Gowanus Bay and Canal
Borough of Brooklyn, Kings County, New York
Feasibility Study

P-7 Milestone Report

March 2005

Executive Summary

More than one hundred years of industrial development and urban pollution has severely degraded the ecosystem of the Gowanus Bay and Canal. Urban development and commercial uses of the Bay, Canal, and surrounding uplands also restrict potential restoration measures. The New York District has completed site investigations and preliminary testing of the sediment and related biological habitats. This testing suggests that the Bay and Canal currently support a degraded community of species that are tolerant to high levels of pollution, and widely fluctuating levels of dissolved oxygen, salinity, and temperature. Furthermore, the sampling suggests that the sediments are polluted to a degree that limits species abundance and diversity throughout the Canal. Investigations conducted to-date indicate that the contaminated sediments in the Canal are likely affecting the health of all Hudson-Raritan Estuary (HRE) ecological communities that feed into the study area.

The restoration of the benthic habitat will first and foremost require a significant reduction or isolation of pollutant-loaded sediments from interacting with the overall ecosystem. Other restoration measures, such as habitat creation, will be considered in concert with a pollutant isolating primary alternative. The information gathered for this feasibility study to-date indicates that the restoration measures that have the most likelihood of success include:

- Wetland creation;
- Upland planting of appropriate riparian species; and
- Dredging and capping of contaminated sediments.

At this point in the study, the New York District recommends the further refinement of alternatives that incorporate the dredging of benthic sediments with the simultaneous capping of the remaining contaminated sediments. Additional work will also be undertaken to determine the feasibility of wetland creation in the canal. The required depth of sediment removal will be determined by hydrodynamic modeling of the flushing regime that will provide optimum ecosystem restoration benefits. Other important factors to be considered will include geotechnical issues, navigation of existing commercial traffic, and durability/sustainability of the project.

Future feasibility study investigations will focus mainly on establishing the link between sediment contamination and the health of the HRE's biotic community. Additional sediment sampling and analysis is required for the upper 2.5 feet of sediment. The types of biologic analyses that will be required will largely be determined by the type of habitat evaluation method selected. It is expected that the habitat evaluation method will focus on the potential ecosystem risk posed by contaminated sediments in the Bay and Canal to the HRE's biotic community.

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1 Introduction

1.1 Purpose of Report

This report provides documentation supporting the Gowanus Bay and Canal Ecosystem Restoration Feasibility Study P-7 Formulation Briefing. As stated in the Planning Guidance Notebook (ER 1105-2-100, 22 April 2000), the purpose of the feasibility study is to identify, evaluate and recommend to decision makers an appropriate, coordinated, implementable solution to the identified water resources problems and opportunities. The resulting report should be a complete decision document, referred to as a feasibility report. The feasibility report shall provide a sound and documented basis for decision makers at all levels to judge the recommended solutions.

The P-7 Formulation Briefing is an internal Division-District Milestone identified in CENAD Policy Guidance dated 28 March 1996. The P-7 Formulation Briefing is conducted early in the feasibility phase of the analysis as a means of managing and directing the course of the study. The intention of the P-7 Formulation Briefing milestone is to present the culmination of all investigations and study activities conducted to date, so that future investigations and study activities can best meet the study objectives and focus on promising alternative plans in greater detail.

This P-7 Report represents the current state of knowledge concerning ecosystem restoration in the Gowanus Bay and Canal. Much information has been collected and analyzed, which forms the base of knowledge that will direct the remainder of the study. This P-7 Report, as read-ahead material for the P-7 Formulation Briefing, identifies generalized solutions that show the most likelihood of success and identifies the study activities that will be carried out in order to fully evaluate alternatives and select a recommended ecosystem restoration plan.

1.2 Authorization

The Gowanus Bay and Canal Ecosystem Restoration Study is being carried out under the Corps of Engineers' General Investigations (GI) Program. The study was authorized under the Hudson-Raritan study authorization, in a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, dated 15 April 1999, which reads:

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the New York and New Jersey Channels, published as House Document 133, 74th Congress, 1st Session; the New York and New Jersey Harbor Entrance Channels and Anchorage Areas, published as Senate Document 45, 84th Congress, 1st Session; and the New York Harbor, NY Anchorage Channel, published as House Document 18, 71st Congress, 2nd Session, as well as other related reports with a view to determining the feasibility of*

environmental restoration and protection relating to water resources and sediment quality within the New York and New Jersey Port District, including but not limited to creation, enhancement, and restoration of aquatic, wetland, and adjacent upland habitats."

The Section 905(b) Preliminary Analysis was approved on 28 July 2000. The Gowanus Canal was identified as one of 82 sites deemed to initially warrant further investigations. The non-Federal partner is the New York City Department of Environmental Protection. The Feasibility Cost Sharing Agreement between the Federal government and the non-Federal partner was signed on 08 January 2002.

1.3 Study Area

The Gowanus Bay and Canal have been extensively altered since the first European settlements in the area. At that time the Gowanus Bay region included several islands and inlets to the north of the present channel. The area of Gowanus Creek was a low-lying swampy area that supported limited agriculture. The creek itself provided power for Brooklyn's earliest industries, such as tide mills. Freeke's Mill stood on Gowanus Creek as early as 1661 and five mills were built along the waterway in the 18th and early 19th centuries (Hunter Research, Inc. *et al.*, 2004). Additionally, several dams and millponds were constructed in the Gowanus and Red Hook areas. As late as 1841, the area southwest of Hamilton Avenue and between Third Avenue and Gowanus Bay was described as marshland too shallow for navigation. Construction of the Erie and Red Hook basins in the 1850's greatly altered the shoreline of Gowanus Bay. The Gowanus Canal extending north from Hamilton Avenue in the general vicinity of the former Gowanus Creek was completed in 1870 (construction lasted from 1853-1870) for the dual purposes of providing drainage for 1,700 acres within the southern portion of the City of Brooklyn and to extend ship traffic into south Brooklyn (Kopper and Black, 1978).

Waterborne Commerce Statistics Center Data for 2002 indicate that Gowanus Bay and Canal are regularly used for commercial navigation. In 2002, 1,300,000 short tons of cargo were transported in the Bay and Canal. The most common cargo was petroleum products (847,000 tons) followed by sand and gravel (433,000 tons) and waste and scrap metal (20,000 tons). The cargo was transported by tug-barge combinations..

The Gowanus Bay and Canal Project Area was defined during a study team meeting held at New York City Department of Environmental Protection (NYCDEP) Headquarters, Queens (16 December 2002) as the entire marine portion of the Gowanus Bay and Gowanus Canal east of Red Hook. More specifically, the western limit of the study was defined as a north-south running line beginning at the southwestern outboard corner of the Erie Basin and proceeding grid south to the 39th Street Pier. The total area of the marine portion of the project is 198 acres, of which 181 acres are in the Bay west of the Gowanus Expressway and 17 acres are in the Canal proper. The terrestrial extent of the project area includes all real properties bordering the marine portion of the project area. In addition, further investigation and plan formulation may establish the need to expand the study area to include contributing surface and subsurface drainage areas to Gowanus Bay and Canal.

Gowanus Bay and Canal are located in New York Congressional Districts 11 – Major Owens (D) and 12 - Nydia Velasquez (D).

Figure 1 presents an aerial photo of Gowanus Bay and Canal and surrounding areas. All figures are presented in pages 41 – 44 at the end of this document.

1.4 Existing Water and Related Projects

Federal involvement in water and water related projects at the Gowanus Bay and Canal can be traced back to Section 2 of the River and Harbor Act of 1880, which authorized examination of navigation improvements at Gowanus Bay. The River and Harbor Act of 1881 authorized a channel 18 feet deep at mean low water from Gowanus Bay to the Hamilton Avenue drawbridge. The River and Harbor Act of 1896 authorized a 26-foot deep channel from the junction with the Red Hook channel to the foot of Percival Street. The most current authorization, which includes a 30-foot deep main channel (Red Hook channel to the foot of Percival Street), a 30-foot deep branch channel (towards the Henry Street Basin), and an 18-foot deep channel (from Percival Street to the Hamilton Avenue Bridge), is based on a Chief of Engineers Report to the Secretary of the Army, dated 19 September 1950.

In 1972, the New York District issued a report recommending that no improvements be made to the northern portion of the Gowanus Canal beyond the authorized federal channel due to insufficient economic interest. The report also cited that dredging for environmental purposes, which was an identified local interest, was beyond existing Corps authorization. In 1979 through 1981 the New York District conducted investigations concerning the deepening of the Federal channels in Gowanus Bay and found those improvements to be in the Federal interest based on estimated economic benefits. The deepening project was not constructed because suitable placement of the contaminated dredged material could not be resolved. The most recent maintenance dredging of the federal channels occurred in 1975.

Gowanus Bay and Canal are located within the Port District of New York and New Jersey. The Bay and Canal were identified as an ecosystem restoration opportunity site by the Hudson-Raritan Estuary Ecosystem Restoration Reconnaissance Study 905b Preliminary Analysis(July 2000). The feasibility analysis of ecosystem restoration in the Gowanus Bay and Canal is based on the recommendations and Project Management Plan developed during the reconnaissance study.

1.5 Report Organization

The Report is organized as follows: The next section presents a brief synopsis of studies and reports conducted prior to this feasibility study. These studies and reports include work conducted by the Corps and by others. Section 3 is a brief presentation of studies conducted for this feasibility study. Section 4 describes existing conditions in the Bay and Canal based on information contained in the studies and reports discussed in sections 2 and 3. Section 5 portrays future conditions in the study area as they are expected to be found without Corps participation in an ecosystem restoration project. Section 6 presents the problems and opportunities that have been identified by the feasibility study to-date and presents a preliminary assessment of restoration measures and alternative plans. The development of environmental benefit evaluation methods is discussed in Section 7 with references to other feasibility studies conducted by the Corps. Section 8 presents a brief discussion of the forthcoming technical investigations that will be conducted during the remainder of the feasibility study. Policy issues that have arisen during the course of the analysis are discussed in section 9. Section 10 presents a brief concluding statement. A Data Appendix is included that supports the statements made in the main text.

2 Prior Studies and Reports

2.1 Prior Studies by the Corps

U.S. Army Corps of Engineers, New York District, Section 905(b) Preliminary Analysis Expedited Reconnaissance Report, Hudson Raritan Estuary, Port of New York and New Jersey Environmental Restoration (July 2000). The reconnaissance study demonstrated that there is a Federal interest in ecosystem restoration and related water quality improvements within the New York and New Jersey Port District, which was identified as the surrounding greater metropolitan New York City region within an approximate 25-mile radius of the Statue of Liberty in the New York - New Jersey Harbor. The reconnaissance investigation identified 82 potential environmental restoration sites for inclusion in the reconnaissance analysis. This investigation was based on information gathered from meetings with numerous Federal and non-Federal agencies, the New York/New Jersey Harbor Estuary Program Habitat Workgroup, private organizations, individual citizens, and site visits. Gowanus Bay and Canal were included as one of the 82 sites identified in the expedited reconnaissance report.

