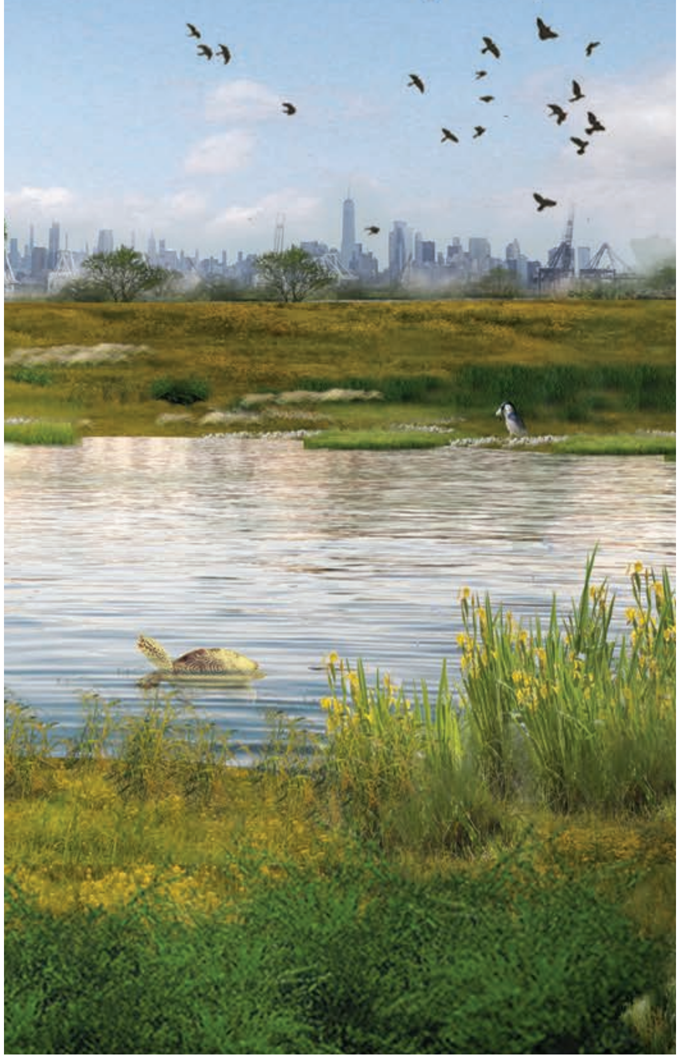
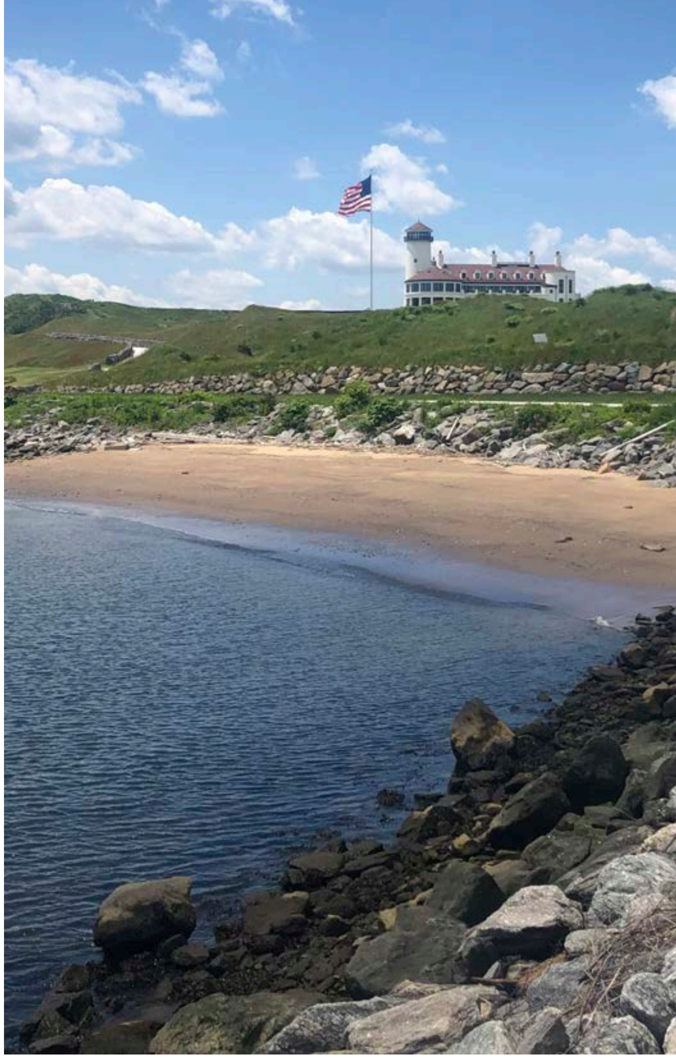




BAYONNE URBAN COASTAL DESIGN: AN INTEGRATED APPROACH

APPENDIX

AUGUST 30, 2019

BAYONNE GOLF CLUB
New York Harbor

RUTGERS
CUES — Center for Urban Environmental Sustainability

STEVENS INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY

TABLE OF CONTENTS

I. INTRODUCTION

LITERATURE REVIEW

Type	Author	Title	Year	Location	Habitat Type	Summary	Takeaways	Website	Reviewer
Storm Surge Protection	Park, Y.H.; Oh, Y.-M.; Ahn, S.M.; Han, T.H.; Kim, Y.-T.; Suh, K.-D.; and Won, D.	Development of a new concrete armor unit for high waves	2019	South Korea/General		Concrete armor unit development design process, wave resiliency rating, and comparison with existing armor units. Hudson stability coefficient is used by the US Army Corps of Engineers as ratings for shoreline protections.	Finding optical concrete armor needs to satisfy design and functional needs.	https://doi.org/10.2112/JCOASTRES-D-17-00224.1	FLY
Wave/Tide Attenuation	Yin, Z.; Wang, Y.; and Yang, X.	Regular wave run-up attenuation on a slope by emergent rigid vegetation	2019	General		Wave attenuation using rigid vegetation as energy dissipation. The system's performance depends on the slope of the land area, the distance between the vegetation and the toe of the slope, and the wave's steepness.	Wave dissipation depends on the slope, the distance to the vegetation and type of waves	https://doi.org/10.2112/JCOASTRES-D-17-00200.1	FLY
Sediment Transport	Ganju, Neil K.	Marshes are the new beaches: integrating sediment transport into restoration planning	2019	General	Marshes	General guidelines of sediment dynamics. Demonstrates how shorelines retreats when dredging is done to nearby shallow waters. Shows the mitigation of shoreline retreat by having organic material trapping sediments.	Depth profile of marshes must be controlled or create engineered control to prevent erosion and coastline retreat.	https://doi.org/10.1007/s12237-019-00531-3	FLY
Storm Surge Protection, Vegetation	Hu, Kelin; Chen, Qin; Wang, Hongqing	A numerical study of vegetation impact on reducing storm surge by wetlands in a semi-enclosed estuary	2015	Breton Sound Estuary, LA	Estuary	Numerical modelling of wetlands compared to existing field data. Heatmap of useful wave attenuation index available for looking up optimal dimensions for wetlands development.	Showed that the density and height of the vegetation is capable of reducing storm surge. Furthermor, it contains useful model for future development.	http://dx.doi.org/10.1016/j.coastaleng.2014.09.008	FLY
Hydrodynamics	Stark, J.; Smolders, S.; Meire, P.; Temmerman, S.	Impact of intertidal area characteristics on estuarine tidal hydrodynamics: A modelling study of the Scheldt Estuary	2017	Scheldt Estuary, Netherlands & Belgium	Estuary	Numerical modelling of intertidal area, zones that have the capacity for storage of tides. Study suggest that change in the tidal flats will result in varying tidal range.	Study looks at the impact of adding tidal flats along a estuary and how it can affect tide water flow	https://doi.org/10.1016/j.ecss.2017.09.004	FLY
Wave/Tide Attenuation	Smolders, S.; Plancke, Y.; Ides, S.; Meire, P.; Temmerman, S.	Role of intertidal wetlands for tidal and storm tide attenuation along a confined estuary: a model study	2015	Scheldt Estuary, Netherlands & Belgium	Estuary	Numerical modelling of intertidal wetlands for storm attenuation. Location and size of the wetland will determine the effect it has in storing extra water against storm surges and rising tides.	Study looks at how tidal flats/wetlands can mitigate tides and storm surge.	http://www.nat-hazards-earth-syst-sci.net/15/1659/2015/doi:10.5194/nhess-15-1659-2015	FLY
Vegetation	Rupprecht, E.; Möller, I.; Paul, M.; Kudella, M.; Spencer, T.; van Wesenbeeck, B.K.; Wolters, G.; Jensen, K.; Bouman, T.J.; Miranda-Lange, M.; Schimmels, S.	Vegetation-wave interactions in salt marshes under storm surge conditions	2017	General		Study investigates how storm surge affects vegetation in salt marshes. Vegetation can be damaged overtime during high storm surges. Also, the vegetation can increase the flow velocity of water when encountering high velocities, while decreasing the flow velocity when lower velocities is present.	Findings recommends that vegetation must be monitor for certain scenarios as they are not able to withstand full forces of the sea. Engineer control must be done in order to prevent any large biomass loss.	https://dx.doi.org/10.1016/j.ecoleng.2016.12.030	FLY
Storm surge, Tides, Modelling	Iglesias, I.; Venâncio, S.; Pinho, J.L.; Avilez-Valente, P.; Vieira, J.M.P.	Two models solutions for the Douro Estuary: Flood risk assessment and breakwater effects	2019	Duoro Estuary	Estuary	Two modelling approach to determine the effect of breakwaters against storm surge and flood. Two model approach can help verifying each other.	Two model approach can help determine whether current solutions will hold against historic flood events.	https://doi.org/10.1007/s12237-018-0477-5	FLY
Storm surge protection	Orton, Philip M.; Talke, Stefan A.; Jay, David A.; Yin, Larry; Blumberg, Alan F.; Georgas, Nickitas; Zhao, Haihong; Roberts, Hugh J.; MacManus, Kytt	Channel shallowing as mitigation of coastal flooding	2015	Jamaica Bay, NY	Bay	Study of shallowing flood plain as part of storm surge mitigation in different ways and use modelling approach to investigate the impact of storms like Sandy. Different scenarios are presented, while all of them did result in reduction of flood level, not all of them were effective.	Study shows that shallowing of the bay and the channels the leads into it can be effective at reducing peak water level during storm events.	https://doi.org/10.3390/jmse3030654	FLY

Wave/Tide attenuation, Vegetation	Foster-Martinez, M.R.; Lacy, J.R.; Ferner, M.C.; Variano, E.A.	Wave attenuation across tidal marsh in San Francisco Bay.	2018	San Fransisco Bay, CA	Bay	A study done by integrating vital parts of the salt marsh like depth of the marsh, the length at which extend the marsh covers, the vegetation available, and the transport of sediments. Findings show how a healthy marsh can attenuate incoming waves and how similar systems can be incorporated as part of future coastal protection plans.	The study shows how a tidal marsh works, what vegetation is present and how can this model example can be applied in other areas.	https://doi.org/10.1016/j.coastaleng.2018.02.001	FLY
Sediment transport, Wave/Tide attenuation	Wilberg, Patricia L.; Taube, Sara R.; Ferguson, Amy E.; Kremer, Marnie R.; Reidenbach, Matthew A.	Wave attenuation by oyster reefs in shallow coastal bays.	2019	Chesapeake Bay, Delmarva Peninsula, VA	Bay	Findings suggest the in low energy condition, oyster reefs can reduce wave height and energy. At high energy condition, however, the effect is greatly reduced.	The article suggest that oyster reefs can be used in shallow water to mitigate erosion and coastline retreat.	https://doi.org/10.1007/s12237-018-0463-y	FLY
Sediment transport, Wave/Tide attenuation	Karimpour, Arash; Chen, Qin; Twilley, Robert R.; 2017	Wind behavior in fetch and depth limited estuaries	2017	Breton Sound & Terrebonne Bay, LA	Estuary	The study is conducted to determine the effect of wind on the creation of waves that contributes to the acceleration of the deterioration of wetlands.	Winds lead to the generation of waves and increase wave energy in depth limited estuary. This can contribute to the acceleration of erosion of the sediments.	https://doi.org/10.1038/srep40654	FLY
Sediment transport	Duvall, Melissa S.; Wiberg, Patricia L.; Kirwan, Matthew L.	Controls on sediment suspension, flux, and marsh deposition near a bay-marsh boundary	2019	Chesapeake Bay, VA	Marshes, bay	Study aims to find how wind, water height, waves, storms, and sea-level rise will affect sediment transport in a marsh. Sediment transport is measured by finding bottom shear and turbidity of the water and correlated to the data taken.	Sediment deposition Is driven by current and wind as they move sediment around. However, as sea level keeps rising, deposition will continue to slow down.	https://doi.org/10.1007/s12237-018-0478-4	FLY
Sediment Transport	Allison, M.A., C.A. Nittrouer, A.S. Ogston, J.C. Mullarney, and T.T. Nguyen	Sedimentation and survival of the Mekong Delta: A case study of decreased sediment supply and accelerating rates of relative sea level rise	2017	Mekong Delta, SE Asia	Delta	Study found the effect of controlling river flow and its contribution to sedimentation in deltas, specially during seasons of high flow and low flow, most following local weather patterns.	Effects of human flow control, sea level rise, and weather patterns on accelerating sediment transport.	https://doi.org/10.5670/oceanog.2017.318	FLY
Sediment Transport	Mariotti, G.	Revisiting salt marsh resilience to sea level rise: Are ponds responsible for permanent land loss?	2016	Cape May, NJ; Terrebone Bay, LA; Cote Blanche Bay, LA	Marshes	Study is determine to investigate the effect on ponds in marshes, and how sea-level rise is contributing to its existance and creation.	The ponds have different effect on the marsh. Depending of the cases, ponds can either become larger when it keeps eroding its surroundings, or sediments can slowly fill it to allow vegetation to grow.	http://dx.doi.org/10.1002/2016JF003900	FLY
Sediment Transport, Vegetation	Redfield, Alfred C.	Development of a New England Salt Marsh	1972	Great Marshes at Barnstable, MA	Marshes	The article wants to analyze the natural process in which the marsh has established in the area, the history of the marsh since its beginnings and how it has held up against all recurring and past events, including sea-level rise.	The work provides insight of the process the marsh has been developed. It can be useful for the creation of artificial marshes.	https://www.jstor.org/stable/1942263	FLY

Engineering	Elliott, Michael; Mander, Lucas; Mazik, Krysia; Simenstad, Charles; Valesini, Fiona; Whitfield, Alan; Wolanski, Eric	Ecoengineering with ecohydrology: Successes and failure in estuarine restoration	2016	General		The paper is exploring multiple projects taken in salt marsh restoration. The article is describing the process of the building and restoration with insights of the effect of the construction and changes done on the ecosystem.	The article gives useful information about the past events leading to the construction/restoration of wetlands and marshes, and their short-term and long-term effects that required or would require further engineering solutions.	http://dx.doi.org/10.1016/j.ecss.2016.04.003	FLY
Hydrodynamics	Alan F. Blumberg, Liaqat Ali Khan, John P. St. John	Three-dimensional hydrodynamic modle of New York harbor region	1999	New York harbor		Comprehensive study of the hydrodynamics of the New York harbor region.	Contains useful figures		FLY
Sediment Transport	Rafael Cañizares, Jennifer L. Irish	Simulation of storm-induced barrier island morphodynamics and flooding	2008	Long Island, NY		Modelling of barrier island when affected by storms	View of effect of storm on the sediments of barrier islands, useful for design perspectives.	http://dx.doi.org/10.1016/j.coastaleng.2008.04.006	FLY
Sea Level Rise	Vivien Gornitz, Stephen Couch, Ellen K. Hartig	Impacts of sea level rise in the New York City Metropolitan area	2001	New York City		Study done on the effect of sea level rise on New York City	The article shows different aspect of sea level rise and its impact on urban areas as well as marshes		FLY
Sea Level Rise	Andrew C. Kemp, Benjamin P. Horton	Contribution of relative sea-level rise to historical hurricane flooding in New York City	2013	New York City		Study analyzes the effect of sea level rise on flooding	Historical data suggest the future storm flooding will cause higher surge.	10.1002/jqs.2653	FLY
Sediment Dynamics	Ganju NK	Marshes Are the New Beaches: Integrating Sediment Transport into Restoration Planning. Estuaries and Coasts	2019			Marsh restoration projects must include sediment measures and models that consider sediment dynamics, this will help identify where restoration will be most successful.			AL
Vegetation	Charbonneau, Bianca R. and Wootton, Louise S. and Wnek, John P. and Langley, J. Adam and Posner, Michael A.	A species effect on storm erosion: Invasive sedge stabilized dunes more than native grass during Hurricane Sandy.	2017	Island Beach State Park, NJ		Vegetation is vital to dune resiliency, as well as the vegetation profile. Coastal dunes with *Carex Kombugi* , an invasive species, was more resilient to collision erosion due to Hurricane Sandy than dunes vegetated with native *Ammophila breviligulata* .			AL
Oyster Reefs	Wiberg PL, Taube SR, Ferguson AE, Kremer MR, Reidenbach MA	Wave Attenuation by Oyster Reefs in Shallow Coastal Bays	2018			Oyster reefs at depths between 0.5-1.0 m have been shown to reduce wave height 30-50% (and therefore wave energy).			AL
Coastal Resiliency	Georgia Basso, Jamie M. P. Vaudrey, Kevin O'Brien & Juliana Barrett	Advancing Coastal Habitat Resiliency Through Landscape-Scale Assessment	2018			Estuary restoration often fails due to vague goals and a lack of integrating science into the planning process. This study was made to provide a better quantitative understanding of the ecosystem condition t enable science based goals for more successful restoration. Specifically for tidal wetlands this study identified saltwater intrusion, open water, impervious cover surrounding marsh as the indicators for wetland health		DOI: 10.1080/08920753.2018.1405328	AL
Sediment Dynamics	Nicholas K. Coch	Sediment Dynamics in the Upper and Lower Bays of New York Harbor	2016	Upper & Lower Bays of NY Harbor	Bay	The northern part of our site is composed of silty sand sediment facies, souther is composed of clayey sil sand, the two sediment facies contact each other on the site.		https://doi.org/10.2112/JCOASTRES-D-15-00133.1	AL
Vegetation	Johnson O. Ajedegba, Humberto L. Perotto-Baldivieso, and Kim D. Jones	Coastal Dune Vegetation Resilience on South Padre Island, Texas: A Spatiotemporal Evaluation of the Landscape Structure	2019	South Padre Island, Texas	Coastal Dune	Analysis from available remote sensing imagery showed that Hurricane Dolly caused fore dunes washout resulted in 5% decrease in overall vegetation and a decrease in edge and patch densities. The dune ecosystem had a full recovery from this loss.		https://doi.org/10.2112/JCOASTRES-D-18-00034.1	AL

Living Shorelines	Donna Marie Bilkovic, Molly Mitchell, Pam Mason, and Karen Duhring	The Role of Living Shorelines as Estuarine Habitat Conservation Strategies	2016	n/a	Living Shorelines	Living shorelines are defined as created or enhanced environments that improve ecosystem quality while reducing erosion. The aim of this paper is to raise awareness of and explain living shorelines as a viable, prefered option for coastla management.	Gives a hostory of shoreline management, defines living shorelines and explains their science & value. It then gives various case studies as examples of the positives of living shorelines	http://dx.doi.org/10.1080/08920753.2016.1160201	AL
Ecotone Ecosystems	Alberto Basset, Enrico Barbone, Michael Elliott, Bai-Lian Li, Sven Eric Jorgensen, Paloma Lucena-Moya, Isabel Pardo, David Mouillot	A unifying approach to understanding transitional waters:Fundamental properties emerging from ecotone ecosystems	2013	n/a	Transitional waters	This paper aims to explain transitional water through an ecotone framework anf understanding. It highlights the ectone dimensions, scales , and properies of transitional waters. It's a legal term for management purposes. TWs are defined by their [rp[erties and their complexities redfeines ecotones, which will help enable future coastal climate solutions	this paper explains transitional waters and theyre place in an ecotone framework, discussing transitional water dimensions, scales, function, biodiversity and paradoxes. It gives a good scientifici overview of transitional waters and their properties but it was a really hard read and it didntreally give any new applicable information. It's a synthesis paper more than anything e;se.	https://doi.org/10.1016/j.ecss.2012.04.012	AL
Marsh elevation, Vegetation	Donald R. Cahoon & James C. Lynch & Charles T. Roman & John Paul Schmit & Dennis E. Skidds	Evaluating the Relationship Among Wetland Vertical Development, Elevation Capital, Sea-Level Rise, and Tidal Marsh Sustainability	2019	Jamaica Bay NYC	salt marsh	When salt marsh surfafce elevation rates keeps p with sea level rise, the salt marsh is maintained and continues to grow, meaning an increased elevation capital and a vegetated tidal marsh. When marsh elevation can not keep up with sea level ruse it is continually flooded, loses integrity, the marsh dies and there is low vegetative integrity. It also seems that the higher the marsh elevation, the better the marsh is at sustainaing elevation.	a salt marsh will maintain vegetation (indication of health) be healthy if it can accrete and miantain it's elevation with regard to sea level rise. [not clear if the presence of vegetation ensures elevation change or if when elevation is is maintained vegetation is maintained?)	https://doi.org/10.1007/s12237-018-0448-x	AL
Estuary Ecosystems, Management	M.G. Chapman, A.J. Underwood, Mark Anthony Browne	An assessment of the current usage of ecological engineering andreconciliation ecology in managing alterations to habitats in urbanestuaries	2018	n/a	urban estuaries	Estuary habitats and management is not binary, but rather exists on a spectrum. Estuary hbaitats can range from novel to natural, with both being found in the same lovation. Management can be categorized as passive or active. It is important to quanitfy goals.			AL
Estuary Ecosystems, Management	Joy B. Zedler	What's New in Adaptive Management and Restoration of Coasts and Estuaries?	2016		coasts and estuaries			DOI 10.1007/s12237-016-0162-5	AL

Seal Level Rise, Coastal Resilience	Karen Thorne, Glen MacDonald, Glenn Guntenspergen, Richard Ambrose, Kevin Biffington, Bruce Dugger, Chase Freeman, Christopher Janousek, Lauren Brown, Jordan Rosencranz, James Holmquist, John Smol, Kathryn Hargan, John Takekawa	U.S Pacific coastal wetland resilience and vulnerability to sea-level rise	2018	pacific coast of the continental US	estuaries	Models show that high and moderate sea level rise will result in a loss of high and middle marsh elevation. This elevation loss will transform these marsh sites into low marshes and mudflats. The only 3 of the 14 sites that remained subtidal had high sediment accretion rates			AL
Sedimentary Dynamics, Shoreline Stabilization	Cindy M Palinkas, Lawrence P Sanford, Evamaria W. Koch	Influence of Shoreline Stabilization Structures on the Nearshore Sedimentary Environment in Mesohaline Chesapeake Bay	2017	Chesapeake Bay		Studies resulted in no results for sedimentary environments, there were general trends seen but not found to be statistically signifigant			AL
Biodiversity, Habitat Complexity	Rebecca L. Morris, M. Gee Chapman, Louise B. Firth, Ross A. Coleman	Increasing habitat complexity on seawalls: Investigating large- and small-scale effects on fish assmeblages	2017	Sydny harbour, Australia	intertidal seawall	year long study added flowerpots to seawalls found no signifigant change on large and small species densities between sites with flowerpots and ssites without.		DOI: 10.1002/ece3.3475	AL
Sea Level Rise, Sedimentation		Sediment starvation destroys New York City marshes' resistance to seal level rise		Jamaica Bay NYC	marshes				AL
Restoration, Topography	Heida L Diefenderfer, Ian A. Sinks, Shon A. Zimmerman, Valerie I. Cullinan, Amy B. Borde	Designing topographic heterogeneity for tidal wetland restoration	2018	Pacific northwest	estuarine and tidal freshlands	Topogrpahic mounds add to habitat diversity and health, as well as provide spaces that don’t flood, which increases plant diversity			AL

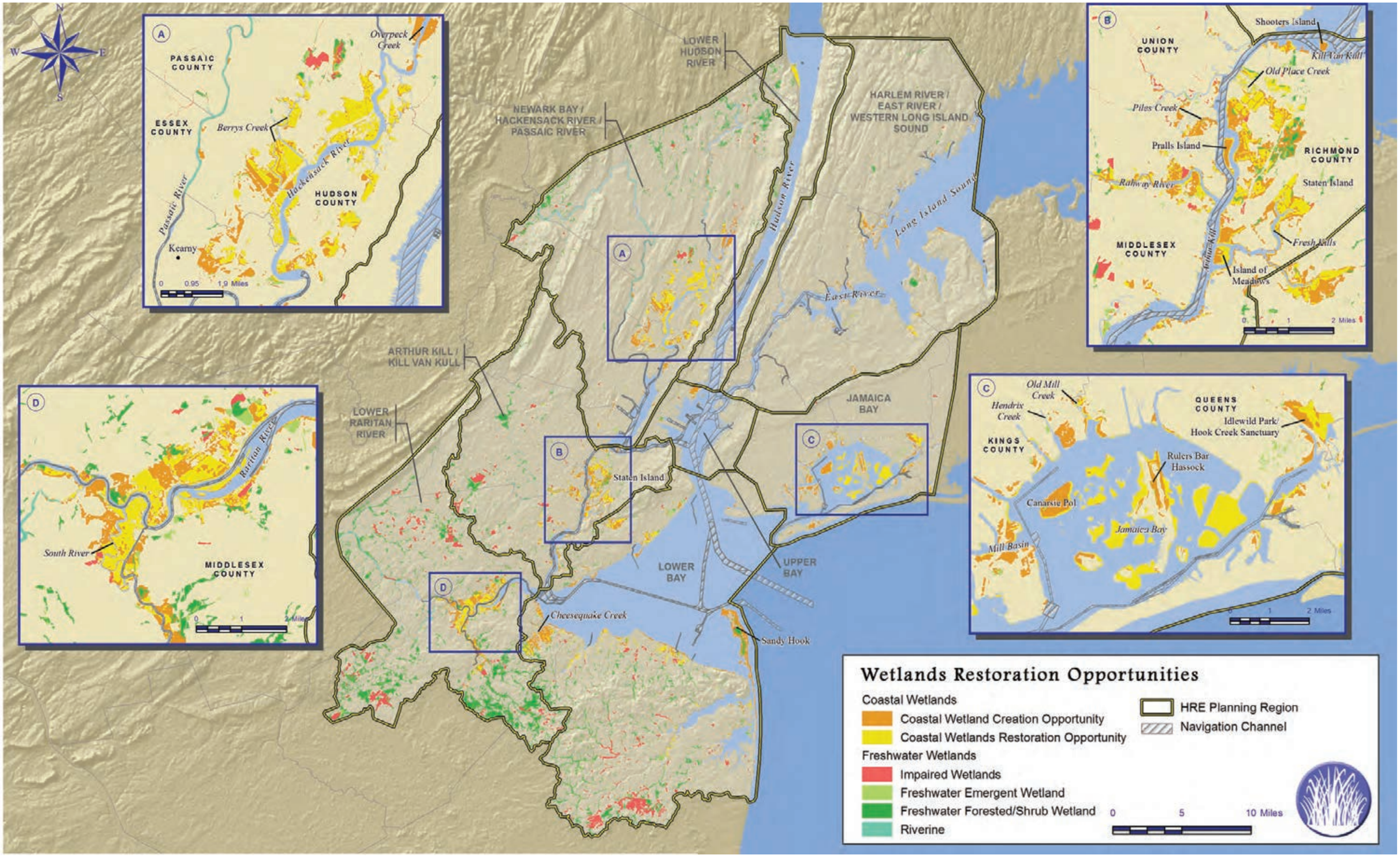
HRE COMPREHENSIVE RESTORATION PLAN TABLES/MAPS

TEC	Target Statement
Wetlands	Create and restore coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage.
Habitat for Waterbirds	Restore and protect roosting, nesting, and foraging habitat (i.e., inland trees, wetlands, shallow shorelines) for long-legged wading birds.
Coastal and Maritime Forests	Create a linkage of forests accessible to avian migrants and dependent plant communities.
Oyster Reefs	Establish sustainable oyster reefs at several locations.
Eelgrass Beds	Establish eelgrass beds at several locations in the HRE study area.
Shorelines and Shallows	Create or restore shoreline and shallow sites with a vegetated riparian zone, an inter-tidal zone with a stable slope, and illuminated shallow water.
Habitat for Fish, Crab, and Lobsters	Create functionally related habitats in each of the eight regions of the HRE.
Tributary Connections	Reconnect and restore freshwater streams to the estuary to provide a range of quality habitats to aquatic organisms.
Enclosed and Confined Waters	Improve or maintain water quality in all enclosed waterways and tidal creeks within the estuary to match or surpass the quality of their receiving waters.
Sediment Contamination	Isolate or remove one or more sediment zone(s) that is contaminated until such time as all HRE sediments are considered uncontaminated based on related water quality standards, related fishing / shellfishing bans or fish consumption advisories, and any newly-promulgated sediment quality standards, criteria or protocols.
Public Access	Improve direct access to the water and create linkages to other recreational areas, as well as provide increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation.
Acquisition	Protect ecologically valuable coastal lands throughout the HRE from future development through land acquisition.

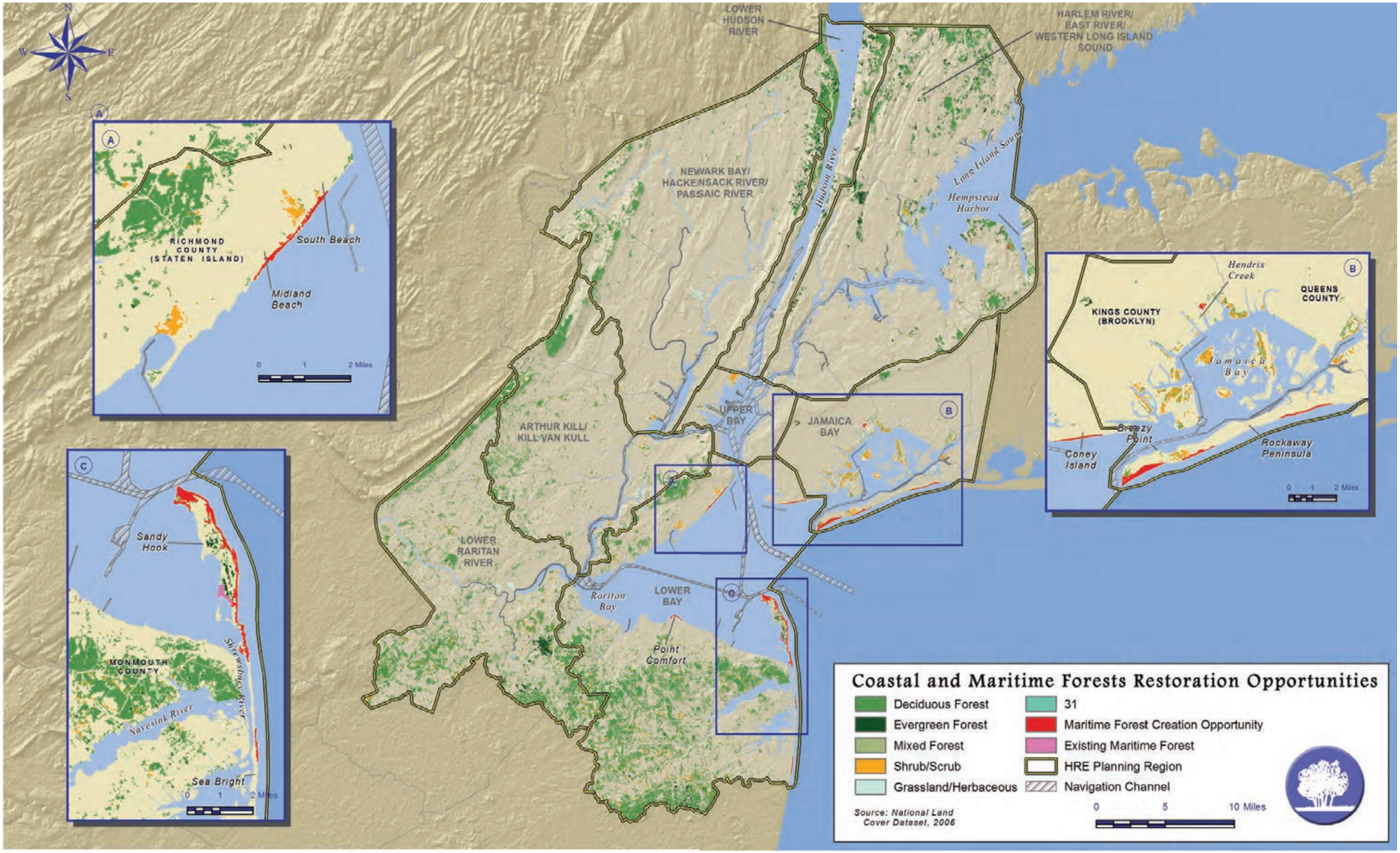
Source: HRE CRP Ver. 1.0 2016

TEC	2020	2050
Wetlands	Create and/or restore a total of 1,000 total acres of freshwater and coastal wetland	Continue creating an average of 125 acres per year for a total system gain of 5,000 acres
Habitat for Waterbirds	Enhance at least one island without an existing waterbird population in HRE regions containing islands and create or enhance at least one foraging habitat	All suitable islands provide roosting and nesting sites and have nearby foraging habitat
Coastal and Maritime Forests	Establish one new maritime forest of at least 50 acres and restore at least 200 acres among several coastal forest/upland habitat types	500 acres of maritime forest community among at least three sites and 500 acres of restored coastal forest/upland habitat
Oyster Reefs	20 acres of reef habitat across several sites	2,000 acres of established oyster reef habitat
Eelgrass Beds	Create one bed in at least three HRE regions	Three established beds in each suitable HRE region
Shorelines and Shallows	Develop new shoreline sites in two HRE regions	Restore available shoreline habitat in three HRE regions
Habitat for Fish, Crab, and Lobsters	Complete a set of two related habitats in each HRE region	Complete four sets of at least two related habitats in each HRE region
Tributary Connections	Restore connectivity or habitat within one tributary reach per year	Continue rate of restoring and reconnecting areas
Enclosed and Confined Waters	Upgrade water quality of eight enclosed waterways	Upgrade water quality of all enclosed waterways
Sediment Contamination	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years
Public Access	Create one access and upgrade one existing access per year	All waters of the HRE are accessible
Acquisition	Acquire a total of 1,000 acres to be preserved at an average rate of 200 acres per year	Acquire and preserve 200 acres of coastal property per year for a total of 6,000 acres

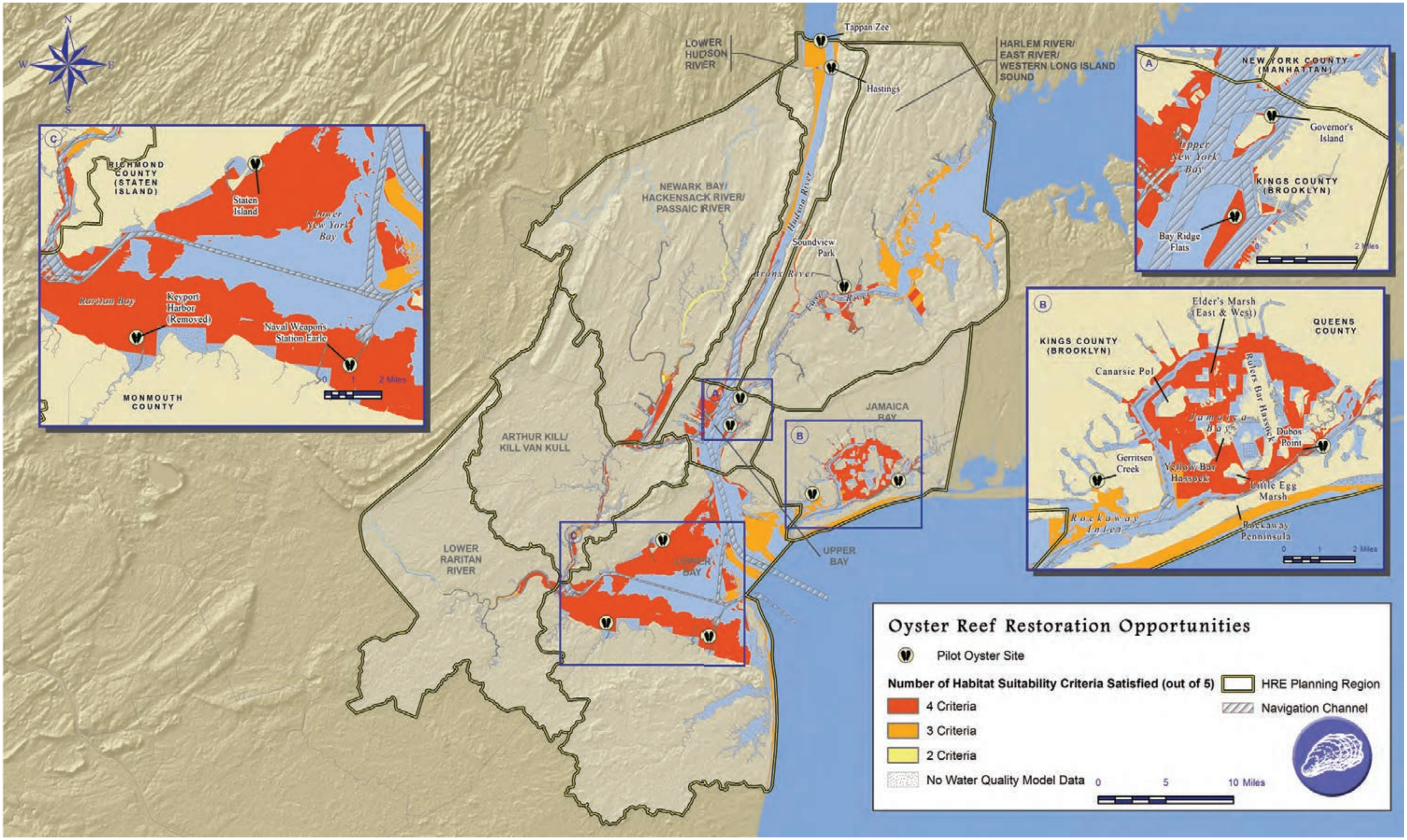
Source: HRE CRP Ver. 1.0 2016



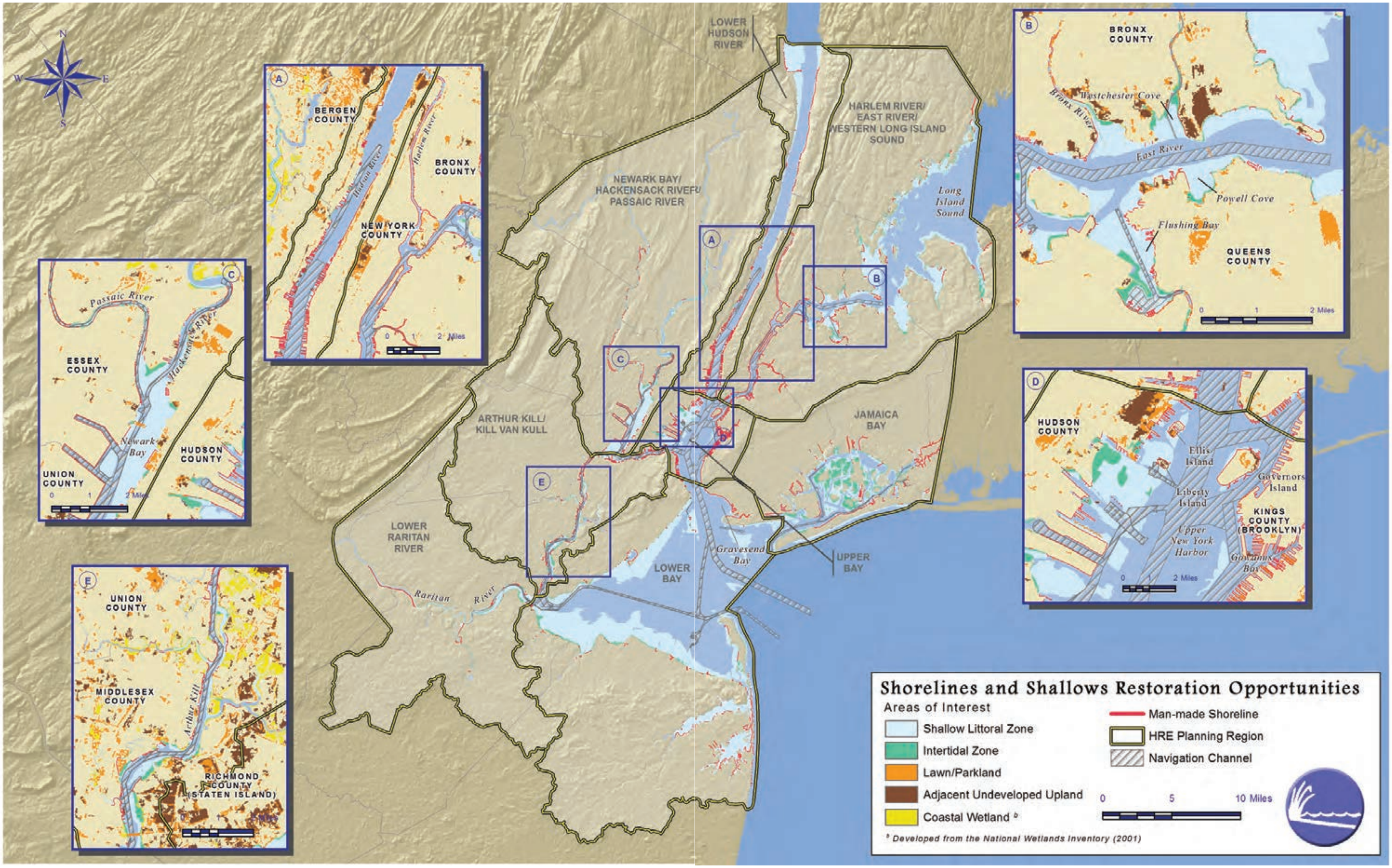
Source: HRE CRP Ver. 1.0 2016



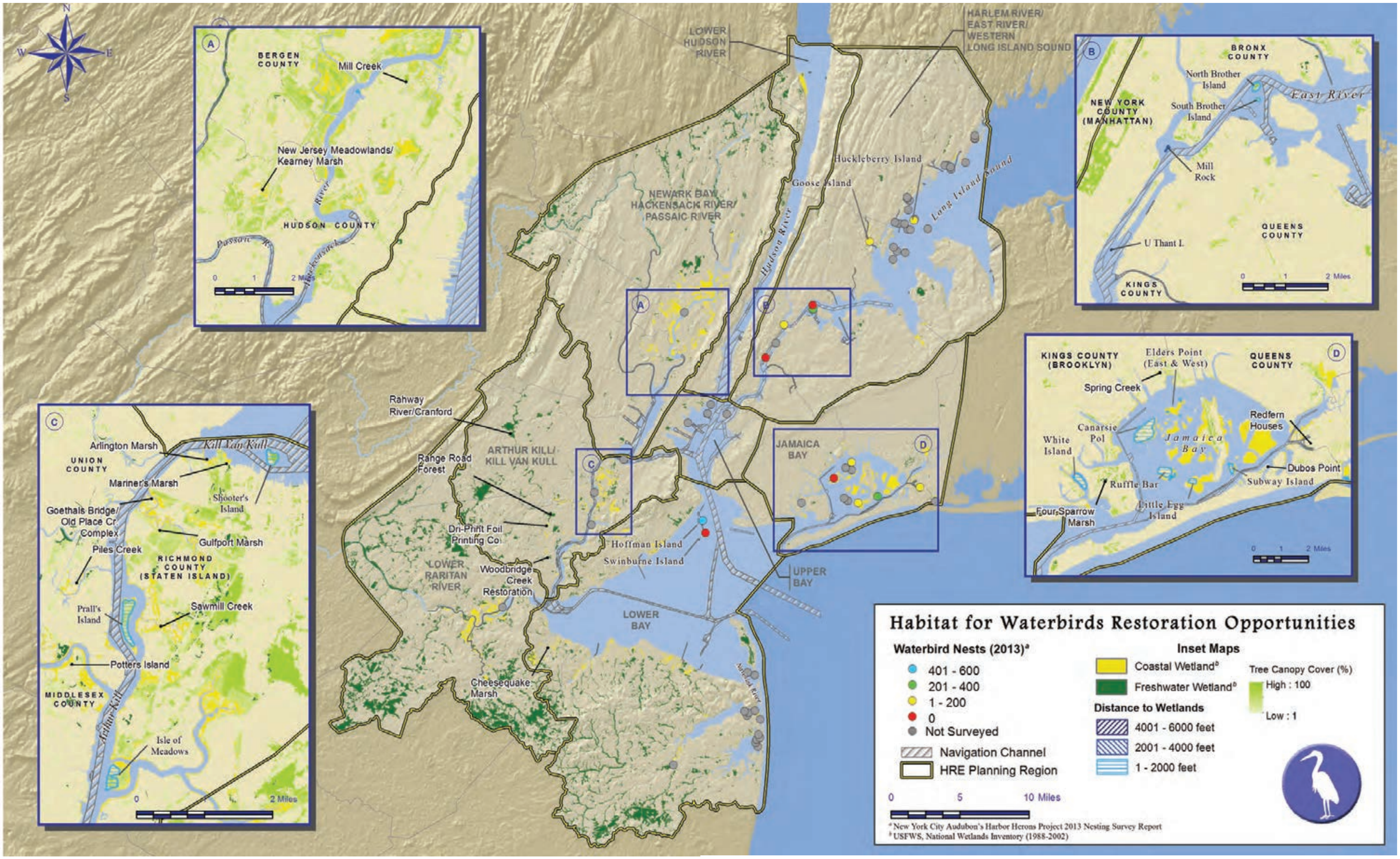
Source: HRE CRP Ver. 1.0 2016



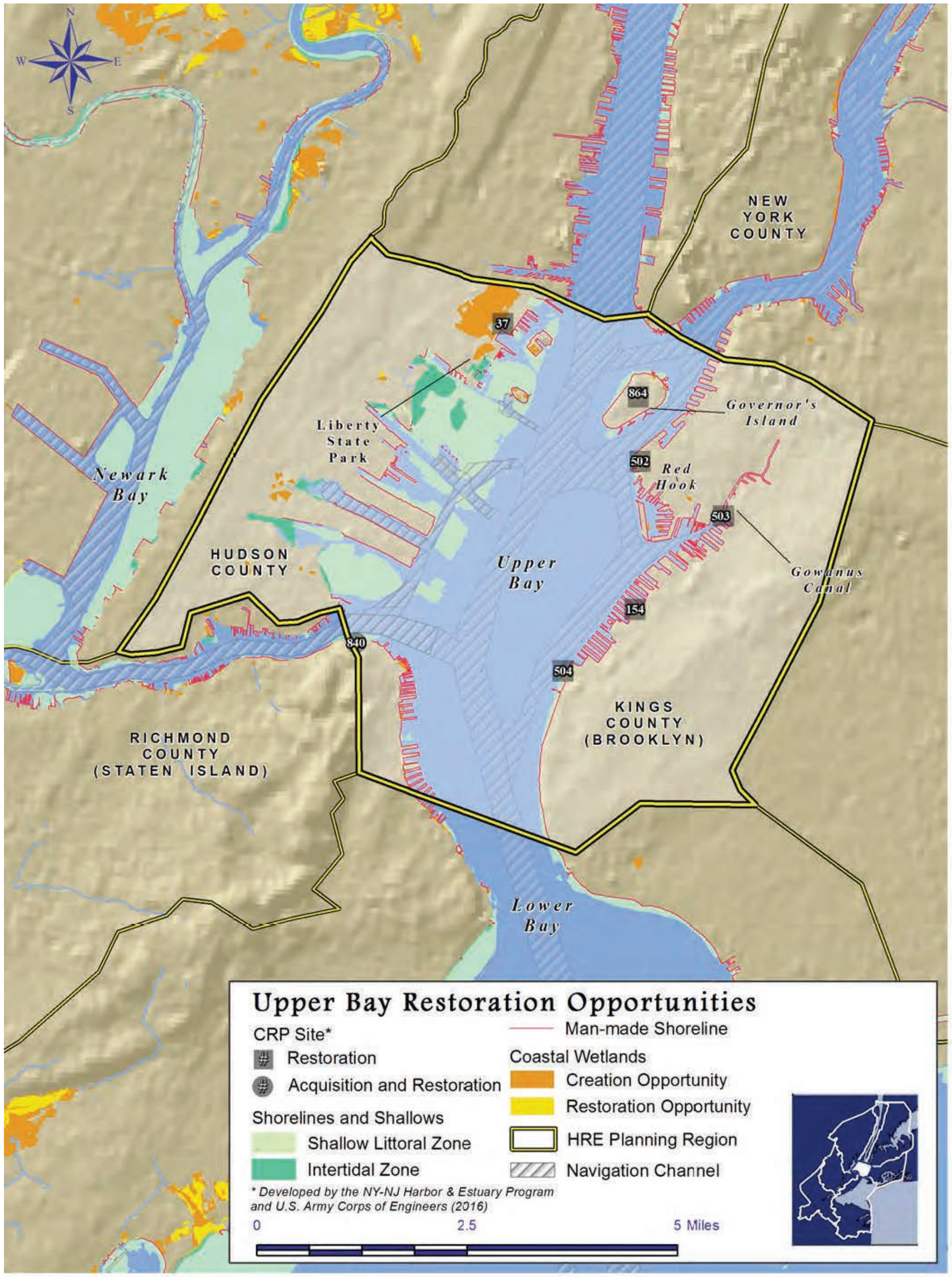
Source: HRE CRP Ver. 1.0 2016



Source: HRE CRP Ver. 1.0 2016



Source: HRE CRP Ver. 1.0 2016



HRE Planning Region	CRP Sites[1]													TBD[2]
Jamaica Bay	46	35	0	28	1	0	23	21	6	16	42	12	8	4
Lower Bay	52	33	1	38	1	1	6	4	15	0	38	23	21	7
Lower Raritan River	26	6	0	7	0	0	1	3	5	0	9	6	22	16
Arthur Kill/ Kill Van Kull	31	19	2	15	0	0	5	7	15	0	23	9	15	5
Newark Bay/ Hackensack River/ Passaic River	76	46	0	6	0	0	22	31	41	5	62	36	21	9
Lower Hudson River	10	3	0	6	0	0	4	3	1	0	5	7	2	2
Harlem River/ East River/W. Long Island Sound	48	21	3	20	2	0	19	21	19	9	21	17	12	25
Upper Bay	7	3	0	0	1	0	3	5	0	1	5	4	1	1
TOTAL CRP SITES	296	166	6	120	5	1	83	95	102	31	205	114	102	69

[1]Special CRP Sites for each planning region are presented in Appendix D: Atlas of Restoration Opportunities.

