Final Report
Sustainable Shorelines Demonstration Project
Nyack Beach State Park, Town of Upper Nyack, New York

Prepared for:

Hudson River Estuary Program
c/o New York State Department of Environmental Conservation
Hudson River National Estuarine Research Reserve
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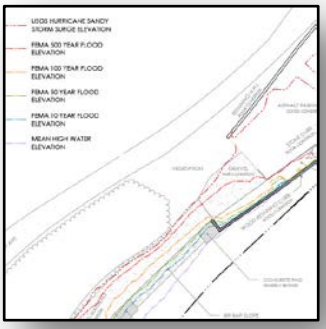
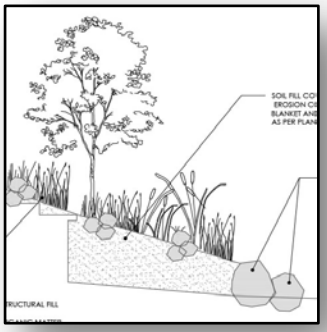
PO Box 315, Staatsburg, NY 12580
http://www.dec.ny.gov/lands/4920.html





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1. Project Overview

This Nyack Beach State Park Sustainable Shorelines Demonstration Project Final Report details the work conducted by Princeton Hydro, LLC, and our project partner the American Littoral Society, pertaining to the development of living shoreline designs for Nyack Beach State Park. The purpose of the overall project was essentially two-fold:

1. Working in close cooperation with Nyack Beach State Park stakeholders, create shoreline designs for the Nyack Beach State Park that are stable, resilient to extreme storms and enhance ecological value and public use of the site, and
2. Integrate elements into the shoreline designs that will help make the Nyack Beach State Park shoreline more resilient to damages linked to climate change and rising sea levels.

As identified in both our proposed scope of work and the Request for Proposals issued by the Hudson River Estuary Program (HREP), the final selected shoreline designs should be consistent with the *Master Plan for the Nyack Beach State Park* and promote goals 2, 6 and 12 of the *2010-2014 Hudson River Estuary Action Agenda*, which are as follows:

1. Goal 2 - Conserve, protect and enhance river and shoreline habitats to assure that life cycles of key species are supported for human enjoyment and to sustain a healthy ecosystem
2. Goal 6 - Address the causes of climate change in the Hudson Valley and prepare for projected impacts to safeguard our health and safety and to protect the natural resources and local economies that sustain our communities
3. Goal 12 – Celebrate partnerships and success.

Additionally, as clearly stated in the Hudson River Habitat Restoration Plan (Miller, 2014), “despite recent improvements to the Hudson River… there is a profound need for habitat restoration.” As such, another goal of the Sustainable Shorelines Demonstration Project was to improve available habitat and habitat resources.

With these goals and objectives in mind, the Princeton Hydro team worked closely with the Hudson River Estuary Program (HREP), Nyack Beach State Park staff and the other project stakeholders to generate “ecologically-enhanced, engineered shoreline treatment(s)…that resist erosion, enhance the recreational use of the site…and improve the site’s habitat…for fish and wildlife species.”

Given the recent efforts of both HREP, New York State Department of Environmental Conservation (NYSDEC) and New England Interstate Water Pollution Control Commission (NEIWPCC) to secure construction funds to actually implement the project’s designs, the resulting shoreline designs would also need to be both permitable and constructible, meaning

that the designs would need to be consistent with exiting NYSDEC regulations and not be cost prohibitive to construct. As such in developing the proposed shoreline designs the Princeton Hydro team consulted State and Federal regulations governing waterfront projects and fully took into consideration guidance offered by NYSDEC during the early stages of design development. We also implemented a "tread lightly" approach to the project. Overall this entailed the promotion of nature-based as opposed to over-engineered solutions. It also was intended to enhance rather than redo satisfactory existing elements of the Nyack Beach State Park site as well as build upon post Hurricane Sandy repairs to the park and its shoreline. Such a "tread lightly" approach should not only enhance the designs' consistency with NYSDEC regulations, but control the overall costs of the three selected restoration designs.

Finally, it was made clear from the comments received from the stakeholders during site walks, project meetings, and draft plan review that the selected designs should not lessen the public's use and enjoyment of the Park. This included access to the river and the Park's intertidal, nearshore areas. Thus our project approach would need to be sensitive to Park use and utilization. At the same time, as directed by the Nyack Beach State Park staff, our designs should help minimize the supervisory responsibilities of park staff by controlling the public's access to environmentally sensitive areas and areas that may pose a risk to the public.

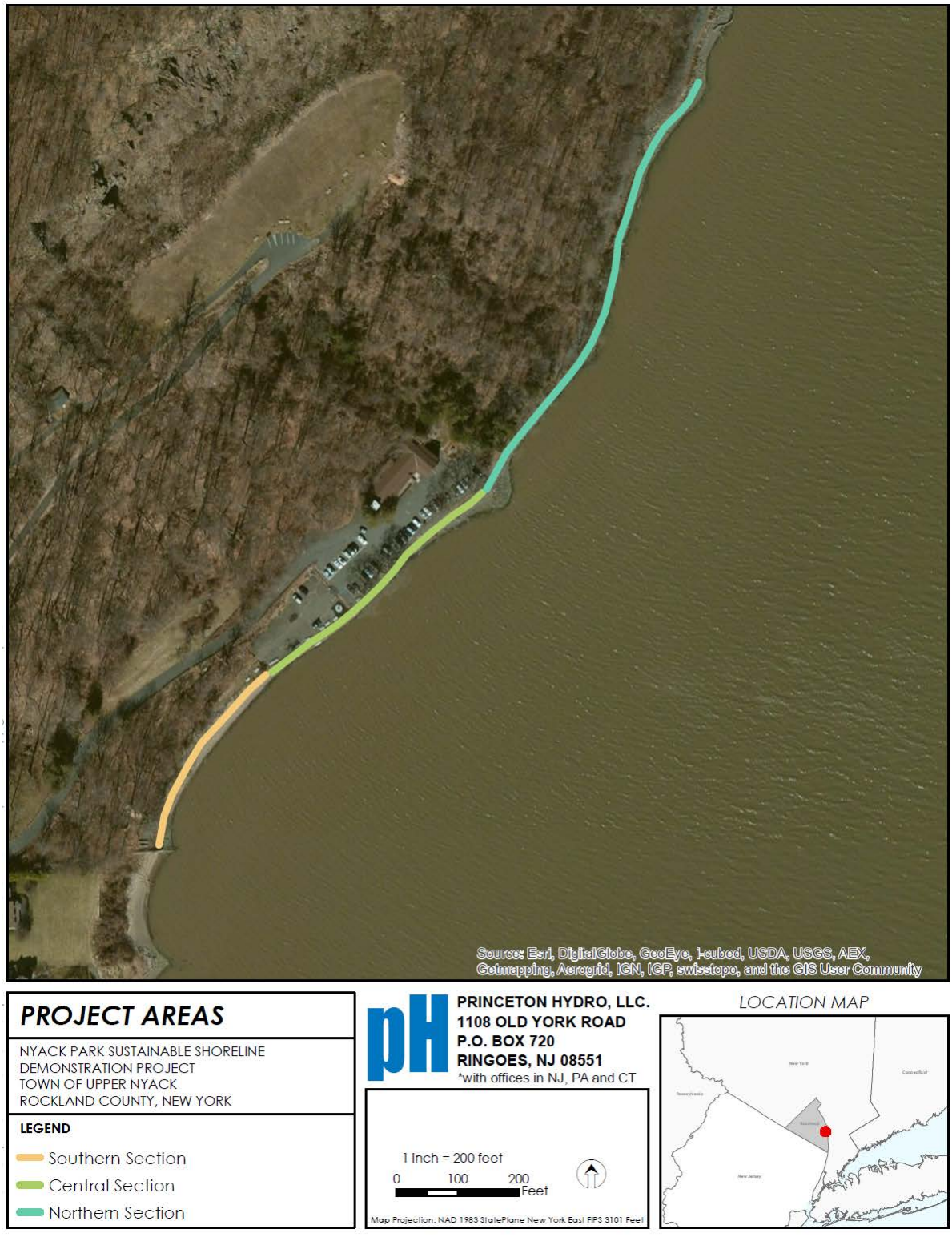
Reflecting on all of the above restoration goals and stakeholder needs, the final shoreline designs developed for the Sustainable Shorelines Demonstration Project would need to be environmentally resilient, ecologically beneficial, consistent with the Park's existing and future uses, and buildable at a reasonable price.

To facilitate our review of existing conditions and the development of the proposed sustainable shoreline plans, the Nyack Beach State Park Site was divided into three easily distinguished sub-areas: South Section, Central Section and North Section (Figure 1.1).

