

**HUDSON RIVER
FOUNDATION**

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**ADVANCING SCIENCE AND RESOURCE PROTECTION IN THE HUDSON RIVER
PARK ESTUARINE SANCTUARY**

Summary:

Since its founding over 35 years ago, the Hudson River Foundation (“the Foundation” or “HRF”) has considered the stretch of the Hudson River in the area now established as the Hudson River Park Estuarine Sanctuary to be a priority for the Foundation’s mission of Hudson River research and restoration. On its own initiative and at the urging of numerous governmental, scientific, environmental and other civic entities and interests, the Foundation has been extensively, continuously, and increasingly involved in efforts to understand, protect and improve the ecological resources of this area.

This focus, shared by the interests noted above, has been especially sharpened in recent weeks by Governor Cuomo’s announcement of the goal of achieving an agreement among these interests that would both resolve issues related to the development of the proposed Hudson River “Pier 55” on the west side of Manhattan and lead to the expeditious completion of the Hudson River Park. The terms of a potentially sweeping agreement would include removing impediments to the construction of the pier in exchange for completion of Hudson River Park and the enhancement of the Estuarine Sanctuary by providing greater protection of aquatic resources and sufficient funding to implement the Hudson River Park Sanctuary Management Plan. As part of these collaborative discussions, the Hudson River Foundation has been asked to provide guidance as to what might be included in a revision to the management plan for the Sanctuary. As detailed below, the Foundation, in consultation with scientific and technical experts, has developed a suite of recommendations for research and restoration projects, at a total estimated cost of approximately \$134 million, to address the resource protection, environmental research, and associated education and public access needs in the Sanctuary. Such an investment will make possible the full realization of the important and very significant goals embodied in the original vision and enabling legislation for this remarkable and unique urban estuarine sanctuary.

Background

The Hudson River Park Act, signed into law in 1998, declared that, “*The marine environment of the park is known to provide critical habitat for striped bass and other aquatic species. It is in the public interest to protect and conserve this habitat.*” Consequently, one of the provisions of the Act was designation of the area of the Hudson River within Hudson River Park as the Hudson River Park Estuarine Sanctuary. The Act further directed the Hudson River Park Trust, working in consultation with the New York State Department of Environmental Conservation and other agencies and organizations, to develop a management plan for the Sanctuary.

The Act contained five objectives for which the management plan should provide:

- a. *Conservation of the marine resources found in the area, with special consideration for habitat values;*
- b. *Environmental education and research;*
- c. *Public recreational use of the water section, including boating, fishing and swimming;*
- d. *In the portions of the water section adjacent to park/commercial uses, authorized commercial maritime uses; and*
- e. *Other water-dependent uses permitted in the water section under this act.*

A Hudson River Park Estuarine Sanctuary Management Plan (“Plan”) was originally prepared in 2002. It grouped the above-referenced five considerations into four key management areas: resource protection, public access and recreation, education, and environmental research. Specific objectives were established for each of these areas, and an action plan was developed for short, near-term and long-term actions. Fifteen years later, the Plan is still the official reference document for managing the Sanctuary, although the degree to which its various elements have been implemented has varied considerably. The Trust has recently convened an advisory committee to review the goals and actions of the Plan, with a view toward its revision, a process that the Foundation actively supports and in which it is directly engaged.

In response to interest expressed by all parties to the effort to reach the agreement sought by Governor Cuomo and noted above, the Foundation is providing here its insights and guidance as to what an enhanced management plan might include, especially as such a plan relates to scientific research and monitoring to support management and restoration activities.

Observations and Current Context

- The Act specifies a process that includes multi-agency and multi-organization coordination to develop a sanctuary management plan. A rewrite of the plan should require the same or a similar process. The Plan, as originally written, contains a carefully reasoned set of broad objectives to achieve the marine protection and conservation goals of the Act.
- The fundamental mission and purpose of the Foundation, including the New York-New Jersey Harbor & Estuary Program (HEP) that it manages, and its experience and history in guiding and funding relevant research and convening the broad community of policy makers, regulators, scientists, environmentalist and other civic activists, enables it to provide multi-dimensional guidance for this effort:
 - HRF has funded a significant amount of research directly related to conditions in the Sanctuary, including studies of the impacts of pile-supported structures in the Sanctuary, nearshore habitats throughout the harbor, the persistence of bacteria in sediments near CSOs, sediment transport in the lower estuary, and fish migrations, among other topics. The Harbor & Estuary Program is currently funding work on the quality of benthic habitats in the Sanctuary;
 - HRF has worked closely with the Park Trust staff on developing restoration concepts and projects for the Sanctuary;
 - HRF has provided funding and collaborative support for a new HRECOS station located in the Sanctuary;
 - HRF has been a supporter of the River Project within the Park for many years and has encouraged and funded research, education and monitoring at that facility;