[2]CRP Sites, for which TEC restoration opportunities are "To Be Determined."

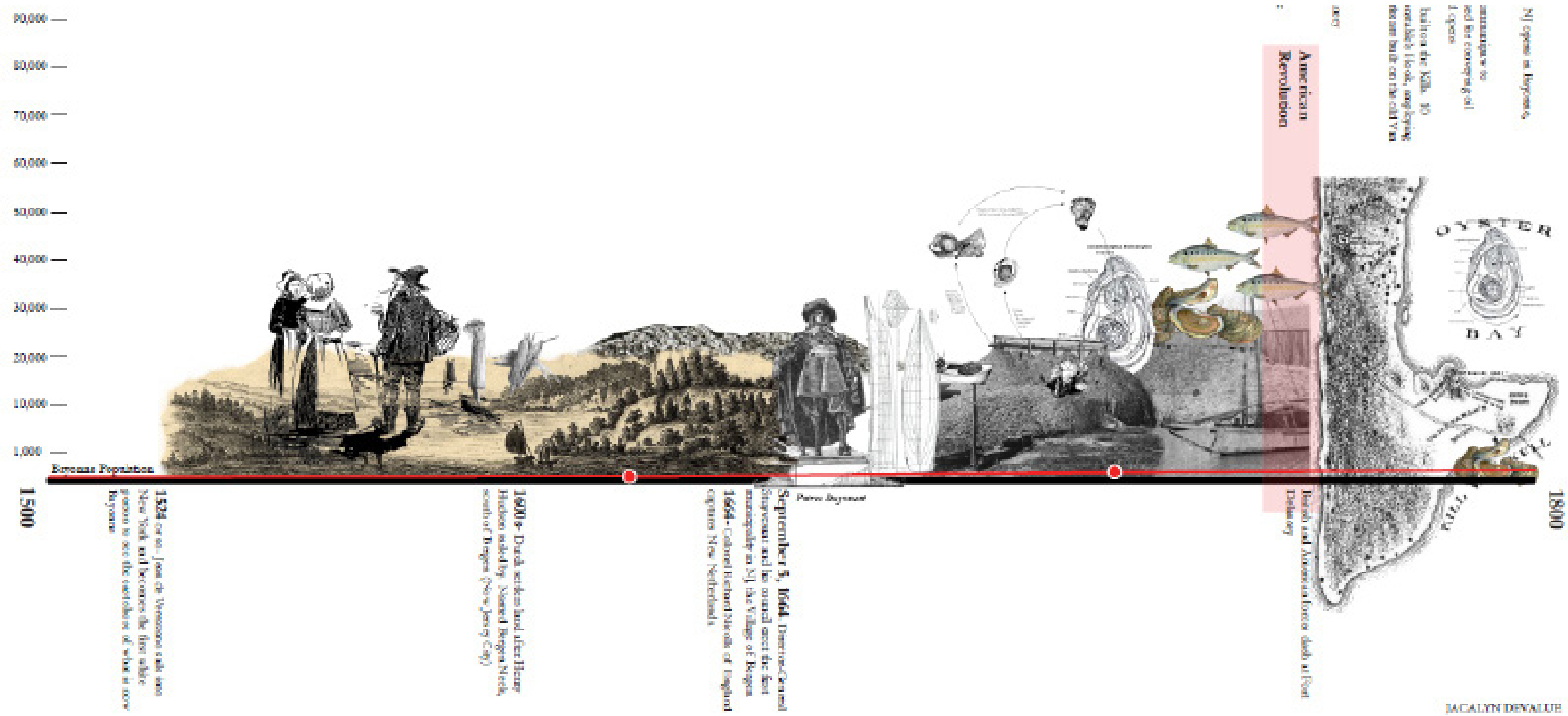
Source: HRE CRP Ver. 1.0 2016

CASE STUDIES

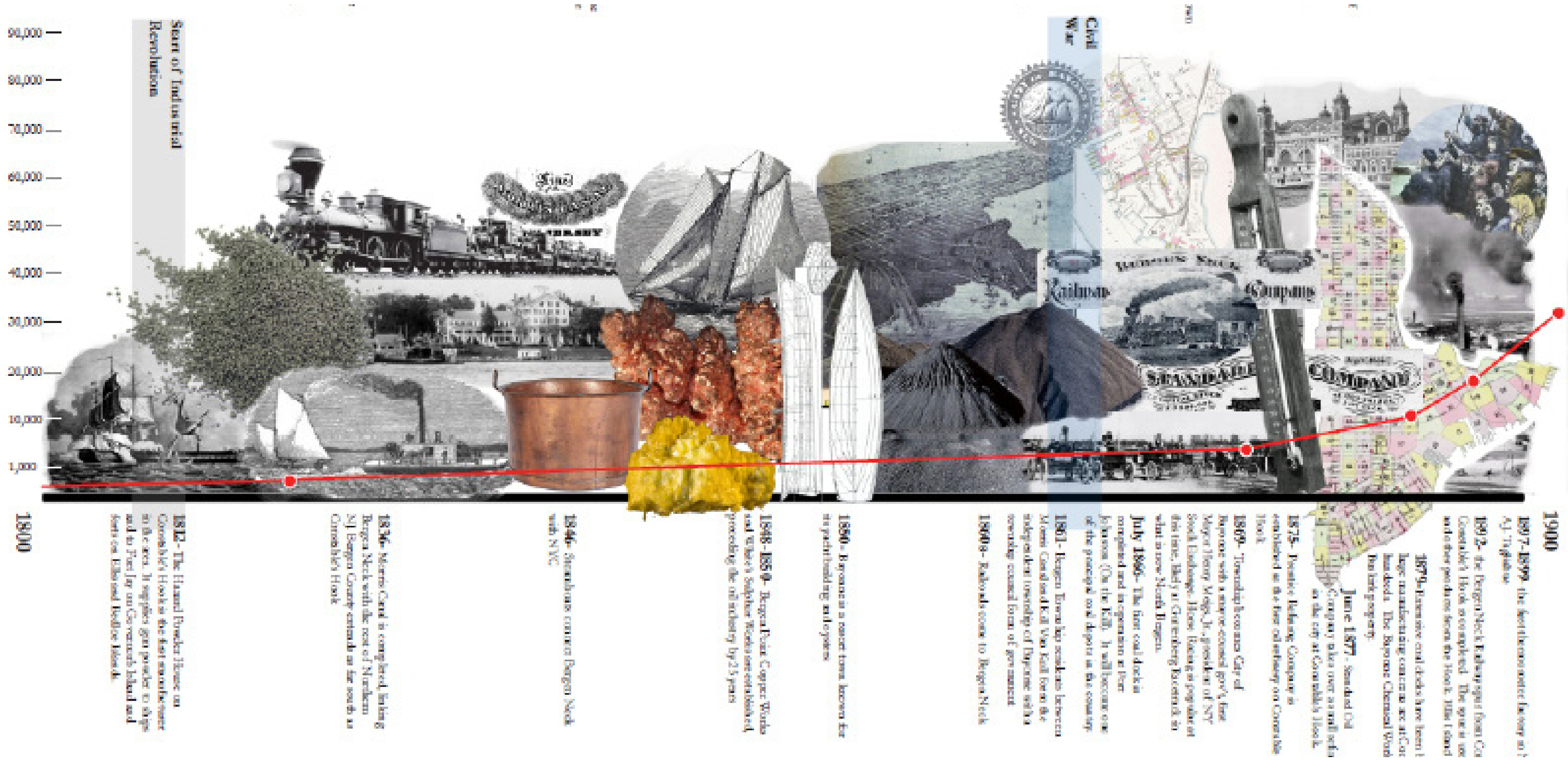
Case Study	Location	Years active	Habitat Typ	Project type	Project Description/Goals	Funding & Cost	Additional Information	Website
Poplar Island	Chesapeake Bay, Talbot County, Maryland, USA	2007-current (expected end date 2029)	Island	dredge materials, built island	Long term environmental restoration of poplar island. 68 million cy of clean dredge from the approach channels of Baltimore harbor protected by 35,000 ft of dikes to restore poplar island. Half of the island is upland habitat and the other half is wetland. Expansion of poplar island was approved in 2007 to add 575 acres to the island as well as raise upward dikes. Final island will have 1,715 acres of habitat: 776 acres of wetland, 829 acres upland, 110 acres embayment	75% USACE, 25% MDOT 667 million	I1847: 1,140 acres ->1990 5 acres -> 2005 1,140 acres. 1990 clusters of low marshy knolls & tidal mudflats. Engineers placed 35,000 ft of containment dike of sand, rock, and stone, pumped in dredge material, and shaped the sediment.Is a hige success story of diamondback terrapins and bird habitat	https://www.nab.usace.army.mil/Missions/Environmental/Poplar-Island/ http://www.poplarislandrestoration.com/Home/About
Elders Point East	Jamaica Bay, NYC, NY, USA	2007	Wetlands/Island	dredge materials, island restoration	The USACE used 200,000 cubic yards of dredged sediments from the NY-NJ channel to restore 40-acres of marshland and to replant *Spartina alterniflora.*	approximately 15 million dollars 65% federal government and 35% of the cost split between the state and city of New York.	Elders point was originally a 132-acre wide island in Jamaica Bay, New York City. Due to erosion and loss of marshland, the land mass was separated into Elders point East and West, connected by a mudflat.	https://www.nan.usace.army.mil/Portals/37/docs/Environmental/Appendix%20E2.pdf?ver=2017-03-02-113002-417
Hamilton Wetlands Complex	Marin County, California, USA	2008-current	Wetlands	Dredge materials, wetland restoration	Originally a wetland, this site was diked, drained, and transformed into an Air Base. In 2008, 6 million cubic yards of dredged sediment, primarily from the Port of Oakland's Harbor Deepening Project, was placed to create 648 acres of restored wetland. The goals of the project were to breach the existing Bayfront levee and construct a new one, to restore former wetlands, and to provide lasting flood protection for the surrounding areas.	286,219,000 dollars, of which 25% is paid for by the state coastal conservancy and the remainding is funded by the USACE	The restored island includes intertidal marsh and mudflat, seasonal wetlands, and upland areas, and is continuously monitored as part of an adaptive restoration plan. It is a habitat for migratory birds, salt marsh harvest mice, and includes a 2.7 mile trail for public access.	https://hamiltonwetlands.scc.ca.gov/about/
Breton Island	Plaquemines Parish, Louisiana	1998-Current	Island	Dredge materials, island restoration	The USACE placed 1.1 million cubic yards of dredged material from the Mississippi-Gulf Outlet to restore 29 acres of the island, as well as 620 acres of shallow intertidal waters	The total project cost approximately 1 million dollars, of which 75% was federally funded and 25% was state funded.	The island is now a part of the natural system that protects the coast of Louisiana, as well a habitat for migratory birds and water fowl. It has been identified as a potential site for shallow water seagrass beds.	https://www.epa.gov/sites/production/files/2015-08/documents/role_of_the_federal_standard_in_the_beneficial_use_of_dredged_material.pdf https://ascelibrary.org/doi/10.1061/40680%282003%2913

II. ANALYSIS

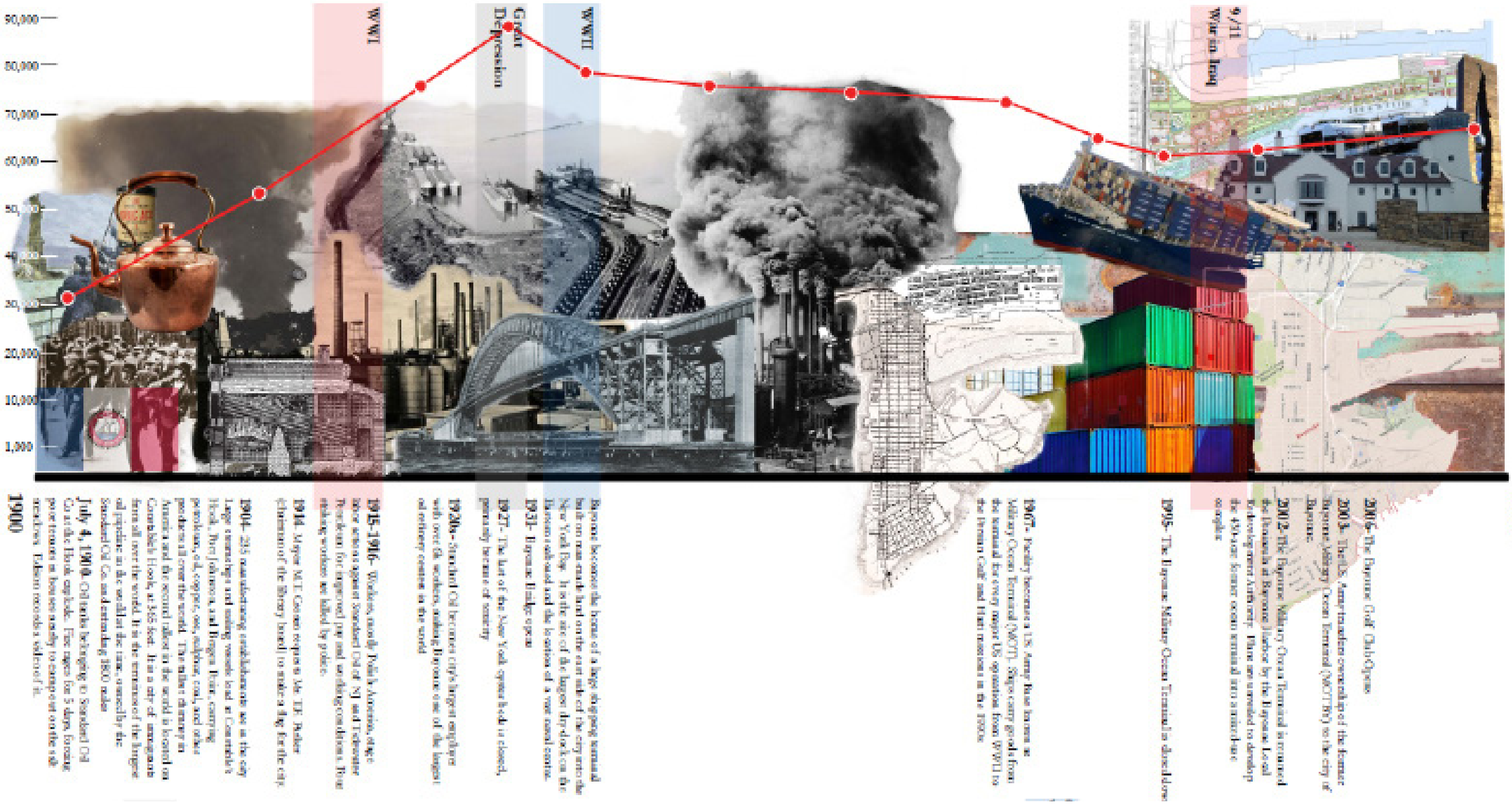
SITE HISTORY



Source: Rutgers, F. Gallagher Praxis Studio - 2019

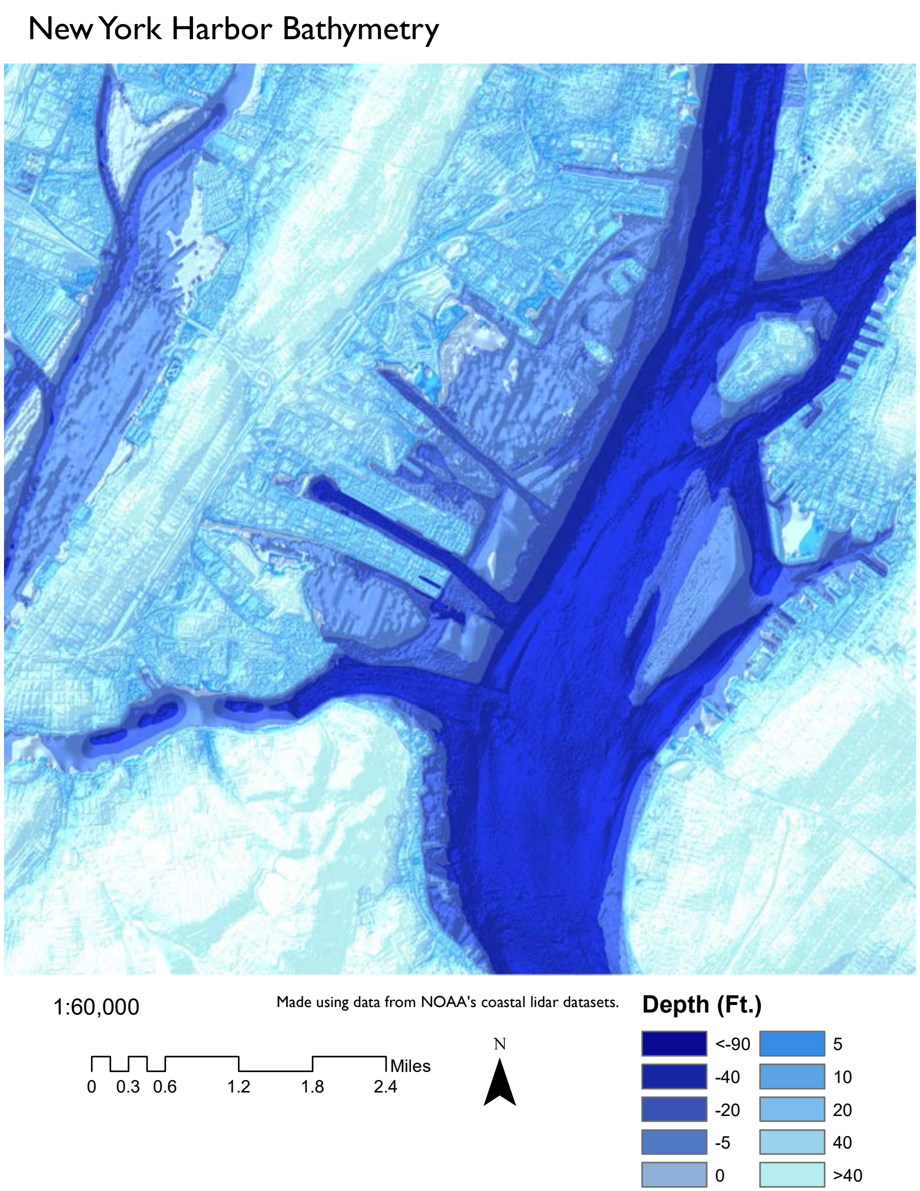


Source: Rutgers, F. Gallagher Praxis Studio - 2019



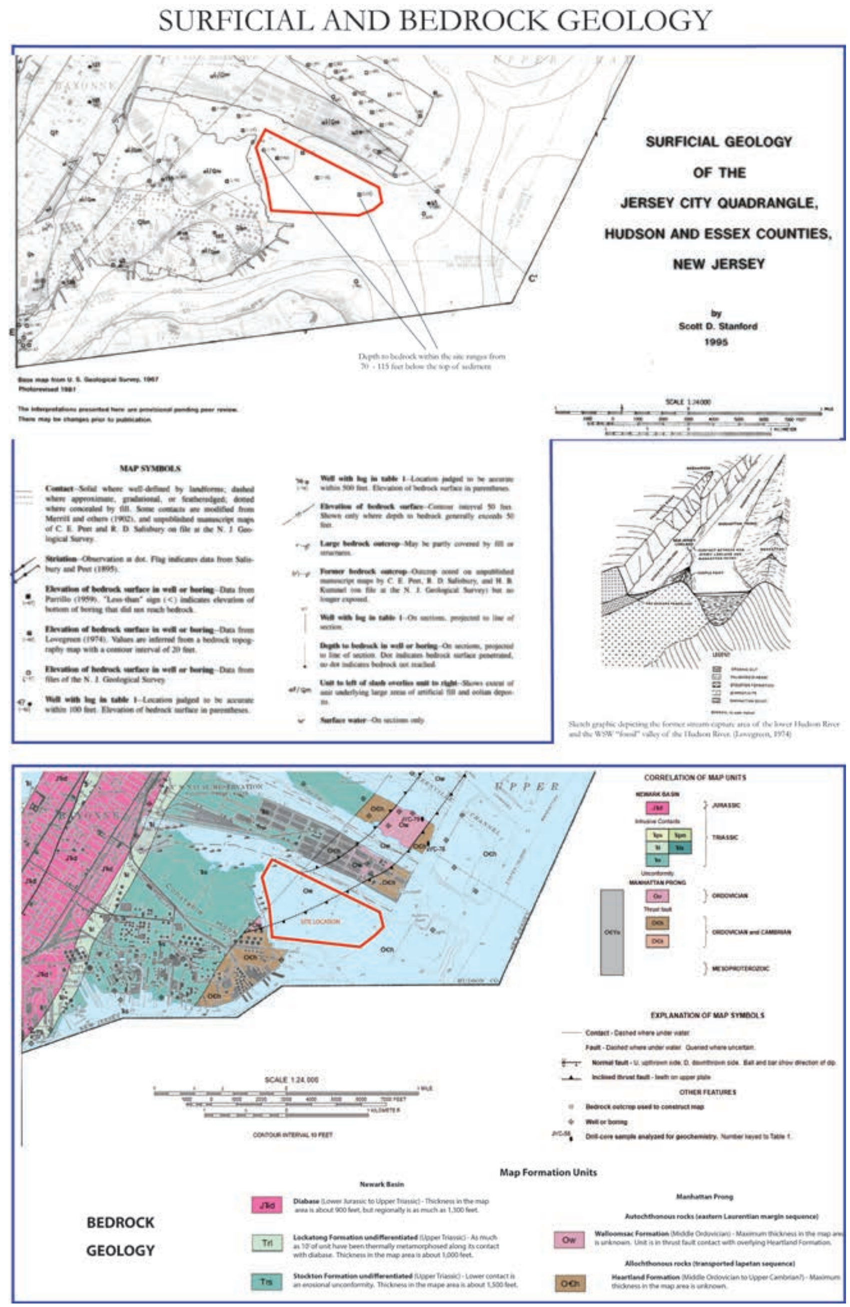
Source: Rutgers, F. Gallagher Praxis Studio - 2019

BATHYMETRIC MAP

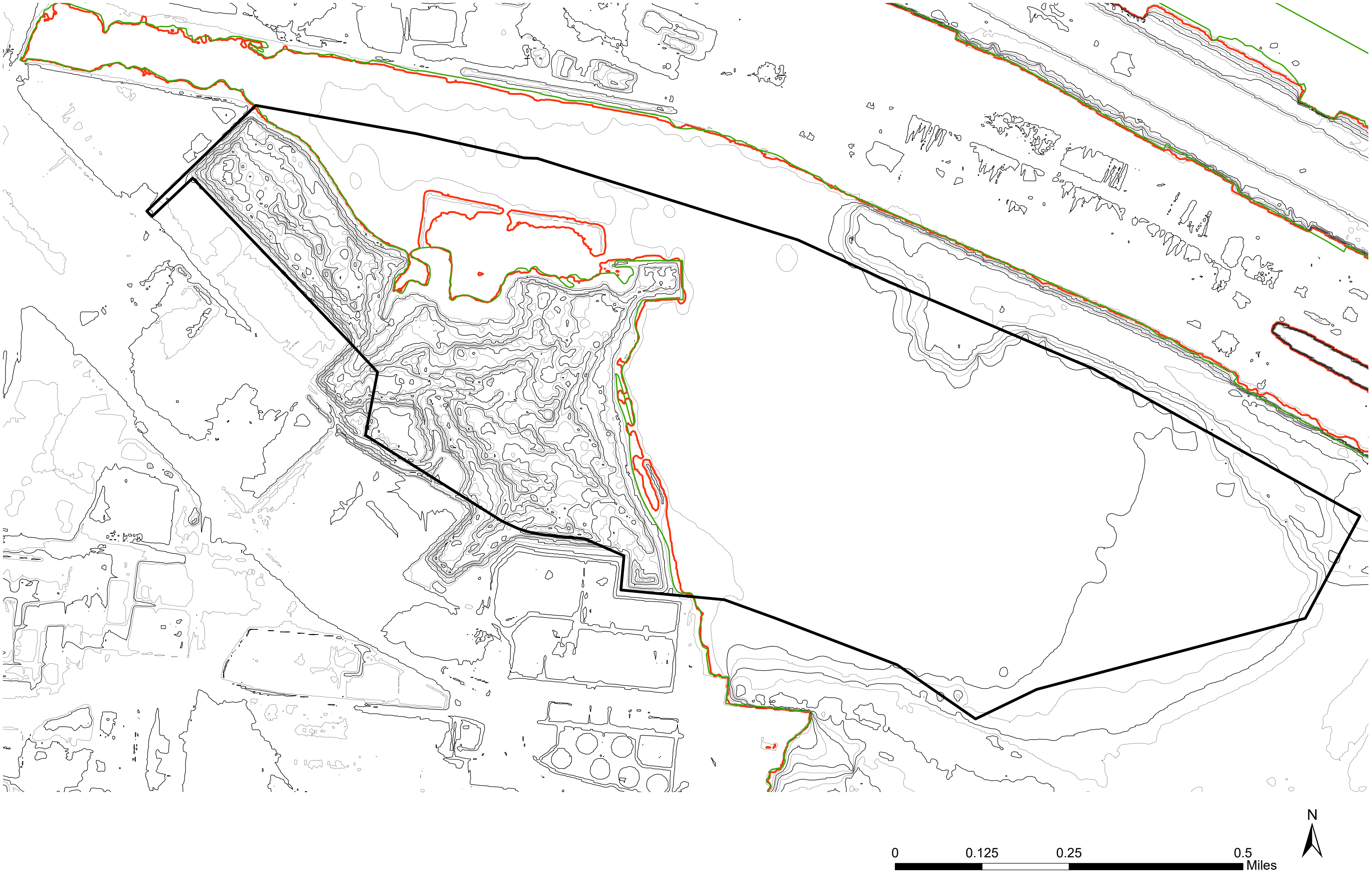


Bathymetry Source: https://maps.ngdc.noaa.gov/viewers/bathymetry/
Geology Source: Bedrock Geologic Map of the Jersey City Quadrangle - Open File Map OFM 110
Surficial Source: Surficial Geology of the Jersey City Quadrangle - Open File Map OFM 20

GEOLOGY MAP



SITE BASE MAP



Source: NJDEP DEM raster data

SITE BENEFITS DATA CALCULATIONS

Coastline protection

Coastline protection was found using Google Earth's path measurement method. The meas-urement was done by contouring along the coastlines inside the contract area. Also includes coastlines on the opposite side of the channel that is adjacent to the contract area.

Land protection

Land protection was found using Google Earth's polygon measurement method. The meas-urement includes areas behind the coastlines outlined as part of coastline protection.

New forest

The rough estimate was made by assessing the AutoCAD renders of the proposed island.

Carbon capture

The amount of carbon consumed by trees is found using the common ratio of tree acreage and tree carbon capture. This calculation also assumes that the land area for trees is the one we proposed in the designs mentioned above.

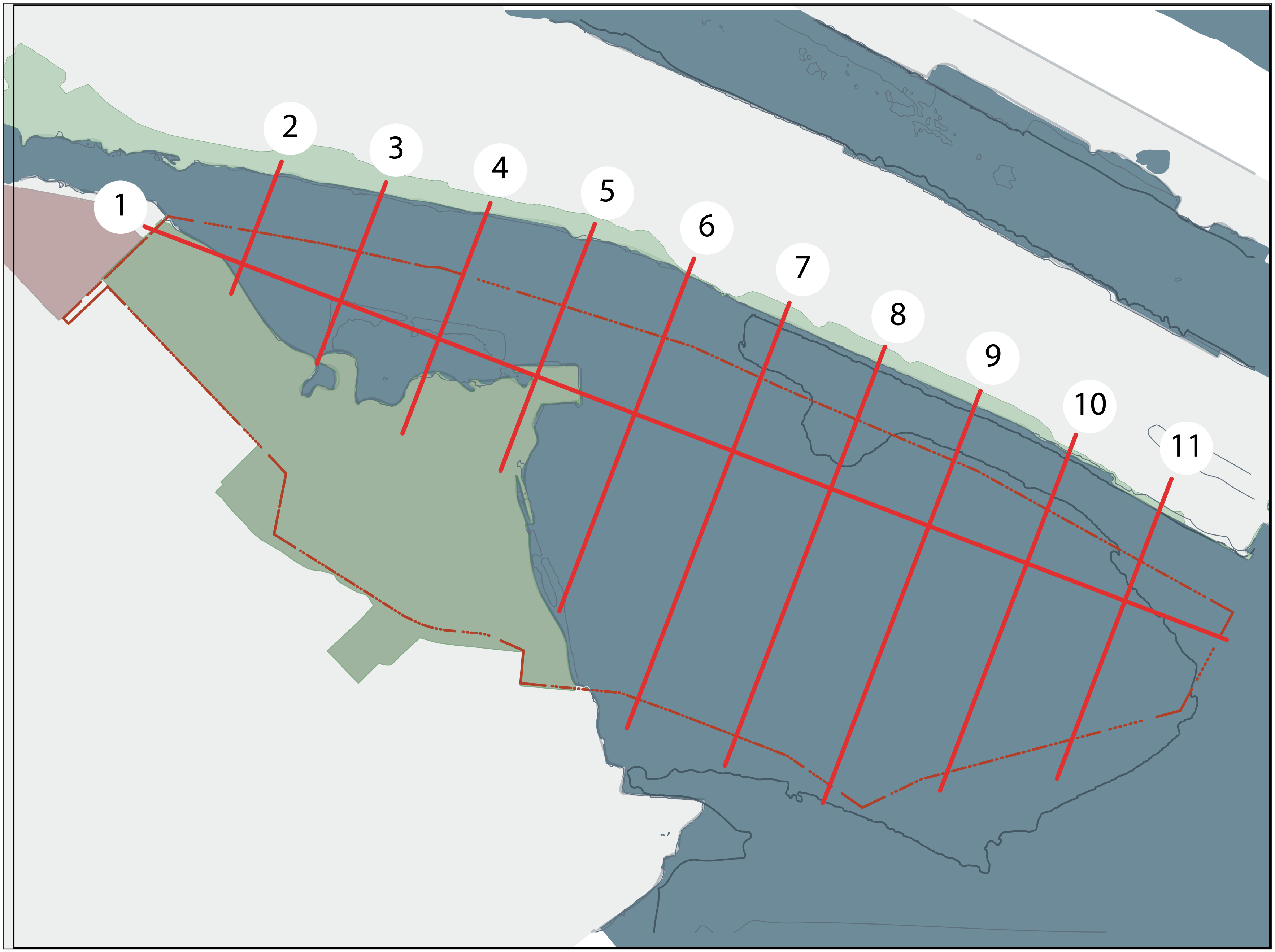
Water storage

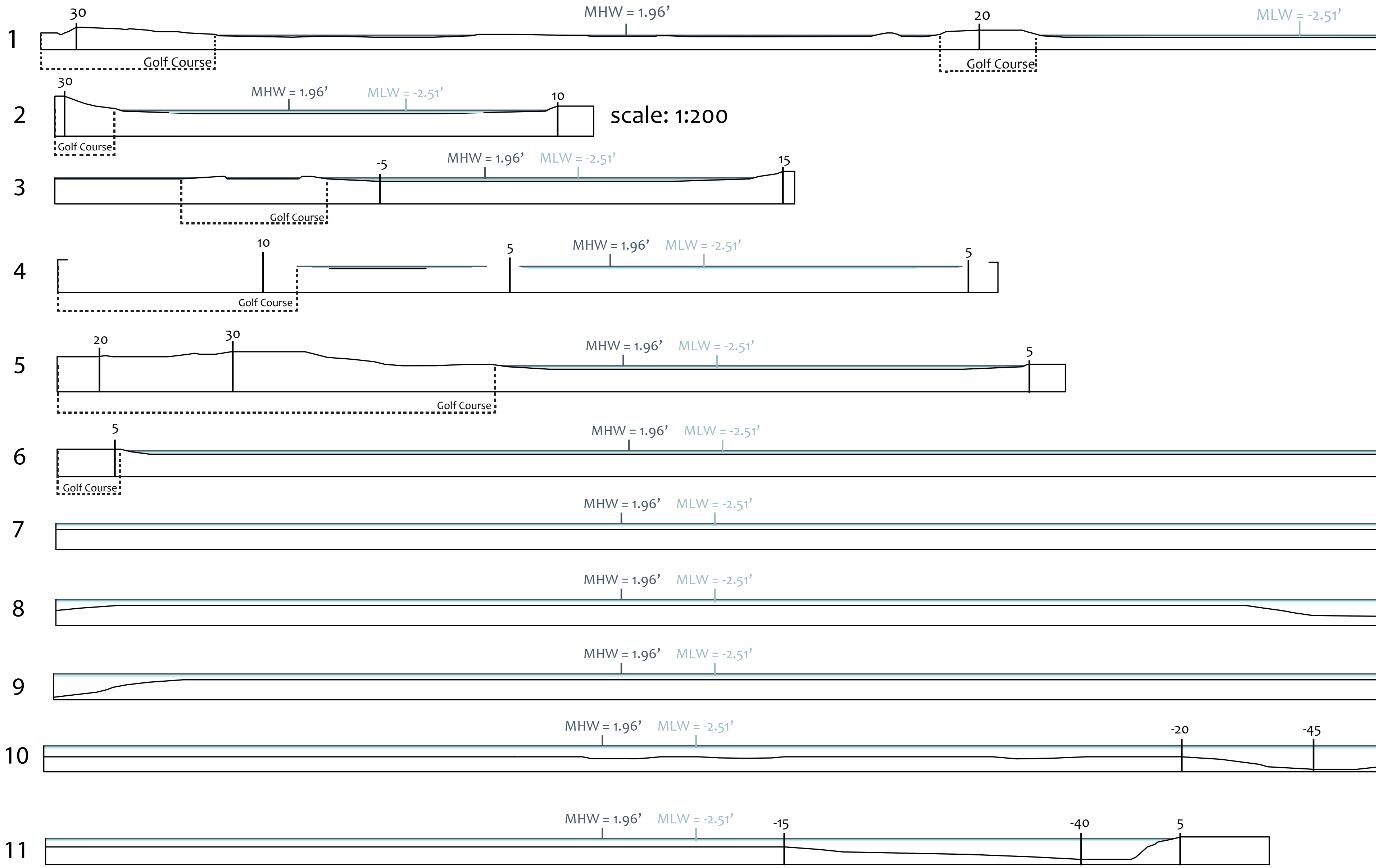
The storage capacity of the island is made by estimating the area which the island occupies. This allows the assessment of an ideal watershed which will be the container for the water. The soil present in the watershed is necessary to determine the void space which water can fill. In this case, the assumption of the soil type is sand.

Education

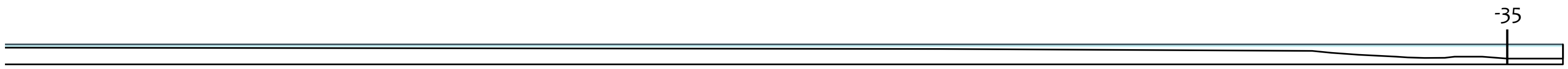
The number of students and schools in Bayonne was found in the data provided by National Center for Education Statistics (NCES). Website: https://nces.ed.gov/ccd/districtsearch/district_detail.asp?-Search=2&details=1&ID2=3401260&DistrictID=3401260

SITE SECTIONS (CURRENT CONDITIONS)

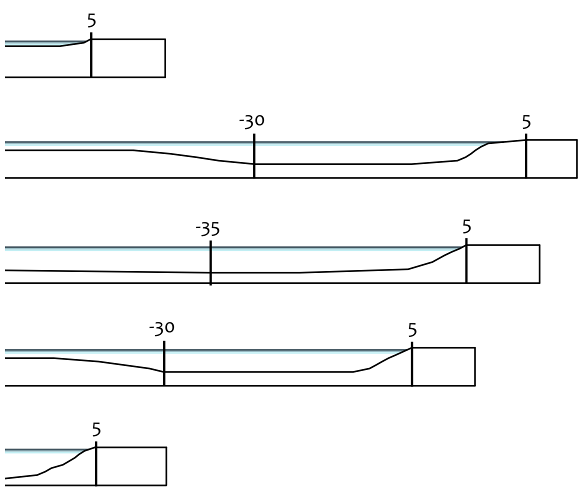



1
30
MHW = 1.96’
20
MLW = -2.51’
Golf Course
Golf Course
2
30
MHW = 1.96’
MLW = -2.51’
10
Golf Course
scale: 1:200
3
-5
MHW = 1.96’
MLW = -2.51’
15
Golf Course
4
10
5
MHW = 1.96’
MLW = -2.51’
5
Golf Course
5
20
30
MHW = 1.96’
MLW = -2.51’
5
Golf Course
6
5
MHW = 1.96’
MLW = -2.51’
Golf Course
7
MHW = 1.96’
MLW = -2.51’
8
MHW = 1.96’
MLW = -2.51’
9
MHW = 1.96’
MLW = -2.51’
10
MHW = 1.96’
MLW = -2.51’
-20
-45
11
MHW = 1.96’
MLW = -2.51’
-15
-40
5

scale: 1:200



scale: 1:100



LAND USE LAND COVER CLASSIFICATION SYSTEM

NJDEP MODIFIED ANDERSON SYSTEM 2002

Derived from: A Land Use and Land Cover Classification System for Use with Remote Sensor Data, U. S. Geological Survey Professional Paper 964, 1976; edited by NJDEP, OIRM, BGIA, 1998, 2000, 2001, 2002, 2005, 2007. (Classes used in NJDEP mapping programs shown in **bold**)

1000 URBAN OR BUILT-UP LAND

The Level 1 Urban or Built-up Land category is characterized by intensive land use where the landscape has been altered by human activities. Although structures are usually present, this category is not restricted to traditional urban areas. Urban or Built-up Land Level II categories include Residential; Commercial and Service; Industrial; Transportation, Communication and Utilities; Industrial and Commercial Complexes; Mixed Urban or Built-up; Other Urban or Build-up and Recreational. Included with each of the above land uses are associated lands, buildings, parking lots, access roads, and other appurtenances, unless these are specifically excluded.

Urban or Built-up Land takes precedence over other categories when the criteria for more than one category are met. For example, recreational areas that have enough tree cover to meet Forest category criteria are placed in the Recreational category.

1100 RESIDENTIAL

The residential category includes single-family residences, multiple-unit dwellings and mobile homes. Also included is the mixed residential group, which is comprised of two or more of the above groups. Residential areas are easily identified on aerial photographs by the shapes and patterns of individual houses, housing developments and multiple dwelling (apartment or condominium) complexes. They can also be identified by their proximity to urban centers or roadways.

Residential areas which are integral parts of other land uses and located on the site of that land use are included in that land use category. For example, residential units may be found on military bases or on college campuses in the form of barracks, apartments or dormitories. These residences would be mapped as their associated land use.

Residential area categories are based on density in terms of dwelling units per acre (DUPA). In order to determine density at Level III mapping scale, an acre grid is placed over residential areas on the photoquad base map and the number of residential structures or portions of a structure is counted. An average number of dwelling units per acre is determined and the area is mapped accordingly. Multiple unit structures, such as 2 or 3-family homes, may be included within single-unit residential areas since they are not extensive enough to be mapped individually. Also, commercial areas too small to be mapped separately may be found within residential areas.

1200 COMMERCIAL & SERVICES

Areas that contain structures predominantly used for the sale of products and services are classified as Commercial and Services.

The main building, secondary structures and supporting areas such as parking lots, driveways and landscaped areas are also placed under this category, (unless the landscaped areas are greater than 1 acre in size in which case they are put into a separate category). Sometimes non-commercial uses such as residential or industrial intermix with commercial uses making it difficult to identify the predominant land use. These categories are not separated out; but, if they exceed 1/3 of the total commercial area, the Mixed Urban category (16) is used. Often, specific uses of some commercial and services buildings cannot be easily identified from photography alone. Some supplemental information is required. These areas generally have a high percentage of impervious surface coverage. Any of the specific uses listed below may be included in the 1200 category, with the exception of Military Installations which are delineated separately under the code 1211.

1300 INDUSTRIAL

This category encompasses a great variety of structure types and land uses. Light and heavy industry are comprised of land uses where manufacturing, assembly or processing of products takes place. Power generation is included here because of its similarity to heavy industry. These areas generally have a high percentage of impervious surface coverage.

1400 TRANSPORTATION, COMMUNICATION & UTILITIES

The transportation, communication, and utilities land uses are often associated with the other Urban or Built-up categories, but are often found in other categories. However, they often do not meet minimum mappable size and are considered an integral part of the land use in which they occur. The presence of major transportation routes, utilities such as sewage treatment plants and power lines, power substations, and communication facilities greatly influence both the present and potential uses of an area. These areas generally have a high percentage of impervious surface coverage.

1500 INDUSTRIAL & COMMERCIAL COMPLEXES

The Industrial and Commercial Complexes category includes those industrial and commercial land uses that typically occur together or in close proximity. These areas are commonly referred to as "Industrial or Commercial Parks." The major types of business establishments located in these planned industrial and commercial parks are light manufacturing, administration offices, research and development facilities, and computer systems companies. Also found here are facilities for warehousing, wholesaling, retailing and distributing.

Industrial and Commercial Complexes are usually located in suburban or rural areas. The key identifying feature is the planned layout of buildings exhibiting the same or very similar construction. Other identifying features include well kept lawns and landscaped areas, ample parking areas and common roadways connecting buildings that also provide access to major highways. The lack of smokestacks, storage tanks, raw materials or finished products, and waste signifies that no heavy industries are present. These areas generally

have a high percentage of impervious surface coverage (~85%) and some may be up to 100%.

1600 MIXED URBAN OR BUILT-UP

This category includes those urban or built-up areas for which uses cannot be separated into individual categories at the mapping scale employed. Areas are identified under the mixed urban category when more than one-third intermixture of another use or uses is evident.

Uses considered in mixed urban include primarily residential, commercial/service, industrial and transportation/communication/utility. Not included in the category are areas considered part of a definable commercial strip as described under 1202. In addition, open land that could be classified for any agricultural use would not be included in the mixed urban category.

1700 OTHER URBAN OR BUILT-UP

Included are undeveloped, open lands within, adjacent to or associated with urban areas. Some structures may be visible, as in the case of abandoned residential or commercial sites that have not yet been redeveloped. The land cover in these areas may be brush-covered or grassy. Large, managed, maintained lawns common to some residential areas, and those open areas of commercial/service complexes, educational installations, etc., are also included. Undeveloped, but maintained lawns in urban parks are also part of this category, if a specific recreational use is not evident. In addition, areas that have been partially developed or redeveloped but remain unfinished are included. Cemeteries were included in this category in 1986 & 1995, but were separated out for 2002.