2. Review of Existing Conditions

The *Final Master Plan for Rockland Lake, Hook Mountain, Nyack Beach and Haverstraw Beach State Parks* (NYS Office of Parks, Recreation, Historic Preservation, 2013) provides a very detailed overview of the historic, recreation and natural resource attributes of Nyack Beach State Park. Located in Rockland County, Nyack Beach State Park is jointly administered by the New York State Office of Parks, Recreation and Historic Preservation (OPRHP) and the Palisades Interstate Park Commission (PIPC). Nyack Beach State Park is part of the Rockland Lake State Park complex. As per the 2013 Master Plan, Nyack Beach State Park was historically part of a quarry operation. Remnants of the operation are represented by the Park's bath house. The 61 acres constituting the linear waterfront park border the western shoreline of the Hudson River. The lands were purchased in 1911 by the PIPC, and from its beginnings the Park was very popular and heavily used. It continues to be a popular destination for hikers, bicyclists, kayakers and anglers.

Figure 1.1 Nyack Beach State Park



Three distinguishing natural features of Nyack Beach State Park are the park's steep topography, the southern sand beach area and its predominant linkage to Hudson River waterfront. As a result of the abrupt change in topography as one proceeds west from the water's edge, Nyack Beach State Park is relatively narrow and the Park's supporting infrastructure (picnic areas, launches, main building, parking lots, etc.) is mostly confined to the immediate waterfront area. Largely as a result of these three factors (width, topography and proximately to the water's edge), Nyack Beach State Park suffered considerable damage during Hurricane Sandy. The damages were largely the result of tidal flooding and the storm's tidal surge. The storm in fact resulted in a peak flood water elevation that exceeded the computed 500 year FEMA flood elevation. Adding to this was damage caused by trees that were felled during the storm by hurricane wind gusts and erosion caused by watershed based stormwater runoff that cascaded down the steep abutting hillsides. This single storm caused not only flood-induced property damage to the State Park's facilities and structures, but severely eroded the Southern Beach of the Park, overtopped and damaged the historic seawall in the Central Section of the Park and damaged the park's North Section walking trail. Photo-documentation of some of the damage was provided by HREP in the RFP issued for this project. Select photographs of the site showing conditions immediately after the hurricane and in the early spring of 2014 are included in Appendix H.

Immediately following the storm, action was taken by Park staff to repair and restore Nyack Beach State Park. The majority of the work that was completed focused on the Central Section of the Park and consisted largely of repairs to the historic seawall and Park facilities. Action was also taken to clear and remove fallen trees and repair public access areas in the southern and northern sections of the Park. However, in light of the damages sustained as a result of the hurricane and the increases in tidal stage projected as a result of climate change, HREP recognized that an approach fostering environmentally sustainable, resilient solutions was needed for the Park, in particular the heavily damaged shoreline of the Park.

3. Project Approach

3.1 Consistency with Master Plan

While the genesis for this project may in part have been the impacts caused by Hurricane Sandy, the institutional support for the Sustainable Shoreline Demonstration Project is reflected in the OPRHP's Vision Statement and Mission Statement. The mission of OPRHP/PIPC emphasizes the need for "responsible stewardship" of the Park's "natural, historic and cultural resources." The Rockland Park Complex Vision Statement also refers to providing the "proper stewardship of its natural and cultural resources" and "reconnecting park visitors to the Hudson River." The importance of stewardship is further recognized in the Master Plan's ten management goals, which in part deal with the following:

- Implementation of improved and innovative stormwater management measures (including pervious pavement and bioretention)
- Improved picnicking opportunities
- Protection of trails from storm event related erosion
- Protection of historic and cultural resources
- Implementation of invasive species control
- Protection of water resources
- Promotion of environmentally sustainable practices
- Increase education and outreach opportunities

In 2013, the OPRHP published the State Environmental Quality Review (SEQR) Findings Statement for the Parks' Final Master Plan/Final Environmental Impact Statement (FEIS). As per the Findings Statement, the goals and objectives of the Master Plan emphasize the importance of achieving "a balance between the protection of the environment and the need to accommodate social and economic considerations." Collectively the Master Plan, FEIS and SEQR findings all recognize the importance of meeting existing and future user needs, while protecting and/or enhancing the Park's natural resource and historical features. It was important that the plans and specifications developed and presented as part of the Sustainable Shoreline Demonstration Project were in keeping with the Master Plan, FEIS and SEQR findings. It was equally important that this project's plans and specifications be consistent with the goals and objectives of the Hudson River Estuary Action Agenda especially those pertaining to adaptation to climate change.

The tasks and associated deliverables of the approved Scope of Work (SOW) for the Sustainable Shoreline Demonstration Project (Appendix A) are summarized below in Table 3.1.

Table 3.1 Project Deliverables By Task

Task Number/Description	Task Deliverable(s)	Date Completed
Task 1 – Site Assessment	Review of available existing data and collection of on-site data. Analysis of existing and future hydrologic and physical impacts affecting shoreline	30 May
Task 2- Preliminary Concepts	Three preliminary design concepts for each of the three shoreline segments	4 June
Task 3 – Preferred Alternative Plans	One stakeholder approved design for each of the three shoreline segments	1 August
Task 4 – Draft Final Report and Draft Full Construction Plans	Draft final report and draft plans for each of the three shoreline segments	31 October
Task 5 – Stakeholder Meetings	Pre-design site meeting and meetings with stakeholders coinciding with completion of Tasks 2, 3 and 7 Multiple conference calls over duration of project	Task 1 – 7 May Task 2 – 4 June Task 3 – 1 Aug Task 7 - TBD
Task 6 – Measure of Project Success	Stakeholder survey	31 October
Task 7 – Final Report and Full Construction Plans	Final report, 90% CD plans and specifications, draft permit materials and construction cost estimates	30 November

Clearly, the focus of this project was to develop plans and specifications for the restoration and protection of the Park's shoreline. The plans and specifications needed to meet the overarching goal of the Sustainable Shoreline Demonstration Project, namely to demonstrate the benefits of "ecologically-enhanced, engineered shoreline treatment(s)." To meet this goal it was critical that the final shoreline designs be:

- Resilient to existing and future tidal stage/surge impacts,
- Resilient to erosion caused by significant storms or icing conditions, and
- Resilient to climate change predicted rises in sea level,

However, at the same time the final shoreline designs would need to be consistent with the Master Plan goals regarding:

- Protection of the Park's aquatic habitats and ecological attributes,
- Enhancement of the Park's overall aesthetics, and
- Supportive of existing and future Park uses.

Additionally, as noted above the designs needed to be permitable, economical, and constructible.

3.2 Technical Approach

Although highly engineered shorelines constructed using rip-rap, sheet pile, or other similar materials provide some degree of protection, such shorelines are essentially ecological deserts. The filling and alteration of intertidal, near-shore areas associated with highly engineered shoreline solutions eradicate habitat. The most obvious habitat loss is associated with the actual placement of fill material in the intertidal area, resulting in the direct physical loss of habitat (Griggs, 2005). However, there are also "passive losses" resulting from the accelerated erosion or accretion of sediment both in front of the armored section of shoreline and in the adjacent non-armored areas (O'Connell, 2011).

As clearly demonstrated by the impacts to the historic seawall caused by Hurricane Sandy, highly engineered shorelines do not necessarily provide the resiliency needed to withstand acute natural perturbations. Also, seawalls, such as the wall characterizing the Central Section of the Nyack Beach State Park site, can actually exacerbate long-term erosional processes. This negative effect is most often associated in straight, smooth, vertical walls, such as the Park's seawall (Dugan and Hubbard, 2011). Such walls tend to reflect, as opposed to dissipate, wave energy. This can lead to scour and erosion at the toe of the wall (Bush et al., 2004 and French, 2001). Additionally, at the terminus of the wall, the adjoining natural shoreline or beach can be subject to more aggressive erosional processes due to the energy deflected by the wall in a direction parallel to the shoreline. While in some cases this can lead to the accretion of sediment, in sediment poor conditions (where little sediment is being transported by riverine or

tidal events) this usually leads to the erosional loss and ecological degradation of the intertidal area (French, 2001).

Thus, although part of this project's goal was to protect the existing historic seawall from future wave, ice, sea level rise and tidal impacts, the extension of the wall for the purpose of protecting adjacent portions of the Nyack Beach State Park's shoreline and intertidal area was never promoted. As noted above, not only would this likely lead to more erosional problems and related maintenance costs (Pilarczyk, 1990), but doing so was not consistent with the overall "sustainable shoreline/living shoreline" goals of this project. Additionally, NYSDEC would clearly consider this a non-permitable activity owing to the required amount of intertidal fill and associated intertidal habitat disturbance.

Therefore the approach taken in the development of the final shoreline designs involved the promotion of living shoreline techniques that would protect the Park's existing features, increase its ecological attributes and improve its environmental resiliency. This overall approach necessitated minimizing shoreline re-grading and the placement of fill, and totally avoiding the use of sheet piling, extensive armoring or installation/extension of any vertical walls.