U.S. Army Corps of Engineers, New York District, Gowanus Creek Channel Review of Reports (Survey), Technical Appendices (September 1981). This report contains the technical appendices from the feasibility study of potential deepening of the federal authorized channels. The feasibility study recommended deepening the federal channels to depths ranging from 32 to 35 feet mean low water. The recommended project was not constructed due to issues concerning placement of the contaminated dredged material. The analyses presented in this review of reports were conducted between 1978 and 1981. The eight technical appendices presented include 1) Problem Identification, 2) Plan Formulation, 3) Benefits and Costs, 4) Public Views and Responses, 5) Fish and Wildlife Coordination and sections from the Draft Environmental Impact Statement, 6) Cultural Resource Reconnaissance, 7) Bioassays, Grain Size Analysis, and Leachate Potential Test, and 8) Dredging Characteristics.

2.2 Prior Studies by Others

Gowanus Canal Community Development Corporation, Gowanus Canal Bulkhead Inventory. March 2000. This document presents the results of a visual survey of all the bulkheads along the Gowanus Canal. Data includes bulkhead type, typical construction methods, and existing structural condition.

Lawler, Matusky, and Skelly Engineers LLP and DMA, Inc., Data Quality Assessment of Biological Data Collected for the New York and New Jersey Harbor Navigation Study; General Comments and QA/QC of the 1998-99, 2000-01 and 2001-2002 Biological Data. April 2004. Biological and associated physiochemical data have been collected by Lawler, Matusky and Skelly Engineers LLP (LMS) in the New York and New Jersey Harbor area for the New York District US Army Corps of Engineers (USACE) since 1998 to characterize essential fish habitat and fish populations, as part of an ongoing harbor navigation project. Three distinct data sets have been compiled during the following sampling periods: 1) October 1998 through September 1999, 2) December 2000 through June 2001, and 3) December 2001 through July 2002. Data was collected at 20 to 30 different sampling stations, including areas adjacent to Gowanus Bay. The various sampling periods included environmental measurements (depth, bottom profiles, substrate composition, weather, and sea conditions), physiochemical parameters (dissolved oxygen (DO), conductivity, salinity, and temperature), and boat-based biological grab samples. Biological samples collected at some or all sampling stations included benthic macroinvertebrates, crab dredge, ichthyoplankton tow, and bottom trawling for fish.

The objective of the analysis was to compare and contrast the three data sets to examine demersal and pelagic fish spawning habits and periodicity, with special emphasis on winter flounder The analysis was also to assess the longer term relationships between the seasonal occurrence of adults and spawning/nursery habitat utilization (also with emphasis on winter flounder).

New York City Department of Environmental Protection (NYCDEP). Final Report on Water Quality and Biological Improvements after Reactivation of the Gowanus Canal Flushing Tunnel. Hazen and Sawyer, P.C., March, 2001. On 05 March 1999 NYCDEP reactivated the Gowanus Flushing Tunnel to improve canal water quality. Currently, water is pumped in one direction, from the Buttermilk Channel to the head of Gowanus Canal. As part of the NYSDEC permit requirements to reactivate the tunnel, NYCDEP monitored physio-chemical parameters and the biota in the Gowanus Canal after reactivation.

The monitoring program included:

- Monthly monitoring of the dissolved oxygen, temperature, and salinity at five sampling locations, four in the canal and one in at the Buttermilk Channel end of the tunnel between November 1998 and March 2000;
- Monthly sampling of benthic organisms at three locations in the canal and one station at the confluence of the canal with New York Harbor between May 1997 and February 2000;
- Sampling of nekton at the inlet to the Gowanus Flushing Tunnel and at the outlet into the Gowanus Canal; and
- Monitoring of flow velocity in the canal after reactivation of the tunnel.

<u>Dissolved Oxygen (DO)</u>

The study was limited to two samples collected prior to the pump start-up and 11 collected afterwards from one location in Buttermilk Channel and four locations in the upper one-quarter reach of Gowanus Channel (head of the Canal to the Third Street Bridge). There is only direct comparability for dissolved oxygen levels between November 1998 and November 1999. Inferential comparison can be made between the December 1998 and the January 2000 samples, suggesting that an approximately 5 parts per million (ppm) increase in dissolved oxygen was achieved by re-activation of the pump. The extended sampling demonstrates some comparability between conditions in Buttermilk Channel and the upper Gowanus and the well-understood inverse relationship through the year between declining DO concentrations and increasing water temperature, due to the physics of water phase change and biological and chemical oxygen demands. Buttermilk Channel DO measurements were consistently slightly higher than all canal stations, suggesting a greater oxygen demand with the Canal. The slightly higher temperatures in the Canal may explain some of this difference during mid to late summer. No conclusions can be drawn regarding the Flushing Tunnel effect on water quality in the portion of Gowanus Canal south of the 3rd Street Bridge.

Benthic Organisms

Benthic macroinvertebrate samples were collected using a 0.04-meter Ponar dredge at four locations in the Gowanus Canal between May 1997 (an isolated sample set) and February 2000. Monthly sampling began in March 1999. The stations are spaced between the head of the Canal and the mouth of the Bay. Samples collected at the head of the Canal and at the 4th Street Turning Basin are approximately coincident with the Canal DO sampling stations. The Hamilton Street Station represents the approximate southern reach of the Canal proper, but is approximately 2,500 feet downstream from the DO sampling stations. The sample at the mouth of the Bay represents conditions distinctly different from the Canal in depth, depositional environment, tidal connectivity and mixing, wind fetch, and distance from potential influence of the re-activated pump.

Benthic sampling stations at the head of the Canal and at the Fourth Street Turning Basin show general upward trends in numbers of organisms, numbers of species, and age of organisms throughout the sampling period. This suggests the occurrence of natural marine succession in recently disturbed sediments, rather than repeated annual recolonization. The study implies a causal relationship with increased DO levels and the improvement in benthic population characteristics.

Nekton/Plankton

Nekton/Plankton samples were collected at two locations (in the Buttermilk Channel and the Gowanus Canal adjacent to where the pump water enters the canal) using a 12-inch ring net, once in May 1997 and in May 1999 (after pump re-activation). Significant increases were measured in the post re-activation sample for numbers of species, numbers of organisms and numbers of life-forms in the Canal. The 199 samples further demonstrated a strong similarity in the population factors between Buttermilk Channel and Gowanus Canal, suggesting recruitment via the flushing tunnel. The data do not assess the effects of pump reactivation on nekton and plankton throughout the Canal, since there is no assessment of water movement relative to tidal or pump influences.

New York City Department of Environmental Protection (NYCDEP). Preliminary Report on the New York Harbor Water Quality Regional Summary. 2001 The preliminary report contains a fish community survey that included portions of Gowanus Bay and Canal. The focus of the survey was to identify the fish populations present and assess their abundance, by trawling and by hydro acoustic surveys. Most of the survey data reported in the preliminary report focused on Gowanus Bay and Red Hook Channel. Within the channel, fish were observed and recorded by eco sounder. In August and September, many fish were seen at, or near the water surface, all through the Canal. In shallow reaches of the Canal, schools of hundreds of small fish were observed swimming below the surface. Large adult blue crabs were also common in the Canal. The report has not been finalized.

National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. 1996 - present. Benthic Habitats of New York/New Jersey Harbor. Published On-Line. The objective of this study was to map benthic (bottom) habitats in New York/New Jersey Harbor in a geographic information system (GIS) using sediment profiling imagery (SPI). The maps developed in this study identify benthic habitat types and their distribution, and are used to document habitat variability. The use of GIS provides the spatial context needed to evaluate biological resource distributions for management and restoration planning.

In October 1994, the US Army Corps of Engineers began collecting data using traditional benthic sampling methods and SPI. The National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center is working with USACE's NY District managers to evaluate these data and develop habitat maps for restoration planning. The maps are being developed to provide spatial information that would be used in the identification of the types of habitat needed in the harbor to promote fish and wildlife populations, locations where those habitats can be created or enhanced, and the information needed to evaluate and prioritize specific restoration and enhancement opportunities.

Results are published on-line at http://www.csc.noaa.gov, and provide a thorough review of the work completed. The data collected was limited to the Upper New York Bay and did not include sample points in the Gowanus Canal. Some samples were collected in the Gowanus Bay and may be useful reference points.

3 Feasibility Study Technical Reports

This section provides a listing and brief review of technical studies that have been conducted for this feasibility analysis. These studies include work conducted by NYCDEP that is also being used for the Use and Standards Attainment Project (USA). The USA project seeks to define, through a public process, more specific and comprehensive beneficial use goals for bodies of water. It also seeks support for prioritization of certain projects and the scientific basis to support the regulatory process. The information developed in these technical studies combined with information from prior studies formed the body of knowledge used to identify problems and opportunities and potential restoration measures for the Gowanus Bay and Canal. The Data Appendix contains a more detailed account of each study.

<u>Literature Searches</u>

Battelle Memorial Institute, Summary of Data Gaps. February 2003.
The purpose of this investigation was to present a summary of existing data gaps concerning baseline quality of water, sediments, and habitats in the project area. The major finding of the report is that the absence of spatially or temporally co-located sediment and biological data makes it difficult to draw quantitative causal relationships between elevated sediment concentrations and observed degradation in the aquatic community.

Battelle Memorial Institute, Review of Existing Data. December 2002.
The results of this investigation indicate that a limited amount of chemical and physical data is currently available. Specifically, eleven reports were identified with relevant sampling data collected from within the Gowanus Canal or Bay. Of these reports, six have data pertaining to sediment and soil chemistry, six describe water quality/chemistry, and five summarize biological data. The majority of the data identified was associated with investigations conducted by NYCDEP or USACE.

DMA Inc., Natural Resource Literature Search. September 2002.
The purpose of the natural resource literature search was to identify and collect existing data that will be used for the Gowanus Bay and Canal Study. During the search process data quality and type were assessed in order to develop an understanding of existing studies that would be useful in determining baseline conditions and to identify data gaps that will be the focus of future data gathering efforts.

<u>Water Quality</u>

New York City Department of Environmental Protection, Use and Standards Attainment Project, Combined Sewer and Stormwater Outfall Summary for Gowanus Bay and Canal, Unpublished, 29 Jun 04. This two page document presents the physical characteristics of the outfalls in and around the study area, including outfall location and drainage area serviced.

New York City Department of Environmental Protection, Use and Standards Attainment Project, Gowanus Canal Waterbody/Watershed Assessment and Preliminary Facility Plan, Power Point slide presentation to the Gowanus Canal Waterbody/Watershed Stakeholder Team, Meeting No. 5, 20 April 2004. The presentation identifies existing and projected water quality in the Gowanus Canal. The presentation also identifies NYCDEP's plan formulation process in the identification of proposed modifications to the Gowanus Pump Station facility.

New York City Department of Environmental Protection, Use and Standards Attainment Project, Combined Gowanus Canal receiving water Model, 14 April 04. Published on-

line at *www.hydroqual.com.* This three page document describes the three dimensional, time-variable coupled hydrodynamic/water quality model of the Gowanus Canal.

