111th Congress, 1st Session – – – – – – – – – – – – – House Document 111–12

HUDSON-RARITAN ESTUARY, LIBERTY STATE PARK ECOSYSTEM RESTORATION INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS), THE DEPARTMENT OF THE ARMY

TRANSMITTING

AN INTERIM RESPONSE TO CONDUCT A FEASIBILITY STUDY TO EVALUATE PROBLEMS AND OPPORTUNITIES ASSOCIATED WITH ECOSYSTEM RESTORATION AND PROTECTION FOR THE NEW YORK AND NEW JERSEY PORT DISTRICT

JANUARY 27, 2009.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

---

U.S. GOVERNMENT PRINTING OFFICE

46–755 WASHINGTON : 2009

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

JAN 15 2009

Honorable Nancy Pelosi
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

HOUSE DOCUMENT NUMBER 111-12

Dear Madam Speaker:

This is an interim response to a resolution adopted by the Committee on Transportation and Infrastructure of the U.S. House of Representatives on April 15, 1999, which directed the U.S. Army Corps of Engineers to conduct a feasibility study to evaluate problems and opportunities associated with ecosystem restoration and protection for the New York and New Jersey Port District. The proposal is described in the report of the Chief of Engineers dated August 25, 2006 for the Hudson-Raritan Estuary, Liberty State Park, New Jersey which includes other pertinent reports and comments. The views of the State of New Jersey and the Department of the Interior are set forth in the enclosed report. The project for environmental restoration, Hudson Raritan Estuary, Liberty State Park, New Jersey, was authorized in Section 1001(31) of the Water Resources Development Act of 2007.

The plan recommended in the Chief's report included a 50-foot wide meandering tidal creek which tapers to a 25-foot wide creek after being connected with a culvert that would be excavated in the dredged material disposal area. This would result in the creation of 46 acres of tidal salt marsh. Approximately 15 acres surrounding the tidal creek system would function as a vegetated buffer zone. The excavated material from the salt marsh would be used to create a berm which slopes toward the interior of the park. An existing 23-acre seasonally flooded wetland would be enhanced by the increased drainage from the disposal berm. With the additional wetlands constructed on the site, the total freshwater wetlands enhanced and constructed as part of the project would be a total of 26 acres. The project would include construction of 25 acres of buffer areas around the freshwater wetlands. The creation of 46 acres of salt marsh at Liberty State Park would significantly enhance the ecological value of salt marshes in the New York and New Jersey harbor. The salt marsh and the improved hydrology for the freshwater wetlands would provide valuable wildlife habitat in the center of the most densely populated area of the country.

Based on October 2008 price levels, the total first cost for construction of the recommended plan is $37,581,000. Cost sharing for construction would be 65 percent Federal and 35 percent non-Federal in accordance with the requirements of the Water Resources Development Act (WRDA) of 1986, as amended. The estimated total Federal first cost of construction is $24,428,000

and the estimated total non-Federal first cost of construction is $13,153,000. All costs for operation, maintenance, repair, rehabilitation, and replacement of the recommended project, estimated at $188,000 annually, are the responsibility of the non-Federal sponsor.

The plan recommended by the Chief of Engineers was identified as the National Ecosystem Restoration plan. Based on October 2008 prices and a Federal discount rate of 4.625 percent, the estimated average annual cost of the recommended plan is $2,415,000. Project benefits include restoration of 160 acres of diverse habitats including a tidal creek, salt marsh, freshwater wetlands, and maritime forested areas. The restoration actions would enhance the surrounding State park lands, providing benefits to a total of 234 acres. Project benefits were projected to result in an increase of 4,436 ecological functional units over the existing conditions.

Army review of this project concluded that the restoration of tidal salt marsh and freshwater wetlands would meet the Federal aquatic ecosystem restoration guidelines. However, to put this proposed project on par with similar Administration supported aquatic ecosystem restoration activities, upland habitat restoration would need to be removed from the project or provided by others as part of a locally preferred plan. Specifically, the project cost estimate identified about $2.2 million of expenditures in the upland management area that would not cost effectively provide aquatic ecosystem restoration benefits. In addition, I would require that prior to execution of the project partnership agreement, the state regulatory agency must provide written approval of the project plans and certify that the project constitutes proper handling of the contaminated materials. Further, the non-Federal sponsor for the project must agree in the project partnership agreement that, as between the Government and the non-Federal sponsor, it will be considered the operator of the project for the purposes of the Comprehensive Environmental Response, Compensation, and Liability Act liability and will be responsible for all claims and liabilities associated with material regulated under the Resource Conservation and Recovery Act, or other applicable law located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress. However, OMB has determined that the project is not consistent with the policy and programs of the President. A copy of its letter is enclosed. I am providing a copy of this

transmittal and the OMB letter, dated January 14, 2009 to the House Subcommittees on Energy and Water Development, and Water Resources and Environment.

Very truly yours,

John Paul Woodley, Jr.

John Paul Woodley, Jr.
Assistant Secretary of the Army
(Civil Works)

Enclosures

5 Enclosures

1. OMB Letter Jan 14,, 2009
2. DOI letter to USACE, Dec 6, 2005
3. HQUSACE response to DOI, May 04, 2006
4. Report of the Chief of Engineers, Aug 25, 2006
5. Hudson-Raritan Estuary, Liberty State Park, New Jersey – Ecosystem Restoration Study, October 2005

01/14/2009 15:29 FAX 202 395 4817 OMB WATER & POWER BRANCH 002

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

January 14, 2009

The Honorable John P. Woodley, Jr.
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, D.C. 20310-0108

Dear Mr. Woodley:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of your recommendation concerning the proposed Hudson-Raritan Estuary, Liberty State Park, New Jersey project.

As you know, the Administration's performance-based construction guidelines for Corps of Engineers aquatic ecosystem restoration ranks each project based on whether it cost effectively restores a nationally or regionally significant aquatic ecosystem that has been degraded by a Corps project or is a restoration effort for which the Corps is uniquely well suited. Based on our review of this project, we have concluded that the Liberty State Park project does not represent an appropriate level of investment from the national perspective.

The Office of Management and Budget does not object to you submitting this report to the Congress. However, when you do, please advise the Congress that the project is not consistent with the policy and programs of the President.

Sincerely,

Richard A. Mertens
Deputy Associate Director
Energy, Science and Water Division

Sutton

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

TAKE PRIDE IN AMERICA

DEC _ 6 2005

ER 05/0939

Mr. Thomas W. Waters
Chief of Policy and Policy Compliance Division
Headquarters
U.S. Army Corps of Engineers, CECW-P (SA)
7701 Telegraph Road
Alexandria, Virginia 22315-3860

Dear Mr. Waters:

The U.S. Department of the Interior (Department) has reviewed the Chief of Engineers' Proposed Report (Chief's Report) on the U.S. Army Corps of Engineers (Corps), New York District's proposed Hudson-Raritan Estuary, Liberty State Park environmental restoration project located in Jersey City, Hudson County, New Jersey. The Department has also reviewed the Final Environmental Impact Statement (FEIS) prepared by the Corps pursuant to the National Environmental Policy Act of 1969, as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*) (NEPA) and submitted in support of the Chief's Report. The Department provides the following comments pursuant to NEPA, the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.* (ESA), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) (FWCA).

CHIEF'S REPORT

The Department concurs with the Corps that the Liberty State Park Restoration Area is currently impaired by invasive species, a lack of tidal and freshwater cover types, and moderate levels of environmental contaminants. The Department generally supports the Corps' selected alternative to enhance the Restoration Area for the benefit of fish and wildlife. Therefore, the Department has no further comment on the Chief's Report recommending implementation of the selected plan.

FEIS

The Department's Fish and Wildlife Service (FWS) provided preliminary comments on the project via letter dated November 8, 2002, and a Planning Aid Letter dated July 14, 2004. In November 2004, the FWS delivered a draft report to the Corps pursuant to Section 2(b) of the FWCA. To date, the FWS has not received comments on the draft FWCA Report from the Corps. Via letter dated October 21, 2005 (ER 05/0787), the Department noted that the Draft Environmental Impact Statement (DEIS) did not incorporate, reflect or reference the information

or recommendations contained in the draft FWCA report. The October 21, 2005, Departmental letter also provided detailed recommendations to clarify and correct information contained in the DEIS. We note that the FEIS has not been revised in light of the Department's October 21, 2005 comments.

As noted in the November 2004 draft FWCA report, the FWS' primary recommendation for the project is to approach the creation and management of habitats in the Restoration Area from a perspective of large blocks of marsh, forest/freshwater wetland, and grassland habitats. To this end, the draft FWCA report includes delineation of recommended Management Areas, based on existing vegetative conditions as well as the Corps' Conceptual Plan for the Restoration Area. Other key FWS recommendations include adaptive management of the proposed marsh, control of invasive vegetation, control of feral dog and cat populations, and ongoing monitoring and management of key bird groups in close coordination with the New Jersey Department of Environmental Protection (NJDEP) Endangered and Nongame Species Program (ENSP).

Regarding environmental contaminants, key FWS recommendations include: cap open upland (non-forested) areas; line wetlands, channels, and their slopes with clean material; perform additional sampling (if capping and lining are not feasible) and ensure that contaminant guidelines are not exceeded; maximize the depth of the cap in the North Cove and use low permeable material (clay); include dieldrin, PCB, and dioxin analyses in any additional sampling performed; characterize stormwater runoff; and sample contaminants in all environmental matrices during post-construction monitoring.

FEDERALLY LISTED SPECIES

The following information was previously provided by the FWS in the November 2004 draft FWCA report.

Two federally listed species are known to occur in the vicinity of the proposed Liberty State Park Restoration Area: the bald eagle (*Haliaeetus leucocephalus*) and piping plover (*Charadrius melodus*), both federally listed as threatened. Both species occur as visitors to Liberty State Park from spring through fall. Piping plovers and bald eagles observed in the park to date were most likely transient individuals moving through on migration. The federally listed (endangered) roseate tern (*Sterna dougallii*) may also pass through the area during migration. However, none of these three species currently nests in the vicinity of the park.

The proposed ecosystem restoration may enhance foraging habitat for transient piping plovers and roseate terns that pass through Liberty State Park during migration. The project is not expected to create nesting habitat for these species. Given the distance to known nesting areas, neither piping plovers or roseate terns are expected to make significant use of the project area as foraging habitat during the nesting season. The project is not likely to adversely affect these species; therefore, no further consultation pursuant to Section 7 of the ESA is required with the FWS for the piping plover or roseate tern at this time.

The project may enhance the suitability of habitats in Liberty State Park for migrant bald eagles. Eagle populations are expanding in New Jersey, and improved habitat conditions may attract

eagles to initiate nesting and/or establish a significant wintering area in the park following completion of the project. The FWS anticipates that the proposed habitat modifications will not adversely affect bald eagles. However, indirect adverse effects (*i.e.*, disturbance, low reproductive success) of attracting eagles to the newly enhanced habitats may occur without proper species management.

The Department recommends that the Corps prepare a brief contingency plan for bald eagle management, and complete informal consultation on the plan with the FWS pursuant to Section 7 of the ESA, during the Planning, Engineering, and Design (PED) phase of the project. If desired, the Corps may designate the NJDEP's Division of Parks and Forestry (DPF) (the non-federal sponsor for post-feasibility phases of the project) as its non-federal representative to prepare and implement the eagle management plan, and to conduct consultation. Recommended plan elements include:

- participation in the ENSP's eagle monitoring program;
- participation in the ENSP's blood sampling and nestling banding program;
- restricted public access within 1.0 mile of any nest site or 0.25 mile of any important wintering sites, in accordance with site-specific recommendations of the ENSP;
- ENSP and FWS review of any major construction activities proposed in the future within 1.0 mile of any nest site or 0.25 mile of any important wintering sites (seasonal restrictions and habitat protections may be recommended on a case by case basis).

CONCLUSION

The Department generally supports the selected alternative for habitat enhancements at Liberty State Park, and has no further comment on the Chief's Report. We urge the Corps to continue coordination with the FWS during the PED phase of project planning, to complete ESA consultation for the bald eagle, and to incorporate FWS recommendations into the final project design.

The Department appreciates the opportunity to review the Chief's Report. If you have any questions regarding the above comments, please contact Mr. Clifford G. Day, Supervisor, New Jersey Field Office, U. S. Fish and Wildlife Service, 927 N. Main Street, Building D, Pleasantville, New Jersey 08232, (609) 646-9310.

Sincerely,

Mary Josie Blanchard

for Willie R. Taylor, Director
Office of Environmental Policy
and Compliance

cc: Director, Fish and Wildlife Service
Director, National Park Service
Director, Geological Survey
U.S. Fish and Wildlife Service, NJFO
Army Corps of Engineers, New York District

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street N.W.
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

MAY 0 4 2006

CECW-P (SA)

Mr. Willie R. Taylor
Director
U.S. Department of the Interior
Office of the Secretary
Office of Environmental Policy and Compliance
1849 C Street, NW
Washington, DC 20240

Dear Mr. Taylor:

We have received your agencies' comments of December 6, 2005, regarding the Hudson Raritan Estuary Liberty State Park Ecosystem Restoration Project Feasibility Report and Environmental Impact Statement. We have also received your Fish and Wildlife Coordination Act Section 2(b) Report dated April 2006. We thank you for the critical support from your New Jersey Field Office technical staff on this important and high profile project.

Your detailed comments will be helpful in the implementation of this project, and will be addressed during the Plans and Specifications stage, when the U.S. Army Corps of Engineers New York District will be in a better technical and logistical position to consider, and hopefully implement, a number of your specific technical recommendations. With regard to the proposed contingency plan for the bald eagle, we do not feel that the development of such a plan is appropriate at this time, given that the Fish and Wildlife Service has determined that the proposed project modifications would not adversely affect the species. Normally, a "no adverse affect" determination leads to the closure of the consultation process pursuant to section 7 of the Endangered Species Act. Please be advised that the Corps of Engineers would support the preparation of a bald eagle management plan should the species be attracted to the site in the future, and would enlist the cooperation of the non-Federal sponsor in the event that future consultation under section 7 of the ESA is warranted.

As your staff is aware, there is much more work to do on this project before construction can begin. This work includes the development of detailed engineering designs, invasive species control/re-planting strategies, and plans for monitoring both during and after completion of construction. These will be fully coordinated with the U.S. Department of the Interior, through the NJ Field Office, and the other environmental review agencies, including the New Jersey Department of Environmental Protection, as appropriate.

If there are any questions, please contact Leonard Houston, Chief, Environmental Analysis Branch, New York District, U.S. Army Corps of Engineers, 26 Federal Plaza, Room 2139, New York, NY 10278 at (917) 790-8702.

Sincerely,

Thomas W. Waters, P.E.
Chief of Planning and Policy Division
Directorate of Civil Works

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CEMP-NAD

August 25, 2006

SUBJECT: Hudson Raritan Estuary, New Jersey, Liberty State Park

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the Hudson Raritan Estuary, Liberty State Park, ecosystem restoration study. It is accompanied by the report of the district and division commanders. These reports are in partial response to a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives adopted 15 April 1999. This resolution requested the Secretary 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." This feasibility study was conducted in cooperation with the non-Federal sponsor (the Port Authority of New York and New Jersey). Pre-construction engineering and design activities for this proposed project will continue under the authority provided by the resolution cited above.

2. The reporting officers recommend a plan of improvement for Liberty State Park (LSP), which consists of the following improvements:

a. Construction of a 46 acre salt marsh and tidal creek system;

b. Construction of a 50 acre upland berm, utilizing 700,000 cubic yards of material from the excavated tidal creek;

c. Construction and restoration of 26 acres of freshwater wetlands;

d. Construction of two drainage pipes;

e. Construction of a drainage swale to connect interior freshwater wetlands;

f. Construction of 15 acres of buffer areas surrounding the tidal marsh, and 25 acres of buffer areas surrounding existing freshwater wetlands. The implementation of these two measures will result in significant incidental benefits to 75 acres of existing uplands that are not the subject of any actions under the recommended plan.

g. Adaptive Management and Monitoring.

3. Based on October 2005 price levels, the total first cost for construction of the recommended plan is $33,376,000. Cost sharing for initial construction will be 65 percent Federal and 35 percent non-Federal in accordance with the requirements of Water Resources Development Act (WRDA) 1986, as amended. The estimated total Federal first cost of construction is $21,694,000, and the estimated total non-Federal first cost of construction is $11,682,000. All costs for operation, maintenance, repair, rehabilitation, and replacement of the recommended project are the responsibility of the non-Federal sponsor.

4. The recommended plan is the National Ecosystem Restoration plan. The proposed restoration of rare and ecologically significant saltwater tidal marsh and tidal creek system, and improvement/protection of existing freshwater wetlands, grasslands, and forest and shrub habitats will provide an improvement to significant habitats in a highly urbanized environment within the New York-New Jersey Harbor. Constructing 46 acres of salt marsh at LSP will increase a scarce resource in the harbor, significantly enhance the ecological value of limited nearby existing salt marshes in the harbor, and contribute invaluable wildlife habitat in the center of the most densely populated area of the country. Use of the excavated material for a sheltering berm provides a cost effective disposal method, improves the hydrology of adjacent freshwater wetlands, buffers the project from nearby developed areas, and provides approximately 50 acres of warm weather grasslands in the southwest corner of the site. Grassland habitat values, largely replaced by agricultural fields in the past, are fast disappearing as agriculture lands are now developed for more intensive uses; therefore, this type of habitat is also considered threatened in New Jersey. The warm weather grasses will provide forage and breeding areas for many passerine and raptor species. They will enhance the potential for successful nesting of the Northern Harrier, a state listed species. The development of 26 acres of freshwater wetland systems will help to restore this locally endangered habitat. While no action is planned for the remainder of the site, consisting of 112 acres in the interior sections of the park, management of the site by the sponsor will provide a protective buffer for these rare habitats. The interior area includes the 23 acres of seasonally flooded wetlands and an urban forest of about 74 acres which is currently dominated by northern hardwood tree species and maritime shrubs assemblages. The urban forest is one of the largest contiguous areas of naturally established successional hardwoods in the metropolitan area and will indirectly contribute to the reestablishment of a diverse ecological mosaic of habitats. Construction impacts associated with this project will be temporary and long term beneficial effects of the project fully compensate for the temporary impacts. Based on October 2005 prices and a Federal discount rate of 5.125 percent, the

estimated average annual cost of the recommended plan is $2,145,000, and a net gain of 4,436 ecological functional units.

5. I generally concur in the findings, conclusions, and recommendations of the reporting officers. The plan developed is technically sound, economically justified, and environmentally and socially acceptable. The plan conforms to essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies and complies with other administrative and legislative policies and guidelines.

6. The views of interested parties, including Federal, State, and local agencies, have been considered. Letters of support for the recommended alternative were provided by the State of New Jersey and the U.S. Fish and Wildlife Service (FWS). Additionally a specific request was made by the FWS for additional coordination on Endangered Species Act consultation for the bald eagle. FWS was notified that the development of a management plan is not appropriate at this time, given that the FWS has determined that the proposed project would not adversely affect the species. The Corps of Engineers has agreed to support the preparation of a bald eagle management plan should the species be attracted to the site in the future, and would enlist the cooperation of the non-Federal sponsor in the event that future consultation under section 7 of the ESA is warranted. The District, Division, and Headquarters have reviewed the impact assessments and found them to be compliant with Corps regulations.

7. Accordingly, I recommend implementation of the authorized project in accordance with the reporting officers' plan with such modifications as in the discretion of the Chief of Engineers may be advisable. My recommendation is subject to cost sharing, financing, and other applicable requirements of WRDA 1986, as amended by Section 210 of WRDA 1996. Also, this recommendation is subject to the non-Federal sponsor agreeing to comply with all applicable Federal laws and policies, including the following requirements:

a. Provide non-Federal costs assigned to ecosystem restoration as further specified below:

(1) Enter into an agreement which provides, prior to construction, 25 percent of pre-construction engineering and design (PED) costs;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs;

(3) Provide all lands, easements, and rights-of-way, including suitable borrow areas, and perform or ensure the performance of any relocations determined by the Federal Government to be necessary for the construction, operation, maintenance, repair, rehabilitation, and replacement of the project;

(4) Provide, during construction, any additional amounts as are necessary to make its total contribution equal to 35 percent of initial project costs assigned to ecosystem restoration;

(5) Provide 35 percent of the costs of monitoring and adaptive management of the ecosystem restoration features as may be determined necessary by the Government; however, financial participation by the Government for monitoring shall not exceed one percent of total ecosystem restoration costs minus the cost of monitoring and adaptive management and financial participation by the Government for adaptive management shall not exceed three percent of total ecosystem restoration costs minus the cost of monitoring and adaptive management;

b. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the completed project, or functional portion of the project, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

c. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal Sponsor, now or hereafter, owns or controls for access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall relieve the non-Federal Sponsor of responsibility to meet the non-Federal Sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

d. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the initial construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal

Government shall perform such investigations unless the Federal Government provides the non-Federal Sponsor with prior specific written direction, in which case the non-Federal Sponsor shall perform such investigations in accordance with such written direction;

g. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project;

h. Agree that the non-Federal Sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

i. If applicable, comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, 42 U.S.C. § 4601 et seq., and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

j. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army;

k. Provide 35 percent of: the costs of any identification, survey or evaluation of historic properties; the costs of any mitigation activities or actions for historic properties or that are otherwise associated with historic preservation; and the costs of data recovery activities associated with historic preservation in excess of one percent of the total amount authorized to be appropriated for the project;

l. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of output it affords or that would hinder future operation and maintenance of the project;

m. For so long as the project remains authorized, the non-Federal Sponsor shall ensure continued conditions of public ownership and use of the property upon which the amount of Federal participation is based;

CEMP-NAD
SUBJECT: Hudson Raritan Estuary, New Jersey, Liberty State Park

n. Recognize and support the requirements of Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element; and

o. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

8. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program, nor the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the Port Authority of New York and New Jersey, the non-Federal sponsor; the State of New Jersey; interested Federal agencies; and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

CARL A. STROCK
Lieutenant General, US Army
Chief of Engineers

NOTICE

LIBERTY STATE PARK, NJ

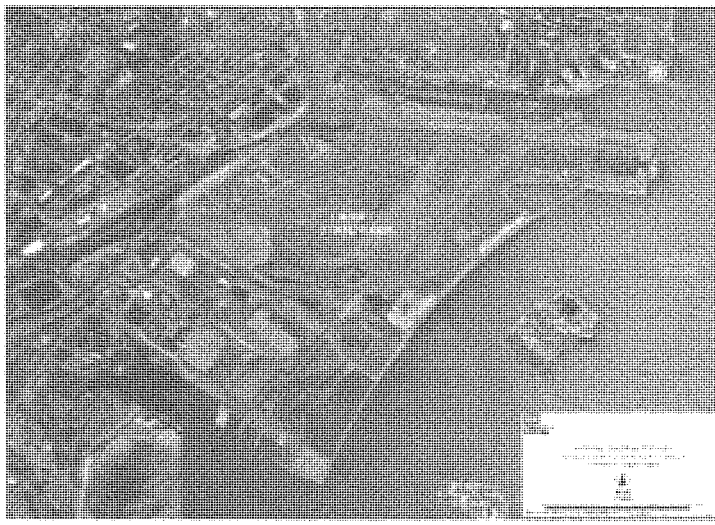
Since Congress has authorized the project, the Army Corps of Engineers does not request that the report be printed. If there are any questions about this, please call Ms. Jester at Corps Headquarters. You can reach Ms. Jester at (202) 761-1379.

US ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT

HUDSON-RARITAN ESTUARY, LIBERTY STATE PARK ECOSYSTEM RESTORATION

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

Volume 1



October 2005

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Integrated Feasibility Report & Environmental Impact Statement

Vol. 1: Main Report & Appendix A

New York District
U.S. Army Corps of Engineers
In Partnership with
The Port Authority of New York and New Jersey

October 2005

Hudson-Raritan Estuary, Liberty State Park
Integrated Feasibility Report and Environmental Impact Statement
Foreword

Liberty State Park is an extraordinary and unique public resource. With the Manhattan skyline, the Statue of Liberty and Ellis Island as a spectacular backdrop, it is also one of New Jersey's most dramatic parks. Liberty State Park is also an important first step of an ambitious restoration process for the Port District section of the Hudson-Raritan Estuary ecosystem restoration study, cost shared with the Port Authority of New York and New Jersey. The New Jersey Department of Environmental Protection (NJDEP) will be the construction cost sharing partner and has made invaluable contributions to the study of Liberty State Park. This foreword provides an overview of the recommended plan's contributions to the region and the context of the planning process, beginning with the significance of Liberty State Park in the New York and New Jersey Harbor.

The historic Central Railroad of New Jersey Terminal (CRRNJ), a grand setting for much of New Jersey's transportation history in the northeast, sits prominently at the north end of Liberty State Park. A two-mile promenade, Liberty Walk, links the picnic area to the Interpretive Center and the CRRNJ Terminal, while presenting visitors with a sweeping view of the Hudson River and Manhattan. Liberty Science Center, a popular attraction for students and families, is located in the park's western section.[1] Together these amenities help visitors learn about the past, experience the natural resources of the present and look towards a future of stewardship.

Liberty State Park was formerly the rail yards of the CRRNJ.[2] After the bankruptcy of the CRRNJ in 1969, the local community advocated for the protection of the land and historic rail terminal. The State of New Jersey has spent the past 30 years acquiring the land, planning and building a park infrastructure that is suitable for public recreation and protecting the associated habitats. With approximately five million visitors annually, the park's development has been an extraordinary success.

The restoration of 160 interior acres, currently fenced off and inaccessible, will provide substantial benefit to all 1,121 acres by linking previously developed and restored, but isolated, components of the park into one cohesive whole. The four components of the restoration project include the creation of approximately 46 acres of salt marsh, the creation and/or enhancement of approximately 26 acres of freshwater wetlands, the creation of approximately 50 acres warm weather grasslands and the enhancement of approximately 100 acres of urban successional northern hardwoods and maritime shrub assemblages (refer to diagrams 1-4).

Salt marshes, which once lined the harbor, were gradually eliminated during the industrial revolution. These endangered remnant pocket marshes exist primarily between piers throughout the harbor. They provide invaluable wildlife habitat in the center of the most densely populated area of the country. The creation of 46 acres of salt marsh at LSP will significantly enhance the ecological value of salt marshes in the harbor (diagram 1).

---

[1] See Section 3.12, Recreation for more detail.
[2] See Section 2, Site History for more detail.

One of the largest remaining marshes is within Liberty State Park, and has been included in New Jersey's Natural Areas system. In addition, a four-acre wetland system has been created as mitigation for waterfront development at a property adjoining the park, and is functioning at a high level. These two sites provide excellent reference for the proposed salt marsh and will help to ensure the success of the project. Freshwater wetlands were eliminated from the Bayonne/Jersey City peninsula, long ago. In fact most of the New York metropolitan area had eliminated these wetlands to make way for development. The creation/enhancement of 26 acres of Freshwater wetland systems will help to restore this locally endangered habitat. The proposal calls for the creation of a series of three wetlands, one of which will provide for deepwater habitat, currently absent from the park (diagram 3). In addition, by regrading the southwest corner of the park with the material excavated from the proposed salt marsh, the watershed of the existing 23 acres of seasonally flooded wetlands will be significantly increased. The improved hydrology combined with minimal control of invasive exotic species will greatly enhance the ecological value of these wetlands (diagram 2).

The excavated material from the salt marsh will be used to create approximately 50 acres of warm weather grasslands in the southwest corner of the site. This use was determined to be the least cost disposal option for the excavated material. With the disappearance of agriculture from the area, and much of the state, this type of habitat is also considered threatened in New Jersey. The warm weather grasses will provide forage and breeding areas for many passerine and raptor species. They will enhance the potential for successful nesting of *Circus cyaneus,* a state listed species that has unsuccessfully nested in the park for the past several years.

The remainder of the site, currently dominated by northern hardwood tree species and maritime shrubs assemblages, will be used as a demonstration urban forest. Its management will focus on assemblage development and the control of invasive species, especially portions closest to the tidal marsh and freshwater wetland that will act as protective buffers for these rare habitats. The urban forest is one of the largest contiguous areas of naturally established successional hardwoods in the metropolitan area. The restoration of maritime forest at this site will provide a unique opportunity for a long-term study of urban forestry, which is not part of the recommended plan, but may be pursued by other parties.

Throughout the planning process, the study team was mindful of a Consent Decree (included as attachment B) issued by the United States District Court, District of New Jersey, in June 2000 on behalf of the Interfaith Community Organization, Inc. to the NJDEP. The Consent Decree describes problematic areas within Liberty State Park identified by the Interfaith Community Organization and outlines mutually acceptable solutions for these areas. It should be noted that although the Court Decree invokes Section 7002 (a)(1)(B) of RCRA, this is only in the context of giving the Federal Court jurisdiction to preside over the case and does not mean that this is a RCRA site. Exhibit A (which is figure 2 of the ESA) is the site plan and identifies the current uses of each section of the park. Chromium Site 15 to the south of Middle Cove and Chromium Site 17 to the south of the Industrial Park contain Hazardous, Toxic, and Radioactive Waste (HTRW) at levels high enough to trigger Federal action. The study team excluded these sites from the study area. As for the remainder of the site, particularly North Cove, Dredge Spoils Storage Area, and the Freight Yard, substances listed under CERCLA/RCRA are listed, but not

at high enough levels to require Federal action. Avoidance of this area was not possible during the course of plan formulation. The consent decree excludes any further action in these areas if the project recommended in this plan is constructed.

The Consent Decree anticipates this restoration feasibility study, explicitly mentioning Army Corps of Engineers involvement in paragraphs 25 to 27 of the text. In brief, if construction of a salt marsh or other desirable habitat in the dredge materials area does not begin by December 31, 2007, NJDEP must place a one-foot cap of clean fill on the area, beyond the one-foot cap already present. The capping measure is a secondary alternative, to be enacted only if the Corps of Engineers finds the restoration project is not feasible. Federal analysis of the site found a restoration alternative that is feasible, provides substantial ecological benefits, and is fortunately in compliance with the requirements of the Consent Decree. Another point to clarify is that Federal participation in restoration of Liberty State Park does not relieve NJDEP of a legal obligation to clean up the site because there is no non-Federal legal responsibility to do so unless the Corps decides not to proceed with the restoration, or construction does not begin before December 31, 2007. In effect, the Consent Decree encourages restoration of the study area.

If the State were to place the one foot cap required if the restoration project does not advance, and the restoration project does move foreword after such local action, then there would be a substantial increase in overall cost a this additional one foot of material would have be removed for implementation of the restoration project. Finally, it should be noted that the busy industrial history of New York Harbor has left its imprint throughout the region in the ubiquitous nature of contaminants in the water and land. No part of the New York and New Jersey metropolitan area can be considered pristine, which is why restoration efforts are so vital here. We are confident that the recommended salt marsh will succeed because there are two nearby existing salt marshes functioning well.

Lastly, with over five million visitors per year, two educational facilities, and existing relationships with several universities, Liberty State Park provides an unparalleled forum for the study and enjoyment of public open space. The proposed project will undoubtedly receive national attention and could be used as a model for the integration and maintenance of diverse habitat structure in an urban context.

Diagram 1 – Tidal Complex

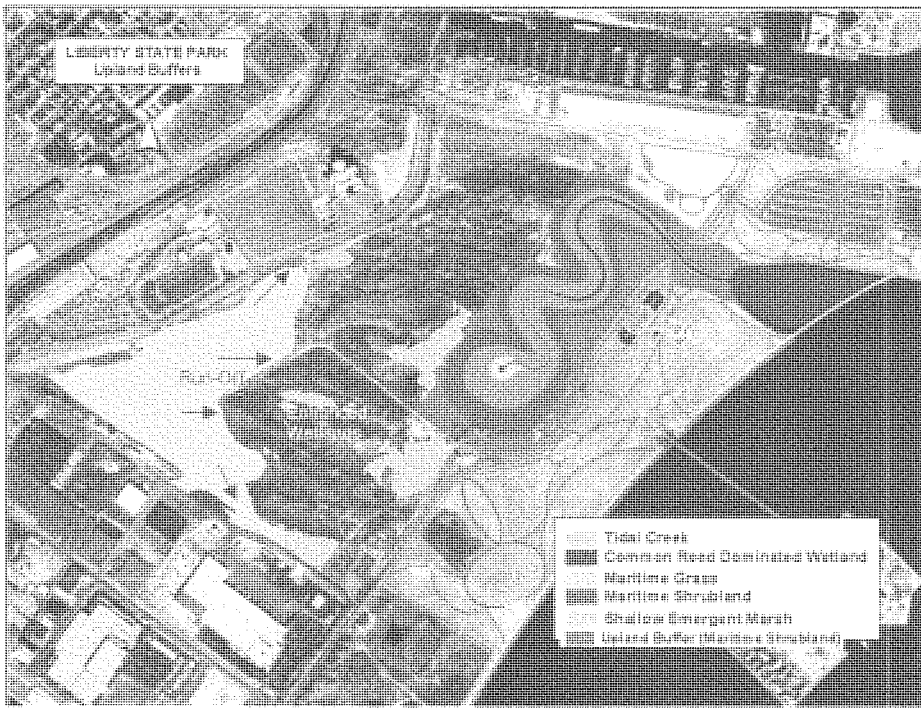


Diagram 2 – Tidal and Related Upland Buffer. The light green and blue shapes out of the tidal creek system denote seasonal wetlands that would benefit from the increased water flow provided by the berm in yellow.

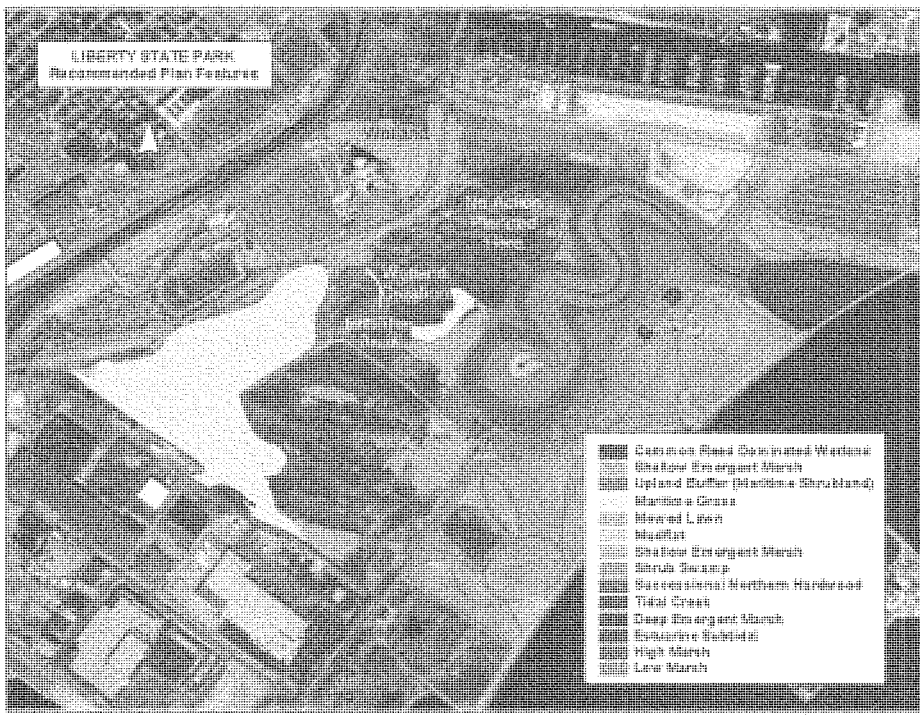


Diagram 3 – Recommended Plan Features. The colored shapes mark the actual extent of the construction in the recommended plan.

Diagram 4, which depicts the recommended plan in conjunction with existing habitats that will remain with implementation of the plan, is on the following page.

Freshwater Wetland

TABLE OF CONTENTS

Table of Contents i
List of Figures v
List of Tables vi
List of Study Members and Report Preparers vii
List of Interagency Study Team Members viii
Glossary of Terms, Acronyms, and Abbreviations ix
Executive Summary xii
Pertinent Data xv

1. INTRODUCTION 1
    1.1 Study Authority 1
    1.2 Study Purpose and Need 3
    1.3 Study Scope 3
    1.4 Report Organization 3
    1.5 Study Area 5
    1.6 National Environmental Policy Act Requirements 5
    1.7 Study Process 6
    1.8 Existing Projects 6
    1.9 Prior Studies and Reports 8

2. SITE HISTORY 13

3. EXISTING CONDITIONS 17
    3.1 Physical Setting 17
        3.1.1 Geology 19
        3.1.2 Topography 21
        3.1.3 Soils 21
    3.2 Climate 23
    3.3 Water Resources 24
        3.3.1 Surface Waters 24
        3.3.2 Water Quality 27
        3.3.3 Regional Hydrogeology and Groundwater 27
    3.4 Socioeconomic Conditions 29
        3.4.1 Population 29
        3.4.2 Economy, Employment and Income 29
    3.5 Cultural Resources 30
    3.6 Land Use 31
        3.6.1 Land Use in Jersey City 31
        3.6.2 Coastal Zone Management 31
    3.7 Biological Resources 32
        3.7.1 Vegetation 33
            3.7.1.1. Terrestrial Vegetation 33

3.7.1.2 Wetland Vegetation 38
3.7.1.3 Invasive Vegetation 41
3.7.1.4 Regulated Wetlands 42
3.7.2 Fish and Wildlife Resources 43
3.7.2.1 Amphibians and Reptiles 43
3.7.2.2 Birds 44
3.7.2.3 Mammals 46
3.7.2.4 Threatened and Endangered Species (TES) 46
3.7.2.5 Benthic invertebrates 47
3.7.2.6 Fish 48
3.7.2.7 Essential Fish Habitat 50
3.8 Air Quality 50
3.9 Noise 50
3.10 Recreation 51
3.11 Aesthetics 51
3.12 HTRW 51
3.13 Transportation and Other Infrastructure 55

4. FUTURE WITHOUT-PROJECT CONDITION 55
4.1 Study Area Conditions that are Unlikely to Change 57
4.2 Study Area Conditions that are Likely to Change 57

5. PURPOSE OF AND NEED FOR PROPOSED ACTION / PROBLEMS AND OPPORTUNITIES 58
5.1 Problems and Opportunities 58
5.2 Planning Objectives, Constraints, and Key Assumptions 58
5.2.1 Planning Objectives 58
5.2.2 Planning Evaluation Criteria 59
5.2.2.1 Engineering Criteria 59
5.2.2.2 Economic Criteria 59
5.2.2.3 Environmental Criteria 59
5.2.3 Planning Constraints 61
5.2.4 Public Concerns 61

6. ALTERNATIVES INCLUDING PROPOSED ACTION / PLAN FORMULATION AND EVALUATION 62
6.1 Identification of Alternative Plans 62
6.1.1 No Action Alternative 62
6.1.2 Alternative Ecosystem Restoration Measures 62
6.1.2.1 Restoration Areas 63
6.1.2.2 Potential Restoration Measures 63
6.2 Screening of Alternative Plans 65
6.2.1. Derivation of Restoration Benefits and Costs 65
6.2.2. Screening of Plans 68
6.3 Plan Evaluation and Comparison 71

6.3.1 Cost Effectiveness and Incremental Cost Analysis of Restoration Plans 71
6.3.2 Combinable Management Measures 72
6.3.3 Outputs and Costs of Combinations 72
6.3.4 Elimination of Economically Inefficient Solutions 74
6.3.5 Elimination of Economically Ineffective Solutions 75
6.3.6 Cost Effective and Least Cost Solutions 76
6.3.7 Average Costs of Remaining Alternatives 78
6.3.8 Recalculation of Average Costs for Additional Levels of Output 79
6.3.9 Incremental Cost Analysis and Pair-wise Comparison of Successive Outputs 81
6.3.9 Summary of Conclusions 82
6.4 Selected NER Plan 83
6.4.1 Tidal Marsh 85
6.4.2 Fresh Water Marsh 88
6.4.3 Upland Buffer and Seasonal Wetlands 97

7. ENVIRONMENTAL CONSEQUENCES 99
7.1 Environmental Effects of Restoration Measures 99
7.1.1 Physical Setting 102
7.1.2 Climate and Weather 102
7.1.3 Water Resources 102
7.1.4 Socio-Economics 1023
7.1.5 Cultural and Historic Resources 103
7.1.6 Land Use 104
7.1.7 Biological Resources 104
7.1.7.1 Vegetation 104
7.1.7.2 Fish and Wildlife Resources 104
7.1.7.3 Threatened and Endangered Species 106
7.1.8 Air Quality 106
7.1.9 Noise 106
7.1.10 Recreation 107
7.1.11 Aesthetics 107
7.1.12 HTRW 108
7.1.13 Transportation and Other Infrastructure 109
7.2 Environmental Justice Summary 109
7.3 Relationship Between Short Term Uses and Long Term Productivity 109
7.4 Irreversible and Irretrievable Commitments of Resources 110
7.5 Unavoidable Adverse Effects and Considerations that Offset Adverse Effects 111
7.6 Cumulative Impacts 112

8. RECOMMENDED PLAN 114
8.1 Ecosystem Restoration 114

8.2 Real Estate 114
8.3 Ecological Monitoring and Adaptive Management 115
8.4 Cost Estimate 115

9. PLAN IMPLEMENTATION 116
9.1 General 116
9.2 Local Cooperation 116
9.3 Cost Apportionment 119
9.4 Pre-Construction Engineering and Design Cost Sharing 120
9.5 Construction Schedule 121
9.6 Financial Analysis 121
9.7 Views of Non-Federal Partners and Other Agencies 121
9.8 Major Conclusions and Findings 123
9.9 Areas of Concern 125

10. PUBLIC INVOLVEMENT 125

11. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS 126

12. RECOMMENDATIONS 128

13. REFERENCES 130

LIST OF FIGURES

Number	Title	Page
1.1	Location Map of Hudson-Raritan Estuary (HRE)	4
1.2	Location Map of Liberty State Park (LSP)	7
1.3	Active Ecosystem Restoration Projects in HRE	10
2.1	LSP/Communipaw Cove Prior to Filling	14
2.2	Filling of Communipaw Cove 1880-1916	15
3.1	New Jersey Geologic Provinces	20
3.2	LSP Topographic/Bathymetric Maps overview	22
3.3	Storm Surges at the Battery, NY	26
3.4	LSP Groundwater Flow Direction	28
3.5	LSP Groundwater Contour	28
3.6	Existing Vegetative Communities	34
3.7	Invasive Species	42
3.8	Regulated Wetlands	43
3.9	2003 Geotechnical and HTRW sampling locations	54
3.10	2004 Geotechnical and HTRW sampling locations	54
6.1	Outputs and Costs of All Solutions	73
6.2	Cost Effective and Least Cost Solutions	78
6.3	Average Costs of Remaining Solutions	79
6.4	Liberty State Park Recommended Plan	84
6.5	LSP Benchmarking and Tidal Datums	86
6.6	LSP Salt Marsh Profile	86
6.7	Freshwater Alternative Plan D with Adjacent Wetlands	91
6.8	Liberty Science Wetland, Plan View	92
6.9	Liberty Science Wetland, Profile View	93
6.10	Biofilter, Plan View	93
6.11	Biofilter, Profile View	94
6.12	Deepwater Emergent Marsh, Plan View	95
6.13	Deepwater Emergent Marsh, Profile View	95
6.14	Infiltration Basin, Plan View	96
6.15	Infiltration Basin, Profile View	97
9.1	Preliminary LSP Construction Schedule	122

LIST OF TABLES

Number	Title	Page
1.1	Active Ecosystem Restoration Projects in HRE	11
3.1	LSP Water Level Observations, Summer and Fall 2003	25
3.2	LSP Terrestrial Communities	35
3.3	LSP Wetland Communities	39
6A	Example Evaluation with Synergistic Interactions	67
6.1	Outputs and Costs of Management Measure Increments	71
6.2	Ability to Combine Management Measures	72
6.3	Outputs and Costs of Combinations	74
6.4	Elimination of Economically Ineffective Solutions	75
6.5	Cost Effective and Least Cost Solutions	76
6.6a	Average Costs of Each Level of Output	79
6.6b	Average Cost for Additional Output, First Recalculation	80
6.6c	Iterations of Average Cost Calculations	81
6.7	Incremental Costs for Solutions with Lowest Average Cost for Additional Output	82
8.1	Ecosystem Restoration Acreages	114
8.2	Real Estate Project Costs	115
9.1	Total First Cost of LSP Recommended Plan	119
9.2	Total Annual Cost of LSP Recommended Plan	120
9.3	Costs Apportionment	120

APPENDICES

A Study Correspondence
B Environmental Compliance & Coordination
C Cultural Resources
D Real Estate
E Engineering
F Cost Estimate

LIST OF STUDY MEMBERS AND REPORT PREPARERS

The following individuals were primarily responsible for the preparation of this integrated feasibility report and environmental impact statement.

Individual	Responsibility
Olivia Ng Cackler	Project Planner
Robert J. Will	Biologist; National Environmental Policy Act
Mark F. Lulka	Project Manager
William P. Shadel	Restoration Biologist
Marty Goff	Engineering Specialist
Kerry Anne Donohue Couch	Project Engineer
Bethany McClanahan	Coastal & Hydraulics
Kristen Van Horn	Geotechnical Specialist
Daniel Kriesant	Hydrology & Hydraulics
Emily Eng	Cost Engineering
Naomi R. Fraenkel	Economics
Lynn Rakos	Cultural Resources
Richard P. Dabal	Hazardous, Toxic, and Radioactive Waste
Robert A. Hass	Real Estate
Stanley Nuremberg	Real Estate
Paul Sabalis	Review & Policy
Roselle Henn	Review & Policy

LIST OF INTERAGENCY STUDY TEAM MEMBERS

The following individuals participated in the development of this project.

Individual	Responsibility	Organization
Frank Gallagher	Project Manager	NJDEP
David Bean	Environmental Specialist	NJDEP
Kim Forth	Fish & Wildlife Biologist	NJDEP
David Risilia	HTRW Specialist	NJDEP
Greg Remaud	Stakeholder	NY/NJ Baykeeper
Michael Britt	Stakeholder	Liberty Science Center
Karen Greene	Biologist	NOAA-Fisheries
Carl Alderson	Restoration Ecologist	NOAA-Fisheries
Wendy Walsh	Fish & Wildlife Biologist	USFWS
John Staples	Fish & Wildlife Biologist	USFWS
Rajini Ramakrishnan	Biologist	USEPA
Mario Paula	Wetlands Biologist	USEPA

GLOSSARY OF TERMS, ACRONYMS, AND ABBREVIATIONS

ABN	Acid Base Neutral
AQ	Air Quality
AF	Alternatives Formulation
BMP	Best Management Practice
C&D	Construction & Demolition Debris
CCMP	Comprehensive Conservation and Management Plan (NYNJHEP)
CCPW	Chromate Chemical Production Waste
cm	Centimeter(s)
CRIP	Comprehensive Restoration Implementation Plan (HREERP)
CRM	Common Reed/Mugwort (terrestrial)
CRW	Common Reed-dominated Wetland (palustrine)
CSO	Combined Sewer Outfall
CZMA	Coastal Zone Management Act
DDT	Dichloro Diphenyl Trichlorethane
DEM	Deep Emergent Marsh (palustrine)
District	New York District (USACE)
DM	Dredged Material
DO	Dissolved Oxygen
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ER	Effects Range
ERI	Environmental Resources Inventory
ER-M	Effects Range-Median
ES	Estuarine Subtidal (estuarine)
ESA	Endangered Species Act
FCSA	Financial Cost Sharing Agreement
FFW	Floodplain Forest Wetland (palustrine)
FR	Feasibility Report
FS	Feasibility Study
FW	Fresh Water
GIS	Geographic Information System
GPS	Global Positioning System
H&H	Hydrology and Hydraulics
HD	Hydrodynamic
HRE	Hudson-Raritan Estuary
HREERP	Hudson-Raritan Estuary Ecosystem Restoration Project
HTRW	Hazardous, Toxic and Radioactive Waste
EFU	Ecological Functional Unit
IC	LSP Interpretive Center
ICA	Incremental Cost Analysis
IDC	Interest During Construction
IR	Integrated Report (Feasibility Report + NEPA document)

IWR	Institute for Water Resources
JCSA	Jersey City Sewerage Authority
JD	Jurisdictional Delineation (wetlands)
LOI	Letter of Interpretation
LSC	Liberty Science Center
LSP	Liberty State Park
LVRR	Lehigh Valley Railroad
MAFMC	Mid-Atlantic Fisheries Management Council
m	Meter(s)
mg/L	Milligrams per liter (ppm)
MHHW	Mean Higher High Water
MHW	Mean High Water
ML	Mowed Lawn (terrestrial)
MLLW	Mean Lower Low Water
MLW	Mean Low Water
MS	Maritime Shrubland (terrestrial)
MSL	Mean Sea Level
NAVD	North American Vertical Datum
NAWMP	North American Waterfowl Management Plan
NEP	National Estuary Program
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NHP	National Heritage Program
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJNHP	New Jersey Natural Heritage Program
NJSHPO	New Jersey State Historic Preservation Office
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRDCSCC	(NJDEP) Non-Residential Direct Contact Soil Cleanup Criteria
NYNJHEP	New York New Jersey Harbor Estuary Program
OSHA	Occupational Safety & Health Administration
PAH	Polynuclear Aromatic Hydrocarbon
P&S	Plans and Specifications
PCB	Polychlorinated Biphenyl
Phragmites	Common reed (*Phragmites australis*)
ppm	Parts per million
PED	Pre-Construction Engineering and Design
Ppb	Parts per billion
Ppt	Parts per thousand
QA/QC	Quality Assurance/Quality Control
RE	Real Estate
SCC	NJDEP Soil Cleanup Criteria

SCS	Soil Conservation Service
SEM	Shallow Emergent Marsh (palustrine)
SM	Salt Marsh (estuarine)
SNH	Successional Northern Hardwood (terrestrial)
SOD	Sediment Oxygen Demand
SOF	Successional Old Field (terrestrial)
SSB	Successional Shrubland (terrestrial)
SSW	Shrub Swamp (palustrine)
STP	Sewage Treatment Plant
SVOA	Semi-Volatile Organic
T&E	Threatened and Endangered (species)
TCL	Target Compound List (USEPA)
TPHC	Total Petroleum Hydrocarbons
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VOAWQ	Volatile Organic Water Quality
WRDA	Water Resources and Development Act

EXECUTIVE SUMMARY

New York District has completed this Integrated Feasibility Report/Environmental Impact Statement (FR/EIS) for the Liberty State Park Ecosystem Restoration Project in accordance with the Principles and Guidelines adopted by the Water Resources Council and the requirements of the National Environmental Policy Act (NEPA) to assess the need for modifying the existing degraded habitat, to evaluate the effects of the restoration activities, to determine a solution that maximizes environmental benefits while minimizing economic costs, and to assess the environmental impacts of the restoration alternatives.

The purpose of the project is to address the adverse impacts associated with past filling activities on the project site, with the overall purpose of improving the environmental quality of the area. This area was altered due to past fill activities and is consequently less productive than the pre-existing ecosystem habitat. The site is dominated by invasive species, which are expected to expand and overwhelm the various vegetative habitats on site without the implementation of ecological management measures described in the plan recommended in this report.

Liberty State Park (LSP) is part of the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study being carried out under the U.S. Army Corps of Engineers General Investigations Program. This feasibility study was authorized in a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, dated 15 April 1999, which reads in part, "Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army (the U.S. Army Corps of Engineers) is requested to.....(determine) the feasibility of environmental restoration and protection relating to water resources and sediment quality within the New York and New Jersey Port District (much of the lower Hudson Raritan Estuary), including but not limited to creation, enhancement and restoration of aquatic, wetland and adjacent upland habitats." The LSP project marks an interim response to the HRE study authority and is the first implementation level of the goals of the HRE Comprehensive Restoration Implementation Plan as defined in the Needs and Opportunities Report.

The proposed LSP restoration project is located in Jersey City, Hudson County, New Jersey, on the western side of Upper New York Bay. It is located directly on the waterfront across the Upper Bay from lower Manhattan and adjacent to the Statue of Liberty and Ellis Island. The proposed project area is approximately 160 acres of mostly undeveloped semi-degraded parkland within a fenced-off portion of Liberty State Park's 598 terrestrial acres. Liberty State Park has an additional 523 tidal acres, for a total of 1,121 acres. The park itself is bounded by residential and commercial neighborhoods to the west, by the Morris Canal to the north, by the Upper Bay to the east and by the "Black Tom" cove to the south.

Numerous surveys, studies, and extensive literature surveys have been conducted to establish necessary baseline information to identify resource shortcomings and potential restoration options. The results of these surveys are presented in the Environmental Resources Inventory (ERI), located in the Environmental Appendix. The results indicate strong opportunities for increasing habitat functionality at this site. Implementation of the plan recommended in this

report is expected to increase and restore more sustainable desirable communities, provide more cover, nesting, and breeding habitat for wildlife, and increase species richness.

Technical screening analysis was performed throughout the project development stages for each of three implementation phases of the proposed project: tidal marsh, fresh water wetlands and terrestrial buffer habitat. For the tidal marsh, a variety of configurations were proposed for consideration, including a single-inlet creek entering the terrestrial portion of LSP at North Cove, a continuous tidal loop entering the terrestrial portions at North Cove and returning to Upper Bay at the former Middle Cove, and an island in the middle of the creek. The single-inlet creek was determined to be the most efficient solution, meeting engineering, technical, and biological requirements. Subsequently, the shape, width and length of the proposed tidal channel, and its associated intertidal flats, low marsh and high marsh habitat were refined through hydrologic modeling. The tidal channel is designed to maximize functional habitat value of the proposed tidal marsh area by increasing the tidal range, and regular tidal flooding and drainage through the maximum area available.

For the fresh water wetland phase, four separate plans were technically analyzed, each delivering different amounts of acceptable quality fresh water to the target area in the central portion of the interior of the site. The selected freshwater plan provides the most amount of water for habitat creation and enhancement without expensive and high-maintenance mechanical pumping from already stressed municipal water supplies. The recommended plan incorporates a self-maintaining gravity-based system for supplying adequate quality water. This water-delivery system obtains additional water from the NJ Transit parking area, which is then filtered in an enhanced wetland area adjacent to the Liberty Science Center (LSC). The levels of the LSC wetland are controlled by a self-adjusting weir, which directs water through a diversion pipe underneath Phillip Street to an additional *Phragmites australis* dominated bio-filter wetland. This bio-filter wetland removes remaining suspended sediment, potential toxicants, and unwanted nutrients. From the bio-filter, a created swale will deliver the substantially enhanced volume and quality of water to a created permanent deep-water emergent marsh. The deep marsh will provide fish, reptile, and other habitat not currently found in Liberty State Park. During high-flow periods, excess water will drain out of the deep-emergent marsh into an infiltration basin, in effect creating an additional, periodically flooded wetland. The high permeability of the infiltration basin soil will allow water to penetrate underlying groundwater sources, in turn feeding an existing jurisdictional freshwater wetland.

Another component of this restoration project involves terrestrial buffers to protect the Federal investment in the wetland and aquatic habitats. Measures include the selective removal of invasive species and other undesirable vegetation. If monitoring indicates that further measures are necessary, the District will consider addition of topsoil and/or sand to selected areas to discourage unwanted vegetation, and promotion of native vegetation through replanting and/or seeding. A berm is planned for the southwestern portion of the site to protect and help isolate the habitat from outside influences. This berm will be created by using soil excavated from the proposed tidal marsh area. This soil, and any industrial residue it contains, will be completely encapsulated within the berm. The berm will act as an isolation barrier for sensitive species and add topographical relief to a relatively flat site. Most buffer habitats will be maintained in the same vegetative community type, while simultaneously controlling invasive species and

encouraging native species. Thus, a mosaic of high-functional value terrestrial habitat will be enhanced and sustained, which includes existing hardwood and maritime forest, scrub-shrub, maritime grassland and old field. Where possible, grassland habitat to be enhanced will be contiguous to enhance feeding areas for raptors and isolation for ground nesting birds. The functional integrity of the existing forested areas will be maintained and enhanced.

The District's National Ecosystem Restoration (NER) plan will result in a significant increase in wildlife habitat value and diversity and estuarine functional value when compared to existing habitat. The NER plan will increase the availability of cover, foraging, nesting and breeding habitat for State threatened and endangered species; restore USEPA designated priority wetlands (e.g., salt marsh); improve water quality; increase the value and availability of spawning and nursery habitat for anadromous fish species; enhance wetland habitat for migratory waterfowl; assist in the enhancement of wildlife habitat corridors; and increase aesthetics and opportunities for passive recreation; and promote science education. In addition the NER plan will meet the multi-jurisdictional, interagency goals and objectives for many programs including the National Estuary Act, the Administration's net wetland increase policy, the joint Corps-NOAA wetland restoration Memorandum of Understanding, and local stakeholders through synergy on an institutional, public and technical level, using the most cost-effective methods.

For further information, please contact:

Olivia Ng Cackler, Project Planner
U.S. Army Corps of Engineers, New York District
Planning Division, Plan Formulation Branch
26 Federal Plaza
New York, NY 10278-0090
ATTN: CENAN-PL-F
PHONE: 917-790-8705
FAX: 212-264-6040
olivia.n.cackler@usace.army.mil
http://www.nan.usace.army.mil

Robert J. Will, Project Biologist and NEPA Coordinator
Army Corps of Engineers, New York District
Planning Division, Environmental Assessment Branch
26 Federal Plaza
New York, NY 10278-0090
ATTN: CENAN-PL-E
PHONE: 917-790-8635
FAX: 212-264-0961
robert.j.will@usace.army.mil
http://www.nan.usace.army.mil

PERTINENT DATA

DESCRIPTION
The identified plan provides for ecosystem restoration in Liberty State Park, Hudson-Raritan Estuary.

LOCATION
Jersey City, Hudson County, New Jersey.

REAL ESTATE REQUIREMENTS
There are no real estate requirements because the prospective implementation non-Federal sponsor, the New Jersey Department of Environmental Protection, owns the project area.

ECOSYSTEM RESTORATION

Restoration Area 234 acres	
- Create Tidal Marsh system	46 acres
Berm	50 acres
Buffer	15 acres
- Create Freshwater wetland system	26 acres
- Enhance Seasonal wetlands	23 acres
Direct Construction Benefits	160 acres
Incidental Construction Benefits	*74 acres*
Total Area Improved	234 acres

Indirect benefits will extend to the Hudson-Raritan Estuary study area (about 500 square miles).

ECONOMICS (October 2004 price levels)

Initial Project Cost	$32,226,850
Annual Initial Cost (Discounted at 5.375 % over a 50-year period)	$ 1,868,532
Annual IDC Cost	$ 111,926
Annual O&M Costs	$ 161,134
Annual Monitoring Cost	$ 8,299
Total Annual Cost (Discounted at 5.375 % over a 50-year period)	$ 2,149,891

COST APPORTIONMENT

		Federal Share (65%)	Non-Federal Share (35%)	TOTAL
Total Project	Initial Project Costs	$20,947,450	$11,279,400	$32,226,850
	Real Estate Costs*		$ 30,000	$ 30,000
	Cash Contribution	$20,947,450	$11,249,400	$32,196850
	O&M Costs		$ 161,100	$ 161,100

* Applicable to required non-Federal cash contribution.

LIBERTY STATE PARK, HUDSON-RARITAN ESTUARY ECOSYSTEM RESTORATION

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

1. INTRODUCTION

This integrated Feasibility Report and Environmental Impact Statement (FR/EIS) investigates the feasibility and environmental impacts of alternative plans to address problems and opportunities associated with ecosystem restoration in Liberty State Park, Hudson-Raritan Estuary.[1] This FR/EIS has been prepared by the New York District of the U.S. Army Corps of Engineers (Corps) under the General Investigations Program of the Corps. The Port Authority of New York and New Jersey (PANYNJ) is the non-Federal partner for this study. The New Jersey Department of Environmental Protection (NJDEP) is the prospective non-Federal partner for project implementation and has played a prominent role in the planning process.