1800 RECREATIONAL LAND

Under this category are included those areas which have been specifically developed for recreational activities, if these areas are open to the general public. Any facilities that are part of a resort complex and open only to patrons of the hotel or motel are not mapped under category 18, but under Commercial and Services category. Facilities mapped as recreational land may charge user fees to the public, such as public golf courses; or, they may be free to the public, such as ball fields on public school grounds. Level III divisions of this category involve identifying the predominant recreational uses of the areas.

5000 WATER

All areas within the landmass of New Jersey periodically water covered are included in this category. All water bodies should be delineated as they exist at the time of data acquisition, except areas in an obvious state of flood. Level I includes four (4) Level II categories; Streams and Canals; Natural Lakes; Artificial Lakes; and Bays and Estuaries. Not included in this category are water treatment and sewage treatment facilities.

5300 ARTIFICIAL LAKES & RESERVOIRS

Artificial impoundments of water larger than three (3) acres used for irrigation, flood control, municipal water supplies, recreation, landscaping and hydro-electric power or the result of an active extractive operation are included in this category. Dams, bulkheads, spillways and other water control structures should be evident and are critical for accurately identifying these features. Also important to remember is that artificial lakes and reservoirs are charged primarily through linear WCs. Photo identification should key on the non-linear shapes of these features, the water control structures, and the signatures discussed in category 5100. All water reservoirs supporting cranberry operations will be included, however, water within dikes will be included in the agriculture codes for the 2002 update.

6000 WETLANDS

The wetlands are those areas that are inundated or saturated by surface or ground waters at a frequency and duration sufficient to support vegetation adapted for life in saturated soil conditions. Included in this category are naturally vegetated swamps, marshes, bogs and savannas which are normally associated with topographically low elevations but may be located at any elevation where water perches over an aquiclude. Wetlands that have been modified for recreation, agriculture, or industry will not be included here but described under the specific use category.

The wetlands of New Jersey are located around the numerous interior stream systems, and along our coastal rivers and bays. New Jersey, by its numerous different physiographic regions, supports various wetland habitats dependent upon physiographic and geological variables. The Level II classification separates wetlands into two categories based on the location relative to a tidal water system.

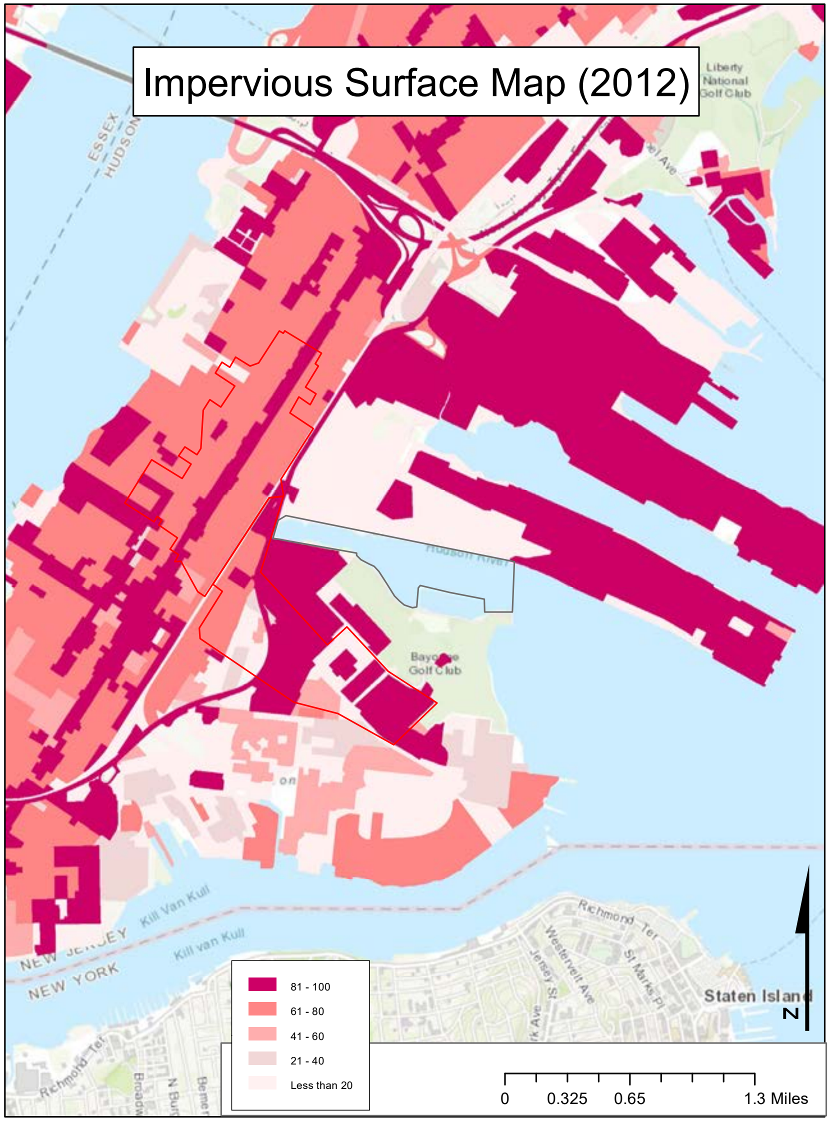
7400 ALTERED LANDS

Altered lands are areas outside of an urban setting that have been changed due to man's activities other than for mining.

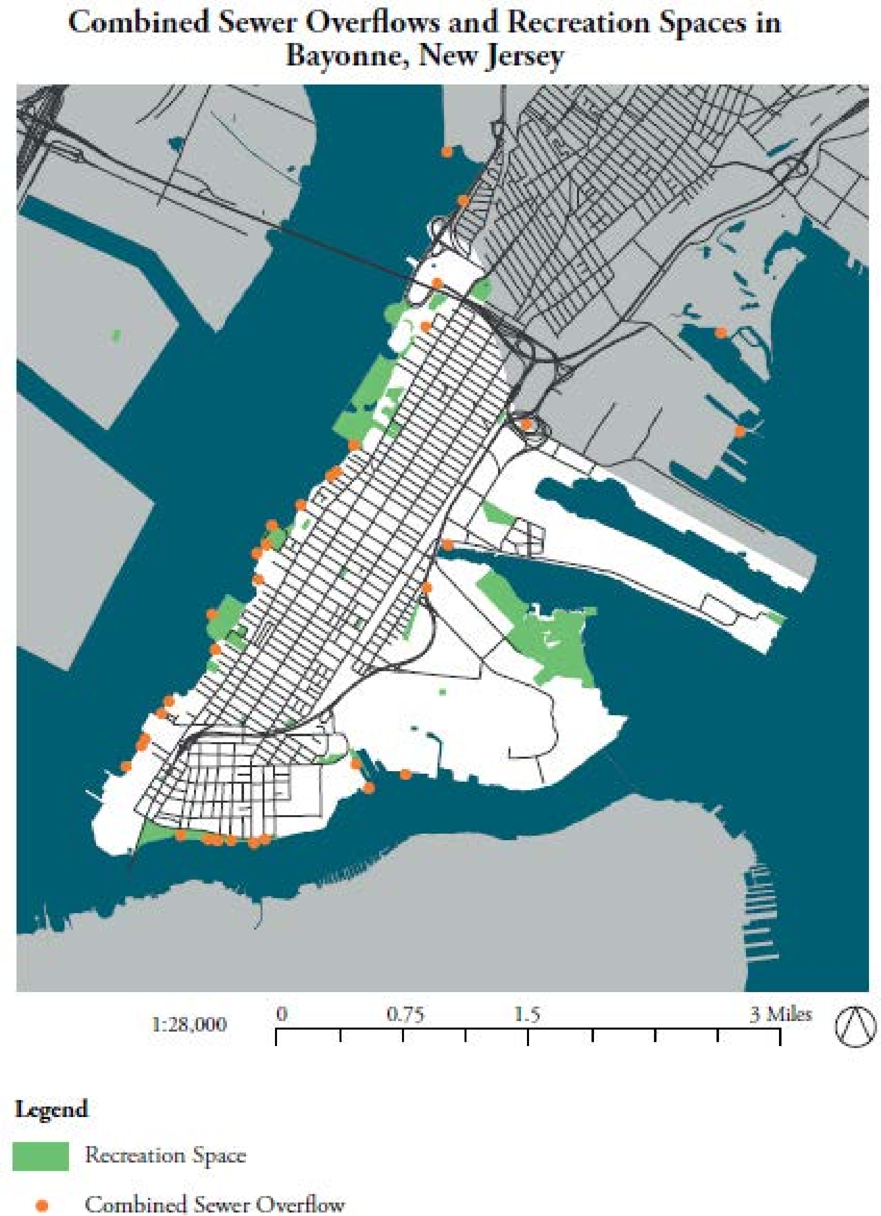
7500 TRANSITIONAL AREAS

This category encompasses lands on which site preparation for a variety of development types has begun. However, the future land use has not been realized. Included are residential, commercial and industrial areas under construction. Also, areas that are under construction for unknown use and abandoned structures are included. These areas are usually sparsely vegetated.

IMPERVIOUS SURFACE & CSOs



Source: NJDEP Land Use data and https://njwebmap.state.nj.us/arcgis/services



Source: NJDEP Land Use data and https://njwebmap.state.nj.us/arcgis/services

FLOODING & STORM SURGE

Source: NOAA and http://www.njfloodmapper.org/slr/

Flooding and Storm Surge Info - http://www.njfloodmapper.org/slr/

Overview: This map shows high-risk (1% annual chance or 100-year floodplain; Zones A, AE, AO, VE) and moderate-risk (0.2% annual chance or 500-year floodplain; Zone X) flood zones designated by the Federal Emergency Management Agency (FEMA).

Some parts of the flood zone may experience frequent flooding while other areas are only affected by severe storms. Areas outside of mapped zones may also be at risk since land use changes could have occurred after the maps were created, changing the flooding potential.

To designate the zones and determine insurance premiums, FEMA conducts flood insurance studies. Incorporated in the studies are statistical data for river flow and storm tides, hydrologic and hydraulic analyses, rainfall and topographic surveys, and storm frequency and intensity models.

This data is showing the Preliminary Flood Insurance Rate Maps (PFIRM). These maps have not been finalized, and are not available for all counties. Zooming in to a smaller area will display the Base Flood Elevation (BFE) in feet for a particular zone.

Legend

Zone A

Zone AE

Zone AO

Zone VE

Zone X - 0.2 Pct

Understanding the map: **Zone A** High-risk areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown.

Zone AE High-risk areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations (BFEs) are shown.

Zone AO High-risk areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet.

Zone VE High-risk areas subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action. Base Flood Elevations (BFEs) are shown.

Zone X - 0.2 Pct Moderate-risk areas subject to inundation by the 0.2-percent-annual-chance flood event generally determined using approximate methodologies.

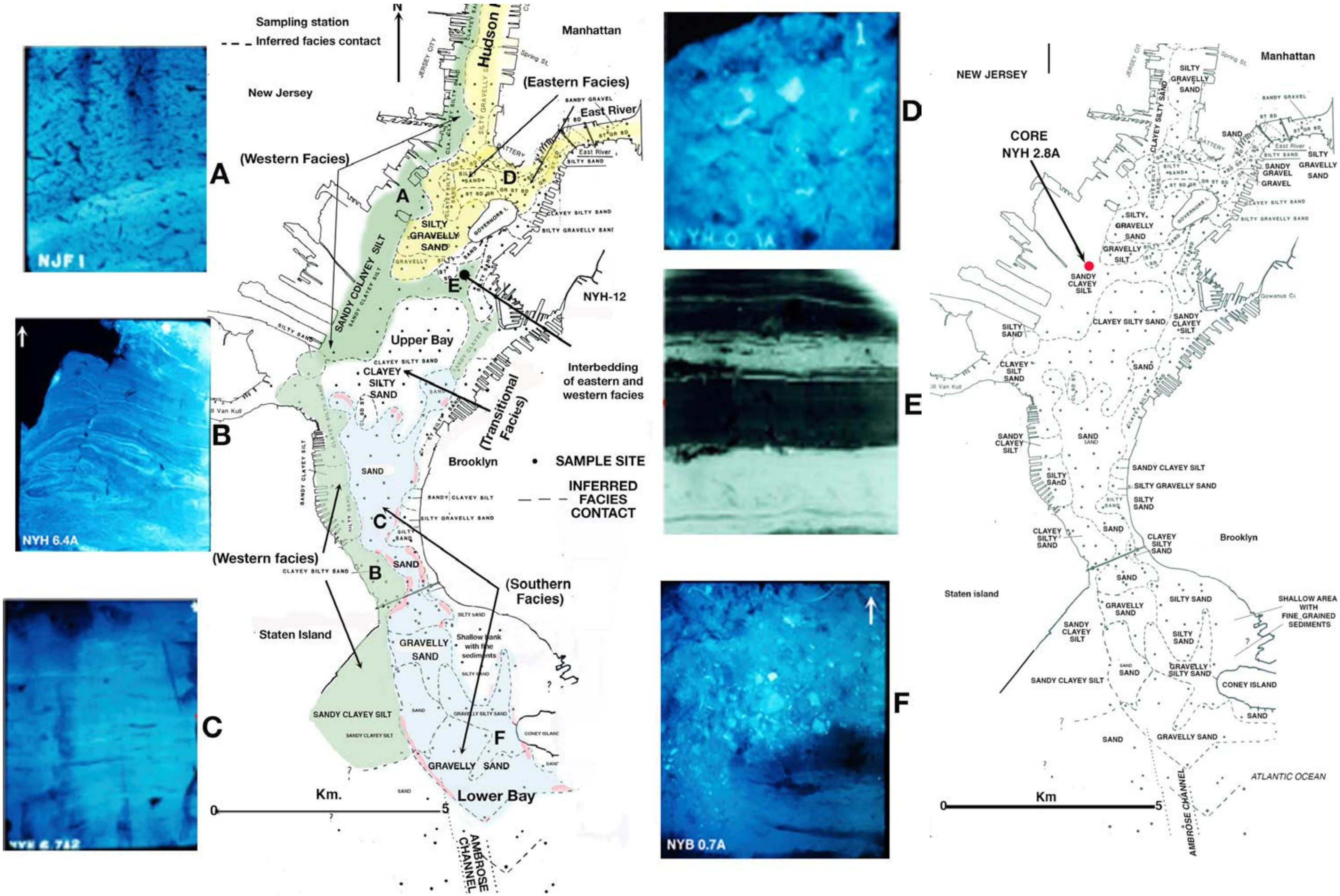
100 Year Flood Events Areas subject to inundation by a flood having a one-percent or greater probability of being equaled or exceeded during any given year.

500 Year Flood Events Areas subject to inundation by a flood having a 0.2 percent or greater probability of being equaled or exceeded during any given year.

Tidal Heights This map illustrates the extent of flood-prone coastal areas based on predicted water levels exceeding specific tidal heights as issued by local National Weather Service offices.

Frequency The coastal flood event frequencies and durations for tide gauges were calculated using observed tidal data over a three year period (2007-2009). The future frequency and duration predictions are based on the addition of half-meter and one-meter sea-level rise.

Source: NOAA and http://www.njfloodmapper.org/slr/

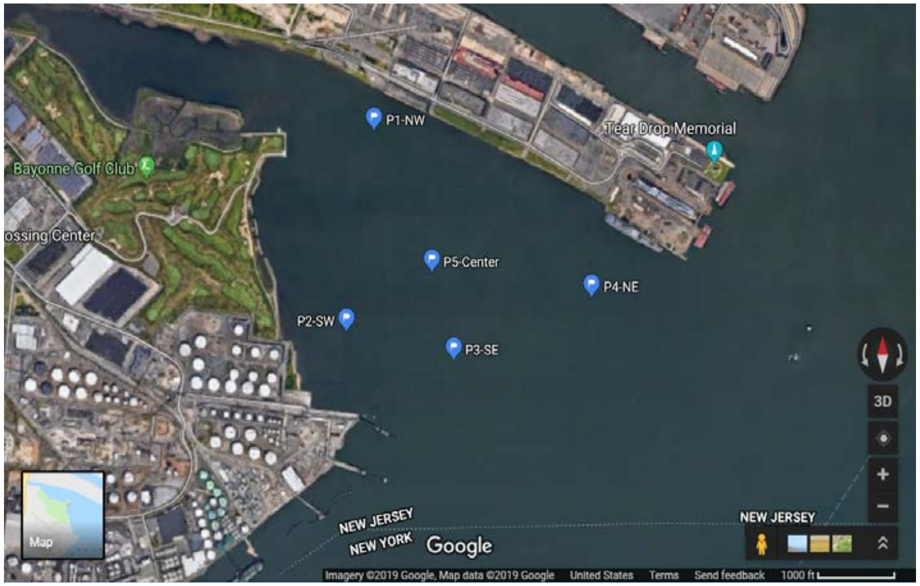


Source: Coch, N.K., 2016. Sediment dynamics in the Upper and Lower Bays of New York Harbor

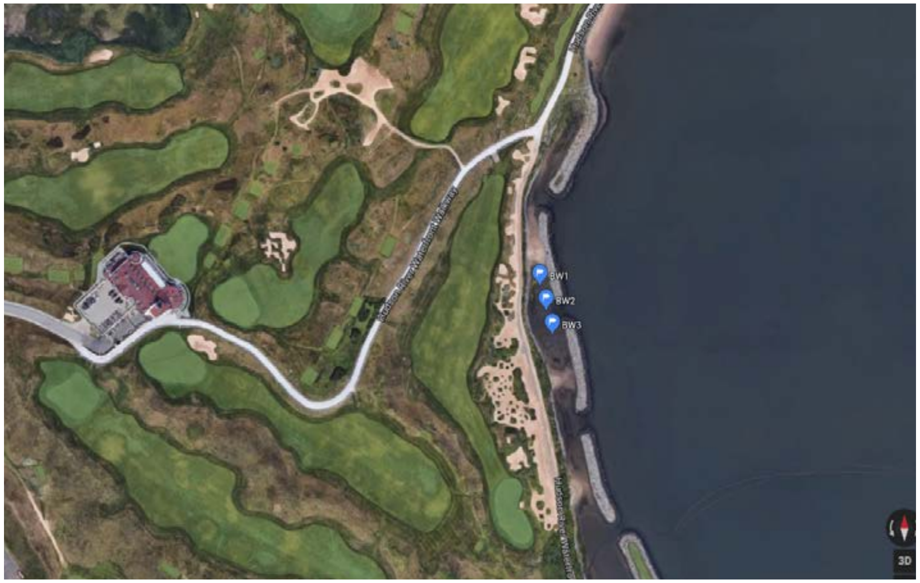
SEDIMENTATION AND WATER QUALITY (CONT.)
Stevens Institute Data

Field Sampling Locations

LOCATION_CODE	LATITUDE	LONGTITUDE	LATITUDE	LONGTITUDE
P1-NW	40°39.889'N	74°05.123'W	40.664817	-74.085383
P2-SW	40° 39.484'N	74° 05.201'W	40.658067	-74.086683
P3-SE	40° 39.426'N	74° 04.896'W	40.6571	-74.0816
P4-NE	40° 39.553'N	74° 04.503'W	40.659217	-74.07505
P5-Center	40° 39.603'N	74° 04.958'W	40.66005	-74.082633
BW1	40°39'44.1"N	74°05'28.6"W	40.66225	-74.091266
BW2	40°39'43.5"N	74°05'28.4"W	40.662095	-74.091213
BW3	40°39'43.0"N	74°05'28.2"W	40.661951	-74.091164



Map of Locations P1-P5.



Map of Locations BW1-BW3.

Water Quality Data

Sampling_Date	Day/night	Weather_condition	Tide	Location_Code	Latitude	Longtitude	pH	Salinity(ppt)	DO(ppm)	Turbidity(NTU)	Secchi_Depth(feet)	Water_temperature;C
4/4/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	9.52	13.3	7.25	3.12	NA	NA
4/4/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	8.77	13.4	6.92	3.89	NA	13.6
4/4/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	8.61	13.8	8.74	4.33	NA	11.3
4/4/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	8.63	14	7.33	4.67	NA	12.4
4/4/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	8.67	13.5	7.5	3.41	NA	13.6
4/24/2019	Day	Dry	High tide	P1-NW	40.66482	-74.085383	7.34	8.08	8.64	5.86	5	16.9
4/24/2019	Day	Dry	High tide	P2-SW	40.65807	-74.086683	7.51	9.55	7.24	8.7	4	18
4/24/2019	Day	Dry	High tide	P3-SE	40.6571	-74.0816	7.58	9.23	8.44	14.9	3	16.5
4/24/2019	Day	Dry	High tide	P4-NE	40.65922	-74.07505	8.05	8.52	8.44	6.91	2.5	17.8
4/24/2019	Day	Dry	High tide	P5-Center	40.66005	-74.082633	7.76	9.39	7.11	9.82	3	17.8
4/25/2019	Night	Dry	Ebb tide	P1-NW	40.66482	-74.085383	7.84	8.55	9.62	8.33	NA	11.4
4/25/2019	Night	Dry	Ebb tide	P2-SW	40.65807	-74.086683	7.87	8.22	10.45	8.91	NA	11.4
4/25/2019	Night	Dry	Ebb tide	P3-SE	40.6571	-74.0816	7.89	8.74	10.71	7.79	NA	11.2
4/25/2019	Night	Dry	Ebb tide	P4-NE	40.65922	-74.07505	7.95	8.57	11.09	7.54	NA	11.5
4/25/2019	Night	Dry	Ebb tide	P5-Center	40.66005	-74.082633	7.85	8.51	7.33	7.37	NA	11.2
4/25/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	7.8	7.47	9.67	6.12	4	12.8
4/25/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	7.77	8.19	8.14	6.63	3.5	12.2
4/25/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	7.79	8.22	9.23	6.53	3.5	12.8
4/25/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	7.77	7.82	9.31	6.71	4	12.9
4/25/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	7.82	8.42	8.14	7.05	3.75	12.9
6/11/2019	Day	After rain event	Low tide	P1-NW	40.66482	-74.085383	7.32	15.1	6.8	4.54	4	20.7
6/11/2019	Day	After rain event	Low tide	P2-SW	40.65807	-74.086683	7.37	14	6.54	6.02	4	21.2
6/11/2019	Day	After rain event	Low tide	P3-SE	40.6571	-74.0816	7.42	14.8	6.64	8.09	3.5	20.1
6/11/2019	Day	After rain event	Low tide	P4-NE	40.65922	-74.07505	7.48	14.6	6.3	4.16	4	20.4
6/11/2019	Day	After rain event	Low tide	P5-Center	40.66005	-74.082633	7.33	15	6.7	7.17	3.5	19.9

Sampling_Date	Day/night	Weather_condition	Tide	Location_Code	Latitude	Longtitude	Mean Al(ppb)	SD Al(ppb)	Mean As(ppb)	SD As(ppb)	Mean Ba(ppb)	SD Ba(ppb)	Mean Cd(ppb)	SD Cd(ppb)
4/4/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	81.83	0.25	14.52	16.48	13.26	0.13	0.12	NA*
4/4/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	76.14	0.54	7.57	8.03	12.90	0.16	0.12	NA*
4/4/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	77.53	0.21	12.94	2.75	12.76	0.03	BDL	NA*
4/4/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	73.85	3.84	12.63	0.74	12.52	0.01	0.11	NA*
4/4/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	78.66	0.00	13.85	3.89	12.51	0.01	0.08	NA*
4/24/2019	Day	Dry	High tide	P1-NW	40.66482	-74.085383	65.37	0.59	4.86	2.87	13.92	0.02	BDL	NA*
4/24/2019	Day	Dry	High tide	P2-SW	40.65807	-74.086683	63.53	1.95	5.18	2.96	13.62	0.03	0.04	NA*
4/24/2019	Day	Dry	High tide	P3-SE	40.6571	-74.0816	64.06	1.22	14.52	0.34	13.47	0.03	BDL	NA*
4/24/2019	Day	Dry	High tide	P4-NE	40.65922	-74.07505	64.50	0.74	8.68	3.20	13.76	0.07	0.09	0.01
4/24/2019	Day	Dry	High tide	P5-Center	40.66005	-74.082633	63.46	1.67	6.95	4.59	13.33	0.01	0.06	0.06
4/25/2019	Night	Dry	Ebb tide	P1-NW	40.66482	-74.085383	58.13	0.47	7.76	0.88	13.70	0.06	BDL	NA*
4/25/2019	Night	Dry	Ebb tide	P2-SW	40.65807	-74.086683	67.56	0.11	8.98	3.26	13.68	0.05	BDL	NA*
4/25/2019	Night	Dry	Ebb tide	P3-SE	40.6571	-74.0816	58.84	0.22	7.72	7.78	13.45	0.01	BDL	NA*
4/25/2019	Night	Dry	Ebb tide	P4-NE	40.65922	-74.07505	61.05	0.11	1.73	NA*	13.41	0.07	BDL	NA*
4/25/2019	Night	Dry	Ebb tide	P5-Center	40.66005	-74.082633	60.16	1.90	6.92	7.38	13.73	0.04	BDL	NA*
4/25/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	58.19	0.56	2.10	1.34	13.74	0.13	BDL	NA*
4/25/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	57.74	0.12	16.87	NA*	13.76	0.01	0.11	NA*
4/25/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	59.88	2.22	9.74	11.70	13.66	0.04	0.03	NA*
4/25/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	60.28	1.54	6.58	3.87	13.52	0.02	0.04	NA*
4/25/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	61.43	0.78	2.01	1.95	13.70	0.03	BDL	NA*
6/11/2019	Day	After rain event	Low tide	P1-NW	40.66482	-74.085383	87.76	1.36	12.85	3.11	19.06	0.31	0.07	0.07
6/11/2019	Day	After rain event	Low tide	P2-SW	40.65807	-74.086683	84.91	0.69	18.63	NA*	19.59	0.56	0.20	0.04
6/11/2019	Day	After rain event	Low tide	P3-SE	40.6571	-74.0816	85.30	1.61	10.52	6.00	20.23	0.15	0.37	0.04
6/11/2019	Day	After rain event	Low tide	P4-NE	40.65922	-74.07505	87.09	2.26	11.43	9.29	20.10	0.57	0.42	0.26
6/11/2019	Day	After rain event	Low tide	P5-Center	40.66005	-74.082633	83.99	0.73	12.76	10.06	19.28	2.30	0.21	0.15

Sampling_Date	Day/night	Weather_condition	Tide	Location_Code	Latitude	Longtitude	Mean Cr(ppb)	SD Cr(ppb)	Mean Cu(ppb)	SD Cu(ppb)	Mean Fe(ppb)	SD Fe(ppb)	Mean Ni(ppb)	SD Ni(ppb)
4/4/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	1.15	0.21	10.95	0.42	1.53	NA*	0.32	0.39
4/4/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	1.27	0.14	10.31	0.00	BDL	NA*	0.48	0.12
4/4/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	1.05	0.31	10.16	0.35	BDL	NA*	BDL	NA*
4/4/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	1.20	0.41	9.88	0.10	BDL	NA*	0.34	NA*
4/4/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	1.07	0.33	10.09	0.01	BDL	NA*	0.36	0.23
4/24/2019	Day	Dry	High tide	P1-NW	40.66482	-74.085383	1.16	0.10	8.94	0.08	BDL	NA*	0.71	0.95
4/24/2019	Day	Dry	High tide	P2-SW	40.65807	-74.086683	0.88	0.06	8.40	0.64	BDL	NA*	0.55	0.42
4/24/2019	Day	Dry	High tide	P3-SE	40.6571	-74.0816	0.96	0.06	8.11	0.13	BDL	NA*	1.46	NA*
4/24/2019	Day	Dry	High tide	P4-NE	40.65922	-74.07505	1.09	0.01	8.50	0.00	BDL	NA*	1.12	NA*
4/24/2019	Day	Dry	High tide	P5-Center	40.66005	-74.082633	0.90	0.03	7.92	0.11	BDL	NA*	0.37	0.27
4/25/2019	Night	Dry	Ebb tide	P1-NW	40.66482	-74.085383	1.02	0.16	7.80	0.45	0.24	NA*	0.45	0.00
4/25/2019	Night	Dry	Ebb tide	P2-SW	40.65807	-74.086683	1.35	0.25	7.52	0.08	6.47	0.64	BDL	NA*
4/25/2019	Night	Dry	Ebb tide	P3-SE	40.6571	-74.0816	0.99	0.20	7.41	0.15	BDL	NA*	0.44	NA*
4/25/2019	Night	Dry	Ebb tide	P4-NE	40.65922	-74.07505	1.17	0.00	8.09	0.03	BDL	NA*	1.21	NA*
4/25/2019	Night	Dry	Ebb tide	P5-Center	40.66005	-74.082633	0.98	0.30	7.73	0.31	BDL	NA*	1.12	NA*
4/25/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	0.94	0.35	7.45	0.07	BDL	NA*	0.77	0.16
4/25/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	0.97	0.34	7.72	0.21	BDL	NA*	BDL	NA*
4/25/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	0.98	0.04	7.65	0.23	BDL	NA*	0.66	0.02
4/25/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	0.81	0.01	7.31	0.20	BDL	NA*	0.19	NA*
4/25/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	1.12	0.06	7.07	0.44	BDL	NA*	0.25	0.07
6/11/2019	Day	After rain event	Low tide	P1-NW	40.66482	-74.085383	0.67	0.30	10.94	0.46	0.51	NA*	1.27	0.31
6/11/2019	Day	After rain event	Low tide	P2-SW	40.65807	-74.085383	0.44	0.05	10.90	0.43	BDL	NA*	1.38	0.16
6/11/2019	Day	After rain event	Low tide	P3-SE	40.6571	-74.0816	0.50	0.11	10.92	0.15	BDL	NA*	1.20	0.60
6/11/2019	Day	After rain event	Low tide	P4-NE	40.65922	-74.07505	0.39	0.26	11.80	0.76	BDL	NA*	1.06	0.06
6/11/2019	Day	After rain event	Low tide	P5-Center	40.66005	-74.082633	0.73	0.19	10.42	0.90	BDL	NA*	1.97	0.70

Sampling_Date	Day/night	Weather_condition	Tide	Location_Code	Latitude	Longtitude	Mean Pb(ppb)	SD Pb(ppb)	Mean Se(ppb)	SD Se(ppb)	Mean Zn(ppb)	SD Zn(ppb)	Note
4/4/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	2.83	0.80	15.69	16.98	BDL	NA*	There was an error during measuring temperature at P1.
4/4/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	5.16	NA*	20.04	5.93	BDL	NA*	Therefore, the value was excluded.
4/4/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	2.17	0.92	22.29	7.88	BDL	NA*	
4/4/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	3.78	NA*	23.78	2.11	BDL	NA*	Secchi depth was not measured for this sampling event since we
4/4/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	2.60	0.65	11.19	9.58	BDL	NA*	obtained the secchi disc after this sampling event.
4/24/2019	Day	Dry	High tide	P1-NW	40.66482	-74.085383	BDL	NA*	9.30	5.17	BDL	NA*	
4/24/2019	Day	Dry	High tide	P2-SW	40.65807	-74.086683	2.20	2.73	3.83	1.50	BDL	NA*	
4/24/2019	Day	Dry	High tide	P3-SE	40.6571	-74.0816	1.91	1.93	3.78	1.51	BDL	NA*	
4/24/2019	Day	Dry	High tide	P4-NE	40.65922	-74.07505	1.39	NA*	9.56	9.61	BDL	NA*	
4/24/2019	Day	Dry	High tide	P5-Center	40.66005	-74.082633	2.55	1.03	12.05	12.61	BDL	NA*	
4/25/2019	Night	Dry	Ebb tide	P1-NW	40.66482	-74.085383	1.98	2.40	20.47	NA*	BDL	NA*	Secchi depth was not measured for this sampling event since it
4/25/2019	Night	Dry	Ebb tide	P2-SW	40.65807	-74.086683	0.96	0.72	5.13	5.69	BDL	NA*	was dark.
4/25/2019	Night	Dry	Ebb tide	P3-SE	40.6571	-74.0816	0.72	0.40	8.65	0.27	BDL	NA*	
4/25/2019	Night	Dry	Ebb tide	P4-NE	40.65922	-74.07505	1.41	NA*	14.95	2.02	BDL	NA*	
4/25/2019	Night	Dry	Ebb tide	P5-Center	40.66005	-74.082633	0.51	NA*	10.46	8.35	BDL	NA*	
4/25/2019	Day	Dry	Low tide	P1-NW	40.66482	-74.085383	1.58	1.61	13.11	NA*	BDL	NA*	
4/25/2019	Day	Dry	Low tide	P2-SW	40.65807	-74.086683	3.12	NA*	6.23	4.00	BDL	NA*	
4/25/2019	Day	Dry	Low tide	P3-SE	40.6571	-74.0816	0.45	0.31	5.85	1.48	BDL	NA*	
4/25/2019	Day	Dry	Low tide	P4-NE	40.65922	-74.07505	1.04	NA*	8.19	2.24	BDL	NA*	
4/25/2019	Day	Dry	Low tide	P5-Center	40.66005	-74.082633	1.26	0.71	3.94	2.58	BDL	NA*	
6/11/2019	Day	After rain event	Low tide	P1-NW	40.66482	-74.085383	0.30	NA*	37.29	10.65	BDL	NA*	
6/11/2019	Day	After rain event	Low tide	P2-SW	40.65807	-74.085383	4.41	NA*	24.91	6.35	BDL	NA*	
6/11/2019	Day	After rain event	Low tide	P3-SE	40.6571	-74.0816	BDL	NA*	33.98	5.04	BDL	NA*	
6/11/2019	Day	After rain event	Low tide	P4-NE	40.65922	-74.07505	BDL	NA*	45.49	12.10	7.40	NA*	
6/11/2019	Day	After rain event	Low tide	P5-Center	40.66005	-74.082633	5.13	NA*	33.10	8.45	0.59	NA*	

BDL: Below Detection Limit

pH, salinity, DO, turbidity, secchi depth, and water temperature were measured on-site. Dissolved metals (Al, As, Ba, Cd, Cr, Cu, Fe, Ni, Pb, Se, and Zn) were mesaured in the lab in duplicate, except 6/11/2019 samples that were measured in triplicate.

NA: Not Available, please see note column for the details

NA*: Standard deviation could not be calculated since less than two values were not BDL.

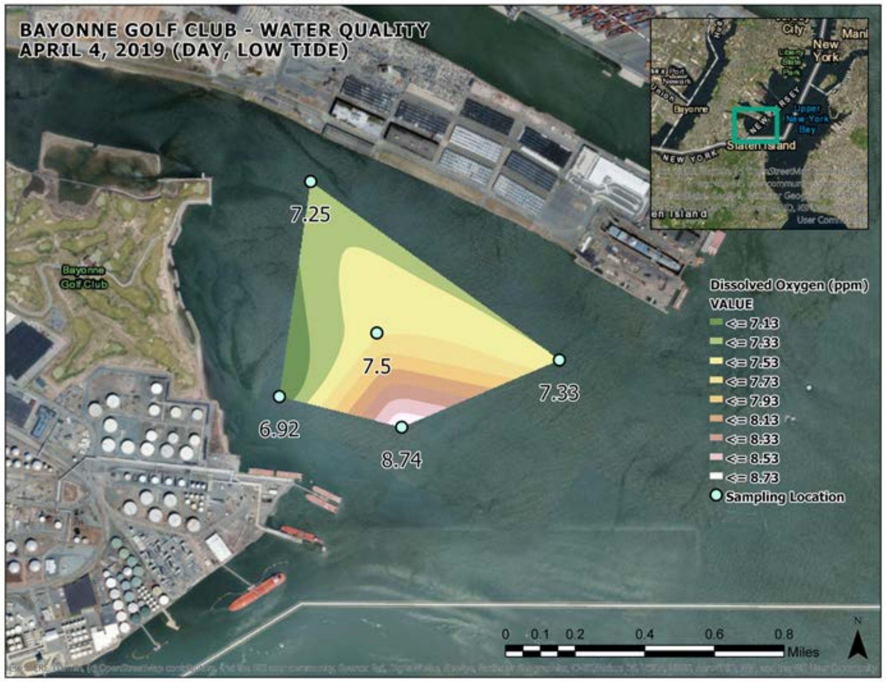

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
81.83
78.66
73.85
76.14
77.53
Al (ppb)
VALUE
<= 74.76
<= 75.64
<= 76.52
<= 77.40
<= 78.28
<= 79.16
<= 80.04
<= 80.92
<= 81.81
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
13.26
12.51
12.52
12.9
12.76
Ba (ppb)
VALUE
<= 12.59
<= 12.68
<= 12.76
<= 12.84
<= 12.93
<= 13.01
<= 13.09
<= 13.17
<= 13.26
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

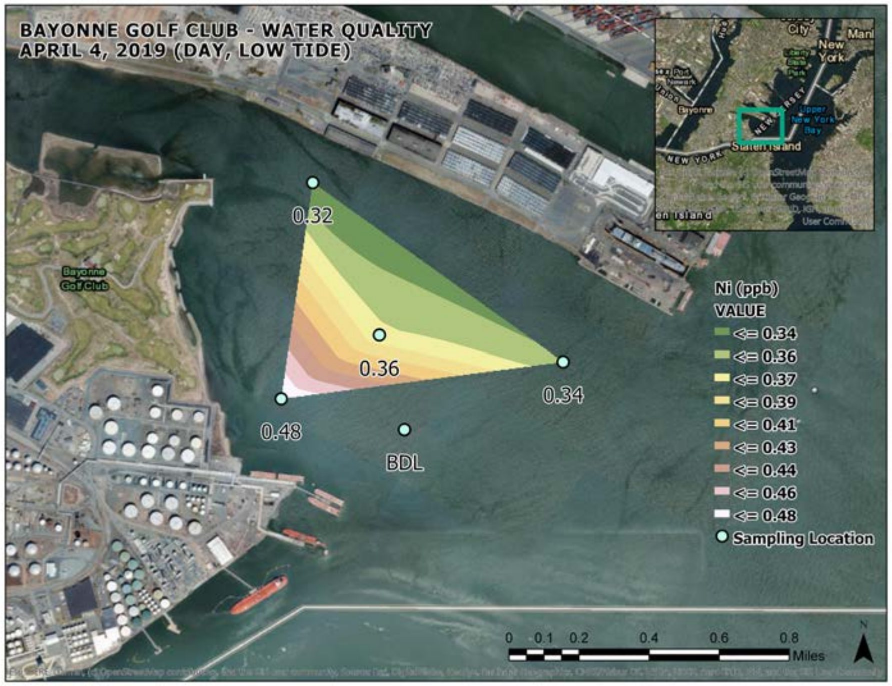

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
14.52
13.85
12.63
7.57
12.94
As (ppb)
VALUE
<= 8.40
<= 9.16
<= 9.93
<= 10.69
<= 11.45
<= 12.22
<= 12.98
<= 13.75
<= 14.51
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
0.12
0.08
0.11
0.12
BDL
Cd (ppb)
VALUE
<= 0.09
<= 0.10
<= 0.11
<= 0.12
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

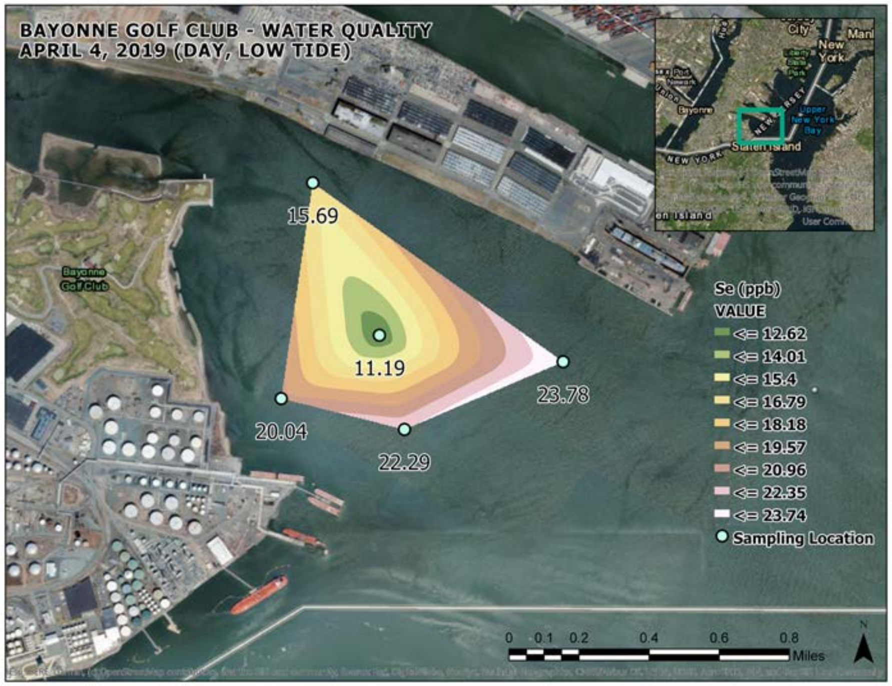

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
1.15
1.07
1.2
1.27
1.05
Cr (ppb)
VALUE
<= 1.07
<= 1.10
<= 1.12
<= 1.15
<= 1.17
<= 1.20
<= 1.22
<= 1.24
<= 1.27
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

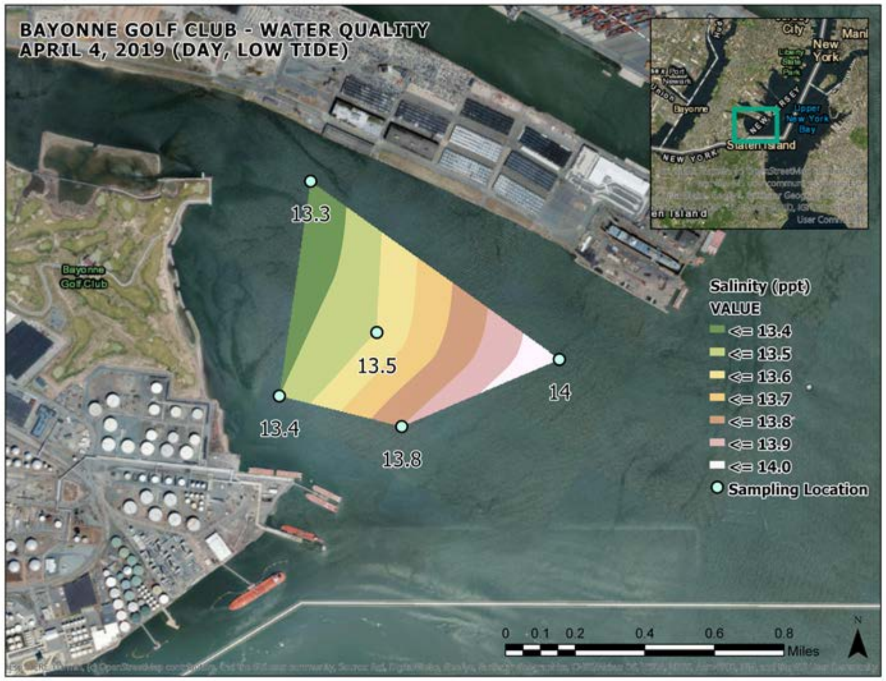

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
7.25
7.5
7.33
6.92
8.74
Dissolved Oxygen (ppm)
VALUE
<= 7.13
<= 7.33
<= 7.53
<= 7.73
<= 7.93
<= 8.13
<= 8.33
<= 8.53
<= 8.73
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

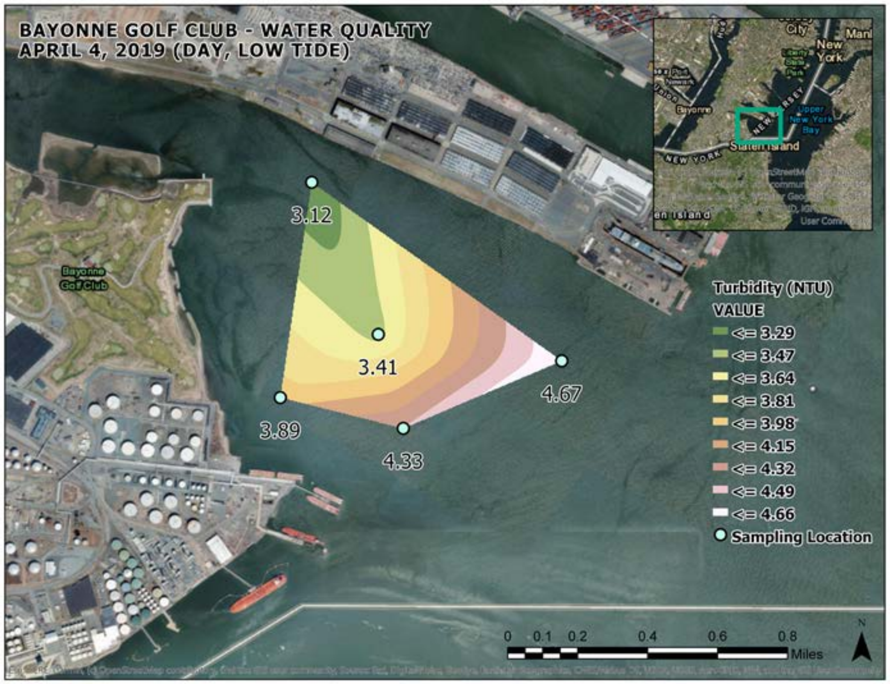

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
10.95
10.09
9.88
10.31
10.16
Cu (ppb)
VALUE
<= 10.00
<= 10.12
<= 10.24
<= 10.36
<= 10.47
<= 10.59
<= 10.71
<= 10.83
<= 10.95
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
0.32
0.36
0.34
0.48
BDL
Ni (ppb)
VALUE
<= 0.34
<= 0.36
<= 0.37
<= 0.39
<= 0.41
<= 0.43
<= 0.44
<= 0.46
<= 0.48
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
Pb (ppb)
VALUE
<= 2.51
<= 2.84
<= 3.16
<= 3.49
<= 3.82
<= 4.15
<= 4.48
<= 4.8
<= 5.13
Sampling Location
2.83
2.6
3.78
5.16
2.17
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8
Miles