Bathymetry

NY District USACE, June 2003. Bathymetric data was collected for the Gowanus Canal during June 2003 by CR Environmental, Inc of Falmouth, MA under a contract with the NY District USACE, using a boat mounted 200 kHz Echo-sounding fathometer. Horizontal position was ascertained using DGPS and projected to New York State Plane, NAD 1983, feet. Tidal correction relied on three vertical benchmarks established at Columbia Street pier, 537 Smith Street and the Carroll Street Bridge. The vertical datum used is NGVD 1929, mean lower water.

Sediment Characteristics

Baltimore District USACE, Site Investigation Gowanus Bay and Gowanus Canal, Kings County, NY. September 2003. Sediment cores were collected at 36 locations in Gowanus Bay and Canal during March 2003 by the Baltimore District USACE. An additional sample was taken at two of the 36 locations for quality control purposes. Samples were selected from 30 of these cores and submitted for laboratory analysis for various physical characteristics, bacterial colony analysis, and chemical constituent group analyses.

AMEC Earth and Environmental, Inc and Northern Ecological Associates, Inc., Sediment Quality Evaluation Report Gowanus Bay and Canal Ecological Restoration Project. August 2004. The sediment characteristics data collected by the Baltimore District's sampling effort was evaluated and used to develop a hazard score for each sampling location. The hazard score was alternatively based on comparison with published threshold toxicity values for various toxicants and the magnitude of threshold exceedance, tempered by professional opinion. The hazard score, however, did not account for vertical distribution of contaminants (samples ranged from 2.5 feet to 30 feet below the sediment surface).

Environmental Site Assessment

NY District USACE, Final Phase I Upland Site Assessment. July 2004 Prior to implementing any remedial, water quality, and/or environmental restoration activities, the USACE-NYD is required to prepare a Phase I Environmental Site Assessment (ESA) of the Gowanus Canal, Channel, Bay, and surrounding upland areas. The ESA was conducted in accordance with provisions of the National Environmental Policy (NEPA) that require Federal agencies to identify environmental consequences resulting from Federal actions. The USACE-NYD, under an existing inter-agency agreement with the USEPA, Region 2, has prepared an ESA for the upland portions and properties immediately surrounding/adjacent to the Gowanus Bay and Canal watershed.

<u>Biological Assessments</u>

NY District USACE, Gowanus Canal Benthic Sampling Data Documentation. August 2003. Benthic macroinvertebrate samples were collected at 29 sites during April 29 and 30, 2003. Samples were obtained using a petite ponar dredge, which collects substrate materials to a depth of one to six inches, depending on the texture and structure of the material. Samples were analyzed by the Huntsman Marine Science Center, Brunswick Canada. Limited water quality sampling (DO, temperature, salinity) was also conducted.

Lawler, Matusky, and Skelly Engineers LLP, Gowanus Bay and Canal Fish and Epibenthic Sampling. Final Revised Report December 2004.
Gowanus Bay and Canal aquatic biological data were collected over four sampling periods from October 2003 to June 2004. Data collected included adult fish, ichthyoplankton, crab and epibenthic invertebrate communities, and water quality parameters. Limited water quality sampling (DO, temperature, salinity) was also conducted.

NY District USACE, Final Wetland Creation General Investigation Report. May 2004.
The stated goal of the report is to present a feasibility level review of the potential for creating wetlands in the Gowanus Canal. Fifteen potential wetland creation sites are identified and described, and the characteristics of each potential conceptual design are described as it pertains to each site.

DMA, Inc., Terrestrial Flora and Fauna Characterization. October 2004 Terrestrial and avian fauna were assessed during four brief site visits conducted between October 2003 and September 2004. A modified point-count method was used tallying all birds and mammals observed along the Gowanus Canal as viewed from the water. All vascular plant species encountered were identified and their relative importance within the project area was estimated during each observation using weighted averages of ratings for Dominance, Life Form, Nativity and Wetland Status.

<u>Cultural Resources</u>

Hunter Research, Inc, Raber Associates, Northern Ecological Associates, Inc.: National Register of Historic Places Eligibility and Cultural Resources Assessment for the Gowanus Canal, Borough of Brooklyn, Kings County, New York in Connection with the Proposed Ecosystem Restoration Study. December 2004. This study provided a historic overview of the Gowanus Canal area but concentrated on the construction of the canal and associated structures such as bridges and basins. It was determined that the entire canal and all basins, pump house and flushing tunnel as well as a number of other structures associated with canal industries comprise a National Register of Historic Places eligible district. The New York State Historic Preservation Office and New York City Landmarks Preservation Commission concur with this evaluation.

4 Existing Conditions

This section presents the results of preliminary evaluations of existing physical, chemical, and biological characteristics of Gowanus Bay and Canal. Some additional investigations will be conducted to more fully characterize existing conditions as required for feasibility level assessment of restoration alternatives.

4.1 Bathymetry

Figure 2 shows the maximum extent of usable topographic coverage that could be generated from the bathymetry data. Full coverage is available for the extent of the Canal and for nearly all of the Bay. Approximately 15 percent of the project area along the southern portion of the Bay is outside the present dataset, including the Henry Street Basin, which is an active commercial shipping channel.

4.2 Existing Water Quality

The NYSDEC has designated the Gowanus Canal with use classification SD (severely degraded), which is the most restrictive New York State Saline Surface Water Standard use classification. Water bodies with use classification SD are not suitable for primary or secondary contact recreation (due to total coliform levels) or fish propagation (due to low levels of dissolved oxygen). SD designated waters are expected, at best, to only support fish survival. Based on data collected for the NYCDEP's Use Standard Attainment (USA) Project, the Gowanus Canal above Hamilton Avenue does not meet the SD designation's minimum (never below) dissolved oxygen standard of 3.0 mg/L. Gowanus Bay, which NYSDEC includes as a part of the Upper Bay for use classification purposes, has a designated use classification I, which is one level less restrictive than the SD classification. Use designation I indicates the water body can support fish survival and propagation, and is suitable for secondary contact recreation.

Table 1 below, based on NYCDEP's USA project data, presents NYSDEC's categorization of water quality in the Gowanus Canal. Categorizations include the New York State Saline Surface Water Standard use classification, the New York State Clean Water Act 303(d) list of impacted water bodies, and the New York State waterbody inventory/priority waterbody list (WI/WPL) that the state uses to prioritize water quality problems.

Table 1: Gowanus Canal Water Quality Regulatory Designations, Uses, and Restrictions

Designated Use Class SD – Fish Survival	
Dissolved Oxygen Never less than 3.0 mg/l	Not currently attained
Coliform Bacteria	No Standards Identified
New York State 303(d) List 2004	
Use Affected	Fish Propagation
Pollutant	Oxygen Demand
Sources	Urban Runoff, CSO, Storm water
Action Plan	Scheduled for TMDL (DO)
Waterbody Inventory/Priority Waterbody List (2002)	
Use Impairment	Aquatic Life, Recreation, Aesthetics
Severity	Aquatic Life Precluded Recreation Impaired Aesthetics Stressed
Pollutants	Oxygen Demand, Pathogens, Floatables, Odors, Oil and Grease, Nutrients
Sources	CSOs, sediment, urban runoff, stormwater, industrial discharge

Source: NYCDEP

Limited water quality sampling was also conducted during aquatic biological sampling events. Sampling did not take place during the late summer, which is typically the season with the lowest DO. Dissolved oxygen concentration in water is largely dependent on water temperature, and to a lesser degree, salinity. As water temperature increases, the amount of oxygen capable of being held in solution decreases. Similarly, as salinity increases, the amount of oxygen that can be held in solution decreases. Trends in dissolved oxygen levels were similar across various locations in the Bay and Canal, remaining between 4 mg/L and 10 mg/L. As a reference, dissolved oxygen in New York Harbor typically ranges between 6 mg/L and 12 mg/L during the same period.

Water quality in the Gowanus Canal and, to some unknown extent Gowanus Bay, is periodically impacted by combined sewer outfall (CSO) releases that occur during storm events. Table 2 below presents the existing conditions annual CSO release volumes and frequency of release for the CSO outfalls in the Gowanus Canal.

Table 2: CSO Existing Conditions Average Discharge Characteristics for an Average Year (million gallons)

Location/ID	Overflow Volume	Overflow Frequency	Average Volume per Event
Gowanus Pumping Station	188.4	53	3.56
Second Avenue Pumping Station	75.8	47	1.61
19th Street and 3rd Avenue	14.6	30	0.49
Outfall RH 031	7.7	11	0.70
Outfall 035	2.1	8.0	0.26
R 22	1.6	19	0.08
Carroll Street and 3rd Avenue	1.0	5.0	0.20
R 24	0.9	13	0.07
R 23	0.5	13	0.04
R25	0.2	8.0	0.03
Totals	292.8	207	-

Source: NYCDEP

4.3 Existing Sediment Quality

4.3.1 Sampling Method

A preliminary sediment sampling and analysis program was conducted to initiate a characterization of Bay and Canal sediments and to support the design of future sediment contamination investigations. Thirty-eight sediment sampling locations were identified in Gowanus Bay and Canal. Sampling was conducted during March 2003 (USACE Baltimore 2003). Samples were selected from 30 locations and submitted for laboratory analysis for various physical characteristics, bacterial colony analysis, and chemical constituent group analyses. Sediment cores were collected to a maximum depth of about 30 feet below the present bottom depth. A total of 616 linear feet of sample cores were collected. From this, there were 305 samples shipped for laboratory analysis. There were 202 chemical samples analyzed and the data reported. Chemical analyses for constituent groups included volatile organics, semi-volatile organics, priority metals, poly-chlorinated biphenyl (PCB), pesticides and total petroleum hydrocarbons (TPH).

The sediment data provides a thorough geomorphologic characterization of the various conditions found below the substrate in the Bay and Canal. The sediment data describes the physical, historical, and geomorphic setting of the Bay and Canal. In addition, the sediment data provides a preliminary characterization of location and concentration of contaminants within the sediments.

4.3.2 Sediment Characteristics

The substrate of the Bay and Canal are composed of interbedded sand and clay members. The upper reaches of the Canal tend to have the finest grain-size and least consolidated sediments. With the exception of a few areas within the canal, the bottom of the Gowanus Canal is typically covered with a layer of very wet, very soft, dark gray to black, highly plastic clay, often with a trace of sand and some occasional gravel. The clay typically has a decaying organic type odor associated with it. A weak hydrocarbon-type sheen is visually evident in some samples. The clay layer may not occur in several areas of the Canal. Notably, this clay layer is absent on the South side of the Canal near 20th Street; within and near the 6th Street basin; and near the Carroll Street Bridge. Sands and gravels were typically encountered at the channel bottom in these areas. Beneath the soft, high plastic clay layer there are sands, silty sands, and poorly graded sands, often with traces of gravel. These sands are dark gray to brown in color and also exhibit a slight hydrocarbon sheen.

The chemical constituency of the sediments was evaluated and used to derive hazard scores for each sampling location. The hazard scores were based on comparison with published threshold toxicity values for various toxicants, the magnitude of threshold exceedance, and background conditions identified in the literature. The hazard scores provide a preliminary combined affects assessment of the contamination dataset. The index approach allows for comparison among the various sample locations and provides for a preliminary characterization of contamination throughout the Bay and Canal. These hazard scores do not attempt to express ecological risk or toxicological effect and do not account for depth variation in the samples.