4. Data Collection and Analysis – Task 1

In order to prepare the plans and specifications for Nyack Beach State Park it was necessary to obtain, review, collect and generate various types of data. Of particular importance were data pertaining to river flood stage for various storm events (2-year through the 100-year), river flow data, ice scour data and projected increases in water surface elevation linked to forecasted climate change. This section of the report reviews various data used to prepare the final plans.

4.1 Preparation of Quality Assurance Protection Plan

During the project's initial data acquisition phase, it was determined that the proposed designs would greatly benefit from the collection of supplemental on-site data. The project team determined that there was specifically a lack of information pertaining to the distribution, density and types of submerged aquatic habitat present that existed adjacent to the study area. It was also determined that in order to fully evaluate upland planting and stormwater management options it would be helpful to have a better understanding of the site's basic soil properties (i.e., grain size distribution, percent organic matter, and general soil stratigraphy). The submerged aquatic habitat data would be used to help us identify the types of enhancements or protections that could be implemented through this project that would be most in keeping with the site's existing aquatic habitat features (or lack thereof). The soil data would be used to assist our assessment of possible stormwater management solutions and any types of soil amendments that could be needed to facilitate the establishment of vegetation in areas slated in the plans for new planting or restoration planting. The collection of these

supplemental data would require the preparation of a Quality Assurance Protection Plan (QAPP).

On 6 March 2014 the initial draft QAPP was submitted by Princeton Hydro to NEIWPCC for review. Princeton Hydro then made the required edits and changes to the draft QAPP and, by April 2014, the QAPP was finalized and subsequently approved by NEIWPCC (Appendix B).

4.2 Assessment of Existing Conditions – Use and Analysis of Existing Data

The assessment of the site's existing conditions was intended to provide the Princeton Hydro team with a perspective of the site's problems as based on both the review of available data/information and site-specific supplemental data collected by our staff. Although the Princeton Hydro team was supplied with a substantial amount of information by HREP for Nyack Beach State Park, certain types of data such as topographic, land use, ecological and soils data were lacking. Because these data would become the basis of the conceptual designs generated as part of Task 2 and the refined designs submitted as part of Task 3, the collection of site-specific data would be needed as a supplement to the data available through other sources including NYSDEC, NOAA and USGS.

Princeton Hydro's assessment of existing conditions first involved the acquisition and/or review of existing, publically available data for the project site and the immediately adjacent upland areas. Data sources, included internet links for some, are provided below:

- Geographic Information System (GIS) data layers
    - United States Department of Agriculture, Natural Resources Conservation Service, Soil Survey Geographic Database (SSURGO) Database
    - Land use and land cover
    - NYSDEC delineated wetlands
- Light Detection And Ranging (LIDAR) topographic data (http://coast.noaa.gov/digitalcoast/data/coastallidar)
- USGS Gage Stations (Hudson River: Tarrytown, NY, Piermont Pier, NY, and Hastings-on-Hudson, NY) tidal gaging stations http://waterwatch.usgs.gov
- National Oceanic and Atmospheric Administration (NOAA) tidal gaging stations http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8518919
- Recent aerial photos
    - Google.com/maps (2014)
    - Bing.com aerial (2014), bird's eye (2012)
    - ESRI, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX,
    - Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
- Meteorological data (nrcc.cornell.edu/page_climod.html)

- New York Harbor Observing and Prediction System (NYHOPS), Stevens Institute, http://hudson.dl.stevens-tech.edu/maritimeforecast/
- Site photos provided by Nyack Beach State Park staff (Appendix H)

During this initial data acquisition phase we also obtained and reviewed various documents obtained on-line or via HREP, in particular NYSDEC and NOAA publications, some of which are listed in the Referenced Publications section of this report.

4.3 Assessment of Existing Conditions – On-Site Data Collection

Following the receipt of the approved QAPP Princeton Hydro scheduled a date for the collection of the supplemental on-site data. On 7 May 2014 Princeton Hydro personnel conducted a one-day intensive reconnaissance of the Nyack Beach State Park site during which the following types of data collection activities were conducted:

- Identification of prominent upland, wetland and riparian vegetation occurring within the boundaries of the project site,
- Identification of prominent invasive up-land plant species occurring within the boundaries of the project site,
- Qualitative assessment of shoreline, intertidal and submerged aquatic habitat, and
- Basic investigation of the site's soils via the collection of shallow, hand auger core samples. These samples were subsequently analyzed by Princeton Hydro's ASSHTO certified laboratory for grain size distribution and organic content.

During the 7 May site visit we also had the opportunity to further photo-document existing conditions of the three sub-areas of the project site (South Section, Central Section and North Section). Also, some casual polling of Park users was conducted on that day as well. This polling was highly informal and involved simply asking users their position on such design considerations as the extension of the seawall, creation of a fishing pier/dock, relocation of the kayak launch area, the recreational quality of the fishery, etc. It should be noted that none of these data were tabulated, but were shared with the project stakeholders during the presentation of the conceptual plans during the 5 June project meeting.

During the 7 May field investigation a boat based submerged aquatic vegetation (SAV) survey of the nearshore intertidal area was conducted by Princeton Hydro personnel. The survey was conducted during an incoming (flood) tide. Over the course of the sampling effort water elevations increased only 0.25 ft.

In keeping with the approved QAPP, the survey entailed conducting observations of SAV along transects spaced at a distance of approximately every 250' of shoreline, extending from the southern boundary of the Park to the northern extent of the project area. The SAV sampling was conducted using the line-intercept method (Madsen, 1999). A total of eleven (11) transects were surveyed. Along each transect a 150' float line was extended perpendicular from the shoreline out into the river. Along the transect line a 1 m^2 PVC quadrat was lowered

into the water at distances of 50', 100' and 150' from the shoreline. The presence or absence of SAV within the quadrat was assessed based on visual inspection of the bottom using a Viewscope© and the actual sampling of the bottom using a long-handled sampling rake. The SAV survey yielded no data. Specifically, within each of the sampled quadrats along each transect we neither observed nor collected any SAV.

During this survey we also collected some basic bathymetric data. These data were collected using a graduated depth rod/sediment probe equipped with a GPS unit. Overall, the water depths in the study area were very shallow, averaging 2.8 feet. Due to the shallow water depths the graduated depth rod/sediment probe was used rather than the dual beam sounder/fathometer. This was done in order to increase the accuracy of the water depth measurements. When water depths are shallow there is a tendency for the fathometer to produce excessive back scatter and echo resulting in faulty data.

We found the nearshore area to be relatively uniform and flat and for the most part lacking any significant submerged structure. The only portion of the nearshore area where submerged rock (2' diameter material) was detected was at the far northern end of the Central Reach. Water depths extending out from the beach into the river were characterized as shallow, typically ranging between 2-3' and no greater than 5.5'. No significant drop off was recorded at distances as much as 300' from the shore.

Three sediment samples, one representing the South Section, Central Section and North Section areas, were collected approximately 75' from the shore. These samples were subsequently processed by Princeton Hydro's AASHTO certified soils lab for grain size distribution and percent organic content. The lab results are provided in Appendix B. Summarizing these data, the nearshore areas paralleling Nyack Beach State Park can be best characterized as a silt-sand complex, with the finer grain sediments observed in the South Section and Central Section areas. Overall, based on our observations and the data derived through the sampling effort, it appears that the entire Park shoreline can best be characterized as a shallow silt-sand flat, devoid of SAV, and lacking any significant subsurface structure (rocks, boulders, etc.).

The field data were used along with the site data obtained from the above-noted secondary sources, along with information obtained through the review of the available reports and literature, to prepare three concept designs for each of the three sections of the project site (South Section, Central Section and North Section).

Finally, as part of the data acquisition phase of the project Princeton Hydro personnel primarily used the available LIDAR and USGS river/tidal stage data to compute the following water elevations:

- Mean high tide

- FEMA 10 Year Storm
- FEMA 50 Year Storm
- FEMA 100 Year Storm
- FEMA 500 Year Storm, and
- USGS Hurricane Sandy Storm Surge Elevation

These elevations were subsequently plotted on a plan of the project site, and were later used extensively in the preparation of the Preliminary Designs (Task 2).

4.4 Assessment of Existing Conditions – Computational Analyses

4.4.1 Wave, Wake, and Wind Analysis and Ice Floes Assessment

Hudson River flow data were obtained from multiple sources. The effective FEMA FIS (March 2014) for this reach of the Hudson River was utilized for storm event hydrology. Table 4.1 below is developed from Table 6 of the FIS for Hudson River in Rockland County, New York - Summary of Stillwater Elevations (feet-NAVD88):

Table4.1

Location	10-% 10-Year	2-% 50-Year	1-% 100-Year	0.2% 500-Year	Base Flood Elevation
Hudson River Rockland County except Village of Piermont	5.1	6.1	6.7	7.9	7
Hudson River – Village of Piermont	5.1	6.1	6.7	7.9	7-9

These data consisted of United States Army Corp of Engineers (USACOE) HEC-RAS modeling files that were used by the Princeton Hydro team to determine anticipated shear stresses and velocities proximate to the project location. River flow data were also augmented by USGS stream flow gages and data obtained via the Stevens Institute New York Harbor Observing and Prediction System (NYHOPS) database. Tidal data and tidal statistics were obtained from existing nearby USGS and/or NOAA tidal gaging stations located on the Hudson River. The Piermont gaging station data records were used extensively as part of this project.