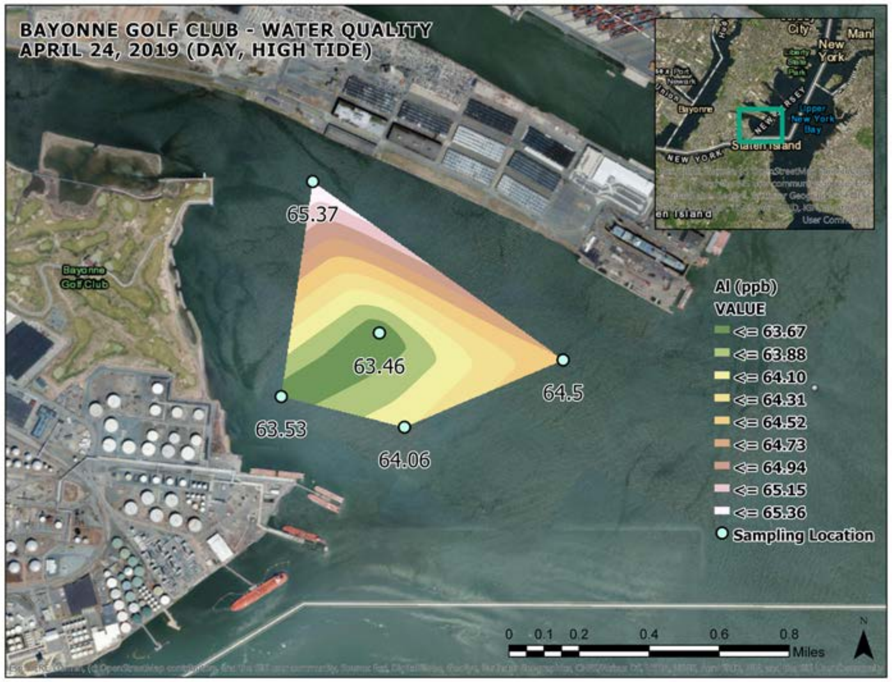

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
Se (ppb)
VALUE
<= 12.62
<= 14.01
<= 15.4
<= 16.79
<= 18.18
<= 19.57
<= 20.96
<= 22.35
<= 23.74
Sampling Location
15.69
11.19
23.78
20.04
22.29
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8
Miles

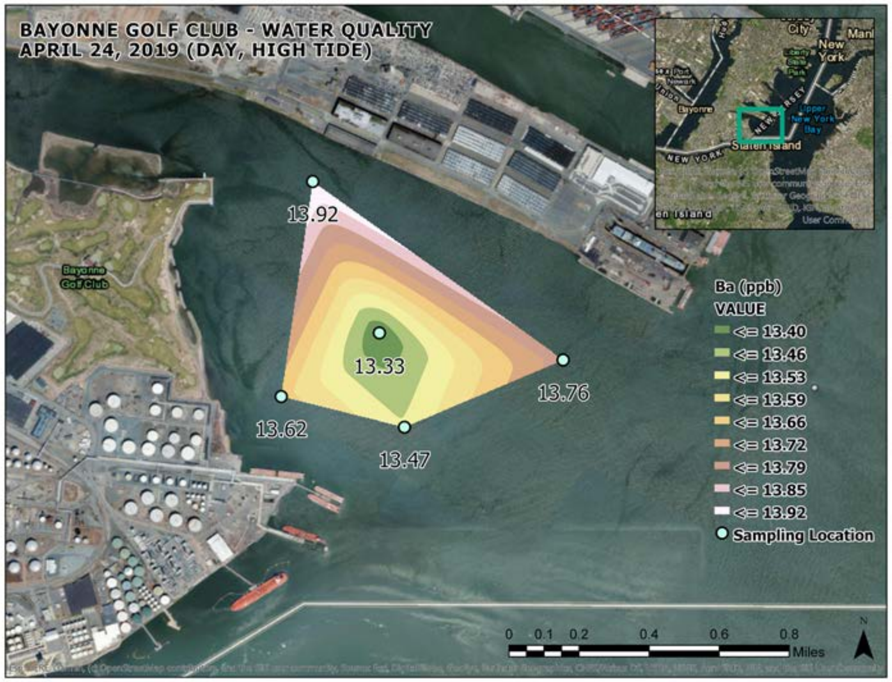

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
Salinity (ppt)
VALUE
<= 13.4
<= 13.5
<= 13.6
<= 13.7
<= 13.8
<= 13.9
<= 14.0
Sampling Location
13.3
13.5
14
13.4
13.8
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8
Miles

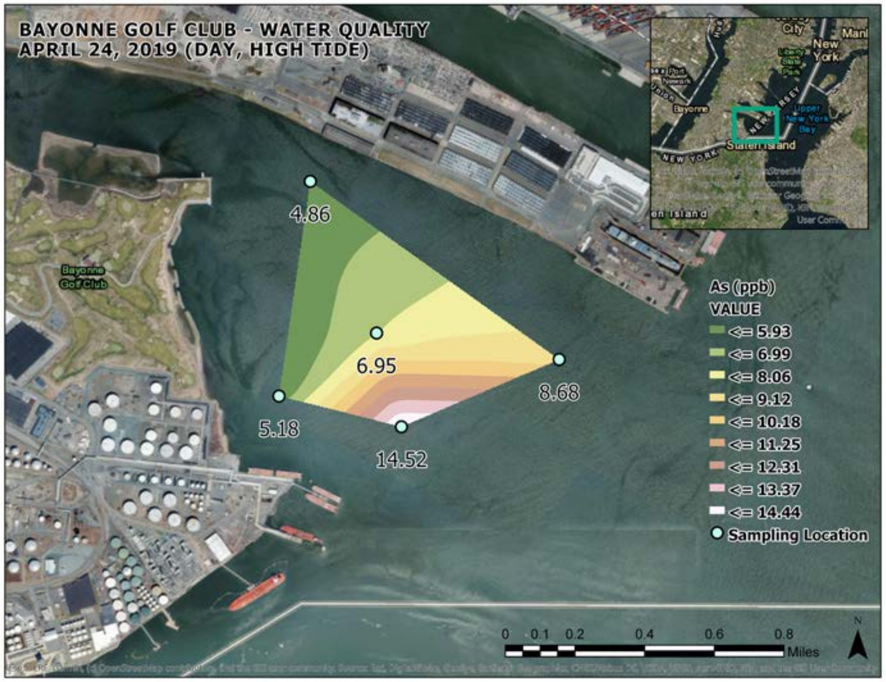

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
Turbidity (NTU)
VALUE
<= 3.29
<= 3.47
<= 3.64
<= 3.81
<= 3.98
<= 4.15
<= 4.32
<= 4.49
<= 4.66
Sampling Location
3.12
3.41
4.67
3.89
4.33
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
NA
13.6
12.4
13.6
11.3
Bayonne Golf Club
Staten Island
Water Temperature (°C)
VALUE
<= 11.6
<= 11.8
<= 12.1
<= 12.3
<= 12.6
<= 12.8
<= 13.1
<= 13.3
<= 13.6
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

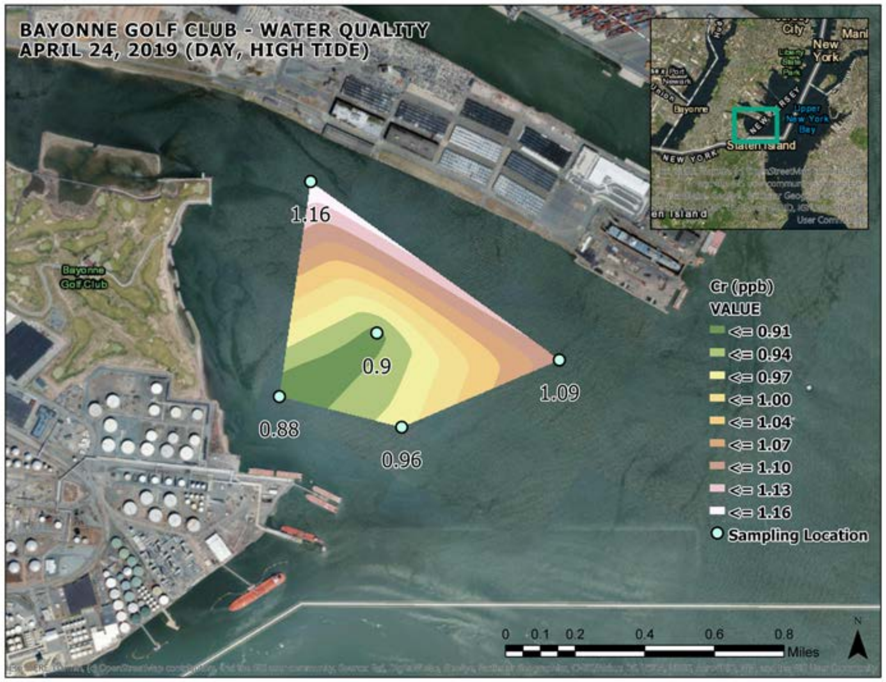

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
9.52
8.67
8.63
8.77
8.61
Bayonne Golf Club
Staten Island
pH
VALUE
<= 8.71
<= 8.81
<= 8.91
<= 9.01
<= 9.11
<= 9.21
<= 9.31
<= 9.42
<= 9.52
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
65.37
63.46
64.5
63.53
64.06
Al (ppb)
VALUE
<= 63.67
<= 63.88
<= 64.10
<= 64.31
<= 64.52
<= 64.73
<= 64.94
<= 65.15
<= 65.36
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
13.92
13.33
13.76
13.62
13.47
Ba (ppb)
VALUE
<= 13.40
<= 13.46
<= 13.53
<= 13.59
<= 13.66
<= 13.72
<= 13.79
<= 13.85
<= 13.92
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

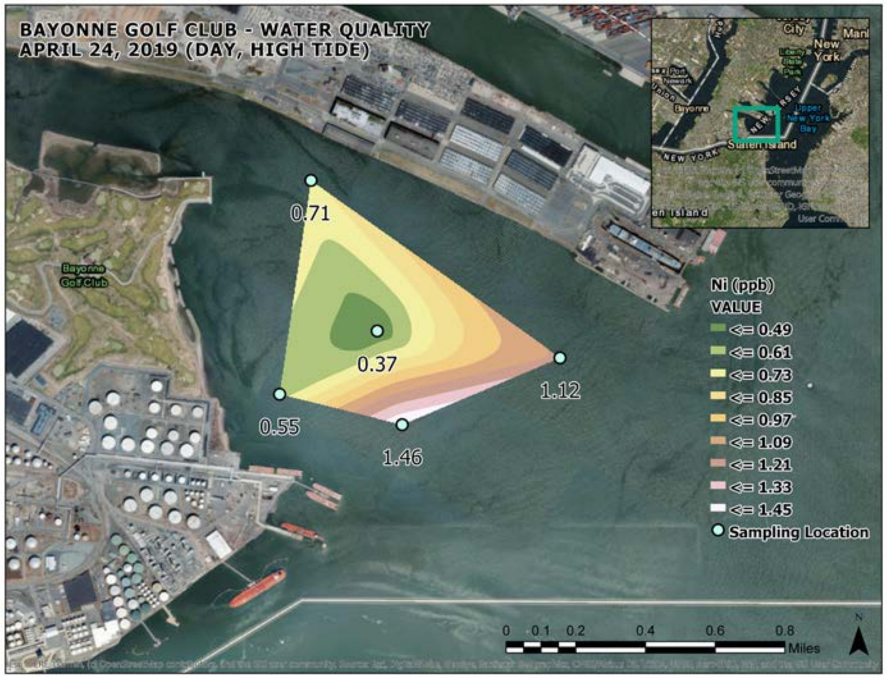

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
4.86
6.95
8.68
5.18
14.52
As (ppb)
VALUE
<= 5.93
<= 6.99
<= 8.06
<= 9.12
<= 10.18
<= 11.25
<= 12.31
<= 13.37
<= 14.44
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

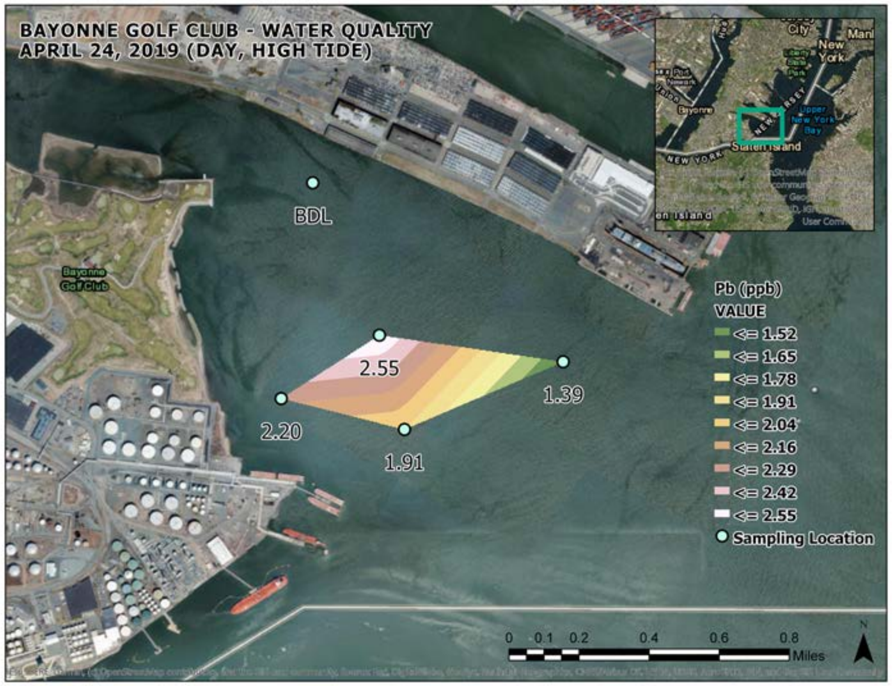

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
BDL
0.06
0.09
0.04
BDL
Cd (ppb)
VALUE
<= 0.05
<= 0.06
<= 0.07
<= 0.08
<= 0.09
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
Bayonne Golf Club
1.16
0.9
1.09
0.88
0.96
Cr (ppb)
VALUE
<= 0.91
<= 0.94
<= 0.97
<= 1.00
<= 1.04
<= 1.07
<= 1.10
<= 1.13
<= 1.16
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
Bayonne Golf Club
8.64
7.11
8.44
7.24
8.44
Dissolved Oxygen (ppm)
VALUE
<= 7.28
<= 7.45
<= 7.62
<= 7.79
<= 7.96
<= 8.13
<= 8.30
<= 8.47
<= 8.64
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
Bayonne Golf Club
8.94
7.92
8.5
8.4
8.11
Cu (ppb)
VALUE
<= 8.03
<= 8.15
<= 8.26
<= 8.37
<= 8.49
<= 8.60
<= 8.71
<= 8.82
<= 8.94
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

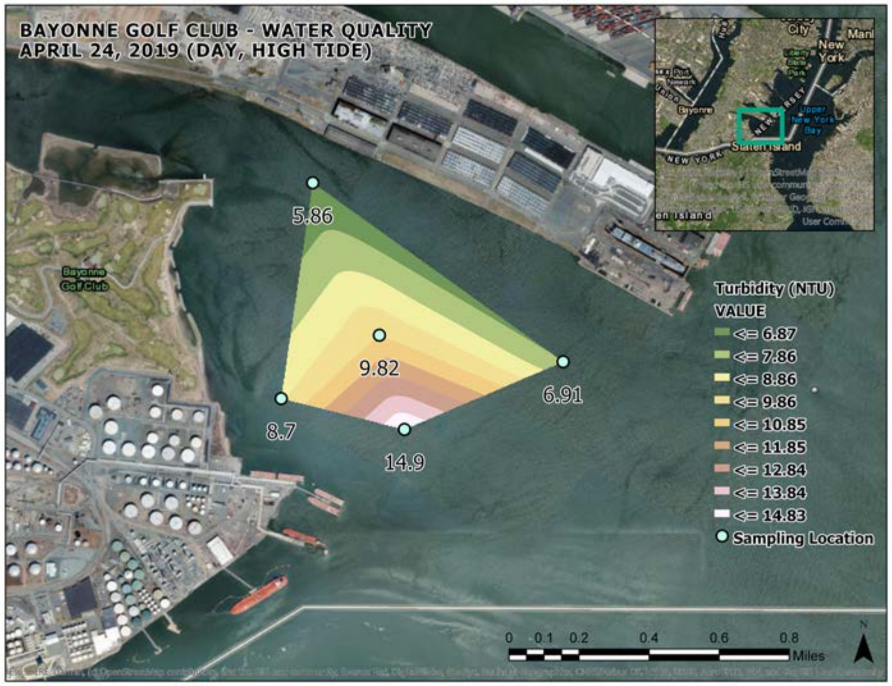

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
Bayonne Golf Club
0.71
0.37
1.12
0.55
1.46
Ni (ppb)
VALUE
<= 0.49
<= 0.61
<= 0.73
<= 0.85
<= 0.97
<= 1.09
<= 1.21
<= 1.33
<= 1.45
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
BDL
2.55
1.39
2.20
1.91
Pb (ppb)
VALUE
<= 1.52
<= 1.65
<= 1.78
<= 1.91
<= 2.04
<= 2.16
<= 2.29
<= 2.42
<= 2.55
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
9.3
12.05
9.56
3.83
3.78
Se (ppb)
VALUE
<= 4.70
<= 5.61
<= 6.53
<= 7.45
<= 8.36
<= 9.28
<= 10.19
<= 11.11
<= 12.03
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
8.08
9.39
8.52
9.55
9.23
Salinity (ppt)
VALUE
<= 8.25
<= 8.41
<= 8.57
<= 8.73
<= 8.90
<= 9.06
<= 9.22
<= 9.38
<= 9.55
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
5
3
2.5
4
3
Secchi Depth (ft)
VALUE
<= 2.8
<= 3.1
<= 3.3
<= 3.6
<= 3.9
<= 4.2
<= 4.4
<= 4.7
<= 5.0
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

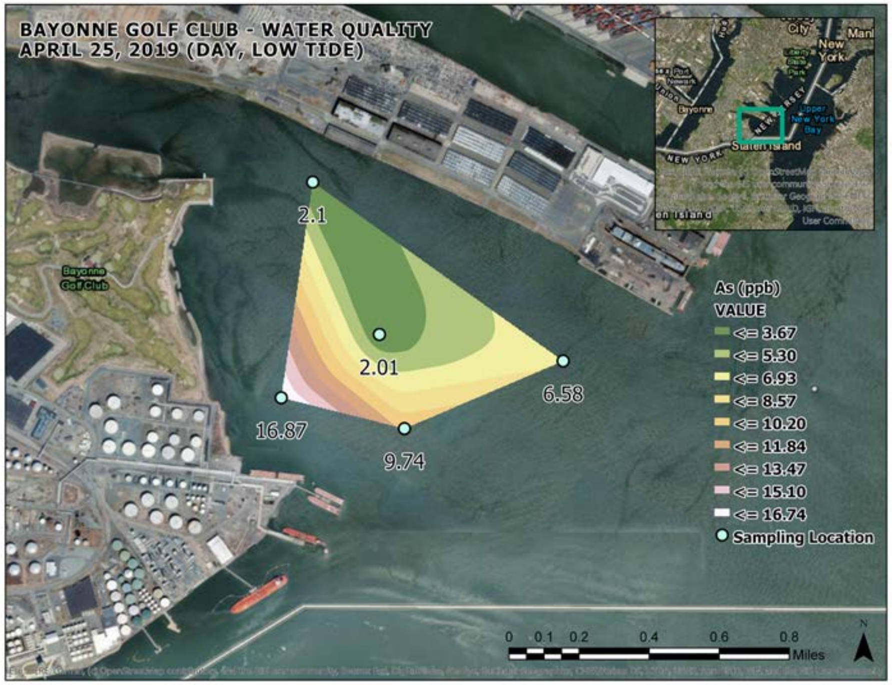

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
5.86
9.82
6.91
8.7
14.9
Bayonne Golf Club
Turbidity (NTU)
VALUE
<= 6.87
<= 7.86
<= 8.86
<= 9.86
<= 10.85
<= 11.85
<= 12.84
<= 13.84
<= 14.83
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
7.34
7.76
8.05
7.51
7.58
Bayonne Golf Club
pH
VALUE
<= 7.42
<= 7.50
<= 7.58
<= 7.66
<= 7.73
<= 7.81
<= 7.89
<= 7.97
<= 8.05
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 24, 2019 (DAY, HIGH TIDE)
16.9
17.8
17.8
18
16.5
Bayonne Golf Club
Water Temperature (°C)
VALUE
<= 16.68
<= 16.84
<= 17.01
<= 17.17
<= 17.34
<= 17.50
<= 17.67
<= 17.83
<= 17.99
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
Al (ppb)
VALUE
<= 58.16
<= 58.57
<= 58.98
<= 59.38
<= 59.79
<= 60.2
<= 60.6
<= 61.01
<= 61.42
Sampling Location
58.19
61.43
60.28
57.74
59.88
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
Ba (ppb)
VALUE
<= 13.55
<= 13.57
<= 13.60
<= 13.63
<= 13.65
<= 13.68
<= 13.71
<= 13.73
<= 13.76
Sampling Location
13.74
13.7
13.52
13.76
13.66
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
As (ppb)
VALUE
<= 3.67
<= 5.30
<= 6.93
<= 8.57
<= 10.20
<= 11.84
<= 13.47
<= 15.10
<= 16.74
Sampling Location
2.1
2.01
6.58
16.87
9.74
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
Cd (ppb)
VALUE
<= 0.04
<= 0.05
<= 0.06
<= 0.07
<= 0.07
<= 0.08
<= 0.09
<= 0.10
<= 0.11
Sampling Location
BDL
BDL
0.04
0.11
0.03
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles

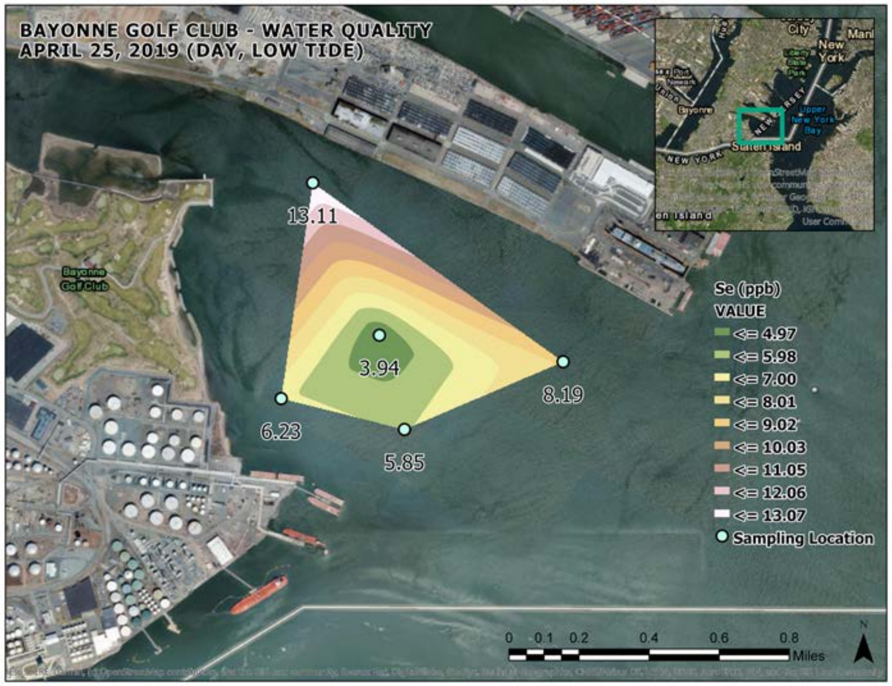

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
0.94
1.12
0.81
0.97
0.98
Cr (ppb)
VALUE
<= 0.85
<= 0.88
<= 0.91
<= 0.95
<= 0.98
<= 1.02
<= 1.05
<= 1.08
<= 1.12
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

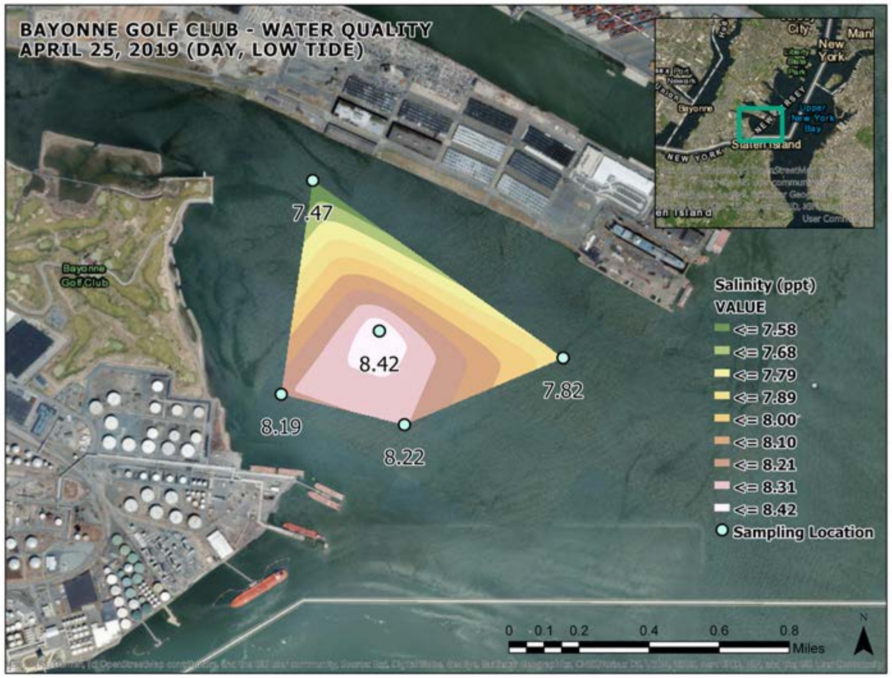

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
9.67
8.14
9.31
8.14
9.23
Dissolved Oxygen (ppm)
VALUE
<= 8.31
<= 8.48
<= 8.65
<= 8.82
<= 8.99
<= 9.16
<= 9.33
<= 9.5
<= 9.67
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

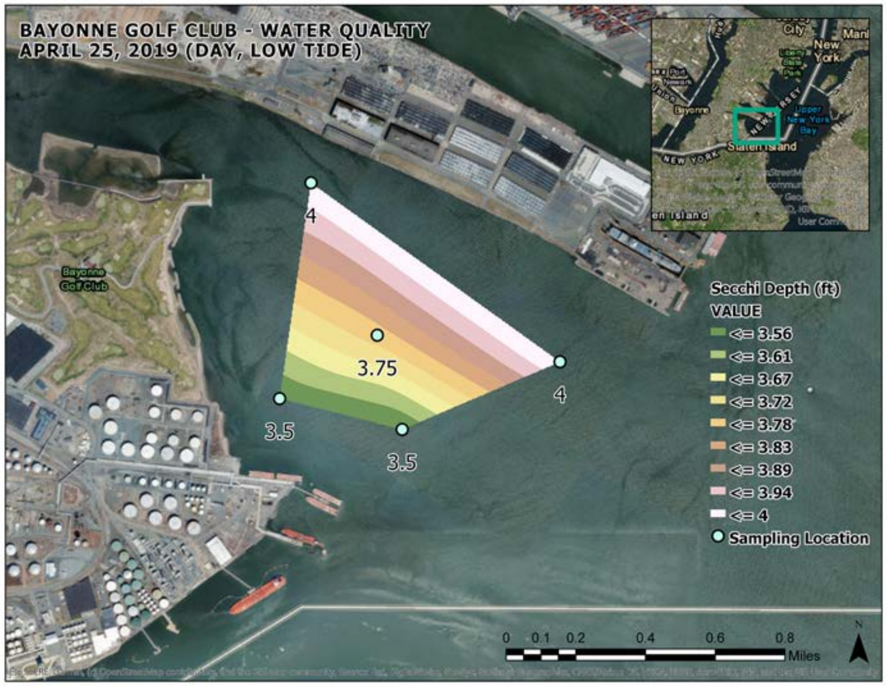

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
7.45
7.07
7.31
7.72
7.65
Cu (ppb)
VALUE
<= 7.14
<= 7.22
<= 7.29
<= 7.36
<= 7.43
<= 7.50
<= 7.57
<= 7.65
<= 7.72
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
0.77
0.25
0.19
BDL
0.66
Ni (ppb)
VALUE
<= 0.26
<= 0.32
<= 0.38
<= 0.45
<= 0.51
<= 0.58
<= 0.64
<= 0.70
<= 0.77
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
1.58
1.26
1.04
3.12
0.45
Pb (ppb)
VALUE
<= 0.75
<= 1.05
<= 1.34
<= 1.63
<= 1.93
<= 2.22
<= 2.51
<= 2.81
<= 3.10
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

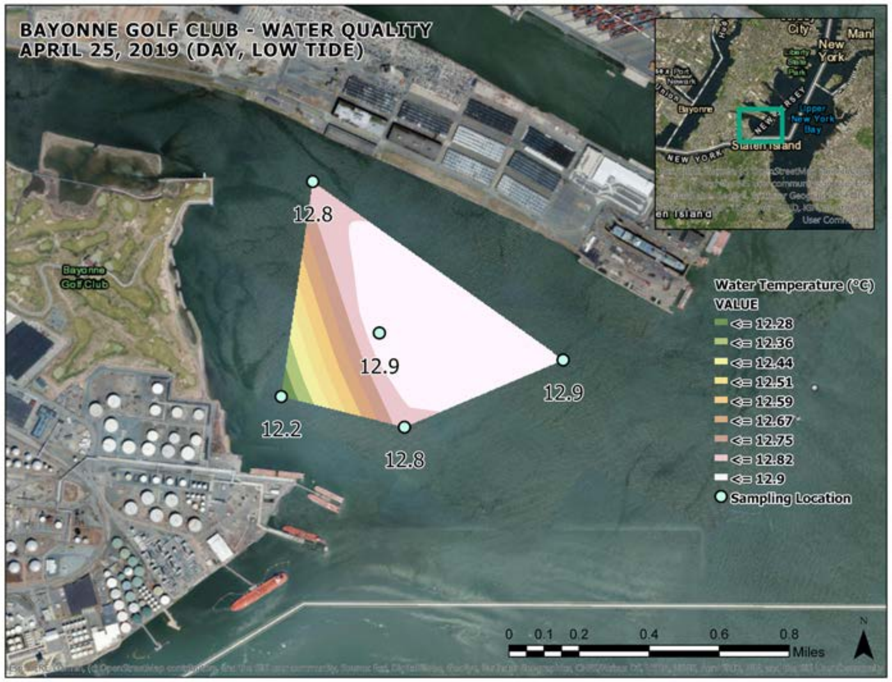

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
13.11
3.94
8.19
6.23
5.85
Se (ppb)
VALUE
<= 4.97
<= 5.98
<= 7.00
<= 8.01
<= 9.02
<= 10.03
<= 11.05
<= 12.06
<= 13.07
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
7.47
8.42
7.82
8.19
8.22
Salinity (ppt)
VALUE
<= 7.58
<= 7.68
<= 7.79
<= 7.89
<= 8.00
<= 8.10
<= 8.21
<= 8.31
<= 8.42
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
4
3.75
4
3.5
3.5
Secchi Depth (ft)
VALUE
<= 3.56
<= 3.61
<= 3.67
<= 3.72
<= 3.78
<= 3.83
<= 3.89
<= 3.94
<= 4
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
Turbidity (NTU)
VALUE
<= 6.23
<= 6.33
<= 6.43
<= 6.53
<= 6.64
<= 6.74
<= 6.84
<= 6.94
<= 7.05
Sampling Location
6.12
7.05
6.71
6.63
6.53
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles

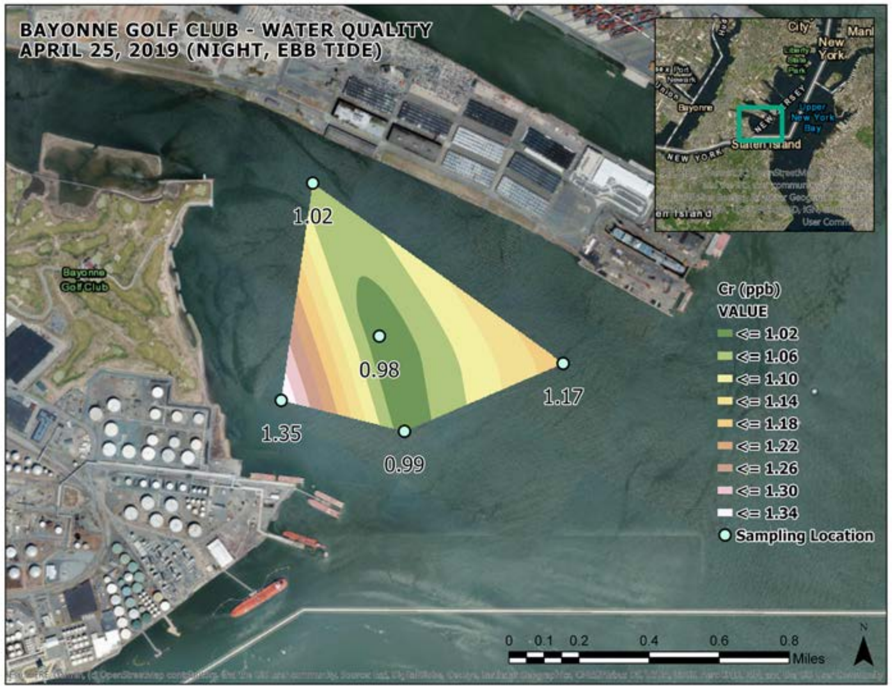

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
pH
VALUE
<= 7.78
<= 7.78
<= 7.79
<= 7.79
<= 7.80
<= 7.80
<= 7.81
<= 7.81
<= 7.82
Sampling Location
7.8
7.82
7.77
7.77
7.79
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles

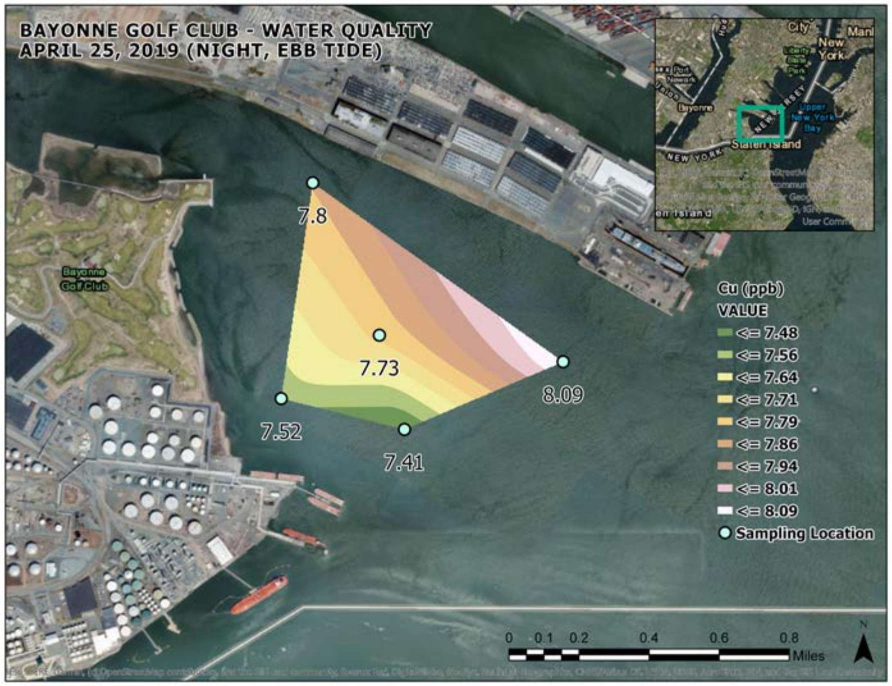

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (DAY, LOW TIDE)
Water Temperature (°C)
VALUE
<= 12.28
<= 12.36
<= 12.44
<= 12.51
<= 12.59
<= 12.67
<= 12.75
<= 12.82
<= 12.9
Sampling Location
12.8
12.9
12.9
12.2
12.8
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles

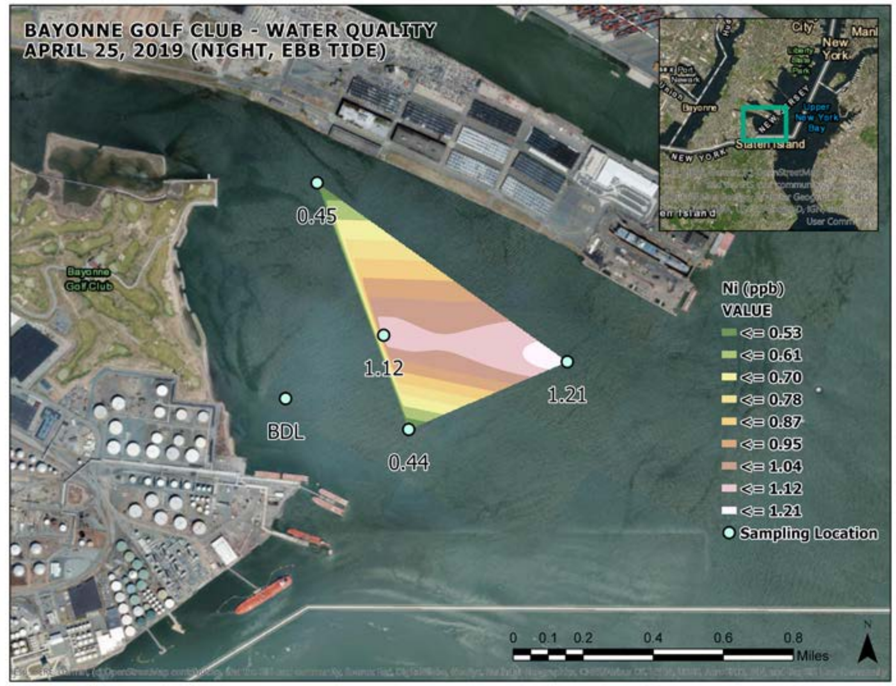

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
58.13
60.16
61.05
67.56
58.84
Sampling Location
Al (ppb)
VALUE
<= 59.18
<= 60.22
<= 61.25
<= 62.29
<= 63.33
<= 64.37
<= 65.40
<= 66.44
<= 67.48
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
13.7
13.73
13.41
13.68
13.45
Ba (ppb)
VALUE
<= 13.45
<= 13.48
<= 13.52
<= 13.55
<= 13.59
<= 13.62
<= 13.66
<= 13.69
<= 13.73
Sampling Location
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles

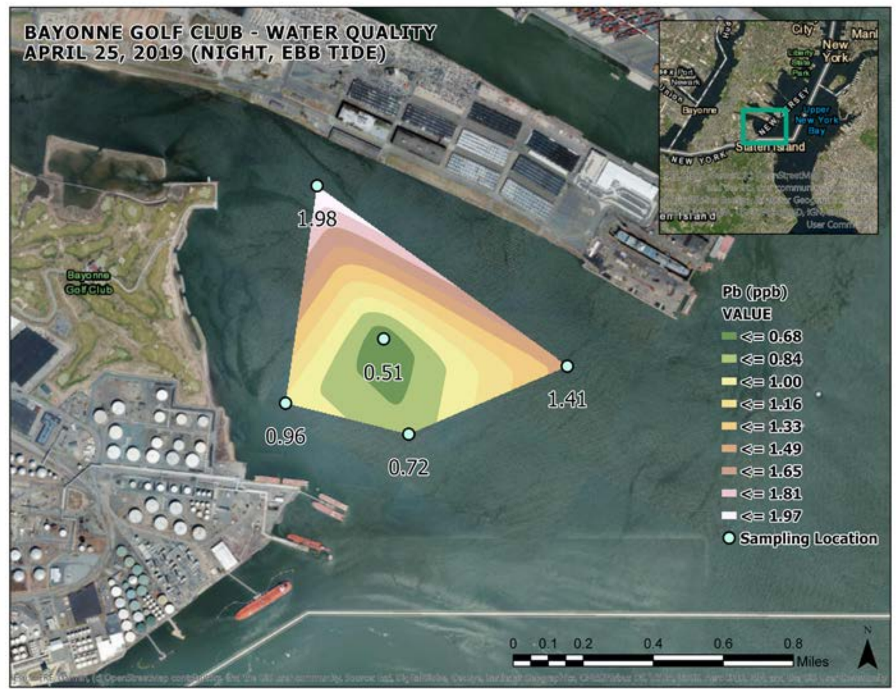

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
7.76
6.92
1.73
8.98
7.72
Sampling Location
As (ppb)
VALUE
<= 2.55
<= 3.35
<= 4.15
<= 4.95
<= 5.75
<= 6.56
<= 7.36
<= 8.16
<= 8.96
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
1.02
0.98
1.17
1.35
0.99
Cr (ppb)
VALUE
<= 1.02
<= 1.06
<= 1.10
<= 1.14
<= 1.18
<= 1.22
<= 1.26
<= 1.30
<= 1.34
Sampling Location
Bayonne Golf Club
0 0.1 0.2 0.4 0.6 0.8 Miles

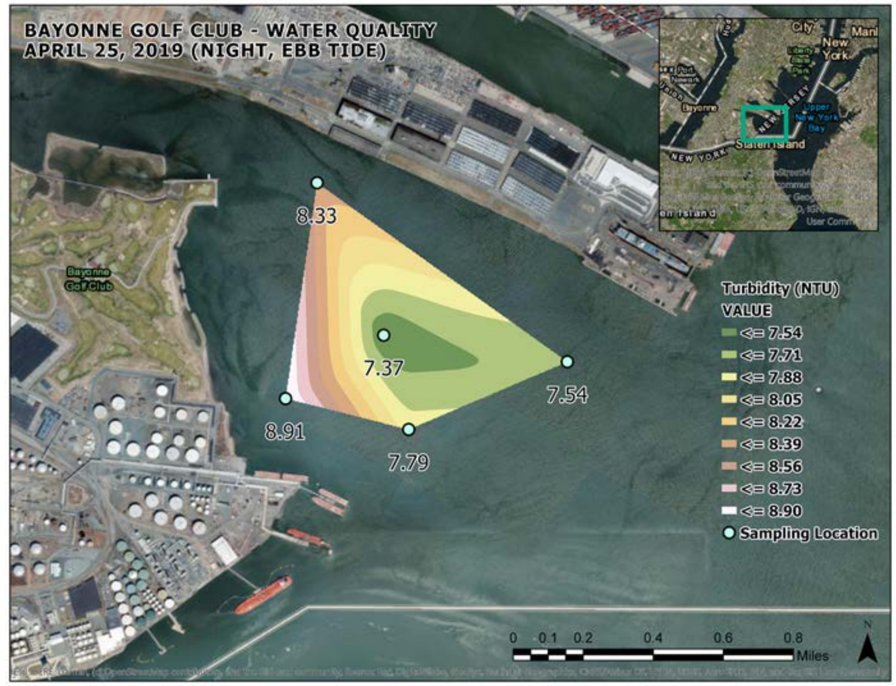

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
7.8
7.73
8.09
7.52
7.41
Cu (ppb)
VALUE
<= 7.48
<= 7.56
<= 7.64
<= 7.71
<= 7.79
<= 7.86
<= 7.94
<= 8.01
<= 8.09
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

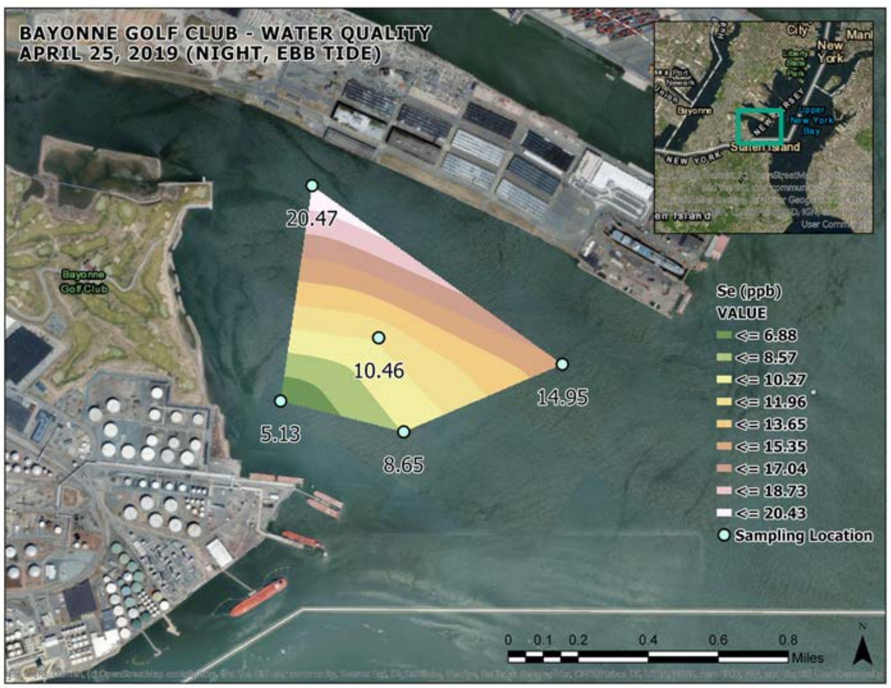

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
0.45
1.12
1.21
BDL
0.44
Ni (ppb)
VALUE
<= 0.53
<= 0.61
<= 0.70
<= 0.78
<= 0.87
<= 0.95
<= 1.04
<= 1.12
<= 1.21
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

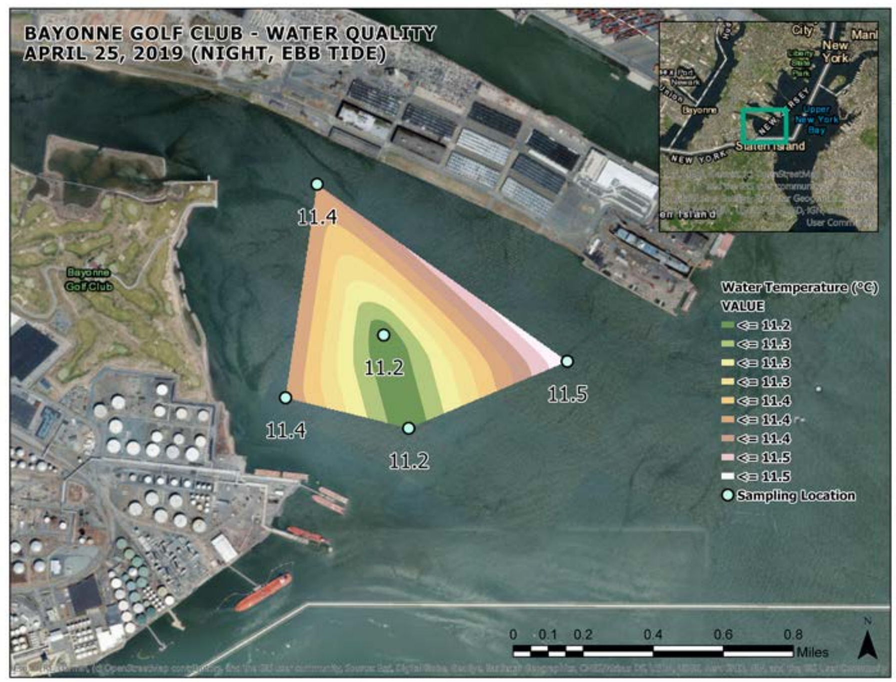

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
9.62
7.33
11.1
10.5
10.7
Dissolved Oxygen (ppm)
VALUE
<= 7.8
<= 8.2
<= 8.6
<= 9.0
<= 9.4
<= 9.8
<= 10.3
<= 10.7
<= 11.1
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
1.98
0.51
1.41
0.96
0.72
Pb (ppb)
VALUE
<= 0.68
<= 0.84
<= 1.00
<= 1.16
<= 1.33
<= 1.49
<= 1.65
<= 1.81
<= 1.97
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
8.55
8.51
8.57
8.22
8.74
Salinity (ppt)
Value
<= 8.28
<= 8.34
<= 8.39
<= 8.45
<= 8.51
<= 8.57
<= 8.62
<= 8.68
<= 8.74
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