Figure 3 presents an interpolated distribution of hazard scores throughout the Bay and Canal. The hazard scores represent the cumulative characteristics of sediments from 2.5 feet to 30 feet below the bay and canal bottom. A comparison between the hazard score distribution and the bathymetric data (Figure 2) indicates a general correlation between bottom elevation and hazard score; both the bottom and the hazard score seem to rise together in the shallow upper part of the Canal and they diverge in the deeper Bay. An exception to this general correlation is the presence of a deep hole in the mid-Bay that has a relatively high hazard score. It appears that accumulations of sediment in the upper Canal are more highly contaminated and that highly contaminated sediments had also collected in the deepest hole in the Bay. This preliminary observation cannot be definitively validated by the existing dataset because the hazard scores did not account for depth of sample, however, it provides a starting point for a characterization focused on the relationship between sediment contamination and habitat quality.

4.4 Existing Habitats

4.4.1 Terrestrial Flora

Vegetation was assessed during four site visits conducted between 30 October 2003 and 11 September 2004. As expected at this highly urbanized location, vegetated areas are very limited along the canal edge and also within 200 feet of the canal. The vegetation found in these few areas is of ruderal type, *i.e.*, plants that colonize disturbed sites. There were 88 species identified making up the plant community adjacent to the Gowanus Canal during the site surveys. The observed community is very low in diversity and strongly dominated by five species: Tree-of-Heaven, Virginia Creeper, Boston Ivy, Annual Wormwood and Wild Black Cherry. Only three species that strongly indicate the presence of a wetland community, *Spartina patens, Spartina alternifolia,* and *Atriplex patula* were found along the Canal but their occurrence was exceedingly rare. Although a few stems of *Spartina* species were found sprouting from bulkhead crevices near water level in the Canal and in riprap along Gowanus Bay, there were no vegetated wetland communities identified in the study area. While no vegetated wetlands exist, NYSDEC may consider portions of shoals or mudflats "wetlands" for jurisdictional purposes.

A weighted community characterization was conducted using weighted averages of Life Form, Nativity, and Wetland Status ratings (Table 3 below). This type of characterization is often employed in describing tidal and freshwater wetland communities (see Data Appendix for numerical designations and calculations).

Table 3: Existing Conditions Weighted Community Characterization

Category	Rating	Discussion
Life Form	3.16 – 4.40	Dominant Life forms are tall herbs and vines
Nativity	2.92 – 2.99	Community dominated by native weeds and non-native hybrid plant species
Wetland Status	3.97 – 4.02	Non-wetland community dominated by species that occur in wetlands at frequencies less than 33%

The community characteristics identified in Table 3 above are indicative of a frequently disturbed, highly stressed plant community. Normal or restored communities occurring elsewhere in the bio-geographic region, such as Riparian Forest, High Salt Marsh, and Back Dune, might have the characteristics described in Table 4 below. The comparison is one way to get a sense of the magnitude of disturbances to biotic communities within the study area. For example, a natural or restored community would have a relatively high Nativity Rating (5 in this example), but the observed Nativity Rating is less than 3, indicating the dominance of non-native species. Similarly, the Wetland Status of a natural or restored High Marsh community would be rated between 1 and 2, but the existing community is rated at approximately 4.

Table 4: Normal or Restored Weighted Community Characterization

Community	Life Form	Nativity	Wetland Status
Riparian Forest	5.5 - 6	5	4 - 5
High Salt Marsh	1 - 3	5	1 - 2
Back Dune	4 - 5	5	3 - 6

4.4.2 Terrestrial and Avian Fauna

As defined within the Ecological Communities of New York State (Reschke, 1990), the aquatic and adjacent terrestrial habitat at the Gowanus Canal is marine and terrestrial cultural (the term cultural referring to extensive human influence). Both the marine and terrestrial cultural communities are typically "created and maintained by human influence to such a degree that the physical conformation of the substrate, or the biological composition of the resident community is substantially different from the character of the substrate or community as it existed prior to human influence." The shore of much of Gowanus Bay and Canal is characterized as marine rip-rap/artificial shore where the "community of a constructed marine shore in which the substrate is composed of broken rocks, stones, wooden bulkheads or concrete placed so as to reduce erosion (Reschke, 1990).

The adjacent uplands are urban vacant lots and urban structure exteriors. The urban vacant lot is "an open site in a developed, urban area that has been cleared either for construction or following the demolition of a building" (Reschke, 1990). Nooks and crannies in the structures may provide nesting habitat for birds and insects as well as roosting sites for bats. Birds characteristically found in urban vacant lots and urban structure exteriors include common nighthawk on rooftops, American robin, rock dove, and house sparrow. Threatened or Endangered species are not known to frequent the Gowanus Canal.

Terrestrial and avian fauna was assessed during four site visits conducted between October 2003 and September 2004. A modified point-count method was used tallying all birds and mammals observed along the Gowanus Canal and Gowanus Bay shoreline as viewed from the water. This method provides a qualitative indication of the diversity of species utilizing a habitat as well as the relative abundance. In all, 20 bird species, two mammalian species (domestic cat and Norway rat), and no reptiles or amphibians were observed. A full species list is presented in the Data Appendix.

The steep-sided bulkheads of the canal leave almost no edge habitat for wading birds to forage within the Gowanus Canal. A black-crowned night heron was observed foraging beneath a building structure on the west shore of the Gowanus Bay, but not within the Canal itself. The Canal itself only provides useful foraging to birds that feed in the open water. The double-crested cormorants and belted kingfishers observed feeding within the Canal give evidence that there are adequate fish numbers to provide a limited number of birds forage. Waterfowl (e.g., Atlantic brant, black duck) were observed resting and foraging in the Gowanus Bay and would be common there during migration.

4.4.3 Fish and Epibenthic Invertebrates

Gowanus Bay and Canal aquatic biological data were collected over four sampling periods from October 2003 to June 2004. Sampling was conducted in five general sample reaches from Gowanus Bay to the eastern terminus of Gowanus Canal. Sample reaches were selected to provide data on the aquatic community over the entire spatial extent of the Gowanus Bay and Canal.

Sampling locations were selected to overlap with sediment quality samples collected during summer 2003. Within the Canal, data were collected on finfish, crab and benthic invertebrate communities, and water quality parameters. Additionally, ichthyoplankton (i.e., fish eggs and larvae) throughout the Bay and Canal and finfish within the Bay were sampled with active gears, towed for a distance and not fixed to one location. The full report, including methods descriptions, all data, data analyses, tables, graphs, charts and maps, are presented in Attachment: Fish and Epibenthic Invertebrate Sampling Program, Revised Final Report December 2004.

Fish Community

Over the years organic matter has accumulated and has contributed to low dissolved oxygen (DO) concentrations in the Bay and Canal (Hazen and Sawyer 2001). To improve water quality the Gowanus Flushing Tunnel was re-activated in 1999 to pump water into the Canal from Buttermilk Channel. The input of "new" water has increased DO concentrations in the Canal, although not to levels typically found in other areas of New York / New Jersey Harbor (see discussion in section 4.2 Existing Water Quality).

The fish composition in Gowanus Bay and Canal is dominated by migratory species common in the New York / New Jersey Harbor and estuaries of the Middle Atlantic Bight. Few resident species (e.g., cunner and tautog) were collected in the Gowanus Bay or Canal as adults or in early life stage, suggesting that the study area lacks habitat necessary to support a resident fish community. Urbanization in the Bay and Canal has virtually eliminated the physical habitat typical of natural tidal creeks (e.g. undercut banks, flooded vegetation, in-stream structure). The degraded habitat conditions (biotic and abiotic) in the Bay and Canal may be limiting the potential for a resident fish community.

Because the physical habitat conditions in Gowanus Bay and Canal are less important to migratory species, their presence is most likely linked to the periodic occurrence of suitable water quality conditions. The migratory species occurrence observed during the surveys corresponded to periods of peak abundance for many of these species in the Harbor (USACE 2003). For example, striped bass, the most common species collected during the adult fish surveys, was caught in every reach of the Bay and Canal, but only during the October and December surveys. Striped bass is also one of the dominant species collected during adult fish surveys conducted elsewhere in the Harbor during October and December (USACE 2003).

Poor water quality (e.g., low dissolved oxygen, high temperatures) frequently present abiotic barriers to the establishment of a resident fish community. Although dissolved oxygen levels are typically high in estuaries, dissolved oxygen levels are often reduced in areas with high inputs of organic material (Moyle and Cech 1988). In Gowanus Canal, dissolved oxygen concentrations have been observed below 3.0 mg/L (the NYSDEC dissolved oxygen standard) during August (Hazen and Sawyer 2001). These low concentrations are thought to result from increased water temperature and oxygen demand in the Canal (Hazen and Sawyer 2001). Extended periods of reduced dissolved oxygen are lethal for some species while others will migrate from areas during periods of low dissolved oxygen (Moyle and Cech 1988).

The results of the ichthyoplankton sampling suggest that little significant fish spawning occurs in Gowanus Canal, but that some spawning may occur in Gowanus Bay. The few eggs collected in the Canal (especially in the upper reaches) were dominated by pelagic species that spawn within the water column that could have drifted in from other areas.

These results suggest that ichthyoplankton may be drawn into the Gowanus Canal from Buttermilk Channel through the Gowanus Flushing Tunnel or drift in from the Gowanus Bay via the incoming tide.

Winter flounder is an important recreational and commercial species that is common as adults and early life stages throughout the Harbor. Winter flounder eggs have been collected in areas adjacent to Gowanus Bay during other sampling programs (USACE 2003). No winter flounder eggs were collected in Gowanus Bay or Canal during this investigation. Because winter flounder have demersal, adhesive eggs that are believed to be hatched in close proximity to where they were spawned, these results suggest that spawning does not occur in the Canal. Winter flounder were collected as post yolk-sac larvae at the upper reach of the Canal. Because winter flounder larvae have limited swimming ability, i.e., they mostly rely on tidal currents for movement (Able and Fahay 1998), is not clear if the hydrodynamics of the Canal are such that winter flounder ichthyoplankton could be transported from the Bay into the Canal. The relatively high winter flounder larval densities in the upper reach of the Canal during March compared to the other reaches further supports that ichthyoplankton may be transported into the Canal via the Gowanus Flushing Tunnel. This finding is consistent with findings by Hazen and Sawyer, 2001, for nekton and plankton near the tunnel outlet.

Invertebrate Community

The invertebrate species collected in the Gowanus Bay and Canal are common throughout the New York / New Jersey Harbor because the Harbor is the source population for species recruitment to Gowanus Canal through the Flushing Tunnel and tidal exchange (Hazen and Sawyer 2001). The species collected were primarily fouling organisms that colonize hard substrates. Species abundances were low compared to a typical epibenthic community in New York / New Jersey Harbor (USACE 1999, Woodhead *et al.* 1999). There was also an abundance of opportunistic and pollution tolerant species that inhabit disturbed habitats. Opportunistic species are typically found in poor environmental conditions because they are able to colonize an area rapidly once conditions start to improve.

