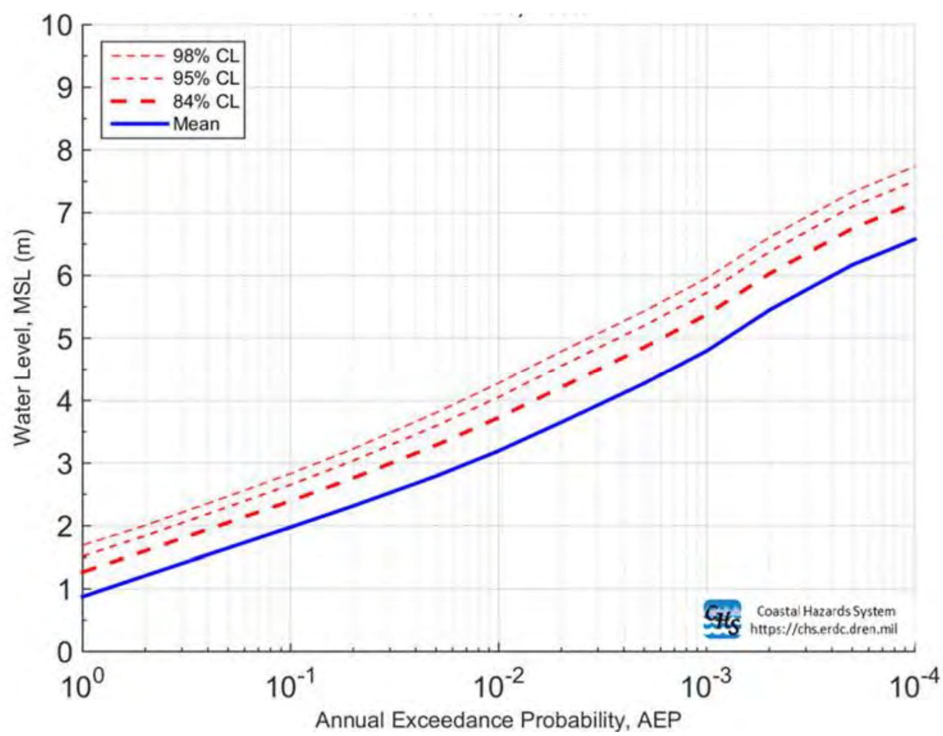
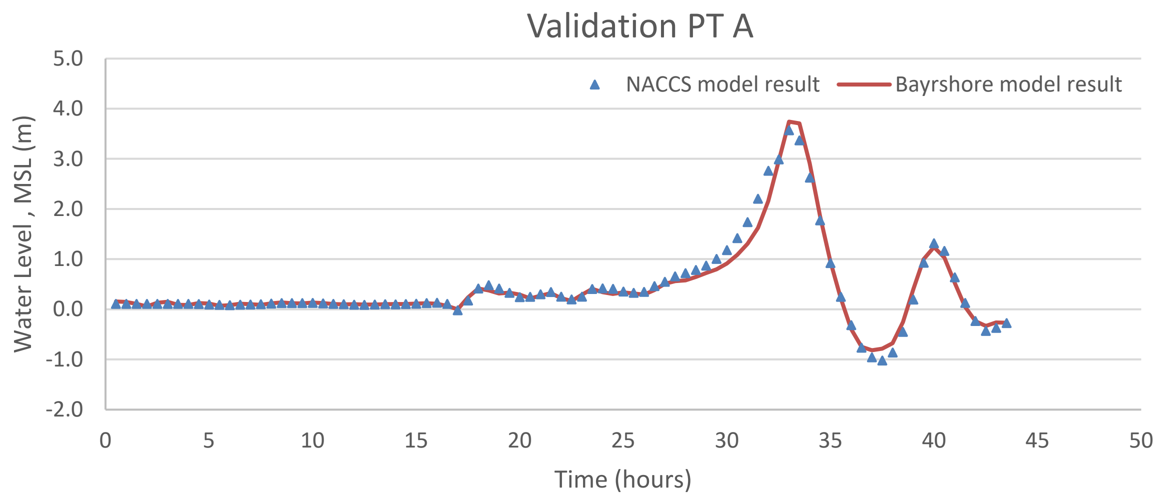


Figure 7 AEP curve at the ocean boundary location (NACCS (2015) Save Point 3866) depicted in Figure 6. This figure is obtained from the USACE Coastal Hazards System portal. MSL refers to water levels above Mean Sea Level.

The Bayshore model was run through Amazon Web Services (AWS) cloud with ADCIRC v51. Water levels time series from two validation points were compared with the results from NACCS (2015) at same locations. As shown in Figure 8, the Bayshore model was able to reproduce the storm surge and capture the peak values very well. The correlation coefficient is 0.99 at both point A and B, and the root mean square error (RMSE) is 0.14 m at point A and 0.09 m at point B.



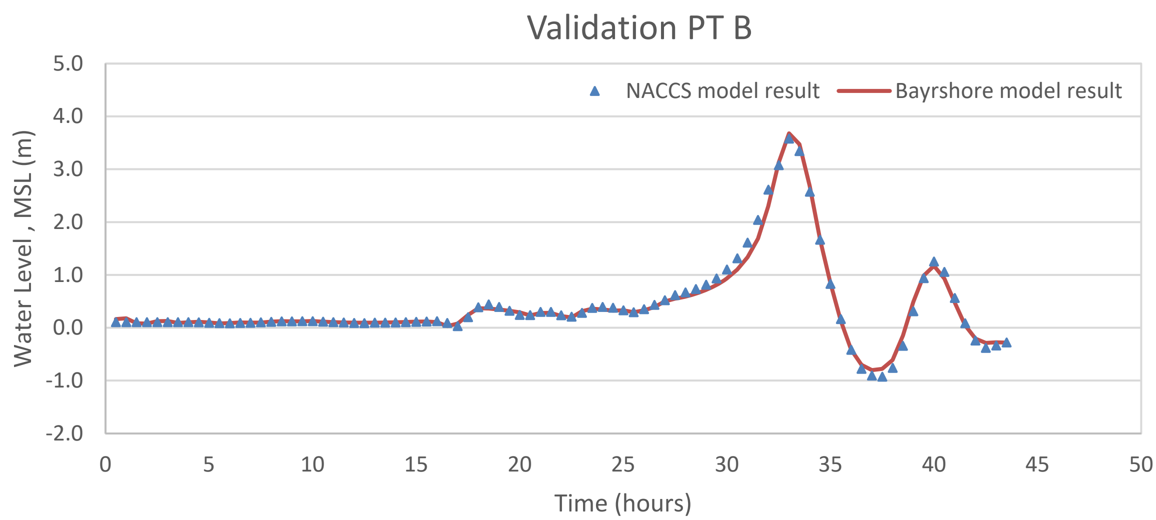


Figure 8 Comparison of modeled water levels with NACCS (2015) results from a validation point at Cliffwood beach (Top) and Union Beach (Bottom).

Wave Validation

This validated hydrodynamic model grid will be used to run the tightly coupled ADCIRC+SWAN modeling system used to compute both hydrodynamic and wave response to coastal storms. The NACCS (2015) study archives significant wave height and peak period at the save points. This information is insufficient to directly provide wave boundary conditions for the coupled ADCIRC+SWAN modeling system. Efforts are ongoing to obtain the required wave information from USACE-ERDC at the model boundary to validate the model performance of waves. In the event that we are unable to obtain the data from USACE-ERDC, assumptions on the spectral shape of the waves will be made to determine necessary boundary conditions for coupled ADCIRC+SWAN.