1.1 Study Authority

Liberty State Park is part of the Hudson-Raritan Estuary Environmental Restoration Study being carried out under the U.S. Army Corps of Engineers' General Investigations Program. The study was authorized by a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, dated 15 April 1999, Docket 2596, 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 Liberty State Park (LSP) Integrated Feasibility Report/ Environmental Impact Statement is an interim response to the study authority noted above. Its purpose, as stated in the HRE §905(b)

[1] The recommendation to integrate the FR and the EIS can be found in Engineering Regulation 1105-2-100, Appendix G, paragraph 10.

Reconnaissance Report (NYD, 2000), is to advance restoration of the estuary and provide both a springboard and model on which to develop the overall restoration plan, known as the Comprehensive Restoration Implementation Plan (CRIP). As such, reconnaissance phase recommendations for LSP have been drawn primarily from the overall HRE §905(b) Reconnaissance Report Analysis.

The HRE Reconnaissance Report of 2000 identified site-specific water resource problems as well as regional water resource problems. These sites can be categorized into seven degraded habitat types: 1) inter-tidal wetlands/mudflats, 2) freshwater wetlands/riparian habitat, 3) benthic habitat, 4) shallow water habitat, 5) shoreline/coastal habitat, 6) fish habitat, and 7) shellfish habitat. Local project partners also identified continuous ecosystem degradation problems such as fragmentation of past restoration efforts in the estuary, impacts of infrastructure improvements, and impacts of urban development including but not limited to brownfields, refuse landfills, and infrastructure encroachments on tidal flow.

The Port Authority of New York and New Jersey (PANYNJ) became the non-Federal partner for the Hudson Raritan Estuary Feasibility Study by signing the Feasibility Cost Sharing Agreement in May 2001. The Port Authority and the Corps, with input from local sponsors, identified two main goals in the feasibility study of potential solutions: (1) a single comprehensive estuary-wide analysis of ecosystem restoration needs and opportunities to be used as an implementation plan for future restoration within the estuary, including, but not limited to: analysis and recommended solutions to benthic habitat restoration, salt marsh restoration, reef restoration, infrastructure encroachments on tidal flow, debris and derelict structures impact on coastal habitats, brownfields impact on coastal habitat, and refuse landfill impacts on coastal habitat and; (2) ecosystem restoration at 13 representative sites identified as priority restoration sites.

Initially, the two components of the Hudson-Raritan study, CRIP development and site restoration, will proceed on parallel tracks because there are potential restoration sites that have local public support, few constraints on land use, and willing implementation cost-sharing partners. Because the system has been degraded and suffers from acute resource losses, and because site availability and sponsorship can be significant constraints for each potential restoration site, it is important to move forward now with sites that have sponsorship and are free from substantial constraints as building blocks while the CRIP development is underway. The initial restoration projects, in coordination with other restoration activities in the Hudson-Raritan Estuary, beyond providing immediate relief to the resource-stressed system, will provide a foundation of experience in both the technical and management aspects of restorations, which will be used to refine the CRIP during its development. In addition, the initial restoration projects will be prominent in the public involvement program to showcase the HRE study and to investigate partnering opportunities.

The Liberty State Park project includes most of the seven degraded habitat types described in the HRE Reconnaissance report. Results from restoration efforts at Liberty State Park will have exceptional value to the planning and construction of future projects within the Hudson-Raritan Estuary.

1.2 Study Purpose and Need

The Hudson-Raritan Estuary study is a comprehensive program. Within it is the PANYNJ district, roughly defined as being within a 25-mile radius of the Statue of Liberty, which represents the most impacted portion of the estuary (Figure 1.1). The magnitude of restoring such a huge, highly urbanized area is considerable. As part of the Hudson-Raritan Estuary Reconnaissance Report completed in 2000, the District identified the need for "building blocks," that is, projects that could be built while the general Hudson-Raritan Estuary study was still being formulated. Building blocks provide an immediate and important ecological benefit to the estuary. Additionally, the study team can use the results from these interim projects to evaluate the success of the various projects, and their inherent restoration measures, and incorporate this information into the CRIP to calibrate predictive ecological models. Liberty State Park is the first of these building blocks.

In general at Liberty State Park, the cumulative effects of environmental degradation have adversely impacted the study area. Aquatic, wetland and associated upland habitats have experienced significant water resources problems. Industrialization and development, including prior wetland filling, hydrologic and benthic changes and deterioration of sediment quality have contributed to creating conditions that do not support a productive ecosystem. Loss of rare, valuable and diverse habitats and increased vulnerability and susceptibility to the encroachment of invasive species are the primary aquatic, wetland and upland habitat problems. The study area is in need of improvements that will reestablish diverse habitat, based on indicator species, and measures that will set forth the conditions to allow the restored ecosystem to be sustainable.

1.3 Study Scope

The Liberty State Park Integrated Feasibility Report and Environmental Impact Statement is an interim response to the Hudson-Raritan Estuary Study Authority that will focus mostly on Liberty State Park itself. A full response to the overall Hudson-Raritan Estuary study authority is in progress. This integrated report will discuss the overall Hudson-Raritan Estuary study when necessary and pertinent.

1.4 Report Organization

The FR/EIS begins with existing conditions and problem identification. This section ends with a description of what will happen if this project is not constructed. The existing conditions and problem identification section is followed by the plan formulation section, in which the study team presents the recommended plan, how it identified the recommended plan, and what carrying out the recommended plan would involve.

The main report summarizes the results of the feasibility studies and contains sections appropriate for NEPA documentation. Technical appendices, which present details of technical investigations conducted during the feasibility study, are attached.

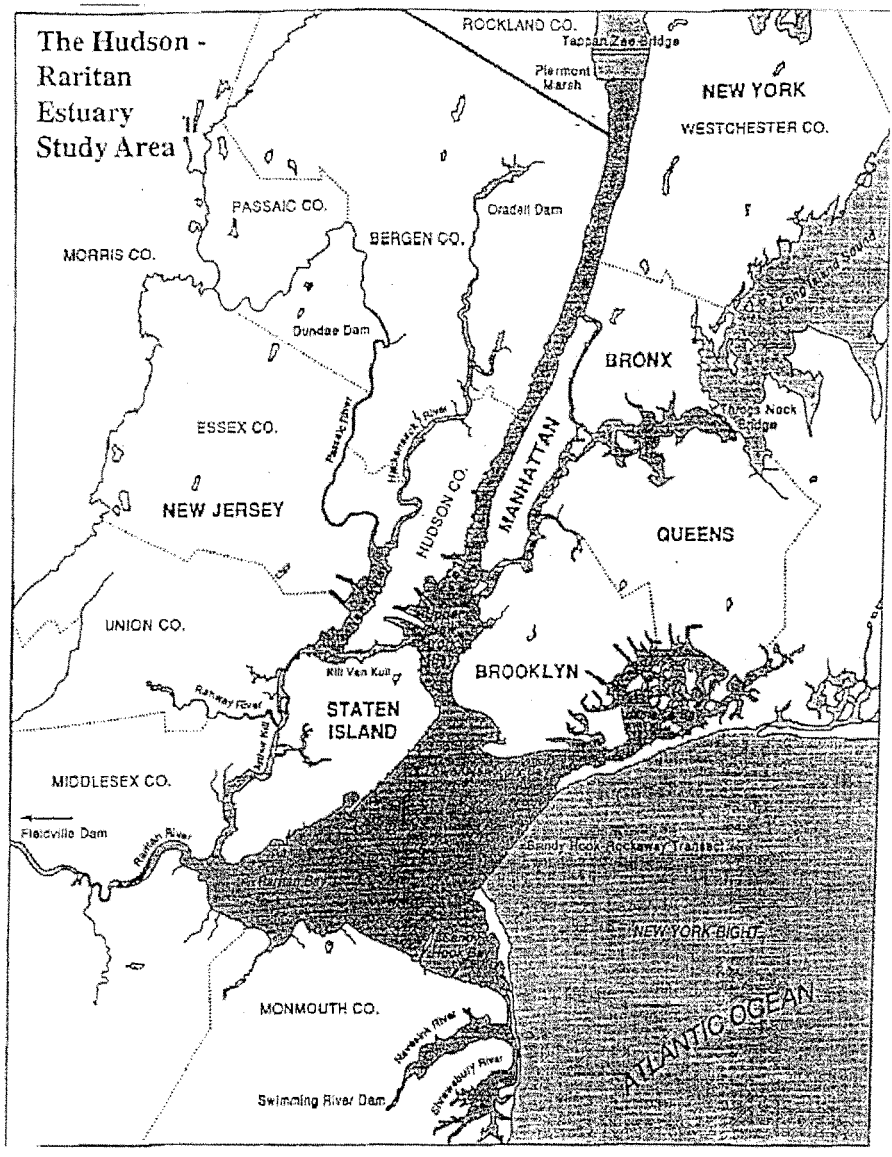


Figure 1.1 Location Map of Hudson-Raritan Estuary, as defined in the Hudson-Raritan Estuary Reconnaissance Study of 2000

1.5 Study Area

The PANYNJ district, roughly defined as being within a 25-mile radius of the Statue of Liberty, represents the most impacted portion of the Hudson Raritan Estuary (HRE) and is commensurate with the broad study area limits of the HRE effort. The defined study area under this interim response consists of the Liberty State Park representative site, located in Jersey City,

Hudson County, New Jersey, is on the western side of New York's Upper Bay, a few hundred feet from Ellis Island and the Statue of Liberty (Figure 1.2). The park consists of 598 mainly degraded upland and wetland acres and 523 tidal acres, for a total of 1,121 acres. Liberty State Park was once mostly open cove and coastal marshland until people started filling it during the 1860s with assorted fill material, including construction debris and garbage to create a large urban rail yard. The rail yard and nearby properties were converted into an urban waterfront park in 1976 as part of the United States bicentennial celebrations. LSP is not yet complete, however, and 160 acres of mostly undeveloped parkland is proposed for habitat restoration under this project. The restoration of this now fenced off and inaccessible interior section will provide substantial benefit to all 1,121 acres by linking previously developed and restored, but isolated, components of the park into one cohesive whole.

1.6 National Environmental Policy Act Requirements

The National Environmental Policy Act[2] (NEPA) requires that federal agencies document the environmental impacts of all federal actions significantly affecting the human environment. As required in Sec 102 of the Act, proposals for major Federal actions shall include a detailed statement on:

- The environmental impact of the proposed action;
- Any adverse environmental effects that cannot be avoided if the action is implemented;
- Alternatives to the proposed action, including no action;
- The relationship between short-term uses of the environment and long-term productivity; and
- Any irreversible and irretrievable commitments of resources that would be involved if the proposed action is implemented.

The implementation of the recommended plan for LSP has been determined by the District to be a significant Federal action requiring NEPA documentation via an EIS. This does not mean that the District has determined that there is a significant negative impact on the environment from the recommended plan. Quite the opposite has been determined by the District, as documented in detail in the following pages of this report, which demonstrates that the net effects of this singularly purposed environmental restoration project are overwhelmingly positive (Sections VII and VIII).

This FR/EIS was written to incorporate the required sections of a NEPA document (in this case, an Environmental Impact Statement) into a traditional Feasibility Report (FR). The following sections concentrate on NEPA issues:

[2] 42 U.S.C. 4321, et seq.

- Existing Conditions
- The Future Without the Proposed Project
- Purpose of and Need for the Proposed Action
- Environmental Consequences of the Recommended Plan

Scoping (investigating, discussing and resolving NEPA issues) was conducted over the past several years and included extensive coordination with the appropriate Divisions of the NJDEP (the anticipated non-Federal sponsor for project implementation), federal agencies (USFWS, USEPA, NOAA), and public advocacy groups (LSP Planning Committee, NJ Audubon Society, the NY-NJ Baykeeper, etc). A public meeting to receive comments, and several meetings with the LSP Planning Committee, were an integral part of the public scoping process.

In addition to documenting impacts, the USACE also must document compliance with all applicable federal, state and local permit requirements and approvals thereof (Section 11, Compliance with Environmental Requirements).

1.7 Study Process

New York District is responsible for conducting the overall feasibility study in cooperation with the non-Federal partner for the feasibility study phase, the PANYNJ. The feasibility study and eventual implementation of the project continue to receive strong support from PANYNJ and the NJDEP, owner of the park. These non-Federal interests are committed to working with the Corps to address opportunities for ecosystem restoration at Liberty State Park.

As will be explained in detail in this document, plan formulation for ecosystem restoration was conducted in close coordination with Federal and State of New Jersey regulatory resource agencies, including U.S. Fish and Wildlife Service, NOAA, USEPA and NJDEP.

As part of scoping activities, a public scoping meeting was held at LSP in October 2002 to solicit comment on the range of issues to be examined in the EIS as permitted by CEQ Regulations (40 CFR 1500-1508) and the U.S. Army Corps of Engineers Regulation (ER-200-2-2).[3] The purpose of the scoping process is to 1) formally establish a dialog and coordination with local, County, State, and Federal agencies and the public; and 2) identify issues and concerns that may be associated with the project. Specifically, the preliminary information provided to resource agencies and the public during scoping presents potential ecosystem restoration solutions; discusses existing biological and cultural resources located within the study area; preliminarily identifies the direct, indirect, and cumulative impacts of the project; and identifies the local, County, and State policies and permits applicable to the project.

1.8 Existing Projects

The New York District has conducted numerous studies and prepared prior reports related to the Hudson-Raritan Estuary study area. Authorized Federal ecosystem restoration projects currently

[3] Minutes to the public scoping meeting located within the Environmental Appendix.

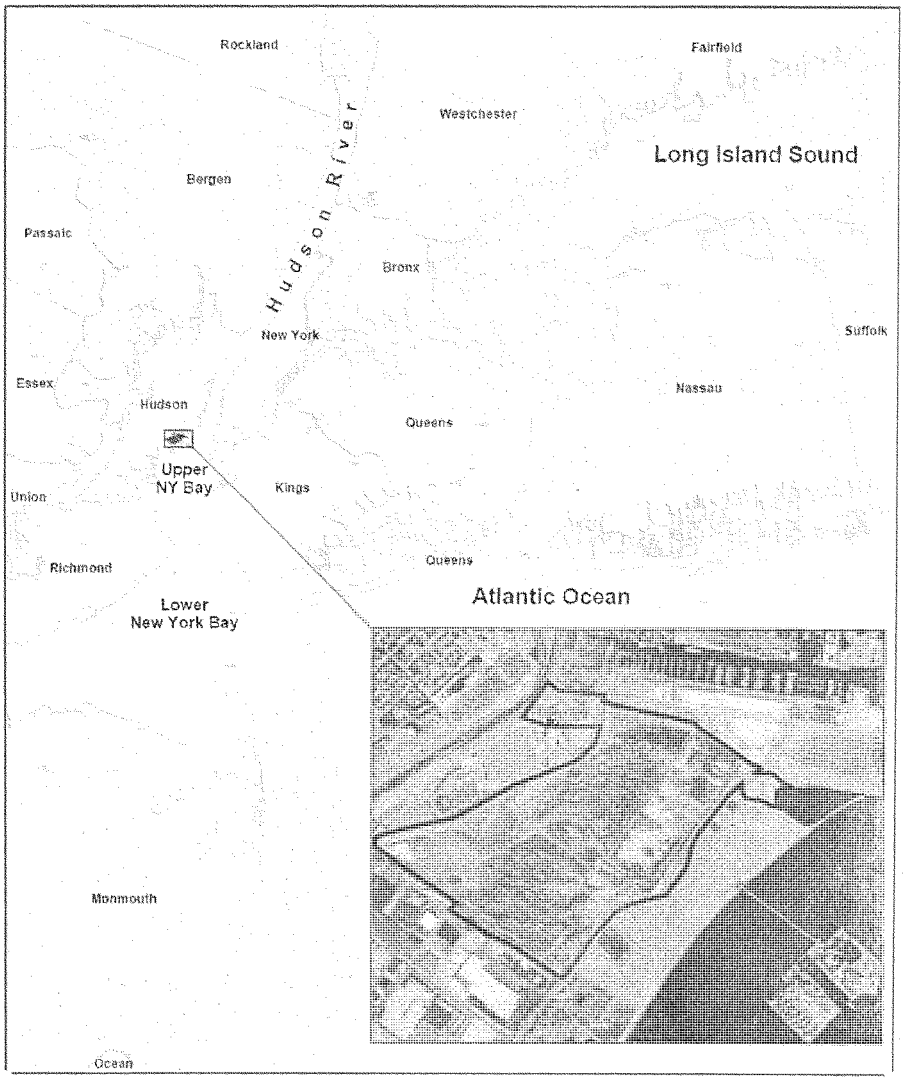


Figure 1.2 Location Map of Liberty State Park

underway by the New York District are mapped on Figure 1.3 and listed in Table 1.1. Attachment 1 contains a more extensive table detailing projects underway in New York District.

1.9 Prior Studies and Reports

Other system-wide USACE General Investigations eeosystem restoration projects, planned or underway, in the HRE area include the Jamaica Bay Ecosystem Restoration Project, the Hudson River Ecosystem Restoration Project, the Flushing Bay and Creek Ecosystem Restoration Project, the Bronx River Basin Ecosystem Restoration Project, the South River Hurricane & Storm Damage Reduction and Ecosystem Restoration Project, and the Saw Mill River Basin Ecosystem Restoration Project. Studies under Section 206 and Section 1135 of the Continuing Authorities Program include Gerritsen Creek, Jamaica Bay (CAP), Spring Creek, Jamaica Bay (CAP), Lincoln Park, Jersey City (CAP), Rahway River, New Jersey, and the Jamaica Bay Marsh Islands Erosion project. Within the HRE program, studies have begun on Hackensack Meadowlands, Lower Passaic River, Gowanus Canal, Newtown Creek and Sherman Creek. Liberty State Park would be the first large scale component of an ecosystem restoration project in the area to be implemented.

Within the Corps' Civil Works navigation mission, the Rivers and Harbors Act of 1874 authorized the first Federal navigation improvements to the Hudson Raritan Estuary. Most recently, a major feasibility study for the New York Harbor Deepening Program was completed in 1999 and serves as the decision document for 50 foot channel depth in New York Harbor, as authorized by the Water Resources Development Act of 2000. A Limited Reevaluation Report for New York Harbor was produced in 2003. The Flood Control Act of 1937 authorized the first Federal Flood Control Projects in the Hudson Raritan Estuary. Closer to the subject at hand, New York District built a seawall, levee and pedestrian walkways at Liberty State Park as part of a flood protection project authorized by the Supplemental Appropriations Act of 1985.

A summary of reports produced by the Army Corps of Engineers on Liberty State Park is listed below:

1. Effects of Construction of the Liberty State Park on Hydraulic Characteristics of New York Harbor (September 1976).
2. Cultural Resource Reconnaissance Liberty State Park (produced by Historic Conservation and Interpretation for New York District) (May 1977).
3. Plan of Study, Liberty State Park (April 1980).
4. Liberty State Park, New Jersey, Levee and Seawall Design Memorandum and Project Design (June 1981): resulted in construction of levee, seawall, and pedestrian walkway known now as Liberty Walk on the eastern edge of the park, completed in 1987.
5. §905(b) Reconnaissance Report of the Hudson-Raritan Estuary (June 2000): Federal interest was identified in pursuing ecosystem restoration in the Hudson-Raritan Estuary. A two-pronged approach was identified, in which a Comprehensive Restoration Implementation Plan would be developed in conjunction with site-specific restorations at 13 identified building blocks. Liberty State Park is the first of these building blocks recommended for implementation.

6. Restoration Opportunities in the Hudson-Raritan Estuary (April 2001): a technical supplement to the §905(b) Reconnaissance Report that identifies specific estuarine and coastal restoration opportunities within HRE.

In conducting this feasibility study, a number of documents were consulted that had been prepared by others. A partial list is contained in the References section of this report. The most notable of these were the "Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary;" prepared in May 2003 by the Regional Plan Association based on the recommendations of the Harbor Estuary Program Habitat Working Group and Estuary Stakeholders; "General Design Memorandum for The Parks Interior Section;" prepared by the New Jersey Department of Environmental Protection Division of Parks and Forestry in October 2001.

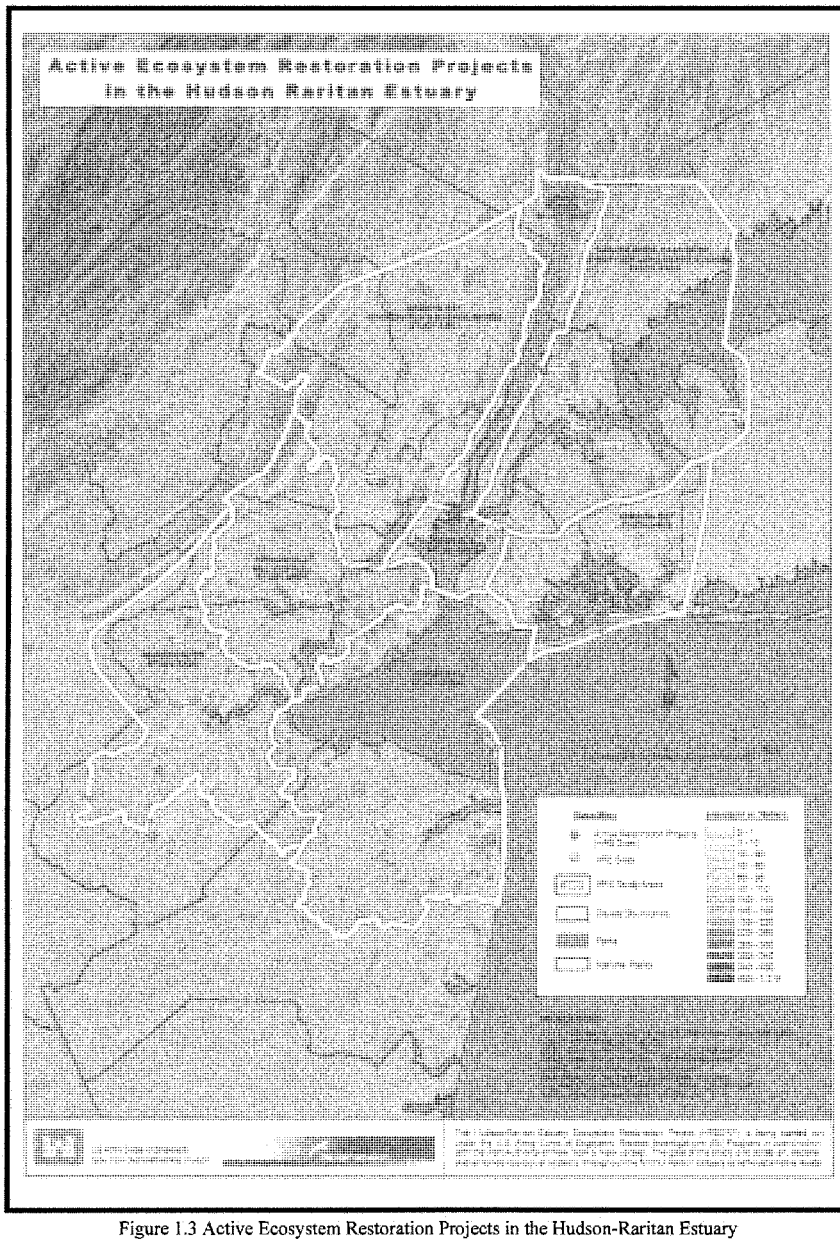


Figure 1.3 Active Ecosystem Restoration Projects in the Hudson-Raritan Estuary

Table 1.1. A Partial List of Active New York District Projects Related to Ecosystem Restoration in the Hudson-Raritan Estuary.

PROJECT	COUNTY, STATE	PHASE	NON-FEDERAL SPONSOR	MAP LABEL[1]
HRE EFFORTS				
Liberty State Park (one of the original 13 sites identified in the HRE Reconnaissance Report)	Hudson County, NJ	Feasibility Phase Investigations	Port Authority of New York and New Jersey	1UB
Comprehensive Restoration Implementation Plan (CRIP)	New York, New Jersey	Feasibility Phase Investigations	Port Authority of New York and New Jersey	N/L
HRE-Sherman Creek (one of the original 13 sites identified in the HRE Reconnaissance Report)	New York, NY	Feasibility Phase Investigations	Port Authority of New York and New Jersey	9HEL
HRE-Newtown Creek (one of the original 13 sites identified in the HRE Reconnaissance Report)	Kings County, NY and Queens County, NY	Feasibility Phase Investigations	Port Authority of New York and New Jersey	32 HEL
HRE- Hackensack-Meadowlands	Bergen County, NJ, and Hudson County, NJ	Feasibility Phase Investigations	New Jersey Meadowlands Commission	20NHP
HRE - Lower Passaic	Passaic County, NJ; Essex County, NJ; Hudson County, NJ, and Bergen County, NJ	Feasibility Phase Investigations	New Jersey Department of Transportation, Office of Maritime Resources	7NHP
HRE - Gowanus	Kings County, New York	Feasibility Phase Investigations	New York City Department of Environmental Protection	3UB
GENERAL INVESTIGATIONS				
NY & NJ Harbor Deepening Project	New York & New Jersey	PCA on May 28	The Port Authority of New York and New Jersey	N/L

1. The characters in this column indicate the label by which the site can be located on Figure 1.3, when applicable. Some projects, such as the CRIP, were too comprehensive to be located with a single point.

PROJECT	COUNTY, STATE	PHASE	NON-FEDERAL SPONSOR	MAP LABEL[1]
GENERAL INVESTIGATIONS (continued)				
South River Flood Control and Ecosystem Restoration	Middlesex County, New Jersey	Feasibility Phase Investigations	New Jersey Department of Environmental Protection	N/L
Jamaica Bay Ecosystem Restoration Project - Including Dead Horse Bay, Spring Creek, Fresh Creek, Brant Point, Bayswater, Hawtree, and others	Queens, New York	Feasibility Phase Investigations	New York City Department of Environmental Protection	3JB, 6 JB, 44JB, 52 JB
Hudson River Ecosystem Restoration Project	New York	Feasibility Phase Investigations	New York State Department of Environmental Conservation and the New York State Department of State	N/L
Flushing Bay and Creek Ecosystem Restoration Project	Queens, New York	Feasibility Phase Investigations	The Port Authority of New York and New Jersey and the New York City Department of Environmental Protection	25HEL
Rahway River Basin Flood Control and Environmental Restoration Project	New Jersey	Feasibility Phase Investigations	New Jersey Department of Environmental Protection	12AK
Woodbridge River Basin Flood Control and Environmental Restoration Project	New Jersey	Feasibility Phase Investigations	New Jersey Department of Environmental Protection	32AK
Bronx River Basin Ecosystem Restoration Project	Bronx, New York Westchester, New York	Feasibility Phase Investigations	Westchester County Department of Planning, New York City Department of Environmental Protection	18HEL
Saw Mill River Basin Ecosystem Restoration Project	Westchester, New York	Feasibility Phase Investigations	Westchester County Department of Planning	N/L

PROJECT	COUNTY, STATE	PHASE	NON-FEDERAL SPONSOR	MAP LABEL[1]
CONTINUING AUTHORITIES PROGRAM				
Lincoln Park (Section 1135)[2]	Jersey City, New Jersey	Feasibility Phase Investigations	New Jersey Department of Environmental Protection	2UB
Gerritsen Creek (Section 1135)[2]	Kings County	Pre-Construction Engineering & Design	New York City Department of Parks	19JB
Spring Creek (Section 1135)[2]	Queens County, Kings County	Feasibility Phase Investigations	New York City Department of Parks	3JB
Soundview Park (Section 206)[3]	Bronx County	Feasibility Phase Investigations	New York City Department of Parks	17HEL
Hempstead Harbor (Section 206)[3]	Nassau County	Feasibility Phase Investigations	Town of North Hempstead	20HEL

Notes:
1. The characters in this column indicate the label by which the site can be located on Figure 1.3, when applicable. Some projects, such as the CRIP, were too comprehensive to be located with a single point.
2. Section 1135 of Water Resources Development Act 1986: Project Modifications for Improvements to the Environment
3. Section 206 of Water Resources Development Act 1996: Aquatic Ecosystem Restoration

2. SITE HISTORY

The project area at Liberty State Park was once mostly open water known as Communipaw Cove (Figure 2.1). The name comes from the Native American term, "Gameonpa," meaning, "where the water remained." Before the site was filled in the industrial era, the Lenape Indians used it mainly for fishing and collecting oysters.

The Dutch first moved into the area around the 1630s, buying land from the Lenape to create the district of Pavonia. However, disputes over land and property between the Dutch and the Lenape created friction between the two groups, which culminated in the Dutch-Indian War (1643-5). The Dutch repurchased the land of Pavonia in 1658 from the Hackensack Indians in an effort to avoid any more misunderstandings over property rights. The transaction created what is now Hudson County. A village named Communipaw was established at the cove. While the nearby village of Bergen rapidly developed, Communipaw Cove was used mostly for oystering, fishing, and running a ferry to Manhattan across the Hudson River. Such uses persisted after the English took over the area from the Dutch in 1664. The surrounding area was populated with factories, equipment, and experienced other effects of industrialization. However, Communipaw Cove remained a quiet, rural area where people went to fish and collect oysters until it was filled in the late 19th century.

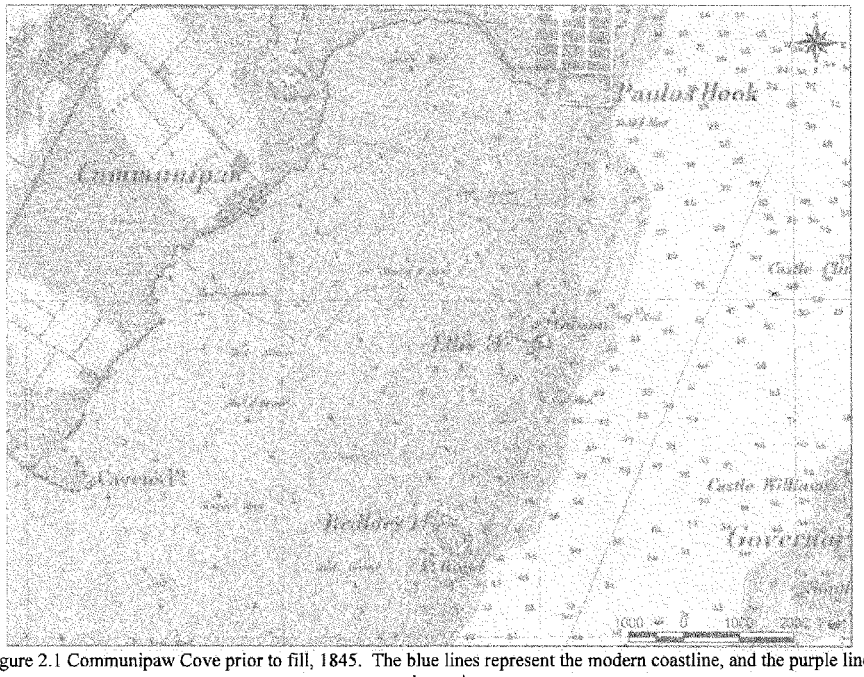


Figure 2.1 Communipaw Cove prior to fill, 1845. The blue lines represent the modern coastline, and the purple line represents the project area.

The railroad industry was the primary force behind the filling and development of the Cove. Jersey City's location, right on New York Harbor and connected to the mainland, made it a logical hub between the ships that sailed into the harbor and the trains that carried the goods inland. The Wharf Act of 1851[4] permitted shoreline property owners to build docks and other structures on the water with nothing more than consent from the County Board of Freeholders. Railroad companies capitalized on the Wharf Act, buying lots to fill for the creation of land. There were a number of competing railroad companies in the area, but the primary entity responsible for filling the cove was the Central Rail Road of New Jersey, which placed over 20 million cubic yards into the cove from approximately 1880 to 1916 in a north to south direction (Figure 2.2). The bulk of Liberty State Park as it exists today was created through railroad activities, although some isolated filling activity may be associated to other entities over the course of history.

Economically speaking, these activities were a boon to Jersey City, and its fortunes rose along with those of New York Harbor. Effects upon local natural resources at Communipaw, however, were another matter. The oyster, fish, and mudflat habitats are now defunct. Industrialization also took its toll in terms of contamination. Chromium processing plants in the area polluted the soil. There was also slag and ash from the railroads.

[4] New Jersey L.1851, p.335.

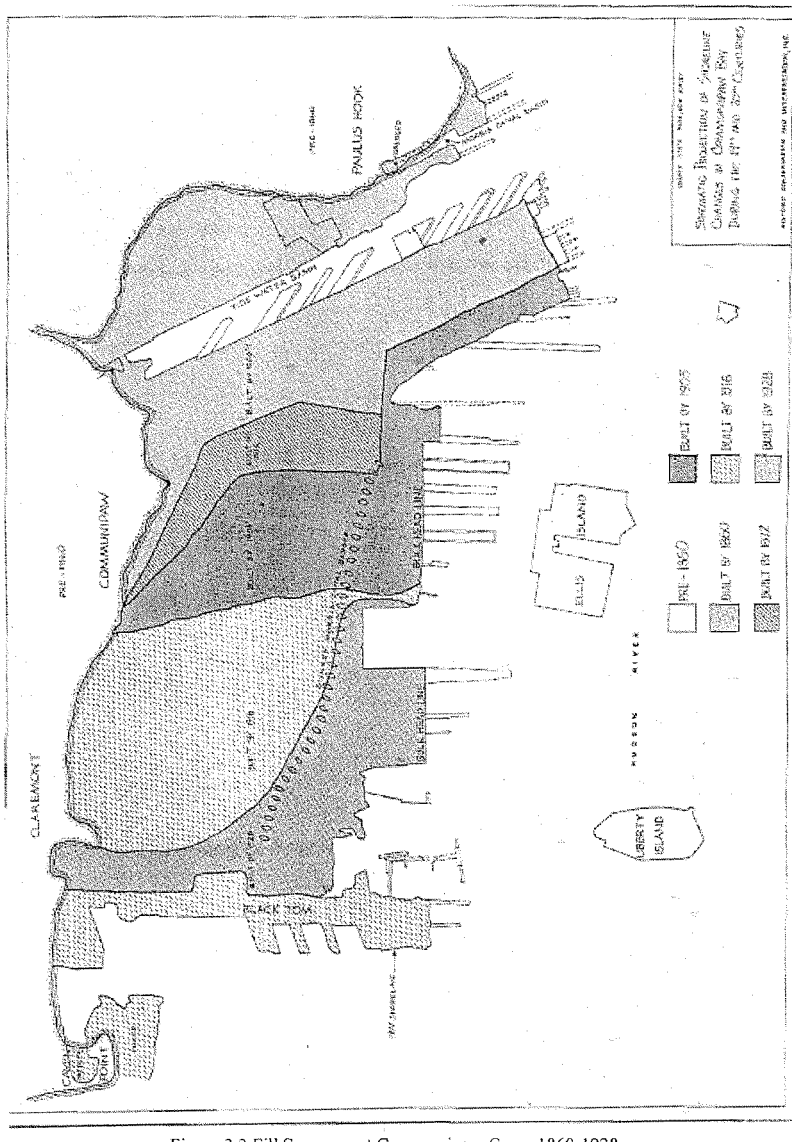


Figure 2.2 Fill Sequence at Communipaw Cove, 1860-1928

Evidence of contamination is present today in the portions of Liberty State Park that are fenced off.

The fortunes of the railroad industry at Jersey City declined in the middle of the 20th century due to a decreased demand for resources such as coal. The waterfront rail yards were abandoned by 1967 with the bankruptcy of the Central Railroad of New Jersey, and came into the possession of Jersey City. In the following decade, the former railroad site was proposed for extensive waterfront revitalization. Jersey City turned the land over to the State of New Jersey, which used a combination of federal and state funds to convert the site into Liberty State Park (LSP 2003). Liberty State Park opened to the public in 1976 as part of the national bicentennial celebrations. Approximately 160 acres, mostly within the interior of the park, remain undeveloped. The proposed ecosystem restoration project focuses on these 160 acres.

3. EXISTING CONDITIONS

3.1 Physical Setting

The Liberty State Park Site is located in Jersey City, New Jersey, along the lower Hudson River, approximately two (2) miles south of the Holland Tunnel Crossing and on the mainland, just west of Ellis Island (Figure 1.2). Located in Hudson County, NJ, the potential restoration site is generally bordered by Phillip Street on the west[5], the mowed grass areas south of Audrey Zapp Drive on the north, Freedom Way on the east[6], and Thomas McGovern Drive on the south.

Liberty State Park is located within the Hudson Raritan Estuary, specifically the lower Hudson River Estuary, in Jersey City, Hudson County, New Jersey. Historically, as late as the mid 1800's, the general area that now encompasses LSP was predominantly shallow open water, intertidal mud flat, and salt marsh along its western fringes adjacent to the South Bergen glacial moraine that runs north-south along this part of the New Jersey shore. The vast majority of the proposed restoration area, as well as the majority of LSP itself, was shallow open water estuary ranging in depth from approximately 2 to 6 feet MLW (according to 1845 bathymetry).[7]

The outline of the proposed restoration area is superimposed upon a map of existing physical/cultural conditions in Figure 2.1. The entire LSP is anthropogenically derived; it is made from fill, rubble, dredged material, construction and debris materials, cinder from railroad operations and other wastes, as documented exhaustively in chronological sequence in Figure 2.2. The Cultural Resources appendix also contains many representative photographs of existing physical conditions at the proposed restoration area.

The undeveloped area in the center of the park has remained undeveloped and a fence restricts access to the public due to the presence of polynuclear aromatic hydrocarbons (PAHs), pesticides, and metals that exceed the NJDEP residential clean up criteria (MacFarlane 2001). Some of the fill in the undeveloped area comprises materials dredged from the Upper Bay during construction of the LSP causeway. Due to the historic use of the park as a rail yard, there is little historic drainage into the park from outside. Recent construction, such as the Liberty Science Center and the New Jersey Transit Light Rail Terminal and parking lot, contribute storm water runoff to the fringes of the park, but not to the interior.

The area surrounding Liberty State Park is essentially fully developed with little room for additional development. Commercial and industrial development is immediately adjacent to the park to the west and south. LSP is bordered on the west by a highly industrialized, commercialized and densely populated urban area of Jersey City, on the north by the Morris Canal, on the east by Upper Bay and on the south by the "Black Tom" cove. The physical setting of each of these areas is described in further detail below.

[5] Except for the Liberty Science Center wetland area, which extends to the New Jersey Turnpike.
[6] Except for the tidal creek inlet area, which extends to North Cove.
[7] Figure 3.1 of the Cultural Resources appendix (1845 USGS Coast chart) shows the outline of most of the proposed restoration area. The outline does not include the Liberty Science Center wetland and the proposed tidal creek inlet area, which were added later in the project development process. (This applies to all of the figures in the Cultural Resources Appendix.) As per the 1845 chart, the LSC wetland area had a greater proportion of salt marsh than the remainder of the proposed restoration area.

Jersey City

The area west of LSP in Jersey City is characterized by extensive industrialization and by intense residential development, the majority of which is working class neighborhoods. The mostly elevated NJ Turnpike also dominates the view just west of LSP at the base of the South Bergen/Communipaw glacial moraine. There is also a light rail link that partially moves through the same transportation corridor as the NJ Turnpike. Since LSP is built on fill in the Upper Bay at the base of this eastward sloping landscape, surface water of degraded quality tends to flow towards LSP. This is primarily street drainage from the physical settings described above. However, this water is the only feasible source of abundant fresh water to enhance fresh water wetland and aquatic habitat in the proposed restoration area (refer to section 3.3.1). The Liberty Science Center is another dominant physical feature on the western edge of LSP.

Morris Canal Area

The Morris Canal and the high-rise structures of the rejuvenated Jersey City waterfront dominate the area north of LSP. The canal itself, although connected to the Upper Bay, is now a dead-end basin with poor flushing characteristics. It has hypoxic to anoxic dissolved oxygen conditions in the summer months, also partially due to the discharge of a large CSO at its head. However, attempts to cleanup and provide waterfront recreational amenities to this area are moving ahead. There is a walkway near the mouth of the canal that connects LSP to the Jersey City waterfront area. This walkway provides pedestrian access to LSP from PATH trains, light rail, and bus. The Grove of Remembrance (Millennium Park) is a special area of LSP dedicated to residents of New Jersey who lost their lives at the World Trade Center on 11 September 2001. This is a grassy area with trees and appropriate landscaping that will remain separate from and not be negatively affected by the proposed restoration project.

Upper Bay

The entire eastern side of LSP is abutted by Upper Bay. The bay's vistas of lower Manhattan, Ellis Island, the Statue of Liberty, and the Verrazano Bridge are prominent at LSP. This position at the heart of the urban portion of the Hudson-Raritan Estuary underlies the appeal of this park and separates it from most other park locations in the region. Upper Bay has variable water quality that changes frequently with weather, tides and seasons, which was taken into consideration in restoration plans. The proximity of the bay and the tidal forces directly fronting the eastern side of LSP is the key characteristic that makes tidal marsh restoration feasible at this site. The bottom of the bay along the promenade (east) side of LSP is a varied mixture of mud, rock and other coarse material. It varies from biologically stressed to highly productive depending on location and currents. Fishing, both from boat and shore, is popular in this portion of the estuary, particularly around Ellis Island and the Statue of Liberty.

In general, incoming (northward moving) tidal currents tend to bring higher salinity, better quality water from the southern, cleaner portion of Upper Bay. However, CSO discharges may contribute to water quality degradation in North Cove during high precipitation periods when STP capacities are exceeded. Likewise, on outgoing (southern moving) tides, poor-quality water from the Morris Canal may affect the eastern waterfront area of LSP, including North Cove. In general, however, WQ is sufficiently high enough to support benthic and fish communities in North Cove and the proposed tidal marsh.

Black Tom Area

To the south of LSP is the remaining unfilled portion of "Black Tom", a formerly industrialized cove area with many pilings and anthropogenic rock and rubble structures. On the distant side of the cove is Port Liberté, an upper-income housing development that has spurred clean-up activities in this area. There is currently a major golf course under construction in this area. The Black Tom itself is an area of generally poor water quality, but is more open to the wind driven waves of Upper Bay than Morris Canal. LSP visitors can sometimes see harbor seals on rocks in this area.

3.1.1 Geology

New Jersey has a very diverse geology containing rocks ranging from the Precambrian Era to the current Holocene Era. Overall, the rock of these different Eras are distributed across the state from north to south according to age, although the order is reversed in the New Jersey Highlands due to thrusting of deeper and older Precambrian rocks over younger Paleozoic rocks. Four major geologic provinces occur in New Jersey, namely: (i) Appalachian Valley and Ridge, (ii) New England (Reading Prong), (iii) Piedmont, and (iv) Coastal Plain. The four geologic provinces are shown in Figure 3.1. The Liberty State Park project site is located within the Piedmont physiographic province. Rocks of the Piedmont province include inter-bedded sandstone, shale, conglomerate, basalt, and diabase. They underlie a broad lowland interrupted by long, generally northeast-southwest trending ridges and uplands. The rocks of the Piedmont Province are of Late Triassic and Early Jurassic age (230 to 190 million years old). They rest on a large, elongated, crustal block that dropped downward in initial stages of the opening of the Atlantic Ocean – one of a series of such blocks in the eastern part of North America. These dropped-down blocks form valleys known as rift basins. Sediment eroded from adjacent uplands, and was deposited along rivers and in lakes within the basins. These sediments became compacted and cemented to form conglomerate, sandstone, siltstone, and shale, which commonly have a distinctive reddish-brown color.

New Jersey has undergone three major glaciations. The last glacier (the late Wisconsin advance) began to melt back from its maximum extent approximately 20,000 years ago. North of the last glaciation, the surface is covered with glacial deposits. Upland areas in this region are thinly draped with till, and unsorted mixture of sand, clay, and boulders deposited directly from the glacier. Valleys and lowlands are filled with up to 350 feet of sand and gravel deposited from glacial melt water and silt and clay that settled in glacial lakes. Much of the surficial deposits include artificial fill, alluvial, estuarine, and eolian sediments of postglacial age, and glacial melt water deposits that are of late Wisconsin age. During each glaciation, sea levels dropped as water from the ocean was transferred to ice sheets. Rivers extended and deepened their valleys to conform to the lower sea levels. When the ice sheets melted, sea level rose, flooding the deepened valleys and establishing new shorelines. The present configuration of the shoreline is the result of rapid post-glacial rise in sea level. Many of the estuaries along the shore are drowned lower reaches of former river valleys. Mud and sand transported by rivers is gradually filled the former river valleys, creating extensive wetlands.

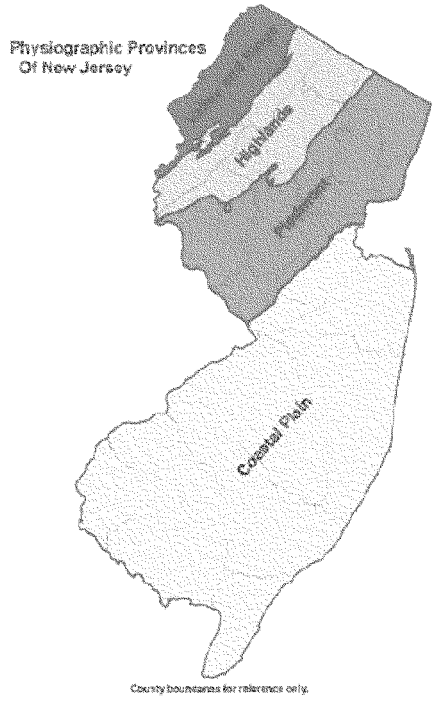


Figure 3.1 New Jersey Geologic Provinces

LSP is located at the south end of the glacial ridge (moraine) separating the Newark Bay Basin from the lower Hudson Basin, along the east edge of the Piedmont Physiographic Province. Bedrock deep beneath the project area is Triassic-Jurassic sedimentary formation. The entire LSP was created from fill material between the mid 1800's and the 1960's. There is no natural geology. Prior to fill, LSP was predominantly shallow open water, with much intertidal flat and some salt marsh along the western fringe, correlating to the shoreline at that time. The type and volume of fill varies between locations within the site. Previous investigations of the fill material at Liberty State Park by NJDEP (NJDEP 1995) indicate that the material consists primarily of cinder and ash fill, mixed rubble and debris, and dredged material, likely underlain by organic clay, glacial melt water deposit, alluvial deposits, and glacial till. Bedrock in nearby New Jersey Geological Survey (NJGS) borings is 40 feet deep or deeper. There are no rock outcrops anywhere on LSP, although they do occur in some parts of the New York-New Jersey Harbor, and natural substrate is between 15 to 30 feet below the surface.

Heaving sands have also been reported by NJDEP at depths greater than 20 feet. A freshwater wetland that exists at the west side of the site must be supported and maintained. Given the coarseness of the fill, the project area soil is extremely pervious, which partially accounts for the

lack of permanent fresh water habitat on the site. The geology of the site is described in greater detail in Appendix E.

3.1.2 Topography

There is no macrotopography to LSP, as it is a relatively flat site due to the nature of its use as a railroad yard for over a century. Small linear berms between the old railroad tracks were created during the construction of the railroad yard. Typically, changes in elevation exist only as the result of the additional deposition of dredged material or the construction of DM containment berms following cessation of rail operations. Additional changes in relief commenced with the construction of LSP, which including the addition of a shorefront promenade and removal of the pier system that serviced the rail operations.

Microtopography (less than a few feet) varies depending on location. Topographic and bathymetric surveys were conducted in 2003 and are documented in the Engineering Appendix. It is clear from the topographic survey that water tends to settle where microtopographic elevations are low, for relatively short period due to the high permeability of site substrate. In some locations, microtopography has encouraged the formation of wetlands, such as Jurisdictional (JD) wetlands No. 3 and No. 8 (Figure 3.8). Microdepressions also occur around remnant railroad tracks. Often these sites support small and fragmented but numerous patches of fresh water wetland vegetation. Slopes on site are very shallow, making manipulation of gravity flow of surface water difficult.

North Cove is a shallow indentation in the predominantly straight eastern shoreline of LSP facing Upper Bay. Depths vary from Mean Low Water (MLW) along the internal shoreline of North Cove to about 6 feet MLW at the center of the cove near the promenade. Bathymetry east of the promenade in Upper Bay is a generally shallow "flat" but is crossed by dredged channels in certain areas. The bathymetry of North Cove is discussed in further detail in Appendix E. See Figure 3.2 for the overview sheet of the LSP topographic/bathymetric maps. The individual sheets (1-4) can be found in the Engineering Appendix.

3.1.3 Soils

Topsoil is thin and shallow, and non-existent in some locations. The existing upper soil horizon has developed from overgrowth-derived organic matter since incremental abandonment of the railroad yards. As mentioned previously, deeper soils are virtually all anthropogenic fill materials of varying texture. The geotechnical cores taken for this project indicate alternating lenses of sand and clay to a depth varying between 15 and 30 feet below the current surface of LSP. At this depth, the pre-1860's (pre-fill) natural alluvial soils of the estuary are reached. Small amounts of peat, indicting former approximate depths of relict salt marsh are found in some locations. The US Department of Agriculture (USDA) Soil Conservation Service (SCS) has not prepared a Soil Survey Report of Hudson County. However, a preliminary mapping based on field observation was published in 1952. In general, natural soils (sediments) in the vicinity of the project area were derived from stratified drift and wash from glacial till. More specifically, the project area would have been inundated alluvium and muck prior to landfill creation.

Figure 3.2 – Overview of LSP topographic/bathymetric maps

The results of the geotechnical analysis indicate that the soils vary considerably across the site. Both fine-grained and course grained soils are present. Soils in virtually all of USCS soil classification are found on site. The project site is overlain with coarse-grained soils.[8] Average thickness of this coarse-grained layer is about 14-ft, although local variations exist with both thinner layers (3-ft) and thicker layers (30-ft plus) encountered. Underlying this coarse-grained layer is a layer of fine-grained soil.[9] This fine-grained layer was observed in about 85% of the drill holes, and was encountered at an average depth of 13-ft. The thickness of this fine-grained layer ranged from 1.5-ft. to 27-ft, averaging out about 12-ft throughout the site. Subsequent lower layers of coarse-grained and then fine-grained soils were occasionally encountered. At surface depths to 4.5 ft below grade, approximately 90% of the soil is poorly graded silty sand and approximately 6% is clay. This largely accounts for the generally very high infiltration rate of this site. However, there may be clay lenses at depth that restrict and redirect groundwater flow, potentially causing "perched" water tables that contribute to the existence of JD wetlands and the wetter parts of some terrestrial habitats. Man-made debris materials were found in about 27 of the 49 total drill holes. Near surface excavation of this material should present no unusual excavation problems. However, deeper excavations, notably excavation of the proposed tidal inlet in the vicinity of the North Cove, may require additional earth moving and dewatering equipment to allow excavation to take place within the soft clay layer. An initial phase (Phase I) of drilling and sampling program was performed during August and September of 2003. Thirty-eight drill holes were completed and a comprehensive geotechnical testing program was performed. An additional phase (Phase II) of drilling and sampling program was performed in February 2004. The results of the geotechnical investigation can be found in Appendix E. Chemical contamination of soil is addressed in section 3.12 (HTRW).

3.2 Climate

The climate of Jersey City, New Jersey, is characteristic of the Middle Atlantic seaboard. Marked changes in weather are frequent, particularly during the spring and fall. The winters are normally moderate, and the summers are generally hot and humid with frequent thunderstorms. Precipitation is also moderate, with about 45 inches falling annually, well distributed throughout the year. Summer totals of precipitation are slightly higher than those of winter. Average monthly temperatures ranges from 38 to 78 degrees Fahrenheit with extremes ranging from 22 degrees below zero to 105 degrees F at Newark, NJ. The growing season averages 174 days. However, early spring vegetation can start growing in late February and late autumn flowers can bloom outdoors until December under beneficial conditions. The mean annual relative humidity varies from 53 to 73 percent. Prevailing winds are from the northwest with an average annual velocity of approximately 10 miles per hour. The number of days with rainfall of 0.01 inch or greater averages about 122 per year, generally contributing to keeping soil moisture content in the region relatively high through the growing season, although droughts can occur.

Appropriate climate and precipitation data was analyzed for this project to develop a water budget and predict the potential for enhancing fresh water wetland habitats. This analysis is described in detail in the Engineering Appendix (Hydrology and Hydraulics of Fresh Water Wetlands Report, Section 3.3).

[8] Sands, silty sands, silty gravels, etc.
[9] Clay, clay with traces of shells, sand, and gravel, etc.

3.3 Water Resources

3.3.1 Surface Waters

TIDAL INFLUENCES

The project is located on the western banks of Upper New York Bay, at the mouth of the Hudson River, which has a drainage area of 13,370 square miles. While the project area originally was shallow estuary, filling activities and hardening of the shoreline have disconnected the area from the tide. For this study, water level recorders in the South Cove and in Morris Canal observed tidal signals for a period of 6-14 weeks. The South Cove gage was the closest gage to the proposed tidal creek inlet in the North Cove. The results of the tidal analysis at the South Cove gage revealed that the tidal ranges (diurnal tide range, great diurnal tide range, and spring tide range) at LSP for the period of record 31-July 2003 to 11-Sept. 2003 were 4.69, 4.82 and 6.39 ft, respectively.

All the tidal data computed can be found in table 3.1. Mean High Water (MHW) and Mean Low Water (MLW) are calculated by measuring the elevation differences between the highest water level and lowest water level for each tide cycle in the period of record. Diurnal Tide Range (RangeM) is the difference between the MHW and MLW data. In this region of the North Atlantic Ocean, there is one slightly higher tide within each two tide cycle segments. Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW) are calculated by measuring the elevation differences between the highest water level and lowest water level within each two tide cycle segments. Great Diurnal Tide Range (RangeGD) is the difference between the MHHW and MLLW datums. Mean High Water Spring (MHWS) and Mean Low Water Spring (MLWS) are calculated by measuring the difference between the highest water level and lowest water level that occurs during each full and new moon (approximately twice a month). Spring Tide Range (RangeS) is the difference between the MHWS and MLWS data.

The observations from the other gages were compared to the NOAA Tide Station 8518750 at The Battery, NY, 2000 ft directly across the bay, and the signals were extrapolated to the 1983-2001 Tidal Epoch using the NOAA, modified range ratio method (Appendix E). Readings from the Battery were deemed to best represent the anticipated conditions because of its relative position to the proposed tidal creek and North Cove. The results of the extrapolation revealed that the 1983-2001 Tidal Epoch for the South Cove diurnal tide range, great diurnal tide range, and spring tide range at LSP is 4.51, 4.84 and 5.60 ft, respectively. All the data observed and calculated can be found in Table 3.1

STORM SURGES

Hurricanes and Northeaster storm events frequently influence the tide stage in Upper New York Harbor Bay. The Liberty State Park Causeway Project (USACE 1981) determined the frequency of these high water events (Figure 3.3). Morris Canal and the North Cove will experience similar stages for the same storm surge events. Audrey Zapp Drive on the north side, Phillip Street on the west side, Thomas McGovern Drive on the south side and Freedom Way along the east side all lie at elevations between 8 – 10 ft NAVD88. All currently act as shore protection for the more frequent storm surge events. The proposed tidal wetland will be connected to the

Location	Morris Canal	South Cove	NOAA-NOS Battery, NY	Morris Canal	NOAA-NOS Battery, NY	NOAA-NOS Battery, NY	Reconstructed* South Cove
start	31-Jul	31-Jul	31-Jul	31-Jul	31-Jul	1983 to	1983 to
finish	11-Sep	11-Sep	11-Sep	21-Nov	21-Nov	2001	2001
MHWS	3.01	2.72	3.14	3.17	3.28	2.44	2.29
MHHW	2.36	1.96	2.58	2.24	2.43	2.28	1.91
MHW	2.25	1.84	2.24	2.19	2.12	1.95	1.75
MTL	-0.06	-0.51	-0.11	-0.08	-0.08	-0.31	-0.51
MLW	-2.37	-2.65	-2.46	-2.34	-2.27	-2.57	-2.77
MLLW	-2.39	-2.86	-2.46	-2.38	-2.47	-2.78	-2.93
MLWS	-3.20	-3.67	-3.14	-3.26	-3.24	-3.06	-3.31
RangeM	4.62	4.69	4.70	4.53	4.39	4.52	4.51
RangeGD	4.75	4.82	5.04	4.60	4.90	5.06	4.84
RangeS	6.21	6.39	6.28	6.43	6.52	5.50	5.60

*Reconstructed South Cove Tidal Datums were used for the design of the tidal wetland. They were obtained by comparing the South Cove and Battery datums from 31-Jul-2003 to 11-Sep-2003, and reconstructing them to the 1983-2001 tidal epoch, using the Battery as the primary record.
**All elevations are in ft NAVD88

Table 3.1 Liberty State Park Water Level Observations: Summer and Fall 2003

bay via the proposed tidal creek inlet in the North Cove. The existing elevations of the adjacent upland area surrounding the proposed tidal wetland are about 10ft NAVD88. The proposed tidal wetland will flood for lower frequency events and the tidal event will be contained within the wetland. It is anticipated that the wetland will be resilient enough to withstand these flood events, just as natural tidal wetlands currently do in the vicinity of Liberty State Park. In the proposed Fresh Water Wetland area, the scenario is the same as the fresh water wetland. The proposed project will not affect any structures.

FRESH WATER HYDROLOGY

Currently, the project site is encompassed within the interior of Liberty State Park. The streets adjacent to the park drain into ditches that discharge either into Morris Canal or into the Harbor. The watersheds included in the proposed project consist of four catchment areas: (1) the interior of Liberty State Park, (2) the Liberty Science Center (LSC) and parking lot, (3) the existing wetland area immediately adjacent to the Science Center, and (4) the NJ Transit parking lot and adjacent drainage area.

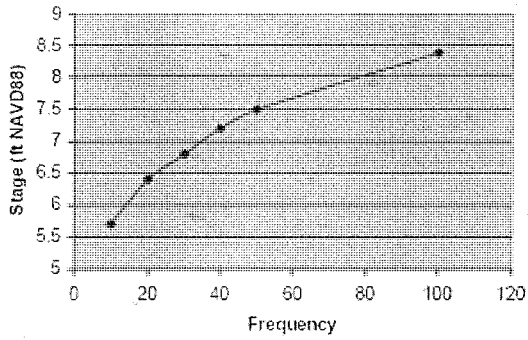


Figure 3.3 Storm Surges at the Battery, NY

In the interior of Liberty State Park, there are several small drainage areas within the park itself due to the lack of significant relief within the park, the presence of old berms, dredged material mounds, and other debris mounds. There are numerous small drainage areas and several existing freshwater wetlands areas that will be retained in the proposed plan. Near the center of the park, an existing shallow emergent marsh is adjacent to the 45-acre dredged materials area. North and west of this wetland is upland terrain. This upland area has potential for restoration due its proximity to potential sources of additional freshwater runoff. The drainage area for the existing, two-acre shallow emergent marsh is approximately 20 acres, all of it pervious. No additional impervious areas provide runoff to this area. No significant source of runoff is currently routed to the proposed tidal wetland.

The drainage area within the LSC complex can be divided into two main subcatchment areas: the LSC parking lot and the LSC itself, which consists of roof drains, walkways, and nearby mowed areas. The LSC parking lot is approximately 10.4 acres, 89% of which is impervious. Along Phillip Street is a drainage ditch referred to as the East Ditch. This ditch primarily provides the conduit for runoff from the LSC parking lot to the Morris Canal. The drainage area of the LSC itself is approximately 8.5 acres, with 50% of it impervious. Runoff from the LSC flows to either the West Ditch along Phillip Street or to the adjacent wetland.

An existing wetland is currently located immediately north of the LSC. The wetland area is approximately 2.3 acres in size, with an immediate drainage area consisting of the New Jersey Transit parking lot and a small adjacent area totaling approximately 11.13 acres.

Across the NJ Turnpike from the Liberty Science Center is the NJ Transit Light Rail Liberty State Park Station, which provides service to Bayonne, Jersey City and Hoboken. The terminal consists of an outdoor station and a parking lot. The NJ Transit terminal area is divided into the three subcatchment areas: the parking lot and interior detention basin, the southern terminal area and detention basin, and the northern terminal area and drainage swale.