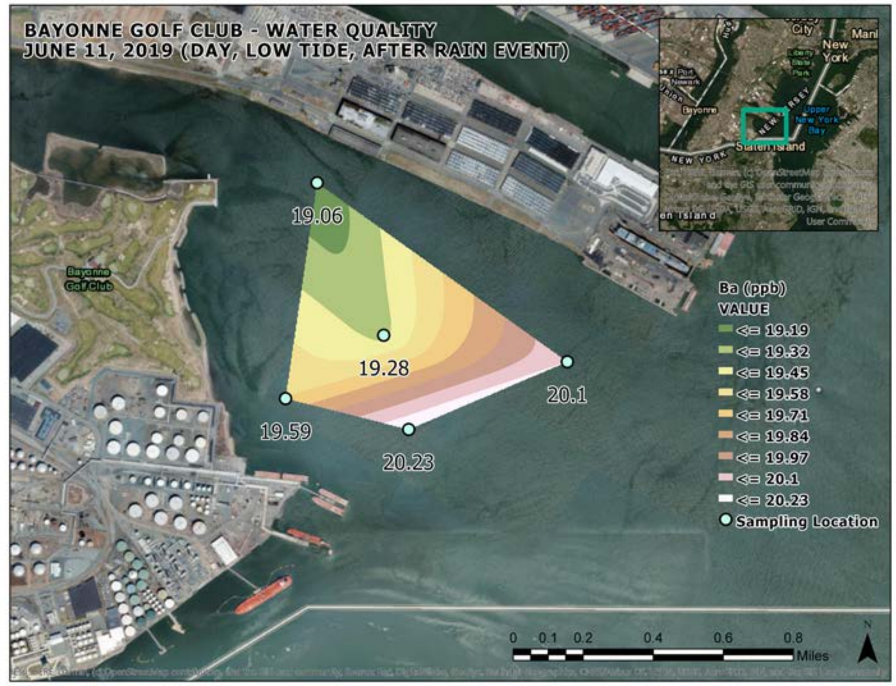

BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
8.33
7.37
7.54
8.91
7.79
Turbidity (NTU)
VALUE
<= 7.54
<= 7.71
<= 7.88
<= 8.05
<= 8.22
<= 8.39
<= 8.56
<= 8.73
<= 8.90
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
20.47
10.46
14.95
5.13
8.65
Se (ppb)
VALUE
<= 6.88
<= 8.57
<= 10.27
<= 11.96
<= 13.65
<= 15.35
<= 17.04
<= 18.73
<= 20.43
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
Bayonne Golf Club
11.4
11.2
11.5
11.4
11.2
Water Temperature (°C)
VALUE
<= 11.2
<= 11.3
<= 11.3
<= 11.3
<= 11.4
<= 11.4
<= 11.4
<= 11.5
<= 11.5
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
APRIL 25, 2019 (NIGHT, EBB TIDE)
7.84
7.85
7.95
7.87
7.89
Bayonne Golf Club
pH
Value
<= 7.85
<= 7.86
<= 7.88
<= 7.89
<= 7.90
<= 7.91
<= 7.93
<= 7.94
<= 7.95
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles
Staten Island
Upper New York Bay


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
87.76
83.99
87.09
84.91
85.3
Al (ppb)
VALUE
<= 84.42
<= 84.83
<= 85.25
<= 85.67
<= 86.08
<= 86.5
<= 86.92
<= 87.33
<= 87.75
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

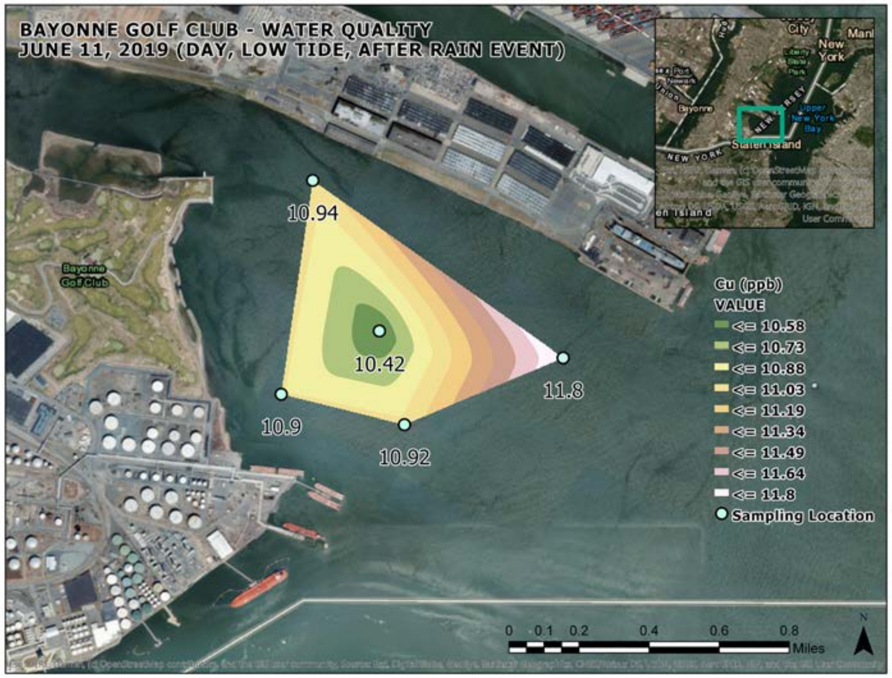

BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
19.06
19.28
20.1
19.59
20.23
Ba (ppb)
VALUE
<= 19.19
<= 19.32
<= 19.45
<= 19.58
<= 19.71
<= 19.84
<= 19.97
<= 20.1
<= 20.23
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
12.85
12.76
11.43
18.63
10.52
As (ppb)
VALUE
<= 11.43
<= 12.32
<= 13.21
<= 14.1
<= 15
<= 15.89
<= 16.78
<= 17.67
<= 18.56
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

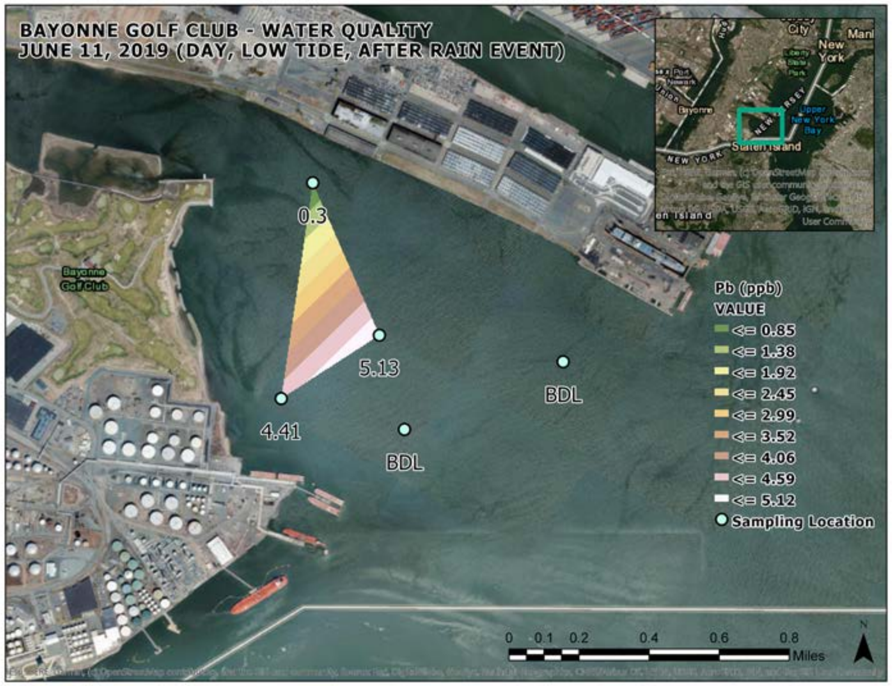

BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
0.07
0.21
0.42
0.2
0.37
Cd (ppb)
VALUE
<= 0.11
<= 0.15
<= 0.19
<= 0.23
<= 0.26
<= 0.3
<= 0.34
<= 0.38
<= 0.42
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
0.67
0.73
0.39
0.44
0.5
Cr (ppb)
VALUE
<= 0.43
<= 0.47
<= 0.5
<= 0.54
<= 0.58
<= 0.62
<= 0.65
<= 0.69
<= 0.73
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
6.8
6.7
6.3
6.54
6.64
Dissolved Oxygen (ppm)
VALUE
<= 6.36
<= 6.41
<= 6.47
<= 6.52
<= 6.58
<= 6.63
<= 6.69
<= 6.74
<= 6.8
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
10.94
10.42
11.8
10.9
10.92
Cu (ppb)
VALUE
<= 10.58
<= 10.73
<= 10.88
<= 11.03
<= 11.19
<= 11.34
<= 11.49
<= 11.64
<= 11.8
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
1.27
1.97
1.06
1.38
1.2
Ni (ppb)
VALUE
<= 1.16
<= 1.26
<= 1.36
<= 1.46
<= 1.56
<= 1.66
<= 1.76
<= 1.87
<= 1.97
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
0.3
5.13
4.41
BDL
BDL
Bayonne Golf Club
Pb (ppb)
VALUE
<= 0.85
<= 1.38
<= 1.92
<= 2.45
<= 2.99
<= 3.52
<= 4.06
<= 4.59
<= 5.12
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

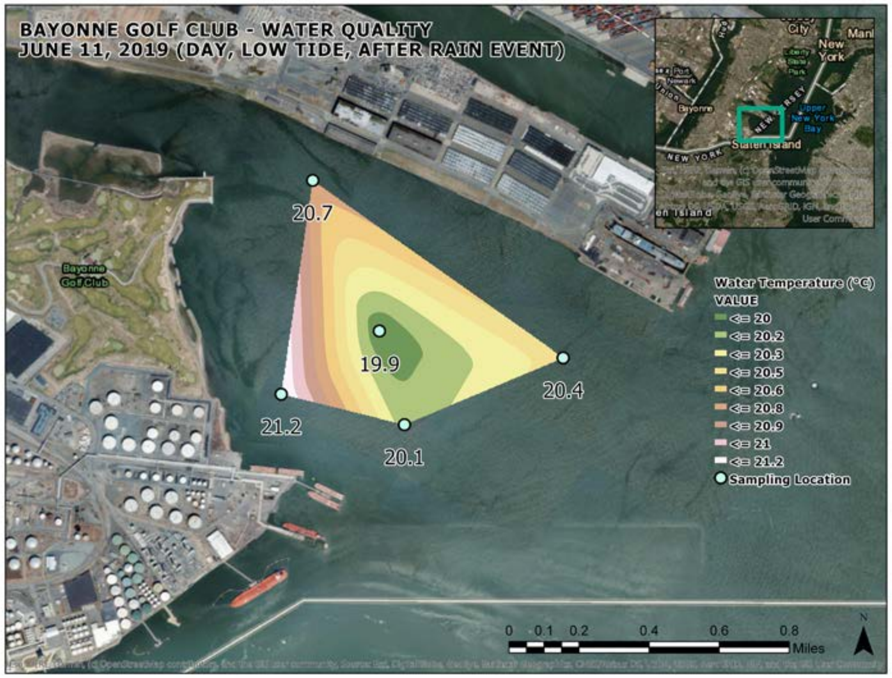

BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
37.29
33.1
45.49
24.91
33.98
Bayonne Golf Club
Se (ppb)
VALUE
<= 27.27
<= 29.55
<= 31.82
<= 34.09
<= 36.36
<= 38.63
<= 40.91
<= 43.18
<= 45.45
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
15.1
15
14.6
14
14.8
Bayonne Golf Club
Salinity (ppt)
VALUE
<= 14.1
<= 14.3
<= 14.4
<= 14.5
<= 14.6
<= 14.7
<= 14.9
<= 15
<= 15.1
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
4
3.5
4
4
3.5
Bayonne Golf Club
Secchi Depth (ft)
VALUE
<= 3.6
<= 3.6
<= 3.7
<= 3.7
<= 3.8
<= 3.8
<= 3.9
<= 3.9
<= 4
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
4.54
7.17
4.16
6.02
8.09
Turbidity (NTU)
VALUE
<= 4.6
<= 5.03
<= 5.47
<= 5.9
<= 6.34
<= 6.77
<= 7.2
<= 7.64
<= 8.07
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
7.32
7.33
7.48
7.37
7.42
pH
VALUE
<= 7.34
<= 7.36
<= 7.37
<= 7.39
<= 7.41
<= 7.43
<= 7.44
<= 7.46
<= 7.48
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles


BAYONNE GOLF CLUB - WATER QUALITY
JUNE 11, 2019 (DAY, LOW TIDE, AFTER RAIN EVENT)
Bayonne Golf Club
20.7
19.9
20.4
21.2
20.1
Water Temperature (°C)
VALUE
<= 20
<= 20.2
<= 20.3
<= 20.5
<= 20.6
<= 20.8
<= 20.9
<= 21
<= 21.2
Sampling Location
0 0.1 0.2 0.4 0.6 0.8
Miles

Sediment Quality Data

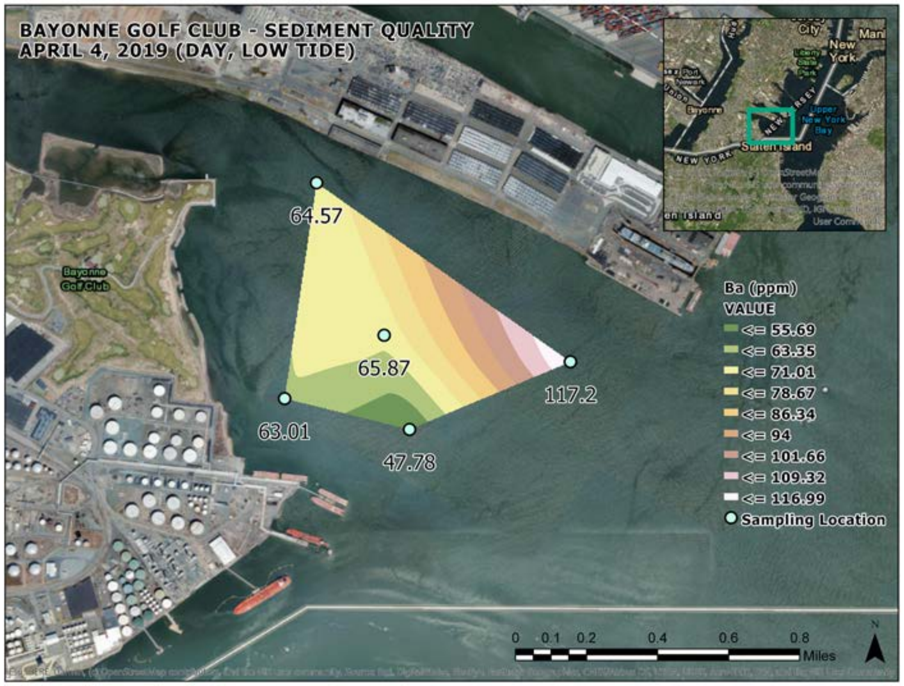
Sampling_Date	Day/night	Tide	Location Code	Latitude	Longtitude	Mean Al (ppm)	SD Al (ppm)	Mean As (ppm)	SD As (ppm)	Mean Ba (ppm)	SD Ba (ppm)	Mean Cd (ppm)	SD Cd (ppm)
4/4/2019	Day	Low tide	P1-NW	40.66482	-74.085383	10645.51	408.31	10.01	2.44	64.57	3.98	1.31	0.10
4/4/2019	Day	Low tide	P2-SW	40.65807	-74.086683	13639.46	373.37	7.84	2.51	63.01	1.83	0.55	0.13
4/4/2019	Day	Low tide	P3-SE	40.6571	-74.0816	9248.62	418.29	9.79	2.66	47.78	4.01	0.78	0.07
4/4/2019	Day	Low tide	P4-NE	40.65922	-74.07505	16317.15	515.64	24.39	4.55	117.20	3.37	3.77	0.04
4/4/2019	Day	Low tide	P5-Center	40.66005	-74.082633	16523.61	258.87	9.12	2.57	65.87	1.88	0.51	0.06
4/3/2019	Day	Low tide	BW1	40.66225	-74.091266	5440.21	753.52	5.94	2.66	51.41	1.48	0.27	0.02
4/3/2019	Day	Low tide	BW2	40.6621	-74.091213	5037.43	92.93	4.99	2.84	58.75	20.98	0.27	0.08
4/3/2019	Day	Low tide	BW3	40.66195	-74.091164	5094.31	1236.86	7.79	3.73	46.41	15.57	0.26	0.18

Sampling_Date	Day/night	Tide	Location Code	Latitude	Longtitude	Mean Cr (ppm)	SD Cr (ppm)	Mean Cu (ppm)	SD Cu (ppm)	Mean Fe (ppm)	SD Fe (ppm)	Mean Ni (ppm)
4/4/2019	Day	Low tide	P1-NW	40.66482	-74.085383	64.17	3.74	75.54	4.22	21681.71	856.74	29.81
4/4/2019	Day	Low tide	P2-SW	40.65807	-74.086683	49.96	1.09	61.71	2.27	27368.75	772.67	57.65
4/4/2019	Day	Low tide	P3-SE	40.6571	-74.0816	44.74	1.39	52.27	3.20	18497.40	682.95	51.55
4/4/2019	Day	Low tide	P4-NE	40.65922	-74.07505	129.44	2.60	162.82	2.78	32462.19	1648.75	38.80
4/4/2019	Day	Low tide	P5-Center	40.66005	-74.082633	55.75	0.44	64.53	0.62	29855.57	424.61	41.44
4/3/2019	Day	Low tide	BW1	40.66225	-74.091266	17.40	2.19	39.05	4.76	14182.01	1327.09	13.37
4/3/2019	Day	Low tide	BW2	40.6621	-74.091213	16.27	1.37	50.30	6.77	16199.61	4449.53	13.54
4/3/2019	Day	Low tide	BW3	40.66195	-74.091164	14.73	6.16	97.56	96.96	14001.29	3012.91	13.36

Sampling_Date	Day/night	Tide	Location Code	Latitude	Longtitude	SD Ni (ppm)	Mean Pb (ppm)	SD Pb (ppm)	Mean Se (ppm)	SD Se (ppm)	Mean Zn (ppm)	SD Zn (ppm)
4/4/2019	Day	Low tide	P1-NW	40.66482	-74.085383	1.07	76.78	4.14	3.25	1.96	137.28	9.33
4/4/2019	Day	Low tide	P2-SW	40.65807	-74.086683	1.36	68.73	1.36	2.45	2.06	154.47	4.11
4/4/2019	Day	Low tide	P3-SE	40.6571	-74.0816	1.75	55.24	0.92	4.88	NA*	114.18	3.26
4/4/2019	Day	Low tide	P4-NE	40.65922	-74.07505	2.12	160.03	0.98	4.14	NA*	277.24	3.28
4/4/2019	Day	Low tide	P5-Center	40.66005	-74.082633	1.06	70.53	1.90	1.61	1.38	164.57	1.93
4/3/2019	Day	Low tide	BW1	40.66225	-74.091266	2.52	55.47	4.09	1.27	NA*	79.22	5.53
4/3/2019	Day	Low tide	BW2	40.6621	-74.091213	1.12	71.11	11.93	0.12	NA*	114.06	18.22
4/3/2019	Day	Low tide	BW3	40.66195	-74.091164	3.18	47.54	25.13	BDL	NA*	97.03	61.30

The analysis was perform in triplicate.
NA*: Standard deviation could not be calculated since two or more replicates were below detection limit (BDL).
BDL: Below Detection Limit


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
10645.51
16523.61
16317.15
13639.46
9248.62
Al (ppm)
VALUE
<= 10126.22
<= 10922.57
<= 11718.91
<= 12515.26
<= 13311.6
<= 14107.95
<= 14904.3
<= 15700.64
<= 16496.99
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
64.57
65.87
117.2
63.01
47.78
Ba (ppm)
VALUE
<= 55.69
<= 63.35
<= 71.01
<= 78.67
<= 86.34
<= 94
<= 101.66
<= 109.32
<= 116.99
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
10.01
9.12
24.39
7.84
9.79
As (ppm)
VALUE
<= 9.69
<= 11.52
<= 13.35
<= 15.18
<= 17.01
<= 18.84
<= 20.67
<= 22.5
<= 24.33
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
1.31
0.51
3.77
0.55
0.78
Cd (ppm)
VALUE
<= 0.87
<= 1.23
<= 1.59
<= 1.95
<= 2.32
<= 2.68
<= 3.04
<= 3.4
<= 3.76
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
64.17
55.75
129.44
49.96
44.74
Cr (ppm)
VALUE
<= 54.23
<= 63.6
<= 72.96
<= 82.33
<= 91.7
<= 101.06
<= 110.43
<= 119.8
<= 129.16
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

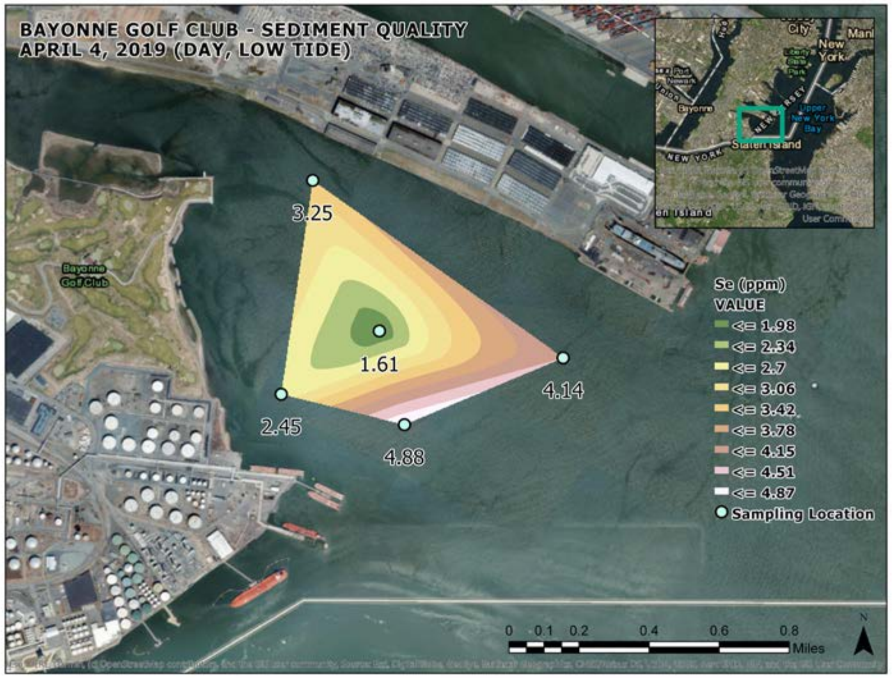

BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
21681.71
29855.57
32462.19
27368.75
18497.4
Fe (ppm)
VALUE
<= 20164.89
<= 21697.94
<= 23230.99
<= 24764.03
<= 26297.08
<= 27830.13
<= 29363.18
<= 30896.22
<= 32429.27
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
75.54
64.53
162.82
61.71
52.27
Cu (ppm)
VALUE
<= 64.66
<= 76.88
<= 89.1
<= 101.33
<= 113.55
<= 125.78
<= 138
<= 150.23
<= 162.45
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
29.81
41.44
38.8
57.65
51.55
Ni (ppm)
VALUE
<= 32.94
<= 36.02
<= 39.09
<= 42.16
<= 45.24
<= 48.31
<= 51.38
<= 54.46
<= 57.53
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
76.78
70.53
160.03
68.73
55.24
Pb (ppm)
VALUE
<= 67.03
<= 78.61
<= 90.19
<= 101.78
<= 113.36
<= 124.94
<= 136.52
<= 148.1
<= 159.68
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
137.28
164.57
277.24
154.47
114.18
Zn (ppm)
VALUE
<= 132.83
<= 150.81
<= 168.8
<= 186.79
<= 204.77
<= 222.76
<= 240.74
<= 258.73
<= 276.71
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles


BAYONNE GOLF CLUB - SEDIMENT QUALITY
APRIL 4, 2019 (DAY, LOW TIDE)
3.25
1.61
4.14
2.45
4.88
Se (ppm)
VALUE
<= 1.98
<= 2.34
<= 2.7
<= 3.06
<= 3.42
<= 3.78
<= 4.15
<= 4.51
<= 4.87
Sampling Location
0 0.1 0.2 0.4 0.6 0.8 Miles

Wave Climatology

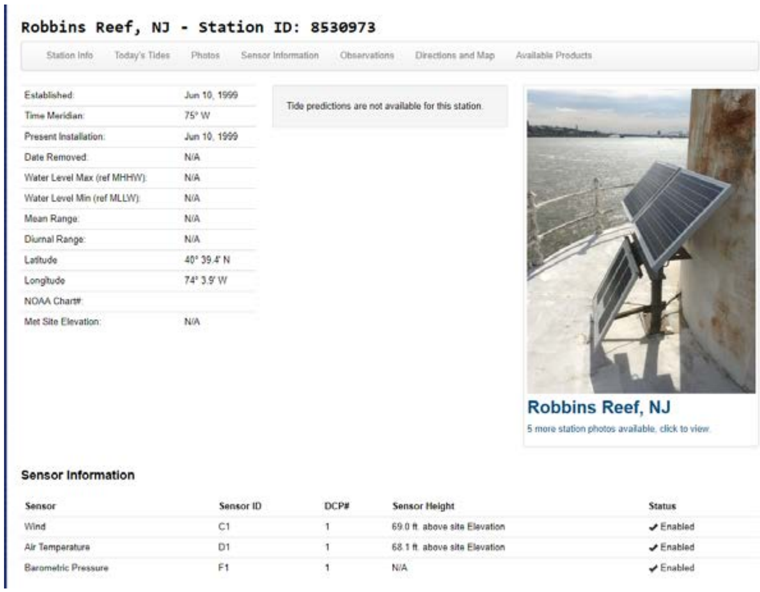
- SMB Method
  - wave prediction procedure based on wave energy growth concepts with empirical calibration
    - $H_s, T_s = f(U, L_F, t_d, g)$

$$\frac{gH_s}{U^2} = 0.283 \tanh\left[0.0125\left(\frac{gX}{U^2}\right)^{0.42}\right]$$

$$\frac{gT_s}{2\pi U} = 1.2 \tanh\left[0.077\left(\frac{gX}{U^2}\right)^{0.25}\right]$$

Historical Wind Data from Robbins Reef

- 10 years of data



Robbins Reef, NJ - Station ID: 8530973

Station Info | Today's Tides | Photos | Sensor Information | Observations | Directions and Map | Available Products

Established:	Jun 10, 1999
Time Meridian:	75° W
Present Installation:	Jun 10, 1999
Date Removed:	N/A
Water Level Max (ref MHHW):	N/A
Water Level Min (ref MLLW):	N/A
Mean Range:	N/A
Diurnal Range:	N/A
Latitude	40° 39.4' N
Longitude	74° 3.9' W
NOAA Chart#:	
Met Site Elevation:	N/A

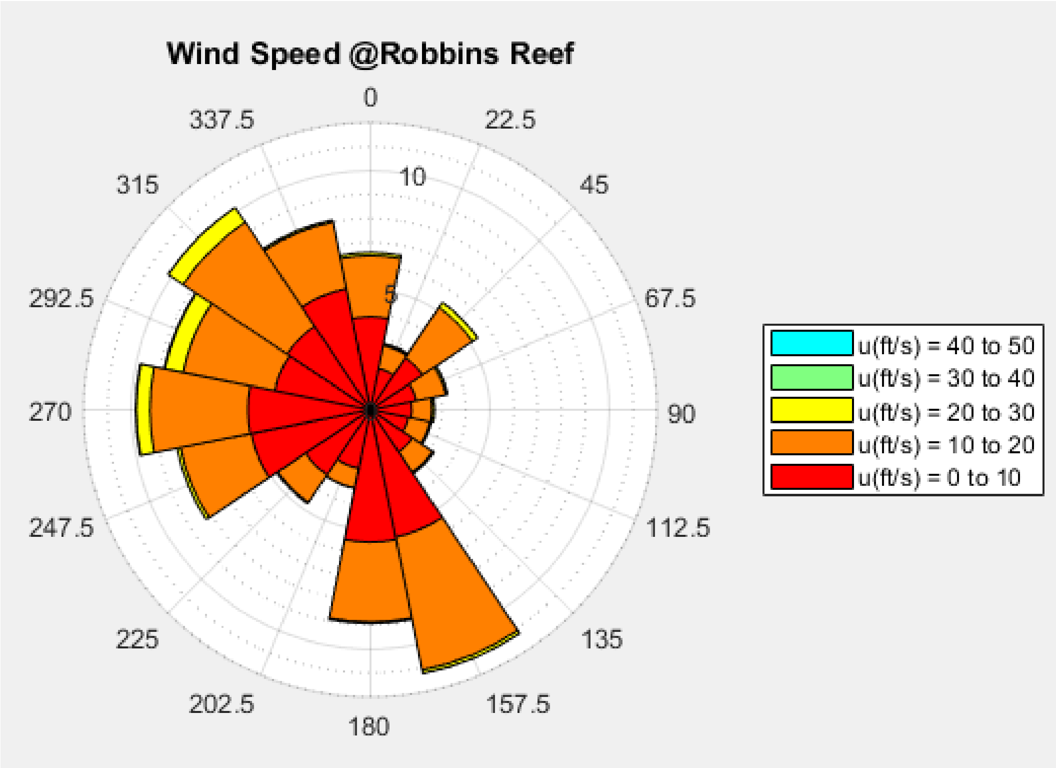
Tide predictions are not available for this station.

Robbins Reef, NJ

5 more station photos available, click to view.

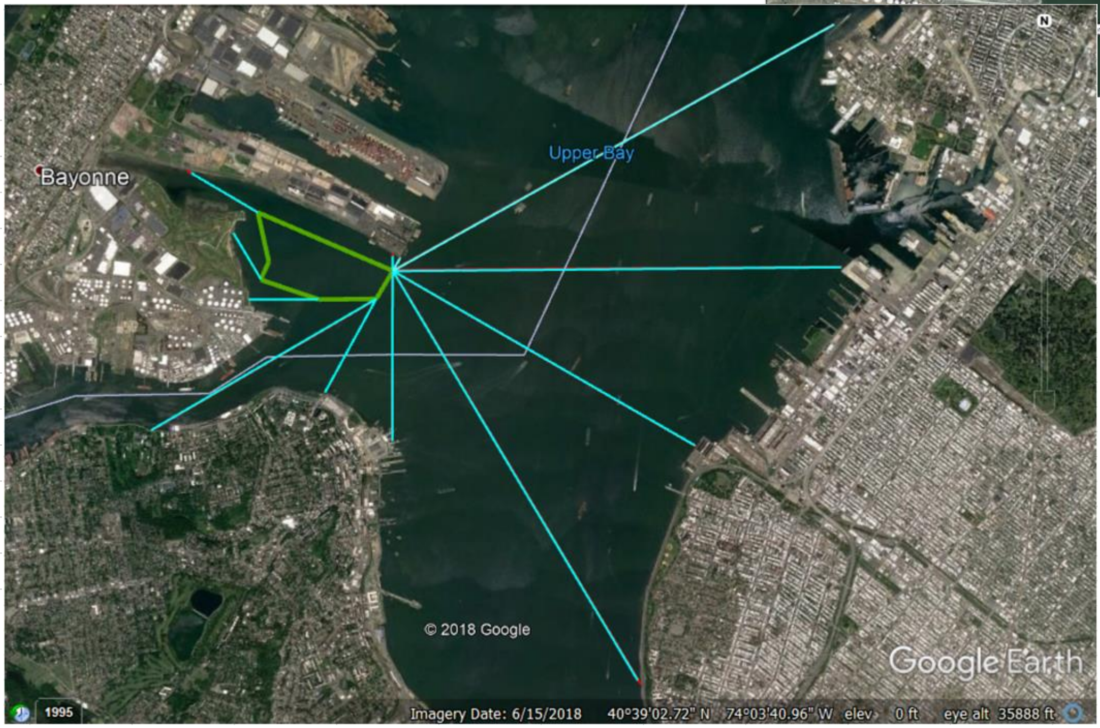
Sensor Information

Sensor	Sensor ID	DCP#	Sensor Height	Status
Wind	C1	1	69.0 ft. above site Elevation	✔ Enabled
Air Temperature	D1	1	68.1 ft. above site Elevation	✔ Enabled
Barometric Pressure	F1	1	N/A	✔ Enabled



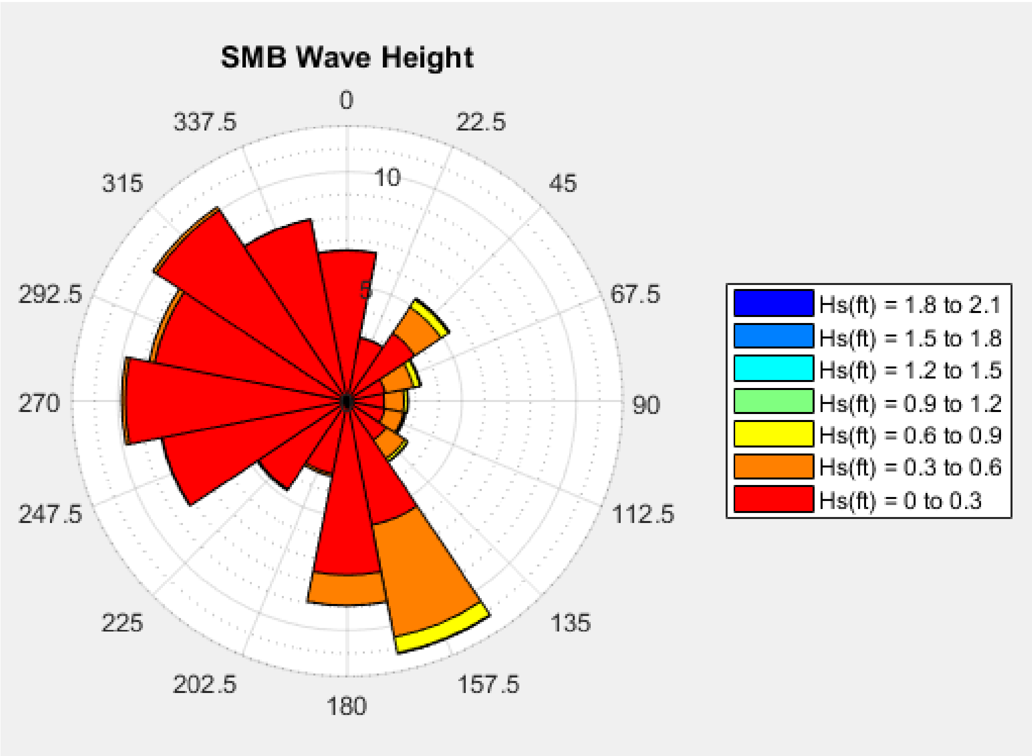
Limited Fetch

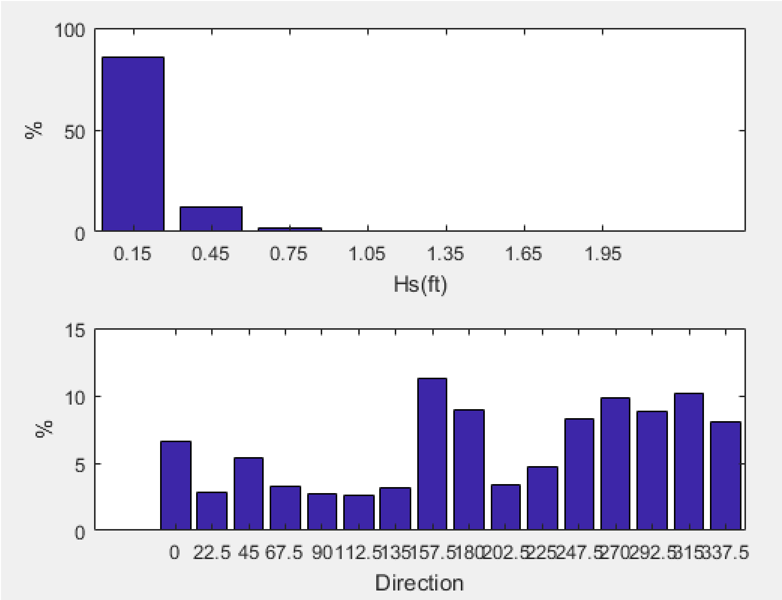
	Approximate	
Degrees	Distance (m)	Distance (ft)
0	179.40	588
30	154.83	508
60	5,164.34	16,939
90	4,602.31	15,096
120	3,563.06	11,687
150	4,901.69	16,078
180	1,729.14	5,672
210	1,087.86	3,568
240	2,663.55	8,736
270	716.07	2,349
300	550.11	1,804
330	837.40	2,747



STEVENS
INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY®

Wind Wave Heights





STEVENS
INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY®

Living Shoreline Engineering Guidelines
(Miller et al., 2015)

Table 1: Parameters Typically Used in the Design of Living Shorelines Projects.

System Parameters	Ecological Parameters
Erosion History	Water Quality
Sea Level Rise	Soil Type
Tidal Range	Sunlight Exposure
Hydrodynamic Parameters	**Terrestrial Parameters**
Wind Waves	Upland Slope
Wakes	Shoreline Slope
Currents	Width
Ice	Nearshore Slope
Storm Surge	Offshore Depth
	Soil Bearing Capacity

Building Block Approach

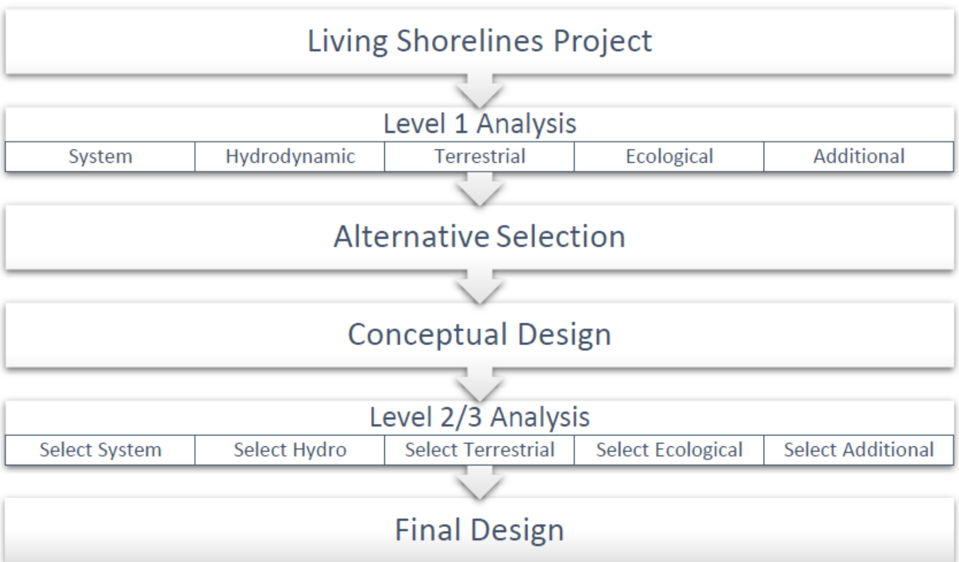


Figure 2: Summary of Building Block Approach

Table 2: Additional Considerations for the Design of Living Shorelines Projects.