- HRF has been an active player in guiding the design of the Estuarium on Pier 26;
- HRF is a recognized convener for exploration of scientific and related policy issues; and
- HRF has previously worked on the development of preliminary scientific study plans for the Sanctuary.
- The *resource protection* and *environmental research* components of the Sanctuary Plan offer many opportunities for scientific collaboration with and guidance from the Hudson River Foundation.
- The *education* and *public access and recreation* components also offer opportunities for engagement with the Foundation, particularly through the Harbor & Estuary Program.
- Because of the immediate goal of opening access to the Hudson River, otherwise improve the site, and engage New Yorkers with its ecological richness, *public access and education* have, over the years, received greater overall attention and support than other portions of the plan.
- *Resource protection* and *environmental research* have received less attention and funding. Trust staff and the River Project have promoted science in the Park and worked with science-based organizations and agencies, including the Foundation, for many years, but the acquisition of scientific data about the Sanctuary has been very limited.
- A report on key species of the Sanctuary (a centrally important study that would serve as a baseline for understanding habitats in the Sanctuary) has not been undertaken. This report was to be written and updated every five years. However, a Cornell University study of the impacts of World Trade Center disaster-related dredging did provide some basic information about key species in the Sanctuary.
- There has been some work on the enhancement objectives related to the ecological piers and pile fields.
- The existing Plan identified water quality issues (in the Sanctuary) that are related to pollution discharges, most notably combined sewer overflows (CSOs), and recommended that the Trust work with responsible agencies, particularly NYCDEP, to abate harmful effects. The Plan also calls for evaluating measures that can be implemented to improve CSOs and for monitoring *progress toward reaching the water quality target for swimming opportunities in the Sanctuary*.
- The environmental research component of the Plan states that *knowledge and understanding of the Sanctuary* are needed to improve the ecology of the Hudson River Estuary.

Conclusions and Recommendations

- The existing Sanctuary Management Plan has many laudable goals and objectives; however, not all have been met or even pursued over the past 15 years, in particular those related to environmental research and resource protection.
- While it may be desirable to create an entirely new Management Plan, there appear to be many ways in which the existing plan can be enhanced and revised to provide additional science and resource protection objectives consistent with the existing plan, so that the goals for the Sanctuary can be finally and fully realized.
- There is a critical need to conduct scientific research and monitoring to understand better the conditions in the Sanctuary in order to manage it.
- As detailed below, the Foundation has developed a suite of recommendations for research and restoration projects, at a total estimated cost of approximately \$134 million, to address the resource protection, environmental research, and associated education and

public access needs in the Sanctuary. This estimate was prepared by the Foundation staff with the input of leading scientists and engineers with knowledge of conditions in the Sanctuary.