3.3.2 Water Quality

Since there is no permanent moving surface water on site (i.e., all surface water is temporary precipitation and/or groundwater derived) on-site fresh water quality is predominantly influenced by the short-term effects of the quality of the water received in storm events. Water quality is also influenced by highly permeable on-site soils, which encourage rapid drainage and turnover in low topographic areas (largely vernal pools). Also, in general (notwithstanding storm events which can occur at any season), there is a water surplus on site during winter and spring, and a deficit in summer and fall. Hence, the effects of on-site water quality are primarily on certain adaptable wildlife species, preferentially affecting seasonally water-dependent amphibians and reptiles (Appendix B). These taxa occur in relatively low abundances and species-richness on this site. There are no fish, since there is no permanent standing water. Thus, water quality is suitable for those species that can occur under these stressful conditions, namely, unreliable and often temporarily completely unavailable water. Even under extremely wet conditions, it cannot be expected that any particular pool or low topographic area will retain standing water for more than a few weeks. During high evapotranspiration (summer/early fall), periods of standing water are generally on the order of days.

There is little connection between fresh water quality and human health, since neither surface nor groundwater is used for drinking, bathing, fishing, or any other direct contact activity. Disease-bearing freshwater dependent species of mosquito undoubtedly breed on-site. However, there is no reason to consider LSP more of a threat to human health than the numerous other locations located throughout the NY-NJ metropolitan region, such as the thousands of clogged and/or slow-draining neighborhood storm drains.

Water quality in North Cove is highly seasonal and tidally variable but generally moderate to poor, although it was apparently good enough to support a fairly representative fish sample in late summer, 2003, when DO concentration is generally at its seasonal low. Limited DO samples taken on the bottom at that time indicated that concentrations were averaging about 5 mg/L, which is generally considered a borderline condition between stressed on non-stressed, although adequate for most HRE species adapted to high variations in DO.

3.3.3 Regional Hydrogeology and Groundwater

As part of the geotechnical analysis (Appendix E) twelve piezometers were installed as permanent piezometers in existing drill holes for long-term groundwater level monitoring purposes. An additional eight temporary piezometers were also installed in selected existing drill holes. Groundwater depths ranged from about 1.3-ft below existing grade to about 5.5-ft below existing grade, as measured from the twenty piezometers installed throughout the site. Maximum fluctuations in groundwater levels up to 3.1-ft were observed in the piezometers. Groundwater gradients between piezometers were typically very flat. Groundwater flow direction and average gradient calculations suggest that groundwater flow direction is about N35^{0} and discharges towards the adjacent Morris Canal (Figure 3.4). A plan view of the groundwater contour map of the 15 November 2003 groundwater readings is shown in Figure 3.5. Due to the possibility of contamination in the ground water and/or proposed excavation elevations and soil contamination, the proposed plan includes an impervious clay layer to be placed where excavation will take place for the fresh water and tidal wetlands.

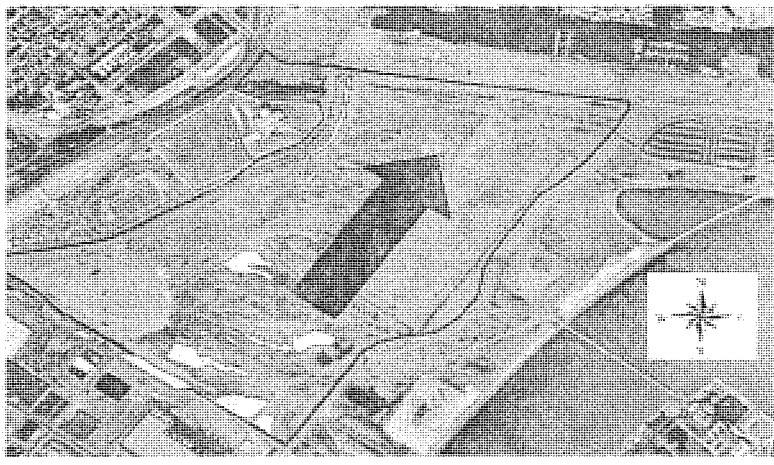


Figure 3.4 LSP Groundwater Flow Direction

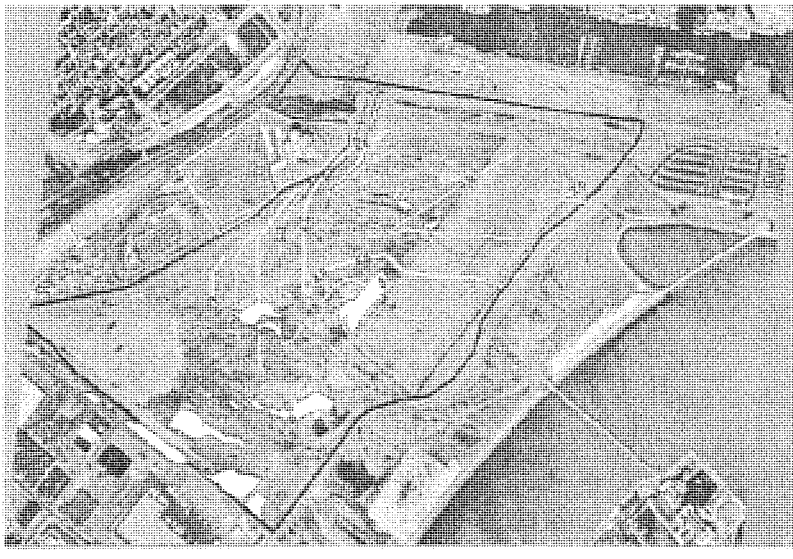


Figure 3.5 LSP Groundwater Contours

3.4 Socioeconomic Conditions

3.4.1 Population

Liberty State Park is located in Jersey City, Hudson County, New Jersey. Jersey City is the most populated of Hudson County's 12 municipalities, with 39% of Hudson County's population residing in Jersey City. With a population of 240,055,[10] Jersey City is the second largest city in New Jersey and the ninth most densely populated city in the United States.[11] The population of Jersey City has grown by 2.2% between 1980 and 1990 and 5% between 1990 and 2000.[12] If the population were to continue to grow at the 1990 to 2000 rate, Jersey City would have a population of 271,454 in 2025 and 306,960 in 2050.

3.4.2 Economy, Employment and Income

Jersey City, Hoboken, Kearny, and Bayonne form the industrial base of Hudson County. Trade, transportation, and utility management related industries comprise the highest proportion of jobs in Jersey City (27%).[13] This is followed by government sector employment, and Jersey City's position as County Seat provides approximately 41,200 (almost 15%) of Jersey City's jobs.[14] The Bureau of Labor Statistics (BLS) estimated the number of individuals working in Jersey City to be 278,800 in the year 2003. Comparing this figure to the number of people residing in the area shows that Jersey City is a locus of employment activity for the region.

Jersey City's industrial sector is changing. Manufacturing is still an important source of employment, and a slight statistical decline in manufacturing is partially offset by the increase in wholesale trade, distribution and transportation related activities.[15] Jersey City remains an important transportation terminus and distribution center for goods passing through New York and New Jersey Harbor, with marked peaks in those industries in the November/December timeframe. New job growth has been slight and has only occurred in the BLS categories of Professional & Business Services and Education & Health Services.

Jersey City has an unemployment rate of 6.7% (March, 2004), which is higher than the unemployment rates for both the state (5.2%) and the nation as a whole (5.7%).[16] The per capita income in Jersey City is $19,410, which stands in sharp contrast to the per capita income of $21,154 for the County, $27,006 for the State, and $21,587 for the United States.[17] Jersey City has a median household income of $37,862. This is partly a result of large populations of children and people over 65. In Jersey City, 18.6% of the population and 16.4% of families live below the poverty line. Of the people living in poverty in Jersey City, 27% are under the age of 18 and 17.5% are 65 or older.[18]

[10] U.S. Census, 2000
[11] Ibid.
[12] U.S. Census 2000 compared with U.S. Censuses for 1980 and 1990.
[13] United States Department of Labor, Bureau of Labor Statistics, 2004
[14] Ibid.
[15] Ibid.
[16] Ibid, March 2004 data
[17] United States Census, 2000
[18] Ibid.

3.5 Cultural Resources

As a federal agency, the Corps must ensure that its projects are compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.). This law requires Federal agencies or project sponsors seeking Federal funding and/or permits to take into account the effect of any undertaking on any cultural resource included in, or eligible for inclusion in, the National Register of Historic Places. A cultural resources investigation was conducted for the Corps in the spring of 2003 for the Liberty State Park Restoration Project. Pan-American Consultants, Inc. (PCI) undertook this work and based much of the research on a previous study by Historic Conservation and Interpretation (HCI). HCI conducted their work in 1977 when Liberty State Park was being developed. Background research, a site walkover and analyses were conducted by PCI but no subsurface testing was undertaken.

The area proposed for wetland restoration was once open water. An analysis of soil borings suggests that the potential for buried Late Pleistocene/Early Holocene deposits is high in certain areas within LSP as a whole (Historic Conservation and Interpretation, Inc. 1977). Near the project area traces of peat were found at approximately 43 feet below mean sea level (MSL). Wood, wood fiber and peat on bedrock were found between 94 and 101 feet below MSL. Work in connection with the restoration project is not anticipated to reach these depths. Shallower deposits (11 – 13 feet below MSL) were found to the south of the project area where bedrock rises rapidly. It is unlikely that any deposits would be encountered in the current project area. The sensitivity for prehistoric resources within the project area is low as the location consists entirely of man-made land and no work is anticipated to reach depths determined sensitive for paleo-environmental data. Work along the western edge of the project area, which was once the Communipaw shoreline and is therefore sensitive for prehistoric and early historic resources, will not include excavation.

As discussed above, land at LSP was created over a period of six decades spanning the late 19th and early 20th centuries to hold the vast rail yards that developed along the Jersey City waterfront. HCI included a projection of shoreline changes in their 1977 report that indicates that land filling in the project area was completed by 1916 (Figure 2.2). Associated with the various fill episodes are likely to be timber cribbing and other construction methods used to retain fill. Late 19th and early 20th century cribbing has been recorded throughout the New York and New Jersey Harbor. The filling episodes were documented as they occurred and this data was included as an appendix to the HCI report. Most of the retaining structures were earthen. It should also be noted that Morris Canal boats were deliberately sunk in 1900 to form a fill retaining structure and may be present beneath the fill. Documentary evidence suggests that these boats are located to the east of the project area, on the opposite side of Freedom Way.

Railroad use within the project area was limited to rails, no longer present, and ancillary structures such as signals and livestock pens. The few remnants of these structures that remain on the property are deteriorated and are not considered eligible for the National Register of Historic Places.

The landscape on the whole was altered considerably with the construction of LSP. Within the park, little evidence remains of the once expansive rail yards. The proposed restoration project is within sight of the Statue of Liberty Ellis Island National Monument and the NRHP listed

Central Railroad of New Jersey Terminal. It is not anticipated that the creation of new wetlands and habitat will have an effect on these important historic sites.

The Liberty Science Center Wetlands Complex area was not under consideration for restoration at the time the cultural study was undertaken, and so has not been surveyed. As the project proceeds, this area will be surveyed and subsequent cultural resources work will be undertaken as required. It is the Corps' opinion that the restoration work for the remaining areas at Liberty State Park will have no effect upon cultural resources if project plans remain as proposed. If excavation is determined necessary in the vicinity of the former Communipaw shoreline than subsurface work may be required. The New Jersey Historic Preservation Office concurred with this evaluation (see Appendix C). This work was also coordinated with the Liberty State Park Resource Interpretive Specialist.

3.6 Land Use

3.6.1 Land Use in Jersey City

The land use category of Liberty State Park is classified as recreational. Adjoining the park to the south is Port Liberté, a residential complex with 1,290 condominiums. Liberty Science Center is on the western side of the park. The northern boundary along the Morris Canal has experienced increased residential development and will be further impacted by the construction of the Jersey City Medical Center. Ellis Island and the Statue of Liberty are located a few hundred feet from Liberty Walk, the eastern boundary of the park.

From a broader perspective, Hudson County's residential areas consist mostly of older housing stock, with most housing units containing two or more dwelling units. Single-family detached dwellings are generally found in Secaucus, Kearny, Bayonne and parts of North Bergen. High-rise apartments are located near the Hudson River along the palisades. Overall residential land usage comprises 5,634 acres, or 14 percent of the land area in Hudson County in 1999. The total residential land area increased by 254 acres, or 4.7 % between 1974 and 1999.

Commercial land usage comprises a total of 1,942 acres or 4.9% of the land area in Hudson County in 1999. The total commercial land area increased by 580 acres, or 43.0%, between 1974 and 1999. Industrial land usage comprises a total of 5,129 acres or 12.9 percent of the land area in Hudson County in 1999. The total industrial land area since 1974 has increased by 580 acres or 12.8 percent.

3.6.2 Coastal Zone Management

Pursuant to the Coastal Zone Management Act of 1972 and the Coastal Zone Reauthorization Act Amendments of 1990, New Jersey has defined its coastal zone boundaries and developed policies to evaluate and issue permits for projects located within the designated coastal zone. These policies are set forth in New Jersey's Rules on Coastal Zone Management (N.J.A.C. 7:7, 7:7E, dated July 18, 1996 and addenda to 7:7 and 7:7E, dated August 19, 1996, and December 1999).

The NJDEP administers the coastal permit program through the Coastal Area Facility Review Act (CAFRA) (New Jersey State Act [N.J.S.A.] 13:19-1 et seq.), the Wetlands Act of 1970

(N.J.S.A. 13:9A-1 et seq.), and the Waterfront Development Law (N.J.S.A 12:5-3). Each of these acts provides a slightly different definition of the coastal zone; therefore, the designated coastal zone consists of the cumulative total of these three definitions.

Since the proposed project is limited to estuarine-related habitat restoration, it is expected that this project will comply with all CZM requirements (see section 11, Compliance with Environmental Regulations, for further details).

3.7 Biological Resources

The Environmental Resources Inventory (ERI) comprehensively describes the biological resources existing on the proposed LSP restoration site (see Appendix B). Past studies, including extensive environmental data provided by the NJDEP and IC/LSC staff, were used to develop this inventory, in addition to biological surveys conducted in 2003 to verify and update relevant portions of these studies. This updated inventory was used to establish an environmental baseline in order to:

- Conduct a comparative analysis of environmental benefits and impacts.
- Develop alternative candidate restoration plans.
- Select the recommended plan (along with engineering feasibility and economic justification).
- Describe environmental impacts of the recommended plan.
- Develop post-construction monitoring plans to evaluate the level of habitat restoration attained from implementation of the recommended plan.

The biological resources described in the ERI that occur in the proposed restoration area are:

- Terrestrial vegetation communities
- Palustrine (FW wetland) communities
- Intertidal vegetative communities[19]
- Benthic invertebrates (North Cove)
- Fish (North Cove)
- Herptiles
- Birds
- Mammals
- TES (threatened and endangered species).

The proposed restoration area vegetative communities and applicable invertebrate, fish and wildlife communities are briefly but systematically described in the sub-sections below, along with species of concern, essential fish habitat, air quality, noise, recreational resources, HTRW site characteristics and transportation and other infrastructure resources. Detailed discussions of biological resources are contained in the ERI. The ERI provides all common and scientific names of species.

[19] None exist within the proposed site, but they do occur in adjacent areas to LSP, and are utilized primarily as biobenchmarks for planning the proposed tidal marsh.

3.7.1 Vegetation

There are two general categories of existing vegetative communities (Figure 3.5) within the proposed restoration site, terrestrial (forest, scrub-shrub and herbaceous) and palustrine (seasonal FW wetlands). These two general community types are further categorized into more specific vegetation communities as described below in sections 3.7.1.1 and 3.7.1.2.

There are no intertidal vegetation communities within the proposed restoration site, however the North Cove (Figure 3.6) is an existing somewhat degraded intertidal mud flat and shallow water habitat. The non-vegetative biological resources (benthos and fish) of North Cove are primarily described below in sections 3.7.2.4, 3.7.2.5 and 3.7.2.6.

With some modification to more accurately categorize disturbed urban conditions, the vegetation communities within the proposed LSP restoration site are based on the descriptions and associations provided in Edinger, *et al.* 2002.[20] In general, the existing communities reflect almost two centuries of anthropogenic disturbance, primarily the result of filling with degraded sediments, rubble, construction waste, coal-ash cinders, blasted rock, railroad ties and rails onto what was formerly mostly shallow water, intertidal flat and salt marsh habitat.[21] The terrestrial and palustrine communities of today are the result of opportunistic vegetation taking hold in a mosaic pattern, often varying significantly among the various microtopographical features, throughout LSP. This is primarily a result of conversion of organic matter that gradually built up enough soil to support the communities in LSP seen today. Where the upper soil horizon is more developed, there tends to be more forest. Some areas remain almost barren because of the presence of cinders and other poor and/or highly permeable substrate. Seasonal wetlands tend to form in microtopographical depressions of various sizes, even between and adjacent to abandoned railroad tracks.

Figure 3.6 depicts eleven vegetative communities within the project site. These are described separately below under the categories of terrestrial and palustrine communities, although in some cases there is overlap in plant species (e.g., *Spartina patens* in a maritime grassland community), as a result of the complex mosaic nature of this site. Again, North Cove has no intertidal or subtidal vegetative communities.

3.7.1.1. Terrestrial Vegetation

Seven terrestrial vegetative communities currently exist within the boundaries of the proposed restoration area (Figure 3.6). Section 2 of the ERI describes these communities in comprehensive detail. Some important characteristics of these communities are summarized below (Note: % coverage of restoration site is based on a 160 acre restoration site rounded to the nearest whole number) in tabular format (Table 3.2):

[20] See Section 2 of the ERI for a detailed description of methodology.

[21] A time-series of fill activities is available in the Cultural Resources appendix, along with maps and photographs of the area at various historic periods.

Figure 3.6 LSP Existing Vegetative Communities

Table 3.2 LSP Existing Terrestrial Communities		
TERRESTRIAL	**Successional Northern Hardwood (SNH)**	**Successional Scrubland (SSB)**
Community Description	Forest located on previously disturbed or cleared sites where shrubs represent less than 50% of vegetative cover	Shrubland located on sites that have been cleared and are dominated by at least 50% shrub species.
Acreage	62.7	4.2
Coverage of Restoration Site	27%	<1%
Location	Throughout site	Southeast part of site
Interspersion	Moderate. Found in large contiguous units at the center of site.	Low. Found in contiguous patches near roadways
Dominant Canopy Vegetation	Quaking aspen, eastern cottonwood, gray birch, tree of heaven, big-toothed aspen, black locust, white pine, red maple, Lombardy poplar, black oak	N/A
Dominant Shrub Vegetation	Winged sumac, smooth sumac, northern bayberry, staghorn sumac	Cut-leaved blackberry, Japanese knotweed
Dominant Herbaceous Understory	Canada goldenrod, cut-leaved blackberry, common reed, mugwort, steeplebush.	Canada goldenrod, common reed
% Invasive/ Opportunistic Vegetation	Moderate/high	Moderate/high
Successional Stage	Early pioneer (poplars and gray birch) and later successional stages (red maple)	Likely succeeded from old field
Identifiable Trends	Possible succession to more shade tolerant hardwoods, such as red maple	Likely succession to SSN community through introduction of wind-dispersed seeds
Probability of Succession to an Invasive Species Dominated Community	Moderate	Moderate to high
Habitat Value	Breeding and foraging habitat for year round resident birds (American robin, downy woodpecker, northern flicker); grassland edge good foraging habitat for birds; Cooper's hawk, northern harrier and red-tailed hawk observed foraging along forest edge in 2003	Cooper's hawk and downy woodpecker foraging; breeding and foraging habitat for many of the same bird species that occur in maritime shrublands

Table 3.2 LSP Existing Terrestrial Communities (continued)		
TERRESTRIAL	**Successional Old Field (SOF)**	**Maritime Shrubland (MS)**
Community Description	Meadow dominated by non-woody herbs and grasses located in cleared and abandoned areas. Most diverse community type within the site (67 identified plant species).	Shrub community located in coastal region exposed to onshore wind and spray. Typically dominated by tall shrubs with tree canopy.
Acreage	49.6	22
Coverage of Restoration Site	21%	9%
Location	Small contiguous areas found along northern edge of site, in the central eastern part of the 45-acre rectangle, and along its western edge.	Throughout most of site generally in shallow depressions
Interspersion	Low. Found in large contiguous areas.	High, in small to moderately sized patches within or adjacent to forest
Dominant Vegetation	Non-woody herbs and grasses including common mullein, Canada goldenrod, spotted knapweed, mugwort, butter and eggs.	Diverse, but dominated by winged and smooth sumac, and to a lesser extent, northern bayberry, Canada goldenrod, common reed, cut-leaved blackberry, gray birch and quaking aspen
% Invasive/ Opportunistic Vegetation	Moderate/high	High/high
Successional Stage	Early successional	Pre-successional to either wetland shrub or successional upland forest, depending on soil moisture, but without management, more likely to succeed to monocultural common reed.
Identifiable Trends	Will likely succeed to SSB and eventually SNH	High soil moisture areas may succeed to wetland shrub communities, dry soil moisture areas to hardwood forest. In either case, without management, likely to be dominated by invasives such as common reed and/or tree of heaven and opportunists such as sumac.
Probability of Succession to an Invasive Species Dominated Community	High	High
Habitat Value	Important foraging grounds for most bird species at LSP because of abundance of seeds and insects. Dense herbaceous cover provides nesting and roosting habitat, but lack of tree/shrub canopy enables predatory birds (northern harrier) to locate songbirds and rodents. Extensive stands of mugwort decrease habitat value of SOF.	Several summer, winter and year-round resident birds use shrubland communities for foraging and breeding. American goldfinch, brown-headed cowbird, yellow warbler, eastern towhee and red-winged blackbird are known to breed within these shrublands. Tree swallow, yellow warbler, American woodcock, chimney swift and American kestrel use shrubland communities as foraging grounds.

Table 3.2 LSP Existing Terrestrial Communities (continued)		
TERRESTRIAL	**Maritime Grassland (MG)**	**Common Reed/Mugwort (CRM)**
Community Description	Dominated by more than 50% grasses and few shrubs located where ocean wind and spray present.	More than 75% cover of the invasive herbs mugwort, common reed and/or Japanese knotweed.
Acreage	14.7.	38.7.
Coverage of Restoration Site	6%.	17%.
Location	Mostly within 45-acre DM deposit. May be affected by brackish groundwater from Upper Bay via ditches to adjacent vegetation. There is a narrow strip next to a brackish ditch apparently connected by culvert to the Morris Canal in the extreme NW portion of the site.	Mostly within 45-acre DM deposit but also a large area next to upland forested area in N. part of the site. A narrow strip also occurs the S. edge of the site adjacent to the industrial area outside LSP, and some isolated areas in the SE portion of the site.
Interspersion	Moderate (mostly wide or narrow contiguous bands adjacent to ditches).	Low, since well-established reed monocultures tend to replace other vegetation.
Dominant Vegetation	Grasses (salt meadow cord grass), herbs (common reed, common mullein, Canada goldenrod and hemp dogbane), shrubs (eastern baccharis, marsh elder) and quaking aspen. Many of these species are salt-tolerant. The source of salt is unknown. Besides undocumented culvert connections, there may be residual salt in DM deposits, and/or salt accumulation in ditches via drainage from adjacent roadways.	Mugwort, common reed, Japanese knotweed. Most frequently occurring subdominant species are purple loosestrife, hemp dogbane and common mullein.
% Invasive/ Opportunistic Vegetation	Moderate/High	Very high/Very high.
Successional Stage	Early successional stage following intense disturbance	Early successional on highly disturbed generally poor soil.
Identifiable Trends	All of these maritime grass communities are located adjacent to and somewhat interspersed among monocultures of common reed (CRM community) and it is likely that reed stands will expand and outcompete and eventually replace the grasses.	Establishment of late successional community unlikely since invasives have adaptations (rhizomal colonization, root toxins) allowing them to outcompete native herbs that reproduce through seed dispersion. Over very long term, non-managed, non-salt influenced communities at LSP will tend to suceeed to SNH
Probability of Succession to an Invasive Species Dominated Community	Very high.	N/A
Habitat Value	High. Similar to SOF habitat, including valuable foraging and ground nesting habitat for the northern harrier (although on-site nesting success questionable).	Because mugwort, common reed and Japanese knotweed tend to grow in monocultures, CRM provides little habitat diversity. Some birds (red-winged blackbird, marsh wren) prefer common reed for nesting, but raptors dislike hunting prey in tall reeds.

Table 3.2 Existing LSP Terrestrial Communities (continued)		
TERRESTRIAL	**Mowed Lawn (ML)**	**Road**
Community Description	Residential, recreational or commercial land in which ground cover is dominated by mowed grasses and there is less than 30% tree cover.	Vegetation rooted in a road or path made of the parent material of the site and maintained by regular trampling of the land surface.
Acreage	5.6	Probably less than a few acres.
Coverage of Restoration Site	2%	Estimated at less than 1%.
Location	Restricted to the tidal channel inlet area adjacent to North Cove and to that portion of the Liberty Science Center wetland area adjacent to Phillip St.	Two unpaved roads in the SE portion of the site
Interspersion	None.	N/A
Dominant Vegetation	Grass.	Mugwort, ragweed, white sweet clover, common mullein, tree-of-heaven wild carrot, other clovers, snakeroot, poison ivy and spotted knapweed.
% Invasive/ Opportunistic Vegetation	N/A.	Very high/very high.
Successional Stage	Very early	Remains in early successional pioneer stage due to compacted soils and frequent trampling.
Identifiable Trends	None	None
Probability of Succession to an Invasive Species Dominated Community	None (assuming continued maintenance).	N/A.
Habitat Value	Foraging for American robin, ring-billed gull, rock dove and eastern squirrel. Raptors sometimes hunt on lawns.	Some road edges represent an ecotone that attracts wildlife. Habitat value of this community at this site is probably minimal, given the abundance of similar adjacent habitat.

3.7.1.2 Wetland Vegetation

Figure 3.6 shows 4 wetland vegetation communities that currently exist within the boundaries of the proposed restoration area. Section 2 of the ERI describes these communities in exhaustive detail. A brief description follows in Table 3.3:

Table 3.3 LSP Existing Wetland Vegetation Communities		
Wetland	**Floodplain Forest Wetland (FFW)**	**Shrub Swamp (SSW)**
Community Description	Hardwood forest that normally grows in low terraces of river floodplains or deltas.	Non-tidally influenced perennial wetland dominated by tall shrubs, less than 50% tree canopy cover.
Acreage	0.26	0.13
Coverage of Restoration Site	<1%	<1%
Location	One small contiguous area in the wet SE part of the site mostly surrounded by SNH forest and common reed. This area is JD wetland 6 (Figure 2-5 in the ERI).	Two small areas completely surrounded by and in the interior of SNH in the southern portion of the site. These areas are JD wetlands 12 and 18 (Figure 2-5 in the ERI).
Interspersion	None	Very little
Dominant Vegetation	Cottonwood, gray birch and sensitive fern	Winged sumac and common reed. Other species found were purple loosestrife, cut-leaved blackberry, gray birch, sensitive fern, quaking aspen, mugwort and Canada goldenrod.
% Invasive/ Opportunistic Vegetation	Low/Moderate	N/A
Successional Stage	Late successional stage maintained by relatively high water table (within 100year flood plain of Upper Bay).	This community represents a transitional habitat between shallow emergent palustrine marsh and floodplain forested wetland, as evidenced by the presence of species common to all 3 communities.
Identifiable Trends	None (regularity of inundation determines degree of succession to later stage community. Decrease in water levels may escalate progression towards common-reed dominated community or SNH).	Purple loosestrife and common reed could eventually outcompete the other species in this community, succeeding to a common reed dominated wetland without succeeding to the surrounding forest community.
Probability of Succession to an Invasive Species Dominated Community	Low if water levels maintained or increased; potentially high due to proximity of monocultural common reed if water levels decrease.	Very high
Habitat Value	Foraging and breeding habitat for a number of passerine and predatory birds. Fowler's toad could potentially utilize this community.	Similar to maritime shrubland community. Nine bird species observed in this community are known to breed in this community type, and 16 bird species observed on site are known to use shrub swamps for foraging.

Table 3.3 LSP Existing Wetland Vegetation Communities (continued)

Wetland	Shallow Emergent Marsh (SEM)	Common Reed Dominated Wetland (CRM)
Community Description	Seasonally flooded non-tidally influenced perennial wetland saturated throughout the year having less than 50% tree canopy cover.	Wetland dominated by common reed and purple loosestrife. Created, maintained, or modified by human activity to such a degree that substrate, hydrology and/or biological communities are substantially different than prior to human disturbance.
Acreage	10.2.	13
Coverage of Restoration Site	4.5%.	6%.
Location	Four moderately large and five unmapped very small areas located primarily in the forested zone in the southern and central portion of the site. The 4 larger areas are JD wetlands 3, 4, 7 and 20 (figure 2-5, ERI).	Interspersed throughout the project site (mapped on figure 2-3 of the ERI). As shown on figure 2-5 of the ERI, these areas are JD wetlands 2, 8, 9, 10, 11, 13, 14, 19 and 23. The "LSC" wetland is also a CRM wetland, however this particular area is not mapped as a JD wetland.
Interspersion	High.	High
Dominant Vegetation	Purple loosestrife, common reed, gray birch, wool grass and steeplebush.	Common reed and/or purple loosestrife. Subdominants include winged sumac, sensitive fern, steepelebush and Canada goldenrod.
Successional Stage	The earliest successional stage wetland type in the project area.	Common reed outcompeted other vegetation soon after deposition of dredged material, and continues to dominate.
Identifiable Trends	Tendency to succeed to scrub swamp and then forested wetland. However, the significant presence of purple loosestrife and common reed here makes that normal progression questionable.	Likely to remain dominated by monocultural common reed for a long period and may eventually succeed to SNH in the very long term.
Probability of Succession to an Invasive Species Dominated Community	Moderate to high	N/A
Habitat Value	Foraging habitat for many of the birds found in LSP, including the northern harrier, chimney swift, American kestrel, tree swallow and killdeer. Breeding habitat for the bobolink.	Relatively low, and of limited use to raptor predation due to height of vegetation. Red-winged blackbirds and gray catbirds, which tend to prefer this habitat, were infrequently observed in these communities. Other species may use monocultural *Phragmites* for various purposes, but it is generally not preferred.

3.7.1.3 Invasive Vegetation

The reader is referred to Section 2.1.3 of the ERI for a detailed discussion of the relationship between the scale of the problem of existing invasive species on the proposed restoration site, and the interactions between communities with and without project implementation. The important issue of the ecological future of LSP with and without the proposed restoration project and/or the application of aggressive invasive species management is further discussed in sections 4, 6.1.1 and 7.1.7.1 of this report.

Figure 3.7 shows the 5 vegetative communities where invasive species cover a minimum of (dominate) 75% of each community type. Invasive species also represent a significant cover type in most other communities of the proposed restoration area, but at less than 75% coverage. The 5 community types where invasive species dominate, their total acreage and their approximate invasive species coverage are as follows:

1. SNH	62.7 total acres (minimum of approximately 47 acres invasive species).
2. SOF	49.6 total acres (minimum of approximately 37 acres invasive species).
3. CRM	38.7 total acres (minimum of approximately 29 acres invasive species).
4. SEM	10.2 total acres (minimum of approximately 8 acres invasive species).
5. CRW	13 total acres (minimum of approximately 10 acres invasive species).
TOTAL	174.2 total acres (minimum of approximately 131 acres invasive species, or ½ of the entire site).

Note: Exact acreage of invasive vegetation in each community was estimated, not calculated. Consequently, some communities could theoretically be as high as virtually 100% covered by invasive species, although this is unlikely. Invasive species found at this site include common reed, mugwort, purple loosestrife and tree-of-heaven. Table 2-1 of the ERI lists the dominant species (including invasive) for all community types found at the LSP restoration site.

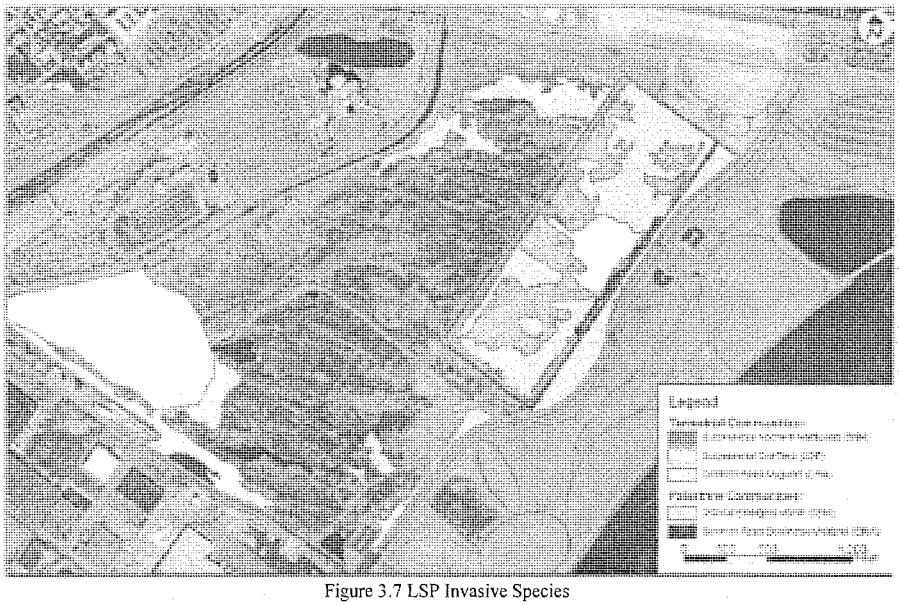


Figure 3.7 LSP Invasive Species

3.7.1.4 Regulated Wetlands

The methodology and results of surveys to identify and map New Jersey State regulated (freshwater) wetlands are described in Appendix B (ERI, section 2.2). There are no NJ State regulated tidal wetlands within the proposed LSP restoration site, although a few small parcels of wetland within the proposed restoration area may be indirectly tidally influenced through ditches, culverts, and possibly groundwater via elevated hydraulic head pressure from Upper Bay and the Morris Canal. The tidal influence could lead to possible increase in salinity to minimal brackish levels, but there is no observable effect on water elevation. There may also be some residual salt in the groundwater of the former dredged material deposits contributing to the growth of salt-tolerant plants in some of the wetter areas. Some wetlands are also located near roadways and could reflect higher levels of salt due to street, highway, parking lot, and other infrastructure-related impermeable surface runoff. Thus, the effect of tides with respect to salt contribution to wetland soils in the interior of LSP is likely overstated.

Figure 3.8 indicates the location of 23 hydrologically discrete NJ State regulated freshwater wetlands within the proposed restoration site. Each regulated wetland is labeled according to wetland type according to NJDEP wetland regulations. A summary of the description of these types and their respective wetland indicators is provided in table 2-2 of the ERI.

A Letter of Interpretation (LOI) was received from the NJDEP, Division of Land Use Regulation pursuant to the New Jersey Freshwater Wetlands Protection Act (N.J.S.A. 13:9B), verifying the accuracy of the methodology used to determine the presence of NJ regulated wetlands and

compliance of the wetland mapping with applicable regulations (see ERI section 2.2). A copy of the LOI is appended to this FR/EIS. A LOI is not a permit to construct in regulated wetlands, it is simply a statement of agreement from the NJDEP that a prospective applicant (the District in this case) has complied with NJDEP regulated wetland mapping requirements.

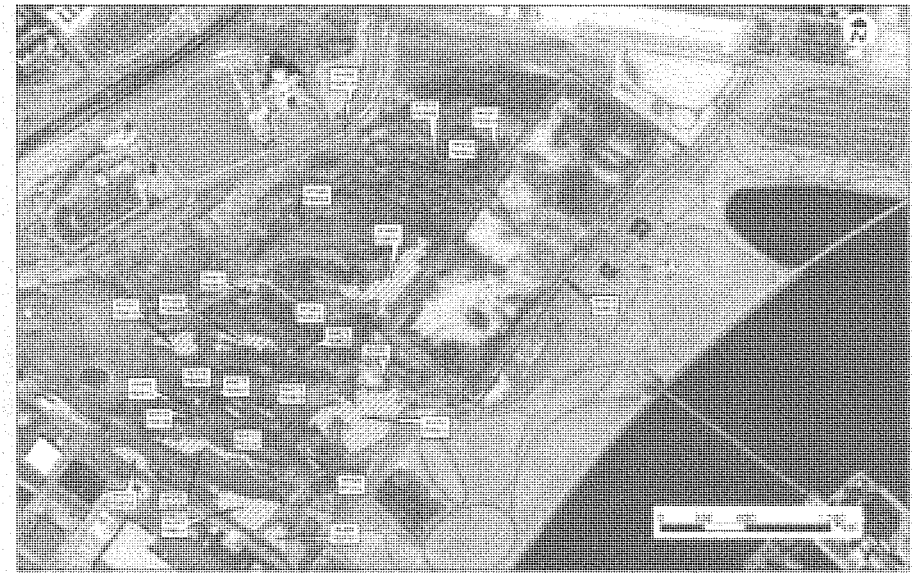


Figure 3.8 LSP Regulated Wetlands

3.7.2 Fish and Wildlife Resources

Much of the ERI is devoted to the detailed description of fish and wildlife resources within and near the proposed restoration area at LSP. The following sub-sections are a summary of that description.

In general, 78 species of birds were observed within the proposed LSP restoration area during the 2003 wildlife surveys, and an additional 52 species were observed in the South Cove salt marsh and adjacent shallow water habitat. Relatively few amphibians, reptile, and mammal species were observed despite the availability of suitable habitat. This is likely the result of these ecological communities developing in a highly urbanized and isolated area, discouraging colonization from adjacent similar communities of the northeast corridor.

3.7.2.1 Amphibians and Reptiles

Previous herptile surveys at LSP suggest minimal use of the site. Only one amphibian (Fowler's toad) and one reptile (eastern painted turtle) were observed in1976. Further surveys were conducted in 2003 for this restoration project (ERI, section 3.1.1). Three amphibian species

(Fowler's toad, green frog and wood frog) and 4 reptilian species (northern brown snake, eastern garter snake, northern water snake and northern diamondback terrapin) were observed in 2003.

This does not suggest that LSP is an improving habitat since sample numbers were small and different methodologies were used in 1976 and 2003. In both surveys, many expected species common in northern NJ were not found (ERI, section 3.1.2). It appears that despite the apparently suitable habitat for herptiles at the LSP restoration site, many expected herptilian species may have been extirpated, or never occurred here. This may be due to:

1. Isolation. LSP is surrounded on 3 sides by Upper Bay, and on the land side is cut off from available sources of recruits to populations by intense infrastructure and dense residential development.

2. Extremely high soil permeability, which promotes rapid water percolation from vernal pools, resulting in spring/summer time periods too short to support viable populations.

3. Toxicity effects in available surface and groundwater, particularly salt in areas closest to Upper Bay.

4. LSP has been impacted by the surrounding urbanized area for hundreds of years, having been created entirely by fill in the 1800's. It is lacking in high-quality fresh water, which further suggests that adequate populations of herptiles were never present on site.

In the absence of more evidence for herptiles at LSP, the history of the site and the available herptile data suggests that it is unlikely that populations of even common species of amphibians and reptiles will prosper in the future under existing conditions.

3.7.2.2 Birds

Avian surveys were conduced in 2003 to update existing NJDEP and other on-site information collected over the years. Abundance, species richness, and habitat use were identified.[22] It is notable that total count results (130 species) include North and South Coves, and thus are skewed in favor of species with an affinity for salt marsh/shallow estuarine water.

During weekly wildlife observations in August, 758 individual birds representing 56 species were recorded within the proposed LSP restoration area, and in North and South Coves. Songbirds were the largest group represented (29 species, 61.7%). Doves and pigeons (13.1%), gulls and terns (11.2%), waterfowl (3.6%), swifts (2.8%), shorebirds (2.5%) raptors (1.6%), cormorants (1.5%), waders (1.2%) and woodpeckers (0.9%) were also represented. Table 3-1 of the ERI lists all bird species observed. The most common species observed were European starling (12.3%), rock dove (10.6%), gray catbird (10.2%), American robin (9.9%), ring-billed gull (7%), song sparrow (6.2%), barn swallow (5.8%) and eastern towhee (3.4%).

Most birds observed were flying and thus not associated with any particular vegetative community. However, of the numerous observations of birds using a particular vegetative

[22] The methodology employed is described in section 3.2.1 of the ERI. Figure 3-1 of the ERI locates the observation stations. Survey results are presented in section 3.2.2 of the ERI.

community, most of the observations were made in mowed lawn, maritime shrubland and successional northern hardwood communities respectively (ERI table 3-2).

The known habitat and seasonal use requirements of the most common bird species observed and that relationship to the vegetative communities present on the site is described in table 3-3 of the ERI. Most common species observed are residents and use a variety of existing habitats, primarily for foraging.

Additional observations of bird utilization of the proposed LSP restoration site were made during northern harrier surveys (ERI, section 4), April 2003 amphibian surveys, October 2003 mammal surveys and by LSC staff between 3 January and 6 June 2003. These supplemental observations yielded another 76 bird species, bringing the total to 130 species observed on or near the proposed restoration site. Of this total, 78 were observed within the proposed restoration site and 52 observed in the South Cove salt marsh and its adjacent shallow water. Appendix C of the ERI contains a comprehensive list of all 130 species observed during all 2003 surveys and the vegetative community in which these species were found, when known.

Section 3.2.2 of the ERI contains a discussion of the habitat preferences of selected desirable avian species that have been observed in the vicinity of LSP and would be expected to utilize the existing project area, assuming availability of suitable habitat and environmental conditions, based on a multitude of sources. A list of representative species follows:

Raptors: Osprey, northern harrier, red-tailed hawk, common barn owl, peregrine falcon, rough-legged hawk, American kestrel, short-eared and long-eared owl, Cooper's hawk, great horned owl, sharp-shinned hawk, turkey vulture, merlin, snowy owl.

Passerines: Song sparrow, American robin, gray catbird, yellow warbler, red-winged blackbird, grasshopper sparrow, savannah sparrow, bobolink, European starling, barn swallow, eastern towhee, American goldfinch.

Waders: Black-crowned night heron, snowy egret, glossy ibis, cattle egret, great egret, yellow-crowned night heron, green heron.

Waterfowl: American black duck, mallard, Atlantic brant, greater scaup, canvasback, Canada goose, bufflehead, oldsquaw, red-breasted merganser, common goldeneye, American wigeon, ruddy duck, white-winged scoter, gadwall, green-winged teal, blue-winged teal, northern pintail.

Shorebirds: Semipalmated sandpiper, semipalmated plover, sanderling, ruddy turnstone, black-bellied plover, dunlin, short-billed dowitcher, greater and lesser yellowlegs, least sandpiper, spotted sandpiper, killdeer, black-bellied plover, Baird's sandpiper.

Gulls and terns: Herring gull, greater black-backed gull, ring-billed gull, laughing gull, common tern, least tern, black skimmer.

Cormorants: Double-crested cormorant, great cormorant.

Rails and coots: Clapper rail, Virginia rail, sora, American coot.

Others: Downy woodpecker, chimney swift, wild turkey, ring-necked pheasant, northern flicker, red-bellied woodpecker, pigeon.

3.7.2.3 Mammals

A small mammal trapping study was conducted between 28 October and 1 November 2003 to update observations made by LSP staff and others over the years (ERI, section 3.3). Several collection devices were used, including pit traps with drift fences, live traps, snap traps, hair snares and cover boards.[23] Prior to this survey, Texas Instruments conducted a mid-sized and small mammal survey in 1976 and found the following species: eastern cottontail rabbit, raccoon, eastern fox, muskrat, meadow vole, Norway rat and the house mouse. Table 3-4 of the ERI lists eleven mammalian species (including feral dogs and cats) found in the 2003 survey. This recent survey suggests changes in the small mammal population of LSP since 1976; specifically, slightly more species and a shift from house mouse to white-footed mouse. White-footed mice were not represented in 1976 but appear to have replaced the house mouse by 2003, and actually are now somewhat abundant. Although numbers are low, the Norway rat and house mouse are still present. The presence of feral dogs and cats and raccoons is a problem for the introduction/reintroduction of certain species of amphibians, reptiles, birds and mammals. This is further discussed under the following TES section and in Section 7, Environmental Consequences, of this report.

3.7.2.4 Threatened and Endangered Species (TES)

It is required by federal law (NEPA, ESA), federal regulations (USFWS, USACE, NOAA-Fisheries) and NJDEP laws and regulations (e.g., Freshwater Wetlands Protection Act) that federal or state endangered or threatened species and /or critical habitats be documented and the impacts on these species and habitats, if any, described.

There are no known Federally listed species or critical habitats within the proposed LSP restoration area. This is based on:

- A thorough literature review of relevant studies.
- Coordination with affected agencies and groups (NJDEP, NOAA-Fisheries, USFWS, NJDEP, IC staff, LSC staff, NJ Audubon Society)
- Extensive biological observations documented in the ERI and this FR/EIS.

There are however, six NJ state listed species found at LSP. Their associated habitats are described in Section 4 of the ERI. The species are Torrey's rush (a grass) and 6 birds (northern harrier, Cooper's hawk, long-eared owl, short-eared owl, Bobolink and Savannah sparrow). Although the bobolink is not officially listed in NJ, this rare bird's habitat preferences are described in section 4.2 of the ERI also. A summary of northern harrier observations during 2003 is provided in Table 4-2 of the Environmental Resources Inventory. Figure 4-1 of the ERI locates the northern harrier observation stations.

[23] Figure 3-1 of the ERI locates the wildlife observation stations and section 3.3.1 of the ERI describes the methodology employed.

In summary, NJ state listed TES have been documented by various sources within the proposed LSP restoration site. Of the 5 state listed birds, only the northern harrier has been documented to have recently nested, although nesting success in 2003 is uncertain. Northern harriers and long-eared owls use LSP for winter roosting and/or foraging. Short-eared owls have been observed foraging on the proposed LSP restoration site but have not been documented using the area for nesting, although an individual was observed roosting in the thickly wooded area adjacent to the LSP Interpretive Center in winter 2003-2004. Savannah sparrows and bobolinks are known to use the proposed LSP restoration site during migration.

3.7.2.5 Benthic invertebrates

Benthic invertebrates were collected in North Cove (section 5.2 and figure 5-1 of the ERI), since a small amount of dredging needs to occur at the head of the cove to provide for adequate tidal exchange in the proposed salt marsh. Grab samples were taken in late summer 2003 and represent the worst-case conditions (highest water temperatures and lowest dissolved oxygen) for shallow benthic communities. Appendix E of the ERI contains a detailed description of the North Cove benthic survey.

The purpose of this survey was three-fold:

1. Characterize the nature of the benthic population in North Cove as a benchmark for the benthic population expected within the proposed tidal creek and salt marsh.

2. Determine the general environmental health of the benthic community in North Cove to address any potential impacts from the proposed restoration project.

3. Assist in the planning of improved habitat functional value in North Cove.

The methodology utilized in the survey is provided in section 5.2.1 of the ERI. Briefly, 21 Ponar grab samples (3 replicate samples at each station) were collected at 7 stations (figure 5-1of the ERI). Four stations (station B-6, B-4, B-5, B-7) were located along a west-east transect beginning at the proposed mouth of the tidal creek and ending just east of the promenade in Upper Bay. The remaining 3 stations (B-1, B-2, B-3) were located in the intertidal zone in the shallowest water possible at the edges of the cove. Analysis consisted of identifying organisms passed though a 0.5mm sieve, sediment texture and % organics. Field observations of visually detectable petroleum hydrocarbons, shell hash, and obvious odors such as petroleum or hydrogen sulfide were recorded.

Table 5-1 of the ERI summarizes the results of the survey. The samples were dominated by polychaete worms. Several species of stress-tolerant polychaetes such as Stroblospio, Nepthys and Capitella were represented. These species are often found in environments with low dissolved oxygen concentration, high organic matter and sewage content and sometimes petroleum hydrocarbons. Amphipods were found in some intertidal zone samples, however, Ampelisca abdita, an indicator of transition (recovering or declining) environmental health, was absent, further suggesting that North Cove sediments are biologically stressed. Horseshow crabs were found, but these are considered to be highly pollution tolerant animals, common in the NY-NJ Harbor in shallows during spring and summer. Although direct comparisons cannot be made,

benthic organisms found in North Cove are somewhat similar to other studies of Upper Bay conducted over the last decade, although North Cove infauna abundance is lower, as expected in a near-shore shallow protected environment. The benthic assemblage in North Cove represents a very early successional stage dominated by small opportunistic worms. It is likely to remain at this stage absent sediment and water quality improvement.

Field observations also indicated that there was a smell of petroleum hydrocarbons and the visual presence of oil droplets in the sampled sediments. This is an indication that North Cove is a source and/or sink of petroleum hydrocarbons. However, this is also characteristic of much of the fine sediment in NY-NJ Harbor. This is discussed further in section 7.1.12 and the HTRW report in Appendix E.

The benthic community of North Cove can be characterized as follows:

1. From a geochemical standpoint, surficial sediments are typical of shallow water in sequestered areas of NY-NJ Harbor, i.e., soft black unconsolidated high organic content fines with evidence of chemical pollution.

2. There is a geological and biological gradient from the near-shore samples to the relatively deeper mid-cove samples, i.e., coarse sediment/low abundance to finer sediment/higher abundance, which is to be expected. It is not known what process is responsible for the coarser sediments near shore. However, wave action in the lower intertidal zone may contribute to winnowing of fines, and /or coarse material may have been deposited to support adjacent rip-rap and still remains near shore since creation of the cove.

3. Infauna abundance and species richness are relatively low compared to higher energy regimes in Upper Bay (as would be expected) such as the NJ flats adjacent to the main shipping channel (refer to NOAA references in Appendix E of the ERI).

4. Species composition is typical of highly stressed shallow urban estuarine environments: dominance of polychaetes, especially Capitella, Streplospio, certain Nephthys and others.

5. The proximity of CSO's between North and South Cove and the Morris Canal may be contributing to the character of the North Cove benthic community, among many other factors.

3.7.2.6 Fish

Since there is no permanent fresh water at LSP, there are no fish. There is, however, a fish population in North Cove, somewhat typical of shallow waters of the NY-NJ Harbor, as described below and in further detail in section 5.3 of the ERI.

Characterization of the fish community in North Cove was accomplished utilizing seine net and trap samples taken during late summer to early fall of 2003 for the following reasons:

1. Establish a baseline for predicting fish use of the proposed tidal creek and salt marsh, which will exchange water with North Cove on a regular basis.

2. Provide a comparison with post-construction surveys to determine level of success of establishment of a viable fish community in the tidal marsh.

3. Determine environmental impacts.

4. Help plan the overall restoration effort and predict and evaluate habitat function changes.

Since small and/or juvenile fish were expected in North Cove, beach seines and traps were used to sample the fish community. The focus on juveniles and small forage fish was due to the expectation that they would primarily utilize the proposed salt marsh habitat. Additionally, it is difficult to impossible to deploy trawls and gill nets in the area inside the promenade. Figure 5-1 and table 5-2 of the ERI describe the location of the 3 sampling stations (F-1, F-2, F-3) and the type of gear used, respectively. Table 5-2 of the ERI also describes the date, depth, number of species caught (species richness) and number of fish caught (abundance) for each gear deployment. Samples were collected from 28 August 2003 to 24 September 2003. As with the benthic community, this late summer collection period represents worst-case (highest temperature/lowest DO) conditions. On the other hand, it is also the best time of the year to capture tropical migrants, particularly in beach seines. Note, however, that there are more variables in the connectivity between fish populations and physicochemical environmental factors than with benthic communities.

Table 5-2 of the ERI indicates that seines were more efficient to capture fish in North Cove than traps, as evidenced by the relative number of fish caught. Of course, direct comparisons in numbers of fish eaught, or species richness, cannot be made because of the difference in gear type and selectivity and length and frequency of deployment of gear types. The total number of fish caught by both types of gear, seines and traps are 257, 205 and 52, respectively. Note that the average depth deployment of seines was approximately 5 feet, while for traps it was approximately 7 feet (necessary because beach seines could not be deployed in the deeper area of North Cove). Table 5-3 of the ERI lists the total of species caught and their average, minimum and maximum length, from which can be construed their life cycle stage, i.e., juvenile vs. adult.

Species collected were alewife, American eel, Atlantic menhaden, Atlantic silverside, bay anchovy, hogchoker, northern pipefish, oyster toadfish, scup, striped bass, summer flounder, tautog, weakfish, white perch and winter flounder. This assemblage represents both juvenile and adult fishes depending on species, however the majority of individual fish caught were juveniles. Both the assemblage and the dominance of juveniles and small forage fish were expected for this shallow habitat in this salinity gradient of the Hudson River Estuary. The presence of hogehoker, white perch and juvenile striped bass indicate the typical salinity range (approximately 10-20 ppt) found in North Cove, although it must be kept in mind that salinity varies considerably over tidal cycles, storm events and seasons in temperate estuaries. Bay anchovy was the most dominant species collected during the survey. All of these species are pollution tolerant to varying degrees and at various life stages and all of them would potentially utilize tidal creek and flooded low marsh habitat.

3.7.2.7 Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Management and Conservation set forth a number of new mandates for the National Marine Fisheries Services (NMFS) (now the National Oceanic and Atmospheric Administration (NOAA)-Fisheries), regional fishery management councils (Councils), and other Federal agencies to identify and protect important marine and anadromous fish habitat. The Councils, with assistance from NOAA-Fisheries, are required to delineate "essential fish habitat" (EFH) for all managed species. Federal action agencies, which fund, permit, or carry out activities that may adversely impact EFH are required to consult with NOAA-Fisheries regarding the potential effects of their actions on EFH, and respond in writing to the fisheries service's recommendations. In addition, NOAA-Fisheries is required to comment on any state agency activities that would impact EFH (NMFS 1998).

Essential fish habitat (EFH) is regulated by NOAA-Fisheries. The North Cove is the only area within this proposed project site where EFH species, or any fish, occur. Of the species listed in table 5-3 of the ERI, several are listed as EFH species. There are also other EFH listed species not found in North Cove in 2003 but known to be present in Upper Bay and are undoubtedly sometimes present in the project area. Coordination with NOAA-Fisheries is on-going. This coordination will be completed before the finalization of this IR and documented in the final report.

3.8 Air Quality

The USEPA assesses overall air quality according to the National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM) and sulfur dioxide (SO_2). Commonly cited sources of criteria pollutants include automobile exhaust emissions, fossil fuel (coal, natural gas and oil) fired power plants, oil refineries, ore smelters, storage and transfer operations involving solvents, and industrial emissions, among others (USEPA 1998).

The study area is located in the New York-Northern New Jersey-Long Island Consolidated Metropolitan Statistical Area (CMSA). According to the National Air Quality and Emissions Trends Report (USEPA 1998), the New York-Northern New Jersey-Long Island CMSA is considered a non-attainment area for CO and is classified as an extreme/severe non-attainment area for O_3 (NJDEP 1999b).

3.9 Noise

For the purposes of this report, noise is defined as unwanted sound, and therefore relative to the receiver, human or non-human. People, heavy equipment, vehicles, airplanes, boats or many other sources could generate unwanted sound. Existing noise levels at LSP are location specific. Noise levels are low compared to most of the surrounding metropolitan area because this is a large and relatively isolated park. The interior (mostly fenced-off) areas are even quieter since they are obviously the most insulated from most significant noise sources. The closer wildlife gets to the four main roads at LSP and the parking lots, the more noise impacts become important. However, it should be noted that nesting and other wildlife functions can occur

immediately behind fencing, despite intense human presence nearby, because of physical isolation by impassable barriers. Boat traffic can also generate noise at times near the Morris Canal and the Black Tom, where boat traffic is concentrated. However, these two areas are sufficiently removed from the proposed restoration area so as not to be considered a major existing source. Likewise, scrap yards at Caven Point generate exceptionally loud noise levels, but these are too far away to be of significant impact to the proposed restoration area. However, noise generated by the industries adjacent to the south near Thomas McGovern Drive and, to a lesser extent, the western side across Phillip Street of the proposed restoration area may have an effect upon species. Two specific areas that may be affected by existing noise impacts within the proposed restoration area are the LSC wetland site (slightly affected by noise generated on the NJ Turnpike and Audrey Zapp Drive), and the tidal creek inlet area (directly open to noise from Freedom Way, in addition to a greater intensity of pedestrian traffic on the surrounding walkways).

3.10 Recreation

Liberty State Park is a premier recreational destination, owned and maintained by the State of New Jersey. Numerous public facilities include the Liberty Science Center and Hall of Technology, Visitors Center, Interpretive Center, the former Central Railroad of New Jersey (CRRNJ) railroad terminal, a swimming pool, hiking trails, picnic area, playground, food concession, and associated parking and roads. Waterfront facilities include the Liberty Landing Marina, a trailer launch, canoeing and boating facilities, and boat storage facilities. There is a pedestrian walkway on top of the seawall and levee built by New York District on the eastern edge of the park.

3.11 Aesthetics

Aesthetics is subjective and depends on what the viewer considers to be pleasant or objectionable. For example, a well-constructed bridge may be considered an eyesore to someone who wants to keep an area entirely "natural," whereas, to the engineer who built the bridge, it could be considered a work of art. To the extent that LSP can be considered a welcome green area in a sea of industrialization and urbanization, the park is highly aesthetical. Liberty State Park has scenic views of the Statue of Liberty, Ellis Island, and lower Manhattan from its Liberty Walk. It also has many recreational venues, as discussed in section 3.10. Generous expanses of grassland are to be found throughout the park. However there are elements of the existing landscape that might be considered objectionable. These are, potentially, the chain-link fences surrounding interior sections of the park that deny access to the public, the interior sections themselves, and invasive vegetation such as *Phragmites*, mugwort and tree of heaven. Additionally, the relative lack of topographical relief, due to the site's past usage as a railroad yard, allows views of the surrounding industrial areas at some points within the park.

3.12 HTRW

The study team screened approximately 520 terrestrial acres at Liberty State Park to arrive at 160 acres of direct project area, avoiding 360 acres that, among other items, contain two chromium sites. It should be noted that the busy industrial history of New York Harbor has left its imprint throughout the region in the ubiquitous nature of contaminants in the water and land. Accordingly, there are substances listed under CERCLA/RCRA within the study area, but not at high enough levels to require CERCLA/RCRA action. The consideration of the 160 acres was

necessary for meeting aquatic habitat restoration goals and was therefore included in the formulation despite the presence of contaminants. The New Jersey Department of Environmental Protection (NJDEP) has conducted numerous environmental investigations within the LSP project area from 1978 to the present (NJDEP 1989; 1995; 2000). Results from these investigations show evidence of relatively widespread soil contamination, but generally at levels below applicable hazardous-waste thresholds. Heavy metals, including arsenic, lead, zinc, and copper, and polynuclear aromatic hydrocarbons (PAHs) are nearly ubiquitous in fill materials at the site, and commonly occur at concentrations above the applicable NJDEP Non Residential Direct Soil Cleanup Criteria (NRDSCC). The second NJDEP criteria used was Impact to Groundwater Soil Cleanup Criteria (IGWSCC). The concentrations of PAHs and metals in common fill materials are generally within the ranges listed in the NJDEP Historic Fill Database, and appear to meet the general definition of "historic fill" under Technical Rules for Site Remediation (N.J.A.C. 7:26E App.D). Therefore, soils other than those containing chromate chemical production waste (CCPW) or petroleum free-product can be probably managed on site, such as by capping with a layer of clean soil and establishing vegetative cover. However, soils that are saturated with petroleum or which contain CCPW generally require either off-site disposal or on-site stabilization.

Petroleum hydrocarbons are commonly present in surface soils, probably as a result of incidental spillage during historic railroad operations, and petroleum free-product has been observed in subsurface soils in two different locations within the park. Traces of Polychlorinated biphenyls (PCBs) and organochlorine pesticides, such as dieldrin and DDT, have also been detected locally at concentrations above the NJDEP NRDCSCC (but generally below applicable hazardous waste thresholds). Additionally, fill materials containing CCPW have been identified at one site adjacent to the project area (brick sewer, southern edge). The presence of hexavalent chromium is a prevalent concern at LSP.