Additional Considerations
Permits/Regulatory
End Effects
Constructability
Native/Invasive Species
Debris Impact
Project Monitoring

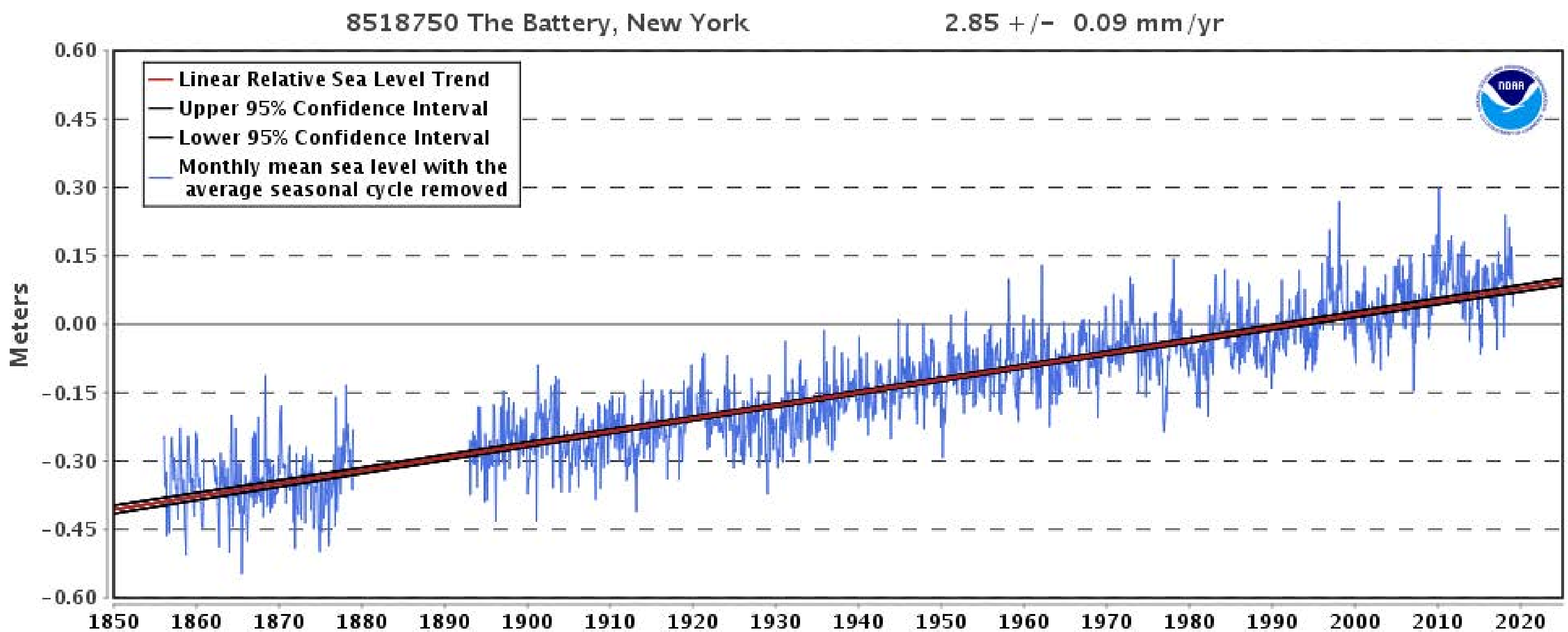
System Parameter:
Erosion History – Restoration Explorer (RE)

Shoreline Change Rate: Not Applicable
Tidal Range: Yes - 5.3 feet
Salinity: Yes - 19.6 ppt
Wave Height: Not Applicable
Ice Cover: Yes - None
Shoreline Slope: Yes - 1%
Nearshore Slope: Yes - 1%

https://coastalresilience.org/project/restoration-explorer/
The Nature Conservancy (2018)

Erosion History – Google Earth

System Parameter:
Sea Level Rise - NOAA



Sea Level Rise Rate (Mean Trend): 2.85 mm/yr

https://tidesandcurrents.noaa.gov/stationhome.html?id=8518750

Sea Level Rise – NJCAA

(Kopp et al., 2016)

Time period	Rate
2010-2030	0.2-0.4 in/yr (5.08-10.16 mm/yr)
2030-2050 (high emissions)	0.3-0.5 in/yr (7.62-12.7 mm/yr)
2030-2050 (low emissions)	0.2-0.4 in/yr (5.08-10.16 mm/yr)
2050-2100 (high emissions)	0.3-0.7 in/yr (7.62-17.78 mm/yr)
2050-2100 (low emissions)	0.2-0.4 in/yr (5.08-10.16 mm/yr)

Sea Level Rise Rate (Upper limit, high emissions): 12.7 mm/yr

System Parameter: Tidal Range

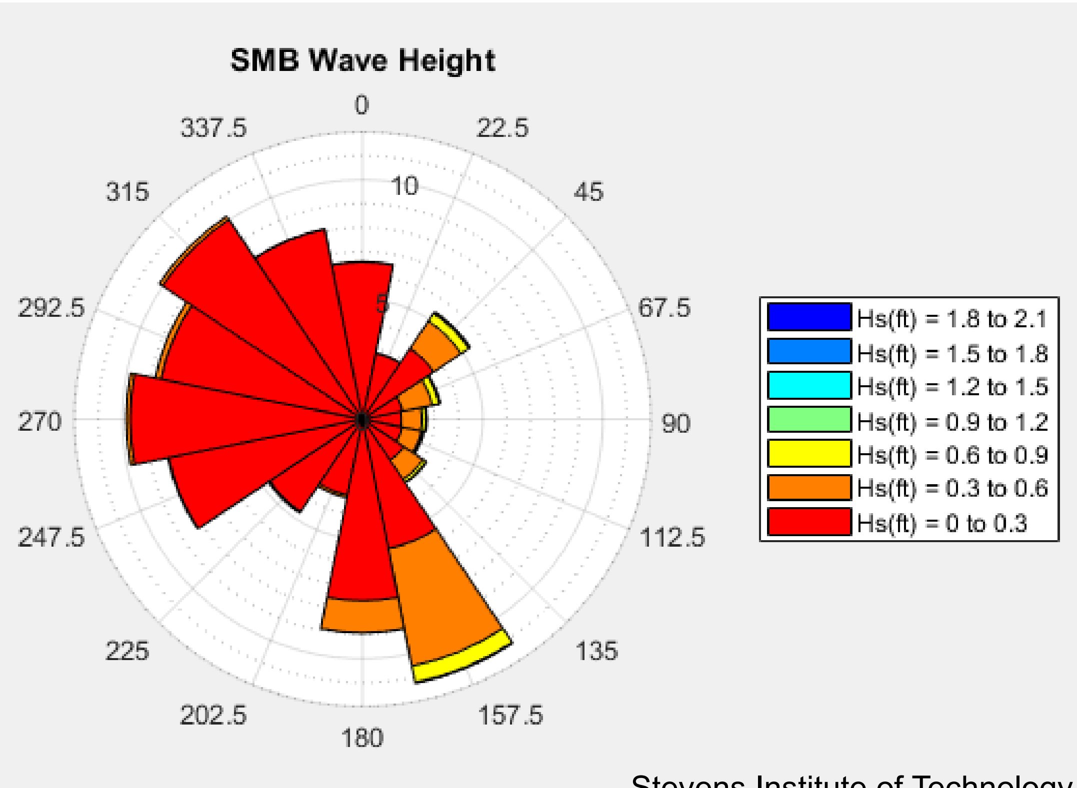
RE Tidal Range: 5.3 ft

NOAA Datum Mean Range (The Battery): 4.53 ft

NOAA Tide Table Mean Range (Constable Hook): 4.74 ft

Constable Hook https://tidesandcurrents.noaa.gov/ports/ports.html?id=8530985

Hydrodynamic Parameter:
Wind Waves



Stevens Institute of Technology

RE Wave Height: 2.1 ft

SMB Predicted Wind Wave Height: primarily <1 ft

Hydrodynamic Parameter: Boat Wakes

STEVENS INSTITUTE of TECHNOLOGY 13

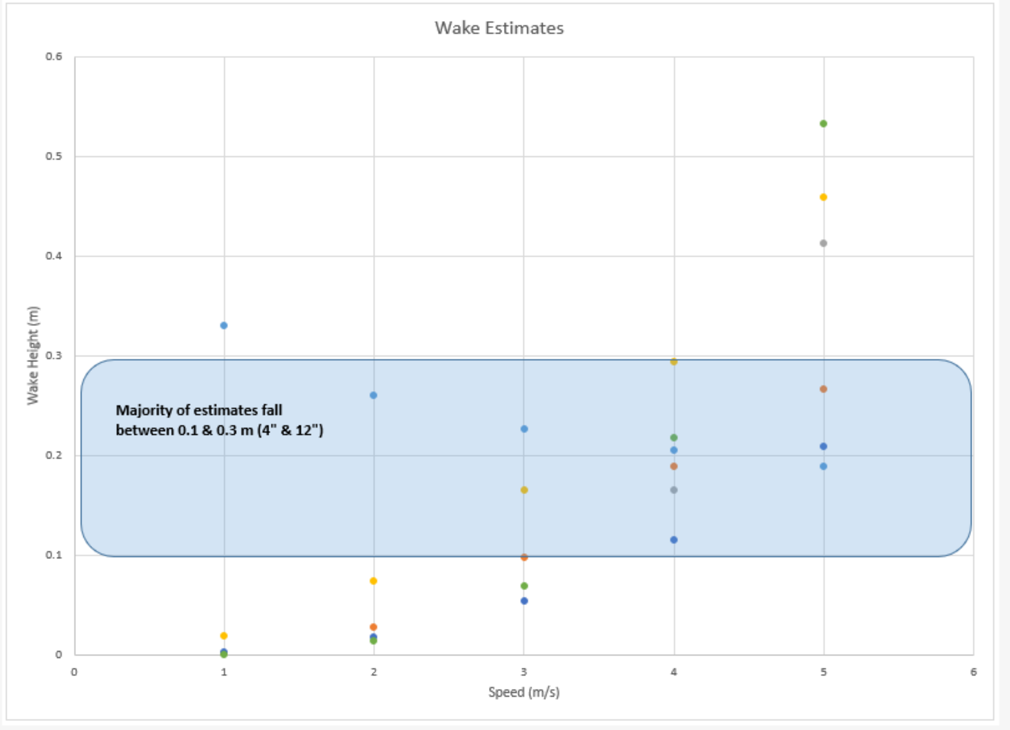
Wake Estimates for Ferry Channel

Assumptions for Calculation:

- Channel depth: 5 meters
- Vessel length: 6 meters
- Vessel beam: 2.5 meters
- Vessel draft: 1 meter
- Distance to bank: 75 meters

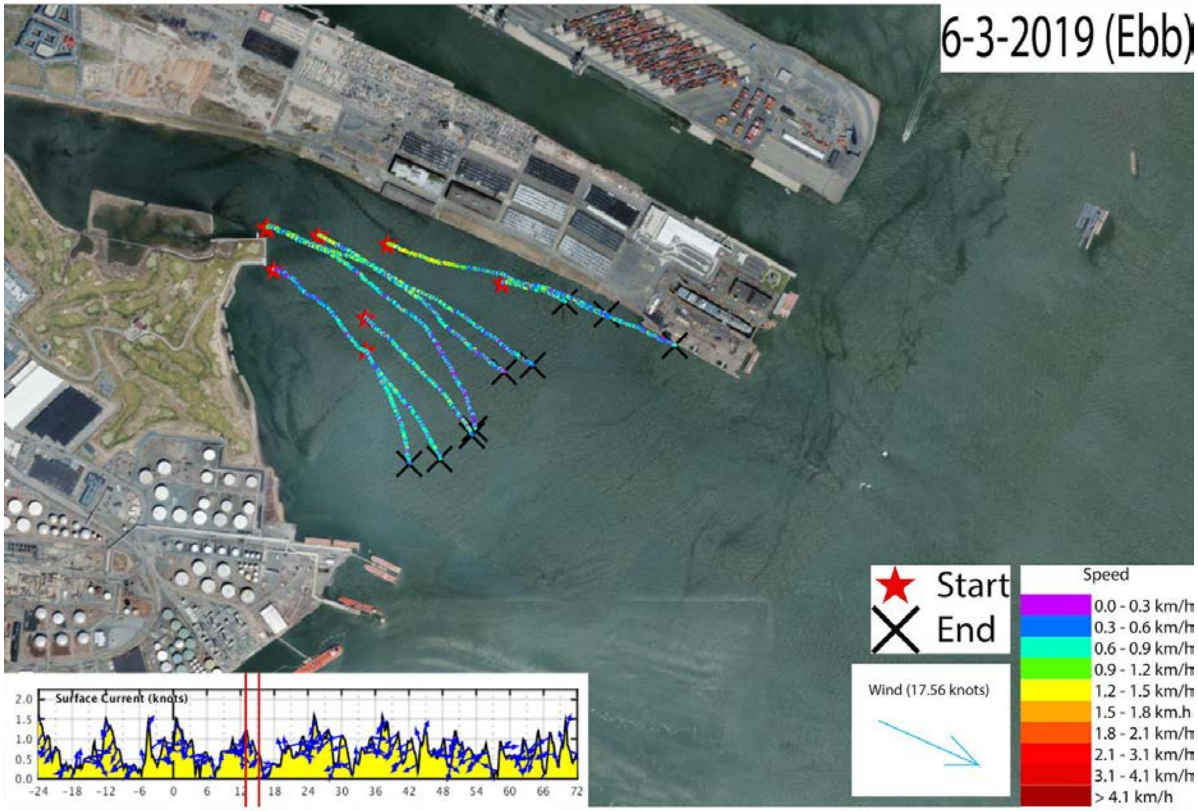
Majority of estimates fall between
0.1 & 0.3 m
or
4 & 12 inches

*Boat wakes generated in the "navigation channel" could additionally be expected to travel down the "ferry channel".



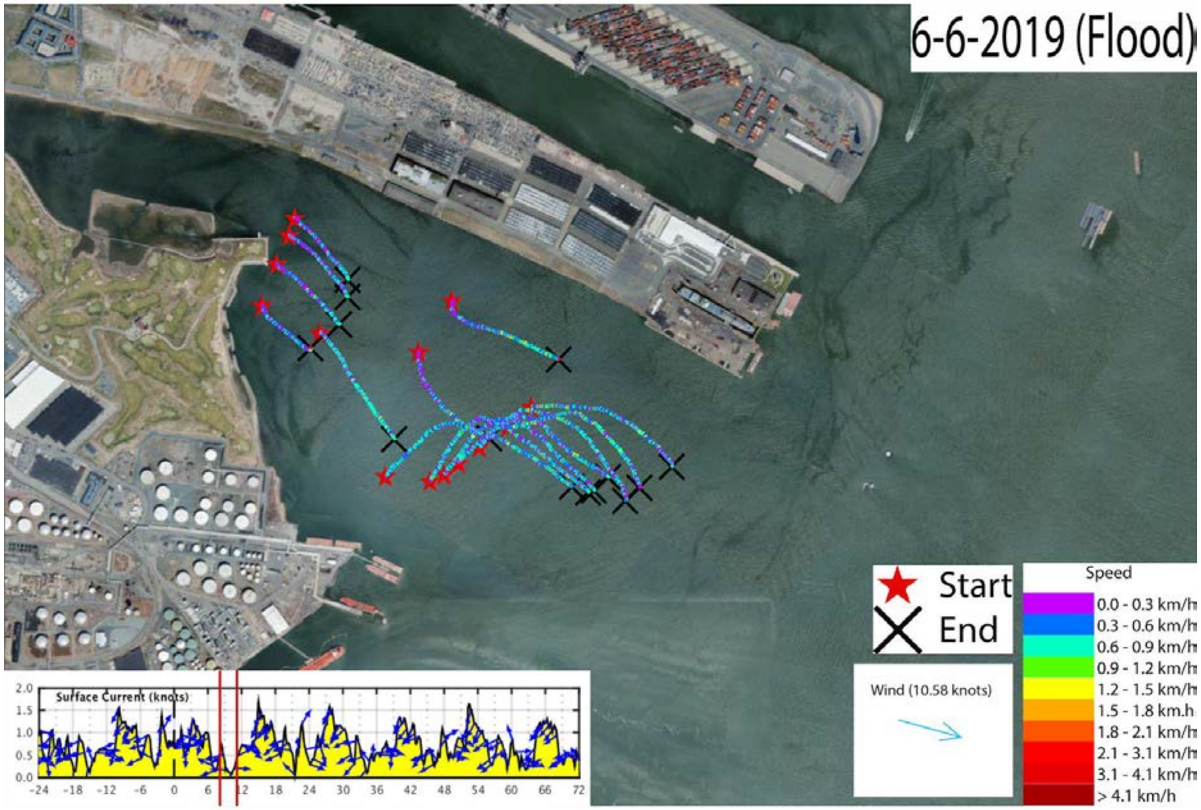
Prediction of vessel-generated waves with reference to vessels common to the Upper Mississippi River System / by Robert M. Sorensen (1997); prepared for U.S. Army Engineer District, Rock Island, U.S. Army Engineer District, St. Louis, U.S. Army Engineer District, St. Paul.

Hydrodynamic Parameter: Currents



STEVENS INSTITUTE *of* TECHNOLOGY 15

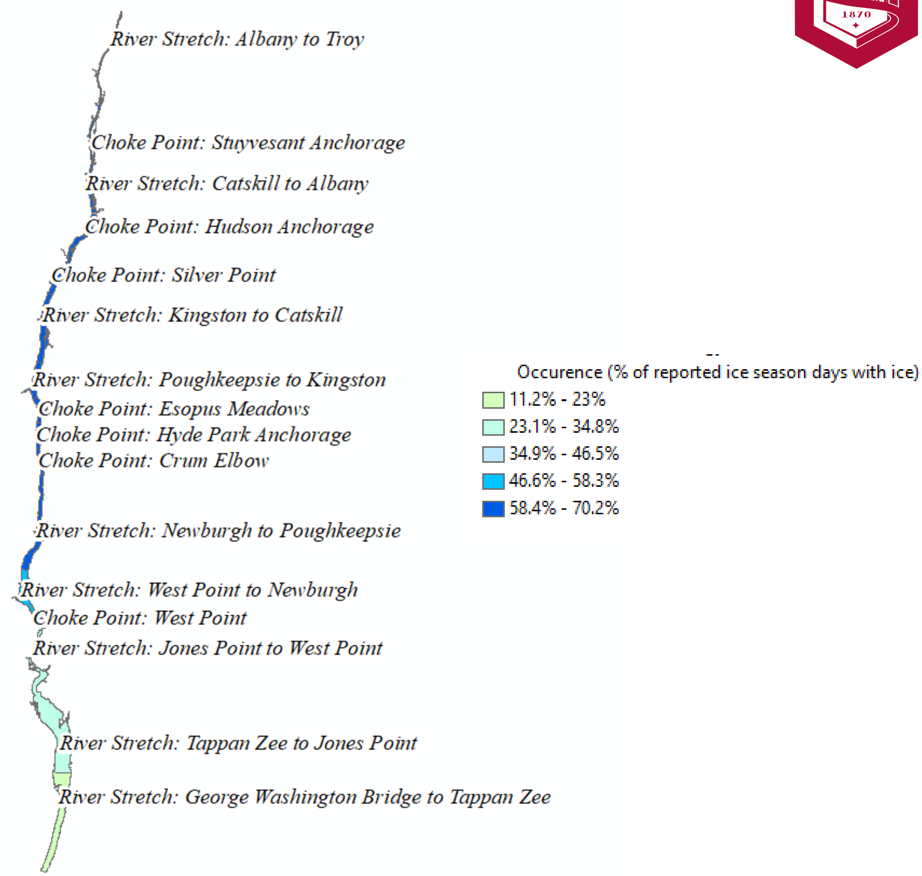
Currents



6-6-2019 (Flood)
Start
End
Speed
0.0 - 0.3 km/h
0.3 - 0.6 km/h
0.6 - 0.9 km/h
0.9 - 1.2 km/h
1.2 - 1.5 km/h
1.5 - 1.8 km.h
1.8 - 2.1 km/h
2.1 - 3.1 km/h
3.1 - 4.1 km/h
> 4.1 km/h
Wind (10.58 knots)
Surface Current (knots)

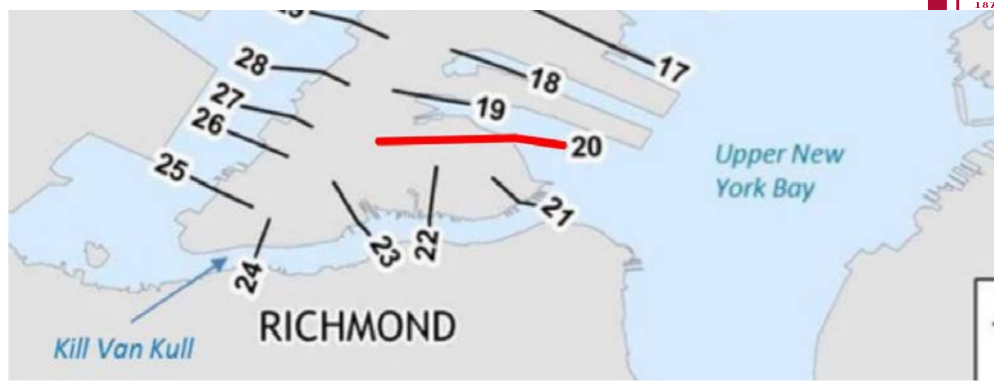
Hydrodynamic Parameter: Ice

- % Ice days decreases moving south down the river
- Site is farther south than southernmost area with data
- Based on trend, small % ice days at site



Hydrodynamic Parameter: Storm Surge

FEMA's Hudson County Preliminary Flood Insurance Study (FIS) Report (2013)



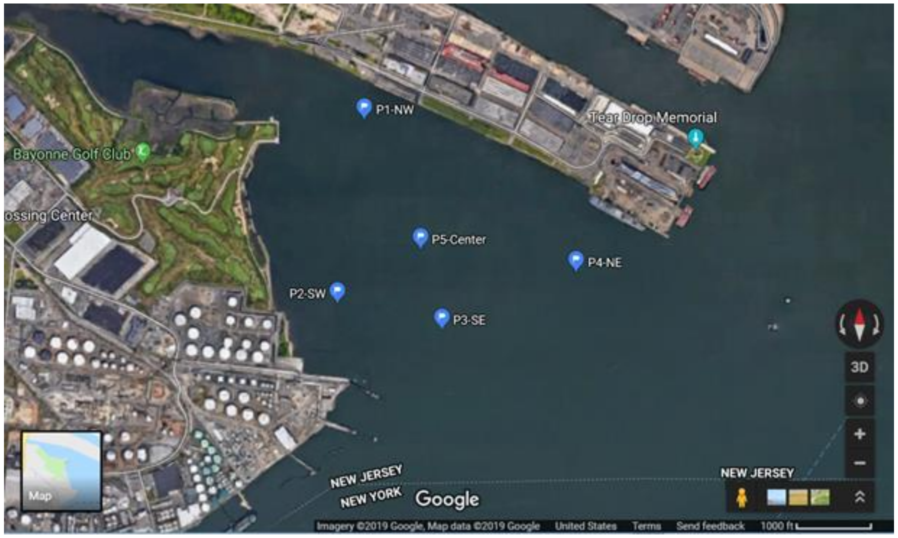
Flood Source	Transect	Starting Wave Conditions for the 1% Annual Chance			Starting Stillwater Elevations (ft NAVD88) Range of Stillwater Elevations* (ft NAVD88)			
		Coordinates	Significant Wave Height	Peak Wave Period	10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Upper New York Bay	20	N 40.662518 W 74.091162	4.44	3.91	7.2 6.8 - 7.4	10.2 8.6 - 10.5	11.7 11.6 - 11.7	15.2 14.3 - 15.4

https://msc.fema.gov/portal/downloadProduct?productID=34017CV000B

Shoreline Geometry

Habitat	Acres
Estuarine Wetland Complex	102
Maritime Grassland	61
Maritime Shrubland/Forest	27
Total	190

Ecological Parameters:
Sediment & Water Quality



Stevens Institute of Technology

Remaining Parameters:

Ecological

- Sunlight Exposure

Terrestrial

- Upland Slope
- Shoreline Slope
- Width
- Nearshore Slope
- Offshore Depth
- Soil Bearing Capacity

Summary

- Dependent on Island Design
- Likely multiple solutions may be needed for various sides of the island (i.e. ferry channel vs main navigation channel)

	Marsh Sill	Breakwater	Revetment	Living Reef	Reef Balls
Relative Sea Level	Low-Mod	Low-High	Low-High	Low-Mod	Low-Mod
Tidal Range	Low-Mod	Low-High	Low-High	Low-Mod	Low-Mod
Wind Waves	Low-Mod	High	Mod-High	Low-Mod	Low-Mod
Wakes	Low-Mod	High	Mod-High	Low-Mod	Low-Mod
Currents	Low-Mod	Low-Mod	Low-High	Low-Mod	Low-Mod
Ice	Low	Low-Mod	Low-High	Low	Low-Mod
Storm Surge	Low-High	Low-High	Low-High	Low-High	Low-High
Soil Type	Any	Any	Any	Any	Any
Sunlight Exposure	Mod-High	Low-High	Low-High	Mod-High	Low-High
# Conditions Met	8	6	7	8	8

SEA LEVEL RISE

Overview: Use the slider bar above to see how various levels of sea-level rise will impact this area.

Levels represent inundation at high tide. Areas that are hydrologically connected are shown in shades of blue (darker blue = greater depth).

Low-lying areas, displayed in green, are hydrologically "unconnected" areas that may flood. They are determined solely by how well the elevation data captures the area's hydraulics. A more detailed analysis of these areas is required to determine the susceptibility to flooding.

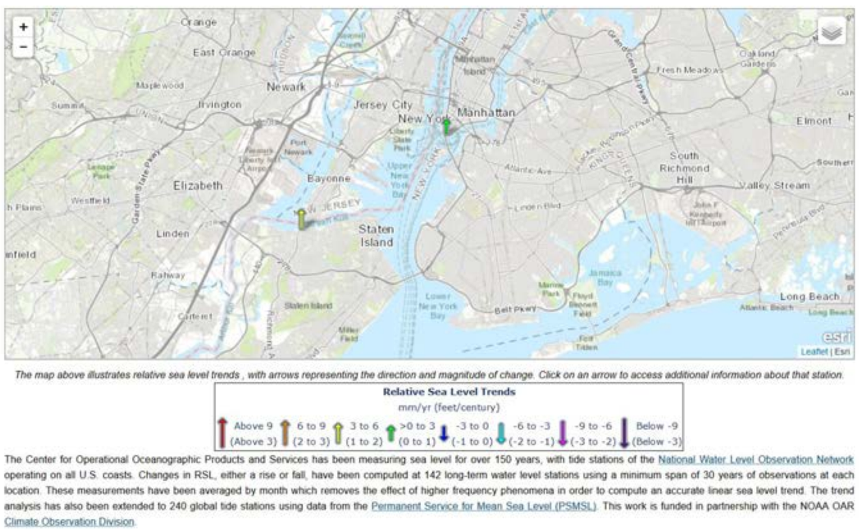
The “Planning Using Total Water Level” approach is a way to visualize a suite of different coastal flood hazard risks. More information about this approach is provided on the “Planning Using Total Water Level” tab.

Understanding the Map: **Data.** The data in the map do not consider natural processes such as erosion or marsh migration that will be affected by future sea-level rise.

Confidence. There is not 100% confidence in the elevation data and/or mapping process. It is important not to focus on the exact extent of inundation, but rather to examine the level of confidence that the extent of inundation is accurate.

Hydrology. The data may not completely capture the areas hydrology, such as canals, ditches, and stormwater infrastructure.

Localized Sea Level Rise - https://www.tidesandcurrents.noaa.gov/sltrends/sltrends.html



Bergen Point, NY – 8519483 The relative sea level trend is 4.3 mm/year with a 95% confidence interval of +/- 0.77 mm/year based on monthly mean sea level data from 1981 to 2018 which is equivalent to a change of 1.41 feet in 100 years

Source: NOAA and https://www.tidesandcurrents.noaa.gov/sltrends/sltrends.html

Sea Level Rise - http://www.njfloodmapper.org/slr/

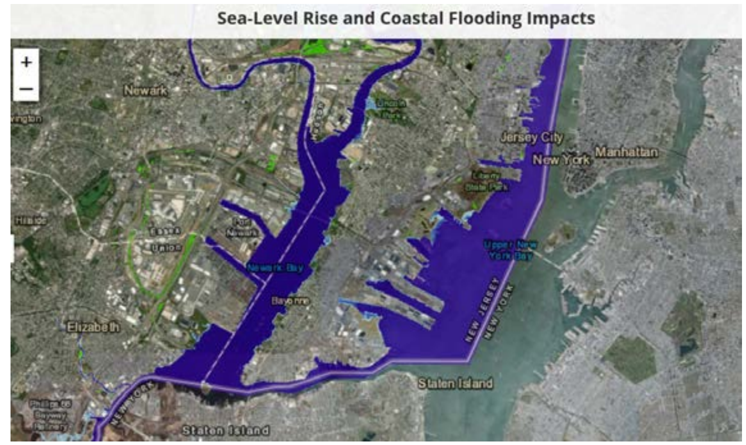
Legend

Water Depth

Low-lying Areas

Area Not Mapped

Visualization Location

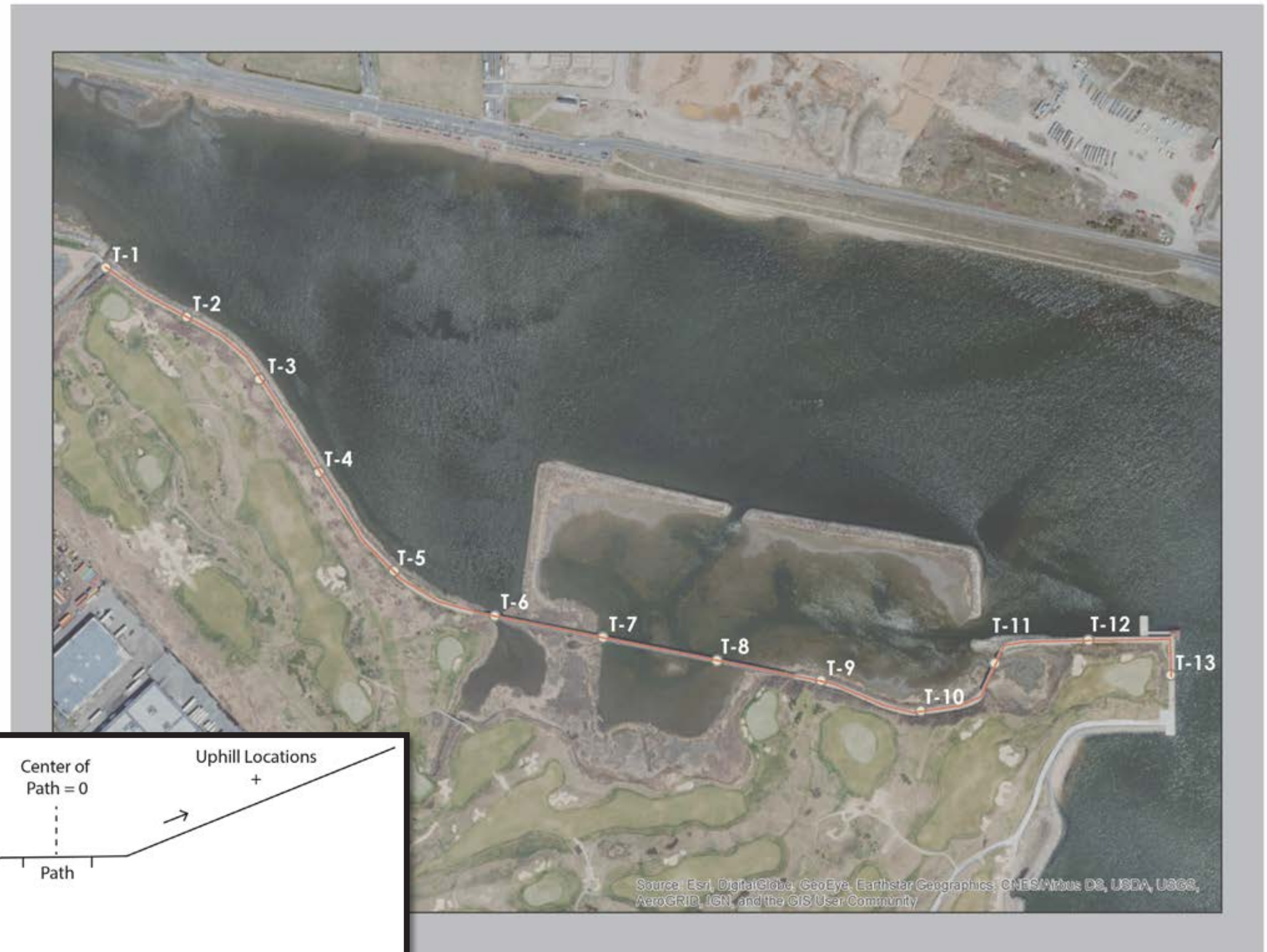


Source: NOAA and http://www.njfloodmapper.org/slr/

Bayonne Golf Club Transect Survey
Conducted by Rutgers CUES on May 16, 2019

Transect Parameters

- 100 meter segments along Hudson River Waterfront Walkway
- 20 meter cross-section
    - 10m uphill
    - 10m downhill



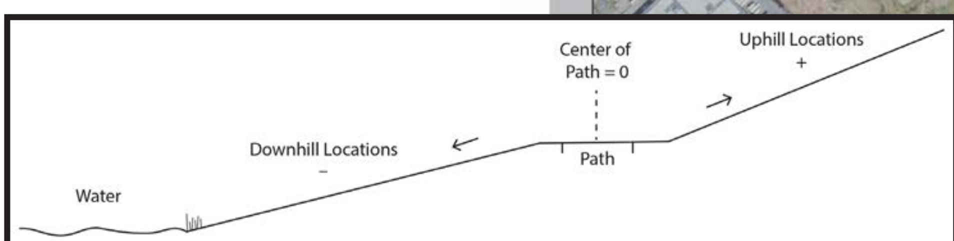
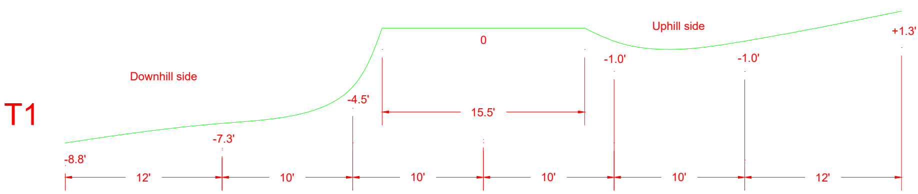


Photo Analysis

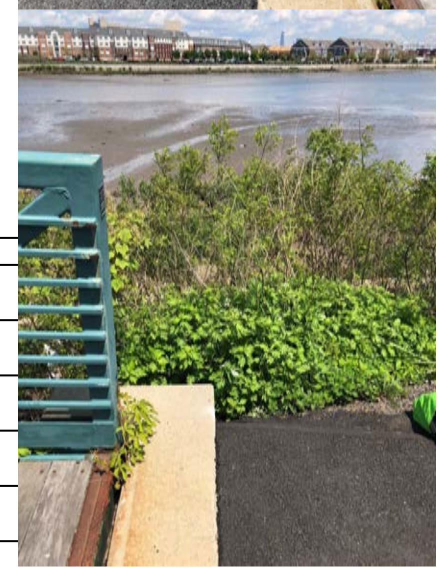
Photo documentation was conducted at each transect point perpendicular to the transect line.

Transect Point T-1

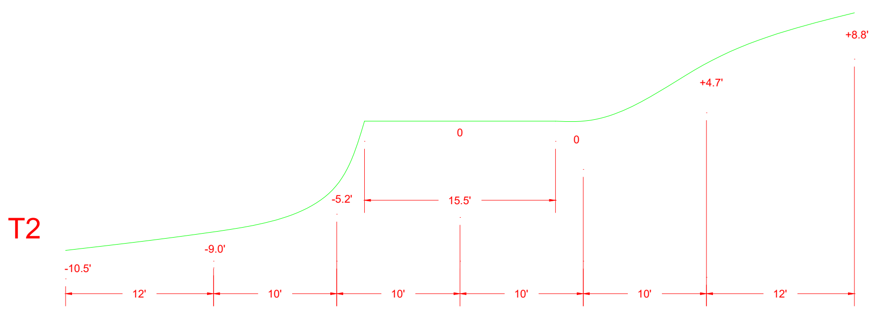
Location	Vegetation Observed
T1 UPHILL	Virginia Creeper *Parthenocissus quinquefolia*
T1 UPHILL	Cleavers *Galium aparine*
T1 UPHILL	Mugworts *Artemisia*
T1 UPHILL	Unknown #1
T1 UPHILL	Purple Crownvetch *Securigera varia*
T1 UPHILL	Unknown #2
T1 UPHILL	Indian Lettuce *Lactuca indica*
T1 UPHILL	Chickweed *Stellaria media*



Location	Vegetation Observed
T1 DOWNHILL	Mugworts *Artemisia*
T1 DOWNHILL	Virginia Creeper *Parthenocissus quinquefolia*
T1 DOWNHILL	False Indigo Bush *Amorpha fruticosa*
T1 DOWNHILL	Unknown Grass #1
T1 DOWNHILL	Saltmarsh Cordgrass *Spartina alterniflora*



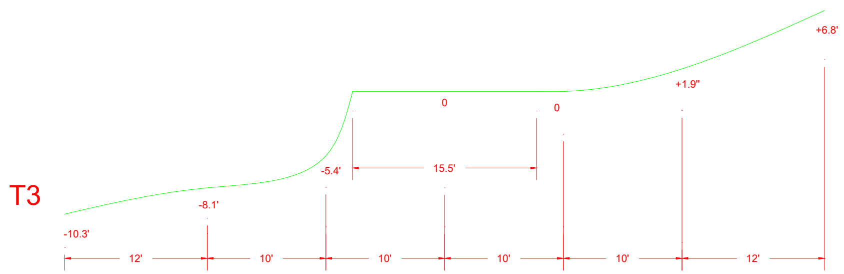
Transect Point T-2



Location	Vegetation Observed
T2 UPHILL	Unknown #3
T2 UPHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T2 UPHILL	Japanese Knotweed *Reynoutria japonica*
T2 UPHILL	Common Reed *Phragmites australis*
T2 UPHILL	Staghorn Sumac *Rhus typhina*

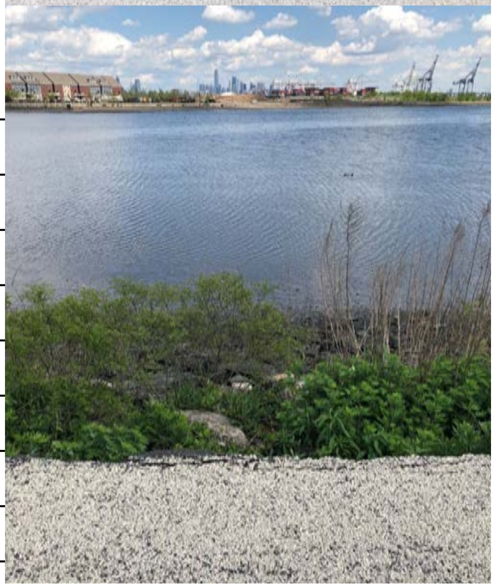
Location	Vegetation Observed
T2 DOWNHILL	Tall Fescue *Festuca arundinacea*
T2 DOWNHILL	Mugworts *Artemisia*
T2 DOWNHILL	False Indigo Bush *Amorpha fruticosa*

Transect Point T-3

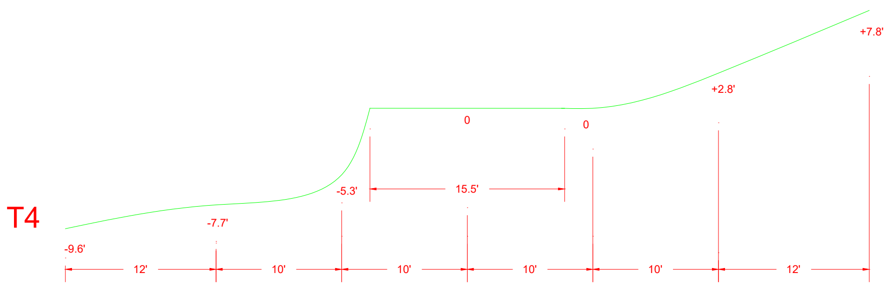


Location	Vegetation Observed
T3 UPHILL	Tea Plant *Camellia sinensis*
T3 UPHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T3 UPHILL	Staghorn Sumac *Rhus typhina*
T3 UPHILL	Mugworts *Artemisia*
T3 UPHILL	White Snakeroot *Ageratina altissima*

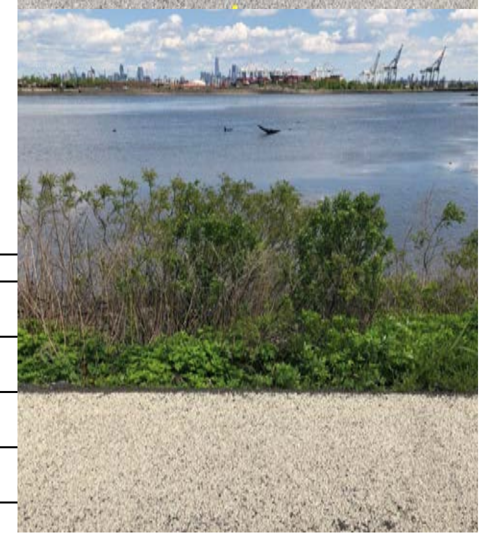
Location	Vegetation Observed
T3 DOWNHILL	Mugworts *Artemisia*
T3 DOWNHILL	Unknown Grass #4
T3 DOWNHILL	Hedge Bindweed *Calystegia sepium*
T3 DOWNHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T3 DOWNHILL	Virginia Creeper *Parthenocissus quinquefolia*
T3 DOWNHILL	Creeping Thistle *Cirsium arvense*
T3 DOWNHILL	False Indigo Bush *Amorpha fruticosa*



Transect Point T-4

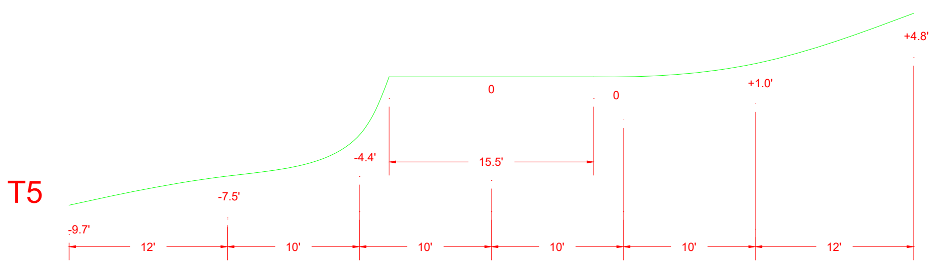


Location	Vegetation Observed
T4 UPHILL	Common Reed *Phragmites australis*
T4 UPHILL	Tea Plant *Camellia sinensis*
T4 UPHILL	Virginia Creeper *Parthenocissus quinquefolia*
T4 UPHILL	Beach Rose *Rosa rugosa*
T4 UPHILL	Unknown #5
T4 UPHILL	Creeping Thistle *Cirsium arvense*
T4 UPHILL	Staghorn Sumac *Rhus typhina*



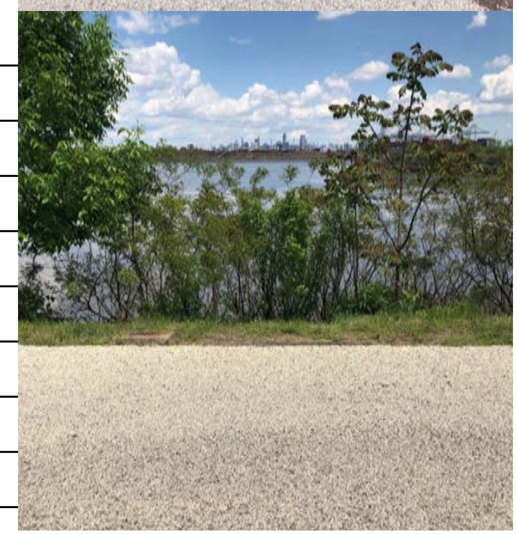
Location	Vegetation Observed
T4 DOWNHILL	Cleavers *Galium aparine*
T4 DOWNHILL	Mugworts *Artemisia*
T4 DOWNHILL	Creeping Thistle *Cirsium arvense*
T4 DOWNHILL	False Indigo Bush *Amorpha fruticosa*

Transect Point T-5



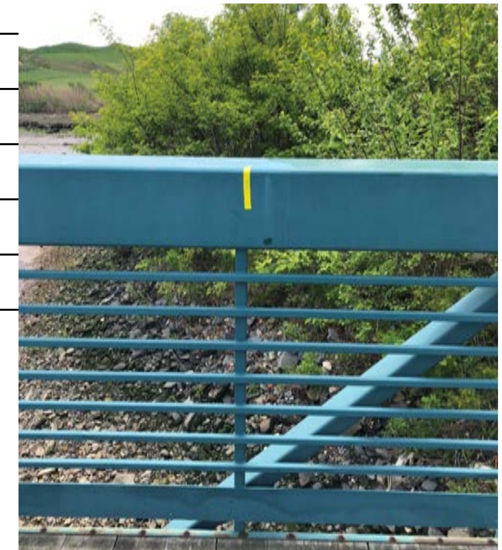
Location	Vegetation Observed
T5 UPHILL	Unknown #3
T5 UPHILL	Common Reed *Phragmites australis*
T5 UPHILL	Mugworts *Artemisia*
T5 UPHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T5 UPHILL	Creeping Thistle *Cirsium arvense*
T5 UPHILL	Unknown #5
T5 UPHILL	Beach Rose *Rosa rugosa*
T5 UPHILL	Staghorn Sumac *Rhus typhina*

Location	Vegetation Observed
T5 DOWNHILL	Unknown #4
T5 DOWNHILL	Unknown #5
T5 DOWNHILL	Unknown #7
T5 DOWNHILL	Unknown #6
T5 DOWNHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T5 DOWNHILL	False Indigo Bush *Amorpha fruticosa*
T5 DOWNHILL	Saltmarsh Cordgrass *Spartina alterniflora*

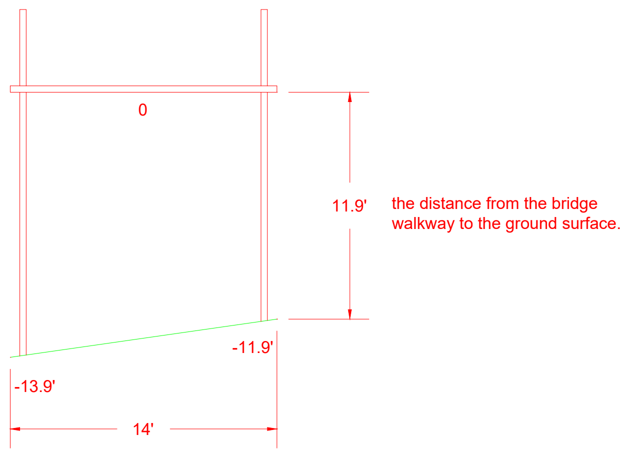


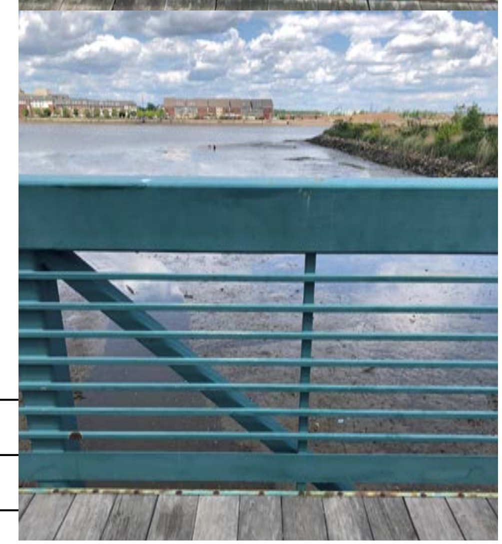
Transect Point T-6

Location	Vegetation Observed
T6 UPHILL	Unknown #8
T6 UPHILL	Unknown #9
T6 UPHILL	Unknown #7
T6 UPHILL	Black Locust *Robinia pseudoacacia*



T6



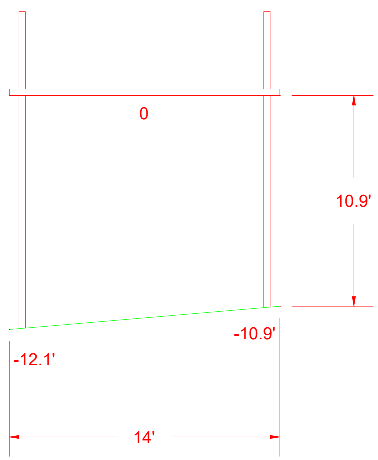


Location	Vegetation Observed
T6 DOWNHILL	--

Transect Point T-7

T7

Location	Vegetation Observed
T7 UPHILL	Saltmarsh Cordgrass *Spartina alterniflora*



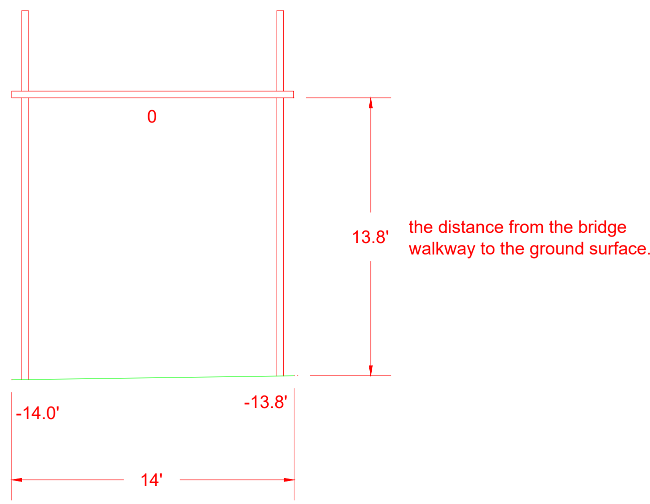
the distance from the bridge walkway to the ground surface.