- The following types of work are recommended:
 1. **Scientific research** should be conducted on key processes that are affecting the Sanctuary ecosystem and on the ways in which other factors, particularly human-induced factors, are affecting those processes and all the biological resources in the ecosystem. This is particularly important toward identifying and evaluating habitats that require greater protection and enhancement/restoration; evaluating the habitat value of existing structures in the Sanctuary; and more fully understanding the impacts of CSOs and stormwater-related discharges, particularly in areas close to shore that have never been assessed. A key starting point is understanding the baseline conditions of the Sanctuary, which should be characterized and then monitored to understand how they are changing. Estimated Cost: \$7.3 million.
 2. **Habitat enhancement projects** should be implemented with directed research guiding their design. The focus should be the designated ecological zones established in the Park: a total of 96 water acres from the northern bulkhead of Battery Park to the Holland Tunnel and a second priority area between Piers 45 and Pier 52 (Gansevoort). Estimated Cost: \$29.8 million.
 3. **Water quality improvements** in designated priority areas are critical to the restoration of habitat as well as improvement of public access to the sanctuary waters. Since combined sewer overflows (CSOs) are likely to be the most significant cause of water quality impairments to the Sanctuary, new research and monitoring should guide the development of plans for their abatement. An analysis of these discharges as well as direct stormwater discharge to the Sanctuary should include an analysis of abatement options, such as green infrastructure and extension of outfalls, and benefits of these improvements for aquatic life and contact recreation. These recommendations are provided with the understanding that the primary responsibility for managing storm water and CSOs falls outside the Park's jurisdiction. Estimated Cost: \$75.0 million.
 4. **Environmental monitoring** of the Sanctuary should be conducted to evaluate success and support adaptive management of implemented projects. Estimated Cost: \$6.0 million.
 5. There are two key projects within the Park's 10-year capital plan that would provide **science support and public education** opportunities. The first floor of the proposed Estuarium on Pier 26 will include a laboratory space for scientists and aquatic exhibits. The marine portion of the Pier 52 Gansevoort Peninsula will be a key ecological habitat as well as a place for the public to have direct contact with the shoreline in a safe manner. Estimated Cost: \$16.2 million.

LIST OF RECOMMENDED PROJECTS FOR THE RESOURCE PROTECTION AND ENVIRONMENTAL RESEARCH NEEDS OF THE HUDSON RIVER PARK ESTUARINE SANCTUARY

1. Research to Increase Knowledge of the Hudson River Park Sanctuary (Sanctuary)

1.1. Characterization of Sanctuary habitat

1.1.1. Evaluating the physical processes affecting the environmental quality, habitat and physical stability of the Sanctuary.

This study will apply high-resolution measurement techniques in combination with advanced modeling to provide critical research advances that will help guide the management and stewardship of the Sanctuary. The specific components of the study include the following:

- A. High resolution surveys of water properties, currents and bottom sedimentary conditions within the Sanctuary and adjoining Hudson estuary;
- B. Time series measurements of currents and water properties for two years to document the tidal, seasonal and event-related physical mechanisms (natural and anthropogenic);
- C. Sedimentological and geochemical studies to determine patterns and rates of sediment deposition and erosion;
- D. High-resolution numerical model of physical transport processes, sediment transport and morphological evolution.

Timeframe: Three Years. Estimated cost: \$1,000,000.

1.1.2. Characterization of fish utilization of open inter-pier areas

This study will build off the work of Bain et al. 2006, following a similar approach and using multiple sources of information including seasonal catches for pelagic and bottom fishes and crabs from trawl (Tucker and otter), seine, and gill net surveys from the shoreline to the pierhead line.

Timeframe: Three years. Estimated cost: \$750,000.

1.1.3. *Characterization of fish utilization of under-pier areas and pile fields*

This study will build on the work of Drs. Able and Grothues, Rutgers University, utilizing multiple sampling methods including fish traps and gill net surveys to determine pelagic and bottom fish abundance and diversity of juvenile and adult fishes in piling fields and under piers as well as in relation to other structural components within the Sanctuary.

Timeframe: Three years. Estimated cost: \$750,000.

1.1.4. *Colonization Study of hard substrates at piers and bulkheads*

This study will assess population levels and biodiversity of organisms colonizing the piling fields, piers, bulkheads and other structural components of the Sanctuary.

Timeframe: Two years. Estimated cost: \$300,000.

1.1.5. *Larval population study to determine the source populations of settling bivalve larvae and the settlement sites of dispersing larvae.*

The study will examine larval connections of bivalve populations and enhance understanding of the spatial scale of these interactions.

Timeframe: Three years. Estimated cost: \$500,000.

1.1.6. *Characterization of benthic habitat in the Sanctuary*

This study will follow the recently completed DEC and HEP benthic mapping studies, providing a more comprehensive benthic sampling survey, including a detailed characterization of the piling fields and under-pier areas to provide a complete comprehensive map of the geophysical properties and benthic community composition of the entire Sanctuary.

Timeframe: Two years. Estimated cost: \$500,000.

1.1.7. *Water quality interaction*

Understanding how changes in water quality, including long-term water quality improvements and episodic CSO events influence fish and benthic communities of the Sanctuary. These data will identify potentially important variations in water properties from the near-surface layer to the bottom as well as longitudinal variations from the near shore to the deeper water. Five real-time water quality sensors will be deployed: 1) near the bulkhead 2) mid-zone between the bulkhead and pierhead at the surface, 3) mid-zone at the bottom, 4) pierhead at the surface and 5) pierhead at the bottom.