Within LSP, dredged material is contained within a 45-acre rectangle (Figure 3.9). The dredged sediment is presently contained by a series of eight foot high earthen berms, constructed by PANYNJ during 1980-1981 using existing fill material excavated on-site (NJDEP 2000a). Dredged material was deposited in two episodes, in connection with the construction of the Liberty Walk Seawall project on the eastern edge of the park in the 1980s. In 1981, 93,000 cubic yards were deposited in this area, followed by 225,000 cubic yards in 1987. The dredged material was capped with clean soil, which experienced some erosion in the dry winter of 1991-1992. In response, NJDEP arranged to recap the berms and establish vegetative cover during the summer of 1993 (NJDEP 2000a). In 1995, NJDEP conducted more soil samples within this 45-acre area and found that soil contaminants within this area were generally similar to the historic fill conditions in other portions of the park, with exception of PCBs and dieldrin (NJDEP 1995a).

Ground water quality at the site is generally reflective of the soil conditions described above. In 1994, the NJDEP Site Remediation Program conducted a site-wide reconnaissance investigation of ground water conditions of at the site, during which 50 ground water samples were collected for laboratory analysis using a Hydropunch direct-push sampling rig. The sampling locations were targeted to specific features that were previously identified by the NJDEP during a review of historical aerial photography (NJDEP 1994). The samples were analyzed for TCL VOCs,

Metals and SVOCs. No VOCs were detected in the samples. However, metals and PAHs were detected locally at concentrations above the NJDEP Groundwater Quality Criteria.

Results from NJDEP investigations are extensive and provide detailed soil contamination data to an approximate depth of five feet below ground surface (bgs) throughout the site. However, because potential ecosystem restoration alternatives consider removal of fill in the 45-acre area to historic marsh and tidal levels, which are at least 12-15 ft bgs, New York District conducted more intensive site HTRW investigations for the feasibility study.

During the first phase in August 2003, 40 soil/sediment contaminant samples were taken throughout LSP, 38 on land, 2 in the North Cove (Figure 3.9).[24] The two North Cove Samples were not collected in this first round, but in the second round. Samples in the first round were taken from 30 feet bgs for two reasons: 1) to find the original, historic surface layer and 2) the assumption that over time, amounts of contamination, spilled fuel oil, hexavalent chromium, other heavy metals and VOA's would have migrated downward through the back fill. All samples were analyzed for: Volatile Organics Library + 15 (VOA+15), Acid Base Neutral Library +25 (ABN+25), Pesticides/PCB's (Pest/PCB), Total Petroleum Hydrocarbons (TPHC), RCRA Metals, Percent Solids (% solids). Considering the known chromium contamination, additional analyses were conducted for hexavalent chromium. The analysis for hexavalent chromium was sent to a laboratory specializing in that particular analysis. The results from this phase showed a relatively low number of borings, 16 out of 38, with measurable contamination at 30 feet bgs. No PCBs or VOAs were found in any of the 38 samples collected. TPHC, dieldrin, Acid Base Neutrals, arsenic, cadmium, copper, lead, mercury and nickel were sparsely scattered throughout the site and few exceeded NJDEP/NRDCSCC thresholds. It is worth noting that hexavalent chromium, the primary concern of this HTRW investigation, came in below the threshold of 10ppm for all samples in which it was detected. One sample, #20 near North Cove, had significant test results and is located at the entrance of the proposed tidal creek (Figure 3.9). Sample #20 exhibited high numbers of Priority Pollutant metals and several compounds of ABNs, signifying a concentration or hotspot of contamination. In the other categories, #20 did not exceed NJDEP criteria.

A second phase was conducted in February 2004, based on results of the August 2003 investigations. The two sediment samples from North Cove were collected in this second round. This round focused on the route of the proposed tidal creek and collected continuous samples from the surface to 15 feet bgs (Figure 3.10). No pesticides, PCBs, or Volatile Organics were detected in this round. Two areas of concern were identified in the second round, in the area of North Cove and the 45-acre containment area. Samples collected in the second round closest to sample point 20 from the first round showed the highest levels of metals, including hexavalent chromium, arsenic, lead, copper, and zinc. Other contaminants found include petroleum hydrocarbons and semi-volatile organics, also in the North Cove and the 45-acre containment area. At the time of construction, procedures will be in place to manage excavations from this area to ensure that minimal amounts of soil/sediment are released to the general environment and that excavated materials are disposed of properly and securely in the park's on-site placement area.

[24] HTRW samples were taken concurrently with Geotechnical samples.

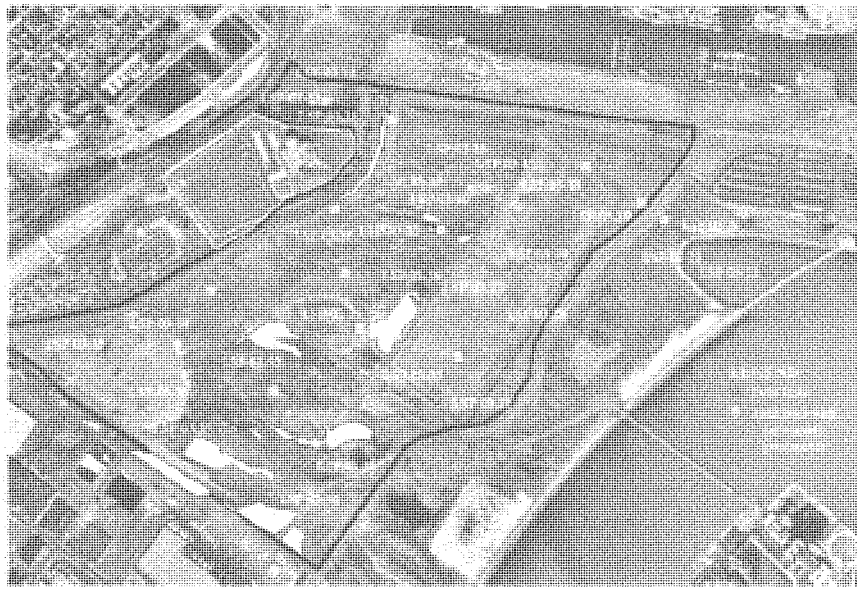


Figure 3.9. 2003 Geotechnical and HTRW sampling locations

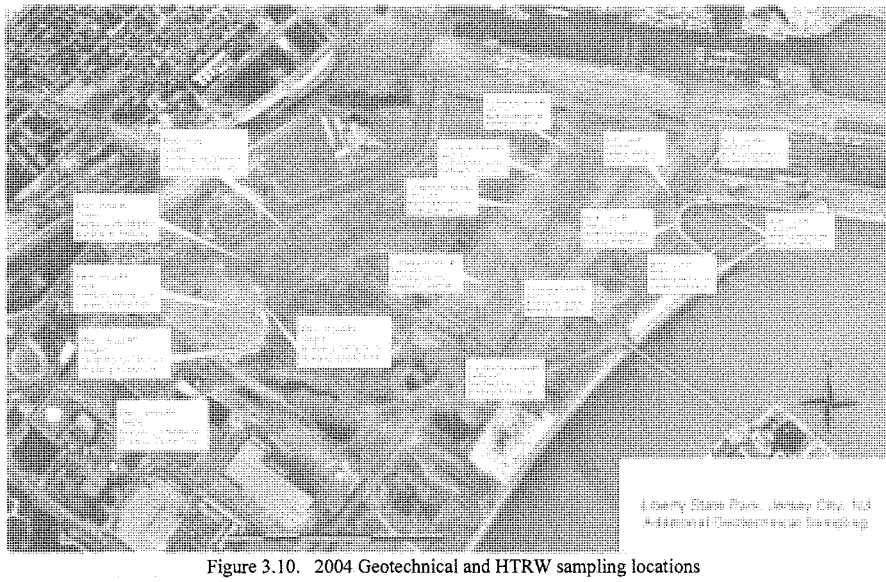


Figure 3.10. 2004 Geotechnical and HTRW sampling locations

3.13 Transportation and Other Infrastructure

Major highways close to Liberty State Park include the New Jersey Turnpike, which is immediately northwest of the project area, and Route 1, 9, also north and west of LSP. Public transportation is available through bus, rail, and ferry. New Jersey Transit operates buses and the Hudson-Bergen Light Rail line. The New Jersey Light Rail Park and Ride has 1,290 parking spaces at its boarding point in the northwest corner of the park, by the Liberty Science Center. Two companies operate ferries: New York Waterway and Circle Line, between LSP and lower Manhattan. New York Waterway ferries stop at the Liberty Landing Marina, and Circle Line ferries stop at the Central Rail Road of New Jersey terminal. Newark International Airport is approximately 7 miles away (by air).

Remnants of the Morris Canal system exist at Liberty State Park and are non-functional. Similarly, there are artifacts from previous railway activities by CCNJR and LVRR that, with the exception of the CCNJR terminal, are non-functional and lack historic significance (refer to Cultural section).

The Jersey City Sewerage Authority (J.C.S.A.) operates a treatment facility (East Side Treatment Plant) immediately to the west of LSP. A utility plan of LSP produced by PANYNJ (1975) shows subsurface electrical, water, telephone, and sanitary sewer service throughout the LSP project area. Three sewer mains operated by the JCSA are pass through the site and discharge to the Hudson between the filled Middle Cove and South Cove: (1) 96-inch diameter steel combined sewer, (2) an 84-inch abandoned brick combined sewer, and (3) an 80 inch by 80 inch reinforced concrete sanitary sewer. No excavation is planned for the area above these sewer mains.

4. FUTURE WITHOUT-PROJECT CONDITION

The study area has experienced severe habitat degradation due to past fill activities, which converted an estuary into an upland environment. In the absence of Federal action, it is anticipated that the study area ecosystem will remain in a degraded condition, with wetland areas dominated by invasive species. In addition, some areas that are currently of higher functional value are expected to degrade in the long term without significant management.

The predevelopment condition of much of the study area was open water and intertidal marsh. Accordingly, it would not be feasible to restore the existing environment to its "original" or "predevelopment" condition. However, restoration to a more ecologically valuable condition is feasible and could restore vital tidal saltwater marsh habitat in the New York Harbor that was once abundant and is currently scarce in the State of New Jersey.

Salt marsh, which is classified as an EPA priority wetland, can support diverse and thriving communities that provide spawning and nursery habitats for commercially valuable anadromous fish (*e.g.*, striped bass, shad, herring) and for shellfish (*e.g.*, blue crabs and oysters), as well as many species of waterfowl that nest and/or use the marshes as a migratory stopover. In many areas where *Spartina*-dominated marshes still exist, they have become degraded and are subject to *Phragmites* encroachment. As in the case of Liberty State Park, where *Spartina* marsh still

persists, it has been dislocated, reduced in functionality and encroached upon by more aggressive vegetation.

Seasonally flooded freshwater wetlands already exist at Liberty State Park. However, they are generally small, fragmented parcels that serve primarily as drainage areas and are not high quality wetlands, consisting mostly of common reed and purple loosestrife. Also, the surface water of these wetlands disappears in the later months of summer, consequently limiting the overall habitat functional value and making it impossible for some water-obligate species (fish, and some amphibians, reptiles and vegetation) to exist at all on this site. Currently, these wetlands are scattered throughout the site, mainly existing as vernal pools that are more often dry than wet. As a result of these combined factors, the wetlands in their current state are an untenable habitat for some important habitat species.

Terrestrial habitat at Liberty State Park is dominated by opportunistic tree species such as poplars and gray birch that often colonize disturbed areas because they generally have high light requirements, can colonize bare mineral soils, and are tolerant of poor soil conditions. Old field, grassland, and scrub-shrub are distributed in a mosaic pattern across most of the interior of the site. Half of the upland zones are overrun by invasive species, which will continue to spread, if no action is taken.

With no ecosystem restoration or enhancement at this site, its habitats will continue to degrade. Some of the site's existing habitats would further degrade as a result of continued expansion of the invasive plants, further limiting the abundance of wildlife populations and reducing biodiversity. Wetlands within the LSP restoration site will likely continue to decrease in functionality over the next ten years without the proposed restoration project. Common reed and/or purple loosestrife are common in most of the freshwater wetlands. It is likely that, with the possible exception of the floodplain-forested wetland, existing wetlands will develop into monocultures of these invasive species. In addition, the water-filtration/groundwater recharge capacity of the existing freshwater wetlands would decline as wetlands succeeded to drier habitats because of the lack of reliable water sources.

Habitat of valuable and state-listed species such as the Northern Harrier will be threatened by increased nearby traffic. Currently, the N. Harrier uses some of the 45-acre containment area for nesting. As the popularity of Liberty State Park grows, increased pedestrian and vehicular traffic from the Liberty Science Center, the Marina, and Liberty Walk may negatively affect the current N. Harrier habitat. Through ecosystem restoration, Northern Harrier habitat would be created in better, less fragmented locations.

Maritime shrubs are located throughout the old field communities, and the acreage of the grasses is likely to decrease as the shrubs become dominant. Existing maritime grassland communities are located adjacent to monocultures of the invasive species common reed and mugwort. The invasive species will likely encroach upon the grasslands and eventually out-compete them for resources, and the maritime grasslands will likely be rare or non-existent within the Liberty State Park restoration area in as little as ten years. The threat to maritime grasses and shrublands is important from an aquatic ecosystem perspective because these upland habitats act as the first line of defense against the invasive species for tidal marshes and freshwater wetlands.

In summary, the problems at Liberty State Park are:

- Loss of habitat biodiversity
- Loss of rare habitat
- Loss of habitat for rare or special-interest species
- Vulnerability of existing desirable wetland habitats to invasive species and an inadequate water supply
- Expansion of *Phragmites* and other invasives

The site's inaccessible contaminated area would remain as such rather than potentially serving as a publicly accessible wildlife habitat, which is especially important given the public visitation of this park. With no habitat restoration, opportunities would not be realized for greater biodiversity in estuarine-related ecological functions, significantly increased scientific education, and passive recreation that restoration at this site offers.

Given the density of the New York Metropolitan area, it is possible that some entity would eventually develop the study area at Liberty State Park for recreational purposes if a restoration project were not implemented. However, at this moment, there is no evidence that anyone is planning to develop the park. Additionally, a Consent Decree[25], which requires remediation if the restoration project is not implemented, places some technical constraints on the development of the park. The Liberty State Park Development Commission (LSPDC) investigated the feasibility of turning the study area into a golf course in the 1970s, but was ultimately dissuaded by strong public sentiment. The LSPDC has since been dissolved, and with the technical constraints of the Consent Decree, development of the restoration along these recreational lines would probably be more difficult than the habitat restoration anticipated in the Consent Decree.

4.1 Study Area Conditions that are Unlikely to Change

Some existing conditions are not expected to undergo significant changed during the period of analysis. For example, most aspects of the physical setting are expected to remain largely unchanged over the planning period, specifically topography and soils, including contaminant levels that degrade the ecological value and possibly human health, necessitating the continued denial of public access to a premier harbor park. The HTRW situation (essentially unusable contaminated area in the interior) will likely remain as is. In addition, no significant changes are anticipated for cultural and historic resources, air quality, and noise.

4.2 Study Area Conditions that are Likely to Change

Without project implementation, invasive species (primarily phragmites, purple loosestrife, mugwort, tree of heaven, Japanese knotweed) are likely to increase in coverage, there will likely be a gradual transition to drier habitats (with resulting loss of wetlands).

[25] Discussed in greater detail in section 5.2.2.3.

5. PURPOSE OF AND NEED FOR PROPOSED ACTION / PROBLEMS AND OPPORTUNITIES

5.1 Problems and Opportunities

As described above in existing conditions and without-project future conditions, it is anticipated that in the absence of Federal action, the study area ecosystem will remain in its present condition, accompanied by a long-term decrease in on-site ecological value, due to successional processes and probable accelerated dominance of invasive and opportunistic species.

The predevelopment condition of much of the study area appears to have been open water, intertidal flats, and tidal marshlands. Accordingly, it would not be practical to restore this site to its "original" or "predevelopment" condition. However, restoration to a more ecologically valuable condition, than current and future conditions would bring with no action, is feasible and would restore vital tidal saltwater marsh habitat in New York Harbor that was once abundant and is currently scarce in the State of New Jersey. It would also add considerable terrestrial and palustrine functional value to the site.

Tidal saltwater marshes, which are classified as EPA priority wetlands, can support diverse and thriving communities that provide spawning and nursery habitats for commercially valuable anadromous fish (*e.g.*, striped bass, shad, herring) and for shellfish (*e.g.*, blue crabs and oysters), as well as many species of waterfowl that nest and/or use the marshes as a migratory stopover. Within the HRE, existing *Spartina*-dominated marshes have become degraded and are subject to *Phragmites* encroachment. As in the case of Liberty State Park, where *Spartina* still persists, it has been relegated to the margins of the *Phragmites* marsh. Ecosystem restoration in Liberty State Park would provide an important contribution to the local and regional ecology in the New York metropolitan area by returning some of the high functional value wetland, forest, grassland and shrub habitat that has been systematically altered over time.

5.2 Planning Objectives, Constraints, and Key Assumptions

The Federal objectives in making investments in water resource/ecosystem restoration projects are to contribute to National Ecosystem Restoration (NER) and National Economic Development (NED). USACE planning objectives must be consistent with Federal, State, and local laws and policies, and technical, economic, environmental, regional, social, and institutional considerations. Recommended restoration plans should maximize benefits to the environment and meet local preferences to the fullest extent possible.

5.2.1 Planning Objectives

In pursuit of the goal to restore degraded ecosystems in the study area, the following restoration objectives were established:

- Increase habitat functionality;
- Restore under-represented habitat (*e.g.*, permanently flooded FW wetlands);
- Increase habitat for rare or special-interest species (*e.g.*, raptors),
- Restore tidal wetlands to estuary;
- Stabilize/protect existing desirable wetland habitats;
- Reduce invasive species (*e.g. Phragmites*, mugwort, and Japanese knotweed);

- Improve water quality on-site and in the estuary;
- Increase recreational opportunities (as a secondary consequences of restoration activities);
- Restoration projects should have a useful life span of at least 50 years;
- Contribute to national ecosystem restoration by providing more natural habitat in the densest metropolitan region in the country; and
- Maximize NER benefits in all plan components.

5.2.2 Planning Evaluation Criteria

Each potential solution will be evaluated with regard to engineering, economic, environmental and social criteria. The evaluation of each solution will be done using National Ecosystem Restoration (NER) guidelines.

5.2.2.1 Engineering Criteria

Plan alternatives for ecosystem restoration for this analysis were based on a 50-year project life and period of analysis. The intent is to formulate a plan that does not have unacceptable impacts on environmental and cultural resources and will be environmentally sustainable for the life of the project, with minimal maintenance needs.

5.2.2.2 Economic Criteria

In accordance with the overall objectives of the study, the plan should minimize the total cost including investment, operations, maintenance, and replacement, and the overall economic impact on the surrounding area. Accordingly, plan formulation shall follow these economic criteria:

- Alternative plans will be compared on the basis of Cost Effectiveness and Incremental Cost Analysis. Costs to be considered in the analysis should include, but not be limited to construction cost; interest during construction; lands and damages, easements, rights-of-way, relocations, and disposal areas; and average cost of operation and maintenance and/or major replacement costs.
- Appropriate risk and uncertainty analyses will be required to determine the sensitivity of economic variables, including items such as the increase in cost of required construction materials.
- To quantify the relative benefits of each of the proposed alternatives for ecosystem restoration, the ecological functions and societal values of the existing and the proposed habitat types will be determined through a modified version of the USACE New England Highway Methodology.[26] It was chosen for its ability to evaluate a range of habitat types, and the ecological outputs in this modified version will be termed Ecological Functional Units (EFU).

5.2.2.3 Environmental Criteria

Plan alternatives will be assessed and compared for acceptability based on overall ecosystem benefits and the potential impacts each may have on the human environment as a result of implementation. The environmental evaluation will be conducted in accordance with the

[26] The modification is described in section 6.2.1.

National Environmental Policy Act of 1970, as amended (42 U.S.C. 4321 et seq.). Public and interagency coordination has been conducted and will continue to be conducted to aid in the screening of alternatives and identification of environmental concerns, including social concerns for environmental acceptability.

Specifically, predicted alterations of habitat structure, substrate type or other physical, chemical or biological condition will be considered for evaluation of the alternatives. Plans will be in compliance with a Consent Decree issued by the United States District Court, District of New Jersey, in June 2000 on behalf of the Interfaith Community Organization, Inc. to NJDEP, stipulating safe handling procedures during construction at Liberty State Park. These procedures and processes will ensure that appropriate measures would be taken upon construction implementation. Compliance measures governing conservation and development actions include but are not limited to the following constraints as stipulated in the Consent Decree:

- Utilization of an approved Health and Safety Plan
- Preservation of existing fencing for public safety
- Use of certified, clean fill material
- Utilization of grading stakes to ensure clean fill tolerances of 1 ft. are met
- Limits on public access to walkways and observation areas
- Use of specified public signage
- Employing vegetative or physical barriers in direct proximity of walkways where contaminants may be present

Notwithstanding the above constraints and provisions, Corps of Engineers policy regulations governing contaminants as outlined in ER 1165-2-132 would apply during the PED and construction phases, and the provisions of NJAC 7:26E-1.1 related solely to site remediation shall be the responsibility of the non-Federal sponsor.

Furthermore, the improvement plans will also be assessed on the basis of their consistency with the New Jersey State Coastal Zone Management Program and all other applicable local, state and federal environmental or cultural resource laws and regulations, including, but not limited to, the Magnuson-Stevens Fishery Conservation and Management Act of 1996, as amended (16 U.S.C. 1801 et seq.); the Endangered Species Act of 1973, as amended (7 U.S.C. 136, 16 U.S.C. 460 et seq.); the Fish and Wildlife Coordination Act of 1958, as amended (16 U.S.C. 661 et seq.); the Clean Water Act of 1977, as amended (33 U.S.C. ss/1251 et seq.); the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); and the Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1455).

Marine fishery and shellfishery resources and essential fish habitat, as well as water quality, are of concern in analyzing potential environmental impacts. Threatened and endangered species resources at Liberty State Park include the New Jersey state-listed Northern Harrier, Cooper's hawk, long-eared owl, short-eared owl, bobolink, Savannah sparrow, and Torrey's rush. There are no Federally-listed species at Liberty State Park.

5.2.3 Planning Constraints

The formulation and evaluation of alternative plans was constrained by a variety of considerations. The planning constraints used to guide this feasibility study are listed below:

Technical Constraints

- Plans must be realistic and use proven technologies;
- Plans must represent sound, safe, acceptable engineering solutions;
- Plans must be in compliance with USACE Engineering Regulations;
- Plans must be complete and not dependent on future projects.
- Plans must incorporate Environmental Operating Principles where practicable.

Environmental Constraints

- Plans must be evaluated in a systems context in order to improve the ability of the features to function as self-sustaining systems;
- Plans must be formulated in consideration of intended and unintended effects, both on and off of the project site;
- Plans must be formulated recognizing the attainable restoration state, given the influences of human activities and culturally induced changes in the landscape that are likely to persist and influence system conditions after project completion.

Economic Constraints

- Plan benefits must justify plan costs through efficient use of funds;
- Plans must be efficient; accomplishment of one economic purpose cannot unreasonably impact another economic system.

Regional and Social Constraints

- The needs of the region must be considered and one area cannot be favored to the unacceptable detriment of another;
- The potential impact of the project on other areas and groups must be considered;
- All reasonable opportunities for development within the study scope must be weighed against each other.

Institutional Constraints

- The plans must be consistent with existing Federal, state, and local laws;
- The plan must provide public access to the project in accordance with Federal and State laws and regulations;
- The plan must be fair and find overall support among stakeholders.

5.2.4 Public Concerns

A public scoping meeting was held in the study area in October 2002. Corps representatives discussed ecosystem restoration opportunities in Liberty State Park with interested parties, and solicited their input to the study. Specifically, local interests and the public at large were invited to identify their issues and concerns regarding the direction, process, and potential finds of this investigation. Public response was very positive. Some individual concerns were raised about the project effect on the northern harrier, which have been addressed in this report (see Section 7). The minutes to this meeting can be found in the Environmental Appendix.

6. ALTERNATIVES INCLUDING PROPOSED ACTION / PLAN FORMULATION AND EVALUATION

6.1 Identification of Alternative Plans

Previous reports were consulted in the development of restoration features for screening and served as the starting point for the development of restoration features for screening. These included the Reconnaissance Report of the Hudson-Raritan Estuary (New York District, 2000); General Design Memorandum for the Parks Interior Section (NJDEP Division of Parks and Forestry, October 2001); and the Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary (Regional Plan Association, May 2003). Possible alternative plans have been formulated through screening of restoration features and evaluation of potential planning alternatives. The plans that have clear environmental benefits, potential economic and technical feasibility, and would not appear to have significant adverse effects on environmental and cultural resources have been identified for further evaluation. Those plans that do not meet the goals of the feasibility study and would not be implementable are identified but not carried further for more detailed evaluation.

The study team screened approximately 520 terrestrial acres at Liberty State Park to arrive at 160 acres of direct project area, avoiding 360 acres that, among other items, contain two chromium sites. It should be noted that the busy industrial history of New York Harbor has left its imprint throughout the region in the ubiquitous nature of contaminants in the water and land. Accordingly, there are substances listed under CERCLA/RCRA within the study area, but not at high enough levels to require CERCLA/RCRA action. The consideration of the 160 acres was necessary for meeting aquatic habitat restoration goals and was therefore included in the formulation despite the presence of contaminants. Excavation of these materials will not trigger any CERCLA/RCRA action.

6.1.1 No Action Alternative

If no action is taken, Liberty State Park will lose biodiversity, and, as a result, functional habitat value. Maritime grasslands and freshwater wetlands are especially at risk. Existing maritime grassland communities are located adjacent to monocultures of the invasive species common reed and mugwort. The invasive species will continue to encroach upon existing grasslands and eventually outcompete them for resources. As a result, maritime grasslands will likely become non-existent within the Liberty State Park restoration area at some future point. Freshwater wetland functional value will likely decrease over time, as common reed and/or purple loosestrife are common in most of the freshwater wetlands, and are poised to spread in many cases. With the exception of the flood-plain forested wetland, it is possible that existing wetlands may develop into monocultures of these invasive species, losing ecological value and further reducing the already severely depleted acreage of tidal wetlands, a key driver of a healthy system.

6.1.2 Alternative Ecosystem Restoration Measures

Alternative plans have been formulated for ecosystem restoration at Liberty State Park. Portions of the park have been developed by other organizations or are set aside for other purposes, such as recreation. Therefore, this proposed project focuses on the approximately 160 undeveloped

acres in the interior of the park. It is anticipated that restoration of this interior section will provide substantial benefit by linking previously developed and restored, but isolated, components of the park into one cohesive whole. This project will provide ecological benefits beyond the area being restored, such as contributions to fish and bird migration, and seed dispersal of desirable native vegetation.

6.1.2.1 Restoration Areas

In accordance with the project's restoration objectives, restoring wetlands that have experienced the most degradation without jeopardizing successful habitat pockets that are already on-site, ecosystem restoration options at Liberty State Park can be conceived as a three–pronged approach:

- Tidal system
- Freshwater wetland systems
- Terrestrial buffers and enhanced wetlands

The tidal system is proposed to replace the extensive fill on the eastern side of Liberty State Park, concentrating on the 45-acre undeveloped, fenced-in portion of the site. Tidal system options address the restoration of lost salt marsh and tidal creek and flats. Some freshwater wetlands currently exist, but they are small and too poor in quality to reliably sustain the listed species that use them now. Upland options are designed to act as buffer zones to protect the resource investment in the tidal system and freshwater wetlands. Some species in the tidal and freshwater wetlands also use nearby upland habitat, so there is a direct ecological tie to the aquatic habitat described above. Seasonal wetlands were included in what are designated terrestrial or upland zones, because of their seasonal nature. The freshwater wetland system refers to a specific set of wetlands near the Liberty Science Center that are interconnected and function as a system.

6.1.2.2 Potential Restoration Measures

The following sections briefly describe various ecosystem restoration measures considered:

1) Removal of invasive species. Invasive species to be removed through clearing, grubbing and regrading include common reed (*Phragmites australis*), Japanese knotweed (*Polyganum cuspidatum*), and mugwort (*Artemisia vulgaris*).

2) Planting of native species. Native species to be planted include *Spartina alterniflora* in wetland areas and maritime shrubs in transitional and upland zones. This measure would be counterproductive without the implementation of measure 1.

3) Topsoil/Sand Treatment. Some habitats will require capping with either topsoil or sand to prevent the recurrence of invasive species. This measure will require 1 to 2 ft for topsoil or 2 to 3 feet of sand per square yard.

4) Addition of water to freshwater wetlands. As stated in the Problem Identification (Section 4.0), existing wetlands are not reliable habitat because their surface water disappears during late summer months. To remedy this situation, water will be channeled from the Liberty

Science Center drainage system and parking lot to an existing biofilter wetland and through a swale to a Deep Emergent Marsh.

5) Enhancement of existing wetlands. The existing wetland associated with the Liberty Science Center is currently dominated by a monoculture of common reed. In this measure, it will be enhanced through the removal of common reed, re-grading, and replanting. This measure requires the implementation of above measure 4 to be productive. An enhanced wetland is impossible without a greater and more reliable water supply.

6) Creation of infiltration basin. An infiltration basin could receive overflow water from the deep emergent marsh, further treating this water. Its soils will be highly permeable and allow quick groundwater recharge. Infiltration basins are also effective in removing both soluble and fine particulate pollutants in storm water discharge. The proposed basin would receive excess storm water during wet periods and larger storms. While this water will have been treated by existing wetlands, during large storms the discharge may still contain some pollutants. In this case the infiltration basin would serve as a further cleansing system as well as providing control of peak discharges for large storms. This measure requires the implementation of measures 4 and 5 to be productive and cost effective in terms of habitat gain.

7) Single inlet tidal creek with on-site placement of excavated material. The path of the proposed tidal creek begins on the western shoreline of North Cove and ends in the southern half of the existing 45-acre dredge material containment area. The location of tidal creek inlet will require the relocation of the Christopher Columbus monument. If the monument were to remain in place, the tidal inlet would have to discharge into the north cove on its northern or southern shores. The scalloped shape of the cove allows the most wave dissipation at the apex of the cove, or its western shoreline. If the tidal creek discharged on the northern or southern shorelines, more dredging and bank stabilization features would be needed to keep the inlet stable and free of excess sedimentation. Thus, creating the tidal inlet at the location depicted is the most effective solution. Additionally, the proposed creek will cross Freedom Way, and consequently requires the construction of vehicular bridge to maintain the road's function. The most efficient angle at which the creek should cross the road is 90 degrees. The creek's course turns 4 times, as more sinuosity creates more fringe habitat. This system is expected to support approximately 35-50 acres of tidal marsh in addition to restoring open water habitat to the area. Presently, sizes under consideration for the tidal creek range from 25 feet to 75 feet wide, and will be refined in the screening process below.

8) Single inlet tidal creek with off-site placement of excavated material. This measure is similar to the single inlet tidal with on-site placement of excavated material, but differs in that the excavated material would be placed off-site

The following ecosystem restoration measures were considered and screened out on technical, biological, and cost-effective grounds:

1) Maximum removal of fill/maximum flooding of site. Maximum removal of fill to its full depth would not provide substantially more habitat gain than removing part of the fill. Maximum removal of the fill would create too much open water habitat, significantly limiting the amount of salt marsh, the restoration of which is a primary goal of this project. Another problem is that it would impair access to Liberty State Park itself, and would also adversely impact the freshwater wetlands that have developed on the edge of the fill. This option is ineligible for further consideration.
2) Flow-through tidal creek. A two-outlet creek was proposed because it seemed to provide the best conditions for tidal flushing at preliminary glance. However, it was determined upon further investigation that the water would rush in from each outlet, rather than going in one direction straight through, resulting in a stagnant pool in the middle of the creek. Although this option was popular at the public scoping meeting, it provides no additional benefits at significant increase in costs and was removed from further consideration.
3) Island in Creek. An island in the middle of the tidal creek was proposed to create some protected habitat for endangered species such as diamondback terrapins and assorted small birds. The island was not feasible from an engineering technical standpoint, as it would impede proper tidal flushing and eventually erode away. This option was removed from further consideration.

6.2 Screening of Alternative Plans

6.2.1. Derivation of Restoration Benefits and Costs

This section describes the derivation of restoration benefits and costs, upon which the Cost Effectiveness/Incremental Cost Analysis will be based.

Restoration Benefits

To quantify effects to the Liberty State Park ecosystem that would result from the proposed alternative plans, an analysis was performed on each of the site's ecological communities for both the existing conditions (No-action Alternative) and proposed alternative plans using a modified version of the USACE New England Highway Methodology. The ecological outputs of the modified New England Methodology are termed Ecological Functional Units (EFUs). This analysis had three major objectives: (1) identify the functions and values provided by the existing communities; (2) evaluate functions and values of the proposed alternative plans; and (3) compare the change in functions and values of the proposed alternative plans versus existing conditions. (The analysis can be found, in full, in Appendix B).

Based on a delineation of the site, it was determined that 12 different ecological communities exist in the project area. In addition, three ecological community types that do not exist in the project area are proposed. Each type was evaluated and assigned a numerical score for 16 functions and values (ERI, Appendix B) and the scores were summed for each type. The results of the functional analysis (the per-acre numerical scores) were used to ascertain the effectiveness of the proposed alternative plans by calculating the numerical difference between the existing conditions and the proposed alternative plans.

Proposed alternative plans consist of one of more of the following habitats: the restoration of a salt marsh, the enhancement of on-site freshwater wetlands, the creation of deep emergent marshes, as well as the enhancement of upland areas immediately adjacent to the proposed marshes and wetlands. Each proposed habitat type is composed of one or more ecological community. The score for each habitat was calculated by multiplying its component communities' score by their sizes and summing the products. The score of the existing conditions (at the location of each habitat) was subtracted from each habitat score, resulting in the net Ecological Functional Units (or benefit) for each proposed habitat. For each proposed alternative plan, the net EFUs were summed, resulting in total EFUs for each plan. This was done for all of the 75 possible combinations of the proposed alternative plans.

Each alternative was further assessed for potential additional benefits resulting from synergistic interactions between its components (freshwater wetlands, salt marsh, etc) that were not already reflected in the sum of its components. This assessment resulted in three additional benefits:

1. Increased biodiversity
2. Water management
3. Threatened or endangered species

For each category, alternatives were assessed using a simple question and, similar to the assessment in the ERI, each alternative was assigned a score (0: none, 1: low, 2: medium, or 3: high) as to how it contributed to the interaction.

Biodiversity

Biodiversity increases as the variety of habitats increases. On this site, the proposed berm, upland management area, and the tidal wetland all add significantly to the diversity of the site. The created and enhanced freshwater wetlands, while valuable additions to the ecosystem, do not add significantly to the diversity because many already exist onsite. For this category, the question was "Does this alternative increase the biodiversity of the site?" If yes, a positive score was assigned based on the relative magnitude of the contribution. The biodiversity scores were assigned as follows:

Alternative	Score
Tidal Creek/Salt Marsh	1
Tidal Creek/Salt Marsh plus Berm	2
Upland Management Area	1
Tidal Creek/Salt Marsh + Berm + Upland Management Area	3

Water management

Alternatives containing both the proposed berm and freshwater wetlands components utilize innovative techniques to gather water that would support the ecological function of adjacent components. Because the site is rather permeable, this is an important project component. The proposed berm is designed in such a way as to direct sheetflow toward the site rather than out of the site and into the stormwater system. In this way, the existence of the berm would improve water availability in other adjacent site components, such as the upland management area. To enhance and create freshwater wetlands, water would be diverted from adjacent parking lots. This will not only support the wetland in question, but by keeping water nearer the surface in these areas, would support improved water availability for adjacent habitats. For this category, the question was "Does this alternative improve the management of onsite water for ecosystem

benefit?" If yes, a positive score was assigned based on the relative magnitude of the contribution. The positive water-management scores were assigned as follows:

Alternative	Score
Berm	2
Berm + Freshwater Wetland #4	3

Threatened or endangered species

While general benefits to threatened and endangered species were already assessed in the ecological functional units for the component habitats of each alternative, some additional specific benefits would accrue due to the interaction between the components in some of the alternatives. Specifically, two State-listed species, short-eared owl (*Asio flammeus*) and northern harrier (*Circus cyaneus*), will benefit from certain characteristics of the proposed component habitats, including large grassy areas, shrub areas, and production of small mammals and birds. For this category, the question was "Does this alternative provide specific benefits to short-eared owl or northern harrier?" If yes, a positive score was assigned based on the relative magnitude of the contribution. The positive threatened-and-endangered-species scores were assigned as follows:

Alternative	Score
Tidal Creek/Salt Marsh + Berm	2
Upland Management Area	1
Tidal Creek/Salt Marsh + Berm + Upland Management Area	3

For each alternative, the additional benefits for each category were summed, multiplied by the size of the alternative, and added to its original value (EFUs) as determined above. This process is illustrated in Table 6A and the results are displayed in table 6.1.

Table 6A - Example evaluation showing: 1) the EFUs resulting from the initial analysis, 2) the addition of synergistic interactions; and 3) the EFUs resulting from the synergistic interactions.

Proposed Alternative Plan Combinations	Ecological Functional Units (EFUs)	Size (acres)	Synergistic Interactions			Total Interaction Grade	Total Interaction EFUs (grade x size)	Total EFUs
			Biodiversity grade	*Water Management* grade	*Threatened Endangered Species* grade			
No A + No B + No C	0	0.0	0	0	0	0	0	0
A_1 + No B + No C	1616	83.9	2	2	2	6	503	2120
A_2 + No B + No C	1336	44.9	1	0	1	2	90	1426
No A + B_1 + No C	62	2.9	0	0	0	0	0	62
A_1 + B_1 + No C	1678	86.8	2	2	2	6	521	2199
A_2 + B_1 + No C	1398	47.8	1	0	1	2	96	1494
No A + B_2 + No C	66	2.9	0	0	0	0	0	66
A_1 + B_2 + No C	1682	86.8	2	2	2	6	521	2203
A_2 + B_2 + No C	1402	47.8	1	0	1	2	96	1498
No A + B_3 + No C	156	6.9	0	0	0	0	0	156
A_1 + B_3 + No C	1772	90.7	2	2	2	6	544	2316
A_2 + B_3 + No C	1492	51.8	1	0	1	2	104	1595
No A + B_4 + No C	415	14.7	0	0	0	0	0	415
A_1 + B_4 + No C	2031	98.6	2	3	2	7	690	2721
A_2 + B_4 + No C	1751	59.6	2	0	1	3	179	1930

The restored, created, and enhanced wetlands that are proposed would restore historic losses of wetland functions and values while enhancing the developing upland communities and their associated wildlife. The salt marsh would add an entirely new host of functions and values that are not currently present on the LSP Restoration site, particularly aquatic habitat. The deep emergent marsh would provide new habitat functions and values that presently do not exist, including deep-water habitat for waterfowl. The shallow persistent open water depressions would provide the important function of groundwater recharge and habitat value. The palustrine emergent marsh would provide bird, mammal and amphibian habitat value. The wet meadow community along the salt marsh would assist important wetland functions of wildlife habitat and flood storage. The scrub-shrub wetland would provide flood flow attenuation to adjacent areas wildlife habitat value. In addition, the re-direction of run-off to the proposed wetlands will help prevent flooding of Audrey Zapp Drive.

The entire restoration plan provides upland, and wetland complex that would be a mosaic of habitats similar to what is present with two additional important ecosystems, the saltmarsh system and deep-water marsh system. Opening the site to the public with a system of walkways and observation platforms would add both aesthetic and educational value to the Liberty State Park interior that does not exist today.

Costs

Implementation costs for each restoration scenario were calculated based on estimates of location, mobilization/demoblization, site access, site preparation and excavation, disposal, planting, erosion and sediment control and monitoring costs. These project construction costs were estimated as part of the planning phase for the purpose of determining project feasibility, and to provide a means of comparing proposed restoration options. The chosen alternative will be designed further, and the quantities and costs will be refined in the cost appendix. However, for the alternative analysis, all alternatives have the same quantity and cost assumptions. A contingency cost of 20% was included to account for uncertainties in the final design and/or implementation of the selected NER Plan. Pre-Construction Engineering and Design (PED) and Management during construction were assumed as 8% and 7% respectively, of the total construction costs. An escalation factor of 3% was included to project the present day construction costs to the estimated midpoint of construction. All labor, material, equipment, overhead, bond and profit costs were considered in the costs. The costs were based on the cost estimate on experience at other projects and published estimating tools such as RS Means©. The derivation of project cost estimates is detailed in Appendix F (Cost estimating).

6.2.2. Screening of Plans

The environmental restoration opportunities for Liberty State Park consist of three components, as well as the no-action alternative. Each "action" alternative could be implemented separately, leaving the other two elements of the project with the no-action option; however, the components are designed to work optimally as a system. These components are:

Tidal Creek/Salt Marsh/Berm Creation:

The study team determined that creation of a Tidal Creek/Salt Marsh would increase tidal flushing of existing wetlands, increase biodiversity, and restore underrepresented habitat in

Liberty State Park, three of the major goals for the area. This feature is designed for the northeast corner of the site beginning at the North Cove and extends into the southern half of the existing 45-acre dredged material containment area. In addition to excavation, regrading to marshland elevations, and planting, the intended location of this project element will require the relocation of the Christopher Columbus monument and the construction of a vehicular bridge to retain the continuity of Freedom Way. In spite of the costs associated with the statue relocation and bridge building, this area of the site is hydrologically and environmentally preferable to locating the creek elsewhere within the project site (see Section 6.1.2.2, no. 7).

In the same vein, hydrological considerations have limited the width of the Tidal Creek to 50 feet. A 25-foot inlet tidal creek was initially suggested for the site in order to emulate the naturally occurring tidal creeks within the Hudson-Raritan Estuary, which tend to be approximately 25 feet in width. After considering the proposed length of the creek and sinuosity, there were hydrological concerns that the creek would silt up over time and lose functionality within the 50-year project life, and the 25-foot Inlet Tidal Creek was screened out. At the other end of the spectrum, the 75-foot Inlet Tidal Creek was expected to function properly within the 50-year project life from a hydraulic perspective, but raised concerns about its biological benefits. As a 75-foot alternative is substantially wider than the naturally occurring tidal creeks in the area, there were ecology-based concerns that so much open water would detract from the amount of desirable salt marsh habitat. For these reasons, the 75-foot Inlet Tidal Creek was screened out in the preliminary screening. A 50' Inlet Tidal Creek, though wider than naturally occurring tidal creeks in the region, was determined to both provide adequate water for proper tidal flushing and ensure that natural sedimentation would not impair its functionality.

For these reasons, the 50-foot Inlet Tidal Creek was the only alternative from the initial screening to potentially accomplish the amount of habitat gain that could economically justify a project recommendation without raising significant hydrological concern. For the purpose of economic analysis, options for the tidal portion are limited to the placement of dredged material coming from a 50-foot Inlet Tidal Creek. These options are:

A-1: 50' Inlet Tidal Creek with On-Site Placement, and
A-2: 50' Inlet Tidal Creek with Off-Site Placement.

The placement of dredged material is limited by the contaminated nature of the area within the fenced-off 45 acres, and the high cost of remediation, off-site transport, and placement. The contamination of the soil makes off-site placement comparatively expensive without any corresponding advantage. As a result, the study team had to formulate alternatives that would allow for the placement of dredged material from the tidal creek on site in an environmentally sensitive manner. The berm creates an opportunity to replace this material in an environmentally sensitive manner for the long term. For this reason, the Berm and Tidal Creek/Salt Marsh are linked because the berm functions as the placement opportunity that allows for less expensive Tidal Creek/Salt Marsh creation, while also providing an additional buffer from surrounding park activities. The berm would also be contoured in such a way as to increase water flow to the seasonal wetlands scattered throughout the park interior.

Freshwater Wetland Enhancement:

In an effort to restore underrepresented habitat, improve water quality, and protect existing desirable wetland habitats, the study team devised a set of alternatives that would formalize and expand freshwater wetlands in the area, an especially rare form of historical wetlands in the harbor. All alternatives considered for this habitat are additive (*i.e.* B-2 incorporates everything in B-1, plus...), they are:

B-1: Route water from the LSC drainage area to the existing biofilter and create deep emergent marsh from existing vernal pool;
B-2: Alternative B-1 plus collecting additional water from the nearby New Jersey Transit parking lot and routing it to the existing wetland at LSC;
B-3: Alternative B-2 plus enhancement of the LSC wetland; and
B-4: Alternative B-3 plus an infiltration basin that would return excess storm water to the freshwater wetland, ensuring that the water was being discharged to an area with high permeability and allowing quick groundwater recharge. Infiltration basins are also effective in removing both soluble and fine particulate pollutants in storm water discharge.

Upland Buffer Management & Seasonal Wetlands:
The upland management alternatives for the Liberty State Park site are designed to protect the salt marsh component and freshwater wetlands from invasive species encroachment, restore underrepresented habitat to the area, and increase overall diversity. For the purposes of this report, Upland refers to areas of the site not designated for tidal or freshwater system options. As for the entire upland area, there are pockets of successful upland habitat for which no action is planned. The options focus on parcels within the upland area that will act as buffer zones for vulnerable wetlands and as foraging zones for species that use the wetlands. The uplands also include seasonal wetlands, particularly in the southern half of the study area (see Figure 3.8). In addition to needing an increased water supply, they also require clearing of invasive species and protective buffers. The study team considered four alternatives for Upland Management:

C-1: Removal of invasive species;
C-2: Option C-1 plus landscaping and planting;
C-3: Option C-1 plus topsoil and erosion control; and
C-4: Option C-2 plus topsoil, landscaping and planting, and erosion control.

Each of the above project elements has been evaluated at varying levels of cost and output. The outputs and costs of these alternatives are presented in Table 6.1, below.

Table 6.1 - Outputs and Costs of Management Measure Increments			
Management Measures	**Management Measure Increment**	**Total Net EFUs**	**Cost**
No Action	None	0	$0
A - Tidal Creek, Salt Marsh & Berm	1- Tidal Creek, On-Site Placement	2120	$22,361,909
	2- Tidal Creek, Off-Site Placement	1426	$101,319,000
B - Freshwater Wetland System	1- Liberty Science Water	62	$1,065,568
	2- 1+ NJ Transit, LSC Existing Wetland	66	$1,692,188
	3- 2 with Enhanced LSC Wetland	156	$2,095,277
	4- 3 + Infiltration Basin	415	$2,300,948
C - Upland Buffer & Seasonal Wetlands	1- Removal of Invasive Species	770	$4,966,432
	2- 1 + Plantings	1051	$12,274,649
	3- 1 + Topsoil + Erosion Control	1051	$22,331,910
	4- 2 + Topsoil + Erosion Control	1051	$29,640,127

6.3 Plan Evaluation and Comparison

6.3.1 Cost Effectiveness and Incremental Cost Analysis of Restoration Plans

Corps ecosystem restoration policies require that restoration projects include Cost Effectiveness and Incremental Cost Analyses (CE/ICA).[27] ER 1105-2-100[28] reads, in pertinent part:

> *CE/ICA are two distinct analyses that must be conducted to evaluate the effects of alternative plans. First, it must be shown through cost effectiveness analysis that an alternative restoration plan's output cannot be produced more cost effectively by another alternative. "Cost effective" means that, for a given level of non-monetary output, no other plan costs less, and no other plan yields more output for less money. Subsequently, through incremental cost analysis, a variety of implementable alternatives and various-sized alternatives are evaluated to arrive at a "best" level of output within the limits of both the sponsor's and the Corps capabilities. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. The most efficient plans are called "Best Buys." They provide the greatest increase in output for the least increases in cost. They have the lowest incremental costs per unit of output.*

CE/ICA analysis uses the "No-Action Alternative" as its baseline against which project benefits are measured. For Liberty State Park, the No-Action Alternative assumes that no Federal actions will be taken to provide for ecosystem restoration, but it does not provide a floor against which absolute habitat gains can be compared. This CE/ICA analysis uses "no cost/no habitat gain" as

[27] ER 1105-2-100, paragraph 7-35 (h.)
[28] ER 1105-2-100, paragraph E-36

its no-action alternative; however, in this specific case, the "No-Action" plan will actually contribute to habitat loss because of the significant numbers of invasive species in the area.

6.3.2 Combinable Management Measures

The management measures presented in Table 6.1, above, are not mutually exclusive and may be combined for added habitat value beyond the Ecological Functional Units (EFUs) that would be created if each was implemented separately. With the exception of the possible economies of scale for berm maintenance and upland management that could be effected if those portions of the project were done in tandem, each option is wholly separable. This means that the Tidal Creek, Salt Marsh, & Berm portion of the project can be implemented with or without the Freshwater Wetland Enhancement or Upland Management. This is true for all three action alternatives presented, as summarized in Table 6.2, below.

Table 6.2 - Ability to Combine Management Measures

(1) Management Measures	(2) Management Measure A	(3) Management Measure B	(4) Management Measure C
A - Tidal Creek/Salt Marsh/Berm Creation		Can be combined or implemented separately.	Can be combined or implemented separately. May be some economies of scale if implemented together.
B – Freshwater Wetland Enhancement			Can be combined or implemented separately.
C – Upland Management/ Terrestrial Buffer			

6.3.3 Outputs and Costs of Combinations

Habitat values in combined measures are not the sum of the habitat values for the two or three separate management alternatives presented separately in Table 6.1, but rather the result of further assessment of what combination, enacted together, would provide. Conversely, costs presented are the sum of what the individual measures would cost if implemented separately. Although there may be possible economies of scale that could occur by implementing certain project increments together (*i.e.* savings in mobilization cost), using full project costs provides a conservative estimate of what the opportunity cost for the project is. Alternative costs have been generated based on previous area ecosystem restoration projects, and the selected alternative will be refined using Micro-Computer Assisted Cost Estimating System (MCACES) software.

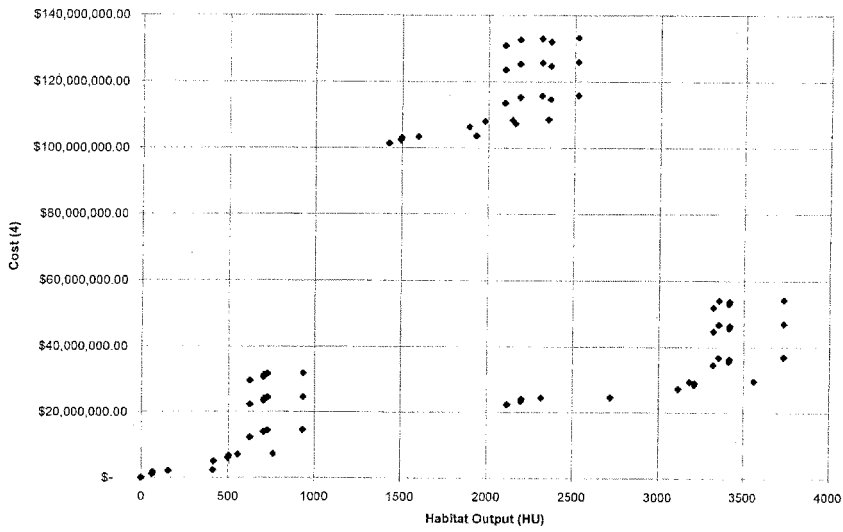
Outputs and costs are presented below in Table 6.3.

Table 6.3 - Outputs and Costs of Combinations

(1) Management Measure Increment Combinations	(2) Habitat Outputs	(3) Costs ($)	(1) Management Measure Increment Combinations	(2) Habitat Outputs	(3) Costs ($)	(1) Management Measure Increment Combinations	(2) Habitat Outputs	(3) Costs ($)
No A + No B + No C	0	$ -	A1 + B3 + C1	3181	$ 29,423,618	A2 + B1 + C3	2395	$ 123,397,478
A1 + No B + No C	2120	$ 22,361,909	A2 + B3 + C1	2139	$ 107,061,709	No A + B2 + C3	707	$ 24,024,098
A2 + No B + No C	1426	$ 101,319,000	No A + B4 + C1	759	$ 7,267,380	A1 + B2 + C3	3414	$ 46,386,007
No A + B1 + No C	62	$ 1,065,568	A1 + B4 + C1	3559	$ 29,629,289	A2 + B2 + C3	2183	$ 124,024,098
A1 + B1 + No C	2199	$ 23,427,477	A2 + B4 + C1	2347	$ 107,267,380	No A + B3 + C3	726	$ 24,427,187
A2 + B1 + No C	1494	$ 101,065,568	No A + No B + C2	625	$ 12,274,649	A1 + B3 + C3	3351	$ 46,789,096
No A + B2 + No C	66	$ 1,692,188	A1 + No B + C2	3319	$ 34,636,558	A2 + B3 + C3	2309	$ 124,427,187
A1 + B2 + No C	2203	$ 24,054,097	A2 + No B + C2	2097	$ 112,274,649	No A + B4 + C3	934	$ 24,632,858
A2 + B2 + No C	1498	$ 101,692,188	No A + B1 + C2	704	$ 13,966,837	A1 + B4 + C3	3734	$ 46,994,767
No A + B3 + No C	156	$ 2,095,277	A1 + B1 + C2	3411	$ 35,702,126	A2 + B4 + C3	2521	$ 124,632,858
A1 + B3 + No C	2316	$ 24,457,186	A2 + B1 + C2	2359	$ 113,340,217	No A + No B + C4	625	$ 29,640,127
A2 + B3 + No C	1595	$ 102,095,277	No A + B2 + C2	707	$ 13,966,837	A1 + No B + C4	3319	$ 52,902,036
No A + B4 + No C	415	$ 2,300,948	A1 + B2 + C2	3414	$ 36,328,746	A2 + No B + C4	2097	$ 129,640,127
A1 + B4 + No C	2721	$ 24,662,857	A2 + B2 + C2	2183	$ 113,966,837	No A + B1 + C4	704	$ 30,705,695
A2 + B4 + No C	1930	$ 102,300,948	No A + B3 + C2	726	$ 14,369,926	A1 + B1 + C4	3411	$ 53,067,604
No A + No B + C1	418	$ 4,966,432	A1 + B3 + C2	3351	$ 36,731,835	A2 + B1 + C4	2359	$ 130,705,695
A1 + No B + C1	3115	$ 27,328,341	A2 + B3 + C2	2309	$ 114,369,926	No A + B2 + C4	707	$ 31,332,315
A2 + No B + C1	1890	$ 104,966,432	No A + B4 + C2	935	$ 14,575,597	A1 + B2 + C4	3414	$ 53,694,224
No A + B1 + C1	500	$ 6,032,000	A1 + B4 + C2	3734	$ 36,937,506	A2 + B2 + C4	2183	$ 131,332,315
A1 + B1 + C1	3207	$ 28,393,909	A2 + B4 + C2	2521	$ 114,575,597	No A + B3 + C4	726	$ 31,735,404
A2 + B1 + C1	2156	$ 106,032,000	No A + No B + C3	625	$ 22,331,910	A1 + B3 + C4	3351	$ 54,097,313
No A + B2 + C1	504	$ 6,658,620	A1 + No B + C3	3319	$ 44,693,819	A2 + B3 + C4	2309	$ 131,735,404
A1 + B2 + C1	3211	$ 29,020,529	A2 + No B + C3	2097	$ 122,331,910	No A + B4 + C4	934	$ 31,941,075
A2 + B2 + C1	1980	$ 106,658,620	No A + B1 + C3	704	$ 23,397,478	A1 + B4 + C4	3734	$ 54,302,984
No A + B3 + C1	556	$ 7,061,709	A1 + B1 + C3	3411	$ 45,759,387	A2 + B4 + C4	2521	$ 131,941,075

Figure 6.1 presents this information in graphic form, which allows for a number of conclusions relating to the cost and environmental effectiveness of certain management measures.

Figure 6.3: Outputs and Costs of All Solutions



There is a cluster of solutions at and above the $100,000,000 that produce less habitat value than some of the less expensive options. These $100,000,000+ solutions all include management measure A2 – Tidal Creek with Off-Site Disposal. There are two related reasons for this. The high cost is the result of the fact that the tidal creek is to be excavated from a contaminated portion of the site and disposing of this material elsewhere is very expensive because they involve more money and less output in EFU terms. On the other hand, creating a berm by placing the material on the site and capping it, provides the opportunity to generate more value producing habitat in Liberty State Park. For this reason, alternative A1, which calls for on-site placement and berm creation, is a better alternative than A2.

There are two other clusters of solutions. The first cluster is centered about the $20,000,000 / 1200 EFU area and is comprised of combinations of alternatives that do not include the tidal creek. The second cluster is at the $40,000,000, 4250 EFU level. These are alternatives that include the tidal creek and berm as well as some combination of Freshwater Wetland Enhancement and Upland Management. This shows that measures that include the Tidal Creek, Salt Marsh, and Berm provide almost four times the habitat value of options that do not.

6.3.4 Elimination of Economically Inefficient Solutions

Solutions are re-ordered by the amount of habitat value they create. This allows for the elimination of economically inefficient solutions, which create the same habitat value as another alternative, but at higher cost. Note that alternatives using Upland Management increments

greater than the Clearing and Grubbing and Landscaping level are eliminated as economically inefficient.

6.3.5 Elimination of Economically Ineffective Solutions

Economically inefficient solutions are omitted from further analysis, and pair-wise comparison of outputs and costs is used to identify which of the remaining solutions are economically ineffective. Economically ineffective solutions are combinations of alternatives that produce less habitat output at equal or greater cost that subsequently ranked solutions. Table 6-4 presents the results of this comparison. Economically ineffective solutions are shaded.

Table 6.4 Elimination of Economically Ineffective Solutions

(1) Management Measure Increment Combinations	(2) Habitat Outputs	(3) Costs ($)	(1) Management Measure Increment Combinations	(2) Habitat Outputs	(3) Costs ($)
No A + No B + No C	0	$0			
No A + B_1 + No C	62	$1,065,568	A_1 + No B + No C	2120	$22,361,909
No A + B_2 + No C	66	$1,692,188	A_2 + B_3 + C_1	2139	$108,380,709
No A + B_3 + No C	156	$2,095,277	A_2 + B_1 + C_1	2156	$107,351,000
No A + B_4 + No C	415	$2,300,948	A_2 + B_2 + C_2	2183	$115,285,837
No A + No B + C_1	418	$4,966,432	A_1 + B_1 + No C	2199	$23,427,477
No A + B_1 + C_1	500	$6,032,000	A_1 + B_2 + No C	2203	$24,054,097
No A + B_2 + C_1	504	$6,658,620	A_2 + B_3 + C_2	2309	$115,688,926
No A + B_3 + C_1	556	$7,061,709	A_1 + B_3 + No C	2316	$24,457,186
No A + No B + C_2	625	$12,274,649	A_2 + B_4 + C_1	2347	$108,586,380
No A + B_1 + C_2	704	$13,966,837	A_2 + B_1 + C_2	2359	$114,659,217
No A + B_2 + C_2	707	$13,966,837	A_2 + B_4 + C_2	2521	$115,894,597
No A + B_3 + C_2	726	$14,369,926	A_1 + B_4 + No C	2721	$24,662,857
No A + B_4 + C_1	759	$7,267,380	A_1 + No B + C_1	3113	$27,328,341
No A + B_4 + C_2	934	$14,575,597	A_1 + B_3 + C_1	3181	$29,423,618
A_2 + No B + No C	1426	$101,319,000	A_1 + B_1 + C_1	3207	$28,393,909
A_2 + B_1 + No C	1494	$102,384,568	A_1 + B_2 + C_1	3211	$29,020,529
A_2 + B_2 + No C	1498	$103,011,188	A_1 + No B + C_2	3319	$34,636,558
A_2 + B_3 + No C	1595	$103,414,277	A_1 + B_3 + C_2	3351	$36,731,835
A_2 + No B + C_1	1890	$106,285,432	A_1 + B_1 + C_2	3411	$35,702,126
A_2 + B_4 + No C	1950	$103,619,948	A_1 + B_2 + C_2	3414	$36,328,746
A_2 + B_2 + C_1	1980	$107,977,620	A_1 + B_4 + C_1	3559	$29,629,289
A_2 + No B + C_2	2097	$113,593,649	A_1 + B_4 + C_2	3734	$36,937,506

6.3.6 Cost Effective and Least Cost Solutions

Table 6.5, below, presents Cost Effective and Least Total Cost Solutions – *i.e.* possible restoration combinations that have passed the test for economic effectiveness and economic efficiency prescribed in IWR Report 94-PS-2.