Conclusions

A site-specific high resolution hydrodynamic model has been developed and validated for the Cliffwood Beach and Union Beach project sites. This high-resolution model was built from the NACCS (2015) model developed by USACE to quantify coastal flood risk from Virginia to Maine. The latest available topo-bathymetric data was used for this model development. The model was validated using a 100-year synthetic storm from the NACCS (2015) storm database and excellent comparisons were obtained when the water levels from this site-specific model were compared with NACCS (2015) results at specific locations close to Clifford Beach and Union Beach. Data gathering efforts are ongoing to obtain the directional spectrum at the NACCS (2015) save points and validate the waves.

Memorandum

TO:	Princeton Hydro, LLC	**DATE:**	06/22/2022
FROM:	Niguo Ye, Michael Baker International, Inc	**SUBJECT:**	Hydraulic RAS2D Modeling Memo

Introduction

The Raritan/Sandy Hook Bay Coastal Resilience Planning Study (Michael Baker International, 2019) identified 11 potential coastal resilience projects to improve the sustainability and resiliency of the Bayshore municipalities from current and future coastal hazards. Based on this study, Monmouth County proposes to advance design for two of these projects. The projects include the Whale Creek Restoration/Cliffwood Beach Stabilization, Aberdeen Township, marsh restoration and maritime forest berm, and Flat Creek Restoration, Union Beach, marsh restoration. Project locations (site 1 and 3) are shown in Figure 1 below. To aid in the concept design, a coastal hydrodynamic model was developed to assess the potential impacts of proposed projects in the study area (Tech memo 20210930). Two hydraulic HEC-RAS 2D models were developed to assess the impact at Sites 1 and 3 separately, using the tidal flood event generated by the hydrodynamic model. This memo provides a summary of the HEC-RAS 2D model development and results.

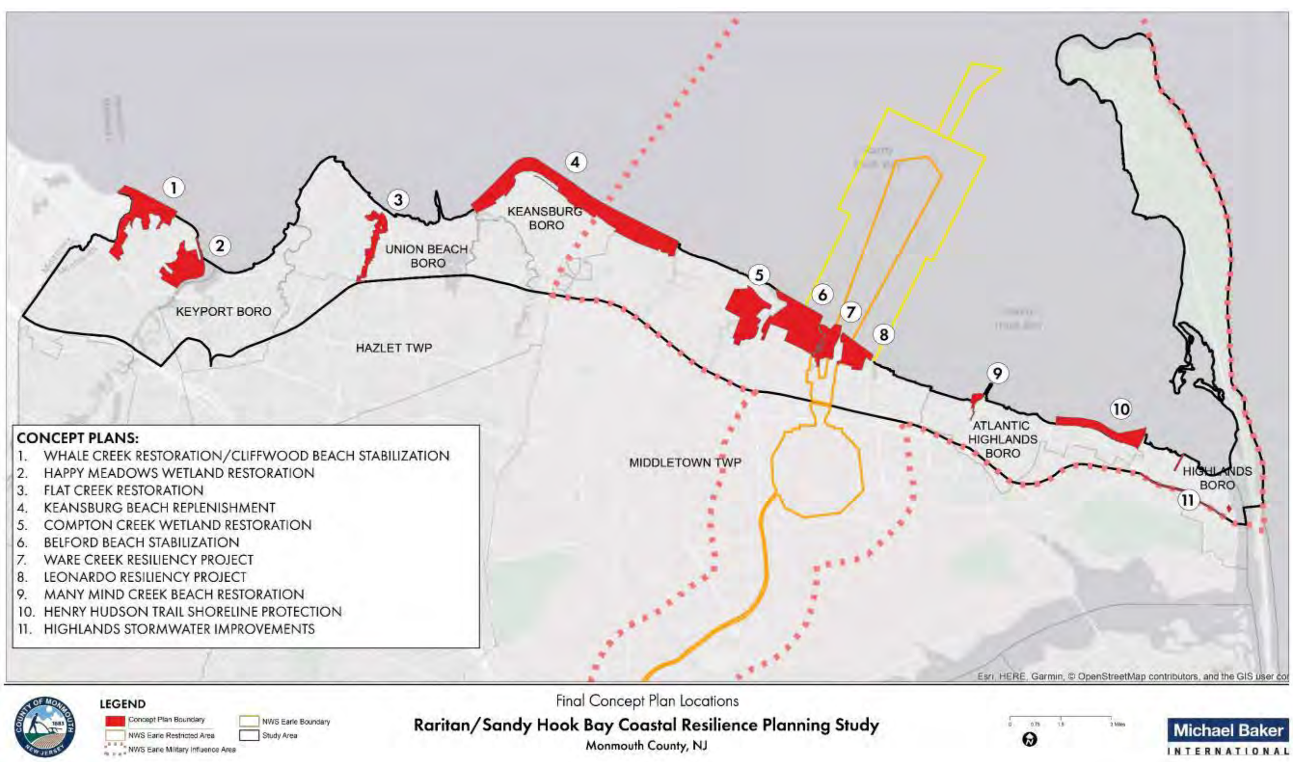


Figure1 Proposed project locations

Model Development

The River Analysis System HEC-RAS v 6.2.0 by U.S. Army Corps of Engineers was selected as the hydraulic modeling platform. Two project domains, one for each project bridge, were set up in the modeling, namely, the West model to evaluate the Ocean Blvd Bridge over Whale Creek, and the East model to evaluate the Union Ave Bridge over Flat Creek. The Bridge locations and the model extents are shown in Figure 2 below.