Benthic and epibenthic invertebrates living in Gowanus Bay and Canal are influenced by water flow at all stages in their life cycle. The hydrodynamic processes (tides, currents and the pumping in of new water via the Gowanus Flushing Tunnel) influence faunal assemblages and the feeding mode of invertebrates (Eckman, 1983). Growth and feeding efficiency of suspension feeders is related to local water exchange rates. Rates of flow affect the amount of seston (suspended food particles such as nekton and plankton) that passes an organism, as well as the time the suspension feeder has to intercept the food (Muschenheim 1987). In turn the quantity and quality of seston influences the rate of growth for suspension feeders.

Polychaetes and amphipods dominated the benthic community and were collected at all sampling sites. Polychaetes are commonly used as bioindicators because they are in direct contact with the sediment and exhibit sensitivity to anthropogenic compounds. *Capitella spp*. and *Streblospio benedicti*, which made up a relatively small component of the invertebrate collections, have been identified as environmental indicator species because they are often found in sediments associated with high organic matter, petroleum, sewage, and low oxygen levels. *Streblospio benedicti* are commonly found in silty sediments and are the most abundant and ubiquitous invertebrate species throughout the Harbor. *Streblospio benedicti* is also an important food source for winter flounder and spot (also known as croaker). *Capitella spp.* is often one of the first groups to colonize areas impacted by dredging or oil spills (Llanso 1991, NOAA 2003). The presence of *Eumida sanquinea* on the settling plates was expected because it is a known epibenthic predator (Pettibone 1983).

Amphipods were present in all five sampling reaches. Amphipod specie richness and densities varied with the seasons and location within the Bay and Canal. Amphipod densities were low in the Canal during the winter and spring. Also, amphipods were not found in the interstitial areas between plates that were located in Gowanus Bay in the winter and spring. In the summer, amphipod abundances increased in both the Bayand Canal. In the winter there were only three taxa of amphipods present compared the eight taxa collected during the spring. *Leptocheirus pinguis, Unciola sp., Corophium sp.* and *Gammarus spp.* amphipods feed on detritus and are found in muddy and sandy substrates. The absence of the amphipod *Ampelesca abdita* is an environmental indicator because this species has limited mobility, is susceptible to pollution, particularly petroleum compounds, and typically is not found in highly polluted sediments (NOAA 2003).

The taxa of polychaetes and amphipods found in the sediments will be considered in the determination of which species to use for future toxicity testing, which will be a significant part of the habitat evaluation method. It is important to note, however, that toxicity studies typically use surrogate species with some or many metabolic characteristics similar to actual species that may occur at a contaminated site.

The most abundant crab species collected during this investigation was the Pacific shore crab, *Hemigrapsus sanguineus*, predominately located in the Canal. The Pacific shore crab is successful in the Canal because it is an opportunistic omnivore that inhabits shallow hard-bottom intertidal habitats or sometimes subtidal habitat. This species can tolerate wide ranges of salinity and temperature. Pacific shore crabs reproduce prolifically with a breeding season from May to September, twice the length of native crabs. The larvae are suspended in the water for approximately one month before developing into juvenile crabs allowing the larvae to travel great distances (McDermott 1998). Because the Pacific shore crab is an invasive species, it competes for the same food source and habitat as indigenous populations, and may impinge on the native populations of mud crabs. The Pacific shore crab may also compete with larger species, like the blue crab, rock crab, lobster, and the non-native green crab. Recent trends show numbers of the Pacific shore crab are steadily increasing while native crab populations are declining (USGS 2002).

Few green crabs were collected during the sampling program. European green crabs are found in a variety of habitats, including protected rocky shores, cobble beaches, sandflats, and tidal marshes. They can also tolerate wide ranges of salinities (4-54 ppt) and temperatures (0-33 °C). The feeding activity of the European green crab greatly impacts populations of mussels (*Mytilus* spp.), dogwhelks (*Nucella lapillus*), and quahogs (*Mercenaria mercenaria*) (Hughes and Hughes 1984).

The epibenthic community living in Gowanus Canal is stressed. Overall, the Gowanus Canal site is low in community complexity and diversity when compared to an established epibenthic community found living on hard surfaces in the East River. During the East River Landing studies (1986-87), settlement plates were used to measure the colonization of epibenthic organisms off of South Manhattan and North Brooklyn piers. The colonization plates were retrieved over one year, for measurement of the extent of attachment and growth of epifauna. The highest densities occurred in August, after a full year of exposure; mean densities were about 82,000 organisms per m^2. A total of 40 taxa were reported although an average number of 14 species were measured per plate. Test surfaces were dominated by the amphipods *Microdeutopus gryllotalpa*, *Jassa sp.*, and *Corophium* sp. *Polydora sp.* was the most common polychaete (EEA 1989).

Gowanus Canal has undergone many transformations and epibenthic and benthic communities do not resemble those found at a typical natural tidal creek. However, the Canal is home to developing epibenthic and benthic communities. The majority of invertebrate species found living in the Canal are tolerant of extreme changes in dissolved oxygen, salinity and temperature. Many of the species present are opportunistic, but their occurrence was in relatively lower abundances than would typically be found at sites suffering environmental degradation only. If environmental conditions continue to improve in the Canal, these opportunistic species may be replaced by other less pollution tolerant species that compete for space and food (Hazen and Sawyer 2001).

Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected at 29 sites during April 29 and 30, 2003. Some sample locations were similar to sample locations used for sediment sampling. Samples were obtained using a petite ponar dredge, which collects substrate materials to a depth of one to six inches, depending on the texture and structure of the material. For each sample location, two samples were submitted for analysis. Samples were analyzed by the Huntsman Marine Science Center, Brunswick Canada, which counted specimens and identified taxa to the lowest possible identification level (LPIL). The analytical results for total specimens from each sampling location were averaged to represent average abundance at that location. Total average abundance for all sampling locations was 3,887 specimens. Thirty-seven different forms were found.

As indicated in Table 5 below, five dominant forms account for more than 93% of the identifications. The data presented in Table 5 indicate that community composition is very low in species diversity, suggesting that the local environment is stressed. The dominant species are known to be highly tolerant of both substrate disturbance and physiochemical stressors (see the Marine Biological Association website, `www.marlin.ac.uk`, for discussion and extensive references). Extensive urbanization and development have stressed the local ecosystem. In summary, the existing conditions describe an aquatic and terrestrial ecosystem that is impaired degraded. .

Table 5: Benthic Macroinvertebrate Occurrence and Abundance

Species	Average Count	Total* Occurrence	Greatest Abundance & location		Relative Importance	Cumulative Importance
Nematoda (LPIL)	2,631	25	1,137	19	67.7%	67.7%
Annedlida: Oligochaeta (LPIL)	384	25	130	19	9.9%	77.6%
Capitella Capitata	386	13	145	29	9.9%	87.5%
Streblospio benedicti	117	12	32	31	3.0%	90.5%
Mediomastus (LPIL)	99	11	24	4	2.5%	93.1%
Leitoscoloplos robustus	69	11	19	31	1.8%	94.8%
Corophium insidiosum	56	9	25	29	1.4%	96.3%
Eteone heteropoda	24	8	14	33	0.6%	96.9%
Mytilus edulis	25	6	11	4	0.6%	97.5%
Polydora cornuta	20	10	9	32	0.5%	98.0%
Jassa marmorata	12	1	12	29	0.3%	98.4%
Caulliriella (LPIL)	10	7	4	4	0.3%	98.6%
Other	54	14	3	31	1.4%	100%
Total	3,887				100%	

*Total sampling locations = 29

5 Without-Project Future Conditions

Overall, the existing mix of industrial, commercial, and municipal uses of the Bay and Canal, with additional residential use in the surrounding uplands, is expected to continue into the foreseeable future. There is no indication of any future changes to commercial navigation in the channel nor are there any indications of major land use changes in the surrounding uplands. Only a few expected or planned changes that will occur in the near future have been identified, including:

- Contaminated material clean-up at the Keyspan site (The cleanup proposal for this site is not yet available and how this may affect ecosystem restoration in the Canal remains unknown.);
- Development of a metal, glass, and plastic recycling facility at the 30th Street Pier in Gowanus Bay (the facility would be also be a truck-barge transfer station); and
- Implementation of NYCDEP's CSO abatement program including facility upgrades at the Gowanus pumping station, improvements to the Buttermilk Channel flushing tunnel operations, and reductions in CSO volumes (see section 5.1 below).
- Local Development Groups have started to develop plans for redevelopment, potential rezoning, and/or parks and open space.

5.1 Without-Project Water Quality

In October 2004, NYCDEP negotiated a consent order with NYSDEC concerning implementation of NYCDEP's CSO abatement program and violations of State Pollution Discharge Elimination System permits. Consistent with that consent order, NYCDEP has developed a Preliminary Waterbody/Watershed Facility Plan which includes:

- Gowanus Pump Station Reconstruction;
- Modernization of the Gowanus Canal Flushing Tunnel (increase average flow rate to 154 million gallons per day);
- Sewer Cleaning and Repair;
- Regulator Weir Adjustments;
- Rehabilitation and Reconstruction of the Second Avenue Pump Station Outfall;
- Periodic Floatables Skimming; and
- Remedial Dredging (a with-project condition).

Table 6 presents the projected volume and frequency of CSO discharges after implementation of NYCDEP's CSO abatement program.

Table 6: Projected Post-CSO Abatement Program Average Discharge Characteristics for an Average Year (million gallons)

Location/ID	Overflow Volume	Overflow Frequency	Average Volume per Event
Gowanus Pumping Station	109.8	43	2.55
Second Avenue Pumping Station	75.8	47	1.61
19th Street and 3rd Avenue	14.6	30	.49
Outfall RH 031	8.5	11	.77
Outfall 035	2.3	10	.23
R 22	1.6	19	.08
Carroll Street and 3rd Avenue	1.0	5	.20
R 24	1.0	13	.08
R 23	0.5	13	.04
R25	0.2	8	.03
Totals	215.3	199	-

Source: NYCDEP

NYCDEP water quality modeling predicts that implementation of the Preliminary Waterbody/Watershed Facility Plan, which includes Federal participation dredging to six feet below mean low water throughout the Gowanus Canal, will improve dissolved oxygen levels throughout the Canal such that the Designated Use Standard would be upgraded to Class I (secondary contact recreation, fish survival and propagation). Minimum dissolved oxygen levels would be always greater than 4 mg/L and average bottom dissolved oxygen levels would be between 7 and 8 mg/L.

5.2 Without-Project Sediment Quality

Currently, information concerning without-project sediment quality is limited to the analysis of deep sediments that was conducted for this feasibility study. It is expected that existing deep sediment characteristics (see section 4.2) will persist into the future without-project condition. Forecasts of future without-project condition sediment characteristics for the upper two feet of sediment need to be conducted. To the extent possible, these forecasted characteristics should be based on existing sediment quality and expected future inputs from CSOs, storm drains, and ground water sources.