(1) Name of Solution	(2) Component Management Measure Increments	(3) Description	(4) Outputs (EFU)	(5) Costs ($)
S0	No A + No B + No C	no action	0	$ -
S1	No A + B1 + No C	Liberty Science Center (LSC) water	62	$ 1,065,568
S2	No A + B2 + No C	Liberty Science Center (LSC) Water and NJ Transit existing wetland	66	$ 1,692,188
S3	No A + B3 + No C	Liberty Science Center (LSC) water and enhanced NJ Transit existing wetland	156	$ 2,095,277
S4	No A + B4 + No C	Liberty Science Center (LSC) water, enhanced NJ Transit existing wetland and infiltration basin	415	$ 2,300,948
S5	No A + No B + C1	Removal of invasive species	418	$ 4,966,432
S6	No A + B1 + C1	Liberty Science Center (LSC) water and removal of invasive species	500	$ 6,032,000
S7	No A + B2 + C1	Liberty Science Center (LSC) Water, NJ Transit existing wetland and removal of invasive species	504	$ 6,658,620
S8	No A + B3 + C1	Liberty Science Center (LSC) water, enhanced NJ Transit existing wetland and removal of invasive species	556	$ 7,061,709
S9	No A + B4 + C1	Liberty Science Center (LSC) water, enhanced NJ Transit existing wetland and infiltration basin and removal of invasive species	759	$ 7,267,380
S10	No A + B4 + C2	Liberty Science Center (LSC) water, enhanced NJ Transit existing wetland, removal of invasive species, and landscaping	934	$ 14,575,597
S11	A1 + No B + No C	Tidal creek creation with on-site placement	2120	$ 22,361,909
S12	A1 + B1 + No C	Tidal creek creation with on-site placement, Liberty Science Center (LSC) water	2199	$ 23,427,477
S13	A1 + B2 + No C	Tidal creek creation with on-site placement and Liberty Science Center (LSC) water, NJ Transit existing wetland	2203	$ 24,054,097
S14	A1 + B3 + No C	Tidal creek creation with on-site placement, Liberty Science Center (LSC) water, and enhanced NJ Transit wetland	2316	$ 24,457,186
S15	A1 + B4 + No C	Tidal creek creation with on-site placement, Liberty Science Center (LSC) water, and enhanced NJ Transit wetland, and infiltration basin	2721	$ 24,662,857
S16	A1 + No B + C1	Tidal creek creation with on-site placement and removal of invasive species	3113	$ 27,328,341

(1) Name of Solution	(2) Component Management Measure Increments	(3) Description	(4) Outputs (EFU)	(5) Costs ($)
S18	A1 + B2 + C1	Tidal creek creation with on-site placement, Liberty Science Center (LSC) water and NJ Transit existing wetland, and removal of invasive species	3211	$ 29,020,529
S19	A1 + B4 + C1	Tidal creek creation with on-site placement, Liberty Science Center (LSC) water, enhanced NJ Transit existing wetland and infiltration basin, and removal of invasive species	3559	$ 29,629,289
S20	A1 + B4 + C2	Tidal creek creation with on-site placement, Liberty Science Center (LSC) water, enhanced NJ Transit wetland and infiltration basin, and removal of invasive species and landscaping	3734	$ 36,937,506

A graphic representation of these solutions, in the form of a total cost curve, presents a clearer view of the opportunity costs of the remaining alternatives. See Figure 6.2, below. Please note that the EFU scale is compressed, which makes it appear as though solutions falling on the lower end of the spectrum have lower average cost. This is a result of the distortion arising from the compressed scale.

Figure 6.2 - Cost Effective and Least Cost Solutions

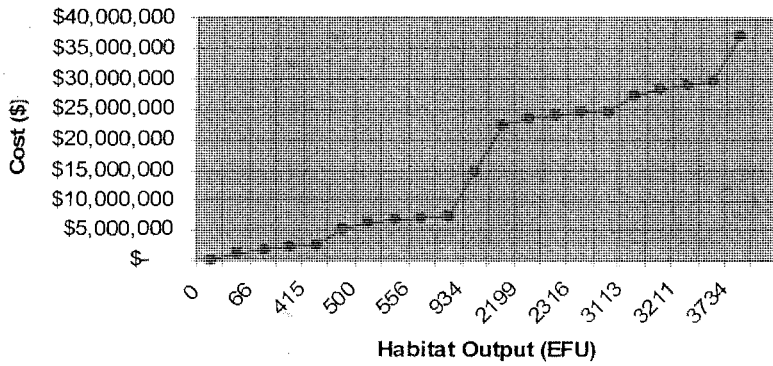


Figure 6.2 allows for a number of observations. Plans S1 to S4, at the left end of the curve, represent options using only Freshwater Wetland alternatives without any other type of habitat mitigation. These provide relatively little in terms of habitat value until they are combined with increments of Upland Management or Tidal Creek, Salt Marsh & and Berm. When combined

with Upland Management alternatives C1, Clearing and Grubbing, habitat output increases greatly. Nonetheless, this is not a result of synergies between them but rather the mere act of adding the values of those increments together. Any synergistic output from combining measures is limited to 60 EFUs.

Including Landscaping to the Freshwater Wetland alternatives 3 and 4 increases the habitat value but doubles the cost of the restoration from approximately $7M to $14.5M. Solutions involving salt-water habitat creation increase the cost of site mitigation to above $22M; however, creating the Tidal Creek, Salt Marsh, & Berm provides for a significant jump of more than 2000 EFUs. Adding the Freshwater Wetland opportunities to the tidal creek creation adds more value to the combination, with more than 150 EFUs in habitat output added in the A1 + B4 (Solution 16) alternative than would be created just adding the values of the separate projects together. Adding the Upland Management increment of Clearing and Grubbing to the salt water and freshwater combinations adds more than twice the habitat value of the Clearing and Grubbing increment alone. In these cases, the habitat value produced by the increments is 1715-1810 EFUs greater than the sum of the individual components.

6.3.7 Average Costs of Remaining Alternatives

The remaining solutions are arranged in Figure 6.3, below, to show their average cost per unit of habitat value created.

Figure 6.3 Average Costs of Remaining Solutions

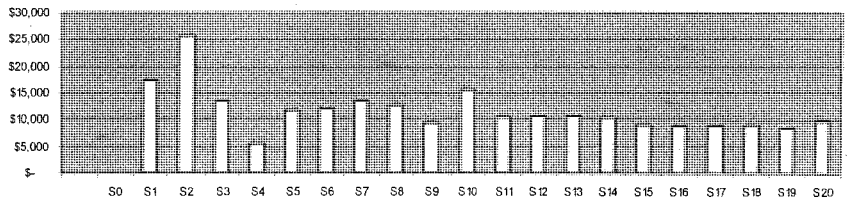


Figure 6.3 shows that the alternative that provides habitat value at least cost is Solution 4, the largest increment of freshwater wetland creation with no other project components. Comparing Figure 6.3 and Figure 6.2, we find that Solution 4 will provide only 415 EFUs, far less than other potentially economically effective and efficient environmental restoration plans for the site that provide greater habitat value.

Figure 6.3 also shows that until the Freshwater Wetland Enhancement alternatives get to their final increment, they are relatively expensive for the amount of output they create. In fact, solutions that use any other freshwater alternative but the largest increment result in higher average costs than freshwater alternatives using the same saltwater and upland combinations without the greatest increment of freshwater wetland restoration. Alternatives using both freshwater and saltwater, without upland management options, have a higher average cost than

alternatives using all three sets of habitat mitigation alternatives. Thus, alternatives that maximize diversity of habitat also have lower average costs.

6.3.8 Recalculation of Average Costs for Additional Levels of Output

After the initial average cost calculation, solutions with greater average cost but smaller habitat output are eliminated from further analysis. Average costs of additional outputs are calculated for the remaining solutions by first subtracting the habitat value and cost of the solution with the initial average cost calculation. This process is iterative, with solutions of higher average cost eliminated from further analysis and subtraction of the output and cost of the previous lowest average cost solution. Table 6-6a shows the initial average cost calculation from Section 6.3.7, with the lowest average cost solution identified.

Table 6-6a Average Costs of Each Level of Output

(1) Management Measure Increment Combinations	(2) Habitat Outputs	(3) Cost ($)	(4) Average Cost ($ per EFU)
S0 = No A + No B + No C	0	$ -	
S1 = No A + B_1 + No C	62	$ 1,065,568	$ 17,174
S2 = No A + B_2 + No C	66	$ 1,692,188	$ 25,687
S3 = No A + B_3 + No C	156	$ 2,095,277	$ 13,473
S4 = No A + B_4 + No C	415	$ 2,300,948	$ 5,547
S5 = No A + No B + C_1	418	$ 4,966,432	$ 11,881
S6 = No A + B_1 + C_1	500	$ 6,032,000	$ 12,064
S7 = No A + B_2 + C_1	504	$ 6,658,620	$ 13,212
S8 = No A + B_3 + C_1	556	$ 7,061,709	$ 12,701
S9 = No A + B_4 + C_1	759	$ 7,267,380	$ 9,575
S10 = No A + B_4 + C_2	934	$ 14,575,597	$ 15,606
S11 = A_1 + No B + No C	2120	$ 22,361,909	$ 10,550
S12 = A_1 + B_1 + No C	2199	$ 23,427,477	$ 10,653
S13 = A_1 + B_2 + No C	2203	$ 24,054,097	$ 10,919
S14 = A_1 + B_3 + No C	2316	$ 24,457,186	$ 10,559
S15 = A_1 + B_4 + No C	2721	$ 24,662,857	$ 9,063
S16 = A_1 + No B + C_1	3113	$ 27,328,341	$ 8,779
S17 = A_1 + B_1 + C_1	3207	$ 28,393,909	$ 8,854
S18 = A_1 + B_2 + C_1	3211	$ 29,020,529	$ 9,038
S19 = A_1 + B_4 + C_1	3559	$ 29,629,289	$ 8,352
S20 = A_1 + B_4 + C_2	3734	$ 36,937,506	$ 9,892

Table 6-6b, displays the outputs and costs of remaining levels of output and compares them to the 415 EFUs, which was found to have the lowest average cost per Ecological Functional Unit. Column 3 shows the level of added habitat beyond the initial 415 EFU level and Column 5 shows the additional cost for that extra level of habitat value beyond the 415 EFUs. Column 6 displays the average cost for each additional unit of output. This was calculated by dividing additional cost by additional output at each remaining level of output. The level of output with the lowest average cost per additional habitat unit is shaded.

Table 6-6b - Average Cost for Additional Output, First Recalculation

(1) Name of Solution	(2) Component Management Measure Increments	(3) Outputs (EFU)	(4) Costs ($)	(5) Addl. Cost ($)	(6) Average Cost per Addl. Output
S4	**No A + B4 + No C**	415	$ 2,300,948	$ -	$ -
S5	**No A + No B + C1**	418	$ 4,966,432	$ 2,665,484	$ 841,856
S6	**No A + B1 + C1**	500	$ 6,032,000	$ 3,731,052	$ 43,809
S7	**No A + B2 + C1**	504	$ 6,658,620	$ 4,357,672	$ 48,871
S8	**No A + B3 + C1**	556	$ 7,061,709	$ 4,760,761	$ 33,725
S9	**No A + B4 + C1**	759	$ 7,267,380	$ 4,966,432	$ 14,430
S10	**No A + B4 + C2**	934	$ 14,575,597	$ 12,274,649	$ 23,643
S11	**A1 + No B + No C**	2120	$ 22,361,909	$ 20,060,961	$ 11,768
S12	**A1 + B1 + No C**	2199	$ 23,427,477	$ 21,126,529	$ 11,840
S13	**A1 + B2 + No C**	2203	$ 24,054,097	$ 21,753,149	$ 12,165
S14	**A1 + B3 + No C**	2316	$ 24,457,186	$ 22,156,238	$ 11,653
S15	**A1 + B4 + No C**	2721	$ 24,662,857	$ 22,361,909	$ 9,695
S16	**A1 + No B + C1**	3113	$ 27,328,341	$ 25,027,393	$ 9,276
S17	**A1 + B1 + C1**	3207	$ 28,393,909	$ 26,092,961	$ 9,345
S18	**A1 + B2 + C1**	3211	$ 29,020,529	$ 26,719,581	$ 9,556
S19	**A1 + B4 + C1**	3559	$ 29,629,289	$ 27,328,341	$ 8,692
S20	**A1 + B4 + C2**	3734	$ 36,937,506	$ 34,636,558	$ 10,435

The table allows for elimination of solutions that have higher average costs per additional output than alternatives that can provide as much or more output at lower cost (solutions in the same column above the shaded entry). A summary of the results is presented in Table 6.6c, below. The table presents ranking of solutions by lowest average cost outputs.

Table 6-6c - Iterations of Average Cost Calculations (for average cost per additional output)

Average Cost for Additional Output ($ per HU)

(1) Solution	(2) Management Measures	(3) Habitat Output	(a) Original, see 6-6a	(b) First, see 6-6b
S0	No A + No B + No C	0	$ -	
S1	No A + B1 + No C	62	$ 17,174	
S2	No A + B2 + No C	66	$ 25,687	
S3	No A + B3 + No C	156	$ 13,473	
S4	No A + B4 + No C	415	$ 5,547	$ -
S5	No A + No B + C1	418	$ 11,881	$ 841,856
S6	No A + B1 + C1	500	$ 12,064	$ 43,809
S7	No A + B2 + C1	504	$ 13,212	$ 48,871
S8	No A + B3 + C1	556	$ 12,701	$ 33,725
S9	No A + B4 + C1	759	$ 9,575	$ 14,430
S10	No A + B4 + C2	934	$ 15,606	$ 23,643
S11	A1 + No B + No C	2120	$ 10,550	$ 11,768
S12	A1 + B1 + No C	2199	$ 10,653	$ 11,840
S13	A1 + B2 + No C	2203	$ 10,919	$ 12,165
S14	A1 + B3 + No C	2316	$ 10,559	$ 11,653
S15	A1 + B4 + No C	2721	$ 9,063	$ 9,695
S16	A1 + No B + C1	3113	$ 8,779	$ 9,276
S17	A1 + B1 + C1	3207	$ 8,854	$ 9,345
S18	A1 + B2 + C1	3211	$ 9,038	$ 9,556
S19	A1 + B4 + C1	3559	$ 8,325	$ 8,692
S20	A1 + B4 + C2	3734	$ 9,892	$ 10,435

Table 6.6c shows how average costs rise as the number of EFUs increases. After Solution 4, Solution 19 has the lowest average cost per EFU. The table shows a steep jump in average cost between Solution 19 and Solution 20 for relatively small habitat gain. This shows that Solution 19 is a "better buy" than Solution 20.

6.3.9 Incremental Cost Analysis and Pair-wise Comparison of Successive Outputs

Table 6.7 presents incremental costs. These are calculated by dividing the difference between total costs of two solutions (the additional cost between them) by the number of additional habitat units created by the higher cost option.

Table 6.7 - Incremental Costs for Solutions with Lowest Average Costs for Additional Output					
(1) Name of Solution	**(2) Component Management Measure Increments**	**(3) Description**	**(4) Outputs (EFU)**	**(5) Costs ($)**	**(6) Incremental Costs ($ per EFU)**
No Action	No A + No B + No C	no action	0	$ -	
S4	No A + B_4 + No C	LSC water, enhanced NJ Transit existing wetland and infiltration basin	415	$ 2,300,948	$ 5,547
S19	A_1 + B_4 + C_1	Tidal creek creation with on-site placement, LSC water, enhanced NJ Transit wetland, and removal of invasive species	3559	$ 29,629,289	$ 9,170

Solution 4 will provide only 415 EFUs, far less than other potentially economically effective and efficient environmental restoration plans for the site that provide greater habitat value. For this reason, Solution S19 is a "better buy" than Solution S4 for each additional unit of habitat it creates.

6.3.9 Summary of Conclusions

Off-site placement of material excavated from the tidal creek is extremely costly and provides less habitat value than less costly alternatives using on-site placement, as exhibited in Figure 6.1 – Outputs and Costs of All Solutions.

Alternatives using Upland Management increments greater than the Clearing and Grubbing and Landscaping level were eliminated from further consideration because they are economically inefficient. The same habitat value can be created at lower cost. Alternatives using Upland Management increments with added erosion control and topsoil (C3 and C4) were eliminated from further consideration after Section 6.3.4 - Elimination of Economically Inefficient and Economically Ineffective Solutions.

Measures that include habitat restoration in the saltwater portion provide almost four times the habitat value of options that do not, as shown in Figure 6.2 – Cost Effective and Least Cost Solutions. Until the Freshwater Wetland Enhancement alternatives get to their final increment, they are relatively expensive for the amount of output they create. In fact, solutions that use any other freshwater alternative but the largest increment result in higher average costs than freshwater alternatives using the same saltwater and upland combinations without the greatest increment of freshwater wetland restoration. These facts are shown in the analysis of Figure 6.3.

Table 6.6b – Solutions with Lowest Average Cost per Additional Habitat Output shows how average cost rises as habitat output increases. The table shows a steep jump in project cost between Solution 19, the tidal creek with on-site placement/maximum freshwater habitat restoration/minimum upland management (Clearing and Grubbing) and Solution 20, the same

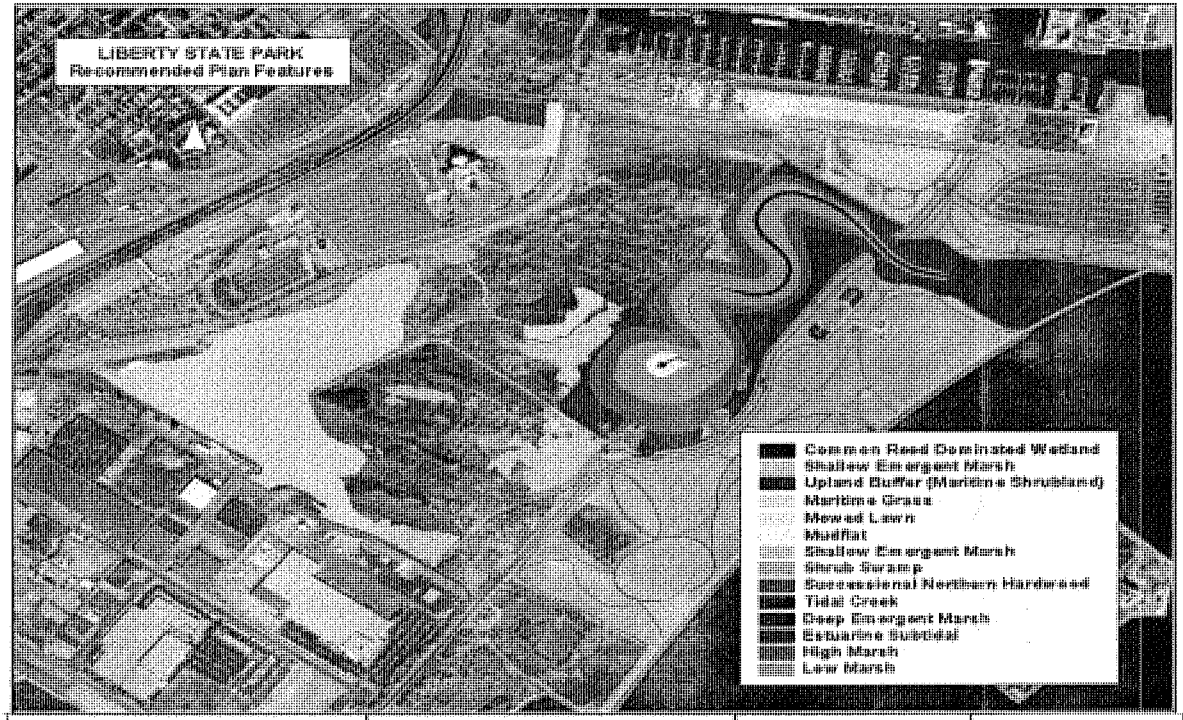
tidal and freshwater increments with the next highest increment of upland management (Clearing and Grubbing with Landscaping) for relatively small habitat gain. Solution 4, LSC water, an enhanced LSC wetland, an infiltration basin, and removal of invasive species had the lowest average cost, but did not address the planning objective of restoring tidal wetlands to the estuary (Section 5).

Table 6.7 shows that the incremental cost of Solution 19 - tidal creek creation with on-site placement, LSC water, enhanced LSC wetland, and removal of invasive species – has a lower incremental cost than the next best alternative which left out the tidal creek. For this reason, Solution S19 is a "better buy" than Solution S4 for each additional unit of habitat it creates. Beyond providing the 1186 EFU of the freshwater and upland combination, the cost per additional EFU decreases when the tidal creek is added to the restoration plan, allowing an additional 3144 EFU to be created for a total of 3559 EFUs.

For these reasons, Solution 19 - the creation of a tidal creek with on-site material placement (berm creation), freshwater wetland enhancement including Liberty Science Center water, an enhancement of the LSC wetland, and an infiltration basin, and clearing and grubbing of the upland portion of the site – for an estimated total cost of $29,629,289 and an estimated habitat output gain of 3559 EFUs, is recommended.

6.4 Selected NER Plan

The following sections describe the design details of Solution 19, the selected NER plan, show in Figure 6.4.



LIBERTY STATE PARK
RECOMMENDED PLAN

Figure 6.4

6.4.1 Tidal Marsh

Salt marsh vegetation communities are tightly coupled with the tidal regime. Water levels fluctuate over the daily and monthly tidal cycle, flooding the shoreline for different periods of time. The period of inundation is dictated by elevation contours, and zonation among plant species occurs along these contours. The location of plant species along the gradient is determined by the species' tolerance to salinity and water (frequency, duration, and/or depth of inundation). Species that are tolerant to water and salinity occur at lower elevations in the intertidal zone, between the Mean High Water (MHW) level and the Mean Low Water (MLW) level. Less tolerant species occur at higher elevations, which are inundated only during spring-tide high water levels.

The success of a salt marsh restoration effort greatly depends upon the location of the planted vegetation along the shoreline gradient. Since local conditions vary (salinity, tidal amplitude etc), biological benchmarks measured from surrounding local marsh vegetation and local tidal information should be used as a guide for determining the elevations for vegetation replanting. Elevation ranges of plant communities in reference wetlands can be duplicated in the restored salt marsh.

Thriving wetland communities throughout the Hudson-Raritan Estuary were used to collectively establish the general environmental design criteria and flow prescription for the four proposed tidal wetland communities. To account for varying local conditions, two sites were used as reference sites for the tidal salt marsh: One was in the South Cove of Liberty State Park and the second was just south west of the site in Port Liberté. Their characteristics were documented by Ecosystem Restoration Consultants (ERC) on 17 and 25th September 2003 and 14 October 2003. The results of this biobenchmarking effort is documented in Appendix G of the ERI, and is summarized in Figure 6.5 and Figure 6.6.

The following describe the design criteria for each proposed tidal salt marsh community.

1. Tidal Creeks. Tidal Creeks are permanently flooded for the mean tide range (MHW to MLW). The creeks offer a place for fish to congregate at low water. The substrate of the tidal creeks should be able to retain sufficient Dissolved Oxygen and other water quality parameters to support benthic populations, and to have the proper conditions for sub-aquatic vegetation to eventually take root. The velocities in the creek should not be so great as to trigger unrecoverable deposition and erosion in the channel so that parts of the wetland become hydraulically disconnected from the tide. However, circulation within the marsh is encouraged to facilitate better water quality and to avoid stagnant water. Sinuosity of the creek layout is an important feature as it maximizes fringe habitat, it slows down the high velocities in the creek, and also encourages greater water circulation.
2. Mudflats. Mudflats connect the tidal creeks and low marsh. They will dry out at low tide, although they usually are flooded for more than half of the tide cycle. The mudflats also should be able to retain sufficient Dissolved Oxygen and other water quality parameters to support benthic populations.
3. Low Salt Marsh. In the Hudson-Raritan Estuary and in other estuaries in the Northeast United States, the dominant low salt marsh species is *Spartina alterniflora*.

Spartina alterniflora needs both wet and dry conditions every day, and it is usually found growing between MTL and MHW. The extent of the tall and short form of *Spartina alterniflora* biobenchmarking data was used to determine the regrading and planting plan for low marsh (see Figure 6.5 and Figure 6.6).

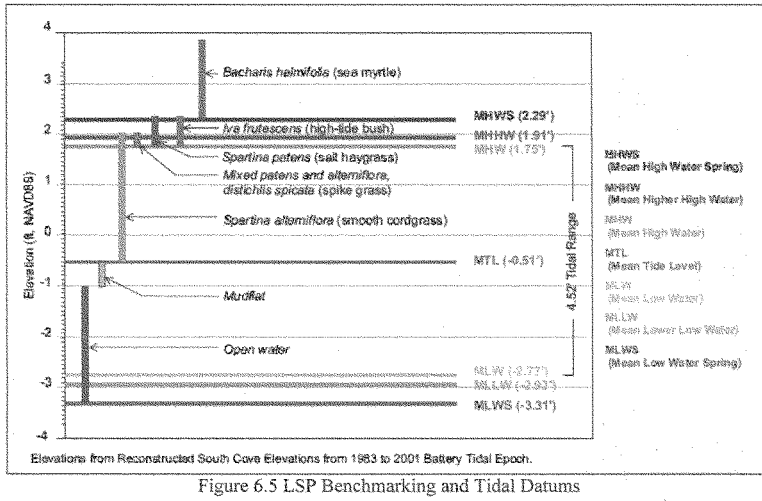


Figure 6.5 LSP Benchmarking and Tidal Datums

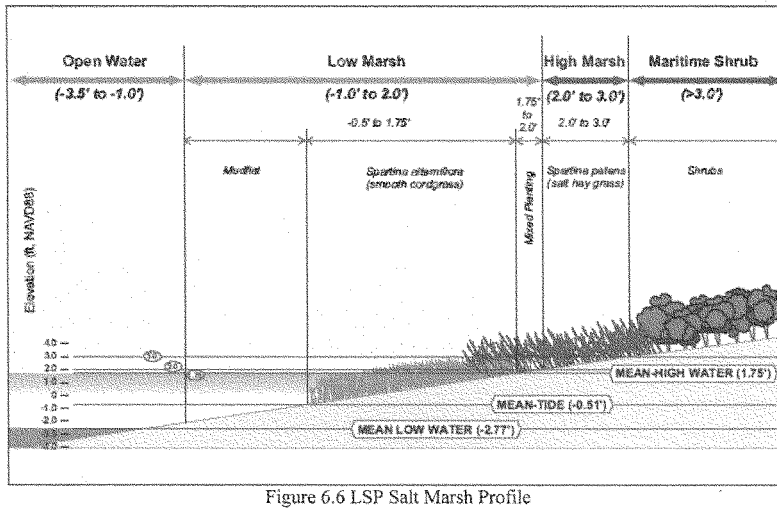


Figure 6.6 LSP Salt Marsh Profile

4. High Salt Marsh. In the Hudson-Raritan Estuary and in other estuaries in the Northeast United States, the dominant high salt marsh species is *Spartina patens*.

However, this zone is usually much less homogeneous than the low marsh, and is often a mosaic of a number of species including salt hay grass (*Spartina patens*), spike grass (*Distichlis spicata*), a short form of smooth cordgrass, black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), high tide bush (*Iva frutescens*) and common reed (*Phragmites australis*) (Tiner 1985). *Spartina patens* grows at a minimum to mean high water spring (elev. 2.29) but often occurs up to the extreme high tide. This upper boundary may be inundated infrequently, in some locations as little as once or twice annually. Such inundation usually occurs during the spring tide cycle (highest annual tides or MHWS) and during the severe storm events. This is confirmed for New Jersey salt marshes by Tiner (1985), who states "The upper margins of the high marsh may be flooded only during storm tides which are more frequent in winter." "Extreme high tide" is not specifically recorded in the regional tide data. While, the highest observed water level was actually over 4 feet above MHWS, about one foot above MHWS or an elevation of 3.3 ft is a reasonable estimate of "Extreme high tide" and a possible upper limit for the high marsh. The *Spartina patens* biobenchmark results are also found in Figure 6.5 and Figure 6.6. The regrading and planting plan for high marsh also was developed by merging the tidal datum and biobenchmarking information, and by incorporating the observations of scientists in the region studying salt marshes.

The material excavated for the creation of the tidal creek will be placed on-site in a berm in the southwest corner of the site. The berm will be contoured in such a way as to increase water flow to the seasonal wetlands in the southern half of the site. To ensure stability, the material will be encapsulated above and below in a clay layer, as the soil tends to be porous. Following the clay layer, a layer of sand will be placed on the berm and seeded with native vegetation. These measures will add stability to the structure in an ecologically sensitive manner.

Components of Proposed Alternatives

Not only was the South Cove tidal marsh used as a biobenchmarking reference site, correlations between the width of the channel (at high and low tide) and the upstream channel length, drainage area and tidal prism were examined and used as a guide to laying out the proposed 36 acre salt marsh. A channel width of 50 ft at the North Cove confluence, tapering to 25 ft at the upstream end of the marsh was found to convey sufficient flooding to the proposed low and high marsh throughout the site while minimizing costly excavation. This analysis is discussed later in this report.

A 48 ft wide culvert will be constructed to facilitate the creation of the tidal creek under Freedom Way, thereby allowing vehicular to continue unimpeded. The culvert is necessary to convey the tidal waters from the North Cove to the proposed tidal marsh within the rectangle. It will have a natural bottom consistent with the sandy bottom proposed for the entire length of the tidal channel (see Engineering Appendix for details).

Natural tidal marsh channels in the region have very mild slopes in the longitudinal direction. The proposed LSP tidal channel slope is 0.0001 ft/ft. The proposed sinuosity, or the ratio between the tidal channel length and the tidal valley length is 1.7, also similar to natural tidal channels in the region.

The maximum slope used in the design of the mudflats was 1V:3H. The geotechnical investigation revealed that unconsolidated, silty material lies in the location of the proposed tidal creek outlet. A 1V:3H slope was suggested by contractors as the steepest slope at which their earth moving equipment can operate comfortably. The marsh will undergo an adjustment period after a few tidal cycles whereby equilibrium slopes will form, and it is anticipated that minimal adjustments will be made to the planting plan to adjust to the equilibrium process. Natural tidal mudflats in the region vary considerably in slope. However, well-established *Spartina alterniflora* dominated tidal marshes have the root structure in the soil to support much steeper slopes. These slopes cannot be constructed without the use of hard structures. Monitoring the slope of the mudflats will be a part of the monitoring plan, and efforts will be made to guide the mudflat slopes to mimic natural systems. A mudflat feature was created at the upstream extent of the tidal channel. This feature adds more essential fish habitat and more diversity to the tidal marsh plan.

The low and high marsh re-grading plan was discussed in the previous section. To stabilize the slopes and to outcompete phragmitites, *Spartina alterniflora* and *Spartina patens* will be densely planted, at a spacing of 18 inches on-center for each plug. To account for contingencies in the regarding equilibrium process, in the elevation zones between low marsh and high marsh, both *Spartina alterniflora* and *Spartina patens* will be planted. Similarly, in the elevation zones between high marsh and maritime scrub/shrub, both *Spartina patens* and spike grass (*Distichlis spicata*), a short form of smooth cordgrass, black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), hightide bush (*Iva frutescens*), sea myrtle (*Baccharis halimifolia*), rose mallow (*Hibiscus moscheutos*), and seaside goldenrod (*Solidago sempervirens*) will be planted.

Low levels of contamination have been found during investigations at Liberty State Park. For added security, to minimize exposing the proposed tidal marsh to contaminants, a one-foot layer of compacted cohesive material will line the footprint of the tidal marsh. The clay layer is also necessary because of the porous nature of the study area soil. A one-ft layer of clean sand will be placed on top of the cohesive material to provide a more common substrate for tidal marsh plants to take root.

The testing conducted for this feasibility report indicated that low levels of contamination might be present in the North Cove. To prevent this material from entering the proposed tidal marsh, and to provide a more suitable substrate for benthic habitats, the entire North Cove below MLLW, out to the Liberty State Park Causeway will also be capped with 1 ft of clean sand.

6.4.2 Fresh Water Marsh

Wildlife Considerations

The Threatened and Endangered listed bird species do not have habitat requirements that include a specific hydroperiod. They can be expected to use wetland or upland habitats provided that the vegetative structure of these habitats meets their needs. For example, the northern harriers prefer grassland habitat with few trees and shrubs. Harriers will nest in both uplands and wetlands, but the pair nesting at Liberty State Park seems to prefer uplands for nesting. For winter roosts,

harriers prefer upland sites. Many sources indicate harriers prefer to nest and roost in fields that are 50 acres or more in size; however, the species has also been documented to nest in habitat blocks as small as 20 acres.

Aside from the northern harrier, none of the other Threatened and Endangered bird species of special concern that were observed during inventory surveys have been documented as breeding in the park. Their use of habitat relies more on habitat with the correct vegetative structure and adequate food resources rather than hydroperiod.

One listed plant species, Torrey's rush, was found on the site. This species has hydrologic requirements and is adapted to specific types of soils. It is a facultative wetland (FACW) species, which means it has the probability of being found in a wetland 67-99% of the time. The Natural Resource Conservation Service's (NRCS) Plant Database indicates this species is adapted to medium to coarse-textured soils and has a low-tolerance for drought conditions. The NRCS lists the minimum and maximum amount of precipitation needed as 14 and 50 inches per year, respectively. The minimum root depth is 10 inches and the species is intolerant of both shade and salinity. This species was identified in a freshwater wetland on-site. That wetland area should be protected during construction while also considering the habitat requirements for the species when enhancing other freshwater wetland habitats on-site.

Besides accommodating the listed species in the design, the primary design goal of the fresh water wetland system was to create a fresh water deep emergent marsh, a habitat that once was prevalent in Hudson County, NJ, and now is very rare. Enhancing existing fresh water wetlands and enhancing storm water runoff quality from adjacent parking lots were secondary goals.

Hydraulic and Hydrology Considerations

The minimum water requirements for wetland sustainability are determined by a combination of factors that require balance. In order to maintain a wetland with a permanent pool of water and sufficient flow to maintain good water quality, sufficient drainage area is required. Without supplementing the water supply through pumping, a minimum watershed of ten acres is required for maintaining a year round permanent pool of approximately one acre. A second rule of thumb is that four acres of contributing watershed are needed for each acre-foot of storage (Md SCS 1976; Schueler 1987). For this plan, five to nine acres of contributing urban watershed are available for each acre-ft of planned wetland storage. This range of ratios suggests that the watershed is sufficiently large to support the planned wetlands. Relying on a smaller watershed than this would make maintaining a permanent pool difficult and would produce large fluctuations in the water level due to evaporation and infiltration losses.

There are many hydrologic and hydraulic considerations important to wetland restoration and construction. The primary list of design criteria includes the following basic interrelated elements:

- Hydrologic setting,
- Flood duration and timing,
- Water depth,

- Flow velocities and hydraulic retention time,
- Storage capacity, and surface area

Hydrologic Setting: The hydrologic setting of the wetland describes the location of the wetland in relation to other water bodies. The hydrologic setting is important to all wetland functions, but is of particular importance to groundwater recharge/discharge, sediment retention, flood-flow alteration, and production export. The existing and proposed freshwater wetlands within Liberty State Park are generally independent of any other water body (e.g., stream, river, lake, etc.). They occur in typically heterogeneous material that has a relatively shallow water table. Thus, they are presumably influenced by a fluctuating water table. The proposed wetlands would be constructed in the same general area (park interior) as the existing wetland in similar substrate types.

Flooding Duration and Timing: The existing wetlands within Liberty State Park are typically seasonally wet (i.e., during the spring and fall), with the exception of the Liberty Science Center wetland, which is frequently flooded from runoff from the NJ Transit terminal and parking lot. Similarly, the drainage ditches along Phillip Street are frequently flooded with runoff from the Liberty Science Center. Based on the hydrologic budget analysis, diversion of stormwater runoff from the parking lots adjacent to the park into the proposed wetlands will result in the proposed wetlands maintaining measurable pool depths most of the year.

Water Depth: Water depth is an important factor in determining the types and extent of vegetation supported by the wetland. The existing wetlands are shallow, seasonal wetlands, most likely augmented by a rising water table during the wet seasons of the year. The proposed wetland system would have both shallow and deepwater areas to support a greater abundance of plants and wildlife than the existing wetlands.

Flow Velocity and Hydraulic Retention Time (HRT): Maintaining a low velocity related level of flowing water shear stress is important to several wetland functions. As a result of the shallow gradient of the park and the detention-design of the wetlands, velocities will be minimal. The HRT is defined as the average amount of time that a parcel of water stays within the wetland before exiting. The HRT is the key design criteria for water quality enhancement functions such as sediment/toxicant removal and nutrient removal/transformation. For this feasibility analysis, the focus was on flood frequency and duration, and depth. It is expected that the wetland system will cause a measurable increase in HRT, which will further result in improved water quality entering the Harbor. Obviously, excessive HRT in the wetland could result in wetland water quality problems such as low dissolved oxygen and the production of sulfide and methane gases. However, frequent runoff is expected to provide frequent flushing of the wetland system.

Storage Capacity and Surface Area: The storage capacity is most important in the flood-flow alteration function because the amount of available storage in the wetland determines how much of the runoff can be routed into and through the wetlands. The storage capacity may also affect aquatic abundance and diversity, in that larger wetlands will have more potential for groundwater recharge, greater volume and surface area, and may support more aquatic organisms. Storage capacity was used in this analysis to reach design water surface elevations based on seasonal inflows. The wetland bottom area is important for groundwater recharge and discharge. Ground

water recharge was not a primary concern of the proposed designs; it is anticipated that the wetlands will be lined with a low permeability liner. Runoff inflows were expected to be sufficient to overcome evapotranspiration, even during the drier months of the year.

Components of the Proposed Alternative

In order to maximize habitat function and value, the freshwater wetland system will have four primary components: (1) an enhanced Liberty State Park wetland, (2) a Biofilter (BF) wetland, (3) a Deep Emergent Marsh (DEM), and (4) natural connecting swales (Figure 6.7). The proposed freshwater wetland system should be located in the center of the park, in close proximity to the proposed tidal wetland. Ideally, the DEM should be at least 400 or 500 feet away from the nearest road or heavily used area.

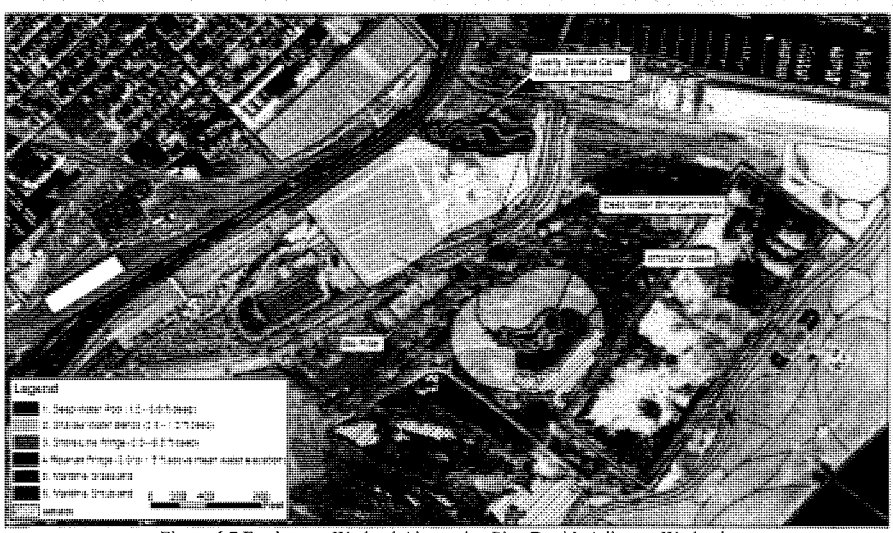


Figure 6.7 Freshwater Wetland Alternative Plan D with Adjacent Wetlands

The proposed freshwater wetlands will contain a number of hydrologic/habitat zones, as follows:

Zone 1. Deep Water Pool (1-6 feet deep), to support submerged aquatic plants such as wild celery, sago pondweed, and redhead grass.

Zone 2. Shallow Water Bench (6-12 inches between groundwater level and the discharge invert), to support emergent aquatic plants. Proposed plants are obligates and are relatively intolerant to drawdowns. Typical plants in this zone include: Pickerelweed (*Pontederia cordata*), Duck potato, (*Sagittaria latifolia*), and Soft stem bulrush (*Scirpus validus*).

Zone 3. Shoreline Fringe. This is a regularly inundated area, which supports wet meadow scrub-shrub wetland, including plants such as sedges, switchgrass, and buttonbush. This zone is typically between the discharge invert and an overflow elevation.

Zone 4. Riparian Fringe. This is a periodically inundated area, which supports wet soils or scrub-shrub transition, including plants such as red osier dogwood, red maple, and swamp oak. This zone is typically above the overflow elevation.

Features in the Proposed Plan

Enhanced LSC Wetland (Wetland 1): The wetland will be enhanced through the removal of the common reed and purple loosestrife, regrading, and replanting. The enhanced wetland will contain Zones 2 through 5 as described above. Figure 6.8 and 6.9 shows the enhanced LSC wetland. The area of the wetland will be 2.27 acres, and the perimeter 2,033 ft.

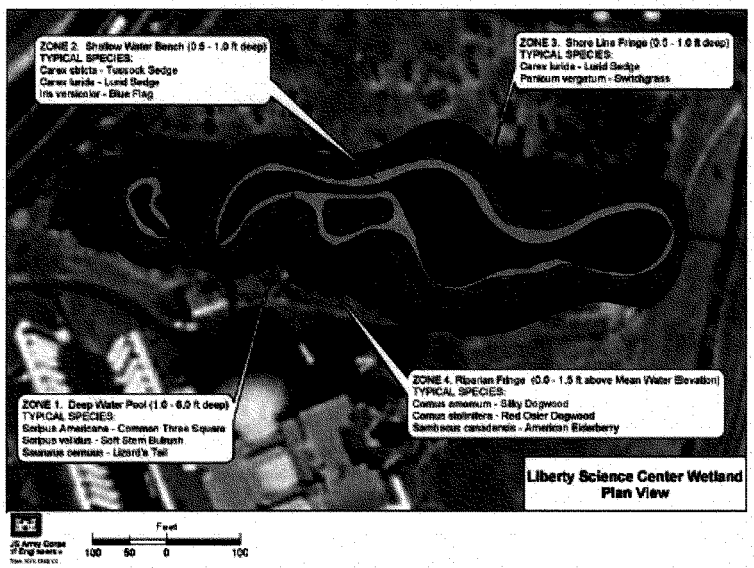


Figure 6.8 LSC Wetland, Plan View

Biofilter Wetland (Wetland 2): The second wetland will be designed for water quality pre-treatment and contain wetland Zones 2 through 5 as described above. The wetland will provide pre-treatment by removing coarser sediments, trash, and debris. This pre-treatment should also provide for the significant removal of particulate pollutants. The deeper areas of the wetland will function as either a permanent pool or shallow marsh areas. The deep area will enhance the removal of soluble phosphorus and nitrogen. Figures 6.10 and 6.11 show the Biofilter wetland. The area of the wetland will be 0.79 acres, and the perimeter 1,442 ft. As the Biofilter will be

composed of *Phragmites australis*, which generally does not attract species, it is not anticipated to be an attractive nuisance or adversely affect wildlife species in other similar ways.

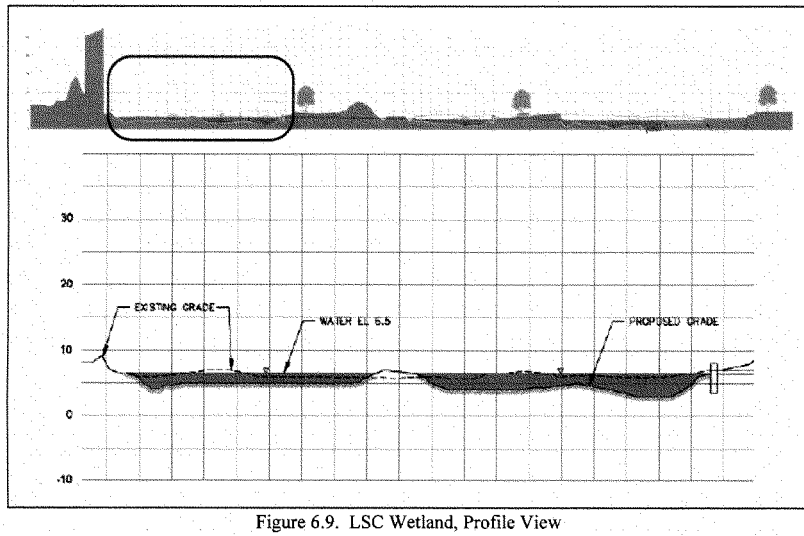


Figure 6.9. LSC Wetland, Profile View

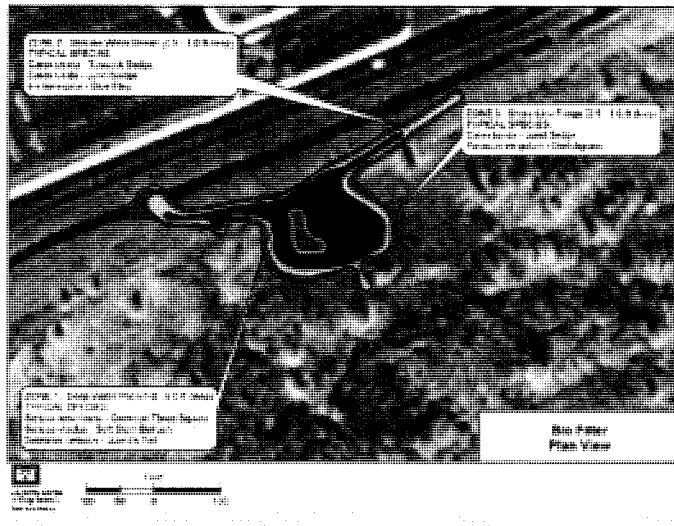


Figure 6.10 Biofilter, Plan View

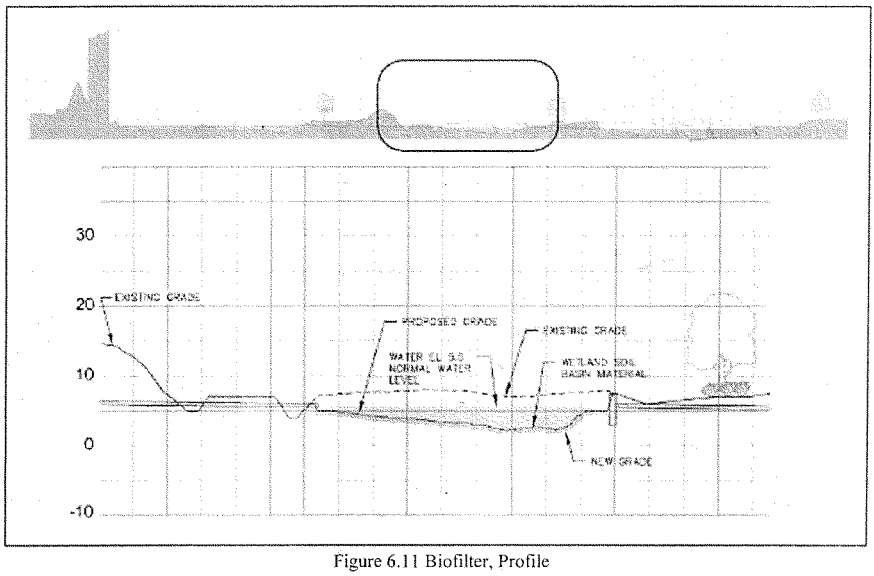


Figure 6.11 Biofilter, Profile

Deepwater Emergent Marsh (Wetland 3): The mean water elevation of the DEM will be approximately 5.0 ft NAVD with bottom elevation around 0.0 ft NAVD.[29] The wetland area is about 1.8 acres, the perimeter is 1,397 ft., and average volume is approximately 32,700 cubic feet. The perimeter is about 148 ft. These dimensions include all four of the wetland zones. The deepwater areas of the wetland should be permanently flooded. The zone between the typical low level and the overflow outlet may be seasonally flooded. Above the overflow elevation will be a transition zone to upland areas. Figures 6.12 and 6.13 show the DEM.

[29] See Figure B-3 of Appendix B of the Hydraulics and Hydrology Freshwater Wetlands Report (Appendix H of this report).

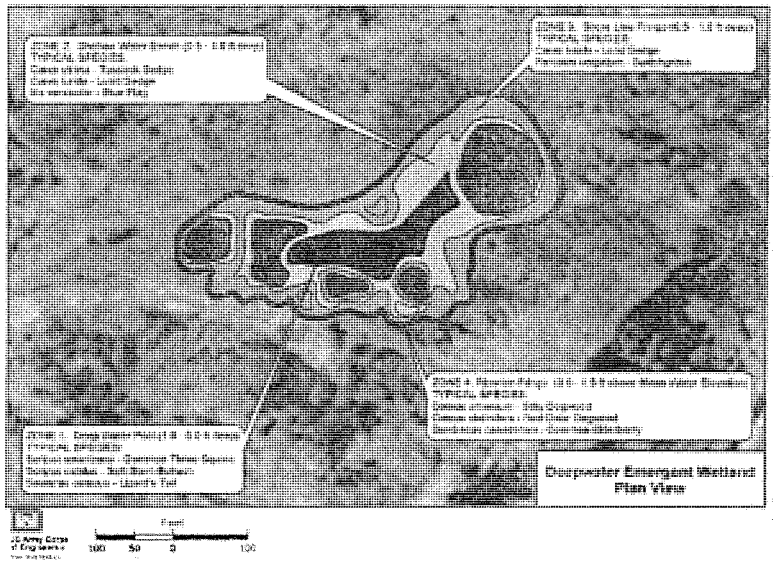


Figure 6.12 Deepwater Emergent Marsh, Plan View

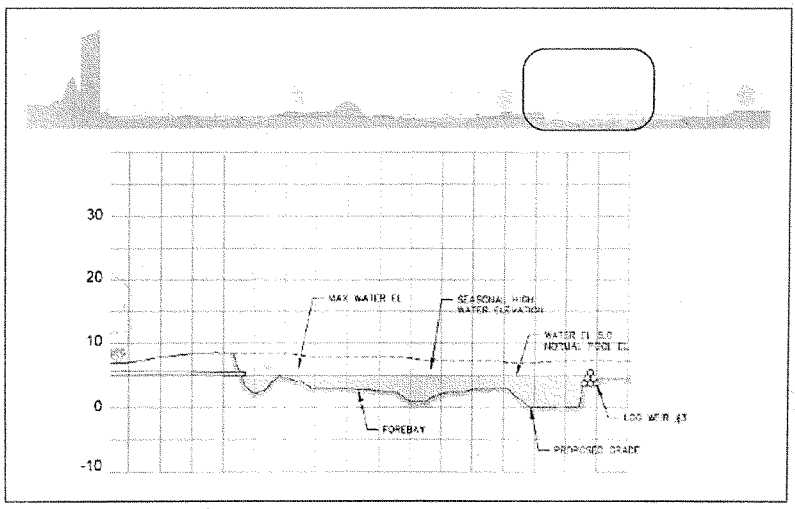


Figure 6.13 Deepwater Emergent Marsh, Profile View

Connecting Swales: Natural swales will connect the wetland system within the park to limit structural components in the freshwater system, provide additional functional value, and

maintain the ecological nature of the site. Swale slopes should be graded as close to zero as drainage will permit. Between the biofilter (5.5 ft NAVD) and the deep emergent marsh (5.0 ft NAVD) there is a half foot elevation drop in about 400 feet or a slope of about 0.125%. Side slopes of the swale will be about 3:1 (h:v) or less. The swales will be planted with a dense cover of water tolerant, erosion resistant grass. This grass will not be mowed close to the ground to avoid impeding the filtering and hydraulic functions of the swale. Since the system will use parking lot runoff, sensitive grass species with a low salt tolerance such as bluegrass, should be avoided. Reed canary grass is ideal but is also considered an invasive species.

Infiltration Basin: One method of returning excess stormwater to the interior of the site would be to direct this excess to an infiltration basin. This would ensure that the water is being discharged to an area with high permeability and allow quick groundwater recharge. Infiltration basins are also effective in removing both soluble and fine particulate pollutants that may still be in the stormwater discharged. The basin would be receiving this water during wet months and/or during larger storms. While this water will have been treated by the other constructed wetlands, the discharge may still contain some pollutants during large storms. In this case, the basin would serve as a final polishing system along with providing control of peak discharges for large design storms. The high permeability soils are well suited for use as an infiltration basin with little soil augmentation required. The infiltration basin, shown in Figures 6.14 and 6.15, would provide an impoundment by excavating the soil to an elevation of approximately elevation of 4.5 NAVD. The impoundment will store a defined quantity of about 3 acre feet of runoff, allowing it to slowly infiltrate through the permeable soils of the basin floor. The floor would be graded as flat as possible and a dense native grass cover would be established to promote infiltration, add habitat value and bind up deposited sediments.

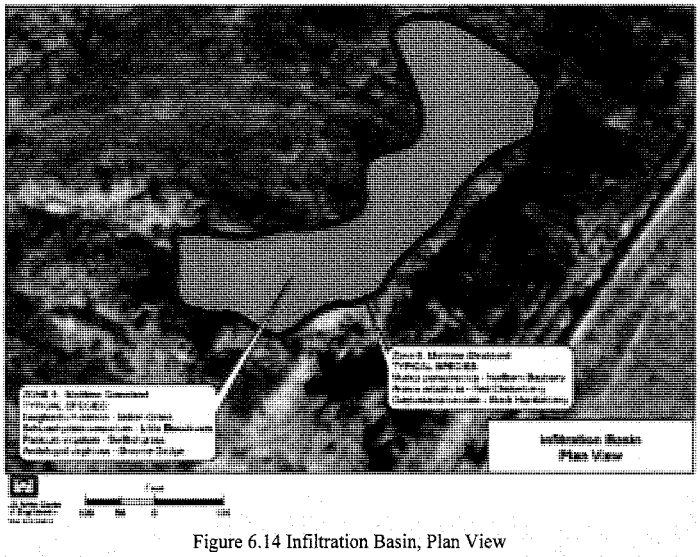


Figure 6.14 Infiltration Basin, Plan View

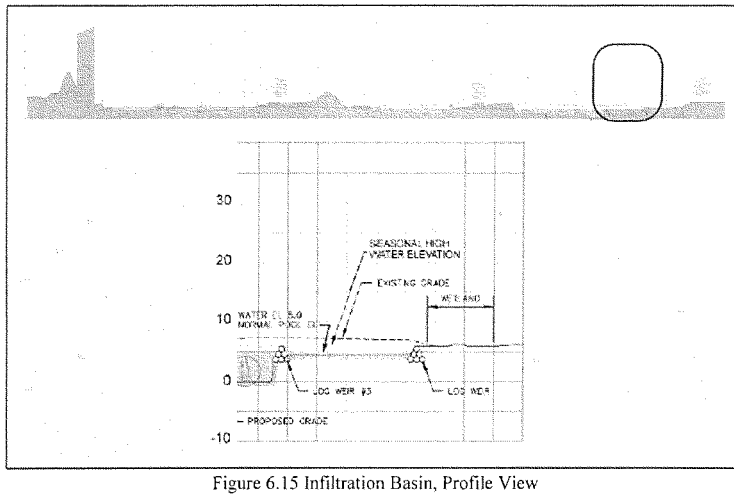


Figure 6.15 Infiltration Basin, Profile View

6.4.3 Upland Buffer and Seasonal Wetlands

Within the project areas not designated for the tidal system or the freshwater wetland systems, invasive species such as *Phragmites* and mugwort are thriving. The presence of these very aggressive invasive species, so close to the proposed tidal and fresh water wetlands, imposes a great risk to the sustainability of these communities. Therefore, in order to ensure the integrity of the restoration, upland buffer zones for the tidal wetlands and the freshwater wetlands throughout the site (including the freshwater wetland system and the seasonal wetlands) are included as a necessary part of project implementation. Where monitoring of the cleared upland areas show that additional measures are required, a mixture of clean fill and topsoil could be brought in where needed, and maritime scrub/shrub plants could be planted in the places where vegetation of low habitat value currently exists, to create a protective buffer for these water resource solutions. Some of the seasonal wetlands themselves are infested with invasive species, and will require clearing and grubbing to function properly. This area, along with the tidal and fresh water systems, will be managed in the years following construction to minimize the reintroduction of invasive species. The location of these buffer zones will be refined in the Pre-Construction Engineering and Design (PED) phase.

Although the berm is technically a byproduct of the tidal marsh construction, the result will be an upland environment and is consequently discussed in this section. Its functions are directly linked to the aquatic habitat portions of the site, as it increases water flow to the now seasonal wetlands. The berm also protects the tidal marsh and freshwater wetland habitats from the industrial activities right outside the park. It should be noted that there are vast swaths of successful upland habitat with no wetlands. Nothing is planned for these swaths.

There is proposed trail that is part of NJDEP's General Management Plan that will be planned and constructed at 100% non-Federal cost. NJDEP will coordinate with USACE to ensure that the recreational feature is compatible with the ecosystem features.

7. ENVIRONMENTAL CONSEQUENCES

7.1 Environmental Effects of Restoration Measures

Implementation of the recommended plan is expected to result in a substantial net increase in estuarine-related functional habitat value throughout the proposed restoration area. Thus it is determined that there will be no significant adverse impact to the environment as a result of implementation of the proposed restoration project.[30]

There will be minor, acceptable permanent exchange of habitat in low-functional value vegetative communities. There will be some substantial but temporary permitted construction impacts in relation to the excavation of the contaminated soils of the tidal marsh area and the safe upland placement and encapsulation of this material. In every case, throughout this project area, the physical replacement of habitat will result in a net increase in functional habitat value, including JD wetlands and relatively high value existing terrestrial habitat, such as in the proposed tidal marsh area.

Potential non-significant adverse environmental impacts and their rationale for non-significance are summarized as follows:

a) Tidal marsh habitat exchange. Estuarine functional habitat value will increase very substantially as a result of altering existing habitat for salt marsh, including tidal creek, intertidal flat, low marsh and high marsh. The expected change in habitat function is detailed in table 6-3 and figure 6-2 of the ERI. Effects on the northern harrier, which uses the existing MG, are addressed in section 7.1.7.3. A clay layer of thickness meeting NJDEP requirements will be placed on top of the newly exposed soil right after excavations for the salt marsh to prevent potential bio-uptake. Topsoil will be placed on top of the clay layer to make the tidal marsh amenable to planting of *S. alterniflora, S. patens* and other salt marsh plants. The thickness of the clay layer will be determined by NJ DEP requirements to prevent the upward migration of contaminants present in the soils below the depth of excavation. It should be thick enough to be stable from an engineering standpoint and deep enough to prevent root penetration through the clay layer.

b) Excavation, transport and encapsulation of contaminated soil. It is expected that the proposal to excavate, transport, place and encapsulate the contaminated soils to be removed from the 45-acre rectangle for the construction of a salt marsh system will have an overwhelmingly positive effect on the environment. This expectation is based on the following:

1. Contaminated soils to be excavated will be handled strictly according to the Health and Safety Plan approved by the NJDEP and applicable OHSA rules and regulations. This may include reducing effects through use of watering down surface soils during excavation to reduce or eliminate air borne contamination; the addition of soil treatment

[30] The criteria, metrics and rationale for this determination are summarized in the ERI, specifically, section 6 (Functional Assessment of Ecological Communities), figure 6.2 (Cumulative Functional Values of Existing Conditions and the Proposed Habitat Restoration Plan at LSP) and table 6.3 (Functional Assessment Scores for Existing and Proposed (i.e., Recommenced Plan)) Conditions at LSP).

and/or flocculants to stabilize before transport; and other BMP as appropriate to reduce impacts. JD fresh water wetland # 3 will be converted to salt marsh and MG (compare figure 3.8 to the map of recommended plan).