All analyses and calculations with regard to coastal engineering were checked to ensure conformance with USACOE Manual *EM 1110-2-1100 "Coastal Engineering Manual".* The NYHOPS data were further utilized to augment and cross-check all the data sources used with regard to surface currents, water levels, and wind/wave fields, proximate to the project location. Use of the NYHOPS database was strengthened by the number and relative proximity

of the various gaging stations located within this reach of the Hudson River (Tarrytown, NY, Piermont Pier, NY, and Hastings-on-Hudson, NY).

One of the prominent elements of the living shoreline approach promoted for this project was the strategic placement of appropriately sized boulders in the nearshore area. As noted above, the data collected during our site inspection showed that there was very little in the way of subsurface structure present along the Park's shoreline, especially along the South Section and Central Section areas.

Such boulder clusters are recognized by both NOAA and ALS as functional elements of a living shoreline design. As opposed to standard hardened shorelines (i.e. those armored with rip-rap) the boulder clusters can be utilized in concert with emergent marsh or wetland vegetation to create "hybrid" living shorelines (ASMFC, 2010). The boulder clusters are used as a means of reducing or dissipating wave energy, while at the same time creating or enhancing habitat for fish and encrusting invertebrate species. When placed in advance of existing vertical walls (as in our case) the boulder clusters can help decrease the erosive energy at the toe of the wall. Again, as is the case with the Nyack Beach State Park design, the boulder clusters were also viewed as a means of helping to protect the emergent marsh vegetation proposed for planting at the toe of the wall. To increase their habitat value, where appropriate, boulder clusters can also be seeded with oyster spat. This is a possibility for the Nyack Beach State Park site given its proximity to the known oyster beds located further south in the vicinity of the Tappan Zee Bridge.

The shoreline rock sizing analysis conducted by Princeton Hydro involved the use of the guidance developed by the USACOE Waterways Experiment Station (WES), and subsequently utilized in multiple federal agency design manuals. In particular, we relied on the use of the Federal Highway Administration's (FHA) HEC 11 Manual "Design of Riprap Revetment" (FHA, 1989), and in particular Equation 11.

To determine the design wave height, we utilized the historic water surface elevation data obtained from the published data records for USGS Gage Station 01376269 (Hudson River, Piermont, NY). This gage station is approximately two (2) miles downstream of the Nyack Beach State Park project site. This is also the closest river gage station to the project site. These data were used in conjunction with the equations available in Kamphuis, 1996.

Our analysis of river gage data showed that the historic maximum water surface elevation was 10.68 feet (as measured at the Piermont gaging station). This occurred on 29 October 2012 during Hurricane Sandy.

The river's historic mean water surface elevation was determined by averaging available daily mean water surface data, again recorded at Piermont gaging station, from November 2010

through May 2014. As based on those data the historic mean water surface elevation is 1.23 feet.

A fraction of the difference in historic maximum and mean was then assumed as the design wave height. This was achieved by using a factor of 0.59. For this project it was determined that a design wave height of 0.4-0.78 feet was appropriate. It should be noted that a more detailed analysis of wave height contribution is possible, but requires complex calculations involving wind speed, fetch distance and other parameters. For this project the more simplistic analysis was appropriate and generated the correct level of detail.
Along with tidal amplitude and wave height we also considered the possible impacts of ice as part of the proposed sustainable shoreline design. Ice damage and ice flow assessments were evaluated using the recommendations contained in USACOE HEC 11 Manual. The analyses and calculations with regard to potential impacts due to ice flows were also conducted in conformance with the USACOE Cold Regions Research and Engineering Laboratory (CRREL) *Special Reports 99-2 "Ice Jam Database", 95-18 "Structural Ice Control",* and *98-14 "Non-structural Ice Control."* Additionally, technical assistance from the CCREL Ice Engineering Group was obtained by Princeton Hydro by means of email and teleconference. Additional recent Hudson River ice flow information, available via the internet through NYC Parks Department, NYSDEC, and the US Coast Guard, were reviewed and utilized as needed by Princeton Hydro. Based on our analyses, the proposed rock diameter was increased in size by a factor of 1.2. This adjustment is consistent with the HEC 11 recommended values of between 1.2 and 1.5.

4.4.2 Stormwater Management Analysis

The *NYSDEC Stormwater Management Design Manual* (NYSDEC, 2010) was referenced during the development of the stormwater management solutions for the project's South Section and Central Section. The proposed stormwater controls include riprap swales, stormwater piping, a concrete baffle wall, a SNOUT device, permeable pavement, and riprap slope stabilization. It should be noted the stormwater management measures for both of these sections of the project area were developed after the presentation of the preliminary concepts as based on input received from the project stakeholders.

South Section

The South Section drainage area that was selected for management is totally impervious. The proposed swale system was sized using HydroCAD, version 10.0 and the 2-year, 24-hour duration storm event. The 2-year flow from the approximately 0.207 acres of paved parking area is 0.71 cfs. The swale dimensions were sized to meet this capacity resulting in a one foot deep, one foot wide bottom trapezoidal channel with 4H:1V side slopes. The swale has a longitudinal slope of 0.17 feet per foot. The maximum 2-year velocity in the swale is 2.53 fps and the 100-year velocity is 3.24 fps however the rock for the swale was sized based on the wave height of 3.64 feet as discussed in the previous section. This yields a D_{50} of 25 inches with material sizes ranging from 12 inches to 36 inches as per Table 4.2 adapted from the *New York Standards and Specifications for Erosion and Sediment Control*.

The porous pavement path was designed in accordance with the Standards from the NYSDEC Manual; however, since no additional area is directed to the path, no specific sizing calculations were completed. The materials specified were cross-checked with the material specification found in Chapter 5 of the Design Manual.

Central Section

The existing erosion occurring off the north end of the parking lot was addressed via reconfiguration of curbing to direct the stormwater into a stable conveyance system consisting of a standard inlet box modified with a SNOUT, a 15 inch diameter HDPE with backflow prevention gate and flared end section. The pipe discharges into a riprap lined swale. The proposed system was sized using HydroCAD, version 10.0. All calculations were completed using the TR-55 methodology and the swale capacities were designed for a 2-year, 24-hour duration storm event. The 2-year flow from the approximately 0.319 acres of paved parking area is 1.09 cfs. The swale dimensions were sized to meet this capacity resulting in a one foot deep, one foot wide bottom trapezoidal channel with 4H:1V side slopes. The swale has a longitudinal slope of 0.13 feet per foot. The maximum 2-year velocity in the swale is 2.84 fps and the 100-year velocity is 3.50 fps however the rock for the swale was sized based on the wave height of 3.64 feet as discussed in the previous section. This yields a D_{50} of 25 inches with material sizes ranging from 12 inches to 36 inches as per the below table for the *New York Standards and Specifications for Erosion and Sediment Control*.

Table 4.2 Riprap Gradation

Class	Layer Thickness (in.)	Max Velocity (ft./s.)	Wave Height (ft.)		PERCENT FINER BY WEIGHT											
					D_{10}			D_{50}			D_{85}			D_{100}		
					Wt. (lbs.)	d_o (in.)	d□ (in.)	Wt. (lbs.)	d_o (in.)	d□ (in.)	Wt. (lbs.)	d_o (in.)	d□ (in.)	Wt. (lbs.)	d_o (in.)	d□ (in.)
I	18	8.5	-		5	5	4	50	10	8	100	13	10	150	15	12
II	18	10	-		17	7	6	170	15	12	340	19	15	500	22	18
III	24	12	2		46	10	8	460	21	17	920	26	21	1400	30	24
IV	36	14	3		150	15	12	1500	30	25	3000	39	32	4500	47	36
V	48	17	4.8		370	20	16	3700	42	34	7400	53	43	11,000	60	49

d_o = gravel material d□ = angular rock riprap
Wt = weight in pounds

The SNOUT was sized to provide the water quality benefit of reducing flow to allow sediment and trash to be removed. Additionally, the SNOUT is designed in such a way to also prevent floatables (bottles and oils) from traveling downstream. A tide gate in the form of a backflow preventer is proposed on the downstream end of the pipe to prevent backflow from the Hudson River from entering the storm sewer network.

5. Development of Shoreline Designs

In keeping with the approved SOW, Princeton Hydro progressed the proposed restoration of the Nyack Beach State Park through a series of iterations, each of which was presented to and vetted with the project stakeholders.