5.3 Without-Project Habitats

For the most part, future without-project habitats are expected to be very similar to existing habitats. No significant changes are forecasted for terrestrial habitats. The lack of vegetated wetland habitat is also expected to persist into the future. The water quality improvements expected to occur in the without-project condition will marginally improve aquatic habitats so that they will more closely resemble aquatic habitats found in the Upper Bay. An investigation into forecasting future without-project aquatic habitat species composition and abundance has not been completed. Future without-project condition aquatic habitat characteristics would be based on the water quality and sediment quality projections described in the preceding sub-sections. Projections of future aquatic habitat characteristics should also take into account other factors, such as habitat improvements throughout the HRE that may influence communities within the Bay and Canal.

6 Preliminary Plan Formulation

Plan formulation is in accordance with the Principles and Guidance of the Water Resources Council, as defined in ER 1105-2-100. Plan formulation is an iterative process, and plan development will be refined as additional data gathering and analysis proceeds.

6.1 Problems, Goals, Opportunities, and Constraints

This section presents a summary of the initial problems and opportunities identified during the first phase of the feasibility study. At this point, the primary water resources problem appears to be an impaired and degraded aquatic and terrestrial habitat, and the virtual non-existence of any wetlands in an area that was once extensively a tidal marsh and creek system . Although the problems and opportunities identified by the Gowanus Bay and Canal Ecosystem Restoration Feasibility Study are confined within the immediate study area, these problems and opportunities also relate to the greater Hudson-Raritan Estuary (HRE). Ecosystem problems and restoration opportunities throughout the HRE, including those within the Gowanus Bay and Canal, must be considered as a component of the HRE Comprehensive Restoration Implementation Plan (CRIP), which applies a comprehensive, holistic perspective of estuarine functions. The goals of the CRIP include restoring lost habitats, improving connectivity and biodiversity while reducing habitat fragmentation, and developing substantial and sustainable natural ecosystems. To be recommended as a feasible project through the CRIP, each site must be optimized to achieve the best overall function for the Estuary, and not necessarily the site itself. Taken together, the benefits of restoration will exceed the sum of benefits attributable to individual sites. This would also be expected within the Gowanus Canal, where habitat losses are even more pronounced than within the estuary as a whole. The CRIP will also allow for adaptive management at the Gowanus Canal in the future.

The preceding presentation of existing and future without-project conditions includes the readily evident perturbations to the physical, chemical, and biologic characteristics of the Gowanus Bay and Canal. Problems that are physical or structural in nature include the loss of the former Gowanus Creek channel, wetlands and shoreline, loss of adjacent upland forests, and the replacement of freshwater runoff from the Gowanus drainage basin with urban storm water and sewage effluent.

Added to these physical changes have been many decades of industrial processes including extensive wetland fills, deepening of the former creek, and CSO discharges have produced chemical contamination of the sediments (including metals, PCBs, semi-volatiles, and organic sludge) and poor water quality (from reduced tidal and surface water flushing, BOD/COD-driven reductions of dissolved oxygen, visible volatile, semi-volatile chemical and bacterial sheens, and floating effluvia). The combination of physical changes and profound contamination has resulted in a total loss of vegetated wetlands and severe degradation of the remaining estuarine, aquatic, benthic, and adjacent upland habitats in the Gowanus Bay and Canal. These problems point to the potentially larger problem of bioaccumulation of contaminants and ecological risk. Ecological risk in this context refers to the evaluation of the effects of contaminated sediments on production and diversity in the biota, especially the benthic community within the sediments, and does not refer to the impacts of the environment on human health.

6.1.1 Loss of the Gowanus Estuary and Watershed

<u>Problem:</u> Pre-Canal maps indicate that Gowanus Creek was once a natural estuarine ecosystem composed of a dendritic and sinuous complex of tributaries and tidal saltmarshes. Such areas provide the highest unit area productivity of any coastal ecosystem, serving as spawning and shelter areas for many species of fish, habitats for a diverse invertebrate fauna, and critically important feeding areas for birds. During the early years of European settlement, Gowanus Creek was acknowledged as being among the worlds foremost oyster producing beds.

The Gowanus Creek Estuary extended as far east as the present 5th Avenue and as far west as Clinton Street. The northern extent of the estuary was approximately at Dean Street (see Figure 4). Since that time, Gowanus Creek was shortened, straightened, and had terminal basins installed during the construction of the Canal (1860). The channel was deepened to accommodate commercial barge traffic, a use that continues today. The shoreline has been fully engineered and now consists mostly of timber or concrete bulkheads. The resulting aquatic habitat exhibits minimal diversity that may be described as a featureless substrate of slightly undulating, contaminated, soft sediments, bounded by nearly vertical hardened walls.

With the exception of a relatively few public parks and empty lots, the watershed consists of urbanized impervious surfaces. Runoff is high velocity and voluminous. Fresh water inputs into the present Canal are limited to direct precipitation and unknown groundwater contributions (which may transport contaminants from upland soils to the Bay and Canal). Any beneficial value of this fresh water input is strongly offset by CSO and storm water outfall discharges.

Opportunity: Planned improvements to the flushing pump will increase the volume of water imported from Buttermilk Channel. Modifications to the Gowanus Pumping Station CSO are planned to reduce its discharge frequency, however the other nine CSO outfalls are not scheduled for improvement and all ten CSOs will remain (although slightly reduced in frequency of discharge) as sources of pollution into the canal.

It is expected that the existing urban development and infrastructure will remain in place throughout the 50 year planning horizon. Commercial and industrial activities continue to operate along the canal bulkheads, and are expected to continue throughout the planning horizon. Opportunities for restoring a vegetated, earthen shoreline are constrained by existing uses, but still possible in select locations. Commercial navigation in the Bay and Canal is also expected to continue, although commercial navigation is mainly limited to barges and attendant tugs. Overall, opportunities for the restoration of the predevelopment estuarine ecosystem, vegetated uplands, or the watershed (at any meaningful scale) appear to be limited. The opportunities that do exist must be examined carefully as they represent the only means of restoring some habitat diversity other that open water. Consequently, opportunities for small wetlands, localized shoreline restoration and improvement of substrate complexity may yield benefits disproportionate to their size.

6.1.2 Impaired Water Quality

Problem: Currently, ten CSOs flow in excess of 200 times each year, discharging nearly 300 million gallons of untreated sewage into Gowanus Canal. Planned improvements by NYCDEP to the Gowanus Pump Station CSO will reduce the total number of overflow incidents by 4% and the annual volume discharge by 26% to 215 million gallons. Other expected improvements to water quality include increasing the flushing pump output from 154 MGD (million gallons per day) average capacity and 195 MGD peak capacity to 215 MGD and 252 MGD respectively, and improved screening of floatable materials from storm waters (see section 5.1 Without-Project Water Quality). The overall affect of NYCDEP's planned water quality improvements will be to increase dissolved oxygen concentrations to levels similar to those prevalent in the Upper Bay (consistently higher than 4mg/L).

Opportunities: Opportunities to improve water quality (through ecosystem restoration) beyond the improvement already anticipated from planned activities is limited in the Gowanus Bay and Canal. Construction of effective water quality treatment wetlands in the Gowanus Bay and Canal may be difficult, but, in combination with the added habitat diversity, could add substantial supportive benefits.

6.1.3 Impaired Sediment Quality

Problem: Previously collected sediment quality data and new data from preliminary sediment sampling investigations have shown that Gowanus Bay and Canal sediments are contaminated with a wide spectrum of organic and inorganic substances. Chemical and biological oxygen demand is likely to reduce dissolved oxygen levels in both sediment and the water column. Planned increases in the flushing tunnel output are expected to improve oxygen levels and reduce organic concentrations. However, this will not quickly alter the contaminant concentrations in surficial sediments. The presence of these contaminants in sediments would constitute a reservoir for toxic chemical migration through benthic fauna and up the food chain. Contaminant migration through the food chain may be exacerbated by an increase in faunal populations due to the water quality improvements from planned flushing pump and CSO modifications.

Opportunity: Sediment quality can be improved by removal and replacement of existing sediment with clean sediment, by capping existing sediment, or using an appropriate combination of the two approaches. Preliminary information indicates that the depth of contaminated sediment may preclude complete dredging to clean substrate. To more fully evaluate the migration of contaminants through the food chain, investigations would need to be conducted to identify existing characteristics of surficial sediments. Once existing conditions are identified, a model that forecasts the continued contributions of CSOs, groundwater, and other effluent and sediment sources to surficial sediment contamination must be developed in order to assess future without and with-project sediment conditions (see section 6.3 Identification of Preliminary Restoration Plans).

6.1.4 Absence of Riparian Vegetation

Problem: Commercial and industrial activities along and adjacent to the banks of the Canal have eliminated natural upland vegetation along the Canal. Existing vegetation consists exclusively of ruderal species that creates degraded upland conditions and provides few aquatic habitat benefits. The absence of riparian vegetation adversely affects aquatic habitat by increasing water temperatures (and thereby decreasing dissolved oxygen in shallow low energy areas), and by eliminating shaded areas that aquatic species seek out as refuge areas.

Opportunity: Introduction of appropriate riparian trees and shrubs native to coastal regions would provide shade, improve aquatic habitat, and perhaps provide avian habitat as well. Planting may require cooperation of local property owners and should also be coordinated with local community cultural and recreational concerns.

6.1.5 Loss of Wetlands

Problem: There are no vegetated tidal wetlands in the Gowanus Bay and Canal. Vegetated tidal wetlands include those areas that are most typically recognized as tidal wetlands. These areas are categorized by NYSDEC as vegetated coastal shoals, bars, and mudflats (code SV 2200); broad leaf vegetated tidal wetlands (code BV 2500); inter-tidal marsh (code IM 3000); fresh marsh (code FM 3010); graminoid vegetation (code GV 3500); and high marsh (code HM 4000). The once extensive system of historic wetlands has been totally displaced by urban waterfront development and small areas of non-vegetated wetlands that include the non-vegetated wetland categories: coastal shoals, bars, and mudflats (code SM 2010) and littoral zone (code LZ 2020). The absence of vegetated wetlands greatly reduces the spawning, shelter, and forage opportunities for aquatic species in the Bay and Canal.

Opportunity: Expected future physical characteristics of the Canal and watershed (navigation channel, CSOs, bulkheads) and expected future land use of the shoreline and adjacent areas (commercial and industrial) limit large scale restoration of wetlands in the Gowanus Bay and Canal. Creative opportunities may arise, such as filling in a terminal basin to appropriate depth, selectively terracing some unused shorelines, or creative placement in unused embayments or indentions in the shoreline. Given the potential value of new wetlands placed in an area were they are totally absent, the smaller opportunities could yield benefits far above their size alone.

6.1.6 Impaired Fish Habitat

Problem: The physical and chemical degradation to the Gowanus ecosystem, combined with the absence of riparian vegetation and loss of wetlands has greatly impaired fish habitat in the Gowanus Bay and Canal. Investigations of fish populations, mobile macroinvertebrates, and hard structure communities indicate that aquatic habitats within the Canal are of a lower quality than aquatic habitats found within the Upper Harbor and other areas within the HRE.