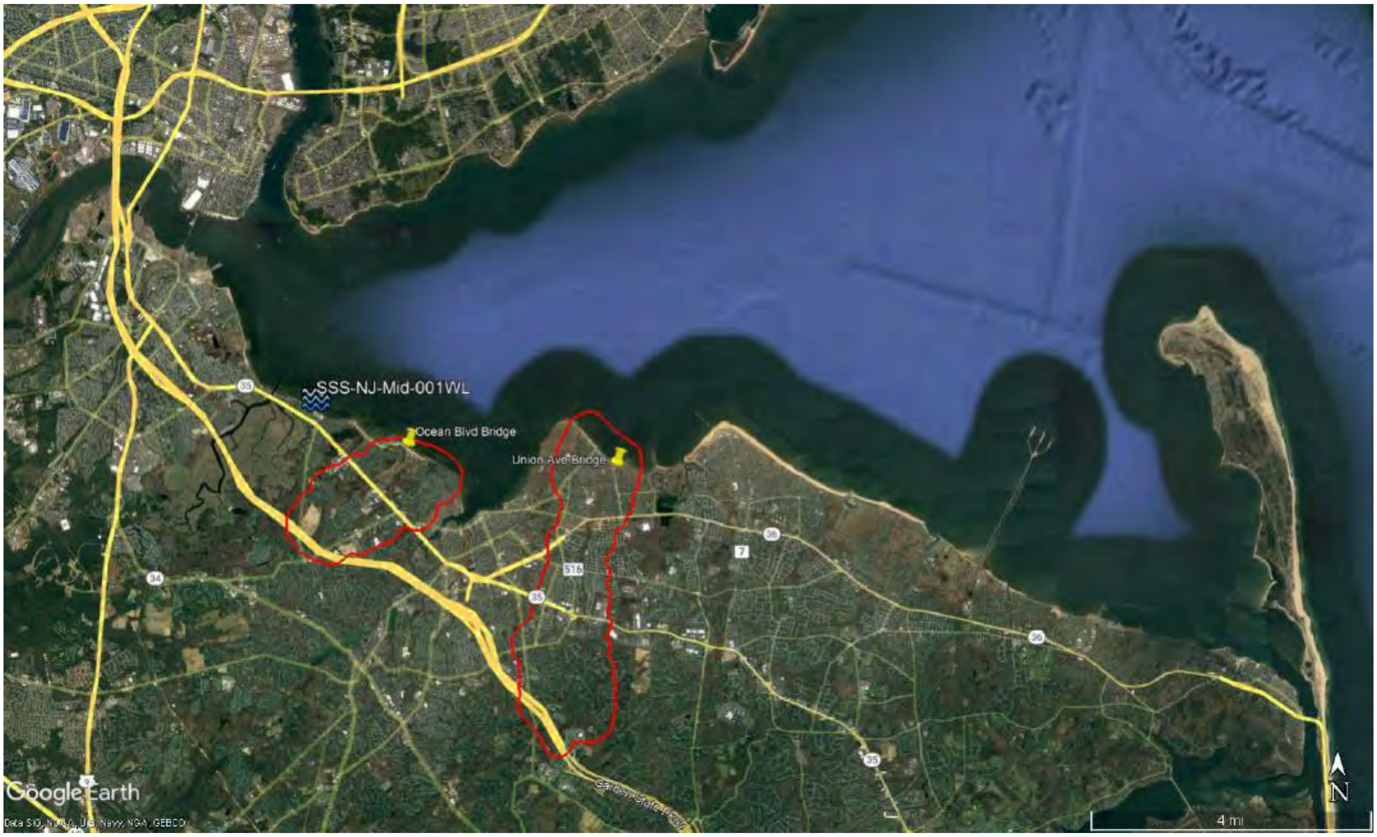


Figure 2 Bayshore Hydraulic modeling locations

As part of the data gathering effort, the latest digital elevation data (DEM) was obtained from NOAA National Centers for Environmental Information (NCEI). Specifically, the NCEI Continuously updated DEM (Continuously Updated Digital Elevation Model (CUDEM) - Ninth Arc-Second Resolution Bathymetric-Topographic Tiles files (noaa.gov)) combined with post-Sandy 2014 LiDAR data 1-meter digital elevation model (DEM) (https://njogis-newjersey.opendata.arcgis.com), was used to build up the terrain in the HEC-RAS model.

The drainage areas for Flat Creek and Whale Creek were used as the model domains. The 2D mesh computational grid was defined for both entire domains with typical grid size of 50 ft by 50 ft. Breaklines were digitized at channels and ridgelines where the direction or control of flow could be affected. Ridgelines include roads, levees, berms, shoreline cliffs and any other hydraulically significant barriers. Channel modifications were made to the terrain at location where bridges or culverts are present. This was done using the terrain modification function by lowering the ground elevation within the RAS-Mapper of HEC-RAS software with estimated span/width using Google Earth Imagery. The coastal terrain was lowered to provide enough storage of water volume for the East domain.

The land use layer was obtained from Land use/Land Cover 2012 update, 2015 Edition for subbasin Sandy Hook and Staten Island from the New Jersey Department of Environmental Protection (NJDEP). A Manning's n value for each land cover type was assigned using TR-55 roughness coefficient values in combination with roughness coefficients from Chow (1959) and Calenda, et al. (2005).

The project bridges were incorporated in the HEC-RAS 2D model as SA-2D connections with information obtained from the as-built plans. In addition, the channel bathymetry in vicinity of the project bridge were deepened in accordance with the as-built plans to provide adequate bridge opening for the flows.

Flood event

A historical flood event, Hurricane Sandy, was selected to validate the model. The flood water elevation at a location near the project sites was obtained from USGS Flood event viewer website (https://stn.wim.usgs.gov/fev/#Sandy). The location of the monitoring site SSS-NJ-Mid-001WL is shown in Figure 2 above. The recorded water elevation was processed to eliminate waves. The processed water surface elevation was then input as stage hydrograph in the HEC-RAS 2D model for validation. The maximum flood elevations at Hurricane Sandy high water marks near the Ocean Boulevard Bridge and the Union Ave Bridge are 13.0 ft and 13.4 ft; respectively, including waves (Figure 3 below). The model results show the maximum water elevation is approximately 8.0 ft at these locations. The validation shows the model can be used to evaluate relative water elevations for different events, but calibration is required for more accurate model simulation. For this study, calibration is not intended.

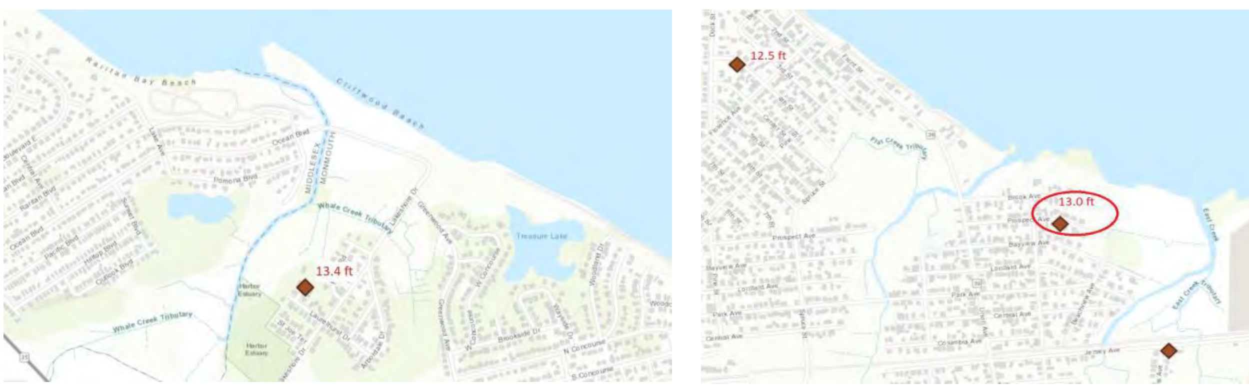


Figure 3 Hurricane Sandy High Water Marks (source: USGS Flood Event Viewer)

Model simulation was performed for the two design events provided by Michael Baker's coastal team: a) 10-year storm event and b) Sunny Day flooding event. The 10-year storm was based on the Annual Exceedance Probability (AEP) analysis result at closest point from the site-specific high resolution hydrodynamic model that was developed and validated from the North Atlantic Comprehensive Coast Study (2015). The Sunny Day flooding event was based on the tidal predication at the closest NOAA gage-Sandy Hook, NJ. A typical spring tide period from June 2021 was selected. A detailed methodology outlining how these coastal storm event hydrographs were generated is provided in the technical memo "Model Validation Memo (20210930)". The coastal stage hydrograph was input into the model as a boundary condition to simulate the tidal flood events.

The 10-year storm event was run for the period of approximately 113 hours from July 11 to July 15. The Sunny Day flooding event was run for the period of approximately 80 hours. The computational interval was set to be 15 seconds with adaptive time step based on courant number.

Sea Level Rise scenarios were evaluated based on *the New Jersey's Rising Seas and Changing Coastal Storm, Report of the 2019* Science and Technical Advisory Panel (STAP), (https://climatechange.rutgers.edu/images/STAP_FINAL_FINAL_12-4-19.pdf). The 50% chance and moderate values for year 2050 (1.4 ft) and year 2070 (2.2 ft) from the STAP report were adopted and applied to the 10-year storm and Sunny Day flooding event stage hydrograph.

All six flooding events: 10-year storm event (current), 10-year storm (2050), 10-year storm (2070), Sunny Day flooding (current), Sunny Day flooding (2050), and Sunny Day flooding (2070) were run and evaluated for both models.