5.1 Preliminary Design – Task 2

The Task 2 Preliminary Design deliverables consisted of three conceptual designs for each of the three sections of the project site (South Section, Central Section and North Section).The concepts were presented to the stakeholders at a meeting held on 5 June 2014. A short summary explaining the proposed approach for each conceptual design was provided to the stakeholders, along with some simple renderings, schematic engineering plans, consisting of plan view and cross-sectional illustration (Appendix C). The concepts were based extensively on the GIS, LIDAR, and field data acquired as part of Task 1, as well as tidal data, sea level rise data and land use data obtained through the various noted sources (e.g., NYSDEC, NOAA, NYHOPS, HREP, etc.). Details of the data collection and analysis are summarized in Section 4 of this report. The development of the conceptual designs also took into consideration our observations of existing natural conditions, Park usage and the Park's users. This included information obtained from Park patrons through informal, unsolicited interviews.

Other data used to guide design decisions was the computed flood elevation data for various size storm events; specifically the FEMA 10, 50, 100 and 500-year storm flood elevations (refer to Section 4.3). Due to the amount of damage that was experienced as a result of Hurricane Sandy, the flood surge elevation attributable to that storm was also taken into consideration in developing the design concepts.

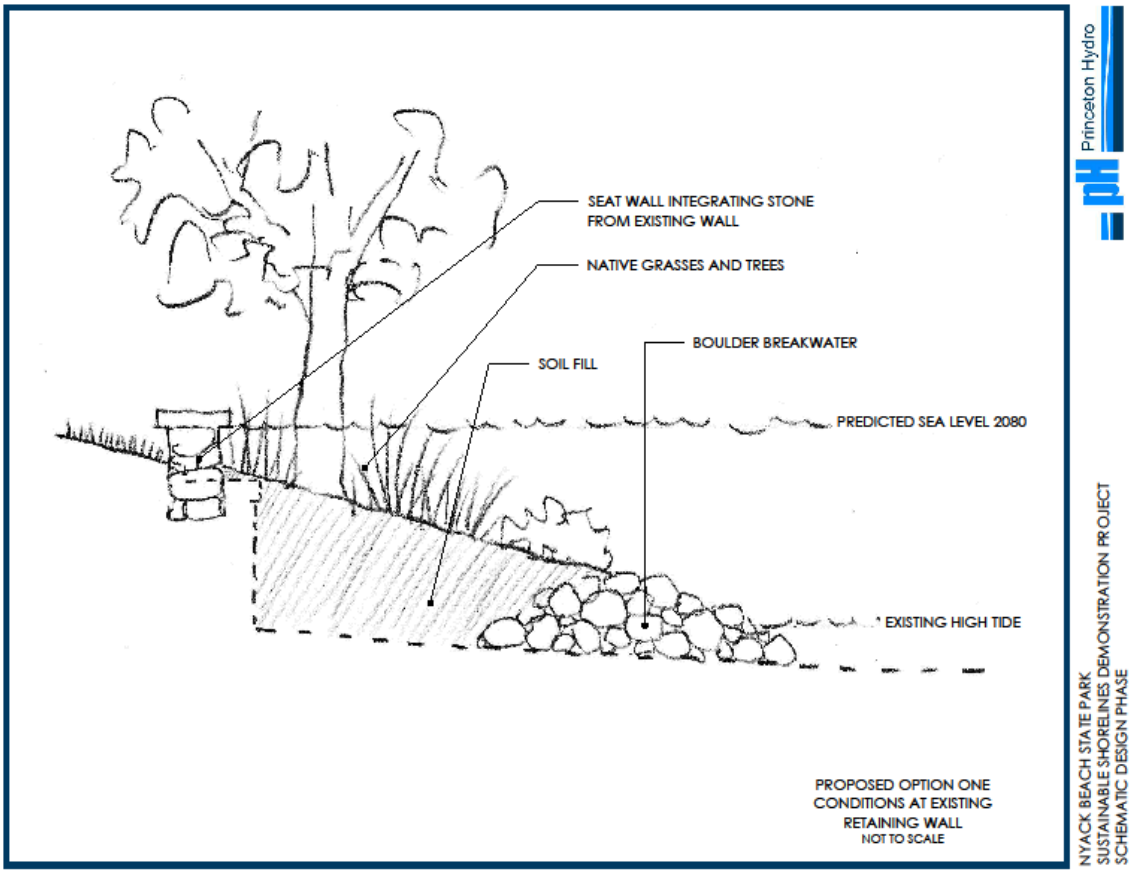
The preparation of the three concepts developed for the South Section and Central Section areas of the Park made extensive use of the fundamental attributes of living shorelines. Essentially, this entailed the integration of technically-sound coastal engineering principles and the project's stated ecological goal of creating more aquatic habitat. Our objective was to protect these areas, both of which were significantly impacted by Hurricane Sandy, from similar damages caused by future storms or as the result of predicted sea level rise. The concepts also included elements that would promote the accretion of sand and sediment as a means of expanding the South Beach area. The conceptual designs developed for the South Section and Central Section areas promoted the use of boulder clusters, vegetated rip-rap and other living shoreline techniques. For example, option 1 for both the South and Central Sections involved the construction of a sub-tidal, boulder breakwater running parallel to the shoreline. The South Section breakwater would be placed approximately 100' from the highwater line. It would not only deflect wave and tidal energy, but facilitate the trapping and accretion of sand and silt. Along the Central Section, the breakwater would be within 20' of the existing shoreline, at the base of the historic seawall. The area between the breakwater and the wall would be backfilled and then planted with emergent marsh vegetation (Figure 5.1). This would

eliminate the "reflective and passive" erosion attributable to the wall, while creating a true riparian interface.

Other options were also presented concerning the Central Section's historic seawall, including one option that called for the wall to be dismantled and partially relocated as an historic display closer to the building. In place of the existing wall a vegetated slope extending to the water's edge would be created.

During our presentation of the conceptual plans, informal guidance was provided by the NYSDEC stakeholder suggesting that many of the sub-tidal options proposed in the concepts would likely be deemed non-permitable. These included options involving the creation of sub-tidal breakwaters, rip-rap groins/jetties and conventional hard-armored engineered solutions. This was largely due to these measures involving the physical modification of the existing shorelines and the placement of new material (fill) above and below the mean high water line. It was suggested that a reduction in the scale of some of these measures (e.g., boulder clusters) could enable these options to be permitted.

Figure 5.1



Also, although discussed with the stakeholders both before and during the 5 June meeting, the initial concepts did not include any Park enhancements consisting of fishing docks or piers. However, recommendations were presented regarding the relocation of the canoe/kayak launch areas, relocation of the picnic tables and reassessment of how the South Section gravel parking area and Central Section paved parking area are defined, configured and utilized. Guidance was also provided for the revegetation of the South Section upland slope area, including the protection or stabilization of trees impacted by the hurricane.

With respect to the North Section area of the study site, it was determined that this area's rip-rap shoreline or adjacent intertidal area did not require any significant alterations, modifications or repairs. Although this section of the Park is subject to storm related impacts, it appears that the majority of the damage that has occurred is actually a function of the inadequate management of stormwater runoff from the adjacent upland watershed areas draining to the Park. Inspection of the hillside adjacent to the walking trail revealed evidence of slope erosion and sedimentation. Additionally, Park personnel described to the Princeton Hydro team the history of past slope failures and flooding problems, some of which were significant enough to trigger rock slides. While these problems need to be further investigated and ultimately corrected they are outside of the scope of this project and would not be addressed through any type of sustainable shoreline solution.

A site walk was conducted immediately following the 5 June presentation of the conceptual designs. The site walk presented an excellent opportunity for the Princeton Hydro team to obtain additional feedback from the project stakeholders. Written comment was also later received from some of the 5 June meeting participants pertaining to specific design elements of each of the conceptual designs.

Princeton Hydro subsequently made use of all of the input, direction and guidance received from the stakeholders to identify one single "preferred design" for each of the three project areas. Using the written and verbal feedback obtained from the project stakeholders Princeton Hydro eliminated some of the preliminary designs and altered elements of some of the more preferred designs to generate the Preferred Alternative Plans generated as part of Task 3.

5.2 Preparation of Preferred Alternative Designs Plans – Task 3

Following the completion of Task 2 and the 5 June meeting with the stakeholder representatives, Princeton Hydro proceeded with the preparation of the Preferred Alternative Design Plans for each of the three project areas; South Section, Central Section and North Section. Once again the development of the preferred alternative designs evolved from the data and information acquired as part of the previously noted field investigations, the interpretation of data derived, developed or acquired from NYSDEC, NOAA, HREP, and the hydrologic, hydraulic and related shoreline data that was developed by the Princeton Hydro team (refer to Section 4).

Of considerable value were the comments received from the NYSDEC. As noted earlier, even though this is a demonstration project it was important that the sustainable shoreline designs were consistent with existing USACOE and NYSDEC regulations, in particular 6NYCRR Part 661. Specifically the placement of fill, construction of berms and related alterations to submerged and intertidal areas is considered presumptively incompatible with the regulations. Although such activities potentially could qualify for a permit, it appeared that the permit process would be difficult. This directly affected options involving the creation of sub-tidal breakwaters, the placement of backfilled coir fiber logs, and the importation of material to create new inter-tidal high and low marsh areas. Unfortunately, such techniques are recognized sustainable, living shoreline techniques (ASMFC, 2010; Bendell, 2006). In preparing the Preferred Alternative Design Plans for each of the three project areas, the Princeton Hydro team paid particular attention to ensure that the various riparian and aquatic elements of the designs were fully consistent with the regulations.