Timeframe: Three years. Estimated cost: \$500,000.

1.1.8. Synthesis of Sanctuary research

The research projects proposed here will be carried out by numerous scientific investigators from a number of scientific research institutions. The studies will characterize the biological resources and physical processes affecting the environmental quality, habitat and physical stability of the Sanctuary. These studies will provide critical data on the connections between the biological and physical processes and observed conditions, filling gaps in our understanding of the Sanctuary ecosystem and the Park's interaction with the broader ecosystem. This project will allow the researchers to work as a collaborative group as part of a multi-institutional research team to produce a synthesis document that describes the state of scientific understanding of the ecosystem function of the Sanctuary.

Timeframe: Two-year study starting after completion of the research studies (year 4). Estimated cost: \$500,000.

1.2. Enhanced understanding of the effects of stormwater and combined sewer overflow discharges on Sanctuary water quality

Stormwater and combined sewer overflow (CSO) discharges release disease-causing microorganisms (pathogens) and other pollutants into receiving water bodies. These discharges can have significant negative environmental impacts (lowering dissolved oxygen), aesthetic impacts (odors) and create health concerns (pathogen contamination) when these waters are used for recreational purposes involving primary and secondary contact. The following studies will assess how the implementation of green infrastructure projects within the sewersheds and direct drainage areas impacting the Sanctuary and

alteration of sewer infrastructure within the Park and the Sanctuary can reduce these impacts.

1.2.1. Profile and identification of Stormwater/CSO issues

The study will model the 37 sewersheds and the direct drainage areas discharging to the Sanctuary to develop estimates of expected stormwater and CSO volumes and frequency of overflows. The study will identify and prioritize potential green infrastructure and other management solutions and estimate the anticipated benefits.

Timeframe: One year. Estimated cost: \$150,000.

1.2.2. Prioritization and concept plans for priority drainage areas

This study will build on the modeling work above to develop a multi-variable decision making matrix to evaluate nine priority drainage areas that contribute stormwater or CSOs directly into two areas in the Sanctuary designated for natural resource protection, on-water recreation, and potentially in-water recreation activities. The models will develop concept plans for green infrastructure and other improvements, including costs and potential impediments to implementation.

Timeframe: Two years. Estimated cost: \$350,000.

1.2.3. Event-based sampling examining the influence of CSO discharge on water, particle and sediment microbial communities within Sanctuary

This study will evaluate the microbial response to CSO discharge, using both traditional cultivation based fecal indicator bacteria (e.g. Enterococci) and molecular genetic (high throughput Illumina sequencing and quantitative PCR) characterization of a broader fecal bacteria community, including known fecal pathogens. Sampling would include sites selected to represent both user/recreation areas in the nearshore environment, open water sites at the end of piers and also a subset of sites in close proximity to major CSOs within the Sanctuary. Microbial communities would be examined primarily in water during the time-course sampling, but a subset of sites/times samples would also be taken to examine free-living and particle-associated microbes in the water column and microbes in nearshore sediment. Each CSO sampling event would begin before precipitation and continue with high-frequency sampling over the 72 hours following CSO discharge. This project, although mostly focused on microbiological dynamics, would also generate very valuable information about CSO discharge on dissolved oxygen levels in the Sanctuary.

Timeframe: One year. Estimated cost: \$400,000.

1.2.4. Three years of high-frequency and high-spatial-coverage microbial water quality sampling in the Sanctuary (years 2-4)

This study will sample 15 sites in the Sanctuary, with water sampled twice weekly in recreational season, and twice monthly in non-recreational season, using both traditional cultivation-based fecal indicator bacteria (e.g. Enterococci) and molecular genetic (high throughput Illumina sequencing and quantitative PCR) characterization of a broader fecal bacteria community, including known fecal pathogens. A subset of sediment and particle samples will also be characterized.

Timeframe: Three years. Estimated cost: \$630,000.