Model result

The model results indicate that during the 10-year events (current, 2050, and 2070) the Ocean Boulevard Bridge is not overtopped during any event. Although the bridge is not overtopped, the approach roadway is overtopped by the flood at the Ocean Boulevard Bridge for all events. The Union Ave bridge is not overtopped for the current 10-year event but is overtopped for both the 10-year 2050 and 2070 events. The maximum flood elevations are very similar to the peak elevation of the coastal stage hydrograph.

Results for the Sunny Day flooding events (current, 2050, and 2070) indicate that there is no overtopping at either bridge structure or the approach roadways; the maximum flood elevation is comparable to the peak elevation of the coastal stage hydrograph. The model results show the maximum flood elevation increases of these Sea level rise scenarios are equivalent to the increase set by the STAP report. Approximate water surface elevations for each model for the various flooding scenarios are summarized in Table 1.

Table 1 Approximate WSEL at Each Structure in Feet (NAVD88)

Flooding Event	**East Model WSEL (Union Ave Bridge)**	**West Model WSEL (Ocean Blvd Bridge)**
10- year (Current)	6.9	7.2
10-year (2050)	8.3	8.6
10-year (2070)	9.1	9.4
Sunny Day (Current)	3.6	3.6
Sunny Day (2050)	5.0	4.9
Sunny Day (2070)	5.8	5.7

Conclusions

Two site-specific high resolution hydraulic models have been developed for the two project bridges at Cliffwood Beach and Union Beach project sites. The latest available topo-bathymetric data was used for this model development. The models were validated using Hurricane Sandy historical flood records. A significant water elevation difference was identified between the historical water elevation and the model simulated water elevation; however, calibration was not intended for this study. The 10-year storm event and the Sunny Day flooding event were assessed for the project bridges. The model result shows the water peak elevation is almost the same as the tidal peak elevation. In the 10-year storm event, flow goes around the bridge and through approach roads; therefore, the bridge itself is not constricting the flow.

APPENDIX E

NJDEP PRE-APPLICATION MEETING FOLLOW-UP EMAIL (PERMITS, ACTIONS, AND RECOMMENDATIONS)

Laura Craig <lcraig@princetonhydro.com>

Monmouth County Bayshore Coastal Resilience Design Study - 5/19/2022 Meeting Follow-up

Locke, Hannah [DEP] <Hannah.Locke@dep.nj.gov> Thu, May 19, 2022 at 4:04 PM
To: "lcraig@princetonhydro.com" <lcraig@princetonhydro.com>, "Amber.Mallm@co.monmouth.nj.us" <Amber.Mallm@co.monmouth.nj.us>, "Harriet.Honigfeld" <harriet.honigfeld@co.monmouth.nj.us>, "David.Schmetterer@co.monmouth.nj.us" <David.Schmetterer@co.monmouth.nj.us>
Cc: "Nolan, Katherine [DEP]" <Katherine.Nolan@dep.nj.gov>, "Pepe, David [DEP]" <David.Pepe@dep.nj.gov>, "Martin-Torres, Chaneice [DEP]" <Chaneice.Martin-Torres@dep.nj.gov>, "Turner, Kara [DEP]" <Kara.Turner@dep.nj.gov>, "Pittfield, Taryn [DEP]" <Taryn.Pittfield@dep.nj.gov>, "Liang, Chingwah [DEP]" <Chingwah.Liang@dep.nj.gov>, "Corleto, Joseph [DEP]" <Joseph.Corleto@dep.nj.gov>, "Voelbel, Deborah [DEP]" <Deborah.Voelbel@dep.nj.gov>, "Staffieri, Kelley [DEP]" <Kelley.Staffieri@dep.nj.gov>, "Lewis, Michael [DEP]" <Michael.Lewis@dep.nj.gov>, "Chris.Minck@usace.army.mil" <Chris.Minck@usace.army.mil>, "Rosita.Miranda@usace.army.mil" <Rosita.Miranda@usace.army.mil>, "Sponaugle, Jessica [DEP]" <Jessica.Sponaugle@dep.nj.gov>, "Patterson, Jessica [DEP]" <Jessica.Patterson@dep.nj.gov>, "Moss, Bennett [DEP]" <Bennett.Moss@dep.nj.gov>, "Wong, Danny [DEP]" <Danny.Wong@dep.nj.gov>, "Milligan, Connor [DEP]" <Connor.Milligan@dep.nj.gov>

Good Afternoon,

It was a pleasure to meet with you today.

If you wish to have additional follow-up meetings with multiple programs, please let our office know and we will coordinate and schedule the meeting accordingly. If you would like to work with any of the individual programs directly, we just ask that you keep us copied on any correspondence so we may update our records.

To close out this email, below is a courtesy conceptual summary of possible permits and action items this project may require (but are not limited to): ***this is neither a comprehensive nor a technical summary***

Land Resource Protection

Coastal – Kara Turner (Kara.Turner@dep.nj.gov)

- A Coastal Zone Management Permit is needed for this work (NJAC 7:7), most of the sites are mapped coastal wetlands, in CAFRA and along a tidal waterbody.
- More information is needed to determine what permits may be necessary. Specifically where the mean high-water line is and the promulgated mapped coastal wetlands line is in relation to what is being proposed.
- Recommend additional discussions with LRP.

Freshwater Wetlands – Taryn Pittfield (Taryn.Pittfield@dep.nj.gov)

- The area is mapped coastal wetlands however the project area should be investigated for freshwater wetlands. Wetlands that are located greater than 15’ landward of the mapped coastal wetlands line would be classified as Freshwater Wetlands.
- Based on the project description if the work described in proposed in freshwater wetlands the following permits appear to be applicable:

1. Restoration activities would likely qualify for a General Permit No. 16 NJAC 7:7A-16. It should be noted that this permit is at 7:7A-16(b)1, which discusses the need for approval or a sponsor by an agency. We have some flexibility on accepting the 'sponsor' agency relative to the project details.
2. Replacing a culvert would likely fall under a General Permit No. 10 (will not qualify under 16 because it is replacement not removal).
3. If a bridge need repairs, it also would likely fall under a General Permit 10. Depending on additional details, a General Permit No. 20 may be required.

- If there is freshwater wetland disturbance it would trigger a review by LRP's T&E unit. If freshwater wetlands were found to be exceptional with 150' buffer, it would likely not preclude the permit from being issued/work being done but may incur timing restrictions of the work and/or requests of particular plantings within the restoration.
- The riparian zone associated with the waterway(s) is 50'. If any areas are confirmed manmade ditches that drain less than 50 acres there would be no riparian zone associated. The project would likely require a Flood Hazard Individual Permit and riparian zone disturbance limits are discussed at NJAC 7:13-11.2, Table 11.2. If disturbance to riparian zone exceeds the limits set forth in Table 11.2 it would require mitigation as discussed at 7:13-13.4(c).
- Recommend additional meetings with LRP.

Flood Hazard Area – Chingwah Liang (Chingwah.Liang@dep.nj.gov)

- For the removal vegetation, plantings of native species and use of herbicide, a Permit by Rule may be applicable.
- More information is needed on the culvert crossings to determine if a hydrological survey is necessary.
- It appears that the current project design is not considered a major development under the Stormwater Rules.
- Recommend additional meetings with LRP.

NJ Division of Fish and Wildlife – Joe Corleto (Joseph.Corleto@dep.nj.gov)

- Recommend a timing restriction (4/1-8/31) for osprey and raptor.
- Recommend a timing restriction (4/1-8/31) for northern diamondback terrapin timing restriction (5/31-8/31), *or* they should address
- Additional discussions may be necessary on timing restrictions and mitigation efforts.