Opportunity: Opportunities for restoring fish habitat in the Gowanus Bay and Canal will be largely dependent on the differences between existing habitat in the Bay and Canal and existing habitat in the Upper Harbor. The dominant influence that the Upper Harbor has on the Bay and Canal, in terms of available species and water quality, indicates that it would be unlikely that fish habitat in the Gowanus Bay and Canal could be improved to levels greater than those existing in the Upper Harbor. Water quality improvements resulting from NYCDEP's CSO abatement programs are expected to support fish survival and propagation in the Bay and Canal. Measures that might build on the expected water quality improvements (in addition to improvements in the benthic food base) could include shaping of the substrate, the placement of underwater structures to improve habitat diversity, and the creation of wetlands.

6.1.7 Impaired Benthic Habitat

Problem: The benthic organisms found in the Gowanus Canal may serve as a vector for bioaccumulation of contaminants into the local food chain (see section 4.4.5 Invertebrate Community). Benthic organisms may be a critical component of the pathway that transports sediment contaminants to higher trophic organisms. Additional investigations would be required to evaluate contaminant pathways and the risk of ecological toxicity (chronic and/or acute) in the local and regional food web.

Opportunity: Improving benthic habitat and reducing source contaminants could be achieved through dredging and capping existing sediments. The existing benthic habitat needs to be gauged against a similar habitat in a reference area in order to determine the potential for benthic habitat restoration. Reducing the reservoir of source contaminants in the sediments could reduce bioaccumulation through the food chain, thereby providing ecological benefits throughout the Upper Harbor and into the larger Hudson-Raritan Estuary System. A surficial sediment sampling program would provide the data necessary to evaluate the distribution of contaminants, the degree of contamination and the associated ecological risk of sediment remediation schemes. Additional investigations would be required to characterize toxicity exposure risk to the higher trophic organisms.

6.2 Identification of Restoration Measures as Components of NER

Restoration measures are the restoration activities (such as dredging) and features (such as constructed wetlands) that can be used individually or collectively to define a restoration plan. Restoration measures that have been identified as potential components of alternative restoration plans include:

- Dredging sediments
- Capping sediments
- Bottom contouring
- Submerged structure
- Shoreline softening
- Planting riparian vegetation
- Wetland creation
- No Action Plan

6.3 Assessment of Preliminary Restoration Plans

The preliminary data gathering and analysis conducted to-date provides sufficient information for the identification and assessment of three generic restorations plans:

- Dredging, as the sole measure
- Capping, as the sole measure, and
- Wetland creation at various locations.

6.3.1 Dredging as the Only Component of a Restoration Plan

Although the sediment and sampling analysis conducted to-date was intended as a preliminary effort, the results of that effort indicate that it is not feasible to dredge down to a depth that would reveal clean sediments. Contaminants have been found in very high concentrations from 2.5 feet below the sediment surface to as deep as 30 feet below the sediment surface (see section 4.3.2 Sediment Characteristics). Given the presence of high concentrations of a variety of contaminants at all depths between 2.5 feet and 30 feet below the sediment surface, dredging, as the only component of a restoration plan, would not effectively improve sediment characteristics. Any restoration plan that would include dredging would also need to include capping with appropriate substrate material. Furthermore, any restoration plan that includes a capping component would need to assess future sources of contaminants such as CSO outputs and groundwater migration, in order to confirm the effectiveness of capping as a long-term improvement of sediment quality.

6.3.2 Capping as the Only Component of a Restoration Plan

The feasibility of capping existing sediments as the only component of a restoration plan is limited by existing bathymetry (see section 4.1 Bathymetry) and continued use of the navigation channels by commercial vessels (see section 1.3 Study Area). Capping existing sediments may be feasible in deeper areas of Gowanus Bay and in areas adjacent to the federal navigation channel, but the shallow depths and narrowness of the Canal indicate that capping of existing sediments in the Canal would likely impede navigation and cause some areas to be exposed at low tides. The feasibility of capping as a restoration measure would be enhanced by combination with a dredging program so that appropriate water depths may be achieved.

6.3.3 Wetland Creation at Various Locations

A "Final Wetland Creation General Investigation Report" (see Attachment: Final Wetland Creation General Investigation Report, USACE 2004) documents an analysis of wetland creation opportunities in the study area. The report is a discussion of various wetland creation opportunities. The stated goal of the Draft Wetland Creation General Investigation Report is

> *...to present a feasibility level review of the potential for creating wetlands in the Gowanus Canal. Created wetlands and other stormwater management practices, in addition to providing habitat and increasing biodiversity and productivity, can be used for containing, maintaining, and treating sources of contamination and sedimentation to the Canal prior to entering the waterway. These constructed wetland systems would be located either at the upper limits of the tidal range, to intercept urban runoff and CSO discharges, or completely within the Canal, handling daily tidal exchange. (page 8)*

Table 7 presents a synopsis of the wetland creation opportunities identified in the Final Wetland Creation General Investigation Report. The square footage and acreage was compiled from the wetland opportunity descriptions contained in the report.

Table 7: Wetland Creation Opportunities Identified in the Wetland Creation General Investigation Report

Site ID	Location	Length Along Canal (feet)	Width Built Out Into Canal (feet)	Total Width Including Uplands	Total Square Feet	Total Acreage
1	South of Gowanus Expressway	200	20	20	4,000	0.09
2	North of Gowanus Expressway	100	30	30	3,000	0.07
3	Lowe's Turning Basin	175	50	50	8,750	0.20
4	North of 9th St. Bridge	300	15	15	4,500	0.10
5	6th St. Turning Basin	670	50	100	67,000	1.53
6	5th St. Earthen Mound	112	15	65	7,280	0.17
7	2nd Avenue CSO	50	15	15	750	0.02
8	3rd St. Bridge CSO	70	30	50	3,500	0.08
9	Degraw St.	50	30	50	2,500	0.06
10	First St.	50	30	50	2,500	0.06
11	Second St.	50	30	50	2,500	0.06
12	Bond St.	50	15	35	1,750	0.04
13	Fifth St.	50	15	30	1,500	0.03
14	2nd St. Community Garden	190	30	110	20,900	0.48
15	Carroll St. CSO	125	30	30	3,750	0.09
Totals					134,180	3.07

Note: Sites 9 – 13 are identified in the report as street end parks

The constraints to creating wetlands in the Gowanus Bay and Canal are based on the narrowness of the Canal and the need to maintain a navigation channel. Little room is left for wetlands to be constructed on a naturalistic sloping shoreline. The solution presented in the Wetland Report is to construct the wetlands on terraces supported by submerged concrete retaining walls. Other solutions may be possible, and given the total absence of this valuable component of an estuarine system, must warrant further investigation.

The Wetland Report also identifies opportunities for construction treatment wetlands at a minimum of three CSO outfall locations (#'s 7, 8, and 15 as identified in the table above). These three wetland creation opportunities have a total area of 0.19 acres. Treatment wetlands are intended to help improve water quality. Under normal conditions, the report states:

> *"Generally, a stormwater wetland system is designed to be a minimum of 3% of the size of the total drainage area in order to adequately accommodate and filter the volume of stormwater runoff received. For the stormwater wetlands in the Gowanus Canal that handle CSO discharge to effectively remove sediment and pollutants, and prevent or minimize contact of fish and wildlife with CSO contaminants, a created wetland*

should be sized to contain and treat the volume of water released during the first pulse of CSO discharge." (page 25)

Given the general size requirements identified by the Wetland Report, the drainage area associated with 0.19 acres of treatment wetland should be approximately 6.3 acres (3% of 6.3 = 0.19), however, NYCDEP calculates the drainage area for these outfalls as approximately 380 acres. Obviously, treatment wetlands will not function fully in treating CSO discharges. They would, however, offer some added improvement to a badly impacted system. Taken in conjunction with their potential ecological value as a key and missing ecological component, treatment wetlands may provide potential value well beyond size alone. Treatment wetland design within the Gowanus Bay and Canal must also consider the intensity of flow during overflow events. For example, one potential treatment wetland opportunity at the Second Avenue outfall has an annual overflow volume of 76 million gallons (average per event: 1.6 million gallons).

The viability of the wetland opportunities proposed in the Wetland Report is not yet fully assessed. The numerous factors that would impact viability include tug and barge traffic (wave forces generated in the narrow confines of the canal), CSO and storm water flow force and velocity (a single event can produce a pulse of three to five million gallons of CSO overflow), water quality during CSO events, and floatables (which have impacted the natural production of wetlands in other NYC waterways, such as Flushing Creek). These factors are a real and persistent part of the Gowanus Canal environment and need to be included in the without and with-project conditions. The size requirements for effective treatment wetlands, and the persistence of navigation and municipal uses of the Bay and Canal in the without-project condition may highlight the turning basin wetlands as the most feasible wetland creation scenario. However, the potential benefits to the system from the creation of treatment wetlands and the added benefits of water quality improvements warrant their continued consideration as this study progresses.

7 Environmental Benefit Evaluation Methods

The environmental benefits resulting from restoration measures such as wetland and upland habitat creation will be measured based on their contribution to the severely depleted inventory of these habitats in the HRE. The environmental benefits of improvements made to the Gowanus Bay and Canal sediments are less straight forward and more complicated to adequately evaluate than the benefits of wetland and upland habitat creation.

An important element of evaluating the benefits of improvements to Gowanus Bay and Canal sediments is establishing the link between sediment contamination and the health and functioning of the biotic community. Investigations conducted to-date in the study area indicate that the contaminated sediments in the study area are likely impacting the health of HRE fish and bird communities that feed in the study area. The reservoir of contaminants found in Bay and Canal sediments potentially pose an unacceptable ecological risk to HRE wildlife.

There are two recent Corps feasibility studies that may serve as precedents and provide guidance in the development of an evaluation method for sediment improvements. One of these studies is the Interim Final Feasibility Study, Elizabeth River Basin, Virginia (June 2001) conducted by the Norfolk District, USACE. The other study is the Muddy River Flood Control and Ecosystem Restoration Feasibility Study, Boston and Brookline, Massachusetts (June 2003), conducted by the New England District, USACE.

The Elizabeth River study characterized environmental benefits based on a functional score using five measurements of environmental health. These five measurements include:

- Benthic Index of Biotic Integrity, which compares benthic community health at the study area to health at a reference area;
- Toxicity of surface sediments;
- Toxicity of subsurface sediments;
- Histopathology (study of lesions and cancers found in study area fish); and
- Rating of sediment quality impacts on wildlife.

A panel of experts was used to develop the functional scores based on the five measures mentioned above. The functional scores mixed quantitative and qualitative information with professional judgment so that alternative plans could be evaluated and incremental benefits could be identified.

The Muddy River study evaluated four ecological guilds that include benthic invertebrates, fish, piscivorous wildlife, and wetland/riparian dependent songbirds. The benthic community was evaluated based on the results of acute and chronic bioassays. A Habitat Suitability Index was developed that compared the survival of organisms in the study area subjected to toxicity testing to the survival of organisms in reference sediments. The evaluation of fish habitat was based on dissolved oxygen levels. The evaluation method used a modified Habitat Evaluation Procedure (HEP) method based on a Habitat Suitability Index for three species of birds, two of the species represented wetland and riparian dependent communities and one species represented piscivorous communities. The selection of these three bird species out of the 175 species that were identified as likely to occur within the study area, was based in part on the availability of data that allowed the establishment of linkages between site contamination and their diet.