The Preferred Alternative Design plans are provided in Appendix C. On 1 August 2014 Princeton Hydro conducted another stakeholder meeting at which time the draft Preferred Alternative Design for each three sections of the Park were presented and discussed. Appendix C also contains the PowerPoint presentation used to introduce the Preferred Alternative Designs.

Following the plans' presentation, further comments were received during that meeting by the Princeton Hydro team from the stakeholders. Highlights of those comments are provided below:

- Visitors were to be further discouraged from using the South Section by means of signage intended to eliminate vehicular traffic and bathing but not deter or obstruct fishing access.
- The upland sloped area of the South Section would be allowed to become naturalized. Although some measures would be taken to help stabilize the slope and secure some of the threatened trees, no extensive changes would be made to this area.
- As noted above, vehicular traffic would be prohibited from the South-Central section eliminating its use to accommodate overflow parking. The gravel surface would be removed and a porous pavement pathway would be created. The purpose of this pathway would be to connect the southern upper walking trail (which runs up the slope to the Park's entrance drive) to a new South-Central Section picnic area and the existing parking areas to the north.
- Along the edge of the hillside, on the slope side of the porous pavement pathway a vegetated, shallow bioswale would be created. The purpose of the swale would be to collect hillside runoff and prevent sediment transport onto/over the new porous pavement path.

- On the water side of the new porous pavement pathway, a new grassed picnic area would be created. These picnic areas will provide the public with an unobstructed view of the river and intertidal area. All of the picnic tables presently located in the central parking lot would be moved to this area. Park personnel intended to use a temporary fencing system to help rotate picnic area use, thus protecting the new grassed from trampling and erosion.
- A subsurface stormwater detention system would be constructed in the South-Central section area directly under the new porous pavement pathway and grassed picnic area. However, following a closer evaluation of the site's geology, it was determined that construction of such as system was not technically practical owing to the shallow depth to bedrock. As such, this element of the plan was later dropped.
- Within the Central Section of the project site, the existing central section "overflow" parking area will be restriped. A stormwater collection system will be developed to help collect some of the drainage from this parking area and direct it to the new subsurface stormwater detention system constructed in the South-Central portion of the site. Although the preferred alternative design for the Central Section does include a stormwater management element, as noted above, the site's shallow depth to bedrock precluded the construction of the proposed sub-surface runoff stormwater and detention system.
- The stairs that create a prominent visual element of the Park's Central Section will be removed. Again, although a recommendation presented in the preferred alternative design, based on a combination of stakeholder feedback, and projected costs, the final plans show the stairs remaining. However, their removal remains an option that could be implemented at a later date.
- The kayak/canoe drop off areas presently located in the South Section area will be relocated to the far the north end of the main parking lot. This will trigger the need to relocate the handicapped parking area. The new kayak/canoe drop off area would make use of some type of aggregate surface to both define the area and limit future user-induced erosion. The kayak/canoe drop off area is not intended for boat trailer use and signage would be placed in the Central Section parking area so alerting Park users. It may also be advantageous to conduct a traffic flow study to identify any user conflicts or safety issues that could result from the relocation of the kayak/canoe drop off area. It is our opinion given that this is not an actual boat launch that such conflicts should be minor and easily addressed through proper signage.
- The North Section of the Park will be largely left as is, with the exception of creating a "no mow" vegetated strip along the water-side of the existing walking path. This now mow area will be seeded with native grasses of the Park's choosing and maintained at approximately 1' in height. This means the strip will be only mowed 1-2 times per year. We suggest suitable signage be developed to

inform and educate Park users as to the function of the strip and minimize complaints about unkempt conditions.

- Restoration of the intertidal areas extending from the South Section through the Central Section would not involve any extensive modification of the intertidal area. Boulder clusters would be strategically placed in the sub-tidal area.
- Narrow high marsh and low marsh planting zones extending from the South Section through the Central Section would be created. High marsh areas would be planted with such species as blue flag iris, marsh mallow, swamp milkweed, seaside goldenrod, and salt hay. The low marsh area would be planted with such species as soft stem bulrush, river bulrush, arrowhead and arrow arum. Quantities and specifications were prepared for the proposed planting plan for these areas.

Revisions were subsequently made to the plans, and the revised plans titled Draft Construction Plans were then submitted to HREP towards the end of September. It should be noted that because of the lack of adequate site-survey data and the limitations of the LIDAR data, it was necessary to sub-contract a local surveyor (J. Peter Boras) to collect some additional topographic information for the South Section area of the site. The site survey was completed in August and those data were used to refine the Draft Construction Plan for the South Section area.

5.3 Preparation of Final Construction Plans – Task 4

Following the submission of the Draft Construction Plans Princeton Hydro received comments and recommendations from HREP. The suggested changes were addressed over the following 30-plus days and final revisions made to the plans. In keeping with primary objectives of the project, the Final Construction Plans prepared for the South Section, Central Section and North Section areas of Nyack Beach State Park followed a “tread lightly” theme. This entailed the integration of naturalized and bioengineered solutions intended to address past storm induced damages, but more importantly increase the site’s storm resiliency and its resilience to climate change induced increases in sea level elevation. At the same time we integrated into our designs features that will increase the site’s functionality for the Park’s users. The key elements of the improvements and restorative measures proposed for each subsection of the site can be summarized as follows:

5.3.1 South Section

- Although heavily damaged by Hurricane Sandy, the consensus was that this area would be best served by allowing it to re-naturalize.
- Near the far southern boundary of the park, the eroded toe of slope of the hillside will be stabilized, with this in part accomplished using large (48” diameter) bounders. Fill will be placed between the boulders and the exiting slope and the area planted with a shade tolerate woodland seed mix.

- The exposed roots of the large trees threatened by slope erosion will be protected by the careful and limited regrading of the hill slope around the affected trees. Where needed, some addition soil can be placed around the exposed tree roots.
- The portions of the hill slope that are exposed to more sunlight will be seeded using an upland meadow mix. This tends to be that portion abutting the south-Central Section of the site.
- Along the water's edge, narrow bands of low marsh and high marsh plant material will be introduced.
- The two concrete kayak launching areas will be removed and revegetated.
- Signage will be installed curtailing vehicular use of the south-central (existing gravel cover) area. Signage will also be used to help limit the public's use of the area with respect to swimming and wading.
- The gravel area between the South Section and Central Section of the site will be converted into a new picnic area. A permeable concrete (or other similar material) pathway will be constructed. The pathway will link the southern upper trail that originates along the Park's entrance drive, to the Central Section parking area and to points further to the north.
- On the water's side of the pathway, the existing gravel will be removed and a new grassed picnic area will be created. Park personnel will move all of the picnic tables from the site's Central Section to this new picnic area. Temporary fencing will be erected and used to control access to the new lawn/picnic area to help minimize trampling and erosion problems. If the lawn surface is found unable to withstand the intensity of use, it can be replaced at a later date with vegetated pavers.

5.3.2 Central Section

- Although constructing a large subsurface stormwater detention system under the new pathway and picnic area to help treat and control runoff from the Central Section parking lot was discussed, it was determined that it would be too costly and difficult to construct. Additionally, once we conducted the stormwater routing analyses it was determined that the runoff volumes are small making such a system unnecessary. As noted above, consistent with the NYSDEC Stormwater Manual, emphasis was given to the management of the runoff emanating from the Central Section parking area during the water quality storm event. Given the relatively small volume of computed runoff, stormwater management for the parking lot would be better addressed using a vegetative filter strip as opposed to a large subsurface detention system.

- The southern Central Section parking area will be striped to better manage vehicular traffic and reduce impervious surface.
- The kayak and canoe launch area will be moved to the far northern end of the parking lot, which will require the relocation of the existing handicap parking spaces slightly to the south. The launch area will be appropriately sloped and constructed using anchored concrete planks tied in with gravel.
- A new baffled catch basin equipped with a SNOUT™ will be installed adjacent to the kayak launch area. This basin will collect and treat runoff from the northern portion of the parking lot. The baffle and SNOUT™ will enable the basin to trap floatables, road grit and sediment. Discharge from the basin to the river will be via a rip-rap lined swale.
- The existing concrete stairs will remain. However, an alternative design has been developed and is included with the Final Construction Plan set should the stakeholders decide at a later date to remove the stairs and create a natural, vegetated slope to the river.
- In the intertidal, sub-tidal area running parallel to the historic stone wall, boulder clusters will be placed in the river. The boulders with be a minimum of 48" in diameter. The placement of the clusters will be such as to not impede fish movement but at the same time provide some type of wave break to protect the wall and minimize the erosion of the intertidal area at the base of the wall.
- At the base of the historic seawall, boulder toe protection will be placed along its entire length. These bounders will be at a minimum 50% embedded in the sediment. The size of these boulders varies.
- Running parallel to the wall, in front of the wall's tow protection (water's side) a narrow band of low marsh vegetation will be planted. Although it was our intent to also establish plants extending from the toe of the wall out to the sub-tidal boulder clusters this would require the importation of soil. This constitutes a "fill", which is considered an incompatible use and therefore not likely to be permitted by the NYSDEC. Because the existing water depths are too great during high tides to support emergent wetland vegetation, but too shallow or exposed during low tides to support true aquatic plants such as *Vallisneria* or *Nuphar*, it will not be possible to establish vegetation in this area.