Coastal Engineering – Deborah Voelbel, Kelley Staffieri, Michael Lewis (Deborah.Voelbel@dep.nj.gov, Kelley.Staffieri@dep.nj.gov, Michael.Lewis@dep.nj.gov)

- Current USACE beach fill, floodgate and interior levee project at Flat Creek.
- If USACE project has already begun the applicant may need a Section 408 permit to determine if the project will alter a federal project. https://www.nan.usace.army.mil/Missions/Regulatory/Section-408/
- Recommended coordination with Coastal Engineering for more information.

U.S. Army Corps of Engineers – Chris Minck (Chris.Minck@usace.army.mil)

- Applicant may need a Nationwide Permit 27 – Aquatic Habitat Restoration, Enhancement, and Establishment Activities.
- Applicant may need a Nationwide Permit 3 for maintenance of the culvert.
- Applicant may need a Section 401 Water Quality Certification.
- USACE coordinates with the National Marine Fisheries Service (NMFS). NMFS typically requests to review draft permits before applications are submitted.
- For further details, please coordinate with USACE.

Office of Science and Policy – Jessica Sponaugle (Jessica.Sponaugle@dep.nj.gov)

- Re: "Using herbicide and native plantings to restore and enhance degraded sections of the marsh that have been overtaken by the non-native, invasive, Common reed (Phragmites australis)" – it from the concept designs, it looks like this would only be happening around tidal creeks and not across the site. If this is the case and there is plenty of P. australis still at the site, wouldn't they expect the P. australis to quickly re-invade?

- DEP encourages them to measure the salinity in the wetland pre-restoration and compare it to the salinity in the estuary. If the projects will increase salinity in the marsh by increasing tidal connectivity, then they may be good candidates for Natural Climate Solutions Grants https://www.nj.gov/dep/climatechange/mitigation/ncs-grant.html

Office of Transactions and Public Land Administration/Green Acres – Jessica Patterson (Jessica.Patterson@dep.nj.gov)

- Most of the parcels included are encumbered by Green Acres as either Cliffwood Beach Park (Aberdeen Township owned), Scholer Park (Union Beach Borough owned) or unnamed undeveloped parkland (owned by both Aberdeen Township and Union Beach Borough).
- While the proposed restoration project constitutes a park improvement and is therefore consistent with GA regulations, we will need a little more information to determine if further GA review/approval will be required.
    - Will there be any easements or restrictions placed on the property as a result of the DLRP permits or funding source? If so, the local unit should review our Change in Use process at N.J.A.C. 7:36-25.6. This is not a GA approval process but an opportunity for the public to comment on the proposal. Since many of these parcels were funded by GA, we will need to review and approve any easement or deed restriction language prior to execution.
    - Please provide more information regarding the proposed replacement of undersized culverts throughout the project area. Will the replacement be done entirely within the road ROW, or will this work entail work outside of the ROW? Any impacts to the encumbered parcels, even temporarily during construction, will require prior GA approval at a minimum.

-

Surface Water Permitting – Bennet Moss (Bennet.Moss@dep.nj.gov)

- No surface water discharge is anticipated from this proposed project. However, if a surface water discharge becomes necessary during construction (i.e., dewatering), a NJPDES Discharge to Surface Water permit will be needed.
- Provided that the discharge is not contaminated, the appropriate NJPDES Discharge to Surface Water Permit is the B7 - Short Term De Minimis permit (see http://www.nj.gov/dep/dwq/gp-b7.htm). This is determined by running a pollutant scan as described in the application checklist where the data can be collected up to a year in advance of the discharge. However, if the discharge is contaminated and the analytical results demonstrate levels greater than the limitations specified in Attachment 1 of the B7 permit (see https://www.nj.gov/dep/dwq/pdf/B7_Final_Permit.pdf), the appropriate NJPDES Discharge to Surface Water Permit is the BGR – General Remediation Cleanup permit (see http://www.nj.gov/dep/dwq/gp_bgr.htm).
- Please note, if a BGR permit is appropriate, a Treatment Works Approval may also be needed for any treatment.

-

Air Permitting – Danny Wong (Danny.Wong@dep.nj.gov)

- The applicant should review the requirements of N.J.A.C. 7:27-8.2(c) 1-21 for stationary permitting requirements. This includes but is not limited to, construction equipment-stationary construction equipment or emergency generators, may require air pollution permits if it is located on the site for longer than one-year N.J.A.C. 7:27-8.2(d)15.
- There are general permits for boilers and emergency generators (https://www.state.nj.us/dep/aqpp/gp.html) if the units can meet the prescribed requirement in the general permits.
- Idling Vehicles- any vehicles involved on the project must adhere to the idling standards (less than 3 minutes) in N.J.A.C. 7:27-14 and 15.
- Air pollution including odors that are detectable offsite that are injurious to human health or would result in citizen complaints are prohibited. N.J.A.C. 7:27-5.2.
- Fugitive Dust - dust emissions either windblown or generated from construction activities should be controlled to prevent offsite impacts or material tracked onto the roadways. N.J.A.C. 7:27-5.2.

Air Bureau of Evaluation and Planning – Connor Milligan (Connor.Milligan@dep.nj.gov)

- The Permit Readiness Checklist indicates that it has not been determined if there will be a lead federal agency for this project, if the project will receive federal support of financial assistance, or if this project requires a federal approval, license, or permit.
- As stated in the Permit Readiness Checklist, if involvement from a federal agency is required for this project, including providing support in any way, providing financial assistance, licensing, permitting, or approving any

activity involved with this project; then a General Conformity Applicability Analysis and possibly a Conformity Determination will be required in accordance with the Federal General Conformity regulation (40 CFR, part 93, Subpart B, Determining Conformity of General Federal Actions to State or Federal Implementation Plans).

Should circumstances or conditions be or become other than as set forth in the information that was recently provided to the NJDEP, the comments and regulatory requirements provided above are subject to change and may no longer hold true. Statements made within this email are not indicative that the NJDEP has made any decisions on whether the proposed project will be permitted.

Thank you for your participation and cooperation during this process. If you have any questions or concerns, please let me know as soon as possible.

Hannah Locke

Environmental Services Trainee

Office of Permitting and Project Navigation

New Jersey Department of Environmental Protection

401 E. State St, Trenton, NJ 08625

Office: (609) 292-3600

Desk: (609) 341-3120

Email: Hannah.Locke@dep.nj.gov

OPPN website

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Monmouth County Bayshore Preapplication Meeting Request.pdf
11338K

Monmouth County Bayshore Design Study

Technical Advisory Committee Meeting

May 10, 2022; 11:00am to 12:30pm

11:00am	Introductions
11:10am	Project overview and presentation of concept designs (PowerPoint)
11:20am	Discussion of Whale Creek/Aberdeen Concept; Solicitation of Feedback
11:50am	Discussion of Flat Creek/Union Beach Concept; Solicitation of Feedback
12:20pm	Next Steps
12:30pm	Close

Attachments:

- Whale Creek/Aberdeen Concept
- Flat Creek/Union Beach Concept

APPENDIX F

TECHNICAL ADVISORY COMMITTEE MEETING MATERIALS AND MINUTES

BAYSHORE COASTAL RESILIENCE DESIGN STUDY
MONMOUTH COUNTY, NEW JERSEY
MAY 2022

Laura Craig, PhD

Director of Ecological Services

Christiana Pollack, GISP, CFM

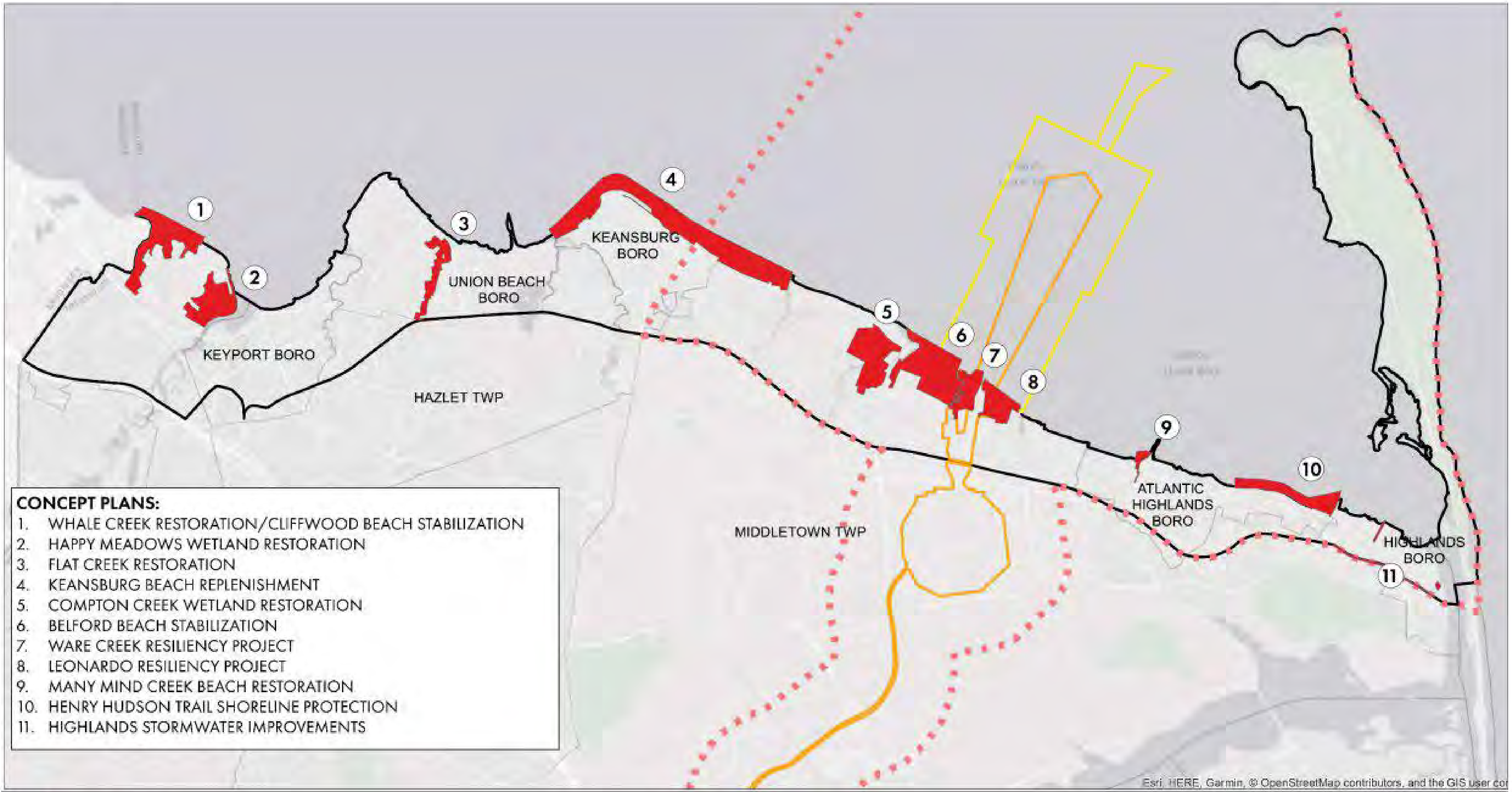
Director of Ecological Services

PRINCETON HYDRO

SCIENCE ENGINEERING DESIGN

PROJECT GOAL

To develop two coastal marsh restoration designs in order to improve the sustainability and resiliency of NWS Earle facilities and navigational channels, USACE projects, and Bayshore municipalities to current and future coastal hazards.



Final Concept Plan Locations

Raritan/Sandy Hook Bay Coastal Resilience Planning Study

Monmouth County, NJ

SCIENCE
ENGINEERING
DESIGN

PRINCETONHYDRO.COM

WHALE CREEK
Aberdeen Township, NJ

FLAT CREEK
Union Beach, NJ

SCIENCE
ENGINEERING
DESIGN

DATA COLLECTION

- ✓ Site characterization & inventory of ecological communities
- ✓ Biological benchmark survey
- ✓ Hydrological monitoring
- ✓ Baseline hydrodynamic model

SCIENCE
ENGINEERING
DESIGN

PRINCETONHYDRO.COM

OPPORTUNITIES

- ✓ Establish, enhance, or restore vegetation community
- ✓ Eradicate invasive species
- ✓ Improve hydrology/flow