2. Rainwater and groundwater that accumulate in the freshwater wetland excavated areas will be treated. This will include using flocculants, stabilizers, pH enhancers, and other biologically acceptable chemicals to reduce the potential for biological uptake of contaminants within the detention basin and upon release to Upper Bay. Water will be consolidated in a detention basin that will precipitate out the required amount of suspended particulates and associated contaminants so that NJDEP WQC standards will be met.

3. Stabilized excavated soil will be transported in a manner conducive to retaining virtually all of the material within earth moving equipment, including the minimization of air quality impacts, from the point of excavation to the point of placement in the berm area.

4. The berm area will be lain over with a clay layer that will encapsulate the contaminated soil and prevent it from entering into groundwater and the environment in general. Another clay layer, if necessary, will be applied over the contaminated soil and then capped with topsoil for stability and seeded with native vegetation. Therefore, no release of bio-available contaminants from the berm is anticipated. Note that the MG surrounding the berm will also receive a treatment of topsoil and/or sand to a depth of potentially 1 foot, possibly more. The thickness of clay and topsoil layers to be established around and on top of the berm are to be determined, but will be at least the minimum required to encapsulate the contaminated substrate placed there.

5. Potential release and bioavailability of contaminants from both the excavated and berm areas will be monitored for 5 years under the proposed monitoring plan (see section 8.3).

c) Dredging of North Cove. The proposed dredging of less than 500 cubic yards is needed in North Cove to facilitate tidal flow in the proposed tidal channel. This action is not expected to result in any significant impact to the environment, including the release of sediment contaminants during dredging, because of the very small amount of dredging required. However, testing conducted to date indicates there is a potential for the presence of contaminated sediments in the area. Impacts from the dredging are expected to be minimal. All materials, excavated and dredged, will be encapsulated in the perimeter berm. The removal and transport methodology will be refined for the dredged material during Plans and Specifications.

d) Restoration of North Cove. Re-contouring of the North Cove bottom (sand capping to approximately an averaged depth of 1 foot) is proposed to restore benthic habitat and isolate existing surficial contaminants from biota. The fine sediments in North Cove have been found, on the basis of testing conducted to date, to have elevated levels for some contaminants of concern (Appendices B and E). Clean sand will be placed over the re-contoured areas to provide an improved benthic environment with higher ecological functionality (see section 3.7.2.5 which provides an analysis of existing benthos). North Cove is a depositional area or "sediment sink"

in the Hudson River Estuary. It is anticipated that additional natural sediments will continue to migrate to this area and mix with the placed sand. This mix of sediments is expected to further enhance habitat values for benthos over time. The re-contouring plan will be refined during Plans and Specs with further modeling to optimize sand placement for geotechnical stability. The intertidal zone within North Cove, although relatively small, may also benefit from restoration depending on the results of additional contaminant testing to be conducted during Plans and Specs. Also, where warranted, identified unwanted debris will be removed from the intertidal zone to promote intertidal productivity and reduce the amount of anthropogenic materials that may trap flotsam that may enter the tidal creek.

e) Elimination of JD wetland # 3. At present, there is an approximately 3-acre common reed dominated JD wetland along the perimeter of the 45-acre rectangle area (ERI Figure 2-5 and Table 2-2). This will be converted to high salt marsh (*S. Patens* dominated) and MG with the result that functional values will be considerably increased (ERI Table 6-3 and Figure 6-2). Conversion of this low-value, invasive species-dominated habitat to high functional salt marsh and MG is not expected to have a significant impact on the environment.

f) Re-plumbing for creation and enhancement of fresh water wetlands. Significant redirection of fresh water sources and sinks within the proposed restoration area will occur upon implementation of this project. This engineering work is not expected to have significant impact on the environment, in fact it is anticipated that the addition of fresh water to areas that currently do not have it will substantially increase functional habitat value in the areas to be restored. Some existing habitat will be lost, although these are generally low-value invasive species-dominated habitats (see Figure 6.4). In addition, an integral part of this recommended plan is the enhancement of fresh water wetlands on site to utilize existing low-value common reed dominated areas as bio-filters to improve WQ for wetlands further down stream.[31]

g) Invasives dominated habitat exchange. Approximately one-half of the existing restoration site is dominated by invasive vegetation, mostly common reed, purple loosestrife, tree of heaven, mugwort, Japanese knotweed and others. Without intensive management, more areas will be dominated by these invasive species and other undesirable opportunistic vegetation, such as winged sumac, consequently lowering overall vegetative diversity. The proposed restoration involves selective removal and control of invasive species. However, small invasive stands of vegetation that do not threaten nearby habitats will be left alone, if appropriate (e.g., where *Phragmites* forms a barrier to isolate a breeding area and is not spreading). Per table 6-3 and figure 6-2 of the ERI, functional habitat value is predicted to increase substantially from application of this practice of replacement with non-invasives. Wildlife such as red-winged blackbird and marsh wren, which prefer common reed for nesting to other habitats, may be reduced in number on site, but they will not be negatively affected in the overall population. They are generally very adaptable and common animals that have numerous other available habitats in the immediate area, and on site, to satisfy their life requirements. Replacement of

[31] See locations of the 2 bio-filter wetlands and the infiltration basin, which itself will be converted from terrestrial, invasive-dominated habitat to a seasonally flooded freshwater wetland on the recommend plan. A detailed description of this re-plumbed engineering is provided in the Engineering Appendix, Hydrology and Hydraulics of Fresh Water Wetlands report, Plan D.

common reed, mugwort, Japanese knotweed and other nearby species with grassland and marsh will greatly benefit raptors, such as the northern harrier, which feed and nest in relatively short grasses.

h) Increased cost to federal and state governments. Implementation of the proposed project will have a negative effect on the taxpayer in the sense that federal tax funds will be used to pay for the federal share of this project. However, this cost is justified based on the benefit-cost analysis performed by the District. Maintenance costs, generally a non-Federal partner responsibility, for the state of NJ will be increased. However, it is also assumed that the cost is justified because many people will enjoy the vastly improved park. Local businesses are expected to have increased revenue as a result of increased visitorship to the park.

i) Increased vehicular traffic. An increase in visitorship to the park would mean more vehicles and noise. However, because there are no new roads, parking lots or massive vehicular infrastructure additions, no significant impacts to the environment are expected.

j) Construction and long-term air emissions. There will be a significant impact to select parts of the LSP during construction. These effects will be temporary and locally restricted. All feasible precautions will be taken to avoid and minimize construction impacts as described in other sections of this report. A small increase in temporary air emissions is expected due to increased visitorship to the park as a result of this restoration.

7.1.1 Physical Setting

Short-term (construction) or long-term significant adverse impacts to the physical setting of the project area are not expected as a result of implementation of the recommended plan. Parts of the project area will look like a typical construction site with associated impacts at varying stages in the construction process, but these temporary impacts will be avoided and minimized to the extent feasible. In general, long-term impacts are expected to be overwhelmingly positive as currently existing fenced-off hazardous waste sites are converted to high value natural habitats, fences are removed and aesthetically pleasing trails and educational amenities are erected, improving the physical setting of the area significantly.

7.1.2 Climate and Weather

No short or long-term significant adverse impacts to climate or weather are expected from implementation of the recommended plan because of the relatively small size of the project. On the contrary, localized vegetative cover and humidity from greater surface water retention will locally have a small effect on temperature and oxygen content of the air.

7.1.3 Water Resources

Significant short or long-term effects on water resources are not expected due to implementation of the recommended plan. All necessary permits, including a NJ State Water Quality certificate will be applied for at the appropriate time in the planning process to insure that short-term temporary construction impacts to water quality are avoided, minimized and rendered acceptable to the State of New Jersey. Long-term permanent water quality impacts are expected to be overwhelmingly positive. NJDEP WQ standards attainment for North Cove are expected to

remain the same or improve, but definitely not get worse due to the expected decrease in residence time of tidal water and consequential increase in DO. Best Management Practices (BMP) will be utilized throughout the site, and likely required by the WQC, during all construction activities.[32]

7.1.4 Socio-Economics

Temporary Construction Effects

Temporary positive effects to the local economy will accrue from the construction of the Recommended Plan due to the introduction of construction workers and resulting purchase of supplies and food. Temporary negative effects include lack of access to certain portions to the park during construction, and air emissions from construction equipment (see Section 7.18 for details).

Long-Term Effects

The implementation of the recommended plan will not have any long-term adverse effects on the local economy, local income, or local housing. The environmental restoration of Liberty State Park may increase visitation to the site by providing visitors additional recreation opportunities. Increased visitation may benefit local businesses by adding demand for amenities and concessions.

The implementation of the recommended plan may also provide the incidental benefit of increasing property values in the area surrounding the site. The improvement of the area in an aesthetically sensitive manner (*i.e.* maintaining sight lines of the Manhattan skyline) and the provision of passive recreation opportunities (overlooks, trails, benches, etc.) inherent in Recommended Plan may add to the desirability of the neighborhoods surrounding the site. Other social benefits of the environmental restoration of Liberty State Park include reduction of the odor and other negative effects of standing water as well as eliminating exposure to the contaminants already existing at the site.

7.1.5 Cultural and Historic Resources

The Liberty Science Center Wetlands Complex area was not under consideration for restoration at the time the cultural resources study was undertaken, and so has not been surveyed. As the project proceeds, this area will be surveyed and subsequent cultural resources work will be undertaken as required. It is the Corps' opinion that the restoration work for the remaining areas at Liberty State Park will have no effect upon cultural resources if project plans remain as proposed. If excavation is determined necessary in the vicinity of the former Communipaw shoreline then subsurface work may be required. The New Jersey Historic Preservation Office concurred with this evaluation (see Appendix C). This work was also coordinated with the Liberty State Park Resource Interpretive Specialist.

[32] Appendix D of the ERI describes the WQ sampling program accomplished to date, and on-going additional sampling, such as groundwater salinity, DO, pH and water table fluctuations.

7.1.6 Land Use

Implementation of ecosystem restoration measures will not adversely affect the current land use in the Liberty State Park study area. Jersey City's economic growth and development will not be restricted by construction of the project because construction is located within the park itself. To the contrary, implementation of the selected plan will benefit the current and future land uses in Jersey City by augmenting the education and recreational capacity of Liberty State Park, and raising the value of adjacent residential and commercial properties.

7.1.7 Biological Resources

In general, biological resources will be enhanced by implementation of the recommended plan (see table 6-3 and figure 6-2 of the ERI). Higher functional value terrestrial vegetative communities are expected to be expanded and enhanced; fresh water wetland communities are expected to, on balance, be expanded in aerial extent and inundation period; a variety of estuarine ecological functional values are expected to be directly enhanced by the creation of the proposed tidal marsh; human values such as recreation, aesthetics, science, education, access to water and wildlife communities and park facilities are expected to be significantly increased.

7.1.7.1 Vegetation

Long-term adverse impacts to vegetative communities in the project area are not expected due to implementation of the recommended plan. There will be temporary construction impacts to specific areas, especially the tidal marsh and berm areas and selected fresh water and terrestrial areas. In all cases, a higher functional value vegetative community will replace areas temporarily affected in an adverse manner by excavation, landscaping and replanting. Depending on the community type desired, there will be varying amounts of time before the functional value of the enhanced communities are realized, with early successional communities (such as MG) achieving their maximum habitat values earlier than later successional communities (such as SNH). Torrey's rush, a NJ State endangered plant species, is present in relatively low numbers on the LSP restoration site, entirely in an MG community.

7.1.7.2 Fish and Wildlife Resources

There are not expected to be to any long-term adverse effects on fish and wildlife resources, including North Cove and the adjacent estuary, as a result of the implementation of the recommended plan.

Under existing conditions, there are no fish in fresh water areas of LSP to impact. DEM habitat with deeper permanently flooded refuge areas will be created which are expected to maintain a fresh water fish and aquatic invertebrate assemblage. Only seasonally flooded wetlands, which obviously do not support fish populations, exist currently at LSP.

In terms of estuarine fish in North Cove and the adjacent Upper Bay, adverse impacts will be limited to the temporary construction phase effects from the small amount of dredging to extend the bottom of the proposed tidal channel to approximately ambient -3.0 MLW depth in North Cove. Since habitat restoration is planned for North Cove as well as the terrestrial and fresh water parts of LSP, measures will be taken to restore this area also. Sand will be placed, to a

depth to be determined, over existing contaminated sediments/biologically stressed benthos of North Cove. The purpose is to isolate sediment contaminants now in the predominantly fine substrate from the Upper Bay, and to allow for a more biologically productive, less stressed benthic community to take hold in the cove, further enhancing the proposed tidal creek and marsh. An enhanced North Cove would be expected to act as a biological bridge to attract fish and invertebrates into the proposed tidal marsh from cleaner, more productive parts of Upper Bay. Sand (sediment transport) movement, if any, over time will be closely measured during the post-construction monitoring period to ensure that the sand cap remains where placed, thus reducing or eliminating contact between the contaminants in the underlying fine substrate of North Cove, and the created tidal marsh and deeper parts of Upper Bay. There is neither salt marsh nor SAV in North Cove or in any adjacent area of Upper Bay. The closest salt marsh to North Cove is South Cove (also part of LSP but not part of the proposed restoration).

The placement of a sand cap over existing North Cove fine sediment is also expected to increase bottom DO levels (primarily through a reduction in SOD), further enhancing fish and invertebrate functionality for the estuarine species and allowing for greater localized species richness. Over time, fine sediments will mix with the sand cap. This is desirable from a benthic habitat standpoint because some species, particularly infauna, prefer mixed sediment. At a point during the post-construction monitoring period (TBD) the efficacy of this habitat enhancement methodology will be reevaluated and a decision made to renourish, if necessary or sufficiently beneficial.

Long-term adverse effects are not expected on amphibians, reptiles, birds and mammals that currently utilize or would potentially utilize the proposed site. On the contrary, the analyses conducted for this EIS found that there would be an overwhelming increase in habitat appropriate to the species that currently utilize the site. This takes into account recognition that some habitat must be exchanged, resulting in a temporary loss of habitat value in the whole restoration site. For example, the known nesting site for the northern harrier within an existing unit of MG habitat located in the central portion of the 45-acre rectangle will be destroyed since virtually this entire area will be excavated for the creation of the tidal marsh system. As part of the overall restoration of LSP, however, habitat connectivity will be increased. The overall functional value habitat will be markedly improved, primarily by the increase in MG in locations currently dominated by mugwort that could be potentially overwhelmed by common reed and other invasive vegetation in the future. This approach is agreeable to USFWS and the NJDEP for the following reasons:

1. The temporary loss habitat function will be replaced by much greater amount of higher functional value habitat in the long term.

2. Species like the northern harrier are ephemeral and adaptable in choosing nesting sites and will benefit from expansion of preferable habitat in the long term.

3. The proposed plan may increase the possibility of successful harrier breeding, which is currently marginal. Large contiguous areas of habitat of preferable grassland habitat will be established that will increase isolation for nesting and substantially increase feeding territory for raptors.

4. Northern harriers can still feed in the salt marsh, and possibly nest in the MG area that will be established along the edges of the new tidal marsh, some of which will be contiguous with a swath of MG that will extend around the western part of the overall restoration site.

The same logic applies to all species and all habitats for the purposes of this restoration project. If information comes to light during further coordination with the agencies and the public that requires certain areas to be left untouched, the District will seriously consider excluding these areas from the final designs for the project as long as doing so does not interfere with implementation of the overall project plan.

7.1.7.3 Threatened and Endangered Species

No significant adverse impacts to any TES are expected as a result of implementation of the recommended plan. There are no Federal TES or critical habitats on site, based on 2003 surveys (ERI). The IC has identified (Appendix B of ERI) some Federal listed species such as the piping plover. However, these were rare sightings, possibly outside the project area, and therefore should not require consultation with the USFWS. There are, however, 7 NJ State listed species found within the proposed restoration area during the 2003 surveys described in the ERI (Appendix A). These are one plant, the Torrey's rush, and 6 birds including the northern harrier, the Savannah sparrow, the long-eared owl, the short-eared owl, Cooper's hawk and the bobolink.

7.1.8 Air Quality

The General Conformity provisions related to the Clean Air Act require a conformity demonstration for each pollutant where the total and indirect emissions from the Federal action exceed the corresponding *de minimis* standard for each pollutant threshold. Preliminary emission estimates were made based on emission estimates generated from similar activities for other projects.

Based on the preliminary analysis, which are solely based on assumptions regarding construction equipment staging and schedule, total direct and indirect NOx emissions appear to exceed *de minimis* threshold of 25 tons per year. In close consultation with the USEPA and the NJDEP, the Corps will conduct a detailed, comprehensive quantitative analysis in the next project phase (PED) to precisely quantify all emissions from the Liberty State Park project and to determine if conformity has been met. Upon completion of the revised emission estimates, if applicability is determined, a Draft General Conformity Determination will be prepared and will undergo formal agency and public review. Results and conclusions of this process will be part of the environmental review, including, as necessary, detailed analyses of alternatives, such as emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions during PED.

7.1.9 Noise

No significant long-term (post construction) noise impacts are expected due to implementation of the proposed project. In fact, the proposed berm in the SW corner of the proposed restoration site

will reduce noise impacts to the interior of the site to a small degree, possibly adding to the isolation effect for sensitive wildlife, such as ground-nesting birds in the MG habitat east and north of the berm. There will, however, be significant short-term (construction phase) noise impacts in localized areas due primarily to the operation of earth moving vehicles. These localized noise impacts will occur primarily on the 45-acre rectangle and the SW corner of the site, due to excavation and creation of the proposed berm area and the North Cove area, due to some re-contouring of the Cove bottom. These noise impacts during the construction period will result in little if any wildlife ecological functionality in the actively constructed areas. Noise impacts to heavy equipment workers will not be significant assuming they follow OHSA and NJDEP Health and Safety Plan rules (head gear, ear protection gear, etc). Once construction is completed in any particular area, noise levels will return to ambient levels. They may actually be reduced over the long-term because of the addition of trees and shrubs and, as stated previously, because of the presence of the berm. Construction windows may be applied to minimize, among other impacts, noise impacts to wildlife. This will be addressed in Plans and Specs when construction schedules are developed. Vehicular traffic will likely increase somewhat because of anticipated increased visitorship to the park. However, existing roads are sufficiently removed from existing habitat areas enough that this should not be a significant impact. Unauthorized vehicular access to the restoration area will not be allowed. Trails will be laid out to minimize noise/human presence impacts to sensitive wildlife and habitats.

7.1.10 Recreation

There is no USACE recreation plan at this time, although NJDEP is planning recreational features to be undertaken at 100% non-Federal expense. Any future recreational features will be coordinated with USACE to ensure compatibility with ecosystem restoration measures. There will be no long-term direct or indirect adverse impacts to any existing or planned recreational areas after construction of the proposed ecosystem restoration measures. Minor, temporary impacts associated with bird watching, fishing, hiking, biking, and boating may occur during construction activities. Once construction is complete, there will be additional recreational opportunity such as walking, running or biking along trail ways within Liberty State Park and the restored area. The passive recreational and educational values of the proposed project are substantial (see table 6.4 in the ERI). In addition, the restored habitats in the study area will increase the aesthetic value of the area.

7.1.11 Aesthetics

No significant long-term adverse impacts on the aesthetics of LSP are expected as a result of implementation of the recommended plan. Quite the opposite is true. Although there will be short-term construction phase impacts to aesthetics during the construction period, the long-term effects on aesthetics will be overwhelmingly positive. Appropriate construction phase fences and methods to reduce runoff, sedimentation and infusion of loosened and dried soil into the air will be implemented per the Health and Safety plan approved by the NJDEP. BMP will be used throughout the construction periods to minimize aesthetic impacts. If necessary, rainwater accumulating in excavated areas would be pumped and/or treated (e.g., addition of flocculants to precipitate out suspended organic particulate complexes and particle-associated contaminants) before being released, possibly into North Cove, a CSO and/or directly to Upper Bay proper. NJ

State WQC requirements will be met, helping to reduce temporary construction related aesthetic impacts.

In the long term, unappealing chain link fences that currently block access to the interior of the proposed site will be removed and replaced by trails, elevated walkways or high value vegetation where feasible. Low intensity pedestrian access for hikers, school children, scientists, birders, and nature lovers will be greatly improved as the interior unpaved/asphalt roads are grassed over. A narrow, naturalistic trail system will be developed to facilitate appropriate access to all of the improved wildlife features of the restored park. Appropriate elevated wildlife and landscape viewing platforms will be built to further enhance the aesthetic qualities of the restored areas. A layer of sand is proposed to be placed over the apparently contaminated sediments of North Cove will also improve the aesthetics of the area by reducing the H2S smell emanating from these sediments (although this is a very minor issue) and by adding to the visual clarity of the water by reducing re-suspension of fine surficial sediments. The most important aesthetic improvement in the restoration plan may be the creation of the berm in SW corner of the proposed restoration area. This berm will block views of the industrial area to the south and west of LSP from the park. The berm will be sloped gently towards the east to the restoration area in to maximize MG and supply additional water to the JD wetlands adjacent to the MG area, and secondarily create a desirable elevated view-shed to the east into the interior of the natural area, and to the Harbor and the lower Manhattan skyline in the distance. This aesthetic improvement will further enhanced by a walking trail, picnic areas, and wildlife observations platforms along the spine of the berm. Trees will also be planted along this spine to aesthetically enhance the picnic areas and to further block the view to the industrial area to the south and west. In the long term, assuming aggressive invasive species control, aesthetics of the restored areas will continue to increase over time as desired vegetation grows and fish and wild life repopulate the restored areas.

The Grove of Remembrance (Millennium Park), which is located adjacent to the north side of the proposed restoration area, will not be affected in the long-term in any way by implementation of the recommended plan.

7.1.12 HTRW

Implementation of the proposed ecosystem restoration measures will remove human and faunal exposure to certain contaminants, which are currently partially exposed at Liberty State Park (hence the necessity for the 45 acre enclosed containment area). As this contaminated material will be secured within a clay-lined berm and topped with at least a foot of clean fill, it will no longer be a danger to the public and ecosystem, within and outside the park.

During construction, levels of certain materials, including PCB's, TPHC's, ABN's, hexavalent chromium, and dieldrin are constituents of potential concern and may, in some locations, exceed NJDEP Soil Clean Up Criteria and Effects Range Criteria, due to the nature of the site's past usage and depositional history. Restoration plans have been considered with the potential presence of these materials in mind, and are addressed through a Health & Safety Plan (see Appendix E). Should any additional concerns arise during the construction phases, procedures for this contingency will be specified in the construction contract.

7.1.13 Transportation and Other Infrastructure

Construction activities will result in minor, temporary impacts to traffic flow and volume within Liberty State Park. An increase in large slow-moving vehicles needed for construction of ecosystem restoration components may decrease traffic flow and increase traffic volume in the area for short times. To help alleviate the temporary impacts associated with construction activities, flagmen would available and construction signs will be posted. Upon completion of construction, no adverse impacts to local transportation systems would occur. A permanent alteration would be the transformation of a segment of Freedom Way from road into a bridge to cross the proposed tidal creek. Public transportation facilities such as rail and ferry would not be affected, except in increased usage as the proposed plan is expected to increase visitorship to LSP.

7.2 Environmental Justice Summary

This site was chosen as the first mainstream HREERP project to be implemented because it advances the goals of the HRE CRIP Needs and Opportunities Report and the Reconnaissance Study, and because of the intense interest of the State of New Jersey to enhance and restore this ideally located NY-NJ Harbor waterfront park, which contains substantial habitat and recreational amenities, much of it ideally suited for improvement. Since the main focus of this project is habitat creation and enhancement within a highly industrialized and densely populated residential area, access to this relatively natural oasis to varied interest groups and income levels will be improved. A system of trails, walkways, observation points, signage and other interpretive aids will provide a greater number of local and regional park visitors an opportunity to experience nature in their own backyard. Consideration will be given to developing the landscape and trail plan for this project to conform to the "greenway" concept of the Urban Rivers Initiative, which is, in part, an attempt to connect the major waterfront recreational amenities of the NY-NJ Metropolitan region to the extent feasible. This would increase the access to LSP to people of various economic backgrounds and people who are dependent on mass-transit. Likewise, trails and boardwalks will be designed in a modern fashion, facilitating access to handicapped individuals.

7.3 Relationship Between Short Term Uses and Long Term Productivity

The long-term productivity of the habitat restoration site at LSP will vastly outweigh the short-term uses. The Environmental Resources Inventory describes how habitat units for the recommended restoration plan are predicted to increase overall from existing conditions for the metrics utilized in the functional assessment and for existing vegetative community cover types.

Short-term uses of the existing site are largely limited, and long-term productivity generally increased as evidenced by the following:

1. The grassy area in the proposed tidal creek inlet area does provide some recreational uses, such as ball playing and jogging. However, this type of recreational activity will be

replaced by relatively higher-value (albeit low-intensity) aesthetics and wildlife observation, and much greater estuarine habitat functional value. The existing environment has none.

2. The Christopher Columbus monument, which presently resides at the head of North Cove must be relocated to another location within LSP to allow for the proper functioning of the proposed tidal creek and salt marsh. This represents an unavoidable short-term loss of recreational value. However, since the location of the monument does not represent an integral part of its value, and LSP staff will relocate the monument to an appropriate place in LSP, this is considered a minor and temporary short-term loss of recreational and aesthetic value. It will be offset by the new location and the establishment of a tidal inlet and salt marsh in its place.

3. The long-term habitant functional value of the entire upland (forest, grassland, fresh water wetland, and other non-tidal habitat) will be generally and significantly increased. As stated in the Future Without Project section, upland habitat will continue to degrade, as it becomes drier, more upland, mostly invasive, low-functional lesser value habitat, dominated by *Phragmites* and Japanese knotweed. This would involve the loss of some existing fresh water wetland, which is the natural process of habitat succession from wetter to drier habitat as organic matter accumulates soil and elevations rise and more aquatic obligate and facultative species are converted to more dry tolerant ones. This is not inherently detrimental. However, considering the history of the NY-NJ metropolitan area and its vast loss of wetlands (one of the main reasons for the Hudson- Raritan Estuary Ecosystem Program), long-term estuarine productivity would suffer under the no action alternative.

4. In the proposed tidal creek and salt marsh area, long-term estuarine productivity would be vastly increased since a filled, contaminated, lower-functional value dredged material disposal area will be converted to a relatively high productivity tidal marsh. Localized long term productivity of the Hudson-Raritan Estuary will increase in this area from very low functional value to a relatively high productivity area of Upper Bay, which itself is characterized by very few remaining tidal wetlands.

5. The long-term productivity of the Liberty Science Center wetland will be significantly increased through the implementation of water management.

7.4 Irreversible and Irretrievable Commitments of Resources

Except for the utilization of fossil fuels during construction of the recommended plan, and the federal and state financial resources needed to implement this project, there will be no irreversible and irretrievable commitment of resources as a result of implementation of the recommended plan. This is evidenced by the following:

1. Cultural resources that could be potentially affected by the implementation of this project were identified by the NJSHPO as being of small concern. Routine monitoring for cultural resources will occur during construction, and construction plans modified as needed to accommodate documentation and/or retrieval of resources. As stated previously, the vast majority of excavation

will occur only in previously filled areas. The entire proposed restoration area is located on 19th and 20th century fill. No natural landscape features will be disturbed.

2. Financial resources of the Federal government, the Port Authority of New York and New Jersey and the State of New Jersey will be irreversibly committed to the planning, construction, monitoring and maintenance (as applicable) of this project in the amounts necessary to implement and maintain the recommended plan for the project life.

3. Construction equipment such as backhoes and bulldozers will irretrievably consume fossil fuels during the construction and maintenance phase of this project. The equipment and amount of fossil fuels to be consumed are documented in the MCACES section of the FR/EIS.

4. Table 6-3 of the Environmental Resources Inventory documents an expected significant increase in functional habitat value throughout much of the proposed restoration site. Thus, there would be little if any irretrievable and irreversible loss of environmental resources from implementation of the recommended plan, and long-term resources will be significantly increased.

7.5 Unavoidable Adverse Effects and Considerations that Offset Adverse Effects

USACE regulations require that sequenced steps be taken to insure that adverse effects of a federal project are avoided and, if unavoidable, minimized. This has been done for the recommended plan as evidenced by the following:

1. There has been close coordination with the NJDEP, and others, for several years during the process of scoping and developing the details of the recommended plan. Alternative plans that may have resulted in significant adverse impacts were eliminated from consideration.

2. Appropriate permits from the NJDEP will specify measures to avoid and minimize potential adverse impacts. These measures will likely include:

   a) Construction monitoring.
   b) Employment of physical methods to reduce or eliminate contact between humans and wildlife and significant concentrations of bioavailable contaminants.
   c) Post-construction monitoring to insure compliance with project plans.

Also, nuisance dust generated from construction will be managed according to a Health and Safety plan approved by the NJDEP (see sample plan in Appendix E).

3. The District has received an LOI from the NJDEP that documents the location of jurisdictional fresh water wetlands. Every reasonable step will be taken to avoid any adverse impact on these existing wetlands. In some cases functional value will be added to JD wetlands by removal of invasive plants and/or increasing inundation period/soil saturation. Ultimately, net wetland benefits will far outweigh any short-term losses.

4. All reasonable steps will be taken to avoid or minimize adverse construction impacts, and these steps will be coordinated with and approved (as appropriate) by NJDEP and other agencies.

5. By nature of this project, i.e., a habitat restoration, the net positive effects must be positive. By definition, any adverse environmental effects will be offset many fold.

7.6 Cumulative Impacts

The cumulative impacts of implementation of the recommended plan will be both positive and adverse.

Positive cumulative impacts include:

1. A significant local and regional addition to estuarine habitat functional value in the Upper Bay region of the Hudson-Raritan Estuary, a heavily developed inner-harbor portion of the system especially hard hit by habitat alteration and reduced resources. This is due to fish and wildlife benefiting from the addition of an extensive salt marsh that will complement already existing nearby habitat, e.g., increased feeding and nesting for shorebirds and a greater contribution to estuarine biogeochemical processes due to the addition of the tidal marsh.

2. This project will add both numerically and value-wise to other projects that also contribute to the restoration of the Hudson-Raritan Estuary restoration efforts, e.g., The Hudson River, Flushing Bay, Jamaica Bay, Bronx River, Gowanus Canal, the Hackensack Meadowlands, the Lower Passaic River and many other planned and smaller, site-specific restoration efforts, as described in this FR.

3. Additional (and previously unavailable) low impact, nature and education related recreational opportunities will be added to those already available, such as the Liberty Science Center and the Statue of Liberty/Ellis Island complex.

4. Additional contaminated soil will be "locked up" (isolated from water, wildlife and humans) adding to the cumulative value of LSP.

5. A major contribution to the cumulative aesthetics of the NY-NJ Harbor area, considering the recommended plan's highly visible location.

6. Because of expected increase in volume of visitors to LSP, an increase on the cumulative effect on spending is expected in the surrounding Jersey City area, e.g., local attractions (Ellis Island, Liberty Science Center), local restaurants, food and provision shops, sporting goods stores, gas stations, etc.

Adverse cumulative impacts include:

1. Temporary addition to the cumulative fossil fuel generated air contaminants in the region (mainly during construction).

2. Increased visitor use of LSP and concomitant contributions to air pollution.

3. Increased need for LSP staff and maintenance efforts, due to increased sensitive habitat that needs expanded management and increased visitorship to newly landscaped trails and wildlife observation points.

8. RECOMMENDED PLAN

8.1 Ecosystem Restoration

The NER plan would involve restoration of those portions of the study area degraded by past fills, contamination, and subsequent *Phragmites* and other invasive species colonization. Specifically, 160 acres would be restored to targeted habits, as summarized in Table 8.1 below:

Table 8.1 Ecosystem Restoration Acreages

Restoration Area 234 acres	
- Create Tidal Marsh system	46 acres
Berm	50 acres
Buffer	15 acres
- Create Freshwater wetland system	26 acres
- Enhance Seasonal wetlands	23 acres
Direct Construction Benefits	160 acres
Incidental Construction Benefits	*74 acres*
Total Area Improved	234 acres

Indirect Benefits will extend to the Hudson-Raritan Estuary study area (approximately 500 square miles). The results of this restoration plan are expected to be significant in institutional, public and technical terms, and consistent with Federal, State, and local laws and resource management plans.

8.2 Real Estate

As described in the Real Estate Plan (Appendix D) and summarized in Table 8.2, the prospective non-Federal sponsor, NJDEP, owns all the lands within the project boundary lines. Accordingly, no further acquisitions of real property, or interests in real property (including site access), are required for this project. Upon signing a PCA, the Corps (NY District) will provide the Sponsor with a legal description of the required project area (approx. 160 acres) and NJDEP, in turn, will submit a formal *Authorization for Entry for Construction* to the NY District. As a State Park, the project area's highest and best use is as State Parkland. It is limited by New Jersey law (NJSA 13:8A-48) to open space uses and is precluded from non-park related uses and from ordinary commercial, industrial, or residential development. Neither can it sold by the State except under specific, limited circumstances. Because the 1) landowner's (Sponsor's) utility derived from the land will be enhanced (rather than diminished) by the proposed project, 2) the project would result in no greater restrictions on the land than are currently in place under New Jersey law, and 3) the Sponsor-owned land was acquired more than five years ago, for cost-sharing crediting purposes, the estimated value of the Project LERRD is zero ($0).[33]

[33] This determination is consistent with the provision on non-economic highest and best use assumptions in paragraph. 4-7.b of ER 405-1-12.

Table 8.2 Real Estate Project Costs	
Administrative Costs	$25,000
Contingency (20%)	$ 5,000
Total	**$30,000**

8.3 Ecological Monitoring and Adaptive Management

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

- Successful establishment of each habitat type (low emergent marsh, high marsh, mudflat, fresh water wetland and upland forest/scrub-shrub, and tidal creek) relative to similar habitats in the region
- Vegetation should occur in proper zones (*e.g.*, hydric species in wet sites) in all layers (tree, shrub, herbaceous) and have adequate characteristics compared to similar habitats in the region
- Air Management Program site constraints
- Water quality, general landscape, sinuosity, and water depth should be similar to natural tidal creeks occurring in the region

The details on how these criteria will be quantified are to be finalized after the NEPA process is concluded and incorporated into the final PED phase.

To ensure the success of the NER Plan, corrective action will be taken if performance criteria are not met. Potential corrective action may include:

- Replanting vegetation in areas where plantings do not meet predetermined criteria
- Enhancing survival of planted vegetation (by applying a fertilizer such as Osmocote)
- Improving tidal flushing
- Installing erosion control devices
- Suppressing encroachment by *Phragmites* through mechanical landscaping techniques, physical removal and/or replanting of desirable species
- Preventing herbivory (by installing fencing)
- Adjusting channel morphology and hydrology, or stabilizing banks
- Adjusting weirs for freshwater wetlands
- Adaptive management as required.

8.4 Cost Estimate

The costs of the selected ecosystem restoration plan are summarized below:

Initial Project Cost	$32,226,850
Operations and Maintenance (O&M) Costs	$ 161,100
Total Annual Project Cost[34]	$ 2,149,891

[34] (Discounted at 5.625%) over a 50-year period.

9. PLAN IMPLEMENTATION

PANYNJ is the feasibility study partner. NJDEP is the identified construction partner. As non-Federal construction partner, NJDEP must sign a Design Agreement that will carry the project through Preconstruction Engineering and Design (PED) phase, which includes development of Plans and Specifications (P&S). The PED phase will be followed by project construction. Funds must be budgeted by the Federal Government and the non-Federal partner to support these activities. A Project Management Plan (PMP) will be prepared to identify tasks, responsibilities, and financial requirements of the Federal Government and the non-Federal partner during PED. A project schedule will be established based on reasonable assumptions for the detailed design and construction schedules.

9.1 General

The Liberty State Park ecosystem restoration project must be authorized by Congress for implementation through a Water Resources Development Act or other legislation. Following Congressional authorization, the project would be eligible for construction funding appropriation of funds. The project will be considered for inclusion in the president's budget on the basis of national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal partner to fund its share of the project cost, and budgetary constraints that may exist at the time of funding.

9.2 Local Cooperation

In accordance with Section 105 (a)(1) of WRDA 1986, the HREERP Feasibility Study was cost shared 50 percent between the Federal government and the Port Authority of New York and New Jersey. The contribution of funds by the local partner indicates their support for a project for Liberty State Park. NJDEP, the prospective construction non-Federal partner, has indicated their intent to implement the Liberty State Park project through a strong record of involvement and coordination in the feasibility study, and a letter of support (Appendix A).

A fully coordinated Design Agreement (DA) package, which will include the non-Federal partner's financing plan, will be prepared subsequent to the approval of the feasibility phase to initiate the PED phase for detailed design. It will be based on the recommendations of the Feasibility Study. The prospective non-Federal partner, the NJDEP, has indicated support of the recommendations presented in this Feasibility Report and its desire to execute a DA for the selected plan.

Specifically, the NJDEP has agreed to comply with all applicable Federal laws and policies and other requirements including, but not limited to:

a. Provide all lands, easements, rights-of-way, and relocations and disposal/borrow areas (LERRD) uncontaminated with hazardous and toxic wastes.

b. Provide an additional cash contribution, if the value of LERRD contributions toward total project costs is less than 35 percent, so that the total non-Federal share equals 35 percent.

c. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are necessarily limited to retaining dikes, waste-weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

d. Operate, maintain, repair, replace, and rehabilitate the completed Project, or functional portion of the Project, at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government, for so long as the project remains authorized.

e. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls, for access to the Project for the purpose of inspection, and, if necessary after failure to perform by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal project partner of responsibility to meet the non-Federal project partner's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

f. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project and any Project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Codes of Federal regulations (CFR) Section 33.20.

h. Assume complete financial responsibility, as between the Federal Government and the non-Federal project partner for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

i. Operate the project for the purpose of CERCLA liability. Operate, maintain, repair, replace and rehabilitate the Project in a manner that will not cause liability to the Federal government to arise under CERCLA.

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of

the Surface Transportation and Uniform1 Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform1 Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

k. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issued pursuant thereto, as well as Army regulation 600- 7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

l. Provide 35 percent of that portion of total historic preservation mitigation and data recovery costs attributable to ecosystem restoration that are in excess of one percent of the total amount authorized to be appropriated.

m. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

n. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

o. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the non-Federal project partner owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing or rehabilitating the project.

p. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.

q. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities that would degrade the benefits of the project.

r. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

In an effort to keep the non-Federal project partner involved and the local government informed, meetings were held throughout the feasibility phase. Coordination efforts will continue, including coordination of this study with other State and Federal agencies. A public meeting for this report was held on September 26, 2005. The correspondence related to this meeting can be found in Appendix A.

9.3 Cost Apportionment

The total first cost of implementing the recommended plan is shown below in table 9.1.

01	LANDS AND DAMAGES	SUBTOTAL	CONTINGENCY	TOTAL
01.03	Real Estate Costs- Local	5,000	1,000	0
01.04	Real Estate Costs – Administration	$20,000	$ 4,000	
	Subtotal	$25,000		
	CONTINGENCY (25%)		$5,000	
01	LANDS AND DAMAGES TOTAL			**$30,000**
06	**FISH AND WILDLIFE FACILITIES**			
06.03.03	Sand Placement in North Cove	$571,889	$114,378	
06.03.04	Tidal Wetland and Disposal Area	$19,070,836	$3,814,168	
06.03.05	Upland Management Area	$1,767,790	$353,559	
06.03.15	Fresh Water Wetland	$1,393,541	$278,709	
	SUBTOTAL	$22,804,056		
	CONTINGENCY (20%)		$4,560,814	
06	FISH AND WILDLIFE TOTAL			**$27,943,850**
30	**PLANNING, ENGINEERING, AND DESIGN**	$1,817,385	$362,075	**$2,057,000**
31	**CONSTRUCTION MANAGEMENT**	$1,778,390	$356,080	**$2,196,000**
	PROJECT SUBTOTAL	$26,399,831		
	PROJECT CONTINGENCY (20%)		$5,278,969	
	TOTAL FIRST COST			**$32,226,850**

Table 9.1 Total First Cost of LSP Recommended Plan

The Total Annual Cost of the Recommended Plan is show in Table 9.2.

Total First Cost	$32,226,850
Interest During Construction (a)	$1,930,404
Total Investment Cost	$34,157,254
Annualized First Cost (b)	$1,868,532
Annualized IDC Cost	$111,926
Operations and Maintenance (c):	$161,100
Monitoring (d)	$8,299
Total Annual Cost	$2,149,892

Table 9.2 Total Annual Cost of LSP Recommended Plan

(a) Interest is 5.375% for all funds expended
(b) 50-year project life
(c) 0.5% of the Total First Cost
(d) Assuming 3 years, at $50,000 per year.

The cost apportionment between Federal and non-Federal total first cost of the selected plan is shown in Table 9.3. Federal participation in projects formulated for ecosystem restoration are 65 percent of the estimated total project first costs, including LERRDs assigned to this purpose. This distribution of costs applies to project implementation, which includes PED phase and construction phase.

As indicated in Table 9.1, the Federal share of the project's total first cost is $20,947,450 or 65 percent of the total. The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of non-Federal interests.

The non-Federal share of the estimated total first cost of the proposed project is $11,297,400 or 35 percent of the total. The non-Federal share consists of a number of components including LERRDs and PED cost sharing.

Table 9.3 Cost Apportionment

		Federal Share (65%)	Non-Federal Share (35%)	TOTAL
Total Project	Initial Project Costs	$20,947,450	$11,279,400	$32,226,850
	Real Estate Costs*		$ 30,000	
	Cash Contribution	$20,947,450	$11,249,400	$32,196,850
	O&M Costs		$ 161,100	$ 161,100

* Applicable to required non-Federal cash contribution.

9.4 Pre-Construction Engineering and Design Cost Sharing

The Pre-Construction Engineering and Design (PED) phase of the project is cost-shared between the Federal Government and the non-Federal partner. PED expenditures are cost-shared at a rate

of 35 percent non-Federal and 65 percent Federal. Adjustments are made during construction to bring the cost of PED in line with actual cost sharing of the project. The PED phase begins with approval of the Integrated FR/EIS and will continue until the plans and specifications are developed; construction is expected to begin shortly thereafter.

9.5 Construction Schedule

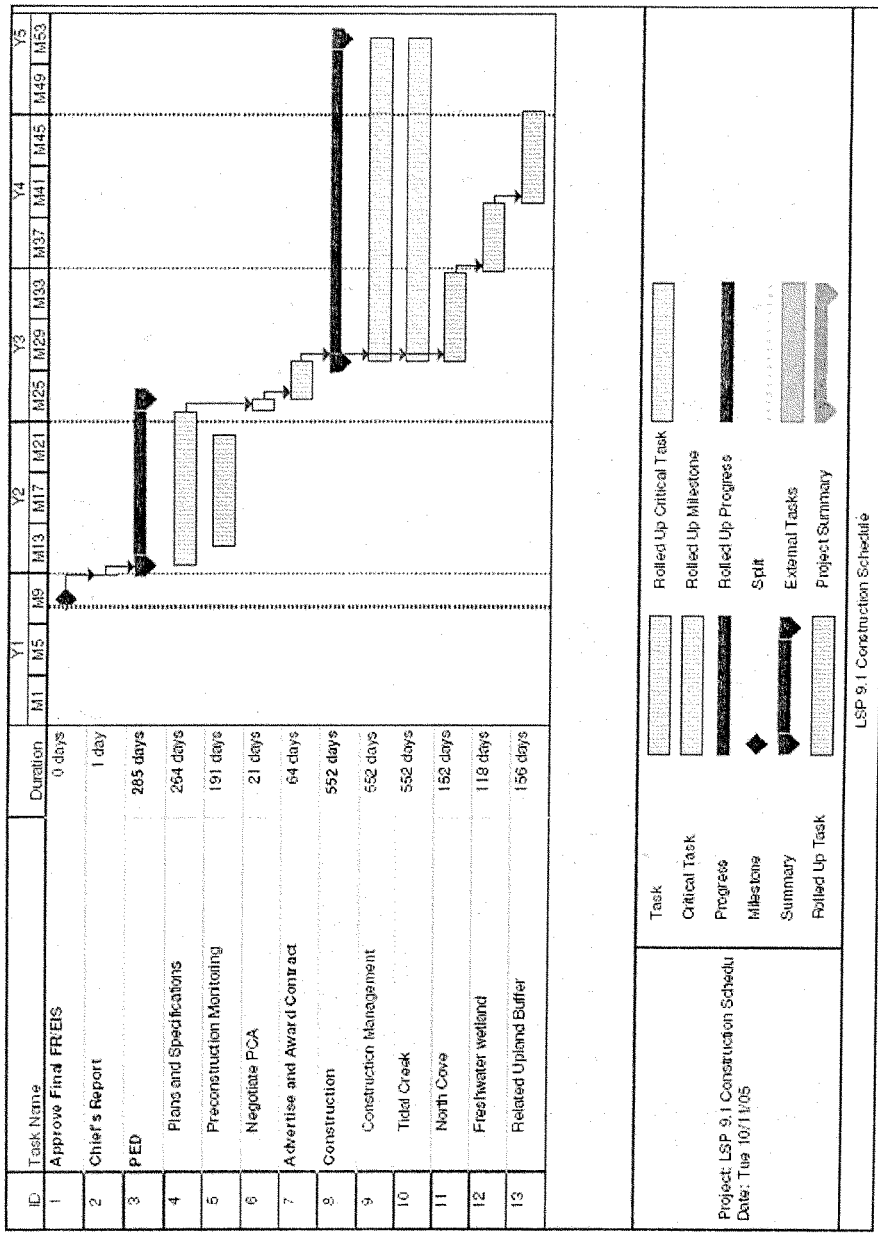
A preliminary construction schedule was developed for the selected plan. The schedule is based on information available to date, and is predicated on the assumptions listed below. A proposed construction schedule for Liberty State Park ecosystem restoration is presented in the Gantt chant in Figure 9.1. The proposed schedule assumes a PED phase of 12 months, with a resultant construction period of 25 months.

9.6 Financial Analysis

For purposes of executing the Design Agreement (DA), NJDEP has stated its intention to seek authorization from the State of New Jersey to act as the non-Federal partner. The state has a stable, non-Federal source of funding for ecosystem restoration projects and further has indicated its intent to enter into a DA at the conclusion for the study.

9.7 Views of Non-Federal Partners and Other Agencies

The selected plan has received strong support from the prospective non-Federal project partner, NJDEP. Affected local governments, including Hudson County and Jersey City, have also expressed their support for the project. This support is documented in the Study Correspondence Appendix (Appendix A). Through project planning and NEPA scoping, a variety of other Federal agencies have been involved in this investigation and support the project goals.


ID
Task Name
Duration
Y1
Y2
Y3
Y4
Y5
M1
M5
M9
M13
M17
M21
M25
M29
M33
M37
M41
M45
M49
M53
1 Approve Final FR/EIS 0 days
2 Chief's Report 1 day
3 PED 285 days
4 Plans and Specifications 264 days
5 Preconstruction Monitoring 191 days
6 Negotiate PCA 21 days
7 Advertise and Award Contract 64 days
8 Construction 552 days
9 Construction Management 552 days
10 Tidal Creek 552 days
11 North Cove 152 days
12 Freshwater wetland 118 days
13 Related Upland Buffer 156 days
Project: LSP 9.1 Construction Schedul
Date: Tue 10/11/05
Task
Critical Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Critical Task
Rolled Up Milestone
Rolled Up Progress
Split
External Tasks
Project Summary
LSP 9.1 Construction Schedule

9.8 Major Conclusions and Findings

New York District has completed this Integrated Feasibility Report/Environmental Impact Statement (FR/EIS) for the Liberty State Park Ecosystem Restoration Project in accordance with the requirements of NEPA to assess the need for modifying the existing degraded habitat, to evaluate the effects of the restoration activities, and to determine a solution that maximizes environmental benefits while minimizing economic costs.

The purpose of the project is to ameliorate the adverse impacts associated with past filling activities on the project site, with the overall purpose of improving the environmental quality of the area. Besides alterations to the topography of the site that buried existing salt marsh/mudflats, the quality of the sediments and adjacent waters have also deteriorated, further jeopardizing the aquatic habitats that they support. The domination by invasive species is expected to expand and continue to overwhelm the various native vegetative habitats on site without the implementation of ecological management measures described in the plan recommended in this report.

Past and present surveys, studies, and extensive literature searches have been conducted to establish necessary baseline information to identify restoration options and evaluate the potential for control of invasive species, isolation of contaminants, and subsequent conversion to more desirable habitats currently underrepresented in the HRE. These underrepresented habitats include salt marsh, deep-water emergent palustrine marsh and significantly enhanced terrestrial habitats such as maritime grassland, scrub-shrub and hardwood forest, with a superior mix of native and wildlife-friendly species. Some of the biological tasks conducted include literature review, existing vegetative community mapping, jurisdictional wetland delineations, faunal surveys, and existing and proposed project habitat evaluation using the New England District USACE Highway Methodology. The results of these surveys are presented in the Environmental Resources Inventory (ERI), located in the Environmental Appendix and summarized in Sections 3 and 7 of this report. The results indicate strong opportunities for increasing habitat functionality at this site. Implementation of the plan recommended in this report is expected to increase and restore more desirable communities, provide more cover, nesting, and breeding habitat for wildlife, and increase species richness.

Technical screening analysis was performed throughout the project development stages for each of three implementation phases of the proposed project: tidal marsh, fresh water wetlands and terrestrial habitat. For the tidal marsh, a variety of configurations were proposed for consideration, including a single-inlet creek entering the terrestrial portion of LSP at North Cove, a continuous tidal loop entering the terrestrial portions at North Cove and returning to Upper Bay at the former Middle Cove, and an island in the middle of the creek. The single-inlet creek was determined to be the most efficient solution, meeting both technical engineering and biological requirements the most successfully. Subsequently, the shape, width and length of the proposed tidal channel, and its associated intertidal flats, low marsh and high marsh habitat were refined through hydrologic modeling. The tidal channel is designed to maximize functional habitat value of the proposed tidal marsh area by maintaining the largest feasible tidal range, and regular tidal flooding and drainage through the maximum area available.

For the fresh water wetland phase, four separate plans were analyzed on technical grounds, each delivering different amounts of acceptable quality fresh water to the target area in the central portion of interior of the site. The selected freshwater plan provides the most amount of water for habitat creation and enhancement without relatively expensive and high-maintenance mechanical pumping from already-stressed municipal water supplies. The recommended plan incorporates a self-maintaining gravity-based system for supplying adequate quality water. This water-delivery system begins procurement of additional water from the NJ Transit parking area, which is then filtered in an enhanced wetland area adjacent to the Liberty Science Center (LSC). The levels of the LSC wetland are controlled by a self-adjusting weir, which directs water through a diversion pipe underneath Phillip Street to an additional *Phragmites* dominated bio-filter wetland. This bio-filter wetland removes remaining suspended sediment, potential toxicants and unwanted nutrients. From the bio-filter, a created swale will deliver the substantially enhanced volume and quality of water to a created permanent deep-water emergent marsh. The deep marsh will provide fish, reptile and other habitat not currently found in Liberty State Park. During high-flow periods, excess water will drain out of the deep-emergent marsh into an infiltration basin, in effect creating an additional, periodically flooded wetland. The high permeability of the infiltration basin soil will allow water to penetrate underlying groundwater, in turn feeding an existing jurisdictional freshwater wetland.

Another component of this restoration project involves terrestrial buffers to protect the Federal investment in the wetland and aquatic habitats. Measures include the selective removal of invasive species and other undesirable vegetation. If monitoring indicates that further measures are necessary, the District will consider addition of topsoil and/or sand to selected areas to discourage unwanted vegetation, and promotion of native vegetation through replanting and/or seeding. A berm is planned for the southwestern portion of the site to protect and help isolate the habitat from outside influences. This berm will be created by using soil excavated from the proposed tidal marsh area. This soil, and any industrial residue it contains, will be completely encapsulated within the berm. The berm will act as an isolation barrier for sensitive species and add topographical relief to a relatively flat site. Most buffer habitats will be maintained in the same vegetative community type, while simultaneously controlling invasive species and encouraging native species. Thus, a mosaic of high-functional value terrestrial habitat will be enhanced and sustained, which includes existing hardwood and maritime forest, scrub-shrub, maritime grassland and old field. Where possible, grassland habitat to be enhanced will be contiguous to enhance feeding areas for raptors and isolation for ground nesting birds. The functional integrity of the existing forested areas will be maintained and enhanced.

The District's NER plan will result in a significant increase in wildlife habitat and estuarine functional value when compared to existing habitat. The NER plan will increase the availability of cover, foraging, nesting and breeding habitat for State threatened and endangered species; restore USEPA designated priority wetlands (e.g., salt marsh); improve water quality; increase the value and availability of spawning and nursery habitat for anadromous fish species; enhance wetland habitat for migratory waterfowl; assist in the enhancement of wildlife habitat corridors; and increase aesthetics and opportunities for passive recreation; and promote science education. In addition the NER plan will meet the goals and objectives of many programs, statutes, and policies on an institutional, public, and technical level.

9.9 Areas of Concern

One area of concern regarding the selected plan for Liberty State Park ecosystem restoration is compliance with the Clean Air Act during implementation. Based on the preliminary analysis, which are solely based on assumptions regarding construction equipment staging and schedule, total direct and indirect NOx emissions appear to exceed *de minimis* threshold of 25 tons per year. In close consultation with the USEPA and the NJDEP, the Corps will conduct a detailed, comprehensive quantitative analysis in the next project phase (PED) to precisely quantify all emissions from the Liberty State Park project and to determine if conformity has been met. Upon completion of the revised emission estimates, if applicability is determined, a Draft General Conformity Determination will be prepared and will undergo formal agency and public review. Results and conclusions of this process will be part of the environmental review, including, as necessary, detailed analyses of alternatives, such as emission offsets, emission credits, emission reduction technologies, and operational modifications to reduce emissions during PED. The plan is fully supported by the non-Federal feasibility study partner, PANYNJ, and the non-Federal construction partner, NJDEP. Affected local governments and interested Federal agencies are also supportive. These parties have full confidence in the anticipated performance of the selected plan in terms ecosystem restoration and benefits to the environment.

10. PUBLIC INVOLVEMENT

NEPA Scoping: The scoping meeting was open to the public and was held at Liberty State Park, on October 16, 2002. Fliers announcing the meeting were sent directly to property owners in the study area, interested parties, and elected officials. Comments and questions were recorded at both meetings and have been summarized in the Environmental Appendix (B).

Public Meeting: The draft report was released August 19, 2005, with the public review period in the Federal Register closing on October 4, 2005. The public meeting was held on September 26, 2005, at Liberty State Park. About 50 people attended. There were no objections to the plan, public response was overwhelmingly positive. A summary of the public meeting is included in the Study Correspondence.

Comments & Responses to the FR/EIS:
Six letters were received in response to the draft report from the following individuals:

Name	Organization/Agency
John Filippelli, Chief of Stategic Planning and Multi-Media Programs Branch	USEPA
Stanley Gorski, Field Offices Supervisor	NOAA-NMFS
Carter Craft, Director	Metropolitan Waterfront Alliance
Troy Ettel, Director of Conservation	New Jersey Audubon Society
Michael Britt, Classroom Workshop Coordinator	Liberty Science Center
Dorothy Winant	Individual

The letters were positive and supportive in nature. Reproduction of these letters, and the responses to them, can be found in the Appendix A. The study team also received approximately six email messages expressing support for the project.

11. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

Federal laws and Executive Orders applicable to all USACE recommended plans, their applicability to this project, and, if applicable, their status, is presented below:

N/A Non-applicable
C In compliance
P Compliance pending[35]

STATUS	PUBLIC LAW (US CODE)/EXECUTIVE ORDER
N/A	Abandoned Shipwreck Act of 1987 (43 USC 2101)
N/A	American Indian Religious Freedom Act (42 USC 1996)
N/A	Agriculture and Food Act (Farmland Protection Policy Act) of 1981 (7 USC4201)
N/A	American Folklife Preservation Act of 1976, As Amended (20 USC 2101)
N/A	Anadromous Fish Conservation Act of 1965, As Amended (16 USC 757a et seq)
N/A	Antiquities Act of 1906, As Amended (16 USC 431)
C	Archeological and Historic Preservation Act of 1974, As Amended (16 USC 469)
C	Archeological Resources Protection Act of 1979, As Amended (16 USC 470)
N/A	Bald Eagle Act of 1972 (16USC 668)
N/A	Buy American Act (41 USC 102)
N/A	Civil Rights Act of 1964 (Public Law 88-352) (6 USC 601)
P	Clean Air Act of 1972, As Amended (42 USC 7401 et seq)
P	Clean water Act of 1972, As Amended (33 USC 1251 et seq)
N/A	Barrier Resources Act of 1982 (16 USC 3501-3510)
P	Coastal Zone Management Act of 1972, As Amended (16 USC 1451 et seq)
N/A	Comp. Environ. Response, Compensation & Liability Act of 1980 (42 USC 9601)
N/A	Conservation of Forest Lands Act of 1960 (16 USC 580 mn)
N/A	Contract Work Hours (40 USC 327)
N/A	Convict Labor (18 USC 4082)
N/A	Copeland Anti-Kickback (40 USC 276c)
N/A	Davis-Bacon Act (40 USC 276)
N/A	Deepwater Port Act of 1974, As Amended (33 USC 1501)
N/A	Emergency Flood Control Funds Act of 1955, As Amended (33 USC 701m)
N/A	Emergency Wetlands Resources Act (16 USC 3901-3932)
C	Endangered Species Act of 1972 (16 USC 1531)
C	E.O. 11988, Floodplain Management
C	E.O. 11990, Protection of Wetlands
C	E.O. 12898, Environmental Justice
C	Estuary Protection Act of 1968 (16 USC 1221 et seq)
C	Equal Opportunity (42 USC 2000d)
N/A	Farmland Protection Policy Act (7 USC 4201 et seq)

[35] In certain cases, per normal procedure, compliance will not be attained until the PED phase of this project, when design-level details, required by reviewing and permitting authorities, can be developed with construction funding.

N/A	Federal Environmental Pesticide Act of 1972 (7 USC 136 et seq)
N/A	Federal Water Project Recreation Act of 1965, As Amended (16 USC 4601)
C	Fish and Wildlife Coordination Act of 1958, As Amended (16 USC 661)
N/A	Flood Control Act of 1944, As Amended, Section 4 (16 USC 460b)
N/A	Food Security act of 1985 (Swampbuster) (16 USC 3811 et seq)
N/A	Hazardous Substance Response Review Act of 1980, As Amended (26 USC 4611)
N/A	Historic and Archeological Data Preservation (16 USC 469)
C	Historic Sites Act of 1935 (16 USC 461) Note: Superceded by NHPA, Section 106
N/A	Jones Act (46 USC 292)
C	Land and Water Conservation Fund Act of 1965 (16 USC 4601)
P	Magnuson Fishery Conservation and Management Act (16 USC 1801)
C	Marine Mammal Protection Act of 1972, As Amended (16 USC 1361)
N/A	Marine Protection, Research and Sanctuaries Act of 1972 (33 USC 1401)
C	Migratory Bird Conservation Act of 1928, As Amended (16 USC 715)
C	Migratory Bird Treaty Act of 1918, As Amended (16 USC 703)
C	National Environmental Policy act of 1969, As Amended (42 USC 4321 et seq)
C	National Historic Preservation Act of 1966, As Amended (16 USC 470)
C	National Historic Preservation Act Amendments of 1980 (16 USC 469a)
N/A	Native American Religious Freedom Act of 1978 (42 USC 1996)
N/A	Native American Graves Protection and Repatriation Act (25 USC 3001)
N/A	National Trails System Act (16 USC 1241)
N/A	Noise Control Act of 1972, As Amended (42 USC 4901 et seq)
N/A	Rehabilitation Act of 1973 (29 USC 794)
N/A	Reservoir Salvage Act of 1960, As Amended (16 USC 469)
C*	Resource Conservation and Recovery Act of 1976 (42 USC 6901-6987)
N/A	River and Harbor Act of 1888, Section 11 (33 USC 608)
C	River and Harbor Act of 1899, Sections 9, 10, 13 (33 USC 401-413)
N/A	River and Harbor and Flood Control Act of 1962, Section 207 (16 USC 460)
N/A	River and Harbor and FC Act of 1970, Sects 122, 209 and 216 (33 USC 426 et seq)
N/A	Safe Drinking Water Act of 1974, As Amended (42 USC 300f)
N/A	Shipping Act (46 USC 883)
N/A	Submerged Lands Act of 1953 (43 USC 1301 et seq)
N/A	Superfund Amendments and Reauthorization Act of 1986 (42 USC 9601)
N/A	Surface Mining Control and Reclamation Act of 1977 (30 USC 1201-1328)
C	Toxic Substances Contol Act of 1976 (15 USC 2601)
N/A	Policy Act of 1970, As Amended (43 USC 4601)
C	Utilization of Small Business (15 USC 631, 644)
N/A	Wild and Scenic River Act of 1968

* Although Liberty State Park is not a RCRA site, RCRA is noted because it was used for determining Federal jurisdiction in the matter of the Consent Decree. The mention of RCRA in the Consent Decree in no way constitutes a finding of fact or law that this is RCRA site.[36] Implementation of the recommended project will satisfy the Consent Decree.