1.2.5. Sanctuary pathogen modeling

Once introduced into the environment, the persistence of microbial pollutants is controlled by complex processes involving various environmental factors including temperature, sunlight, dissolved oxygen, salinity and other variables. There is limited information on how these variables and other natural factors interact and affect survival rates especially with respect to specific organisms of concern *i.e.* fecal coliforms, *E. coli*, and enterococci. The water quality models being applied by NYCDEP do not explicitly model these variables, and the model grid resolution is insufficient to resolve these complex interactions in the nearshore (bulkhead to pierhead) environment. This study will examine the reduction in pathogens achieved by the modeled CSO flows from the green infrastructure studies (1.2.1. and 1.2.2), as well as the effects of the extension of CSO discharge pipes to the pierhead line.

Timeframe: Two years. Estimated cost: \$650,000.

1.2.6. Sanctuary water quality modeling

The models currently being applied to examine Harbor-wide water quality do not have sufficient model grid resolution to resolve fine-scale water quality changes especially for the shallow nearshore areas. This study will develop a high-resolution model for the Sanctuary and examine factors influencing changes in dissolved oxygen, including effects of nutrients, phytoplankton, and sediment oxygen demand. The model will provide forecasts of expected water quality under various scenarios, including

projections of dissolved oxygen levels under the green infrastructure (section 3.1) and combined sewer extension (section 3.2) scenarios developed under section 3.

Timeframe: Two years. Estimated cost: \$300,000

2. Habitat enhancement in two designated high-priority ecological zones

The restoration and enhancement projects detailed below focus on two priority restoration areas within the Sanctuary. The first priority area (Priority Area 1) runs from the northern bulkhead of Battery Park to the Holland Tunnel. The second priority area (Priority Area 2) encompasses the area between Piers 45 and Pier 52 (Gansevoort). The suggested projects are illustrative of the types of projects and expected costs. Restoration projects are generally scalable in size.

2.1. Aquatic habitat restoration/enhancement

This project will create shallow structured habitat to provide spawning areas, nursery areas, refuge for cover-seeking fish and feeding areas for marine life. The restoration will be designed to enhance fish seen in low numbers in the open inter-pier area, enhance invertebrate fauna—by moving species composition away from opportunistic, pollution-tolerant species to targeted species composition—and create habitat corridors connecting piling field habitats, under pier-areas and open inter-pier areas to provide corridors for moving fish and invertebrates through the park.

Timeframe: Three years. Estimated cost: At \$750,000 per acre, restoration of 10 of the 96 acres within the two Priority Areas is \$7,500,000

2.2. Oyster habitat restoration

Oyster reefs and the species making up the overall (fouling) community of invertebrates that naturally develops on hard substrates in estuarine waters (i.e., the “oyster reef community”) provide important ecosystem services such as enhanced biodiversity, wave attenuation, sediment stabilization, and improved water quality. Recently completed oyster restoration research conducted in New York Harbor and near the Tappan Zee Bridge provides important information on how to best design a sustainable oyster reef community that supports these desired ecosystem services. This restoration effort will utilize a range of potential restoration techniques including reef balls and gabion blocks.

Timeframe: Three years. Estimated cost: At \$250,000 per acre, restoration of 25 of the 96 acres within the two priority areas is \$6,250,000.

2.3. Enhancement of piling fields and piers.

Utilizing the data collected in the research studies proposed above, as well as data from ongoing studies at Brooklyn Bridge Park, this project will evaluate and then implement a variety of restoration techniques to enhance the fish, plant and invertebrate communities living within the pile fields and under piers.

Timeframe: Three years. Estimated cost: At \$2,500,000 per piling field or pier structure, enhancement of 5 areas is \$12,500,000.

2.4. Enhancing ecosystem services provided by bulkheads

This study will examine the ecological function of existing bulkheads in Hudson River Park and design and implement enhancement techniques to support an enriched biogenic community of marine flora and fauna. Enhanced ecological bulkheads will provide numerous ecosystem services, including habitat provisioning for targeted species and water quality improvements through improved filter feeding communities. The ecological bulkheads can also improve the structural integrity and longevity of bulkheads.

Timeframe: Three years. Estimated cost: At \$750,000 per 1,000 feet of bulkhead, enhancement of 4,700 linear feet of bulkhead within the two priority areas will cost \$3,525,000.

3. Water quality improvements in designated Priority Areas

Two potential options for reducing stormwater and CSO discharges into the Priority Areas could be considered. The estimated costs are included for both options, which could be combined.