SCIENCE
ENGINEERING
DESIGN

CONSTRAINTS

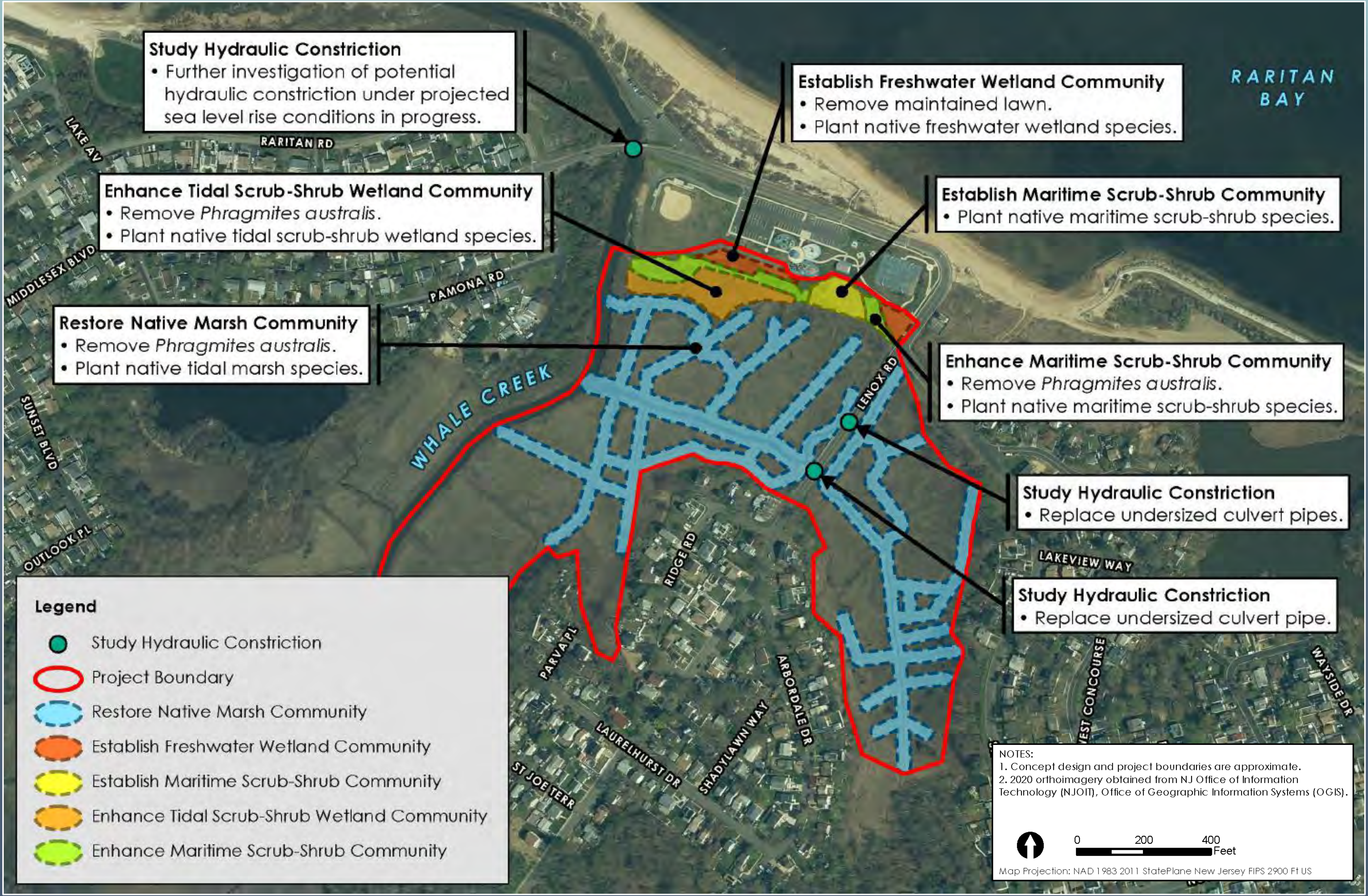
SCIENCE
ENGINEERING
DESIGN

PRINCETONHYDRO.COM

WHALE CREEK OBJECTIVES

- ✓ Remove invasive common reed (*Phragmites australis*)
- ✓ Plant native tidal scrub-shrub, maritime scrub-shrub, and tidal marsh, and freshwater wetland species where appropriate
- ✓ Replace undersized culverts
- ✓ Investigate hydraulic constriction potential under projected SLR conditions along inlet

SCIENCE
ENGINEERING
DESIGN



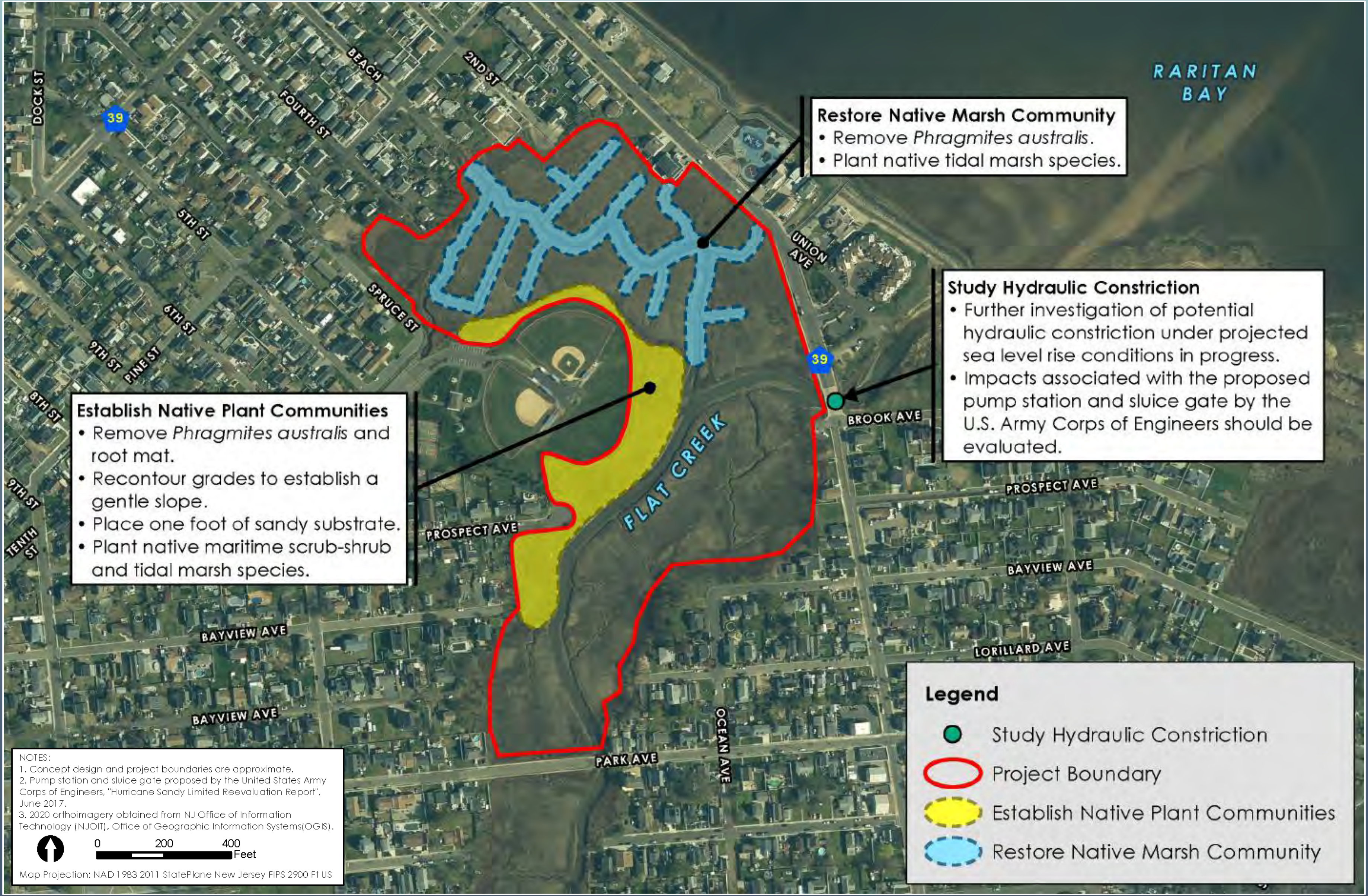
SCIENCE
ENGINEERING
DESIGN

WHALE CREEK CONCEPTUAL DESIGN

PRINCETONHYDRO.COM

FLAT CREEK OBJECTIVES

- ✓ Remove invasive common reed (*Phragmites australis*) and root mat
- ✓ Remove fill piles and recontour grades to establish gentle slopes for planting
- ✓ Plant native maritime scrub-shrub and tidal marsh wetland species where appropriate
- ✓ Investigate hydraulic constriction potential under projected SLR conditions



FLAT CREEK CONCEPTUAL DESIGN

SCIENCE
ENGINEERING
DESIGN

PRINCETONHYDRO.COM

TAC Meeting – Monmouth County
May 10, 2022

Attendees:
Laura Craig, Princeton Hydro
Christiana Pollack, Princeton Hydro
Amber Mallm, Monmouth County Division of Planning
Harriet Honigfeld, Monmouth County Division of Planning
David Schmetterer, Monmouth County Division of Planning
Inkyung Englehart, Monmouth County Division of Engineering
Debby DeJong, Monmouth County Division of Engineering
Shilpa Bhojappa, Monmouth County Division of Engineering
Paul Gleitz, Monmouth County Park System
France Karras, Monmouth County Environmental Council
David Scrivanic, Monmouth County Office of Emergency Management
Merissa Zuzulock, Naval Weapons Station Earle
Anthony Panzarino, Middlesex County Division of Engineering
Fred Tagliarini, Aberdeen Township
Bryan Russell, Aberdeen Township
John Francis Roman, Aberdeen Township
Robert M. Howard, Jr., Union Beach Borough
Dennis Dayback, T&M Associates
David Gentile, U.S. Army Corps of Engineers
Tom Herrington, Monmouth University/NJ Sea Grant
Capt. Al Modjeski, American Littoral Society
Julie Schumacher, American Littoral Society
Meredith Comi, NY/NJ Baykeeper
Ruth Foster, NJDEP
Erick Doyle, NJDEP
Rob VonBriel, NJDEP
Tasha Castaldi, NJDEP
Jena Cosimo, Monmouth Conservation Foundation

Additional TAC reviewers of final report:
Isabelle Stinette, NY/NJ Harbor Estuary Program
Victoria Thompson, Monmouth County Mosquito Control Division
Debbie Voelbel, NJDEP

Monmouth County Bayshore Design Study
Technical Advisory Committee Meeting
May 10, 2022

Project Background/Description: The project goal is to develop two coastal marsh restoration designs to improve the sustainability and resiliency of Naval Weapons Station Earle facilities and navigation channels, USACE projects, and the municipalities that are adjacent to these sites, to current and future coastal hazards.