The results of the without and with-project habitat quality analyses for each of the four guilds was combined to generate habitat units (HUs). HUs were weighted by acreage of various cover types and by degradation factors that accounted for sediment contamination throughout the study area. Baseline condition HUs were compared to future condition HUs such that incremental analyses of alternative plans could be conducted.

For this study, the Project Delivery Team will consult with a variety of experts to develop an appropriate habitat evaluation method based on observable parameters and professional judgment.

8 Forthcoming Technical Investigations

The technical investigations that will be conducted for this feasibility study are identified in the Project Management Plan (PMP). The PMP will be updated to reflect information accumulated from investigations conducted to-date and to reflect the outcome of the P-7 Formulation Briefing. A major focus of the forthcoming investigations will be the development of the link between sediment contamination and the health of the biotic community. All of the investigations to be conducted need to support the development of an evaluation method that can assess the incremental environmental benefits and the incremental costs of alternative plans to identify an NER plan.

8.1 Hydrologic and Hydrodynamic Analyses

NYCDEP has developed a Gowanus Canal Receiving Water Model that was designed to evaluate existing and future water quality conditions. The model has a hydrodynamic component (ECOMSED) and a water quality component (RCA). The model has been designed to also support habitat quality projections in that the model simulates sedimentation rates of settled solids and computes total organic carbon and projects the number of taxa in the sediment.

The hydrodynamic and hydrologic analyses developed for this study to-date do not address the important issue raised in the Phase I Environmental Assessment, which is the potential migration of contaminants from contaminated upland soils to the Bay and Canal. An analysis of groundwater flows and contaminant concentrations may be required if excessive contaminant concentrations are found in upland soils along the Bay and Canal.

8.2 Soil and Sediment Analyses

The Phase I Environmental Assessment recommends sampling of soils adjacent to the Bay and Canal in order to adequately characterize the associated contamination that may have resulted from a long history of industrial land use. The recommended laboratory analyses include USEPA Target Compound List (TCL) VOCs and semivolatile organic compounds (SVOCs); Priority Pollutant (PP) metals and pesticides; PCBs; and total petroleum hydrocarbons (TPHC), as well as a RCRA waste-characterization analysis of selected samples. Field screening for VOCs and radioactive materials is also recommended in the report. If excessive contaminant concentrations are found then the ability to evaluate whether, or for what duration, improved sediment characteristics can be sustained may require the installation and monitoring of wells to determine the volumes and rates of contaminant input through the groundwater pathway.

A consideration in proceeding with the recommendations of the Phase I report is a potential for landowners to be unwilling to allow access to sample for regulated contaminants. Many may fear a CERCLA liability and high potential remediation or legal costs for newly discovered sources of toxic or hazardous materials. Alternatively, it will be difficult to assess the sustainability of a restored Canal and Bay, lacking a full understanding of the groundwater re-contamination pathway. The Phase II

Environmental Assessment will need to be coordinated with the development of the habitat evaluation method and the development of future without-project conditions.

Sediment sampling and analysis will build on the information already gathered from efforts conducted to-date. Additional data will need to be collected to characterize the upper 2.5 feet of sediment. The correlations analysis that was conducted on the characteristics of deep sediments (more than 2.5 feet below the sediment surface) and the macroinvertebrate sampling results did not support the hypothesis that the characteristics of the deep sediments are similar to the characteristics of the upper sediments.

The chemical constituency of the upper sediments will provide information that will be used in the development of the habitat evaluation method. The contaminant concentrations identified in the upper sediments could be used as input into a sediment toxicity model, as developed for the Elizabeth River Study habitat evaluations, or could be used to develop a Hazard Quotient for upper sediments, as developed for the Muddy River Study habitat evaluations.

The chemical constituency of the upper sediments could also be used as an indicator of recent historical and current sediment contaminant loads. In the development of future without-project conditions, it will be critical to predict with some level of certainty the future levels of contaminant concentrations in the sediments. In both the Elizabeth River Study and the Muddy River Study, the relatively lower contaminant concentrations in the upper-most sediments were indications that contaminant loading had been greatly reduced and that future concentrations in the upper sediments would remain below critical levels for sufficient duration. This information will also be useful in assessing the extent to which upland soils and groundwater need to be investigated.

8.3 Biological Analyses

Potential designs of wetland creation and riparian habitat improvements will necessarily require considerations of functionality and survivability and must be evaluated by the habitat evaluation method. Design concerns are briefly discussed in section 8.4 Engineering Design, below.

Preliminary bioassays (potentially both chronic and acute) will be conducted to provide information concerning the link between sediment contamination and the health of the biotic community. Sampling and analysis of contaminants within the upper most sediments will be conducted concurrently with the preliminary bioassays. The types of additional biological analyses to be required will largely be determined by the type of habitat evaluation that will be used in the assessment of alternatives. The biological investigations will need to fulfill the data requirements of the habitat evaluation method. Therefore, the determination of the appropriate types of biological analyses may not occur until after additional sediment sampling and analysis and after the habitat evaluation method (including applicable HEP, habitat suitability indices, risk assessments, etc.) has been selected.

8.4 Engineering Design

There are three main categories of Engineering Design issues that need to be fully addressed in the remaining investigations:

- Wetland creation and riparian habitat improvement,
- Dredging and dredged material placement, and
- Capping of sediments.

Engineering design considerations for wetland creation and riparian habitat improvement can build upon the conceptual design work already conducted for the Wetland Report. Dredging method, equipment, and dredged material placement are major concerns that have not yet been addressed in this feasibility study. There are many dredging and dredge material placement alternatives available for consideration, including innovative decontamination technologies currently being developed by the USEPA, the New York District, and New Jersey Department of Transportation.

Capping design alternatives must also be considered including desired physical characteristics of the substrate, thickness of the cap layer, and hydrodynamic impacts on the placed material.

8.5 Cultural Resources, NEPA Related, and Economic Analyses

The PMP provides full descriptions of all the investigations related to the feasibility study including cultural resource, NEPA related, and economic analyses. Information gathered for the feasibility study to-date has not required any changes to these analyses as presented in the PMP. Similarly, all efforts related to plan formulation remain the same as identified in the PMP.

9 Plan Formulation and Policy Issues

One policy consideration that has arisen during the course of the analysis is the possibility of pursuing the environmental dredging of the Bay and Canal under the authority contained in Section 312 of WRDA 1990, as amended (see Memorandum on Implementation Guidance for Section 312 of the Water Resources Development Act of 1990 (33 U.S.C. 1272), as amended by Section 224 of WRDA 99, dated 25April 2001). This authority specifically identifies the Brooklyn Waterfront as a priority work area for environmental dredging. Although using the Section 312 authority would not impact the conduct of the feasibility study (a feasibility report is required as the decision document, which must be approved by the Assistant Secretary of the Army), it would mean that specific Congressional authority to dredge the Bay and Canal would not be required. In addition, under section 312 (b) the non-Federal partner is responsible for only 35% of construction costs, including removal, remediation, and transport of the dredged material to a disposal site. Construction costs under this section also include all costs related to contaminated material disposal, including lands, easements, remediation and restoration. These construction costs are not cost shared by the Federal government under typical authority.

In accordance with the Corps of Engineers Environmental Operation Principles, all Corps projects must strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life. An objective of all Corps Environmental Projects is to create a sustainable regenerating site. All alternatives formulated must meet sustainability criteria to be further considered for study.

10 Conclusions

The information gathered for this feasibility study to-date indicates that the restoration measures that have the most likelihood of success include:

- Dredging and capping of contaminated sediments;
- Wetland creation, and;
- Upland planting of appropriate riparian species.

The physical constraints of the Bay and Canal and the anticipated future commercial, industrial, and municipal uses of the study area greatly limit wetland creation and riparian habitat improvement opportunities. Restoration alternatives that consist of dredging only or capping only would not be feasible. Alternative plans that combine dredging and capping will be analyzed during the remainder of the feasibility study.

Future feasibility study investigations will focus mainly on establishing the link between sediment contamination and the health of the HRE's biotic community. Additional sediment sampling and analysis is required for the upper 2.5 feet of sediment. The types of biologic analyses that will be required will largely be determined by the type of habitat evaluation method selected. It is expected that the habitat evaluation method will focus on the potential ecosystem risk posed by contaminated sediments in the Bay and Canal to the HRE's biotic community.

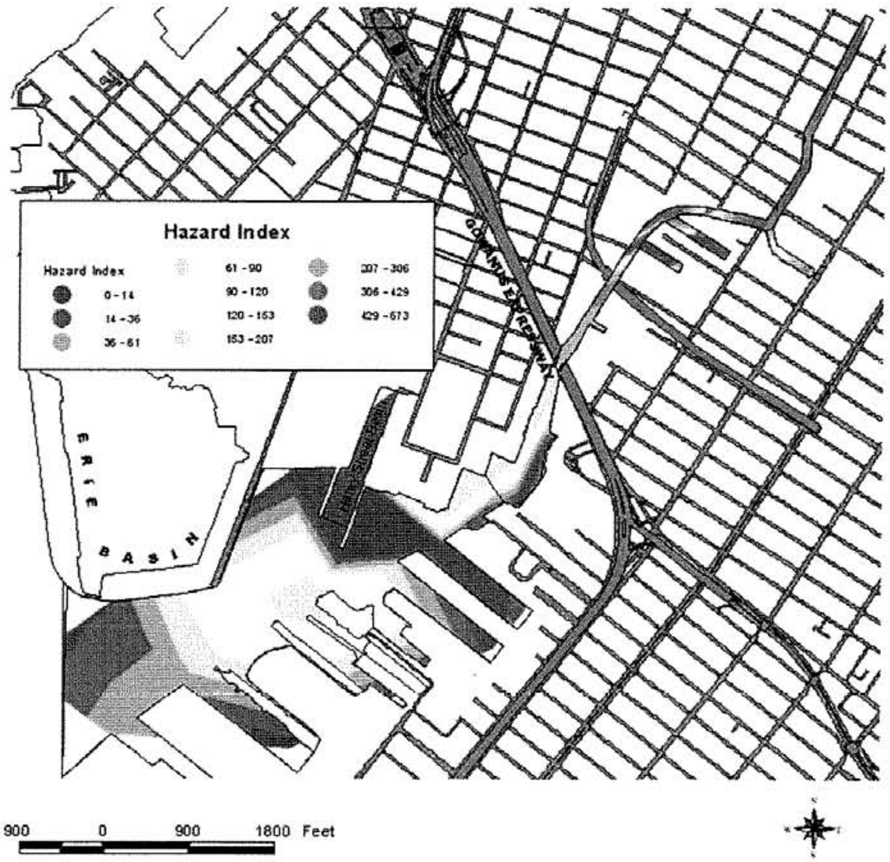
Figure 1: Gowanus Bay and Creek Aerial Photo

Source: USACE, New York Distric

Figure 2: Gowanus Bay and Creek Bathymetry 2003

Source: USACE, New York District

Figure 3: Gowanus Bay and Creek Hazard Index Distribution



Source: USACE, New York District