3.1. Green infrastructure improvements for priority drainage areas

The sewersheds for the nine CSOs discharging directly into the Priority Areas encompass about 540 acres and the area of direct drainage is about 28 acres. This project will implement a variety of green infrastructure strategies, including enhanced tree pits, rain gardens, and/or subsurface storage opportunities in Hudson River Park and other parks, parking lots, and the street right-of-way, as well as green and blue roofs on existing and new structures.

Timeframe: Five years. Estimated cost: Assuming green infrastructure improvements costing \$100,000 can be sited for each acre of available land, and improvements are sited within 250 of the available 540 acres, the estimated cost is \$25,000,000.

3.2. Extensions of CSO outfall pipes to pierhead line for priority areas

Moving CSO discharge pipes from the bulkhead to pierhead line could improve water quality in the near-shore areas of the Sanctuary. These extensions would move effluent away from important shallow water habitat, boat launches and secondary (and potentially primary) contact areas. Extending all of the CSOs discharging directly into the two Priority Areas would require an estimated 5,500 feet of pipe extensions.

Timeframe: 10 years. Estimated cost: Assuming 2,500 feet of pipe extensions are implemented, the estimated cost is \$50,000,000.

4. Sanctuary Monitoring

4.1. Develop a data management and geographic information system to archive and distribute the data collected under the research and monitoring programs.

Timeframe: 10 years, Estimated cost: An initial cost of \$200,000, with annual cost of \$50,000 per year, for a total of \$700,000 over 10 years.

4.2. Continuous Long Term Water Quality Monitoring Water Quality

The five high-resolution weather and water quality monitoring stations established in the research program will be maintained to provide high-resolution long-term water quality data.

Timeframe: Start after completion of the research component. Estimated cost: Annual maintenance of \$20,000 per year, per station, for a total cost of \$600,000 for 10 years.

4.3. High-resolution surveys of water properties, currents and bottom sedimentary conditions within the Sanctuary

Timeframe: Start after completion of the research component, repeat every three years. Estimated cost: \$250,000 per sampling year. With sampling in years 6 and 9, the total cost is \$500,000.

4.4. Monitoring of fish utilization of open inter-pier areas.

Trawl, seine, and gill net surveys of pelagic and bottom fishes and crabs from inter-pier areas from the bulkhead to pierhead line.

Timeframe: Start after completion of the research component, repeat every three years.
Estimated cost: \$250,000 per sampling year. With sampling in years 6 and 9, the total cost is \$500,000.

4.5. Monitoring of fish utilization of under-pier areas and pile fields.

Seine and gill net surveys of pelagic and bottom fish in piling fields and under piers

Timeframe: Start after completion of the research component, repeat every three years.
Estimated cost: \$250,000 per sampling year. Estimated cost: \$250,000 per sampling year.
With sampling in years 6 and 9, the total cost is \$500,000.

4.6. Monitoring of hard substrates at piers and bulkheads.

Timeframe: Start after completion of the research component, repeat every three years.
Estimated cost: \$250,000 per event. With sampling in years 4, 6, 8 and 10, the total cost is \$1,000,000.

4.7. Larval monitoring

Timeframe: Start after completion of the research component, repeat every three years.
Estimated cost: \$200,000 per event. With sampling in years 6 and 9, the total cost is \$400,000.

4.8. Benthic habitat monitoring

Benthic sampling surveys of the benthic invertebrate community and physical and chemical properties of the sediments

Timeframe: Start after completion of the research component, repeat every 2 years.
Estimated cost: \$250,000 per event. With sampling in years 4, 6, 8 and 10, the total cost is \$1,000,000.

4.9. Microbial community water quality monitoring

Microbial monitoring at 10 Sanctuary sites, with water sampled weekly in the recreational season, and once monthly in the non-recreational season

Timeframe: Start after completion of the research component, repeat every two years.
Estimated cost: \$250,000 per event. With s sampling in years 6, 8 and 10, the total estimated cost is \$750,000.

5. Science Support and Public Education

5.1. Pier 26 Estuarium

The Hudson River Park Trust has advanced a proposal for an Estuarium on Pier 26. The proposed 5,000-square-foot first floor of the facility and adjacent outdoor area will include a laboratory space for scientists working in the Sanctuary and aquatic exhibits and classroom space for showcasing the Sanctuary and the work of these scientists to students and the public. The estimated cost of the fit-out of the first floor for these uses is estimated at \$900 square foot plus 15% for design and engineering. An additional \$800,000 is included for the associated outdoor space.