[36] Stated in Paragraphs 1-3 of the Consent Decree.

12. RECOMMENDATIONS

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental, social and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests.

I recommend that the selected plan for ecosystem restoration at Liberty State Park, Hudson-Raritan Estuary, Hudson County, New Jersey project, as fully detailed in this integrated feasibility report and environmental impact statement, be authorized for construction as a Federal project for ecosystem restoration, subject to such modifications as may be prescribed by the Chief of Engineers.

I recommend authorization of the ecosystem restoration plan for Liberty State Park, Hudson Raritan Estuary Ecosystem Restoration Project, with such modifications thereof as in the discretion of the Commander, HQUSACE, as may be advisable. These recommendations are made with the provisions that local interests will:

a. Provide to the United States all necessary lands, easements, rights-of-way, relocations, and suitable borrow and/or disposal areas deemed necessary by the United States for initial construction and subsequent maintenance of the project.

b. Hold and save the United States free from claims for damages that may result from construction and subsequent maintenance, operation, and public use of the project, except damages due to the fault or negligence of the United States or its contractors.

c. Maintain continued public ownership and public use of the shorefront areas upon which the amount of Federal participation is based during the economic life of the project.

d. Provide and maintain necessary access roads, parking areas, and other public use facilities open and available to all on equal terms.

e. Contribute the local share of non-Federal costs for initial construction and operation and maintenance over the economic life of the project, as required to serve the intended purposes.

f. Upon completion of each project feature, acquire, rehabilitate, repair, replace, operate and maintain easements for public access to areas created or enhanced by the project. The cost of the operation, and maintenance of these easements will be the responsibility of the non-Federal sponsor.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch. Consequently,

the recommendations may be modified (by the Chief of Engineers) before they are transmitted to the Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Richard J. Polo, Jr.
Colonel, Corps of Engineers
District Engineer

13. REFERENCES

Fields, James, M. 1990. "Policy-Related Goals For Community Response Studies". *Environment International*, Volume 16, pp. 501-514.

Groundwater Flow Direction and Gradient Calculator [online], LMNO Engineering, Research, and Software, Ltd., http://www.lmnoeng.com/Groundwater/gradient.htm. March 2004

MacFarlane, D.W. 2001. The Ecology of Liberty State Park: A Historical Perspective

National Marine Fisheries Services (NMFS). 1998. The 1996 Amendments to the Magnuson-Stevens Fishery Conservation and Management Act.

NCDC. 2000. Hourly Precipitation Data (1948-1999).

New Jersey Department of Environmental Protection (NJDEP). 1989. *Executive Summary: The History of Environmental Investigations at the Liberty State Park.* NJDEP Hazardous Waste Program, Division of Hazardous Site Mitigation, Bureau of Environmental Measurements and Quality Assurance, Division of Hazardous Waste Management, Bureau of Planning and Assessment.

New Jersey Department of Environmental Protection (NJDEP). 1994. Memorandum dated from 03 October, 1994 from Catherine Drake, Assistant to the Director, Division of Parks and Forestry to Edward Putnam, Assistant Director, Hazardous Site Mitigation.

New Jersey Department of Environmental Protection (NJDEP). 1995. Liberty State Park Soil Sampling Report, August 1995. NJDEP Site Remediation Program.

New Jersey Department of Environmental Protection (NJDEP). 1999. *1998 Air Quality Monitoring Report.* NJDEP, Bureau of Air Monitoring.

New Jersey Department of Environmental Protection (NJDEP). 2000. *Liberty State Park – Dredge Material Storage Area. Remedial Planning and Design Element.* NJDEP Site Remediation Program, Division of Publicly Funded Site Remediation.

New Jersey Department of Environmental Protection (NJDEP). 2001. *General Design Memorandum for the Parks Interior Sections.* Division of Parks and Forestry.

New Jersey Department of Environmental Protection (NJDEP). 2003. New Jersey Stormwater Best Management Practice Manual, Draft February 2003

New Jersey Geological Survey [online],http://www.state.nj.us/dep/njgs/March 2004

Pierce, G. 1993. Planning Hydrology for Constructed Wetlands. Prepared by the Wetland

Training Institute.

Port Authority of New York and New Jersey. 1975. State of New Jersey Liberty Park – Engineering Report on Proposed Landfill in New York Bay. Liberty State Park Existing Utility Plan – Sketch No. SK-LSP-2.

Regional Plan Association. 2003. *Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary.* (Based on recommendations of the Harbor Estuary Program Habitat Working Group and Estuary Stakeholders.

United States Army Corp of Engineers (USACE). 1976. Effects of Construction of the Liberty Sate Park on Hydraulic Characteristics of New York Harbor.

United States Army Corp of Engineers (USACE). 1977. Cultural Resource Reconnaissance Liberty State Park

United States Army Corp of Engineers (USACE). 1978. Protective Noise Levels. A Supplement to the USEPA Report: Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA/ONAC 550/9-74-004, March, 1974, Office of Noise Abatement and Control, Washington, D.C.

United States Army Corp of Engineers (USACE). 1980. Plan of Study, Liberty State Park.

United States Army Corp of Engineers (USACE). 1981. Liberty State Park, New Jersey, Levee and Seawall Design Memorandum and Project Design.

United States Army Corp of Engineers (USACE). 1994. Priority Wetlands for the State of New Jersey. USEPA, Region 2, Marine and Wetlands Protection Branch.

United States Army Corp of Engineers (USACE). 1998. National Air Quality and Emissions Trends Report, 1997, EPA 454/R-98-016, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

United States Army Corp of Engineers (USACE). 1999. *Hudson-Raritan Estuary Ecosystem Restoration Reconnaissance Report.* USACE, New York District. (CENAN-PL-F). Prepared by Northern Ecological Associates, Inc. for U.S. Army Corps of Engineers, New York District.

United States Army Corp of Engineers (USACE). 2003. New York Harbor Deepening Limited Reevaluation Report. (CENAN-PL-F), U.S. Army Corps of Engineers, New York District.

United States Army Corp of Engineers (USACE). 2004. *Liberty State Park Environmental Resource Inventory.* USACE, New York District (CENAN-PL-EA). Prepared by LMS. for U.S. Army Corps of Engineers, New York District, April 2004.

United States Army Corp of Engineers (USACE). 2004. *Site Investigation Liberty State Park Jersey City, NJ.* USACE, New York District (CENAN-EN-HH). Prepared by U.S Army Corps of Engineers, Baltimore District for U.S. Army Corps of Engineers, New York District, April 2004.

United States Army Corp of Engineers (USACE). 2001. Restoration Opportunities in the Hudson-Raritan Estuary. U.S. Army Corps of Engineers, New York District (CENAN-PL-ES).

United States Army Corp of Engineers (USACE). 2003. Phase IA Cultural Resources Investigation of the Hudson-Raritan Estuary Ecosystem Restoration Project, Liberty State Park, Hudson County, New Jersey"

United States Army Corps of Engineers (USACE). 2003. Final Phase 1 Environmental Site Assessment of Priority Sites. Part 1: Liberty State Park, Jersey City, Hudson County, New Jersey. Prepared by AMEC Earth & Environmental, Inc and Northern Ecological Associates, Inc.

United States Army Corp of Engineers (USACE). 2004. Liberty State Park Hydrology and Hydraulics of Fresh Water Wetlands.

United States Army Corp of Engineers (USACE). 2004. Liberty State Park: The Ground Survey Control Report.

United States Army Corp of Engineers (USACE). 2004. Site Investigation. Liberty State Park, Jersey City, NJ. Final Report.

U.S. Fish and Wildlife Service (USFWS). 1999a. Written communication on January 20, 1999 from Lisa Arroyo, USFWS, to Frank Santomauro, USACE, New York District

U.S. Fish and Wildlife Service (USFWS). 2000a. Federally-Listed Rare, Threatened, or Endangered Species. [Online]. Available: http://endangered.fws.gov/wildlife.htm.

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix A

Study Correspondence

Attachment 1

Authorized Flood Control and Navigation Projects in the New York and New Jersey Port District

FLOOD CONTROL PROJECTS WITHIN THE NEW YORK AND NEW JERSEY PORT DISTRICT

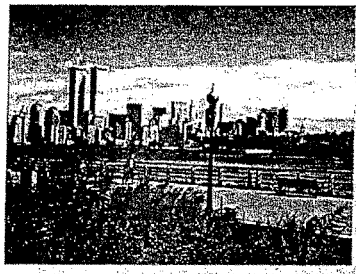
Raritan Bay and Sandy Hook Bay, NJ. Beach Erosion and Hurricane Protection. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 23 Oct. 1982 in accordance with House Document No. 464, 87th Congress, second session.
Rahway, N.J. (Condition of Improvement, 30 September 1986)	Authorization: By 2nd Endorsement letter from OCE dated 12 June 1964, the project was formally adopted for future construction under section 205 of the 1948 Flood Control Act, as amended.
Atlantic Coast of New York City From East Rockaway Inlet to Rockaway Inlet and Jamaica Bay, N.Y. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 26 October 1965 in accordance with House Document No. 215, 89th Congress, First Congress, First Session. Section 72 of the Water Resources Development Act of 6 March 1974 modified the project authorization to permit separate construction of the beach erosion control portion of the multiple purpose project.
Elizabeth River, N.J. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 1965 substantially in accordance with House Document No. 249, 89th Congress, first session.
South Orange, N.J. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 1965 substantially in accordance with House Document No. 67, 89th Congress, first session.
Staten Island, Fort Wadsworth to Arthur Kill, N.Y. Beach Erosion Control and Hurricane Protection (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 27 October 1965 in accordance with House Document No. 181, 89th Congress, First Session.
Yonkers, N.Y. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 1965 substantially in accordance with House Document No. 258, 89th Congress first session.
Green Brook Township, N.J. and Vicinity Snagging and Clearing—Green Brook (Condition of Improvement, 30 September 1986)	Authorization: The Project was authorized pursuant to Section 208 of the 1954 Flood Control Act subject to satisfactory assurances that local interests will comply with the requirements of local cooperation.
Morris and Passaic Counties, N.J. Snagging and Clearing—Pompton River (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized pursuant to section 13 of the 1946 Flood Control Act.
Lincoln Park and Pequannock Township, N.J. Snagging and Clearing—Beaver Brook and Pequannock Township Ditch (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized pursuant to section 2 of the Flood Control Act approved 28 August 1937, was amended.

NAVIGATION PROJECTS WITHIN THE NEW YORK AND NEW JERSEY PORT DISTRICT

Mamaroneck Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1922, modified 1935 & 1960.
Larchmont Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1899, modified 1907.
Echo Bay Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1910, modified 1973.
New Rochelle Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1922.
East Chester Creek, N.Y. (Hutchinson River) (Condition of Improvement, 30 September 1986)	Existing project adopted 1950.
Westchester Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1922, modified 1954.
Bronx River, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1913.
Flushing Bay and Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 23 October 1962.
Manhasset Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1930.
Hempstead Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1910 and modified 1968.
Glen Cove Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1888, modified 1895.
Glen Cove Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1925.
Jones Inlet, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1945.
East Rockaway Inlet, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1930.
Jamaica Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1910, modified 1945 and 1950.
Sheepshead Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1912.
Coney Island Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1907.
Coney Island Creek, N.Y. (Condition of Improvement, 30 September 1986)	Exiting project adopted 1935.
Bay Ridge & Red Hook Channels, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1899, modified 1930.
Gowanus Creek Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1881 to 1952.
Buttermilk Channel, N.Y.	Existing project adopted 1902, modified 1935 & 1962.

(Condition of Improvement, 30 September 1986)	
East River, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1915, modified 1916 to 1970.
Wallabout Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1899.
Newtown Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1919, modified 1930 and 1937.
Harlem River, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1878, modified to 1913.
Hudson River Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1913, modified to 1937.
New York Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project: Ambrose, southerly entrance, Bayside and Main Ship Channels adopted 1884, modified 1933, 1937, 1958, 1965, and 1982.
New York and New Jersey Channels (Condition of Improvement, 30 September 1986)	Existing project adopted 1933, modified 1935, 1950, 1965, and 1985.
Newark Bay, Hackensack & Passaic Rivers, N.J. (Condition of Improvement, 30 September 1986)	Existing project, Newark, adopted 1922, modified 1943, 1954, 1964, 1966, 1975 and 1985. The Kill Van Kull and Newark Bay Channels, New York and New Jersey adopted for construction in 1985.
Elizabeth River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Rahway River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Woodbridge Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project 1902.
Lemon Creek, Staten Island, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1937.
Great Kills Harbor, Staten Island, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1927, modified 1938.
Raritan River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1919, modified 1930, 1937 and 1940.
Washington Canal and South River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1930.
Raritan River to Arthur Kill Cut-Off Channel, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Cheesequake Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1880.
Matawan Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1881.
Keyport Harbor, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1882.
Way Cake Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1945.

Shoal Harbor & Compton Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Sandy Hook Bay at Leonardo, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1950.
Sandy Hook Bay, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1937.
Shrewsbury River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1919,1935,1950, and 1965.
Little Neck Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 23 October 1962.
Atlantic Coast of New Jersey, Sandy Hook to Barnegat Inlet Beach Erosion Control (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the River and Harbor Act of 3 July 1958 in accordance with the House Document No. 332, 85th Congress, second session. The cost-sharing on beach one (Sea Bright to Ocean Township) was modified by the Supplemental Appropriation Bill for 1985.
Perth Amboy, N.J. Beach Erosion Control (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the River and Harbor Act of 27 October 1965 in accordance with House Document No. 186, 89th Congress, first session.
Liberty State Park, N.J. Levee and Seawall and Pedestrian Walkway (Condition of Improvement, 30 May 1987)	Authorization: The project was authorized by Section 152 of the Water Resources Development Act of 1976 (PL94-587) and the Supplemental Appropriation Act of 1985.
Staten Island Rapid Transit Railway Co. Bridge (B&O) Across Arthur Kill, N.Y. & N.J. Alteration of Bridges (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized under provisions of the Truman-Hobbs Act of 21 June 1940. The secretary of the Army, on 5 July 1949 ordered alteration of the existing bridge.
New York Harbor, New York and New Jersey Collection and Removal of Drift (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized in 1915 and modified in 1917 and 1930. The latest modification was by the Water Resources Development Act of 1974 (PL 93-251).



Liberty State Park: A Brief History

The land we know as Liberty State Park can be viewed as a retrospective of the interaction between humans and the environment of the harbor/estuary. The eastern woodland native people built a social structure based upon the abundant resources the harbor provided. Early colonial settlers viewed the area as both a respite from the social oppression of European monarchies and a land rich in the resources needed to support their new life. The Industrial Revolution saw a new type of dependency on the land and water. The harbor now supported a culture whose economic power dominated much of the nation and had a worldwide impact. It created a need for people, the cries for which were heard throughout the world. Approximately 37 million people immigrated to America within a span of 100 years, the largest immigration in history. It was the prosperity of the Industrial Revolution that invited these immigrants to their new country. However, the Industrial Revolution also distanced people from the resource upon which they depended. New technology allowed for the growth of the large cities, and the waterfront -- critical to the shipping of goods -- became property of industries rather than the home of people. During the past 25 years, there have been substantial efforts to reconnect the people with the land and its resources. The resulting revitalization of the resources represents a renewed awareness and knowledge of our dependency upon the harbor. The creation of Liberty State Park is an affirmation of that knowledge.

The mission of Liberty State Park is to provide the public with access to the harbor's resources, a sense of its history and the charge of responsibility for its continued improvement.

Existing Facilities

Liberty State Park opened in 1976 with one primary facility, the Administration/Welcome Center. By the late 1970s, the Central Railroad of New Jersey Terminal had been partially restored and was hosting special events. While restoration work continues today, the building is currently the host of special events, exhibits, offices and is also the point of embarkation for visitors to the Statue of Liberty and Ellis Island. In 1984, the Interpretive Center began to be used for programs for both the general public and school groups. By 1986, Liberty Walk opened allowing free public access to the waterfront for over two miles. The Liberty Science Center, a world class museum and education center, opened in 1993. By 1998 the Liberty Landing Marina began operation providing another means of access to harbor and the "Green Park," 88 acres of landscaped and wildflower meadows that adjoins the walkway, was completed in 1999. A new "Millennium Park" was dedicated in September 2000. With approximately 4 million visitors annually, Liberty State Park has quickly become the most visited state park in New Jersey.

The Parks Interior Section

In the center of the park there remains 251 acres, the former railroad yard, which is undeveloped. The area has been recolonized by various plant communities. These communities represent unique associations of both endemic and nonnative species that can be considered the by-product of the cultural events that have taken place during the past several centuries. Like the local human population these assemblages are diverse and have origins throughout the world. This diversity is further enhanced by the rapid rate of natural succession. Hence, the question has become "what is the true value of the interior section of the park and how should it be managed?"

Looking toward the Future *of* Liberty State Park

Liberty State Park is a green oasis centrally located in metropolitan northern New Jersey. With the Manhattan skyline, the Statue of Liberty and Ellis Island as a spectacular backdrop, it is one of the state's most dramatic parks.

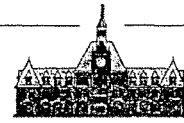
Today, Liberty State Park offers a wide array of educational and recreational opportunities. The history of the park and the region are interpreted at The Central Railroad of New Jersey (CRRNJ) and the environmental attributes are presented at the Interpretive Center and nearby Liberty Science Center. Ferry access to the Statue of Liberty and Ellis Island is available and picnic areas and walkways offer scenic views of the harbor and passive recreational opportunities.

During the past 25 years since the establishment of Liberty State Park we have achieved much success toward both increasing public access to the park and improving and enhancing its environmental attributes.

We would like you to join us now as we announce plans for the future use of the final 251 acres of undeveloped land at Liberty State Park. Together, we can help further enhance this park as a local, state and national treasure.

PLEASE JOIN US!

We invite you to participate in the future development of Liberty State Park by attending a public meeting being held at the Central Railroad of New Jersey Terminal, on Saturday, August 25, 2001 at 10:00 a.m.



THE INTERDISCIPLINARY PLANNING COMMITTEE

There is a great deal of interest in the remaining undeveloped land within Liberty State Park. The Division of Parks and Forestry has implemented a broad-based, goal-driven approach to develop a General Management Plan (GMP) for the interior of the park. The GMP process stresses the fundamental relationship between resource significance and visitor experience. Most importantly, the process results in documentation of planning efforts that build consensus among participants, assure logic and consistency in the proposals, and provide a defensible rationale for decision-making.

Public participation is critical to the success of this planning effort. The planning committee includes: members from the Friends of Liberty State Park; the Liberty State Park Development Corporation; the Liberty State Park Conservancy; the Liberty Science Center; New Jersey Audubon; the Natural Resource Conservation Service; the Hudson/Passaic Soil Conservation District; Jersey City; Hudson County and staff from the Division of Parks and Forestry.

The first public meeting held on January 27, 2001 presented several alternatives. After careful review of the comments received, the committee prepared a preferred alternative which is presented in the draft GMP. The GMP calls for the protection of critical environmental areas, habitat restoration/ enhancement and the development of non-commercial, open space recreation features around the perimeter.

New Jersey Department of Environmental Protection's Division of Parks and Forestry

Proposed Strategies

In order to accomplish both the protection and enhancement of the parks interior section the committee agreed to the following implementation strategies:

1. Freshwater Wetlands - The protection of the wet-thicket and sedge ponds, which currently occupy approximately 3 acres, is critical. A buffer of 100 feet must also be included and the area could be expanded. In addition, the half-acre "moss mat community" which is found in association with the "common reed" should remain intact and perhaps enhanced.

2. Salt Marsh Restoration - Grasses and species of trees typical of early succession currently dominate the dredge spoil site. It may be possible within these and adjoining areas, to create a cross section of the vegetative communities which existed prior to the development of the area. The creation of an area representative of the transition from salt marsh to upland forest would provide for an exceptional study of habitat restoration in the urban environment, while enriching the visitor experience.

   The restoration of both freshwater and saltwater wetlands could re-introduce aquatic habitats to the center of the park and create a network of interconnected wetlands/waterways.

3. Forest Enhancement - The pioneer forest comprises a significant section of the interior. Management strategies in these areas will consist of removing invasive species and introducing a limited amount of wildlife enhancement plantings. In addition, those field areas existing between the wooded areas should be allowed to succeed, creating a more contiguous forest.

4. Interpretive Enhancements - Interpretive trails will be developed in areas already used as former roads to minimize disturbance. However, several connecting trails will have to be developed. These should follow the vegetative communities to allow for wildlife viewing.

5. Recreational Enhancements - Several trails and perimeter green spaces will be established in order to provide open space, non-commercial recreational enhancements, connections between existing facilities and access for interpretation. While the perimeter will serve as a buffer to the more ecologically sensitive areas, its width can vary to create interesting areas capable of supporting trails, which explore interpretive themes, picnic areas, or other forms of open space, non-commercial recreation. The amount of acreage dedicated to the various types of activities would be determined during the future design phase, but should generally follow the wood lot edge.

   The 18-acre soil stockpile area, recently used for the storage of soil used for landscaping purposes throughout the park, will provide for a range of open space, non-commercial recreational activities. Its location in the extreme southwest corner of the site, next to the industrial area and across from the proposed sports complex may lend itself to such use and is critical as a buffer to the more ecologically sensitive areas within the site.

   Visual and noise barriers can be created by using soil to increase the elevation of certain areas within the perimeter. They can function to obscure the view of the industrial area or decrease the noise from traffic along Phillips Drive. They can also be used to create interesting lines of sight between the Liberty Science Center and the Interpretive Center or to direct storm water into the wetland areas.

Feasibility Study

The participation of the US Army Corps of Engineers ("Corps") is key to the successful inclusion of water features and wetland restoration within the site. The Corps has initiated feasibility studies on thirteen sites within the New York/New Jersey Harbor Estuary. These sites are being evaluated for their potential of large scale habitat restoration projects. The Interdisciplinary Planning Committee feels that Liberty State Park, with its significant natural and historic resources, waterfront walkway and Liberty Science Center is by far the most important site within the study area. With the federal support that would result from the Corps' cooperation, the interior section of the park could become recognized internationally as a prototype for restoration ecology in urban environments.

Conclusion

Liberty State Park, the cornerstone of the Gold Coast, is already a successful rehabilitation story. In addition, with the completion of the interior section of the park, it has the potential to be an international showcase for the restoration of a former industrial landscape. The tremendous interest in the remaining undeveloped section of the park is symbolic of a broader struggle that often occurs within New Jersey and throughout much of the nation. That is, to balance the protection of natural resources with the need for continued economic development and recreational opportunities. The General Management Plan that this document summarizes strives to enhance the park in a manor that honors its history while at the same time provides for the open space needs of residents of the surrounding community and state, as well as national and international visitors.

PLEASE JOIN US!

We invite you to participate in the future development of Liberty State Park by attending a public meeting to be held at Liberty State Park's Central Railroad of New Jersey Terminal on Saturday, August 25, 2001. The meeting will begin at 10:00 a.m.

New Jersey Department of Environmental Protection
Division of Parks and Forestry
PO Box 404
Trenton, NJ 08625-0404

August 2001
Printed on recycled paper.

THE PORT AUTHORITY OF NY & NJ

CHRISTOPHER O. WARD
CHIEF OF PLANNING AND EXTERNAL AFFAIRS

ONE WORLD TRADE CENTER, 67E/34S
NEW YORK, NY 10048

(212) 435-5441/6005
(212) 435-3007/6030 FAX

June 9, 2000

Colonel William Pearce, District Engineer
US Army Corps of Engineers New York District
Jacob K. Javits Federal Building
New York, NY 10278-0090

RE: Hudson-Raritan Estuary Environmental Restoration Study: Comments of Draft Reconnaissance Study: Expression of Intent for Feasibility Phase Participation

Dear Colonel Pearce:

The Port Authority of New York and New Jersey, a bistate agency responsible for the maintenance and enhancement of transportation and commerce facilities within the port district, welcomes the opportunity to comment on the draft "Hudson-Raritan Estuary Environmental Restoration Study – Reconnaissance Phase"; we are pleased to reiterate our interest in participating in the next phase of this effort: "Feasibility Phase."

Overall, the NY District Corps of Engineers and its consultants have prepared an excellent analysis of the broad landscape of the port district for this initial study and have developed an appropriately comprehensive list of potential restoration initiatives. Accordingly, our comments on the Draft Study are minor (see attached).

As you may be aware, the Port Authority has already expressed its willingness to participate in the Feasibility Study (see attached October 26, 1999 letter to Vice President Gore). In addition, by letter dated March 2, 2000 (also attached) the Port Authority forwarded to the New York District a list of proposed restoration projects with which we have a strong interest. The more comprehensive list in the draft Reconnaissance Study (87 projects, all within the port district) is a compelling inventory of restoration needs which is similar in kind and inclusive of the Port Authority project list. We believe the Corps' inventory will reflect the interests of environmental groups, shoreside communities and those who work and carry out recreational activities within our Harbor/Estuary. The Corps' more comprehensive list is congruent with Port Authority interests for the following reasons:

- The quality of harbor sediments and the ability to dredge and dispose of them in economically and environmentally acceptable ways are clearly linked to ambient water quality. Ambient water quality is, in turn, highly dependent upon the various uses of our waterways and the local land uses. Restoration projects explicitly address water quality and the improvement will allow for better sediment quality.

- Long-term planning of the Port Authority's commercial port facilities must consider not only their potential for impact on the environment, but must also allow for natural resource values and public access and use opportunities within the Hudson-Raritan Estuary. The comprehensive list of restoration initiatives provides an appropriate array of projects with which port redevelopment plans can be integrated.

- The Port Authority of New York and New Jersey, as an entity of the states, considers port redevelopment actions within the context of the broader public interest and its overall mandate. In so doing, it acknowledges that the economic vitality of the commercial port and the environmental health of the Hudson-Raritan Estuary are inextricably linked. Both are key components in the development of plans, projects, and facilities which are in the best interests of people that live and work in the Port District.

In light of the foregoing, the Port Authority hereby restates its willingness to participate in the Feasibility Phase of the Hudson-Raritan Estuary Restoration Study through financial support and/or in-kind services. In expressing this intention, the Port Authority hopes to encourage other potential sponsors to participate not only in the technical aspects of the Feasibility Study but the financial aspects as well.

Christopher Zeppie, our Chief of Environmental Policy and Planning will remain the Port Authority's point of contact in this effort. Chris can be reached at 212-435-6153.

Very Truly Yours,

Christopher O. Ward
Chief of Planning & External Affairs

CC: Lillian Borrone, PA of NY & NJ
Richard Gemiello, NJ Maritime Resources
Andrew Genn, NYCEDC
James Gilmore, NYSDEC
Jay Hector, ESDC
Frank Santomauro, NYD Corps of Engineers

STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
1035 PARKWAY AVENUE
P.O. BOX 601
TRENTON, N.J. 08625-0601
609-530-3536

CHRISTINE TODD WHITMAN
GOVERNOR

JAMES WEINSTEIN
COMMISSIONER

PLEASE REPLY TO:
NJ MARITIME RESOURCES
PO BOX 837
TRENTON, NEW JERSEY 08625-0837
TELEPHONE: (609) 984-6694
FACSIMILE: (609) 984-1468

June 19, 2000

Mr. Frank Santomauro, P.E.
Chief. Planning Division
New York District, US Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0090

Subject: Hudson-Raritan Estuary Reconnaissance Study

Dear Mr. Santomauro:

New Jersey Maritime Resources (NJMR) has reviewed the draft 905(b) Preliminary Analysis and Expedited Reconnaissance Study for environmental restoration in the Hudson-Raritan Estuary and concurs with the findings and recommendations of the study.

NJMR supports proceeding with the Feasibility Study for the project and will coordinate with the New Jersey Department of Environmental Protection and the Port Authority of New York and New Jersey to develop a feasibility cost sharing agreement (FCSA) by December 2000. We understand the non-Federal cost-sharing requirement for the Feasibility Study is 50% (with up to 25% in-kind contributions).

Pending our review of the Feasibility Study, and availability of sufficient funding, NJMR is willing to serve as a non-Federal sponsor in further project development. We understand the non-Federal cost sharing requirements for the remaining portions of the project are:

Preconstruction Engineering and Design: 65% Federal, 35% non-Federal
Construction: 65% Federal, 35% non-Federal
Operations and Maintenance: 100% non-Federal

We look forward to our continued participation in the Hudson-Raritan Estuary Environmental Restoration Study and the goal to restore the estuary.

Sincerely,

Richard Gimello
Executive Director, NJ Maritime Resources

RG/lab

State of New Jersey

Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

20 June 2000

Mr. Frank Santomauro, P.E.
Planning Division Chief
New York District, Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Subject: Hudson-Raritan Estuary Reconnaissance Study

Dear Mr. Santomauro

The New Jersey Department of Environmental Protection has reviewed the draft 905(b) Preliminary Analysis and Expedited Reconnaissance Study for environmental restoration in the Hudson – Raritan estuary and we concur with the findings and recommendations of the study.

NJDEP supports proceeding with the Feasibility Study of the project and in conjunction with the NJ Office of Maritime Resources and the Port Authority of New York and New Jersey, we will develop a non-federal cost-share arrangement for funding the Feasibility Study. We understand the non-Federal cost-sharing requirement for the Feasibility Study is 50% (with up to 25% in-kind contributions).

Pending our review of the Feasibility Study, and availability of sufficient funding, NJDEP is willing to serve as a non-Federal sponsor in further project development. We understand the non-Federal cost-sharing requirements for the remaining portions of the project are as follows:

Preconstruction Engineering and Design – 65% Federal, 35% non-Federal
Construction – 65% Federal, 35% non-Federal
Operations and Maintenance - 100% non-Federal

DEPARTMENT OF STATE

George E. Pataki
Governor
Alexander F. Treadwell
Secretary of State

Division of
Coastal Resources
41 State Street
Albany, NY 12231-0001

June 22, 2000

Mr. Frank Santomauro, P.E.
Chief, Planning Division
New York District, Corps of Engineers
26 Federal Plaza
New York, NY 10278-0090

Dear Mr. Santomauro:

The Department of State has reviewed the 905(b) Hudson-Raritan Estuary Reconnaissance Study and concurs with your findings and recommendations.

We appreciated the opportunity to participate with Corps staff in the preparation of this study. Top priorities for restoration in the 905(b) study coincide with priority recommendations in the NYNJ Harbor Estuary Program. The Department is pleased to see an increased level of interagency coordination for this undertaking.

The Department supports proceeding with the cost-shared feasibility portion of the study. While unable to commit funds as a local co-sponsor at this time, the Department can provide in-kind support and technical assistance through our program activities in New York City and in our efforts for implementing the NYNJ Harbor Estuary Program.

We look forward to participating in the Hudson-Raritan Ecosystem Restoration initiative with the Corps, the co-sponsors and other involved agencies.

Sincerely,

William F. Barton
Assistant Director

Voice: (518) 474-6000 Fax: (518) 473-2464 E-mail coastal@dos.state.ny.us
www.dos.state.ny.us/cstl/cstlwww.html

State of New Jersey
Department of Environmental Protection

James E. McGreevey
Governor

Bradley M. Campbell
Commissioner

Office of the Assistant Commissioner
Natural & Historic Resources
P.O. Box 404
Trenton, NJ 08625-0404
Tel.: (609) 292-3541
Fax: (609) 984-0836

October 16, 2004

Colonel Richard J. Polo
U.S. Army Corps of Engineers
26 Federal Plaza, Room 2109
New York, NY 10278-0090

Re: Hudson Raritan Estuary – Liberty State Park

Dear Colonel Polo:

The New Jersey Department of Environmental Protection (NJDEP) has reviewed the July 2004 draft of the integrated Feasibility Report/Environmental Impact Statement (FR/EIS) for Liberty State Park, Jersey City. The draft FR/EIS was prepared under the authority of the Hudson-Raritan Estuary study resolution, and proposes wetlands creation and restoration, and grassland and woodland enhancement at Liberty State Park. The project is important to our long-term vision for the park and our joint goal of enhancing the quality of the harbor estuary. We greatly appreciate the time and effort the U.S. Army Corps of Engineers has contributed to the project.

NJDEP concurs with the recommendations contained in the FR/EIS report. Based upon a total estimated cost for this project of $31,678,800, we are pleased to hereby pledge our support and intent to serve as the non-Federal cost-sharing partner in project construction, upon entering into a Project Cooperation Agreement (PCA). As you know from your recent meeting with Commissioner Campbell, Marc Matsil, DEP's Senior Policy Advisor, has been working with your staff to jump-start the design and construction phase through your "Work for Others" program. In accordance with Federal guidelines, NJDEP agrees to be responsible for operations and maintenance of the Liberty State Park project after the fulfillment of the commitments in the PCA. These commitments are consistent with broader initiatives of NJDEP for the area.

We look forward to working with you on this important restoration initiative for the Hudson-Raritan Estuary. Please contact Mr. Frank Gallagher at (609) 439-6527 with any questions that may arise.

Sincerely,

John S. Watson, Jr.
Assistant Commissioner

c. Marc Matsil, NJDEP
Jose Fernandez, Director – DPF
Lynn Fleming, Assistant Director – DPF
Frank Gallagher, Administrator – DPF

LIBERTY STATE PARK - PUBLIC MEETING – SEPTEMBER 26, 2005; 7:00 PM
CENTRAL RAILROAD TERMINAL, LIBERTY STATE PARK, JERSEY CITY, NJ.

On Monday evening, 26 September 2005, a public meeting was held at Liberty State Park, NJ. NJDEP and USACE representatives conducted a poster board session and gave a presentation for all attendees. At the conclusion of the presentation, the public was afforded an opportunity to make statements and voice opinions in either written or oral fashion.

Summary Points – public speakers

1. Mr. Marc Matsil – NJDEP
Mr. Marc Matsil thanked the Corps, Baykeeper, Sam Pesin, the PANYNJ, HEP, HWG and others for their efforts in advancing the project.

His main stated concern is that the project would receive the WRDA match (Federal funds) for implementation. He's been working with Congressman Menendez and has been assured that if the document is signed by 12/31/05 that they will get their match. He wants to use Ambrose Channel sands and to bring the Northern Harrier back to the site. He stressed that non-Federal interests must encourage local officials that we need money for this project because we have new hurdles with every natural disaster.

2. Ms. Martina Hoppe – USFS
Ms. Martina Hope is a resident of Jersey City and she wanted to take the opportunity to introduce herself. In her previous job she worked on the planning committee, and she offered her assistance and guidance for the upland management/forest improvement phase of the project. She would like to assist, if there is funding.

3. Mr. Marvin Silber - NJ Audubon
He is a member of the society who is in the park every day to search for birds. He has documented more than 100 species. He is concerned by the possibility of opening access to the park because of the few hawks and several owls that occupy the park in the winter. His primary area of concern is the southeast corner of the park where Cooper's and red tail hawk occupy. He also stated that the park is one of the only spots in NJ that has a documented occurrence of the snowy owl. Three years ago they returned after a brief hiatus because of the development of the Global Marine Terminal. He suggested that the plan should protect the wild birds of LSP.

4. Mr. Sam Pesin – Friends of Liberty State Park (FOLSP)
Mr. Sam Pesin stated that this is a milestone in LSP History. He suggested a plan for nature trails and habitat. There will be recreation opportunities around the perimeter. It will be a spectacular transformation. He expressed gratitude to Congressman Menendez (who is looking to get more funding), the Corps and the entire project team.

5. Mr. Michel Cuillerier – Sierra Club/FOLSP
Mr. Cuillerier expressed thanks to the Corps and stated that the plan is the result of a long process. He objects to using the words "mainly degraded" when discussing the park in its current state. It is home to many species of flora and fauna and is not necessarily degraded. He suggests changing the wording to "emergent ecosystem". He expressed a concern that there needs to be a systematic public access plan that will avoid impacts to sensitive wildlife. Frank Gallagher responded that human access to the park will be addressed at a later time.

6. Ms. Alicia Richmond – FOLSP
Ms. Alicia Richmond suggested an approach to make more money for the park by dedicating trees for people who had loved ones in Jersey City cemeteries. People could safely visit the trees planted in the park in lieu of the gravestones in the cemeteries. She suggested that the cemeteries in Jersey City are not safe, and this would be an opportunity to raise funds for LSP while doing something for the community. She said that she knew a number of people that were interested in the idea, and that she has already "sold lots of trees".

7. Mr. Mike Selner – Hudson-Meadowlands Sierra Club
Mr. Mike Selner said that he approves of the plan that addresses freshwater and salt water wetlands, and contaminant issues. He looks forward to the implementation of the plan.

8. Ms. Grace Stenlake – FOLSP
Ms. Grace Stenlake shared her memories of the train station with the audience. She suggested putting a light on the flag at the Interpretive Center, and offered to pay for the light bulb.

9. Mr. Greg Giordano – FOLSP
Mr. Greg Arregiodono expressed concern that the trip on Public Transit is too long. He stated that the elevations in the cross sections of the plan are missing. A minor rain event causes ponding on the section of the park east of Freedom Way. This may be a problem during a major storm. He hopes that the issue of drainage has been taken into consideration.

He expressed concern that the Chromium issue has not been addressed in the plan. It is his opinion that there are 3 responsible parties: Allied, PPG and Axis. But, if they removed the Chromium it would probably make their products more costly. He suggested approaching them and asking them to donate the money for restoration.

He compared the Holocaust to what we are doing to the Earth, and what we did to the Native Americans and the African Americans. He pointed out that the Statue of Liberty's back is facing NJ, and that it is symbolic of what we are doing to the Earth.

He suggested that the contracting for the park be done by locals.
He stated that the marina should not exist.
He lastly expressed concern about the drainage issues.

FOLSP

:mber of the FOLSP shared her memories of emigrating from London on t
ıia. After a harrowing journey, she arrived in the US by train to the Centra
d Terminal in Jersey City.

Mr. Greg Remaud – Baykeeper

:g Remaud expressed thanks to the Corps and the entire project team for
sive thinking.

/ point he wanted to make is that the interior of the park should be kept sec
;ested keeping people around the perimeter of the park. He believes that t
good and will tie the park together in a cohesive way.

ts to send a message to Washington and the immediate project delivery tea
ect must move at a faster pace than the normal Corps projects. Otherwise,
ion will move forward without them, or not at all. He reiterated that the pı
move at a normal pace. He described small fund raising meetings and pho
:ies that have taken place recently. He and Mr. Frank Gallagher (NJDEP)
ıtion for the freshwater wetlands portion of the project and received a $1.5
r that component of the plan. At this point they have $11.5 million of ded
n the local end for the restoration project. He is confident that the project i
forward.

Comments and Responses to the LSP Feasibility Report/Environmental Impact Statement

Six comment letters were received on the Feasibility Report/Environmental Impact Statement from the following:

Name	Organization/Agency
John Filippelli, Chief of Stategic Planning and Multi-Media Programs Branch	USEPA
Stanley Gorski, Field Offices Supervisor	NOAA-NMFS
Carter Craft, Director	Metropolitan Waterfront Alliance
Troy Ettel, Director of Conservation	New Jersey Audubon Society
Michael Britt, Classroom Workshop Coordinator	Liberty Science Center
Dorothy Winant	Individual

The letters, which are supportive of the recommended plan, are reproduced starting on the following page with the responses.

Comments fall into two categories:

A – Supportive of the project

B – Concern on schedule of implementation and funding

The comments are marked with text boxes where they appear.

Letter from John Filippelli, USEPA:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

Bob Will
212 264 0961
Hardcopy to follow
L.K.

OCT 05 2005

Paul Sabalis
Project Manager
U.S. Army Corps of Engineers, New York District
26 Federal Plaza
New York, NY 10278

Class: LO

Dear Mr. Sabalis:

The Environmental Protection Agency (EPA) has reviewed the draft integrated feasibility report and environmental impact statement (DEIS) for the Hudson-Raritan Estuary, Liberty State Park Ecosystem Restoration in Jersey City, New Jersey (CEQ#20050378). This review was conducted in accordance with Section 309 of the Clean Air Act, as amended (42 U.S.C 7609, PL 91-604 12 (a), 84 Stat. 1709), the National Environmental Policy Act (NEPA) and the Council on Environmental Quality's regulations for implementing NEPA (40 CFR Parts 1500-1508).

The plan calls for the restoration of a relatively inaccessible 234 acre section of Liberty State Park, which is mostly undeveloped semi-degraded parkland within a fenced-off portion of the Liberty State Park's 598 terrestrial acres. This portion of the park is a former rail yard and dredged material disposal area, and has remained undeveloped and unused due to the presence of contaminants that exceed the New Jersey Department of Environmental Protection Non-Residential direct contact soil cleanup criteria. The preferred plan, which will create approximately 40 acres of salt marsh, and create or enhance 28 acres of freshwater wetlands will sequester any excavated contaminated soils within an upland berm to be created on site. Additionally, the plan calls for the creation of approximately 55 acres of "warm weather grasslands" and the enhancement of approximately 100 acres of "successional northern hardwoods and maritime shrub assemblages."

The proposed restoration plan appears to be sound and generally well-developed. The document states on page 117 that the success criteria for the mitigation plan will be quantified and finalized after the NEPA process and incorporated into the final Pre-Construction Engineering Design phase. In the further refinement of the mitigation plan, we suggest that the Corps include in its plans all the pertinent elements of a comprehensive mitigation plan described in the Corps New York District Regulatory Branch public notice dated January 2005 and found at http://www.nan.usace.army.mil/business/buslinks/regulat/pnotices/mitfinal.pdf. These mitigation guidelines are part of the Federal interagency national mitigation action plan begun in 2002 and instituted to help improve wetland mitigation success.

Based on our review, we do not anticipate that implementation of the preferred alternative will result in significant adverse impacts to the environment. Accordingly, EPA has no objections to its implementation.

A

Sincerely yours,

John Filippelli, Chief
Strategic Planning and Multi-Media Programs Branch

2

TOTAL P.02

Comment A: Support for the project.

Response: Thank you for your letter supporting the recommendation in the Hudson Raritan Estuary (HRE), Liberty State Park feasibility report. It appears that many of your agency's goals and objectives are consistent and compatible with the overall HRE vision and goals for Liberty State Park. The HRE effort maintains broad relevance through the key recognition that the environment, the economy and social well-being are fundamentally interlinked and interdependent.

Letter from Stanley Gorski, NOAA-NMFS:

10/04/2005 10:58 FAX 002

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
James J. Howard Marine
Sciences Laboratory
74 Magruder Road
Highlands, New Jersey 07732

October 4, 2005

Mr. Leonard Houston, Chief
Environmental Analysis Branch
Planning Division
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278-0090

ATTN: Olivia Cockler

Dear Mr. Houston:

Thank you for providing NOAA's National Marine Fisheries Service with a copy of the Draft Integrated Feasibility Report and Environmental Impact Statement for the Hudson-Raritan Estuary Liberty State Park Restoration Project. We have reviewed the document and we support fully the ACOE's plan to restore tidal estuarine and freshwater wetland habitats within Liberty State Park and to enhance a variety of uplands habitats. The selected plan will replace a degraded uplands area with a variety of valuable habitats for fish and wildlife resources. It will also create and enhance essential fish habitat (EFH) for a number of federally managed species including winter flounder (Pseudopluronectes Americanus), summer flounder (Paralichthys dentatus) and their prey species. As the project construction plans are developed, we will work with your staff to complete the required EFH consultation. We may suggest timing restrictions or construction sequencing for work within the North Cove area, but the need for these or any other conservation recommendations to minimize the temporary impacts to EFH that may occur as a result of the construction will be evaluated during the consultation process. Once again, we support fully the Liberty State Park Restoration Project and we look forward to continued coordination on this important effort. A

Sincerely,

Stanley W. Gorski
Field Offices Supervisor

cf: PRD - Crocker
RC - Alderson

Printed on Recycled Paper

Response: See response to above.

Letter from Carter Craft, Metropolitan Waterfront Alliance:

METROPOLITAN WATERFRONT ALLIANCE

September 28, 2005

Mr. Frank Santomauro
United States Army Corps of Engineers
26 Federal Plaza, Room 2145
New York, NY 10278

Dear Mr. Santomauro:

I am writing to express my support for the current progress made by the Army Corps in the restoration of a now fenced-off 234 acres of mostly undeveloped, semi-degraded parkland within Liberty State Park. By restoring this section of the park, two previously restored and developed area of the 1,121-acre park will be connected into one cohesive whole, enhancing the park for all visitors.

Due to past fill activities, industrialization and development on the site, this area is consequently less productive than the pre-existing ecosystem habitat. Local groups monitoring the site have also noted continuous ecosystem degradation problems like a fragmentation of past restoration efforts in the estuary, impacts of infrastructure improvements, and impacts of urban development, including brownfields, refuse landfills and infrastructure encroachments on tidal flow.

The USACE project, which includes increasing and restoring more sustainable desirable communities, providing more cover, nesting, and breeding habitat for wildlife and increasing species richness, will do wonders for the ecology and sustainability of the park and the estuary as a whole. ← A

We hope that the Corps is making this a priority in the region and will not delay its implementation. If we can assist in any way, please let us know how. ← B

Thank you again for your efforts.

Sincerely,

Carter Craft
Director

cc: Sam Pesin, Friends of Liberty State Park

Comment A: See previous responses to Comment A.

Comment B: We are currently advancing the first interim potential project under the overall HRE program authority at LSP in partnership with NJDEP. The availability of Federal funding will influence the actual implementation schedule for LSP, and we will keep you apprised of developments.

Letter from Troy Ettel, New Jersey Audubon Society

NEW JERSEY AUDUBON SOCIETY

Department of Conservation
11 Hardscrabble Road, P.O. Box 693, Bernardsville, NJ 07924 (908) 766-5787 Fax: (908) 766-7775
E-mail: conservation@njaudubon.org Web site: http://www.njaudubon.org/conservation

September 27, 2005

Mr. Robert Will, USACE

USACE, CENAN-PLE

26 Federal Plaza, 2151

New York, NY 10278

RE: Liberty State Park

Dear Mr. Will:

The New Jersey Audubon Society has reviewed the integrated draft Feasibility Report/Environmental Impact Statement (FR/EIS) for Liberty State Park, in Jersey City. The draft FR/EIS, prepared under the authority of the Hudson-Raritan Estuary study resolution, will greatly enhance habitat viability within the park and add to the passive recreational opportunities enjoyed by millions of visitors per year. We greatly appreciate the time and effort the US Army Corps of Engineers has contributed to the project.

The New Jersey Audubon Society concurs with the recommendations contained in the FR/EIS report. The creation and enhancement of wetlands, the establishment of grasslands and the enhancement of the urban woodland called for in the report reflect the intent of the General Management Plan (GMP) that the Division of Parks and Forestry had developed for the park. In addition, the recommendations within the FS/EIS are consistent with broader goals important to New Jersey Audubon Society concerning environmental education opportunities for urban populations in New Jersey, promotion of ecotourism, and restoration/enhancement of habitat for plants and animals native to New Jersey. A

We look forward to working with you on this important restoration initiative for the Hudson-Raritan Estuary. Please feel free to contact me via phone (908) 766-5787 or e-mail troy.ettel@njaudubon.org with any questions that may arise.

Sincerely,

Troy Ettel
Director of Conservation

Response: See previous responses to Comment A.

Letter from Michael Britt, Liberty Science Center

Date: 9/27/2005
To: Robert Will, EIS Coordinator
From: Michael Britt

Subject: Comments on the Liberty State Park Habitat Restoration Project

I was very impressed with the Army Corps of Engineers and NJDEP's exhibit and presentation of the Liberty State Park Habitat Restoration Project at the CRRNJ, on the evening of September 26, 2005. It is a sound plan and once completed will have created an integrated, dynamic, fully-functioning ecosystem. If nothing is done, the area will continue to undergo succession resulting in a lack of habitat diversity and invasive species will increasingly crowd out native plants furthering the degradation of the site and rendering it less suitable for desired wildlife species. Restoration is the only alternative. A

The restoration of 40 acres of dredge-spoils to salt marsh habitat will restore an ecosystem that is vitally and equally important to avian and aquatic life. The marsh will provide crucial stopover habitat for migratory shorebirds and wading birds and spawning habitat for fish. Salt marsh has been vastly depleted in the NY Harbor and any increase in acreage is a true victory.

The preserved 100+ acre forest interior will continue to serve as an important stopover site for Neotropical avian migrants and might attract noteworthy breeding species once the water element is integrated. This forest will serve as a migrant trap and provide tremendous recreational and interpretative experiences. The freshwater wetland provides locally rare habitat for wetland bird species such as rails, bitterns, and grebes, not to mention a great opportunity to introduce native species of reptiles and amphibians.

I am most pleased with the increase in the native warm-season grassland acreage to approximately 60 acres. Not only will it serve as an important foraging site for wintering raptors but also as a vital stopover and potential nest site for endangered and threatened species such as Vesper Sparrow, Grasshopper Sparrow, Savannah Sparrow, Bobolink, Upland Sandpiper, etc. Other species that would benefit include American Kestrel, Northern Harrier, and Barn Owl. All three of these species have bred onsite but are losing habitat yearly to succession. A nest box program for American Kestrel and Barn Owl is highly encouraged. The pine stand at the southeastern corner coupled with the grassland might attract wintering Long-eared Owls. However, it would be ideal if some clearing were done around the stand, so that it receives morning sunlight which is an important characteristic of owl roost sites.

I urge you to aggressively seek and acquire the necessary federal funding to implement this hallmark project. The entire region is depending on it! The end result will be the most impressive urban park in the world; one where nature and humans thrive harmoniously. B

Sincerely,
Michael Britt
Classroom Workshop Coordinator
Liberty Science Center
201 451 0006 x1586
mbritt@lsc.org

Responses: See previous responses to Comments A & B.

Letter from Dorothy Winant, Interested Individual

Mr. Robert Will, USACE

USACE, CENAN-PLE

26 Federal Plaza, 2151

New York, NY 10278

RE: Liberty State Park

Dear Mr. Will:

I have reviewed the draft of the integrated Feasibility Report/Environmental Impact Statement (FR/EIS) for Liberty State Park, in Jersey City. The draft FR/EIS, prepared under the authority of the Hudson-Raritan Estuary study resolution, will greatly enhance habitat viability within the park and add to the passive recreational opportunities enjoyed by millions of visitors per year. We greatly appreciate the time and effort the US Army Corps of Engineers has contributed to the project.

I concur with the recommendations contained in the FR/EIS report. The creation and enhancement of wetlands, the establishment of grasslands and the enhancement of the urban woodland called for in the report reflect the intent of the General Management Plan (GMP) that the Division of Parks and Forestry had developed for the park. The GMP, which had been presented to the public in two meetings, garnered a great deal of support. In addition, the recommendations FS/EIS are consistent with broader goals, concerning water quality and the protection of green space that I have supported for years. A

We look forward to working with you on this important restoration initiative for the Hudson-Raritan Estuary. Please contact, me at (201) 333 7560 with any questions that may arise.

Sincerely,

Dorcey Winant

Mrs. Dorothy "Dorcey" Winant
One Greene Street #212
Jersey City, New Jersey 07302

Mrs. Richard Winant
1 Greene St. Apt. 212
Jersey City, NJ 07302-4547

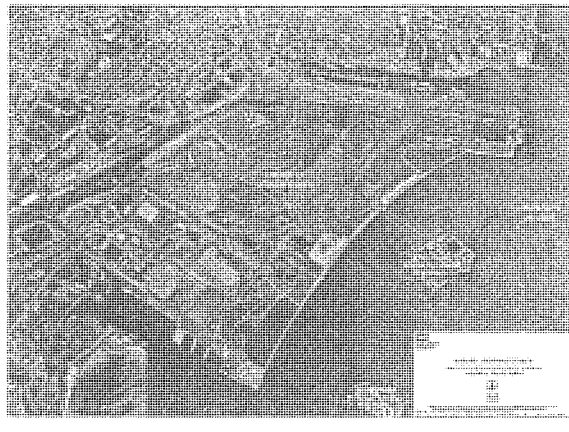
See previous response to Comment A.

US ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT

HUDSON-RARITAN ESTUARY, LIBERTY STATE PARK ECOSYSTEM RESTORATION

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

Volume 2



October 2005

Liberty State Park, Hudson-Raritan Estuary

Ecosystem Restoration

Integrated Feasibility Report & Environmental Impact Statement

Volume 2: Appendices B - D

New York District
U.S. Army Corps of Engineers

October 2005

Appendix B – Environmental

Appendix C – Cultural Resources

Appendix D – Real Estate Plan

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix A

Study Correspondence

Attachment 1

Authorized Flood Control and Navigation Projects in the New York and New Jersey Port District

FLOOD CONTROL PROJECTS WITHIN THE NEW YORK AND NEW JERSEY PORT DISTRICT

Raritan Bay and Sandy Hook Bay, N.J. Beach Erosion and Hurricane Protection. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 23 Oct. 1982 in accordance with House Document No. 464, 87th Congress, second session.
Rahway, N.J. (Condition of Improvement, 30 September 1986)	Authorization: By 2nd Endorsement letter from OCE dated 12 June 1964, the project was formally adopted for future construction under section 205 of the 1948 Flood Control Act, as amended.
Atlantic Coast of New York City From East Rockaway Inlet to Rockaway Inlet and Jamaica Bay, N.Y. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 26 October 1965 in accordance with House Document No. 215, 89th Congress, First Congress, First Session. Section 72 of the Water Resources Development Act of 6 March 1974 modified the project authorization to permit separate construction of the beach erosion control portion of the multiple purpose project.
Elizabeth River, N.J. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 1965 substantially in accordance with House Document No. 249, 89th Congress, first session.
South Orange, N.J. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 1965 substantially in accordance with House Document No. 67, 89th Congress, first session.
Staten Island, Fort Wadsworth to Arthur Kill, N.Y. Beach Erosion Control and Hurricane Protection (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 27 October 1965 in accordance with House Document No. 181, 89th Congress, First Session.
Yonkers, N.Y. (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the Flood Control Act of 1965 substantially in accordance with House Document No. 258, 89th Congress first session.
Green Brook Township, N.J. and Vicinity Snagging and Clearing—Green Brook (Condition of Improvement, 30 September 1986)	Authorization: The Project was authorized pursuant to Section 208 of the 1954 Flood Control Act subject to satisfactory assurances that local interests will comply with the requirements of local cooperation.
Morris and Passaic Counties, N.J. Snagging and Clearing—Pompton River (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized pursuant to section 13 of the 1946 Flood Control Act.
Lincoln Park and Pequannock Township, N.J. Snagging and Clearing—Beaver Brook and Pequannock Township Ditch (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized pursuant to section 2 of the Flood Control Act approved 28 August 1937, was amended.

NAVIGATION PROJECTS WITHIN THE NEW YORK AND NEW JERSEY PORT DISTRICT

Mamaroneck Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1922, modified 1935 & 1960.
Larchmont Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1899, modified 1907.
Echo Bay Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1910, modified 1973.
New Rochelle Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1922.
East Chester Creek, N.Y. (Hutchinson River) (Condition of Improvement, 30 September 1986)	Existing project adopted 1950.
Westchester Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1922, modified 1954.
Bronx River, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1913.
Flushing Bay and Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 23 October 1962.
Manhasset Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1930.
Hempstead Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1910 and modified 1968.
Glen Cove Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1888, modified 1895.
Glen Cove Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1925.
Jones Inlet, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1945.
East Rockaway Inlet, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1930.
Jamaica Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1910, modified 1945 and 1950.
Sheepshead Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1912.
Coney Island Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1907.
Coney Island Creek, N.Y. (Condition of Improvement, 30 September 1986)	Exiting project adopted 1935.
Bay Ridge & Red Hook Channels, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1899, modified 1930.
Gowanus Creek Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1881 to 1952.
Buttermilk Channel, N.Y.	Existing project adopted 1902, modified 1935 & 1962.

(Condition of Improvement, 30 September 1986)	
East River, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1915, modified 1916 to 1970.
Wallabout Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1899.
Newtown Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1919, modified 1930 and 1937.
Harlem River, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1878, modified to 1913.
Hudson River Channel, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1913, modified to 1937.
New York Harbor, N.Y. (Condition of Improvement, 30 September 1986)	Existing project: Ambrose, southerly entrance, Bayside and Main Ship Channels adopted 1884, modified 1933, 1937, 1958, 1965, and 1982.
New York and New Jersey Channels (Condition of Improvement, 30 September 1986)	Existing project adopted 1933, modified 1935, 1950, 1965, and 1985.
Newark Bay, Hackensack & Passaic Rivers, N.J. (Condition of Improvement, 30 September 1986)	Existing project, Newark, adopted 1922, modified 1943, 1954, 1964, 1966, 1975 and 1985. The Kill Van Kull and Newark Bay Channels, New York and New Jersey adopted for construction in 1985.
Elizabeth River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Rahway River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Woodbridge Creek, N.Y. (Condition of Improvement, 30 September 1986)	Existing project 1902.
Lemon Creek, Staten Island, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1937.
Great Kills Harbor, Staten Island, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 1927, modified 1938.
Raritan River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1919, modified 1930, 1937 and 1940.
Washington Canal and South River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1930.
Raritan River to Arthur Kill Cut-Off Channel, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Cheesequake Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1880.
Matawan Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1881.
Keyport Harbor, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1882.
Way Cake Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1945.

Shoal Harbor & Compton Creek, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1935.
Sandy Hook Bay at Leonardo, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1950.
Sandy Hook Bay, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1937.
Shrewsbury River, N.J. (Condition of Improvement, 30 September 1986)	Existing project adopted 1919,1935,1950, and 1965.
Little Neck Bay, N.Y. (Condition of Improvement, 30 September 1986)	Existing project adopted 23 October 1962.
Atlantic Coast of New Jersey, Sandy Hook to Barnegat Inlet Beach Erosion Control (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the River and Harbor Act of 3 July 1958 in accordance with the House Document No. 332, 85th Congress, second session. The cost-sharing on beach one (Sea Bright to Ocean Township) was modified by the Supplemental Appropriation Bill for 1985.
Perth Amboy, N.J. Beach Erosion Control (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized by the River and Harbor Act of 27 October 1965 in accordance with House Document No. 186, 89th Congress, first session.
Liberty State Park, N.J. Levee and Seawall and Pedestrian Walkway (Condition of Improvement, 30 May 1987)	Authorization: The project was authorized by Section 152 of the Water Resources Development Act of 1976 (PL94-587) and the Supplemental Appropriation Act of 1985.
Staten Island Rapid Transit Railway Co. Bridge (B&O) Across Arthur Kill, N.Y. & N.J. Alteration of Bridges (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized under provisions of the Truman-Hobbs Act of 21 June 1940. The secretary of the Army, on 5 July 1949 ordered alteration of the existing bridge.
New York Harbor, New York and New Jersey Collection and Removal of Drift (Condition of Improvement, 30 September 1986)	Authorization: The project was authorized in 1915 and modified in 1917 and 1930. The latest modification was by the Water Resources Development Act of 1974 (PL 93-251).