Location	Vegetation Observed
T7 DOWNHILL	--

Transect Point T-8

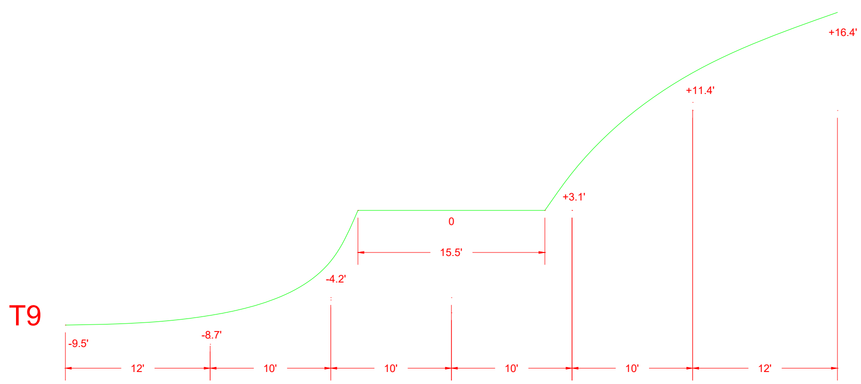
T8

Location	Vegetation Observed
T8 UPHILL	--



Location	Vegetation Observed
T8 DOWNHILL	--

Transect Point T-9

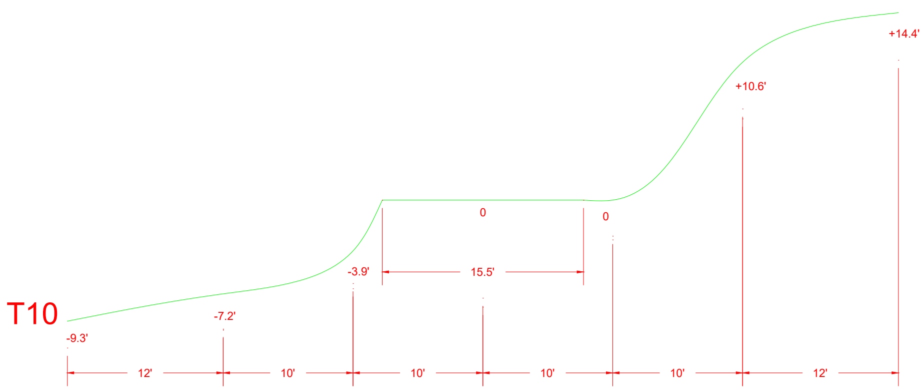


Location	Vegetation Observed
T9 UPHILL	Unknown #10
T9 UPHILL	Virginia Creeper *Parthenocissus quinquefolia*
T9 UPHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T9 UPHILL	Creeping Thistle *Cirsium arvense*
T9 UPHILL	Tea Plant *Camellia sinensis*

Location	Vegetation Observed
T9 DOWNHILL	Mugworts *Artemisia*
T9 DOWNHILL	Creeping Thistle *Cirsium arvense*
T9 DOWNHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T9 DOWNHILL	False Indigo Bush *Amorpha fruticosa*
T9 DOWNHILL	Common Reed *Phragmites australis*
T9 DOWNHILL	Saltmarsh Cordgrass *Spartina alterniflora*

Transect Point T-10

Location	Vegetation Observed
T10 UPHILL	Mugworts *Artemisia*
T10 UPHILL	Japanese Knotweed *Reynoutria japonica*

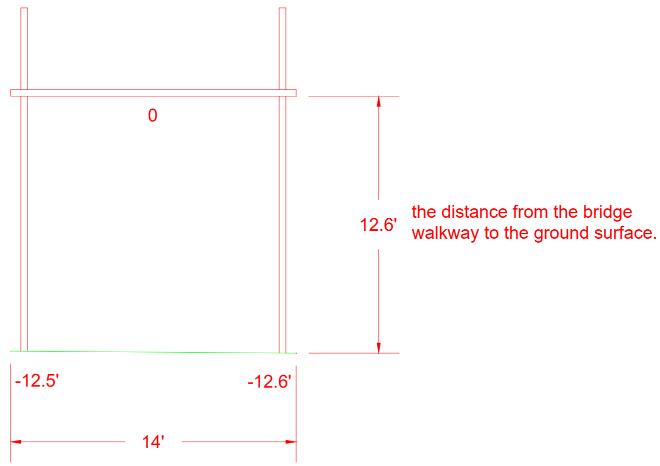


Location	Vegetation Observed
T10 DOWNHILL	Purple Crownvetch *Securigera varia*
T10 DOWNHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T10 DOWNHILL	False Indigo Bush *Amorpha fruticosa*
T10 DOWNHILL	Common Reed *Phragmites australis*

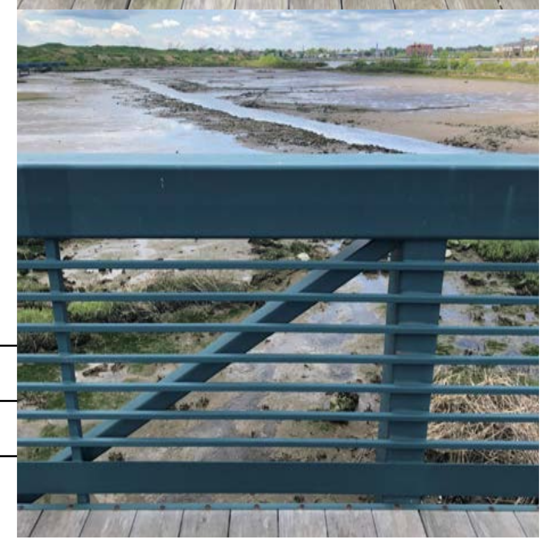
Transect Point T-11

T11

Location	Vegetation Observed
T11 UPHILL	Saltmarsh Cordgrass *Spartina alterniflora*

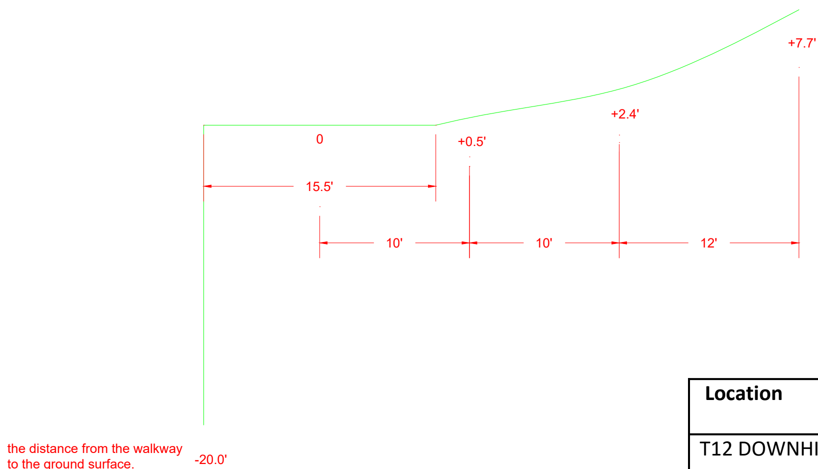


Location	Vegetation Observed
T11 DOWNHILL	Saltmarsh Cordgrass *Spartina alterniflora*



Transect Point T-12

T12

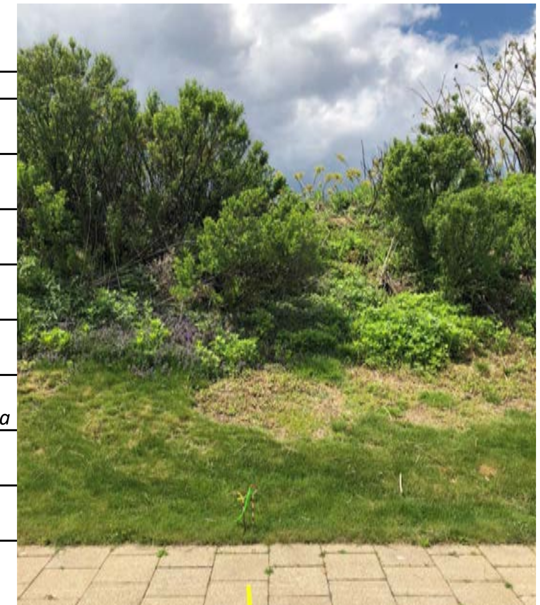


Location	Vegetation Observed
T12 UPHILL	Barberry *Berberis*
T12 UPHILL	Mugworts *Artemisia*
T12 UPHILL	Purple Crownvetch *Securigera varia*
T12 UPHILL	Unknown #11
T12 UPHILL	Common Reed *Phragmites australis*

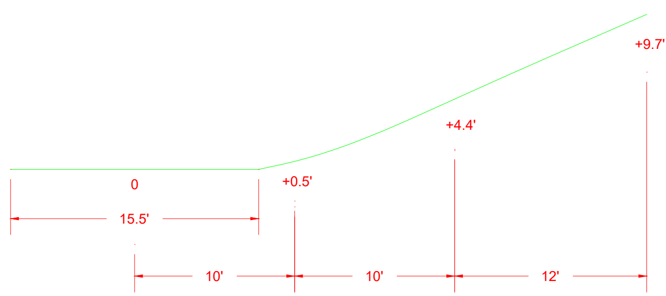
Location	Vegetation Observed
T12 DOWNHILL PLANTING BED	Mugworts *Artemisia*
T12 DOWNHILL PLANTING BED	Porcelain Berry *Ampelopsis brevipedunculata*
T12 DOWNHILL PLANTING BED	Unknown #4

Transect Point T-13

Location	Vegetation Observed
T13 UPHILL	Mugworts *Artemisia*
T13 UPHILL	Creeping Charlie *Glechoma hederacea*
T13 UPHILL	Unknown #4
T13 UPHILL	Tea Plant *Camellia sinensis*
T13 UPHILL	Beach Rose *Rosa rugosa*
T13 UPHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T13 UPHILL	Creeping Thistle *Cirsium arvense*
T13 UPHILL	Staghorn Sumac *Rhus typhina*



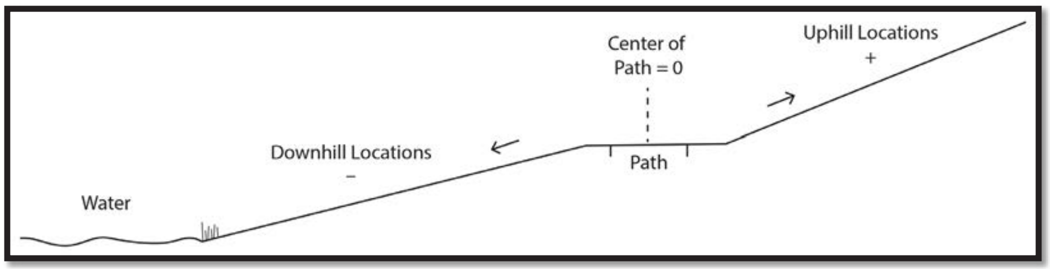
T13



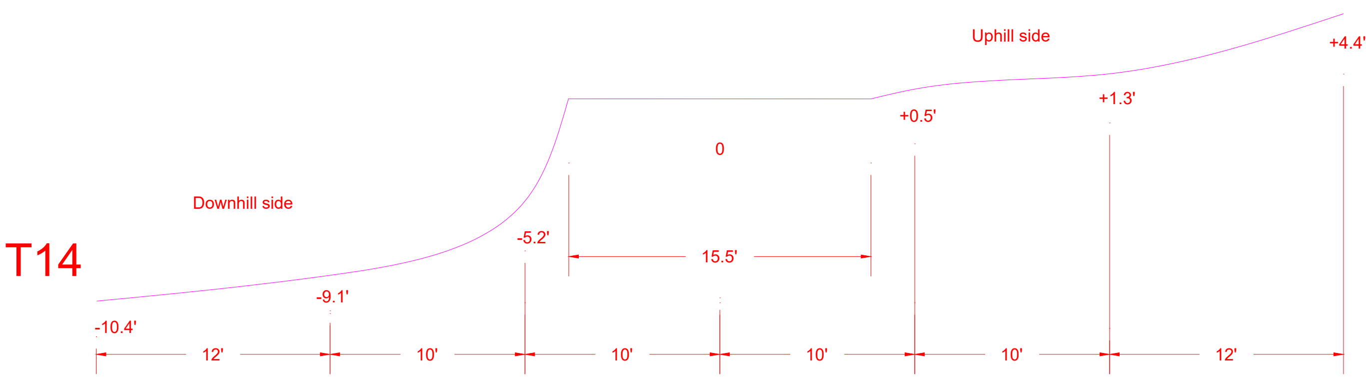
Location	Vegetation Observed
T13 DOWNHILL	--

Photo Analysis

Photo documentation was conducted at each transect point perpendicular to the transect line.



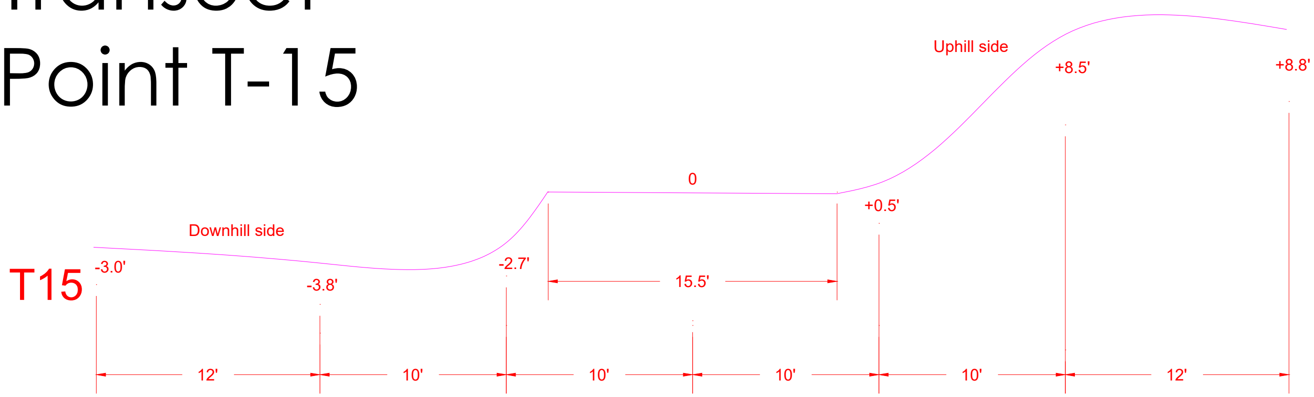
Transect Point T-14



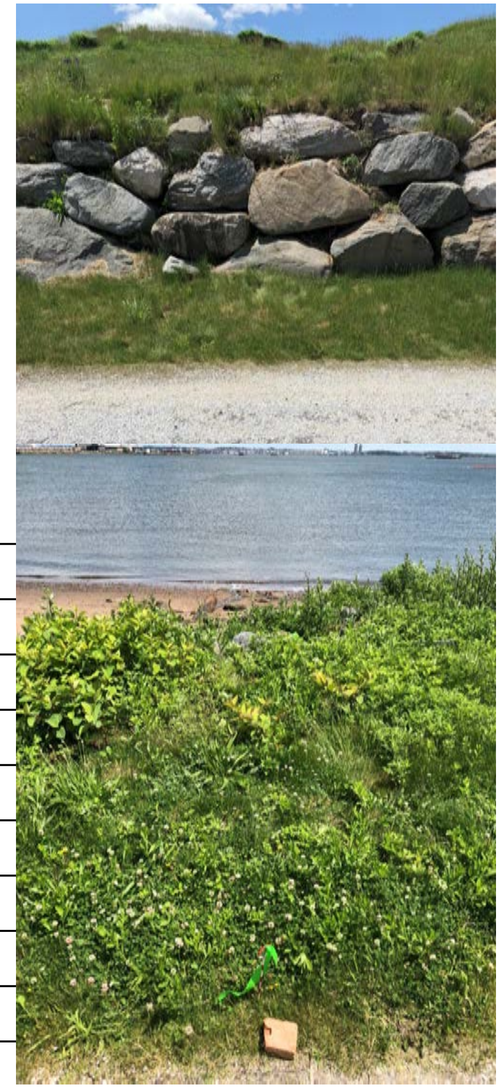
In MHT Zone

Location	Vegetation Observed
T14 DOWNHILL	Mugworts *Artemisia*
T14 DOWNHILL	Unknown #6
T14 DOWNHILL	Sulphur Cinquefoil *Potentilla recta*
T14 DOWNHILL	Bittersweet *Solanum dulcamara*

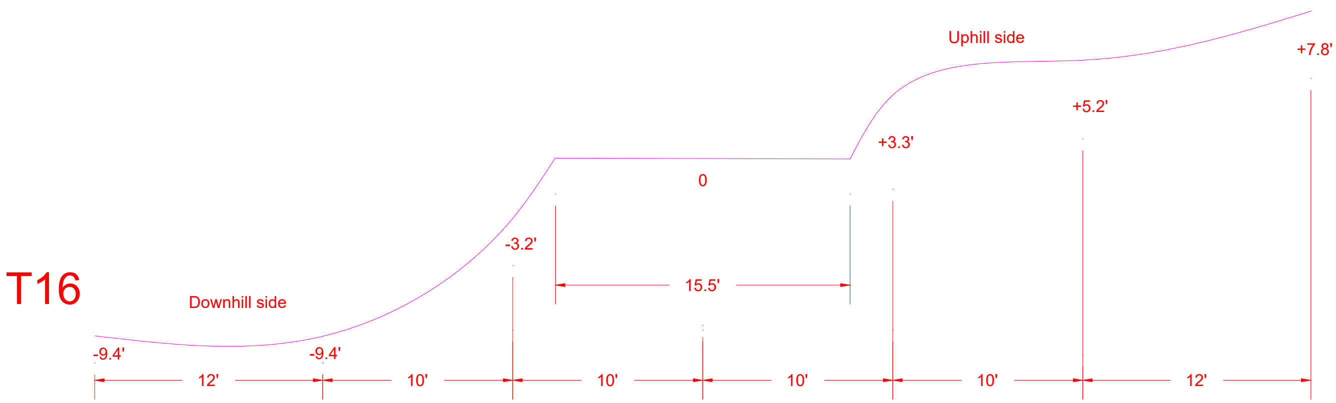
Transect Point T-15



Location	Vegetation Observed
T15 DOWNHILL	Red Clover *Trifolium pretense*
T15 DOWNHILL	Mugworts *Artemisia*
T15 DOWNHILL	Unknown #6
T15 DOWNHILL	Common Dandelion *Taraxacum officinale*
T15 DOWNHILL	Ribwort Plantain *Plantago lanceolata*
T15 DOWNHILL	Purple Crownvetch *Securigera varia*
T15 DOWNHILL	Japanese Knotweed *Reynoutria japonica*
T15 DOWNHILL	Creeping Thistle *Cirsium arvense*

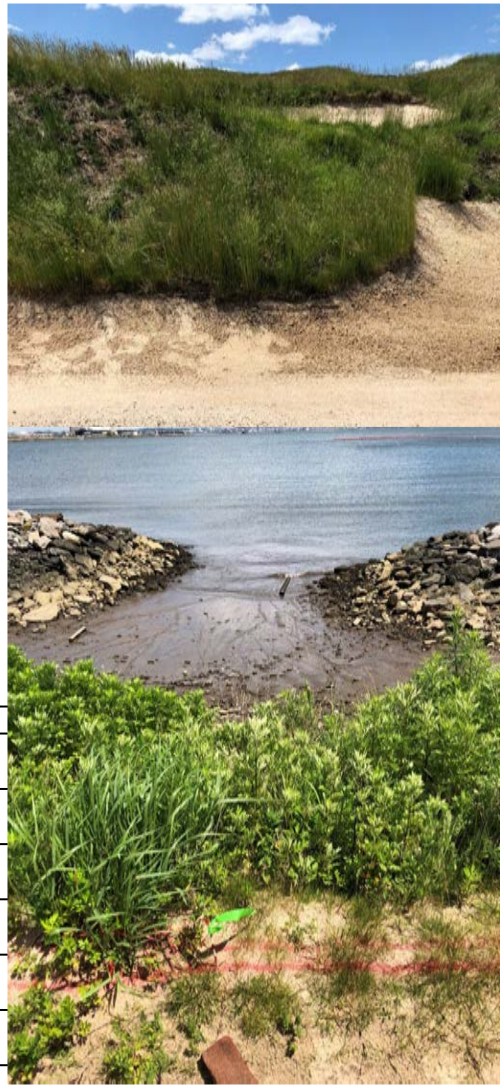


Transect Point T-16

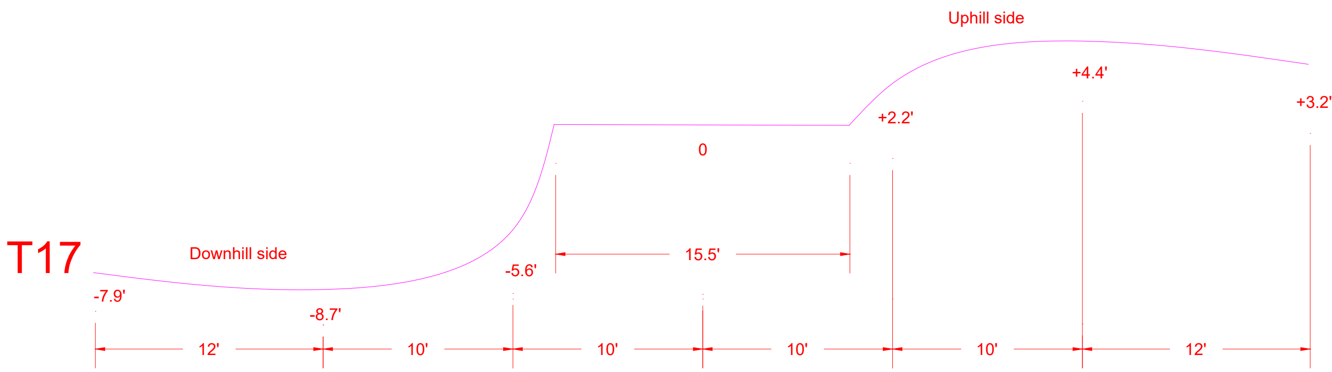


Near MHT Zone

Location	Vegetation Observed
T16 DOWNHILL	Mugworts *Artemisia*
T16 DOWNHILL	Japanese Knotweed *Reynoutria japonica*
T16 DOWNHILL	Unknown Grass Species
T16 DOWNHILL	Unknown Grass Species
T16 DOWNHILL	Unknown Grass Species
T16 DOWNHILL	Unknown Grass Species



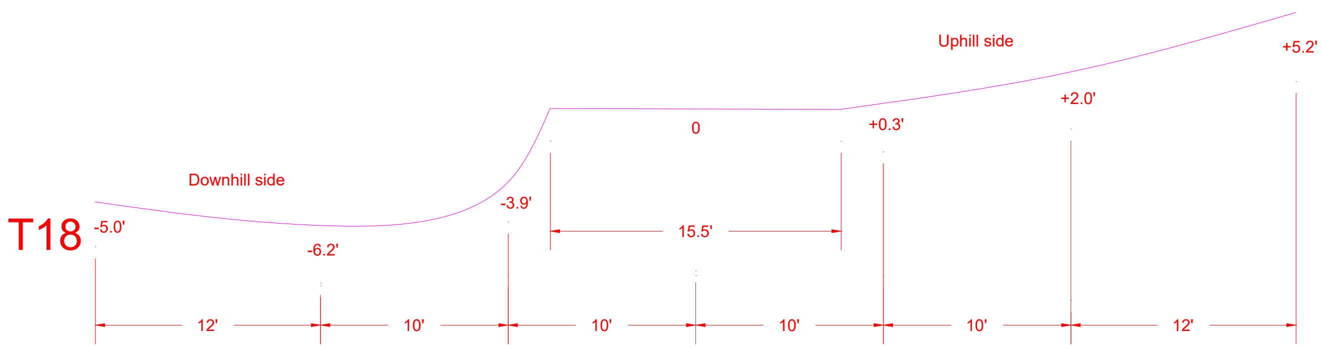
Transect Point T-17



In MHT Zone

Location	Vegetation Observed
T17 DOWNHILL	Japanese Knotweed *Reynoutria japonica*
T17 DOWNHILL	Mugworts *Artemisia*
T17 DOWNHILL	Creeping Thistle *Cirsium arvense*
T17 DOWNHILL	Common Reed *Phragmites australis*

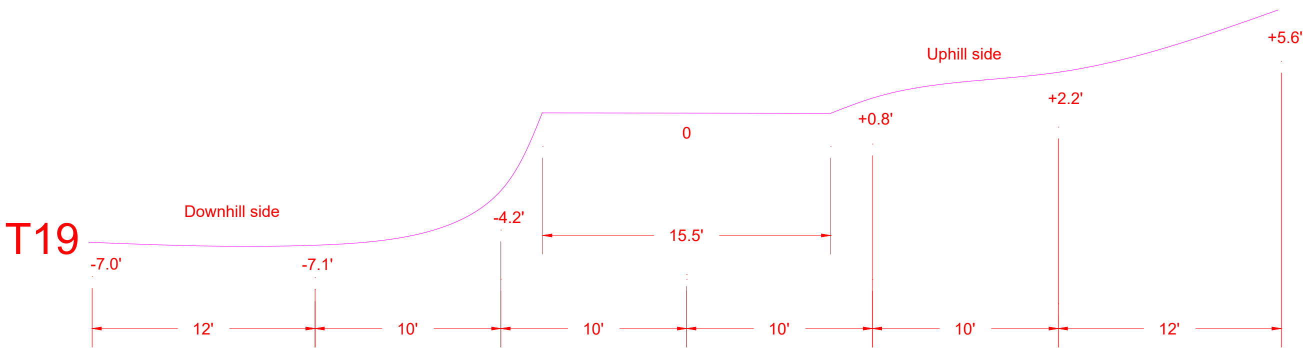
Transect Point T-18



Near MHT Zone

Location	Vegetation Observed
T18 DOWNHILL	Japanese Knotweed *Reynoutria japonica*
T18 DOWNHILL	Unknown Grass Species
T18 DOWNHILL	Purple Crownvetch *Securigera varia*
T18 DOWNHILL	Mugworts *Artemisia*
T18 DOWNHILL	Creeping Thistle *Cirsium arvense*
T18 DOWNHILL	Beach Rose *Rosa rugosa*

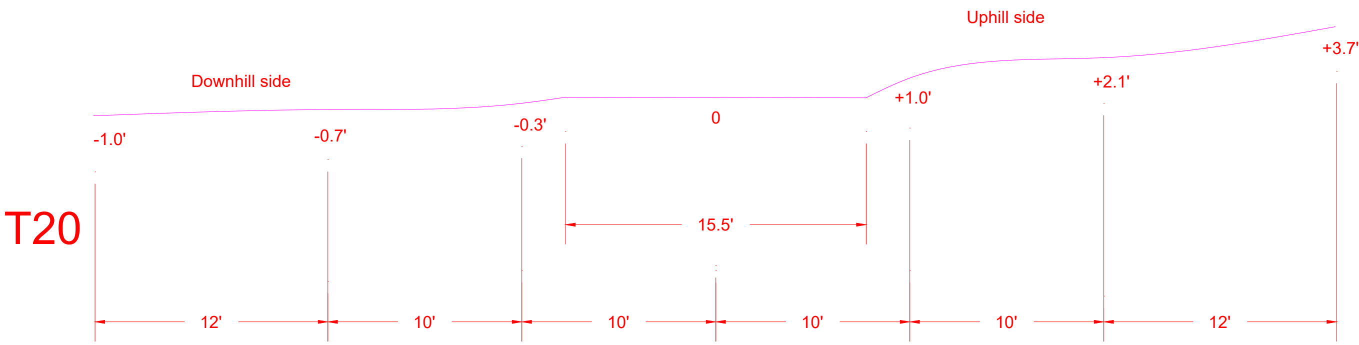
Transect Point T-19



Near MHT Zone

Location	Vegetation Observed
T19 DOWNHILL	Creeping Thistle *Cirsium arvense*
T19 DOWNHILL	Mugworts *Artemisia*
T19 DOWNHILL	Purple Crownvetch *Securigera varia*
T19 DOWNHILL	Canada Goldenrod *Solidago canadensis*
T19 DOWNHILL	Common Reed *Phragmites australis*

Transect Point T-20



Location	Vegetation Observed
T20 DOWNHILL	Virginia Creeper *Parthenocissus quinquefolia*
T20 DOWNHILL	Porcelain Berry *Ampelopsis brevipedunculata*
T20 DOWNHILL	Mugworts *Artemisia*
T20 DOWNHILL	Purple Crownvetch *Securigera varia*
T20 DOWNHILL	False Indigo Bush *Amorpha fruticosa*
T20 DOWNHILL	Common Milkweed *Asclepias syriaca*

SITE INVENTORY - PLANT SPECIES LIST

Plant Species at the Hudson River Waterfront Walkway
Plant species collected on May 16 2019 & June 3 2019

Scientific Name	Common Name
Ageratina altissima	White Snakeroot
Amorpha fruticosa	False Indigo Bush
Ampelopsis brevipedunculata *	Porcelain Berry
Artemisia *	Mugworts
Asclepias syriaca	Common Milkweed
Berberis *	Barberry
Calystegia sepium	Hedge Bindweed
Camellia sinensis *	Tea Plant
Cirsium arvense *	Creeping Thistle
Festuca arundinacea *	Tall Fescue
Galium aparine	Cleavers
Glechoma hederacea *	Creeping Charlie
Lactuca indica *	Indian Lettuce
Parthenocissus quinquefolia	Virginia Creeper
Phragmites australis	Common Reed
Plantago lanceolata *	Ribwort Plantain
Potentilla recta *	Sulphur cinquefoil
Reynoutria japonica *	Japanese Knotweed
Rhus typhina	Staghorn Sumac
Robinia pseudoacacia	Black Locust
Rosa rugosa *	Beach Rose
Salix discolor	Pussy Willow
Securigera varia *	Purple Crownvetch
Solanum dulcamara *	Bittersweet
Solidago canadensis	Canada Goldenrod
Spartina alterniflora	Saltmarsh Cordgrass
Stellaria media *	Chickweed
Taraxacum officinale	Common Dandelion
Trifolium pratense *	Red Clover

Note: This is not a complete plant list. Some plants were unidentifiable and are not included.

Asterisk (*) denotes a non-native species in Eastern US.

Plant identification provided by: Glority LLC's Picture This, Giovanni Caputo, Aleeza Langert, Mouli Luo

Updated: July 5 2019

HRE GENERAL SPECIES LIST AND SPECIES OF CONCERN

Table 1. Birds of Conservation Concern in the HRE (U.S. Fish and Wildlife Service 2016c)

Common Name	Scientific Name	Season Found at Location
American Bittern	*Botarus lentiginosus*	Breeding
American Oystercatcher	*Haematopus palliatus*	Year-round
Bald Eagle	*Haliaeetus leucocephalus*	Breeding
Black-billed Cuckoo	*Coccyzus erythopththalmus*	Breeding
Black Skimmer	*Rynchops niger*	Breeding
Blue-winged Warbler	*Vermivora pinus*	Breeding
Canada Warbler	*Wilsonia canadensis*	Breeding
Cerulean Warbler	*Dendroica cerulea*	Breeding
Common Tern	*Sterna hirundo*	Breeding
Fox Sparrow	*Passerella iliaca*	Wintering
Golden-winged Warbler	*Vermivora chrysoptera*	Breeding
Gull-billed Tern	*Gelochelidon nilotica*	Breeding
Horned Grebe	*Podiceps auritus*	Migrating
Hudsonian Godwit	*Limosa haemastica*	Migrating
Kentucky Warbler	*Oporomis formosus*	Breeding
Least Tern	*Sterna antillarum*	Breeding
Loggerhead Shrike	*Lanius ludovicianus*	Year-round
Marbled Godwit	*Limosa fedoa*	Wintering
Peregrine Falcon	*Falco peregrinus*	Wintering
Pied-billed Grebe	*Podilymbus podiceps*	Year-round
Prairie Warbler	*Dendroica discolor*	Breeding
Purple Sandpiper	*Calidris maritima*	Wintering
Red-throated Loon	*Gavia stellata*	Migrating
Rusty Blackbird	*Euphagus carolinus*	Wintering
Saltmarsh Sparrow	*Ammodramus caudacutus*	Breeding
Seaside Sparrow	*Ammodramus maritimus*	Year-round
Short-eared Owl	*Asio flammeus*	Wintering
Snowy Egret	*Egretta thula*	Breeding
Upland Sandpiper	*Bartramia longicauda*	Breeding
Willow Flycatcher	*Empidonax traillii*	Breeding
Wood Thrush	*Hylocichla mustelina*	Breeding
Worm Eating Warbler	*Helmitheros vermivorum*	Breeding

Source: Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study: Appendix G

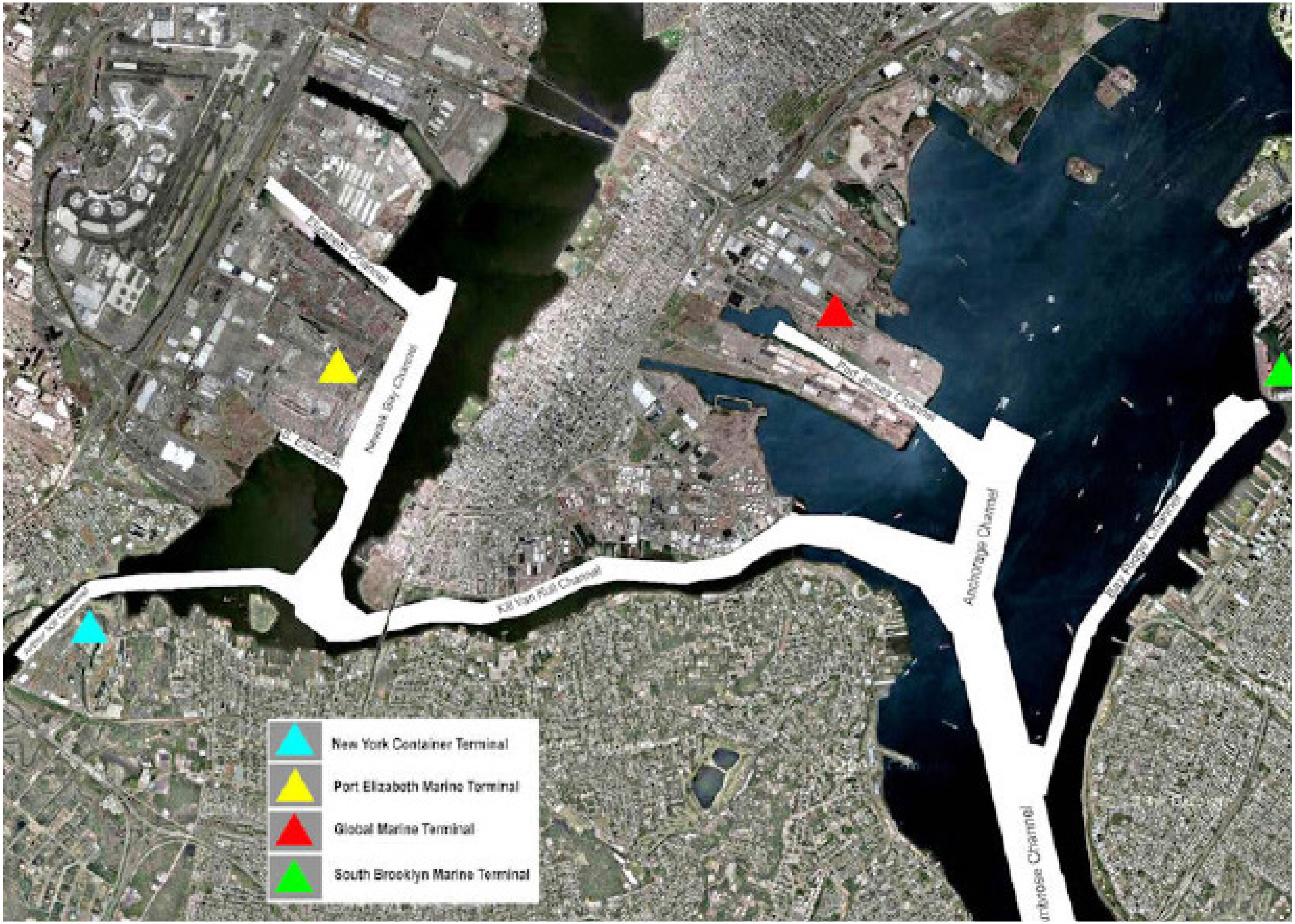
FISH SPECIES WITHIN THE HUDSON-RARITAN ESTUARY

Table 2. Fish of the Arthur Kill/Kill Van Kull, Newark Bay, Upper Lower New York Bay (U. S. Army Corps of Engineers 2013).

Scientific Name	Common Name
Alosa aestivalis	Blueback Herring
Alosa pseudoharengus	Alewife
Ammodytes americanus	American sandlance
Anchoa hepsetus	Striped anchovy
Anchoa mitchilli	Bay anchovy
Anguilla rostrata	American eel
Astroscopus guttatus	Northern stargazer
Bairdiella chrysoura	Silver perch
Brevoortia tyrannus	Atlantic menhaden
Caranx hippos	Crevalle jack
Caranx crysos	Blue runner
Catastomus commersoni	White sucker
Centropristis striata	Black sea bass
Clupea harengus harengus	Atlantic herring
Conger oceanicus	Conger eel
Cynoscion regalis	Weakfish
Dorosoma cepedianum	Gizzard shad
Enchelyopsus cimbrius	Fourbeard rockling
Ethoestoma olmstedi	Tessellated darter
Etropus microstomus	Smallmouth flounder
Fundulus diaphanus	Banded killifish
Fundulus heteroclitus	Mummichog
Fundulus majalis	Striped killifish
Gasterosteus aculeatus	Threespine stickleback
Gobiesox strumosus	Skilletfish
Gobiosoma bosci	Naked goby
Gobionellas shufeldti	Freshwater goby
Leiostomus xantharus	Spot
Gasterosteus aculeatus	Threespine stickleback
Gobiosoma bosci	Naked goby
Gobionellas shufeldti	Freshwater goby
Hippocampus erectus	Lined seahorse
Hypsoblennius hentz	Feather blenny
Lagodon rhomboides	Pinfish
Leiostomus xantharus	Spot
Menidia beryllina	Inland (Tidewater) silverside
Menidia menidia	Atlantic silverside
Merluccius bilinearis	Silver hake
Microgadus tomcod	Atlantic tomcod
Micropogonias undulatus	Atlantic croaker
Morone americana	White perch
Morone saxatilis	Striped bass
Mugil cephalus	Striped mullet
Mugil curema	White mullet
Myoxocephalus aenaeus	Grubby
Notropis hudsonius	Spottail shiner
Obsanus tau	Oyster Toadfish
Ophidion marginatum	Striped cusk-eel
Opisthonema oglinum	Atlantic thread herring
Ostraciidae sp.	Boxfish
Paralichthys dentatus	Summer flounder
Peprilus triacanthus	Butterfish
Prionotus carolinus	Northern searobin
Prionotus evolams	Striped searobin
Pomatomus saltatrix	Bluefish
Pollachius virens	Pollock
Pseudopleuronectes americanus	Winter flounder
Scomberomorus maculatus	Spanish mackerel
Scophthalmus aquosus	Windowpane
Selene setapinnis	Atlantic moonfish
Selene vomer	Lookdown
Sphoeroides maculatus	Northern puffer
Stenotomus chrysops	Scup
Syngnathus fuscus	Northern pipefish
Trichiurus lepturus	Atlantic cutlassfish
Trinectes maculatus	Hogchoker
Urophycis chuss	Red hake
Urophycis regia	Spotted hake

Source: Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study: Appendix G

SHIPPING NAVIGATION CHANNELS MAP



Source: http://www.nyc-arecs.org/nyc_army_map.jpg

III. SYNTHESIS

APPROVED HRE CRP TARGET ECOLOGICAL CHARACTERISTICS (TECs)

Table 1-1. Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area.

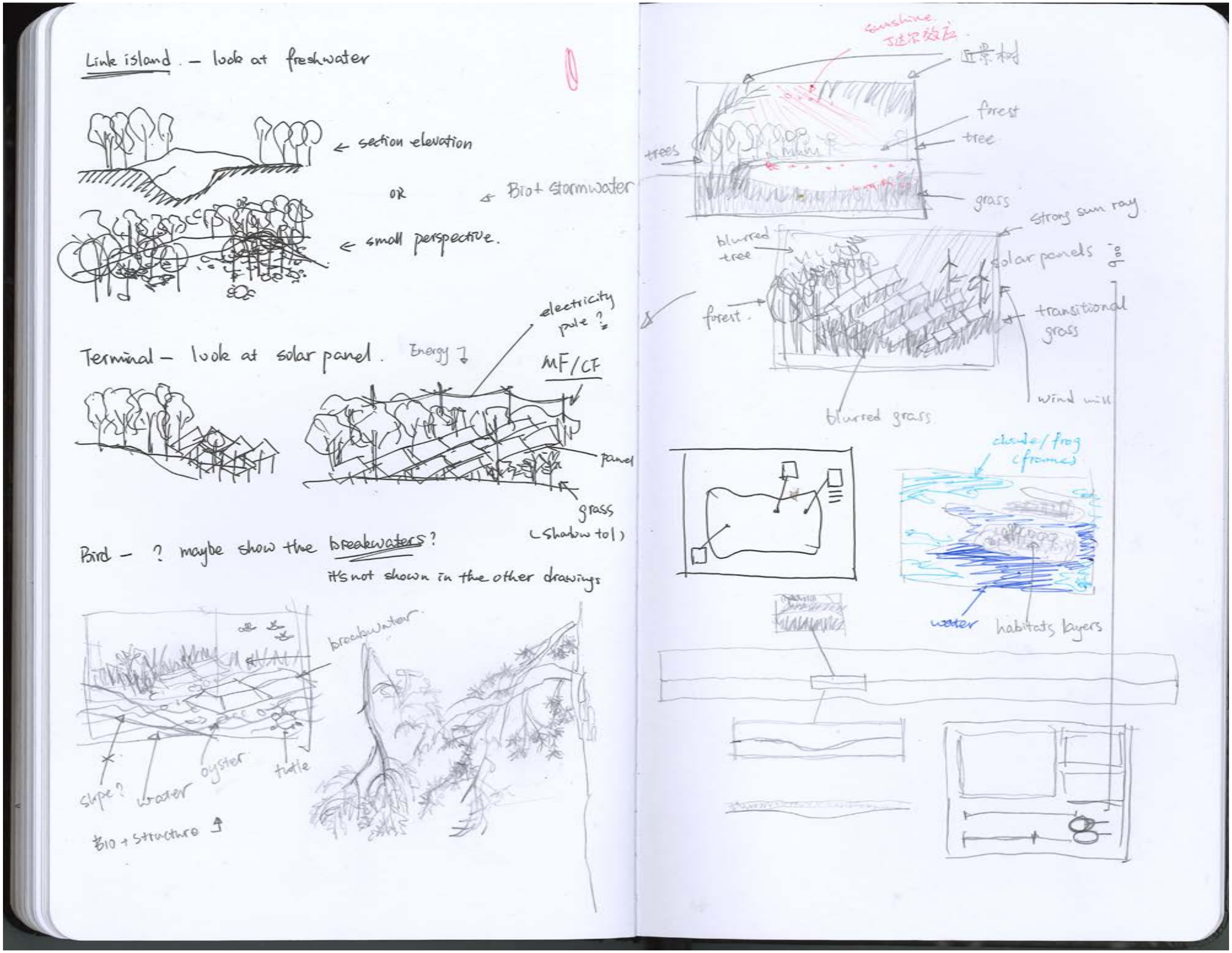
TEC	Target Statement
Wetlands	Create and restore coastal and freshwater wetlands, at a rate exceeding the annual loss or degradation, to produce a net gain in acreage.
Habitat for Waterbirds	Restore and protect roosting, nesting, and foraging habitat (i.e., inland trees, wetlands, shallow shorelines) for long-legged wading birds.
Coastal and Maritime Forests	Create a linkage of forests accessible to avian migrants and dependent plant communities.
Oyster Reefs	Establish sustainable oyster reefs at several locations.
Eelgrass Beds	Establish eelgrass beds at several locations in the HRE study area.
Shorelines and Shallows	Create or restore shoreline and shallow sites with a vegetated riparian zone, an inter-tidal zone with a stable slope, and illuminated shallow water.
Habitat for Fish, Crab, and Lobsters	Create functionally related habitats in each of the eight regions of the HRE.
Tributary Connections	Reconnect and restore freshwater streams to the estuary to provide a range of quality habitats to aquatic organisms.
Enclosed and Confined Waters	Improve or maintain water quality in all enclosed waterways and tidal creeks within the estuary to match or surpass the quality of their receiving waters.
Sediment Contamination	Isolate or remove one or more sediment zone(s) that is contaminated until such time as all HRE sediments are considered uncontaminated based on related water quality standards, related fishing / shellfishing bans or fish consumption advisories, and any newly-promulgated sediment quality standards, criteria or protocols.
Public Access	Improve direct access to the water and create linkages to other recreational areas, as well as provide increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation.
Acquisition	Protect ecologically valuable coastal lands throughout the HRE from future development through land acquisition.

Source: Hudson-Raritan Estuary Comprehensive Restorarion Plan-Ver 1.0 2016

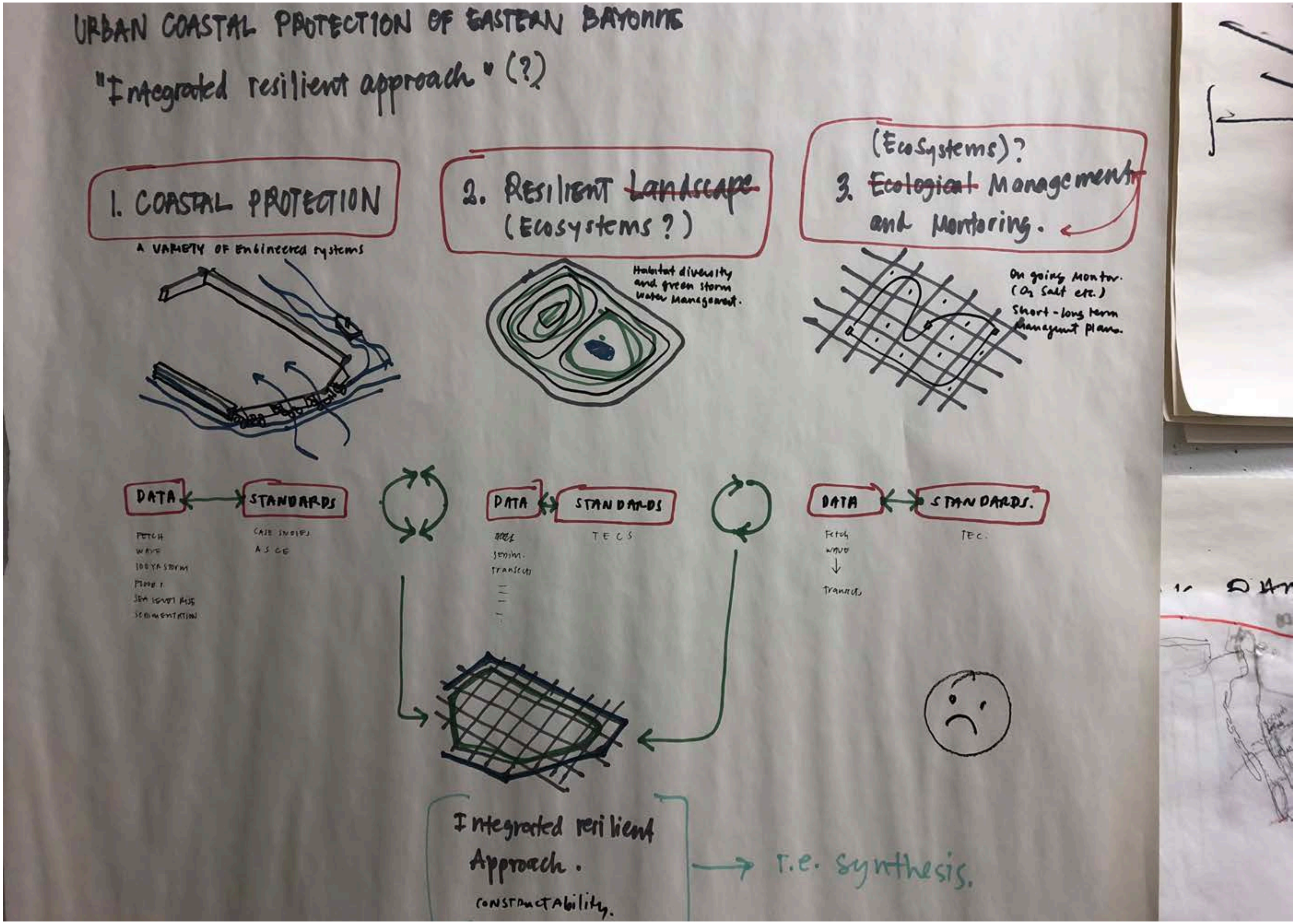
Table 1-2. Short-Term and Long-Term Objectives for Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area.