5.3.3 North Section

- Only a limited amount of work is required in this section of the Park. The proposed improvements are limited to the creation of a vegetated strip running along the water's side of the existing trail. This will become a "no mow zone"

where native grasses will be maintained at a height of approximately 1'. Signage may be erected to educate and inform park users as to the nature and benefit of the "now mow zone."

- As previously noted, most of the damages that have occurred to the North Section area seemed to be linked to inadequately managed stormwater runoff as opposed to tidal, wave or current impacts. This runoff originates from the landward areas upslope of the walking trail. Park personnel documented major erosion events unrelated to Hurricane Sandy causing damage to the trail, and even to sections of the rip-rap shoreline. While the management of upland stormwater runoff is outside the scope of this project, this is recommended as part of the long-term management of the Park's North Reach. As such, it is recommended as a compliment to this project that a thorough investigation of stormwater loading to the North Section walking trail be implemented. Washouts and landslides affecting this area are attributable to runoff which cascaded unmanaged down the upgradient slope. Although forested, the slope is steep and the understory is unstable. As a result, stormwater runoff has the potential to cause significant erosion problems along the majority of the slope face. Correction of this project needs to begin at the top of the hillside and before the runoff becomes concentrated and runoff flows and volumes become excessive.

5.4 Permitting

Based on a review of the NYSDEC Environmental Resource Mapper, the Hudson River is a Tidal watercourse. In the vicinity of the project area the river is assigned a NYSDEC Classification of SC/C in the project vicinity. The SC designation is for saline surface water and the C designation for surface freshwater. The combined designation speaks to the estuarine, tidal condition of the river in the Nyack area. As per NYSDEC, The best usage of both Class SC and C waters is fishing, fish, shellfish, and wildlife propagation and survival and primary and secondary contact recreation. The Environmental Resource Mapper identified that the project location is in the vicinity of Rare Animals and Rare Plants and Significant Natural Communities; specifically Oak-tulip tree forest habitat and old/potential records for bog turtle. Although this is largely a mapping issue with the actual project area not likely affected by either, the fact that it is so mapped will trigger the need for a State Environmental Quality Review Act (SEQR) assessment. Additionally, given that the project requires a SEQR review, it will be necessary to submit a request for a project screening to the New York Natural Heritage Program. As part of the Sustainable Shoreline Demonstration Project, Princeton Hydro prepared the basic information for the SEQR review has been provided on both a Full Environmental Assessment Form and a Short Environmental Assessment Form, both of which are contained in Appendix K.

Based on our review of the NYSDEC and USACOE regulations affecting wetland, stream and coastal areas, it appears that the following permits will be required for the improvements proposed for Nyack Beach State Park:

- A **Stream Disturbance Permit** is required for the disturbance of the bed or banks of a protected stream. This permit is required for all disturbances to the river and its banks and the proposed project activities are considered a Major Protected Stream Project.
- An **Excavation and Fill in Navigable Waters Permit** is required since we intend to excavate or place fill in any navigable waters of the State. The proposed project will be considered a major project under this permit.
- A **401 Water Quality Certification** is required because the project results in placing a fill resulting in a discharge to waters of the United States. The project is considered minor under the regulations.
- A **Coastal Erosion Management Permit –** This permit requires completion of the NYSDEC Coastal Erosion Management Application Checklist
- A **USACOE Section 404 Clean Water Act** approval – This is issued jointly with the NYSDEC permits described above.
- A **USACOE Section 10 Rivers and Harbors Act** approval - This is issued jointly with the NYSDEC permits described above.
- **SPDES Stormwater General Permit for Construction Activity NOI –** This approval is required due to the size of the proposed project being over one (1) acre.

The NYSDEC/USACOE Joint Permit application along with the following items is included in Appendix 11 of this report:

- Joint application form
- Section 9 - Project description and purpose
- Permission to Inspect Property Form
- Location map
- Project Plans
- Photographs
- Environmental Assessment Form (EAF)
- Structural/Archaeological Assessment Form (SAAF)

5.5 Estimated Costs

Detailed cost estimates have been prepared for the construction costs anticipated as well as the engineering, permitting, and construction administration and oversight for the project. These cost estimates have been provided in Appendix J of this report. The total budget for this project, to implement the measures and improvements detailed in the Final Plan is in the range of ±$625,000. The total cost could fluctuate further depending on what is determined needed to meet the project's permitting requirements. Nonetheless, the overall estimated budget is reasonable and of a magnitude that should not impede future grant opportunities.

5.6 Projected Construction Time-Line

In general, the proposed site improvements discussed above and illustrated in the accompanying plans should be relatively straightforward to implement or construct. As noted above in Section 5.5, there will be an environmental review process associated with this overall project that includes the opportunity for public comment. There are also a number of permits that likely will need to be obtained in advance of conducting most of the proposed work, especially that which involves alteration of the shoreline and work conducted in both intertidal and sub-tidal areas. The length of time needed to conduct the required environmental reviews, provide opportunity for public comment, and secure the necessary permits and regulatory approvals is difficult to ascertain. Normally, for projects of this nature we allot at least one to two years for permit-related activities.

With respect to actual implementation and construction activities, the required time can be more easily determined and a construction schedule was developed. It is highly likely that all the elements of the project, with the exception of post-construction monitoring, could be completed in as little as forty days. The construction schedule outlined in Table 5.1 assumes that all of the work proposed for the southern and central portions of the site will occur concurrently.

Table 5.1 - Anticipated Construction Sequence and Time-Line

	Action Item	Days
1	Install Temporary Soil Erosion And Sediment Control Measures As Per Plan	3
2	Move Statue to New Location	1
3	Demo Concrete Stairs is Stair Option One is desired, Retaining Wall and Existing Riprap Slope	5
4	Install Boulder Toe Protection	3
5	Install Random Boulder Clusters Wave Protection	3
6	Till And Grade Project Area As Shown On Plans	2
7	Plant Low Marsh and High Marsh	3
8	Plant and Stabilize Upland Vegetated Slope	2
9	Grade Riprap Swale and Prepare Kayak Launch Ramp	2
10	Install Riprap Swale and Ramp Aggregate	1
11	Install Kayak Launch Ramp	2
12	Excavate and Install Catch Basin and Piping	3
13	Replace Asphalt that was Removed to Install Materials as Specified above and Reestablish Grade	2
14	Saw Cut and Remove Existing Asphalt in Parking Lot	1
15	Install Curb and Around Area Surrounding Parking Lot Area	2
16	Till and Reseed Lawn Area	1
17	Re-stripe Parking Lot	1
18	Remove Temporary Erosion and Soil Stabilization Control Measures and Demobilize	3
TOTAL NUMBER OF DAYS:		40

5.7 Long-Term Operations and Maintenance

Recognizing that the shoreline improvements and stormwater management measures developed for Nyack Beach State Park will require maintenance, Princeton Hydro developed a basic Operations and Maintenance Plan (OMP). The OMP is provided in Appendix F.

A prominent element of the OMP is a comprehensive Monitoring Program comprised of several related requirements including:

- Providing adequate funding, staffing, equipment, and materials.
- Performing routine maintenance procedures on a regularly scheduled basis.
- Performing emergency maintenance procedures and repairs in a timely manner.
- Conducting inspections to determine both the need for and effectiveness of maintenance work.
- Providing training and instruction to maintenance personnel and inspectors.
- Conducting periodic program reviews and evaluations to determine the overall effectiveness of the maintenance program and the need for revised or additional maintenance procedures, personnel, or equipment.
- Instilling pride of workmanship and a commitment to excellence in program personnel.

The OMP identifies the NYSDEC, New York State Office of Parks, Recreation & Historic Preservation as being responsible for the preventative and corrective maintenance of the upland and shoreline improvements detailed on the plans. The OMP covers hardscape elements, vegetation and stormwater management elements of the plan. It provides guidance regarding the frequency of inspection, the types of inspections, the frequency and types of routine maintenance and the action that should be taken in the event that corrective action (e.g., replanting of a slope) is required. Guidance is also provided with respect to the documentation and reporting of all inspection, monitoring and maintenance activities.