Timeframe: Six years. Estimated cost: \$ 6,000,000.

5.2. Pier 52 Gansevoort Peninsula

This large and sheltered area is being planned by the Hudson River Park Trust to feature a rocky shoreline beach, offering the possibility of marine enhancement, a get-down to the water and a variety of water-play activities. The 2004 Sanctuary Plan recommended that the Hudson River Park Trust “monitor progress toward reaching the water quality target for swimming opportunities within the Sanctuary.” This site is perhaps the best opportunity for swimming or at least wading within the Park’s borders. While the design of this important park area depends on resolution of remaining issues with reference to a marine transfer station, the Park has estimated the cost of the marine portion of the Peninsula at \$10.2 million.

Timeframe: 10 years. Estimated cost: \$10,200,000

Detailed Budget Estimate

| 1 | RESEARCH TO INCREASE KNOWLEDGE OF THE HUDSON RIVER PARK SANCTUARY | BUDGET |
|---------------|---|---------------|
| 1.1. | <i>Characterization of Sanctuary habitat</i> | |
| 1.1.1. | Evaluating the physical processes affecting the environmental quality, habitat and physical stability of the Sanctuary. Timeframe: 3 years. Estimated cost: \$1,000,000. | \$1,000,000 |
| 1.1.1. | Characterization of fish utilization of open inter-pier areas Timeframe: 3 years. Estimated cost: \$750,000. | \$750,000 |
| 1.1.2. | Characterization of fish utilization of under pier areas and pile fields Timeframe: 3 years. Estimated cost: \$750,000. | \$750,000 |
| 1.1.3. | Colonization Study of hard substrates at piers and bulkheads Timeframe: 2 years. Estimated cost: \$300,000. | \$300,000 |
| 1.1.4. | Larval population study to determine the source populations of settling bivalve larvae and the settlement sites of dispersing larvae. Timeframe: 3 years. Estimated cost: \$500,000. | \$500,000 |
| 1.1.5. | Characterization of benthic habitat in the Sanctuary Timeframe: 2 years. Estimated cost: \$500,000. | \$500,000 |
| 1.1.6. | Water quality interaction Timeframe: 3 years. Estimated cost: \$500,000. | \$500,000 |
| 1.1.7. | Synthesis of Sanctuary research Timeframe: 2 year study starting after completion of the research studies (year 4). Estimated cost: \$500,000. | \$500,000 |
| 1.2. | <i>Enhanced understanding of the effects of stormwater and combined sewer overflow discharges on Sanctuary water quality</i> | |
| 1.2.1. | Profile and identification of Stormwater/CSO issues Timeframe: 1 year. Estimated cost: \$150,000. | \$150,000 |
| 1.2.2. | Prioritization and concept plans for priority drainage areas Timeframe: 2 years. Estimated cost: \$350,000. | \$350,000 |
| 1.2.3. | Event based sampling examining the influence of CSO discharge on water, particle and sediment microbial communities within Sanctuary Timeframe: 1 year. Estimated cost: \$400,000. | \$400,000 |
| 1.2.4. | 3 years of high frequency and high spatial coverage microbial water quality sampling in the Sanctuary (years 2-4) Timeframe: 2 years. Estimated cost: \$630,000. | \$630,000 |
| 1.2.5. | Sanctuary pathogen modeling Timeframe: 2 years. Estimated cost: \$650,000. | \$650,000 |
| 1.2.6. | Sanctuary water quality modeling Timeframe: 2 years. Estimated cost: \$300,000 | \$300,000 |