TEC	2020	2050
Wetlands	Create and/or restore a total of 1,000 total acres of freshwater and coastal wetland	Continue creating an average of 125 acres per year for a total system gain of 5,000 acres
Habitat for Waterbirds	Enhance at least one island without an existing waterbird population in HRE regions containing islands and create or enhance at least one foraging habitat	All suitable islands provide roosting and nesting sites and have nearby foraging habitat
Coastal and Maritime Forests	Establish one new maritime forest of at least 50 acres and restore at least 200 acres among several coastal forest/upland habitat types	500 acres of maritime forest community among at least three sites and 500 acres of restored coastal forest/upland habitat
Oyster Reefs	20 acres of reef habitat across several sites	2,000 acres of established oyster reef habitat
Eelgrass Beds	Create one bed in at least three HRE regions	Three established beds in each suitable HRE region
Shorelines and Shallows	Develop new shoreline sites in two HRE regions	Restore available shoreline habitat in three HRE regions
Habitat for Fish, Crab, and Lobsters	Complete a set of two related habitats in each HRE region	Complete four sets of at least two related habitats in each HRE region
Tributary Connections	Restore connectivity or habitat within one tributary reach per year	Continue rate of restoring and reconnecting areas
Enclosed and Confined Waters	Upgrade water quality of eight enclosed waterways	Upgrade water quality of all enclosed waterways
Sediment Contamination	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years
Public Access	Create one access and upgrade one existing access per year	All waters of the HRE are accessible
Acquisition	Acquire a total of 1,000 acres to be preserved at an average rate of 200 acres per year	Acquire and preserve 200 acres of coastal property per year for a total of 6,000 acres

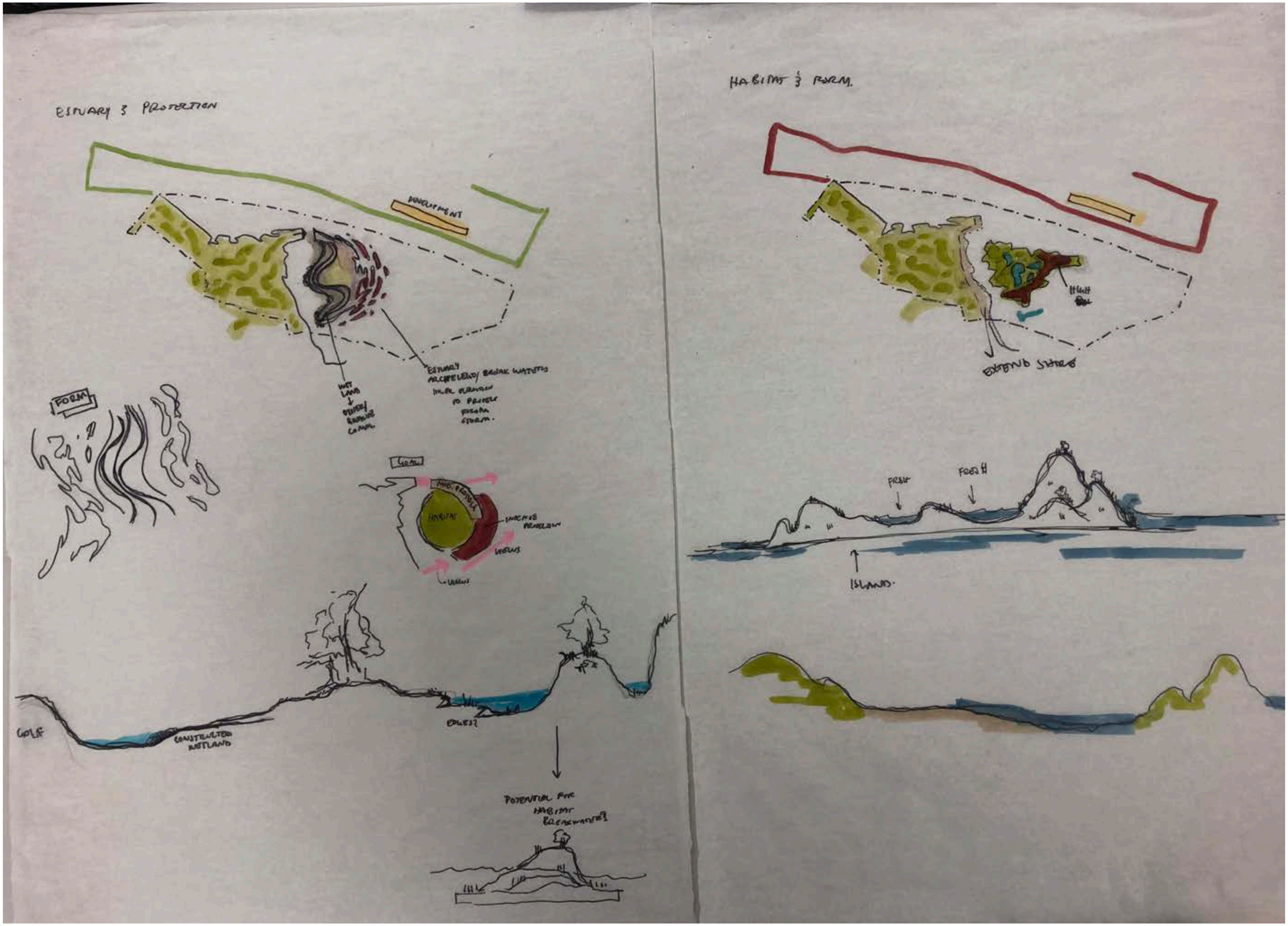
Source: Hudson-Raritan Estuary Comprehensive Restorarion Plan-Ver 1.0 2016

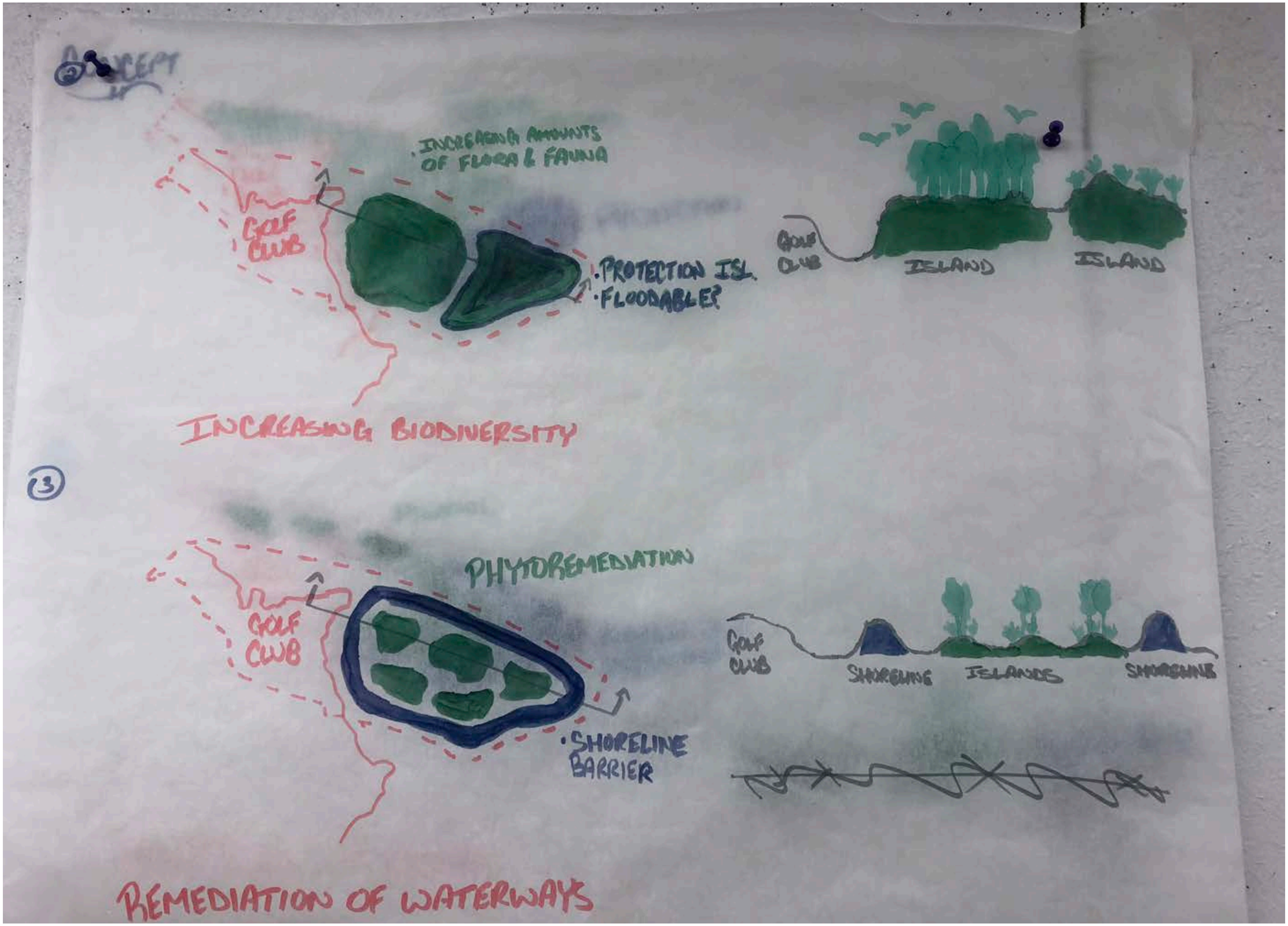


Link island. – look at freshwater
section elevation
OR
Bio+ Stormwater
small perspective.
Terminal – look at solar panel. Energy
electricity pole ?
MF/CF
panel
grass
(shadow tol)
Bird – ? maybe show the breakwaters?
it's not shown in the other drawings
breakwater
slope?
water
oyster
turtle
Bio + structure
sunshine
近景树
forest
tree
trees
grass
strong sun ray
blurred tree
solar panels
forest.
transitional grass
wind mill
blurred grass
water
habitats layers



URBAN COASTAL PROTECTION OF EASTERN BAYONNE
"Integrated resilient approach" (?)
1. COASTAL PROTECTION
A VARIETY OF Engineered systems
2. Resilient ~~Landscape~~ (Ecosystems ?)
Habitat diversity and green storm water management.
(EcoSystems)?
3. ~~Ecological~~ Management and Monitoring.
On going Monitor. (O2 Salt etc.)
Short-long term Management plans.
DATA
STANDARDS
FETCH
WAVE
100 YR STORM
FLOOD
SEA LEVEL RISE
SEDIMENTATION
CASE STUDIES
ASCE
DATA
STANDARDS
TECS
DATA
STANDARDS.
TEC.
Integrated resilient Approach.
CONSTRUCTAbility.
i.e. synthesis.

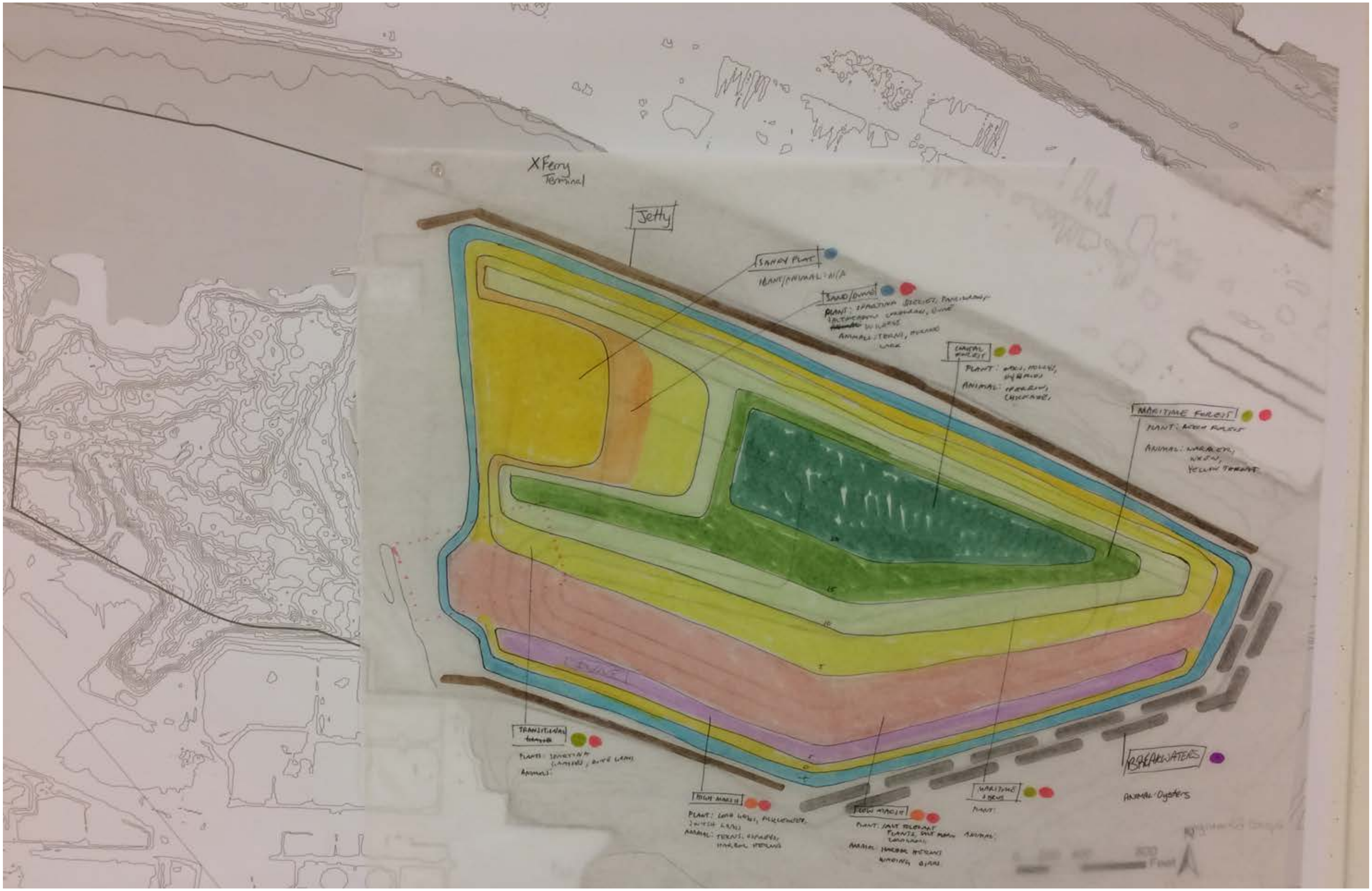




②
CONCEPT
INCREASING AMOUNTS OF FLORA & FAUNA
GOLF CLUB
PROTECTION ISL.
FLOODABLE?
GOLF CLUB
ISLAND
ISLAND
INCREASING BIODIVERSITY
③
PHYTOREMEDIATION
GOLF CLUB
SHORELINE BARRIER
GOLF CLUB
SHORELINE
ISLANDS
SHORELINE
REMEDIATION OF WATERWAYS

MUD FLAT
ANIMALS: OYSTERS, CLAMS, HARBOR HERONS
LOW MARSH
PLANTS: SALT MARSH CORDGRASS
ANIMALS: HARBOR HERON, WADING BIRDS
HIGH MARSH
ANIMAL: OSPREY, HARBOR HERONS.
COASTAL FOREST
PLANT: OAKS, HOLLY
FRESH MARSH
Jetty
BREAKWATERS
Animal: Oysters
MARITIME FOREST
MARITIME SHRUBS
ANIMAL: BLACK CROWNED NIGHT HERON, FISH CROW.
FRESH GRASSES SHRUBS
FRESH FOREST

SANDY FLAT
MARITIME FOREST
COASTAL FOREST
Jetty
N
200 400 800
Feet


X Ferry
Terminal
Jetty
SANDY FLAT
PLANT/ANIMAL: N/A
COASTAL FOREST
MARITIME FOREST
BREAKWATERS
ANIMAL: Oysters
TRANSITIONAL
HIGH MARSH
LOW MARSH
MARITIME
PLANT:
ANIMAL:
Feet


H2o Movement
@ Islands.
DEP
$ / Long term
OWNERSHIP.
Operations/Maintenance.
Best vs. payed.
Stevens
ferry wake study.
protect @ sea level rise.
PERMITS – highlight good things
(Rules / Regs DEP)
BIRDS
now
vs. prop
benefit + cover.
in kind / mitigation.
Proposed Bayonne
Ferry Terminal
From ferry.
Maximize
Eco restoration standards.
bulkhead
Eco revetment.
Mudflat
Animals: Oysters, clams, harbor herons
Low Marsh
Plants: salt marsh cordgrass, glasswort, sea lavender, black grass
Animals: harbor herons, wading birds, diamondback terrapin
Sand catching.
High Marsh
Plants: Cord grass, pickleweed, marsh elder, seaside goldenrod, switch grass, salt grass, salt meadow hay
Animals: Terns, ospreys, harbor herons
Fresh Marsh
VIEW
H2o Catch.
Living Breakwaters
Animals: Oysters
Maritime Shrub
Maritime Forest
Plants: Post oak, Black oak, Scarlet oak, White Oak, Eastern red cedar
Coastal Forest
Plants: Mixed Forest, Oak Mixes, Holly Mixes
Animals: sparrows, chickadees
Existing Driving
Range

FUTURE SITE MANAGEMENT
CUES - Rutgers University & Stevens Institute of Technology

INTRODUCTION

The goal of this project is to create a coastal island in the HRE Upper Bay planning region. The objectives for creating this island are to provide coastal flooding and surge protection to areas along eastern Bayonne, provide much-needed coastal habitats within subtidal, shoreline, and forest zones, and manage/monitor the project as part of long-term learning and understanding of the HRE as it relates to urban impacts, sea level rise, climate change and related urban coastal issues. The project aims to create a variety of habitats, including:

1.) Living breakwaters
2.) Mudflats
3.) Sandy flats
4.) Sandy dunes
5.) Low marshes
6.) High marshes
7.) Upland grasslands
8.) Maritime shrub areas
9.) Coastal forests/Maritime forests
10) Freshwater marshes

All maintenance of the proposed site shall be the responsibility of the property owner, with the following exception: the landscape contractor for the project will be responsible for the maintenance of all landscape plantings for a five (5) years period from the date of final acceptance.

The responsible party for maintenance listed herein shall evaluate the effectiveness of the maintenance plan at least once per year and adjust the plan as needed. Adjustments may include frequency of inspection, replacement plantings, mowing operations or any other item specifically outlined in this Manual.

DEFINITIONS/ABBREVIATIONS

Landscaping: Plant material designed as an integral part of coastal ecology to enhance coastal protection and maximize habitat function and value.

Responsible Party: A person or persons responsible for the maintenance and proper function of the stormwater management/ wetland facility.

PURPOSE

The Bayonne Golf Club property, located along eastern Bayonne, includes more than 300-acres of riparian rights within the HRE Upper Bay (the most of any private land holder in the Upper Bay harbor). This riparian area currently consists of subtidal fine sediments at depths ranging from 5-10 feet below mean tide and supports a handful of finfish, benthic creatures, and shore birds. Although some species currently occupy the area, this design offers an ideal opportunity to greatly increase habitat richness in the Upper Bay. New and expansive habitat will attract a broad range of species back to the area, including “species of concern” along with “Harbor Herons”. Based on data in the HRE CRP, the Upper Bay planning region is lacking in habitat diversity for species historically associated with the estuary.

As a coastal community, Bayonne is highly vulnerable to storm events that create flooding and storm surge, so increasing coastal protection is an important strategy to remaining resilient. Much of the new mixed-use development occurring along the MOTBY terminal, along with commercial and transit areas along the eastern Bayonne shore would benefit from additional coastal protection that this project could provide.

RESPONSIBLE PARTY

Name: Bayonne Golf Club

Address: 1 Lefante Way, Bayonne, NJ 07002

Telephone: (201) 823-4800

FUNCTION/OPERATION

The project will provide a matrix of coastal habitat systems along a highly developed urban space. Much of the natural shoreline within the Upper Bay is lined with bulkhead meant to protect residential, commercial, and industrial infrastructure. Unfortunately, sea level rise and larger/more frequent storm events are leading to flooding and coastal damage. This project would provide additional flood and surge protection along the eastern shore of Bayonne, while also serving as rich habitats within the Upper Bay for a broad range of avian, terrestrial, intertidal, subtidal, and benthic species.

Coastal Protection

A large portion of the island will include shoreline protection in the form of living breakwaters, bulkhead, and revetments. These protective components will help minimize erosion of the island, while also greatly decreasing wave and storm impacts along the eastern Bayonne shoreline.

INSPECTION FREQUENCY

Various components of the design will require routine, annual inspections and maintenance. Special inspections may be required after major storm events to assess damage and conduct any repairs that may be necessary. Inspection reports will be completed and made readily available for client and agency review.

MAINTENANCE AND MONITORING

The maintenance and monitoring of the site can be divided into two specific categories.

1. Maintenance of site monitoring infrastructure.
2. Monitoring and Adaptive Management (ecological)

The maintenance procedures normally required vary in complexity, frequency, and cost.

In general, maintenance procedures for site monitoring infrastructure can be categorized as two types:

1. Functional Maintenance
2. Aesthetic Maintenance.

Definitions of each type of maintenance are presented below:

Functional Maintenance: The maintenance required to keep site monitoring infrastructure functional or operational at all times. Functional Maintenance includes both Preventative (routine) Maintenance and Corrective (emergency) Maintenance.

Aesthetic Maintenance: The maintenance required to enhance or maintain the visual appeal of monitoring infrastructure. While Aesthetic Maintenance is not required for assuring the intended operation, it can improve the quality of life and reduce the amount of required Functional Maintenance.

Functional Maintenance can be further divided into two types:

1. Preventative Maintenance
2. Corrective Maintenance

Preventative Maintenance: Functional Maintenance procedures that are required to maintain an intended operation and safe condition by preventing the occurrence of problems and malfunctions. To be effective, Preventative Maintenance should be performed on a regularly scheduled basis and includes such routine procedures as trail grooming (using a mower or weed-eater), sealing/painting pier decking and the on-site storage building, silt and debris removal, and upkeep of moving parts. Since it is performed on a regular basis, Preventative Maintenance is simpler to schedule and budget for and is easier/less expensive to perform than Corrective Maintenance.

Corrective Maintenance: Functional Maintenance procedures that are required to correct a problem or malfunction on site and to restore the sites intended operation and safe condition. Based upon the severity of the problem, Corrective Maintenance must be performed on an as-needed or emergency basis and includes such procedures as structural and equipment repair, and restoration of vegetated and nonvegetated linings. By its nature, Corrective Maintenance is much more difficult to schedule and budget and is more difficult/expensive to perform than Preventative Maintenance.

Preventative maintenance of site monitoring infrastructure are those tasks required to ensure that the system operates in the manner in which it is intended and to minimize the need for emergency corrective measures.

Tasks associated with this include the following:

1. Trail grooming: A regularly scheduled program of trimming during the growing season along the trails connecting monitoring locations throughout the site.
2. Pier and building maintenance: bi-annual sealing/painting of pier surface and building exterior to avoid rot or wood-boring infestation.
3. Removal of trash and debris: A routine program for the removal of accumulated trash and debris on the shoreline and trails of the site. Disposal of all debris shall be in accordance with applicable codes.
4. Elevation markers maintenance: protect from damage; keep areas surrounding elevation markers free of overgrowth and debris.

Corrective maintenance of site monitoring infrastructure are those tasks which are required on an emergency or non-routine basis to correct problems or malfunctions. These tasks may be completed by the responsible party but will more than likely require professional assistance in the form of a contractor or other source.

MONITORING AND ADAPTIVE MANAGEMENT

In order to monitor the success of the selected TEC habitats, several performance criteria and potential corrective actions were developed. In particular, the ecological success of the habitats will be evaluated based on the following performance criteria:

1. Successful establishment of each habitat type.
2. Vegetation should occur in proper zones (*e.g.*, hydric species in wet sites) in all layers (tree, shrub, herbaceous) and have adequate characteristics compared to similar habitats in the region.
3. Wildlife survey data collection with comparisons to similar wildlife in the region.
4. Water quality, general landscape, sinuosity, and water depth should be similar to natural coastal habitats occurring in the region

The details on how these criteria will be quantified are to be finalized after planting has been established, in general and to ensure the success of intended design, corrective action will be taken if the following criteria are not met:

a. plantings do not succeed and/or;
b. do not attain the expected density and/or
c. colonial plants do not spread and/or;
d. plant indicate signs of stress

Potential corrective action will be undertaken after an analysis and determination of the cause of the failure. Examples of the corrective measures include:

5. Replanting vegetation in areas where plantings do not meet predetermined criteria (after 5-year warranty period the Owner will responsible for replanting dead plant material). Any replanting operation shall be done in accordance with the Health and Safety Plan for the site.
6. Installing erosion control devices
7. Suppressing species having negative impacts on native communities
8. Preventing herbivory (by installing fencing)
9. Adjusting channel morphology and hydrology, or stabilizing banks
10. Adjusting weirs as needed.
11. Adaptive management as required.

In order to monitor the success of the selected TEC habitats, several performance criteria and potential corrective actions were developed. In particular, the ecological success of the created habitats will be evaluated based on the following performance criteria:

1. Sediment accretion rates vs. rates of sea level rise
2. Erosion rates (shoreline and upland)
3. Flora and fauna inventory
4. Ecological succession trends; non-native impacts
5. Water quality
6. Flood and storm surge reduction

AMP Monitoring	Monitoring Frequency	Monitoring Season
Water quality (auto stn)	Real-time	5 min
Sediment accretion rates	Annually	Fall
Erosion rates of various habitats	Annually	Fall
Elevation changes (incl SLR and subsidence)	Annually	Fall
Vegetation coverage/# of species	Annually	Su
Species Surveys	Annually	Su

Design contours of the basin and channels will be inspected periodically for signs of erosion or failure.

Water quality parameters to be monitored include the following:
1. Dissolved Oxygen
2. Salinity
3. Alkalinity
4. pH
5. Nitrate
6. Phosphate

MAINTENANCE

To ensure the success of the design, corrective action will be taken if performance criteria are not met. Potential corrective action may include:
1. Replanting vegetation in areas where plantings do not meet predetermined criteria. During the five-year plant guarantee period, Bayonne Golf Club staff shall coordinate replanting recommendations with the landscape contractor
2. Installing and maintaining erosion control devices where appropriate
3. Preventing herbivory (by maintaining goose fencing) This will be performed by the landscape contractor for the first five years
4. Adjusting habitat contours and elevation, site hydrology, or stabilizing banks
5. Conducting "thin-layer" dredge application as necessary to maintain specific hydrophitic species.

Overview

An example monitoring plan has been drafted using the rendering for Bird Island presented by the Rutgers team at the August 7, 2019, meeting at the Bayonne Golf Club. Rendering with sketched examples of the transects to be discussed below are shown in Figure 1.

Figure 1: August 7, 2019 Rendering of Bird Island showing example monitoring transects.

Monitoring of Bird Island by Stevens Institute of Technology's Coastal Engineering Research Lab's group (Stevens) would focus primarily on three main components of the project:

1. Stability of the shoreline and the elevation of the transitional area from intertidal beach to upper marsh (or other),
2. Stability of wave attenuation structures incorporated into the design, and
3. Performance of the wave attenuation structures.

Should future design of the island incorporate items such as oyster castles, growth of the structures would be an additional component which would require monitoring. Water and sediment quality may also be items of particular interest and are touched on below.

This generalized monitoring plan could be adjusted to better coordinate with the research efforts of other institutions for more comprehensive and publishable research. Furthermore, below represents a generalized plan that would need to be refined to fit the as-built layout of the island.

Proposed monitoring:

Ideally, a BACI (Before-After Control-Impact) Design for documenting and evaluating the change of the island over time would be employed. Unfortunately, as this island would be a unique feature in the lower Hudson River Estuary a suitable control site has not been, and likely will not be, identified. Regardless, significant understanding of the stressors and the corresponding response of the island can still be obtained without the use of a control.

To address the above-stated monitoring goals multiple techniques would/could be employed.

1. Drone Surveys would be performed to:
   a. monitor the footprint (shoreline) of the island over time,
   b. monitor the vegetated shoreline of the island over time
   c. create digital elevation models (DEMs) of the unvegetated shoreline, and
   d. photo-document and monitor the shifting of aerial structural components.
2. Should the drone be insufficient for monitoring the crest elevation of the structures, classic RTK survey points would be collected on the crest of the structures.
3. Transects oriented roughly perpendicular to the shoreline would be walked with RTK GPS equipped backpacks. On the southern and south-eastern edges of the islands, transects would be spaced such that they intersect the center of each breakwater. Examples of such transects are shown in Figure 1. Based on the original design, the spacing between transects would be roughly 45m.

   Additional transects would be collected perpendicular to the shoreline on the other edges of the shoreline, but with a wider spacing (approximately 50 to 75 meters). Density and placement of the transects would potentially be amended if a feature of interest became apparent as the island morphology changes.

4. If higher resolution data is needed for documenting the sedimentation occurring in the intertidal or marsh areas, set tables could be employed for measuring these topographic changes.
5. The performance of any wave attenuation structures (breakwaters, oyster castles, sills, etc.) present on the island should be monitored under various conditions. For this purpose, instrumentation enabled for the collection of wave heights would be deployed landward and seaward of such structures in varied areas around the island to capture the diversity of the structures (i.e. crest height and width) and/or orientation with the shoreline or other structures, wave climate, and beach morphology.
6. Bathymetry would be collected using our RTK-GPS equipped jet ski in the surrounding offshore areas including the MOTBY channel and back basin.
7. Water and sediment quality data analysis may become an area of interest in which case regular water and sediment samples would be collected and analyzed. Additionally, current measurements may be needed in the waters surrounding the island and/or in the area of the back basin.

It should be noted, the use of drones is restricted in some airspace and regulations are still fluctuating as this technology and its uses evolve. Due to the varied uses of this study area and the surrounding area including its airspace and nearby potential threats to homeland security, it is possible that drone research would not be permitted under any circumstances. In this case, proposed monitoring would focus on RTK GPS data collected using a walker and survey poles rather than the drone, and rely on other types of data collection (photogrammetric or other) for structural monitoring.

Monitoring Timeline

Initiation of various portions of the monitoring would likely be staggered based on the construction timeline. The following represents an initial sketch of a timeline for the various monitoring goals:

1. Once wave attenuation structures are in place they should be surveyed immediately and then monitored for structural stability at three, six, and twelve months post-construction. Surveys should be repeated every six months thereafter.
2. Monitoring of the topography of the island should begin once the aerial portion of the island is in place. Monthly drone surveys of the unvegetated island are recommended and should continue on a monthly basis once vegetation has been planted.
3. Topographic and nearshore bathymetric monitoring with RTK-GPS equipped backpacks should be completed along designated transects upon initial planting of vegetation and then again at three, six, and twelve months post-planting. Surveys should be repeated every six months thereafter.
4. Bathymetric monitoring with the jet ski should occur at the start of the project, and be completed after each major stage of construction. Regular bathymetric surveying should occur annually after final post-construction survey has been completed.
5. Monitoring of the wave attenuation capabilities of such structures should occur following completion of the construction of both the structures and the island. Monitoring should take place during various wind/wave/water level conditions. Monitoring should also occur if significant physical changes occur to these structures and following a significant (TBD) increase in mean water levels due to sea level rise.
6. As possible, above noted data collections should also be performed directly before, during, and after major storms.

Educational/Outreach Opportunity

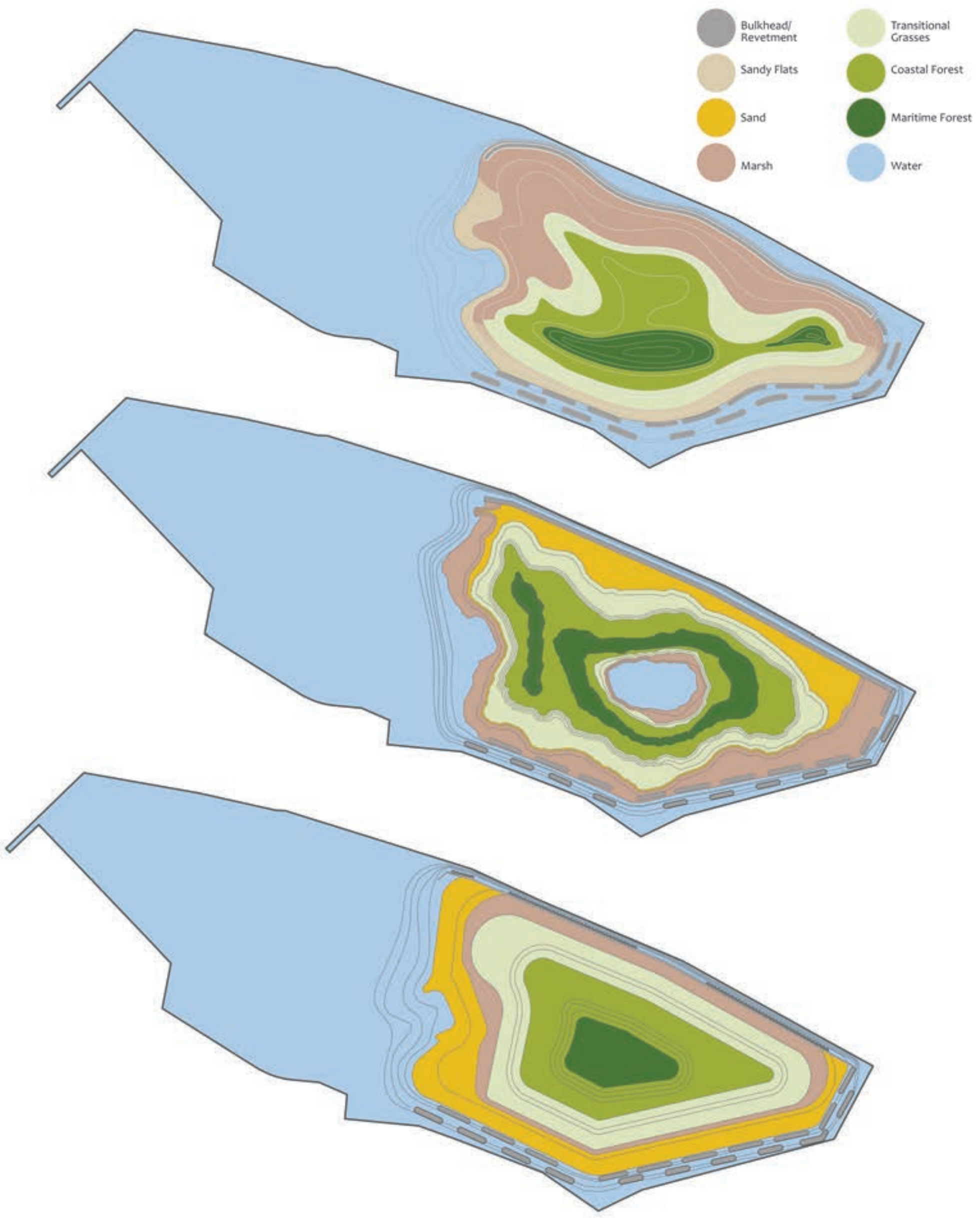
Stevens worked with the Hudson River National Estuarine Research Reserve to develop a low-cost rapid monitoring protocol for monitoring the ecological and structural health of living shorelines projects as part of the Hudson River Sustainable Shorelines Project. This protocol is detailed in The Rapid Assessment Protocol Manual and is described here: https://www.hrnerr.org/hudson-river-sustainable-shorelines/assessing-ecological-physical-performance.

It is envisioned that visitors to the proposed island, acting as citizen scientists using this protocol, would learn about basic surveying techniques while gaining an understanding of the priority items being monitored such as species density and diversity, topographic and bathymetric elevation, wave climate, and structure elevation. The data collected during these surveys would provide valuable information for continuous evaluation of the health of the island.

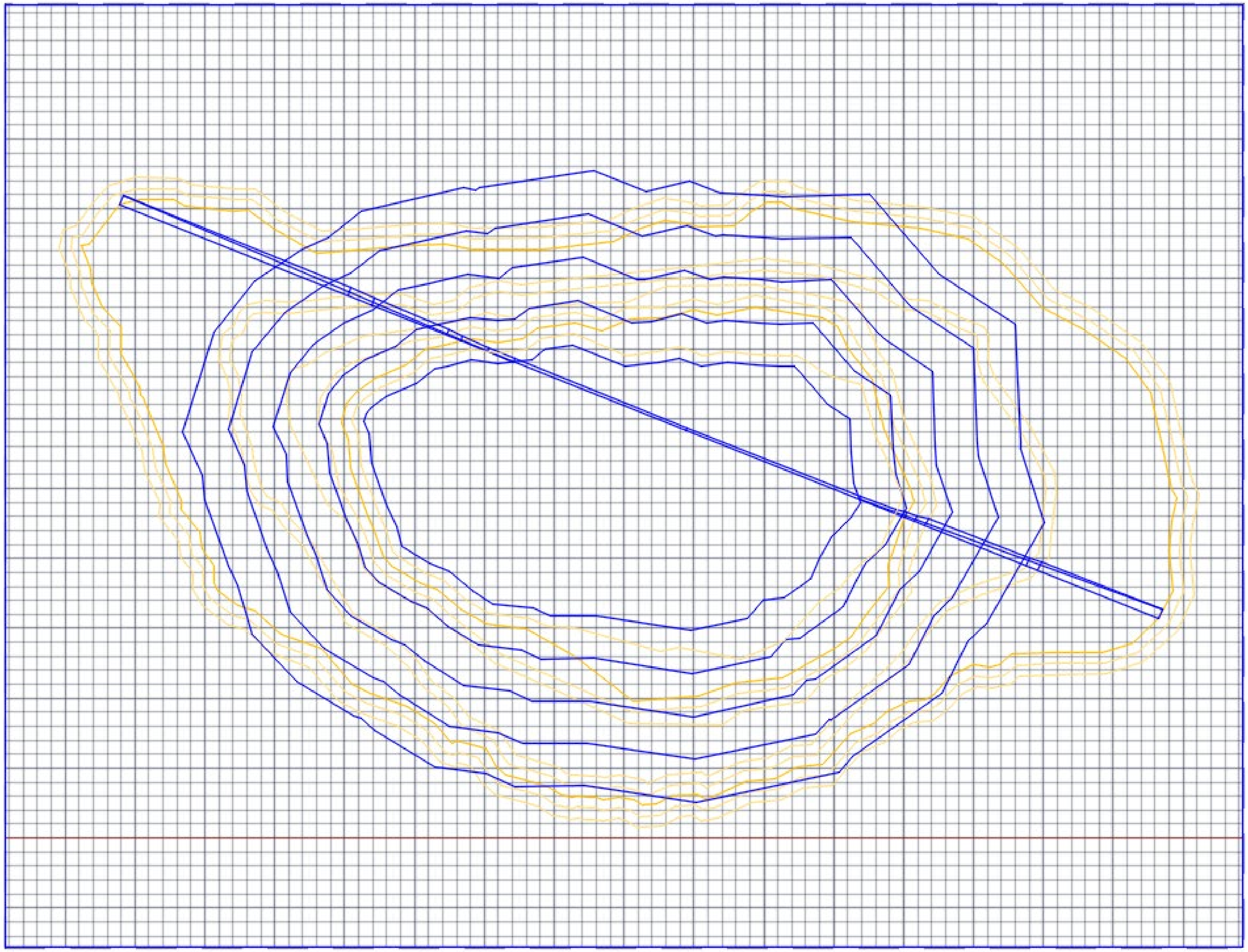
Given the proposed Bird Island layout, 4-5 segments, one on each “edge” of the island and one on the most eastern “point”, with 3 transects each would likely be suggested.

IV. DESIGN OPTIONS

FINAL DESIGN OPTIONS



POND CALCULATIONS



Topography used to determine pond slope and area. Yellow lines are the topography, blue lines are the watershed lines, and the crossline is the one used to determine the distance between each elevation.

Pond Assumptions

An evaluation of the water holding capacity of the pond on Links Island was conducted using HydroCAD and SWMM models. The area inside the 6-feet topography line is 8.62 acres, the area inside the 8-feet topography line is 10.57 acres, and the area inside the 10-feet topography line is 13.22 acres.

Assumptions

1. The watershed draining to the pond begins at the 20 ft. topography line, and water flows downward toward the center of the pond.
2. The watershed is isolated from the rest of the island, meaning that water will only drain into the pond.
3. The watershed discharges past a weir to maintain water levels. The weir is located at the 9.9-feet topography line.
4. The watershed loses water via evapotranspiration.
5. The pond is empty at the beginning of the simulation.
6. The soil type was based on an assumption that the substrate of the maritime island is sand placed on top of dredge material.
7. Curve number (CN) and time of concentration were determined by the values and equations available as part of the modeling program.
8. Parameters for storm type were taken from NOAA Point Precipitation Frequency Estimates. Values ranges used were for 1, 2, 5, 10, 50, 100 and 500-yearstorms.

Method

The parameter values (Tables 1-3) were input into each model program. Sub-catchments and ponds were created using the topographic parameters above. The models, parameter tables, and results are saved in R:\CUES\Projects\36 Bayonne\08 Modelling\pond model.

Results

Using these parameters, accumulation of water occurs in all the modeled storm events. With a storm intensity of 5-year or higher, the water accumulation begins to increase pond depth. In none of the isolated events does the water elevation surpass 8 feet.

Conclusion

The model suggests that runoff water will flow into the pond. The model assumes that the entire watershed will be protected with an impermeable layer (bedrock and impervious liner). The impermeable layer is needed to prevent water from draining from the pond since at designed elevations the pressure head is not enough to maintain the watershed. Also the impermeable layer serves to prevent saltwater intrution.

Elevation	Area - Acres	Difference	Land Use	CN	Soil Type
6	8.62		Shrub	48	A = Sandy
8	10.57	1.95	Shrub	48	A = Sandy
10	13.22	2.65	Shrub	48	A = Sandy
12	14.94	1.72	Shrub	48	A = Sandy
14	16.84	1.9	Mix	57	A = Sandy
16	23.74	6.9	Forest	45	A = Sandy
18	25.62	1.88	Forest	45	A = Sandy
20	37.34	11.72	Forest	45	A = Sandy

Table 1: Topography and soil types

Elevation	Len1 - Ft	Len2	Avg Length	Slp1	Slp2	Avg Slope	Method
20-18	5498	2928	4213	0.000364	0.000683	0.000523	Lag-CN
18-16	584	264	424	0.003425	0.007576	0.0055	Lag-CN
16-14	1324	2436	1880	0.001511	0.000821	0.001166	Lag-CN
14-12	488	252	370	0.004098	0.007937	0.006017	Lag-CN
12-10	336	240	288	0.005952	0.008333	0.007143	Lag-CN
10-8	648	240	444	0.003086	0.008333	0.00571	Lag-CN
8-6	624	864	744	0.003205	0.002315	0.00276	Lag-CN

Table 2: Slope and distances of the topography

Storm Probability	24h Rainfall - In
1	2.76
2	3.33
5	4.26
10	5.05
50	7.26
100	8.4
500	11.6

Table 3: NOAA's Point Precipitation Frequency Estimates

Event - Yr	Runoff - Cfs	Vol - Ac*Ft	Depth In	Elevation	Storage - Ac*Feet	Elevation (Ft)	Storage Ac-Ft
1	0.03	0.067	0.02	5.5	0	6	4.31
2	0.13	0.291	0.09	5.51	0.11	6	4.323
5	0.42	0.942	0.3	5.58	0.691	6.07	4.921
10	0.77	1.727	0.56	5.67	1.44	6.16	5.68
50	2.16	4.787	1.54	6.02	4.454	6.5	8.696
100	3.04	6.744	2.17	6.24	6.396	6.71	10.639
500	5.94	13.177	4.23	6.94	12.8	7.37	17.048

Table 4: Result of the HydroCAD model (first set of values correspond to empty pond; red values correspond to a pond filled up to 6ft)

V. DATA DICTIONARY

DATA DICTIONARY INFO

DATA DICTIONARY

File Name	Short Description	Origin	Date Collected	Scale	Citation	Processing History	Notes
NYC Harbor Water Quality	Provides water quality data of the lower Hudson river	NY Department of Environmental Protection	6/19/2019		Department of Environmental Protection	Salinity and DO data used	Dataset updated weekly
Bayonne Project - Water and Sediment Quality	Water quality data of the site	Stevens Intitute	5/7/2019				
Bayonne Project - Fetch data	Wave induced height data	Stevens Intitute	5/7/2019				Data is modelled after NOAA's wind data
Transect Survey I	Plant information of the area	Rutgers University	5/16/2019			Made plant inventory of the site	
Transect Survey II	Plant information of the area	Rutgers University	6/6/2019				
Jersey City Rainfall Probability	Prediction of amount of rainfall during storms	NOAA	6/18/2019		NOAA	Modelled rainfall catchment requirements	
06-18-2019_NJ_PFIRM	Storm surge height prediction	FEMA	6/18/2019	*	FEMA	Added the baselines to maps for visualization	Numbers seen in the map were added manually
bounds_nj_shp	Outline of all municipalities in NJ (water areas included)	NJOGIS	6/5/2019	*	New Jersey Office of Information Technology (NJOIT), Office of Geographic Information Systems	Clipped to boundaries of Bayonne, Jersey City, Newark and Elizabeth	This dataset was created to provide a location of the design site
Borough Boundaries	Outline of boroughs of New York City	NYCDCP	6/6/2019	*	NYC Department of City Planning	Clipped to boundaries of Staten Island, Brooklyn	this dataset was created to provide a location of the design site
Impervious_Surface_of_New_Jersey_from_Land_UseLand_Cover_2012_Update, Land_lu_2012_gen	NJ Municipalities land use land cover 2012	NJDEPBGIS	6/10/2019	*	NJ Department of Environmental Protection Bureau of Geographic Information Systems; njwebmap.state.nj.us	Clipped to Bayonne and show land use/land cover information based on NJDEP Modified Anderson System 2002.	https://www.state.nj.us/dep/gis/digidownload/metadata/lulc02/anderson2002.html
06-18-2019_NJ_SLR	Sea-level rise and coastal flooding impacts	NOAA Digital Coast	6/18/2019	*	NOAA	Use the sea-level rising and surge data of Bayonne, Jersey City	http://www.njfloodmapper.org/slr/
JCOASTRES-D-15-00133.1	Sedimentation of Upper Bay	Journal of Coastal Research	2016	*	Coch, N.K., 2016. Sediment dynamics in the Upper and Lower Bays of New York Harbor. Journal of Coastal Research, 32(4), 756–767. Coconut Creek (Florida), ISSN 0749-0208.	Took the map from page 759, figure 2 and added to analysis data.	https://bioone.org/journals/journal-of-coastal-research/volume-32/issue-4
topography shapefiles	Topography of the site	NJDEPBGIS	6/10/2019	*	NJDEP	Map topography are taken from this database	https://www.nj.gov/dep/gis/wmalattice.html
bathymatry shapefiles	Bathymatry of the site	NOAA	6/10/2019	*	NOAA	Map bathymetry are taken from this database	https://coast.noaa.gov/dataviewer/#/lidar/search/
Combined_Sewer_Overflow_CSO_for_NJ	Combined Sewer Outflow Map	NJDEPBGIS	7/23/2018	*: Multiple scales	NJDEP	Showed the CSO points on the map of Bayonne	https://www.nj.gov/dep/gis/geowebsplash.htm