6. Measures of Project Success

The primary role of the American Littoral Society (ALS) in this project was to develop and implement a means by which to measure the success of the Sustainable Living Shoreline Demonstration Project. This involved ALS working closely with the HREP and Princeton Hydro to develop a stakeholder questionnaire/survey. This questionnaire/survey was circulated electronically in August to the project stakeholders to gauge the stakeholder's involvement and ownership of the plans and proposed changes/restorations of the Park. The questionnaire and results are provided in Appendix E. Because the project does not proceed beyond the design phase, we utilized the resulting survey data as our Measure of Project Success. As detailed in the SOW, the Sustainable Shoreline Demonstration Project has three separate but related goals:

- Design constructible living shorelines that repair post-hurricane damage but do not limit public access and Park utilization,
- Ensure the final designs are sustainable and accommodate climate induced tidal stage, flooding and wave/ice action impacts, and
- Engage the project partners in the design process and utilize the project as a teaching opportunity about living shorelines and coastal area susceptibility to climate change.

The following are a highlight of survey questions and responses:

Question 3: A goal of the project was to produce positive and measurable outcomes. Did the stakeholder process result in positive and measurable outcomes that promote completion of the project?

- Answers:
    - 37.5% Yes
    - 37.5% Mostly
    - 0% Somewhat
    - 0% Not at all
    - 25% Uncertain

Question 6: Do the designs adequately account for predicted climate-change induced sea-level rise?

- Answers:
    - 14.29% Yes
    - 57.14% Mostly
    - 14.29% Somewhat
    - 14.29% Not at all
    - 0% Uncertain

Question 7: Do the designs adequately account for tidal amplitude, wave and fetch and ice floe conditions?

- Answers:
    - 2857% Yes
    - 0% Mostly
    - 14.29% Somewhat
    - 0% Not at all
    - 57.14% Uncertain

Question 8: In your opinion, will the designs resist erosion?

- Answers:
    - 57.14% Yes
    - 14.29% Mostly
    - 14.29% Somewhat
    - 0% Not at all
    - 14.29% Uncertain

Question 9: In your opinion, do the designs improve habitat for fish and wildlife species?

- Answers:
    - 28.57% Yes
    - 28.57% Mostly
    - 42.86% Somewhat
    - 0% Not at all
    - 0% Uncertain

Question 10: Do the designs incorporate overall sustainability and durability?

- Answers:
    - 42.86% Yes
    - 28.57% Mostly
    - 28.57% Somewhat
    - 0% Not at all
    - 14.29% Uncertain

Question 10: Are the designs suitable for use in the future to secure funding for actual construction?

- Answers:
    - 28.57% Yes
    - 0% Mostly
    - 0% Somewhat
    - 0% Not at all
    - 71.43% Uncertain

Question 15: Do you feel the proposed designs meet the project goals?

- Answers:
  - 37.5% Yes
  - 37.5% Mostly
  - 25% Somewhat
  - 0% Not at all
  - 0% Uncertain

Please see the complete survey questions and answers provided in Appendix E for the full range of measures of project success based on stakeholder input.

7. Summary and Conclusions

The overall goal of the Nyack Beach State Park Sustainable Shorelines Demonstration Project was to create living shoreline designs to demonstrate the benefits of "ecologically-enhanced, engineered shoreline treatment(s)." Whether dealing with future storms or climate change linked predicted rises in sea level, the final designs generated through this project were to be resilient to damages attributable to currents, tides, tidal surges and wave action. However, rather than rely on shoreline management techniques involving the use of standard, heavily armoring, the designs evolving through the Nyack Beach State Park Sustainable Shorelines Demonstration Project were to foster the "living shoreline" concepts of shoreline restoration and protection.

As noted above, the entire Nyack Beach State Park study area suffered significant impact during Hurricane Sandy. Although repairs were made to the Central Reach's historic seawall, there was still evidence of the hurricane's impacts to the site, especially in the South Section area. The site assessment conducted in May revealed that the nearshore, intertidal area of the site to be an extensive, relatively flat sand flat, that was devoid of SAV, and lacking any significant subsurface structure (rocks, boulders, etc.).

The restoration designs developed by Princeton Hydro for both the upland and intertidal elements of the site were ecologically based and fully supported by rigorous engineering analysis. We also emphasized a "tread lightly" approach, opting where possible to minimize site disturbance, and where practical using vegetative solutions. In keeping with the overall scope of the project we also integrated into our design to the fullest extent allowed by current NYSDEC regulations sustainable living shoreline techniques. Some of the limitations we faced in implementing living shoreline techniques are discussed below.

The "tread lightly" approach was primarily used in the restoration of the South Section and North Section portions of the site. In both areas site work was kept to a minimum. In the

North Section area the intertidal area was found to be stable and did not require any restoration. Given the size, placement and mass of the rock presently defining this shoreline, we found this portion of the site to be inherently resilient to storm damage. Additionally, this portion of the Nyack State Beach State Pak is not as affected by the projected climate change induced increases in river elevation as are the South Section and Central Section areas. While the North Section shoreline could benefit from additional submerged and intertidal habitat such measures would be implemented to increase ecological diversity rather than secure the shoreline and mitigate existing and future projected erosional impacts. Our study found that the majority of the impacts that have been sustained to this area over the past decade are a function of inadequately managed runoff emanating from upland areas. Future efforts to protect this area need to focus on improved management of the runoff emanating from the upland areas that drain to this section of the Park.

Regarding the South Section area, the original intent was to incorporate measure in the design that would promote both the protection and the accretion of the beach, as well as increase available submerged and riparian habitat. The majority of the work that would need to be conducted to yield such improvements entails the placement of fill. Presently, such activities are considered incompatible with 6NYCRR Part 661. As a result the majority of the work proposed for the South Section area focuses on the stabilization of the adjacent slope, including the protection of threatened trees, management of exiting invasive vegetation and the reestablishment of an appropriate vegetative understory.

Most of the proposed work is for the Central Reach. This includes a fair amount of work within the water and along the shoreline. This includes measures intended to both protect the historic seawall from future impacts due to storms and climate change induced increases in water elevation, as well as improve the shoreline's habitat structure and diversity. Other elements of the work will help improve the Park's utilization and help manage and treat stormwater runoff.

While the intent of this project was to promote sustainable, living shoreline practices, in reality such work does not constitute the majority of the proposed implementation plan. The original concepts focused a bit more heavily on the implementation of living shoreline practices. However, as has been realized in other studies there appears to be a regulatory gap between promoting and implementing such practices. Clearly Goals 2 and 6 of the Hudson River action Agenda recognize the importance of restoring and protecting coastal areas and promoting "shoreline adaptation strategies". At the same time NOAA, ASMFC and even NYSDEC[1] recognize and promote the value of the living shoreline/soft shoreline approach to shoreline stabilization. However, as detailed in the recent (2013) publication prepared by Restore America's Estuaries a major existing obstacle to the implementation of living shorelines lies with the "lack of understanding by the public and policy makers…and…the existing policy

[1] http://www.dec.ny.gov/permits/67096.html

frameworks". While the permitting and regulatory environment remains somewhat complicated for the implementation of living shoreline solutions, there are examples of how the permitting process and the rules can be modified and/or streamlined to promote living shoreline projects (Luscher, et al, 2006). Obviously, there is the need to control and limit the types of activities conducted in the waters of the State. The purpose of the NYSDEC and USACOE regulations is clearly to protect water quality as well as protect all species and their required habitat. The need for such regulations is especially critical in waterfront areas where there has been a long history of filling and alteration. Again as discussed in Luscher, et al (2006) the regulators should review the existing water, riparian and wetland rules to identify where conflicts exist impeding the implementation of living shoreline practices. Changes can then be integrated into the rules to better promote sustainable shoreline practices while still providing ample protections to critical water and wetland resources. Such changes may need to be accelerated given the projected climate change induced increases in sea level and the impacts this will have on such coastal resources as Nyack Beach State Park.

In summary, the Nyack Beach State Park Sustainable Shoreline Demonstration Project generated plans for the restoration and improvement of the Park's shoreline and adjacent upland areas. The proposed designs are economical, permitable, and are consistent with the direction and input received from the Nyack Beach State Park stakeholders. The ecologically based solutions are backed by rigorous engineering data, especially with respect to the proposed shoreline protection measures. Additionally, the proposed designs integrate, to the fullest extent practical and allowed under current NYSDEC regulations, the basic elements of sustainable living shoreline practices. And while additional living shoreline techniques could be integrated in the future into this project's proposed designs, the designs presented herein increase the site's resiliency to the impacts of future storms and the projected increases in river height caused by climate change. Equally important, the proposed designs enhance the overall use of the Park in a manner consistent with the Park's Master Plan.

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Appendices

A- Scope of Work
B - Site Analysis, including QAPP
C - Schematic Design Documents
D - Construction Documents
E – Stakeholder Outreach Documents
F – Operations and Maintenance Plan
G - Quarterly reports
H - Photographic Log
I – Project Graphics
J- Project Budget
K- Draft Permit Applications