| | | |
|-------------|---|--------------|
| 2 | HABITAT ENHANCEMENT IN TWO DESIGNATED HIGH PRIORITY ECOLOGICAL ZONES | |
| 2.1. | <i>Aquatic habitat restoration/enhancement</i> Timeframe: 3 years. Estimated cost: At \$750,000 per acre, restoration of 10 of the 96 acres within the 2 Priority Areas will \$7,500,000 | \$7,500,000 |
| 2.2. | <i>Oyster habitat restoration</i> Timeframe: 3 years. Estimated cost: At \$250,000 per acre, restoration of 25 of the 96 acres within the 2 priority areas will cost \$6,250,000 | \$6,250,000 |
| 2.3. | <i>Enhancement of piling fields and piers</i> Timeframe: 3 years. Estimated cost: At \$2,500,000 per piling field or pier structure, enhancement of 5 areas will \$12,500,000. | \$12,500,000 |
| 2.4. | <i>Enhancement of ecosystem services provided by bulkheads</i> Timeframe: 3 years. Estimated cost: At \$750,000 per 1,000 ft. of bulkhead, enhancement of 4,700 liner ft. of bulkhead within the 2 priority areas will cost \$3,525,000. | \$3,525,000 |
| 3 | WATER QUALITY IMPROVEMENTS IN DESIGNATED PRIORITY AREAS | |
| 3.1. | <i>Green infrastructure improvements for priority drainage areas</i> Timeframe: 5 years. Estimated cost: Assuming green infrastructure improvements costing \$100,000 can be sited for each acre of available land, and improvements are sited within 250 of the available 540 acres, the estimated cost is \$25,000,000. | \$25,000,000 |
| 3.2. | <i>Extensions of CSO outfall pipes to pierhead line for priority areas</i> Timeframe: 10 years. Estimated cost: Assuming 2,500 feet of pipe extensions are implemented, the estimated cost is \$50,000,000. | \$50,000,000 |
| 4 | SANCTUARY MONITORING | |
| 4.1. | <i>Develop a data management and geographic information system to archive and distribute the data collected under the research and monitoring programs</i> Timeframe: 10 years. Estimated cost: An initial cost of \$200,000, with annual cost of \$50,000 per year thereafter for a total of \$700,000 over 10 years. | \$700,000 |
| 4.2. | <i>Continuous Long-Term Water Quality Monitoring Water Quality</i> Timeframe: Start after completion of the research component. Estimated cost: Annual maintenance \$20,000 per year, per station for a total cost of \$600,000 for 10 years. | \$600,000 |
| 4.3. | <i>High resolution surveys of water properties, currents and bottom sedimentary conditions within the Sanctuary</i> Timeframe: Start after completion of the research component, repeat every 3 years. Estimated cost: \$250,000 per sampling year. With sampling in years 6 and 9, the total cost is \$500,000. | \$500,000 |

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| 4.4. | Monitoring of fish utilization of open inter-pier areas. Timeframe: Start after completion of the research component, repeat every 3 years. Estimated cost: \$250,000 per sampling year. With sampling in years 6 and 9, the total cost is \$500,000. | \$500,000 |
| 4.5. | Monitoring of fish utilization of under pier areas and pile fields. Timeframe: Start after completion of the research component, repeat every 3 years. Estimated cost: \$250,000 per sampling year. Estimated cost: \$250,000 per sampling year. With sampling in years 6 and 9, the total cost is \$500,000. | \$500,000 |
| 4.6. | Monitoring of hard substrates at piers and bulkheads. Timeframe: Start after completion of the research component, repeat every 2 years. Estimated cost: \$250,000 per event. With sampling in years 4, 6, 8 and 10, the total cost is \$1,000,000. | \$1,000,000 |
| 4.7. | Larval monitoring Timeframe: Start after completion of the research component, repeat every 3 years. Estimated cost: \$200,000 per event. With sampling in years 6 and 9, the total cost is \$400,000. | \$400,000 |
| 4.8. | Benthic Habitat Monitoring Timeframe: Start after completion of the research component, repeat every 2 years. Estimated cost: \$250,000 per event. With sampling in years 4, 6, 8 and 10, the total cost is \$1,000,000. | \$1,000,000 |
| 4.9. | Microbial community water quality monitoring Timeframe: Start after completion of the research component, repeat every 2 years. Estimated cost: \$250,000 per event. With sampling in years 6, 8 and 10, the total estimated cost is \$750,000. | \$750,000 |
| 5 | <i>SCIENCE SUPPORT AND PUBLIC EDUCATION</i> | |
| 5.1. | Pier 26 Estuarium Timeframe: 6 years. Estimated cost: \$ 6,000,000. | \$6,000,000 |
| 5.2. | Pier 52 Gansevoort Peninsula Timeframe: 10 years. Estimated cost: \$ 10,200,000 | \$10,200,000 |
| | Total Project Budget | \$134,225,000 |