Eleven projects were identified by the 2019 Coastal Resilience Planning Study; the focus of our efforts are Whale Creek (Aberdeen) and Flat Creek (Union Beach). Each site includes tidal marsh and maritime forest and does not include the adjacent coastline.

The first step was to evaluate the ecological health of the site. Princeton Hydro performed the first site visit in August of 2021. Our first impression was that these are beautiful marsh systems; except for having some invasive species, there are nice high marsh, low marsh, and scrub shrub communities. Collection of quantitative data included biological benchmark surveying to observe the different marsh zones and their elevations. Princeton Hydro also conducted detailed monitoring to understand how each site functions from a hydrologic perspective; this information is valuable for understanding flows and identifying any constraints to flow, and informed the hydrodynamic modeling we performed to understand how the sites respond during storm and sunny day events under various sea level rise scenarios.

Despite a generally healthy condition, there are still several opportunities to improve these marshes. These opportunities include establishing enhancing or restoring the vegetation community, eradicating invasive species (*Phragmites australis*), and addressing flow constrictions (i.e., undersized culverts). Another opportunity, which we're already pursuing, is to model the potential for flow constructions at the bridges located at the mouth of each site.

We identified several constraints at the sites - these include existing adjacent parks and residential areas that tightly border the marshes, which limit the opportunities to restore areas and allow for marsh migration in the face of climate change. We also received early feedback about other potentially complicating issues at the study sites including storm water drainage, lack of ownership of properties, potential complications related to existing or proposed USACE projects (e.g., the tide gate and pump station at the mouth of Flat Creek).

At Whale Creek, objectives include removing invasive common reed, planting native tidal, scrub shrub, maritime, and freshwater wetland species where appropriate (including in some underused areas of Memorial Park); replacing some undersized culverts along Lakeshore Drive; investigating the potential for hydraulic constriction under projected sea level rise at the bridge across the inlet of Whale Creek. At Flat Creek, objectives include removing the invasive Phragmites; removing fill piles and regrading to establish gentle slopes for planting native vegetation where appropriate (i.e., along Scholar Park); and investigating the potential for hydraulic constriction at the bridge at the mouth of Flat Creek.

Note that the following feedback from the TAC has been paraphrased.

Feedback on Whale Creek (Aberdeen) Concept –

Question: There is a concern about taking the low-lying land behind (Memorial) park – where is it relative to the fence line? The jungle gym?	*Response*: Firstly, we are not taking any land – these concepts are just the starting point for a conversation. There is an area on the park side of the fence (between the fence and the active park area) that is low-lying and tends to be wet. We propose changing the plant palette to wetland plants that will naturally flourish in that area. Implementing this idea will require additional study and an understanding of whether or not that lawn space is used by the public on a regular basis.
Question: There is a maritime scrub shrub community proposed in some locations – aren't those plants more salt tolerant/suitable for areas with salt spray?	*Response*: Yes, maritime scrub shrub plants are more salt tolerant and have been recommended for other locations on the site. We would plant the proposed freshwater wetlands with species that are successful in freshwater but can also tolerate salt spray and saltwater input during large storm events
Question: Is there any dredging anticipated? There are concerns about flooding at the site.	*Response*: There is no dredging proposed with the project. Dredging wouldn't offer a lot of additional storage, especially from a coastal storm perspective, because there is an abundant source of water from the Raritan Bay.
Question: Will the proposed freshwater wetland at Memorial Park be a rain garden?	*Response*: No. The water table is too high to facilitate infiltration, which is desirable with a rain garden.
Question: Is there maintenance associated with the proposed projects?	*Response*: Permits often require monitoring up to 5 years. It typically includes observations of planting success and taking inventory of invasive species. Findings may lead to conversations about adaptive management – e.g., additional plantings, invasive species treatment, etc. Responsibilities associated with monitoring or maintenance would need to happen with property owners prior to implementation.
Question: Who would be getting the permits?	*Response*: The permit applicant would be the property owner or an organization, for example a

	non-profit or other government entity, working on the property owner's behalf.
Question: Could the permit for the proposed beach maintenance permit also be used to implement or maintain these projects?	*Response*: it is likely that different permits will be required. We scheduled a pre-application meeting with the NJ Department of Environmental Protection to determine, at least in part, what permits would be required for the project.
Question: Is there funding for project implementation?	*Response*: The current funding is for this study only, and the County does not have any commitment to implementation. There are several sources of funding that could be pursued/used for implementation. These include competitive grants from the federal government, open space dollars, capital funds, etc.
Question: Who is responsible for getting funding?	*Response*: Funding could be secured by the County or municipality, but it could also be secured by a project partner (e.g., a non-profit) working in conjunction with the property owner. Who actually receives the funding and pays to implement the project could depend on who is eligible for the grant/funding source, but the effort is always a partnership/collaboration and requires landowner permission.

Feedback on Flat Creek (Union Beach) Concept –

Question: How will the Army Corps project - the proposed tide gate at the mouth of Flat Creek – impact the hydrology of the site?	*Response*: USACE usually designs these structures so that the flows will remain the same. If the project would seek to increase the flow in the bridge area, USACE would need to know as soon as possible because, while they have already decided on the location of the tide gate, there is still an opportunity to inform the project design. The two projects (i.e., the conceptual designs and the USACE tide gate) need to work together.
Comment: The aerial photograph used for the conceptual design does not show the tee ball fields in Scholar Park. Furthermore, the Borough intends to put a walking trail around the park in the future.	*Response*: The conceptual design was created to work with the existing uses; the tee ball fields, which are not shown in the aerial photo, were considered during design. An updated conceptual design should include a current aerial photo. Likewise, if the Borough wanted to provide a CAD

	file or a conceptual design for the location of the walking path, that could be pictured on the map.
Question: There will need to be wetland mitigation for the USACE tide gate – could restoration of these wetlands partially fill that need?	*Response*: USACE and NJDEP need to work together to determine whether this project could count towards any mitigation credits.
Comment: It would be a great idea to add informational signage to the project since the proposed concepts are in public access areas. Informational signage can educate the public as to what you are doing and why you're doing it.	*Response*: Signage should be considered as part of project implementation.
Comment: It appears that the concepts are focused more on an ecosystem resilience than resilience against future storms and flooding.	*Response*: A project designed for ecosystem resiliency will have different project elements than one designed for flood resiliency, however, several of the ideas we present could serve multiple purposes – e.g., restoration of maritime scrub shrub communities will allow for future marsh migration while helping to maintain habitat diversity.
Question: Did you do any survey work?	*Response*: There was no topographic survey as part of this project. A handheld GPS was used to collect the biological benchmarks.