Looking toward the Future *of* Liberty State Park

Liberty State Park is a green oasis centrally located in metropolitan northern New Jersey. With the Manhattan skyline, the Statue of Liberty and Ellis Island as a spectacular backdrop, it is one of the state's most dramatic parks.

Today, Liberty State Park offers a wide array of educational and recreational opportunities. The history of the park and the region are interpreted at The Central Railroad of New Jersey (CRRNJ) and the environmental attributes are presented at the Interpretive Center and nearby Liberty Science Center. Ferry access to the Statue of Liberty and Ellis Island is available and picnic areas and walkways offer scenic views of the harbor and passive recreational opportunities.

During the past 25 years since the establishment of Liberty State Park we have achieved much success toward both increasing public access to the park and improving and enhancing its environmental attributes.

We would like you to join us now as we announce plans for the future use of the final 251 acres of undeveloped land at Liberty State Park. Together, we can help further enhance this park as a local, state and national treasure.

PLEASE JOIN US!

We invite you to participate in the future development of Liberty State Park by attending a public meeting being held at the Central Railroad of New Jersey Terminal, on Saturday, August 25, 2001 at 10:00 a.m.

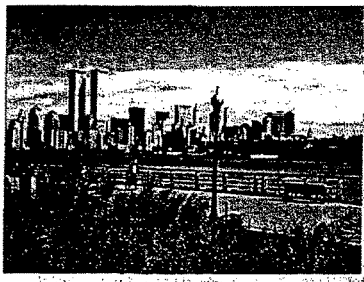
THE INTERDISCIPLINARY PLANNING COMMITTEE

There is a great deal of interest in the remaining undeveloped land within Liberty State Park. The Division of Parks and Forestry has implemented a broad-based, goal-driven approach to develop a General Management Plan (GMP) for the interior of the park. The GMP process stresses the fundamental relationship between resource significance and visitor experience. Most importantly, the process results in documentation of planning efforts that build consensus among participants, assure logic and consistency in the proposals, and provide a defensible rationale for decision-making.

Public participation is critical to the success of this planning effort. The planning committee includes: members from the Friends of Liberty State Park; the Liberty State Park Development Corporation; the Liberty State Park Conservancy; the Liberty Science Center; New Jersey Audubon; the Natural Resource Conservation Service; the Hudson/Passaic Soil Conservation District; Jersey City; Hudson County and staff from the Division of Parks and Forestry.

The first public meeting held on January 27, 2001 presented several alternatives. After careful review of the comments received, the committee prepared a preferred alternative which is presented in the draft GMP. The GMP calls for the protection of critical environmental areas, habitat restoration/ enhancement and the development of non-commercial, open space recreation features around the perimeter.

New Jersey Department of Environmental Protection's Division of Parks and Forestry



Liberty State Park: A Brief History

The land we know as Liberty State Park can be viewed as a retrospective of the interaction between humans and the environment of the harbor/estuary. The eastern woodland native people built a social structure based upon the abundant resources the harbor provided. Early colonial settlers viewed the area as both a respite from the social oppression of European monarchies and a land rich in the resources needed to support their new life. The Industrial Revolution saw a new type of dependency on the land and water. The harbor now supported a culture whose economic power dominated much of the nation and had a worldwide impact. It created a need for people, the cries for which were heard throughout the world. Approximately 37 million people immigrated to America within a span of 100 years, the largest immigration in history. It was the prosperity of the Industrial Revolution that invited these immigrants to their new country. However, the Industrial Revolution also distanced people from the resource upon which they depended. New technology allowed for the growth of the large cities, and the waterfront -- critical to the shipping of goods -- became property of industries rather than the home of people. During the past 25 years, there have been substantial efforts to reconnect the people with the land and its resources. The resulting revitalization of the resources represents a renewed awareness and knowledge of our dependency upon the harbor. The creation of Liberty State Park is an affirmation of that knowledge.

The mission of Liberty State Park is to provide the public with access to the harbor's resources, a sense of its history and the charge of responsibility for its continued improvement.

Existing Facilities

Liberty State Park opened in 1976 with one primary facility, the Administration/Welcome Center. By the late 1970s, the Central Railroad of New Jersey Terminal had been partially restored and was hosting special events. While restoration work continues today, the building is currently the host of special events, exhibits, offices and is also the point of embarkation for visitors to the Statue of Liberty and Ellis Island. In 1984, the Interpretive Center began to be used for programs for both the general public and school groups. By 1986, Liberty Walk opened allowing free public access to the waterfront for over two miles. The Liberty Science Center, a world class museum and education center, opened in 1993. By 1998 the Liberty Landing Marina began operation providing another means of access to harbor and the "Green Park," 88 acres of landscaped and wildflower meadows that adjoins the walkway, was completed in 1999. A new "Millennium Park" was dedicated in September 2000. With approximately 4 million visitors annually, Liberty State Park has quickly become the most visited state park in New Jersey.

The Parks Interior Section

In the center of the park there remains 251 acres, the former railroad yard, which is undeveloped. The area has been recolonized by various plant communities. These communities represent unique associations of both endemic and nonnative species that can be considered the by-product of the cultural events that have taken place during the past several centuries. Like the local human population these assemblages are diverse and have origins throughout the world. This diversity is further enhanced by the rapid rate of natural succession. Hence, the question has become "what is the true value of the interior section of the park and how should it be managed?"

Proposed Strategies

In order to accomplish both the protection and enhancement of the parks interior section the committee agreed to the following implementation strategies:

1. Freshwater Wetlands - The protection of the wet-thicket and sedge ponds, which currently occupy approximately 3 acres, is critical. A buffer of 100 feet must also be included and the area could be expanded. In addition, the half-acre "moss mat community" which is found in association with the "common reed" should remain intact and perhaps enhanced.

2. Salt Marsh Restoration - Grasses and species of trees typical of early succession currently dominate the dredge spoil site. It may be possible within these and adjoining areas, to create a cross section of the vegetative communities which existed prior to the development of the area. The creation of an area representative of the transition from salt marsh to upland forest would provide for an exceptional study of habitat restoration in the urban environment, while enriching the visitor experience.

   The restoration of both freshwater and saltwater wetlands could re-introduce aquatic habitats to the center of the park and create a network of interconnected wetlands/waterways.

3. Forest Enhancement - The pioneer forest comprises a significant section of the interior. Management strategies in these areas will consist of removing invasive species and introducing a limited amount of wildlife enhancement plantings. In addition, those field areas existing between the wooded areas should be allowed to succeed, creating a more contiguous forest.

4. Interpretive Enhancements - Interpretive trails will be developed in areas already used as former roads to minimize disturbance. However, several connecting trails will have to be developed. These should follow the vegetative communities to allow for wildlife viewing.

5. Recreational Enhancements - Several trails and perimeter green spaces will be established in order to provide open space, non-commercial recreational enhancements, connections between existing facilities and access for interpretation. While the perimeter will serve as a buffer to the more ecologically sensitive areas, its width can vary to create interesting areas capable of supporting trails, which explore interpretive themes, picnic areas, or other forms of open space, non-commercial recreation. The amount of acreage dedicated to the various types of activities would be determined during the future design phase, but should generally follow the wood lot edge.

   The 18-acre soil stockpile area, recently used for the storage of soil used for landscaping purposes throughout the park, will provide for a range of open space, non-commercial recreational activities. Its location in the extreme southwest corner of the site, next to the industrial area and across from the proposed sports complex may lend itself to such use and is critical as a buffer to the more ecologically sensitive areas within the site.

   Visual and noise barriers can be created by using soil to increase the elevation of certain areas within the perimeter. They can function to obscure the view of the industrial area or decrease the noise from traffic along Phillips Drive. They can also be used to create interesting lines of sight between the Liberty Science Center and the Interpretive Center or to direct storm water into the wetland areas.

Feasibility Study

The participation of the US Army Corps of Engineers ("Corps") is key to the successful inclusion of water features and wetland restoration within the site. The Corps has initiated feasibility studies on thirteen sites within the New York/New Jersey Harbor Estuary. These sites are being evaluated for their potential of large scale habitat restoration projects. The Interdisciplinary Planning Committee feels that Liberty State Park, with its significant natural and historic resources, waterfront walkway and Liberty Science Center is by far the most important site within the study area. With the federal support that would result from the Corps' cooperation, the interior section of the park could become recognized internationally as a prototype for restoration ecology in urban environments.

Conclusion

Liberty State Park, the cornerstone of the Gold Coast, is already a successful rehabilitation story. In addition, with the completion of the interior section of the park, it has the potential to be an international showcase for the restoration of a former industrial landscape. The tremendous interest in the remaining undeveloped section of the park is symbolic of a broader struggle that often occurs within New Jersey and throughout much of the nation. That is, to balance the protection of natural resources with the need for continued economic development and recreational opportunities. The General Management Plan that this document summarizes strives to enhance the park in a manor that honors its history while at the same time provides for the open space needs of residents of the surrounding community and state, as well as national and international visitors.

PLEASE JOIN US!

We invite you to participate in the future development of Liberty State Park by attending a public meeting to be held at Liberty State Park's Central Railroad of New Jersey Terminal on Saturday, August 25, 2001. The meeting will begin at 10:00 a.m.

New Jersey Department of Environmental Protection
Division of Parks and Forestry
PO Box 404
Trenton, NJ 08625-0404

August 2001
Printed on recycled paper.

THE PORT AUTHORITY OF NY & NJ

CHRISTOPHER O. WARD
CHIEF OF PLANNING AND EXTERNAL AFFAIRS

ONE WORLD TRADE CENTER, 67E/34S
NEW YORK, NY 10048

(212) 435-5441/6005
(212) 435-3007/6030 FAX

June 9, 2000

Colonel William Pearce, District Engineer
US Army Corps of Engineers New York District
Jacob K. Javits Federal Building
New York, NY 10278-0090

RE: Hudson-Raritan Estuary Environmental Restoration Study: Comments of Draft Reconnaissance Study: Expression of Intent for Feasibility Phase Participation

Dear Colonel Pearce:

The Port Authority of New York and New Jersey, a bistate agency responsible for the maintenance and enhancement of transportation and commerce facilities within the port district, welcomes the opportunity to comment on the draft "Hudson-Raritan Estuary Environmental Restoration Study – Reconnaissance Phase"; we are pleased to reiterate our interest in participating in the next phase of this effort: "Feasibility Phase."

Overall, the NY District Corps of Engineers and its consultants have prepared an excellent analysis of the broad landscape of the port district for this initial study and have developed an appropriately comprehensive list of potential restoration initiatives. Accordingly, our comments on the Draft Study are minor (see attached).

As you may be aware, the Port Authority has already expressed its willingness to participate in the Feasibility Study (see attached October 26, 1999 letter to Vice President Gore). In addition, by letter dated March 2, 2000 (also attached) the Port Authority forwarded to the New York District a list of proposed restoration projects with which we have a strong interest. The more comprehensive list in the draft Reconnaissance Study (87 projects, all within the port district) is a compelling inventory of restoration needs which is similar in kind and inclusive of the Port Authority project list. We believe the Corps' inventory will reflect the interests of environmental groups, shoreside communities and those who work and carry out recreational activities within our Harbor/Estuary. The Corps' more comprehensive list is congruent with Port Authority interests for the following reasons:

- The quality of harbor sediments and the ability to dredge and dispose of them in economically and environmentally acceptable ways are clearly linked to ambient water quality. Ambient water quality is, in turn, highly dependent upon the various uses of our waterways and the local land uses. Restoration projects explicitly address water quality and the improvement will allow for better sediment quality.

- Long-term planning of the Port Authority's commercial port facilities must consider not only their potential for impact on the environment, but must also allow for natural resource values and public access and use opportunities within the Hudson-Raritan Estuary. The comprehensive list of restoration initiatives provides an appropriate array of projects with which port redevelopment plans can be integrated.

- The Port Authority of New York and New Jersey, as an entity of the states, considers port redevelopment actions within the context of the broader public interest and its overall mandate. In so doing, it acknowledges that the economic vitality of the commercial port and the environmental health of the Hudson-Raritan Estuary are inextricably linked. Both are key components in the development of plans, projects, and facilities which are in the best interests of people that live and work in the Port District.

In light of the foregoing, the Port Authority hereby restates its willingness to participate in the Feasibility Phase of the Hudson-Raritan Estuary Restoration Study through financial support and/or in-kind services. In expressing this intention, the Port Authority hopes to encourage other potential sponsors to participate not only in the technical aspects of the Feasibility Study but the financial aspects as well.

Christopher Zeppie, our Chief of Environmental Policy and Planning will remain the Port Authority's point of contact in this effort. Chris can be reached at 212-435-6153.

Very Truly Yours,

Christopher O. Ward
Chief of Planning & External Affairs

CC: Lillian Borrone, PA of NY & NJ
Richard Gemiello, NJ Maritime Resources
Andrew Genn, NYCEDC
James Gilmore, NYSDEC
Jay Hector, ESDC
Frank Santomauro, NYD Corps of Engineers

STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
1035 PARKWAY AVENUE
P.O. BOX 601
TRENTON, N.J. 08625-0601
609-530-3536

CHRISTINE TODD WHITMAN
GOVERNOR

JAMES WEINSTEIN
COMMISSIONER

PLEASE REPLY TO:
NJ MARITIME RESOURCES
PO BOX 837
TRENTON, NEW JERSEY 08625-0837
TELEPHONE: (609) 984-6694
FACSIMILE: (609) 984-1468

June 19, 2000

Mr. Frank Santomauro, P.E.
Chief, Planning Division
New York District, US Army Corps of Engineers
26 Federal Plaza
New York, NY 10278-0090

Subject: Hudson-Raritan Estuary Reconnaissance Study

Dear Mr. Santomauro:

New Jersey Maritime Resources (NJMR) has reviewed the draft 905(b) Preliminary Analysis and Expedited Reconnaissance Study for environmental restoration in the Hudson-Raritan Estuary and concurs with the findings and recommendations of the study.

NJMR supports proceeding with the Feasibility Study for the project and will coordinate with the New Jersey Department of Environmental Protection and the Port Authority of New York and New Jersey to develop a feasibility cost sharing agreement (FCSA) by December 2000. We understand the non-Federal cost-sharing requirement for the Feasibility Study is 50% (with up to 25% in-kind contributions).

Pending our review of the Feasibility Study, and availability of sufficient funding, NJMR is willing to serve as a non-Federal sponsor in further project development. We understand the non-Federal cost sharing requirements for the remaining portions of the project are:

Preconstruction Engineering and Design: 65% Federal, 35% non-Federal
Construction: 65% Federal, 35% non-Federal
Operations and Maintenance: 100% non-Federal

We look forward to our continued participation in the Hudson-Raritan Estuary Environmental Restoration Study and the goal to restore the estuary.

Sincerely,

Richard Gimello
Executive Director, NJ Maritime Resources

RG/lab

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

20 June 2000

Mr. Frank Santomauro, P.E.
Planning Division Chief
New York District, Corps of Engineers
26 Federal Plaza
New York, New York 10278-0090

Subject: Hudson-Raritan Estuary Reconnaissance Study

Dear Mr. Santomauro

The New Jersey Department of Environmental Protection has reviewed the draft 905(b) Preliminary Analysis and Expedited Reconnaissance Study for environmental restoration in the Hudson – Raritan estuary and we concur with the findings and recommendations of the study.

NJDEP supports proceeding with the Feasibility Study of the project and in conjunction with the NJ Office of Maritime Resources and the Port Authority of New York and New Jersey, we will develop a non-federal cost-share arrangement for funding the Feasibility Study. We understand the non-Federal cost-sharing requirement for the Feasibility Study is 50% (with up to 25% in-kind contributions).

Pending our review of the Feasibility Study, and availability of sufficient funding, NJDEP is willing to serve as a non-Federal sponsor in further project development. We understand the non-Federal cost-sharing requirements for the remaining portions of the project are as follows:

Preconstruction Engineering and Design – 65% Federal, 35% non-Federal
Construction – 65% Federal, 35% non-Federal
Operations and Maintenance - 100% non-Federal

Your coast, your future
NYSCoasts

DEPARTMENT OF STATE

George E. Pataki
Governor
Alexander F. Treadwell
Secretary of State

Division of
Coastal Resources
41 State Street
Albany, NY 12231-0001

June 22, 2000

Mr. Frank Santomauro, P.E.
Chief, Planning Division
New York District, Corps of Engineers
26 Federal Plaza
New York, NY 10278-0090

Dear Mr. Santomauro:

The Department of State has reviewed the 905(b) Hudson-Raritan Estuary Reconnaissance Study and concurs with your findings and recommendations.

We appreciated the opportunity to participate with Corps staff in the preparation of this study. Top priorities for restoration in the 905(b) study coincide with priority recommendations in the NYNJ Harbor Estuary Program. The Department is pleased to see an increased level of interagency coordination for this undertaking.

The Department supports proceeding with the cost-shared feasibility portion of the study. While unable to commit funds as a local co-sponsor at this time, the Department can provide in-kind support and technical assistance through our program activities in New York City and in our efforts for implementing the NYNJ Harbor Estuary Program.

We look forward to participating in the Hudson-Raritan Ecosystem Restoration initiative with the Corps, the co-sponsors and other involved agencies.

Sincerely,

William F. Barton
Assistant Director

Voice: (518) 474-6000 Fax: (518) 473-2464 E-mail coastal@dos.state.ny.us
www.dos.state.ny.us/cstl/cstlwww.html

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

November 18, 2002

Planning Division

Mr. Bradley Campbell
Commissioner
New Jersey Department of Environmental Protection
P.O. Box 402
Trenton, New Jersey 08625-0402

Dear Mr. Campbell:

I am writing to you in response to your enclosed letter dated May 30, 2002 and recent meetings between our staffs on the restoration of Liberty State Park and evaluating the potential for a smaller spin-off project at the site under the Corps' Continuing Authorities Program (CAP).

Based on a very successful public scoping meeting in October and prior technical meetings between our staffs, we both feel, at this time, that a spin-off study would not save time. Under the current Hudson – Raritan Estuary (HRE) Study, Liberty State Park will continue to be evaluated for an environmental restoration. If it is determined that there is a justifiable separable element for construction that meets the criteria of the CAP, then it would be recommended for design and construction in support of the Comprehensive Restoration Implementation Plan (CRIP), which is also currently being developed under the HRE study.

We look forward to working with the State of New Jersey on this site and the restoration of the Hudson – Raritan Estuary. If you have any questions or concerns, please contact me or Mr. Peter R. Blum, P.E., Team Leader, Plan Formulation Branch at (212) 264-9088.

Sincerely,

Enclosure

Eugene Brickman, P.G.
Chief, Plan Formulation Branch

State of New Jersey
Department of Environmental Protection

ınes E. McGreevey
Governor

Bradley M. Campbell
Commissioner

Office of the Assistant Commissioner
Natural & Historic Resources
P.O. Box 404
Trenton, NJ 08625-0404
Tel.: (609) 292-3541
Fax: (609) 984-0836

October 16, 2004

Colonel Richard J. Polo
U.S. Army Corps of Engineers
26 Federal Plaza, Room 2109
New York, NY 10278-0090

Re: Hudson Raritan Estuary – Liberty State Park

Dear Colonel Polo:

The New Jersey Department of Environmental Protection (NJDEP) has reviewed the July 2004 draft of the integrated Feasibility Report/Environmental Impact Statement (FR/EIS) for Liberty State Park, Jersey City. The draft FR/EIS was prepared under the authority of the Hudson-Raritan Estuary study resolution, and proposes wetlands creation and restoration, and grassland and woodland enhancement at Liberty State Park. The project is important to our long-term vision for the park and our joint goal of enhancing the quality of the harbor estuary. We greatly appreciate the time and effort the U.S. Army Corps of Engineers has contributed to the project.

NJDEP concurs with the recommendations contained in the FR/EIS report. Based upon a total estimated cost for this project of $31,678,800, we are pleased to hereby pledge our support and intent to serve as the non-Federal cost-sharing partner in project construction, upon entering into a Project Cooperation Agreement (PCA). As you know from your recent meeting with Commissioner Campbell, Marc Matsil, DEP's Senior Policy Advisor, has been working with your staff to jump-start the design and construction phase through your "Work for Others" program. In accordance with Federal guidelines, NJDEP agrees to be responsible for operations and maintenance of the Liberty State Park project after the fulfillment of the commitments in the PCA. These commitments are consistent with broader initiatives of NJDEP for the area.

We look forward to working with you on this important restoration initiative for the Hudson-Raritan Estuary. Please contact Mr. Frank Gallagher at (609) 439-6527 with any questions that may arise.

Sincerely,

John S. Watson, Jr.
Assistant Commissioner

c. Marc Matsil, NJDEP
Jose Fernandez. Director – DPF
Lynn Fleming, Assistant Director – DPF
Frank Gallagher, Administrator – DPF

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

November 18, 2002

Planning Division

Mr. Bradley Campbell
Commissioner
New Jersey Department of Environmental Protection
P.O. Box 402
Trenton, New Jersey 08625-0402

Dear Mr. Campbell:

I am writing to you in response to your enclosed letter dated May 30, 2002 and recent meetings between our staffs on the restoration of Liberty State Park and evaluating the potential for a smaller spin-off project at the site under the Corps' Continuing Authorities Program (CAP).

Based on a very successful public scoping meeting in October and prior technical meetings between our staffs, we both feel, at this time, that a spin-off study would not save time. Under the current Hudson – Raritan Estuary (HRE) Study, Liberty State Park will continue to be evaluated for an environmental restoration. If it is determined that there is a justifiable separable element for construction that meets the criteria of the CAP, then it would be recommended for design and construction in support of the Comprehensive Restoration Implementation Plan (CRIP), which is also currently being developed under the HRE study.

We look forward to working with the State of New Jersey on this site and the restoration of the Hudson – Raritan Estuary. If you have any questions or concerns, please contact me or Mr. Peter R. Blum, P.E., Team Leader, Plan Formulation Branch at (212) 264-9088.

Sincerely,

Enclosure

Eugene Brickman, P.G.
Chief, Plan Formulation Branch

MEMORANDUM FOR RECORD June 15, 2002
SUBJECT: HRE Pre-application Meeting with NJDEP on Liberty State Park Page 1 of 3

1. On June 12, in Trenton, NJ, an agency coordination meeting was held with the New Jersey Department of Environmental Protection (NJDEP) to discuss potential restoration plans for Liberty State Park (LSP). The purpose of the meeting was to introduce the agency to the HRE program and present some preliminary restoration designs for LSP so the agency could describe its requirements for permits and approvals. Attachment 1 is a copy of the meeting list of attendees. Attachment 2 is the meeting agenda.

2. Bob Will stated that the purpose of the meeting was to present preliminary restoration conceptual designs so that the agency could identify its requirements for permits and approvals, and to discuss potential constraints to specific restoration designs. He said that we needed to fully understand NJDEP's requirements so that we can determine whether a schedule targeting WRDA 2004 funding can be achieved. The urgency of the schedule was described

3. Those present introduced themselves.

4. Joe Redican described the Corps responsibilities for restoration and the 13 priority sites. He described how LSP was selected as a priority sited And defined The Corps guidelines with respect to selecting a site with an aquatic tie, the need for incremental cost effectiveness, and the NEPA and public participation requirements. He asked that the NJDEP help us define what will be required to obtain state permits in a timely fashion.

5. Roselle Henn stated that most of the restoration sites would likely proceed with an EA, but this site would likely require a full EIS given the nature of the soils. She asked that today's serve as both a Pre-application and a Pre-scoping meeting.

6. Frank Gallagher described the history of the park using the power point presentation provided in Attachment 3. He pointed out that the Park's conceptual plan had been developed with stakeholders and that there have already been two public hearings on the overall plan, and that the plan that we brought on restoration was consistent with the conceptual plan.

7. Bob Will and Frank Gallagher noted that there is great political support for the project and confidence that the non-federal partnership funding would be available.

8. John Roebig and the project team described the two designs included in Attachment 4. The potential to use storm water and grey water from the Science Center and possibly storm water from the adjacent treatment plant was mentioned.

9. Suzanne Dietrick pointed out that the STP discharge and any grey water may be more problematic than using storm water. A general discussion, with all

participants ensued. The NJDEP recommended that discussion of the use of gray water be delayed until it had had an opportunity to learn more about the project from the Science Center's pre-application meeting. More information on the STP discharge is also needed.

10. Virginia Kopkash indicated her concern as the stability of high marsh suggesting that we consider *Baccharis* to restrict the *Phragmites* growth. She also expressed concern about expanding goose populations and suggested that we speak with the New Jersey Meadowlands staff and learn from their experience.

11. Joe Redican and Bob Will agreed to the suggesting indicating that such discussions were already taking place because the Meadowlands was including in the priority sites and were significant stakeholders in the HRE program.

12. Ken Petrone indicated that the southern tidal creek entrance presented a serious problem. The material previously placed in this area had significant contamination and, in fact, is the subject of a NJDEP remedial action to control a contaminant plume in ground water. There are four existing bailing wells and pilot scale tests needed for larger wells.

13. The Corps team acknowledged that it is not possible to cut a stream through this type of material without significant environmental impact. It is likely that the second inlet is not environmentally feasible.

14. No significant problems were identified for the single cut alternative.

15. Constraints identified by the NJDEP included: a. the consent order to remediate the dredge spoils area which will require capping the observation berm; b. the need to certify any soil brought into the site; c. The need for a wetlands delineation and LOI so that wetland impacts can be avoided and minimized to the extent practicable; d. the presence of TES and special habitats.

16. A list of permits and approvals that the NJDEP would require is attached as Attachment 5.

17. Ken Petrone indicated that it would be necessary to characterize the material being removed for placement on the observation berm and that it would be necessary to characterize the area exposed.

18. Allan Motter indicated that ecological criteria not residential clean ups standards would be applied to the project. The material representing the surface of the restored area would have to meet the ecological criteria for acceptance. He also noted that, if a criterion is exceeded, the project is not unpermitable, but a site specific evaluation would be advised.

19. Both Motter and Petrone indicated that to the best of their recollection, the dredged material contained minor contaminant levels that were acceptable for disposal on site. They believe that we will not reach native material in the first 10 to 11 feet. Concern would exist when moving the material to prevent windblown dust, etc. NJDEP would review any plans for "uncapping" and moving the fill to another location. There are now wells in the disposal area, as all sampling was done using a Hydropunch.

20. Virginia Kopkash kindly offered to speak with the NJDEP staff responsible for stream encroachment and waterfront development to determine the applicability and extent of each of these regulatory authorities. The issue is complex because of the previous site work and consent agreement.

21. Assistant Commissioner Marc Matsil joined the meeting to express his interest and support. He is particularly interested in pursuing a "break-away" project that can be fast tracked under the Corps' CAP Section 1135 program, He provided copies of a letter to Eugene Brickman from Commissioner Campbell supporting the concept (Attachment 5).

22. John Sacco described a project that would allow construction of the north inlet and a small portion of the tidal creek.

23. Joe Redican indicated that under the Corps regulations, that plan would not be considered a "stand-alone" project that could be funded under the CAP program. He and the team described and discussed the CAP criteria. All participants suggested various alternative projects that might qualify. The Corps will evaluate options and pursue further conversations with Sacco in order to develop an alternative that would be feasible.

24. Virginia Kopkash indicated that the environmental review requirements of Executive Order 215 would be handled by Larry Schmidt's office.

25. Historical and Cultuial issues are exected to be minimal. There have been comprehensive previous studies that will be provided to the team by Frank Gallagher.

26. The Point of Contact for this matter is Joseph Redican, Project Planner at (212) 264-5538.

CENAN-PL-F
Memorandum for Record

25 September 2003

SUBJECT: Liberty State Park PDT meeting

1. The Liberty State Park PDT convened on 25 September 2003 at the Central Railroad New Jersey terminal (CCNJR) at Liberty State Park to discuss the progress of biological and engineering fieldwork. Representatives from New York District (NAN), Baltimore District (NAB), New Jersey Department of Environmental Protection (NJDEP), Fish and Wildlife Services (FWS), and Environmental Restoration Consultants (ERC) came. See Attachment 1 for list of attendees.

2. Members of ERC updated the PDT on the progress of biological fieldwork via a Powerpoint presentation:
   a. John Roebig (ERC/LMS) gave the flora report. Vegetation flagging and wetland delineations were complete. Tasks currently in progress include survey and mapping; systems analysis of ecosystem components (the interaction between wildlife and habitats, and wetlands and hydrology); evaluating ecosystem functions; and assessing the impacts upon wetlands. In a preliminary summary, invasive species and successional vegetation abound throughout the site. For more details, please contact John Roebig.
   b. Jennifer Curran (ERC/LMS) reported on benthic assessment of the North Cove, fish survey, and on the water quality dry weather baseline. The diversity and abundance of species was low in North Cove compared to the rest of the bay, comprising mostly annelid worms. Fish were generally juvenile. To date, water quality has tested for temperature, dissolved oxygen, salinity, and pH. CSO tests remain to be conducted. Kerry Ann Donohue (CENAN) informed the PDT that 3 tide gauges had been installed in North Cove, South Cove, and Morris Canal. Please contact Jennifer Curran for more details.
   c. Roberta Zwier (ERC/URS) presented on wildlife and endangered species in the test area. 50 species of birds were identified in the study area. Regarding harriers, at least 3 individuals have been spotted (male, female, juvenile). Recent observations suggest that the male and female harrier did not successfully mate this year. Please contact Roberta Zwier for more details.
   d. John Roebig summarized the overall progress as follows:
      i. Biological Inventory 75% complete
      ii. Permit Coordination 15% complete
      iii. Ecological Communities Report 10% complete
      iv. Impact Assessment 10% complete
      v. Synthesis 25%
   e. Frank Gallagher (NJDEP) expressed a preference for including more monitoring and sampling of the upland portion of the site. Bob Will (CENAN) responded that Feasibility funds currently permitted for work to be done primarily in the proposed

tidal creek area, and more funds for sampling and monitoring the upland area could be procured during the Plans & Specs phase.

f. The biological survey work (including vegetation maps) will be presented at the next PDT meeting (6 Nov 2003) by LMS.

3. Jack Berezniak (NAB) and Webster Shipley (NAB) reported on the status of Geotechnical and HTRW testing.
   a. The data collection is complete, with 38 drill holes. Within these 38 holes, 12 permanent and 8 temporary piezometers have been installed. They will monitor for groundwater levels and permeability testing. NAB will coordinate with Bethany McClanahan (CENAN) (who will be handling the H&H at Liberty State Park while Kerry Ann Donohue is on leave) about the tide gauges. According to NAB, the fill turned out to be cleaner than expected.
   b. Soil lab testing, HTRW analysis, and ground water characterization remain to be done. Due to recent damage to NAB's lab by Hurricane Isabel (the samples themselves were not affected), the date for analysis completion is unknown. NAB gave a rough guess of sometime between November and January.
   c. Frank Gallagher asked why geotech samples had not also been taken from the surface of each drill hole, as NJDEP's concern is the heavy concentration of metals on the surface level. There is a possibility that there might be some funds for another geotech data collection with a hand augur for surface samples, although this will require consultation with certain CENAN personnel.

4. At Kerry Ann Dohonue's request, John Dromsky-Reed (ERC/URS) reported on the status of surveys.
   a. Topographic surveys are complete. It was noted that the aerial surveys were used mostly for mapping roads. The ground growth was too dense and will probably require additional field work.
   b. The preliminary results of the bathymetric surveys are in. The hydrologic budget is in development, with the hydrodynamic budget to follow.
   c. David Bean (NJDEP) had a question about sedimentation in the North Cove, namely whether the proposed tidal creek would cause sedimentation to occur further up in the wetland instead of the North Cove where it happens now. Kerry Ann Donohue explained that this would be explored through the H&H modeling. However, she continued, it was more important to model for salinity than for sedimentation. Salinity is the bigger concern because it is more of a factor for the sustainability of the proposed tidal creek system. To clarify, the tidal creek and the fresh water/storm water based wetlands would be discrete entities because the fresh water source is inherently unreliable, while there is a better chance of engineering the tidal creek.

5. Bob Will reminded the PDT that a feasibility report for Liberty State Park was slated for FY 2004 (contingent upon funding), and urged members to keep that in mind.

6. Fish and Wildlife Services expressed their standpoint on LSP work to date. Wendy Walsh acknowledged that since Liberty State Park was built on fill, there are no historical benchmarks for the site, so FWS had fewer reservations about the dynamic measures proposed by the PDT. FWS had a couple of comments:
    a. What is the remediation plan? Even if the fill is up to residential standards, some wildlife species are more sensitive than humans to contaminants. John Dromsky-Reed and other members of the PDT responded that there is no plan to treat the soil, as the contaminated surface soil will be excavated and placed in a berm at the southwest corner of the park, to be capped by at least a foot of clean soil. Steps would be taken to prevent run-off during excavation.
    b. The harrier and other endangered species would require more attention and plan detail. A map could be developed of the endangered species habitats so that they could be protected during work.
    c. FWS and the PDT agreed that the most productive use of FWS coordination money would be for FWS to attend PDT meetings and to join ERC in the field to ensure continuous and more efficient feedback, rather than spend it on a planning aid letter. A coordination report would still be produced.

7. Kerry Ann Donohue informed the PDT all project maps should be converted to the newest aerials.

8. The next LSP PDT meeting will be held at the Interpretive Center, Liberty State Park, on Thursday, 6 November 2003.

9. Questions can be directed to Olivia Ng, Project Planner, at 212-264-9088.

Liberty State Park
25 September 2003
Contacts

Name	Organization	Phone	Email
Olivia Ng	CENAN-PL-F	212-264-9088	olivia.ng@usace.army.mil
Bethany McClanahan	CENAN-EN-HH	212-264-9094	bethany.m.mcclanahan@usace.army.mil
Frank Gallagher	NJDEP DPF	609-292-2734	fgallagh@dep.state.nj.us
Jack Berezniak	CENAB-EN-G	410-962-4450	john.n.berezniak@usace.army.mil
Webster Shipley	CENAB-EN-GGE	410-962-4044	webster.e.shipley@usace.army.mil
Bob Will	CENAN-PL-E	212-264-2165	robert.j.will@usace.army.mil
John Staples	USFWS	609-646-9310 x18	john_staples@fws.gov
John Roebig	ERC/LMS	845-735-8300	jroebig@lmseng.com
Roberta Zwier	ERC/URS	973-785-0700	roberta_zwier@urscorp.com
David Bean	NJDEP/ONRR	609-984-0599	david.bean@dep.state.nj.us
Kerry Ann Donohue	CENAN-EN-HH	212-264-9094	kerry.a.donohue@usace.army.mil
Ray Hinkle	ERC/URS	973-812-6886	ray_hinkle@urscorp.com
Wendy Walsh	USFWS	609-383-3988 x48	wendy_walsh@fws.gov
John Dromsky-Reed	ERC/URS	973-785-0700	john_dromsky-reed@urscorp.com
Jennifer Curran	ERC/LMS	845-735-8300	jcurran@lmseng.com

CENAN-PL-F 11 December 2003
Memorandum for Record

SUBJECT: Liberty State Park (LSP) Project Delivery Team (PDT) Meeting

1) Liberty State Park PDT members met at 10 AM on 11 December 2003 at the LSP Interpretive Center to review the available data and discuss how the information affected the conceptual plans. The following were present:

Name	Organization	Phone	Email
Bob Will	USACE	212.264.2165	robert.j.will@usace.army.mil
Bethany McClanahan	USACE	212.264.9074	bethany.m.mcclanahan@usace.army.mil
Daniel Kriesant	USACE	212.264.9117	daniel.j.kriesant@usace.army.mil
Richard Dabal	USACE	212.264.5746	richard.p.dabal@usace.army.mil
Bob Hass	USACE	212.264.0146	robert.a.hass@usace.army.mil
Olivia Cackler	USACE	212.264.9088	olivia.n.cackler@usace.army.mil
Jack Berezniak	USACE	410.962.4450	john.n.berezniak@usace.army.mil
Wendy Walsh	USFWS	609.383.3938 x48	wendy_walsh@fws.gov
David Bean	NJDEP/ONRR	609.984.0599	david.bean@dep.state.nj.us
John Roebig	ERC (LMS)	845.735.8300	jroebig@lmseng.com
Jennifer Curran	ERC (LMS)	845.735.8300	jcurran@lmseng.com
John Dromsky-Reed	ERC (URS)	973.785.0700	john_dromsky-reed@urscorp.com
Roberta Zwier	ERC (URS)	973.785.0700	roberta_zwier@urscorp.com
Ray Hinkle	ERC (URS)	973.812.6886	ray_hinkle@urscorp.com

2) Geotechnical presentation (Jack Berezniak).
   a. Samples were collected from 38 drills holes. The soils were dominated by silty sand and fat clay, which accounted for roughly 90% of the total volume of samples. Geotechnical data indicates that the soils on the site are generally fine-grained and mostly impervious.
   b. The geotechnical characterization of the soil as mostly impervious needs to be reconciled with the high infiltration rates observed at the park.
   c. A synoptic ground water reading was also taken from piezometers on 15 November 2003. At present, the readings suggest that ground water is closest to the surface in the northeast corner of the park by North Cove and lowest in the southwest corner underneath the proposed berm. However, these readings were taken over a period of two hours and need to be adjusted to account for tidal fluctuations.

3) HTRW presentation (Richard Dabal).
Samples were taken from the bottom of the 38 drill samples (28.5 feet below surface) collected for geotechnical analysis. In summary, they were less contaminated than the history of the site would lead us to believe. Samples were screened for metals, pesticides, acid base neutrals, and especially for hexavalent chrome, in response to the Consent Decree. Two criteria were used:

Effects Range-Low (ER-L), which is the concentration of a chemical (in parts per million) in sediment below which toxic effects are rarely observed among sensitive species; and NJDEP Non-Residential Direct Contact Soil Clean-up Criteria (NRDCSCC). Samples were also taken from the midpoint of 12-15 feet and are currently in storage. However, due to the time that has elapsed, these samples can only be tested for the presence of metals.

a. It was clarified by NJDEP that ER-L is a screening measure for presence and does not always accurately reflect danger to species. The true concern is bio-availability.
b. Hot spots: Sample Point 20 (close to the proposed inlet for the tidal creek) and Sample point 37 (close to the proposed berm). Additional testing around point 20, to the depth of proposed excavation, 15 ft, has been proposed.
c. Need for additional collections: The PDT believes more sampling is required at the midpoint depth of 15 ft in the proposed excavation areas, especially the tidal creek in the fenced-off 45 acres.
d. The importance of screening the groundwater for contaminants was discussed, as it could affect the sides of the proposed tidal creek. If the groundwater is clean, it would eliminate the need for a clay liner for the sides of the tidal creek.

4) Topographic & bathymetric surveys (John Dromsky-Reed). Draft survey results are in and are in the process of being finalized. The draft version is complete enough to use as the basis for the Hydraulic and Hydrologic modeling. They are also available in a 3-D version.

5) H&H Modeling presentation (Dan Kriesant). The entrance to the tidal creek has been modeled using HEC-RAS. At present, the recommendation is have a straight eco-channel as wide as possible as the entrance. This design ensures the necessary velocity to get water into the tidal creek and the wideness maximizes area to support species. Concerns about the closeness of the inlet to the boundary conditions were noted and will be addressed. The next step is to model the portion of the creek within the 45-acre area, using RMA. In this second phase of modeling, the first concern is to determine how far the water can go inland, then how much sinuosity will be possible given the sustainable length, and then finding the right design for proper flooding and draining.

6) Water budget (John Roebig). These are four options for the freshwater wetland sources, and their calculated acre-ft run-off, based on annual average precipitation from 1993-2003:

1 = Wetland catchment (no action)	4.07
2 = 1 + Liberty Science Center	32.94
3 = 2 + NJ Transit Property	67.03
4 = 3 + pumps	TBD

Taken on a monthly base, Plan 2 generates the minimum amount of water necessary to sustain a wetland on a year round basis. It should be noted that this water budget only takes surface water into account. Ground water levels were not factored into the budget. The PDT recommended moving the proposed freshwater deep pool to the north and west of its current location in the conceptual plans because this would bring it closer to freshwater sources and protect it from salt-

water intrusion from the tidal creek. Also, the berm could be contoured to direct more fresh water into the site.

7) Wildlife survey (Roberta Zwier, Ray Hinkle). Additional wildlife data has been collected since the last briefing on wildlife surveys was provided in September 2003. Small mammal trapping was completed from October 28-November 1, 2003. White-footed mice were the most frequently captured species and they occurred in all habitat types. Meadow voles were captured in old-field/meadow habitat. One Norway rat and one house mouse were also captured. Northern harriers and Cooper's hawks were seen foraging within the 250 acres during the small mammal surveys. A long-eared owl was observed in Liberty State Park on Tuesday December 9, 2003.

8) Harbor Herons meeting briefing (Roberta Zwier). The Harbor Herons meeting was discussed in terms of how it could fit with the CRIP and LSP. Predators and a loss of suitable nest trees thought to be the primary factors causing herons to abandon established colonies such as Shooter's Island and Pralls Island. As wading birds are a group of species that require alternate habitats across the larger landscape, it is possible that they may find new nesting areas in potential HRE projects. For instance, Liberty State Park could provide nesting areas for wading birds in its upland habitats. The Harbor Herons Subcommittee is in favor of ecosystem restoration projects but expressed some concerns because projects in the Hudson-Raritan Estuary have the potential to attract wading birds to forage in areas that could expose them to contaminants.

9) Effects on Conceptual Plans

a. Moving the deep freshwater pool to the west, as discussed in item 6.
b. Less smaller, fragmented habitats scattered throughout the site and more larger, contiguous habitats.
c. Instead of sinuous entrance to tidal creek, or culverts, there should be a straight, wide eco-channel (Item 5).

10) Still need:

Ground water screening
Incorporation of tidal information
Mid-depth HTRW samples, 15 ft
Schedule Planning Committee Meeting in January

11) Next meeting on **Tuesday, 13 January 2003, at NJDEP Offices in Trenton, NJ, 10 AM.**

12) Comments and questions can be directed to Olivia Ng Cackler, Project Planner, at 212.264.9088.

CENAN-PL-F February 5, 2004

MEMORANDUM FOR RECORD

Subject: Liberty State Park Project Delivery Team Meeting

1. On February 4, 2004, a Liberty State Park planning project team meeting was held at the New Jersey Department of Environmental Protection offices in Trenton, NJ. The purpose of the meeting was to brief representatives of other federal and state agencies on the technical details of the current conceptual plan. Attachment 1 is the list of attendees. Attachment 2 is the meeting agenda.

2. Marc Matsil, NJDEP Political Liaison, opened the meeting by thanking team members for their enthusiastic efforts on Liberty State Park.

3. Topographic Surveys (ERC). The topographic survey results are complete in draft form, Microstation format, and ready to be merged with results of the bathymetric survey.

4. Geotechnical Survey (USACE). Marty Goff presented for Baltimore District members, who were at LSP collecting more data for the project. A draft geotechnical report summarizing data collected in August 2003 is complete and will shortly be available for distribution. An appendix incorporating the results of the current fieldwork will be attached to geotechnical report. The appendix is expected by April 1. In addition to additional geotechnical and HTRW samples, the groundwater monitoring plan has been set up to monitor water levels, salinity, pH, and dissolved oxygen.

5. Preliminary cost estimates for potential "fast-track" alternatives (USACE). Marty Goff presented approximate cost estimates for 3 options if the State of New Jersey was ready to proceed with construction at Liberty State Park before approval of the feasibility study:
   a. Excavate 5ft of fill material within the 45-acre area to begin the tidal creek course, keeping the excavated material within the containment area: $9 million
   b. Construction of bridge (150 ft) and inlet, but not breaching the North Cove: $6 million
   c. Construction of bridge and inlet, breaching into North Cove: $7 million

   (Options B and C include a pedestrian bridge, temporal shifting of the Columbus monument, and assume no dredging).

   Frank Gallagher expressed reservations about option A, as it does not add to habitat and lacks aesthetic value. Additional general concerns were raised about the "fast-track":
   a. Mark Lulka specified the need for Congressional authorization to give NJDEP credit for any project construction work started before a Project Cooperation Agreement is signed.

b. Karen Greene commented on the difficulty of acquiring all the necessary permits for construction to begin this fiscal year, given the length of permitting processes and that much of the information needed for permits is still developed as part of the Corp's feasibility report (draft scheduled for spring).

6. Hydrodynamic Modeling of tidal creek system (USACE). Dan Kriesant presented preliminary results of hydrodynamic modeling of tidal creek, showing the PDT what was required from an engineering standpoint for adequate flushing of the system. At present, it appears that a 150 ft. eco-channel leading into a 150 ft. wide smooth curve of a tidal creek ending in mud-flat is a viable alternative. Although the design is rather symmetrical, natural processes such as erosion and accretion could give the system a more random, asymmetrical appearance, resembling natural tidal marshes in this area. Carl Alderson recommended using existing natural tidal marshes in the area as a reference in designing the tidal creek. He suggested the creek could be narrowed to 25 feet wide and have more sinuousity. He also recommended keeping as much of the tidal marshland to a 2.5 elevation to minimize phragmites. Engineering Branch will incorporate his concerns to the extent possible in its hydrodynamic modeling to find the best approach.

7. Freshwater system: Hydrologic/hydraulic modeling (ERC). John Roebig presented the water budget. John Dromsky-Reed discussed the hydraulic modeling approach being used in the freshwater system analysis (XP-SWMM). Initial volumes were of run-off estimated using the Simple Method, a pollutant loading formula. The preliminary results of the hydrologic budget analysis will be verified using the hydraulic modeling results from the XP-SWMM model, which are currently under quality control review and should be available in a month.

8. Biological surveys (ERC). Members of ERC presented the results on biological surveys conducted in summer and fall of 2003. Please contact John Roebig for more information on vegetation cover mapping and functional assessments, Jennifer Curran on benthic and fish communities, and Roberta Zwier on wildlife surveys (see Attachment 1).

9. General Discussion.
   a. David Bean drew attention to a passage within the draft Environmental Resources Inventory on benthic sampling within the North Cove, in which some samples had a petroleum order. NJDEP asked if additional grab samples could be taken from North Cove to investigate this further.
   b. Ken Petrone needs chemical characterizations of the work area from soil borings and piezometers to satisfy Site Remediation requirements, which include a Site Characterization Report or Remedial Investigation Report, and a Remedial Action Work Plan. Although Liberty State Park is considered an ecosystem restoration project, the Site Remediation Program considers it a brownfield mitigation project according to NJDEP procedures, due to the presence of contaminated material within the site, for permitting purposes. It is believed the feasibility report, in

conjunction with data already collected by NJDEP and other agencies, will provide sufficient information for development of the Remedial Investigation Plan, which can be developed during the Plans & Specifications phase. Any data gaps may be filled during P&S. The Plans & Specifications themselves may satisfy the Remedial Action Work Plan requirement.

10. The next Liberty State Park PDT meeting is scheduled for March 4, 2004, location TBD. Prior to that, there is a technical meeting scheduled for February 26, 2004, at the Liberty State Park Interpretive Center, 10AM.

11. Questions and comments about this MFR can be directed to Olivia Cackler, Project Planner, at 212.264.9088.

Attachment 1

Liberty State Park Project Delivery Team Meeting Attendance
NJDEP, Trenton, NJ

Name	Organization	Email
Frank Gallagher	NJDEP/DPF	fgallagh@dep.state.nj.us
David Bean	NJDEP/ONRR	david.bean@dep.state.nj.us
Robert Will	USACE/PL	robert.j.will@usace.army.mil
Bethany McClanahan	USACE/EN	bethany.m.mcclanahan@usace.army.mil
Kerry Anne Donohue	USACE/EN	kerry.a.donohue@usace.army.mil
Marty Goff	USACE/EN	marty.goff@usace.army.mil
Anton Navarajah	NJDEP/SRP	anton.navarajah@dep.state.nj.us
Ken Petrone	NJDEP/SRP	ken.petrone@dep.state.nj.us
Roberta Zwier	ERC/URS	roberta_zwier@urscorp.com
Daniel Kriesant	USACE/EN	daniel.j.kriesant@usace.army.mil
Olivia Cackler	USACE/PL	olivia.n.cackler@usace.army.mil
Mark Lulka	USACE/PPMD	mark.f.lulka@usace.army.mil
Edward Demarest	NJDEP/SRP	edward.demarest@dep.state.nj.us
Mario Paula	USEPA/R2	paula.mario@epa.gov
Karen Greene	NOAA Fisheries	karen.greene@noaa.gov
Carl Alderson	NOAA Fisheries	carl.alderson@noaa.gov
John Roebig	ERC/LMS	jroebig@lmseng.com
Rajini Ramakrishnan	USEPA/R2	ramakrishnan.rajini@epa.gov
John Dromsky-Reed	ERC/URS	john_dromsky-reed@urscorp.com
Roselle Henn	USACE/PL	roselle.e.henn@usace.army.mil
Jennifer Curran	ERC/LMS	jcurran@lmseng.com

Attachment 2

AGENDA

Liberty State Park Habitat Restoration Project

NJDEP, 501 East State Street, Trenton, NJ

4 February 2004

1000 Opening remarks (NYD, NJDEP)

1005 Topographic survey (URS)

1015 Results of geotechnical survey (Baltimore District)

1050 On-going additional geotechnical sampling (Marty Goff, NYD)

1100 Preliminary construction cost estimates for "fast-track" alternatives (Marty Goff, NYD)

1130 Hydrodynamic modeling of proposed inlet & tidal creek system (Dan Kriesant, NYD)

1200 Break

1300 Update on water budget/ground water modeling (John Roebig, LMS; URS)

1315 Results of biological survey (John Roebig, LMS; Roberta Zwier, URS)

1400 General discussion-----permits, compliances, schedule, additional issues (all)

1425 Set date, time, place & agenda for next team meeting (all)

1430 Adjourn

CENAN-PL-F April 16, 2004

MEMORANDUM FOR RECORD

Subject: Liberty State Park Project Delivery Team Meeting

1. On April 16, 2004, a Liberty State Park planning project team meeting was held at the Interpretive Center at Liberty State Park. The purpose of the meeting was to brief representatives of other federal and state agencies and park advocates on the progress of the Feasibility Report/Environmental Impact Statement and to discuss coordination efforts. Attachment 1 is the list of attendees. Attachment 2 is the meeting agenda.

2. Progress of Feasibility Report (COE, Planning Division). New York District is working to complete a draft of the Integrated Feasibility Report/Environmental Impact Statement by May 1, 2004, for a one-month internal district review. Portions of the preliminary draft will be made available to interested PDT members before the draft feasibility report is forwarded to North Atlantic Division and onward to Corps Headquarters in June.

    a. A Public Meeting for the feasibility report is scheduled for this summer. Tentatively, one is scheduled for early July before Independence Day, with a possible follow up meeting in September if there is high demand. Planning will coordinate with a POC from NJDEP, to be appointed by Frank Gallagher, on the logistics for this meeting.
    b. The Environmental Resource Inventory will be finalized, and copies are to be distributed to interested parties on April 19-20.
    c. Conceptual Plans. PDT members recommended depicting the buffer zone between the restoration areas and the public access zones in the conceptual plan. Frank Gallagher (NJDEP) will supply Olivia Cackler (Planning) with the Arcview file of the buffer zone, and a written description of this buffer zone to include in the feasibility report. Please note that the direct project area acreage has been adjusted from 251 acres to 225 acres to reflect refinement in restoration plans.

3. North Cove. A technical meeting will be set up for the week of May 17th to discuss coordination issues for the feasibility report, notably petroleum hydrocarbons in the North Cove. At present, the draft feasibility report will state that the PDT will continue to coordinate with NJDEP, while a Contingency Soil Management Remediation Plan is being developed, as well an additional sampling plans for the Plans & Specifications Phase. Greg Remaud suggested this would be a good opportunity to resolve other technical issues, such as Threatened and Endangered Species. PDT members will direct their list of issues to be discussed to Olivia Cackler and Frank Gallagher by May 3 so that the interested parties can be contacted.

4. Planning Committee. PDT members should meet with the LSP Planning Committee to discuss the preliminary results of the recommended plan. This meeting can also be an

opportunity for other key interested parties to attend. Planning will coordinate with NJDEP on attending this meeting.

5. Freshwater Plans. The Hydraulics and Hydrology report is complete. If there are any comments from team members, they should be sent to ERC and Corps Engineering Division immediately for consideration. Of the four alternative plans presented, Alternative D was tentatively selected. It includes adding water from the Liberty Science Center (LSC) drainage and NJ Transit Parking lot, enhancing the existing LSC wetland, a biofilter and deep emergent marsh, and an infiltration basin. At present, the proposed connection between water from LSC drainage and the rest of the freshwater wetland system is a pipe. Frank Gallagher suggested that LSC re-landscaping plans for February 2005 could raise certain site elevations to avoid using the pipe. On one hand, an open pipe utilizes photosynthesis, has increased learning value, and is easier to maintain. On the other hand, it is difficult to achieve the correct grades for water flow without the pipe because the site is so flat. The H&H report will be forwarded to interested parties at NJDEP for comments.

6. Coordination

    a. NJDEP Letter of Interpretation on Jurisdictional Wetlands is in process
    b. Threatened and Endangered Species. A Fish and Wildlife representative was not present, coordination will take place through phone and email.

7. Upcoming meetings to be coordinated:
    a. Technical meeting to discuss North Cove and other issues (week of May 17)
    b. Meeting with LSP Planning Committee (Has date already been set?)
    c. Public Meeting (either early or late summer)

8. Next PDT/Interagency Meeting to date to be determined in May.

9. Questions and comments about this MFR can be directed to Olivia Cackler, Project Planner, at 212.264.9088.

Liberty State Park, NJ
Project Delivery Team Meeting
April 16, 2004
Attendance

Name	Organization	Phone	Email
Frank Gallagher	NJDEP – Dept of Parks & Forestry	609.292.2734	fgallagh@dep.state.nj.us
David Risilia	NJDEP – Office of Dredging	609.292.9342	dave.risilia@dep.state.nj.us
Greg Remaud	Baykeeper/LSPC	732.291.0176	greg@nynjbaykeeper.org
Carl Alderson	NOAA	732.872.3087	carl.alderson@noaa.gov
Roselle Henn	USACE - Planning	212.264.2119	roselle.e.henn@usace.army.mil
Robert Will	USACE - Planning	212.264.1265	robert.j.will@usace.army.mil
Marty Goff	USACE - Engineering	212.264.9074	marty.goff@usace.army.mil
Richard Dabal	USACE - Planning	212.264.5746	richard.p.dabal@usace.army.mil
Adam Perelson	USACE - Planning	212.264.5119	adam.d.perelson@usace.army.mil
Olivia Ng Cackler	USACE - Planning	212.264.9088	olivia.n.cackler@usace.army.mil
Alicia Fox	USACE - Engineering	212.264.9074	alicia.a.fox@usace.army.mil
John Roebig	ERC - LMS	845.735.8300	jroebig@lmseng.com
Jennifer Curran	ERC - LMS	845.735.8300	jcurran@lmseng.com

Attachment 2

Liberty State Park
Project Delivery Team Meeting
April 16, 2004, 10 AM
Liberty State Park Interpretive Center
Agenda

I. Progress of Feasibility Report (Corps of Engineers, Planning Division)
   a. Completed Portions
   b. Summary of conceptual plan
   c. Status of ERI (ERC)
   d. Schedule
   e. ID potential issues requiring coordination/assistance

II. Freshwater Plans (ERC)
   a. Including information from Cornell Ornithology wetlands
   b. Comments on H&H report?

III. Coordination with NJDEP
   a. North Cove
   b. Other HTRW?
   c. LOI on Freshwater Wetlands

IV. Threatened and Endangered Species (Corps of Engineers, F&W)
   a. Coordination on species listed

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix B

Environmental Compliance and Coordination

US Army Corps
of Engineers ®
New York District

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

Liberty State Park
Environmental Resources Inventory

April 2004

TABLE OF CONTENTS

List of Tables iii

List of Figures v

List of Appendices vi

List of Acronyms vii

Executive Summary and Conclusions: viii

1. INTRODUCTION 1

1.1 Overview of The HRE 1

1.2 Project Objectives 2

1.3 Liberty State Park 2

1.4 Proposed Restoration Project Description 5

1.5 The Environmental Resources Inventory 5

2. TERRESTRIAL AND PALUSTRINE VEGETATION COMMUNITITES 8

2.1 Community Composition 8

2.2 Regulated Wetland Communities 26

3. WILDLIFE 40

3.1 Amphibians and Reptiles 40

3.2 Birds 41

3.3 Mammals 57

3.4 Summary 59

4. ENDANGERED AND THREATENED SPECIES 61

4.1 Endangered and Threatened Vegetation 61

4.2 Endangered and Threatened Wildlife 61

4.3 Summary 72

5. NORTH COVE AQUATIC COMMUNITIES 73

5.1 Water Quality 73

5.2 Benthic Invertebrates 73

5.3 Vertebrates 81

6. FUNCTIONAL ASSESSMENT OF ECOLOGICAL COMMUNITIES 88

6.1 Proposed Restoration Plan 88

6.2 Methodology 93

6.3 Evaluation Results 106

6.4 Summary 119

7. REFERENCES 121

LIST OF TABLES

Table 2-1. Dominant vegetation in the vegetation communities at Liberty State Park, Jersey City, NJ. 12

Table 2-2. Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ 31

Table 3-1. Birds observed during the August 2003 wildlife surveys at Liberty State Park, Jersey City, NJ 45

Table 3-2. Birds observed utilizing habitats in Liberty State Park, Jersey City, NJ 47

Table 3-3. Habitat requirements of birds observed in Liberty State Park during August 2003 ERC surveys 48

Table 3-4. Mammals observed at Liberty State Park during August 2003 wildlife surveys and October 2003 small mammal trapping survey 60

Table 4-1. Status, habitat requirements, and records of sightings for New Jersey State-listed threatened and endangered species observed within the LSP Restoration site, Jersey City, NJ 62

Table 4-2. Summary of observations of ETS birds during the August 2003 ETS surveys at Liberty State Park, Jersey City, NJ 70

Table 5-1. Summary data for benthic grab samples at the North Cove of Liberty State Park, Jersey City, NJ 77

Table 5-2. Description of siene and trap net sampling effort during August and September 2003 at the North Cove of Liberty State Park, Jersey City, NJ 83

Table 5-3. Total length (mm) of fish collected during August and September 2002 surveys at Liberty State Park, Jersey City, NJ 85

Table 6-1. Ecological functions evaluated for vegetation communities in the Liberty State Park restoration site, Jersey City, NJ 95

Table 6-2. Brooks and Croonquist (1990) biological characteristics and rank designations, and the number of evaluated wildlife species that fall under the ranks 105

Table 6-3. Example of wildlife functional analysis for Maritime Shrubland communities at Liberty State Park, Jersey City, NJ 107

Table 6-4. Functional assessment scores for existing and proposed conditions for the Liberty State Park Restoration site, Jersey City, NJ 110

LIST OF FIGURES

Figure 1-1. Location of Liberty State Park Restoration site, Jersey City, NJ 4

Figure 1-2. Liberty State Park Restoration site 6

Figure 2-1. Liberty State Park vegetation communities mapped in 1996 by MacFarlane (2001) 9

Figure 2-2. Locations of transects set for 2003 Liberty State Park community mapping effort 11

Figure 2-3. Existing Liberty State Park vegetation communities 15

Figure 2-4. Invasive species map, Liberty State Park, Jersey City, NJ 25

Figure 2-5. Regulated wetlands in Liberty State Park, Jersey City, NJ 30

Figure 3-1. Liberty State Park wildlife observation stations 42

Figure 4-1. Liberty State Park northern harrier observation stations 69

Figure 5-1. Sampling stations in the North Cove of Liberty State Park, Jersey City, NJ 74

Figure 6-1. Maximum habitat plan for the Liberty State Park Restoration site 89

Figure 6-2. Cumulative functional values of existing conditions and the proposed habitat restoration plan at Liberty State Park, Jersey City, NJ 109

LIST OF APPENDICES

Appendix A. Inventory of plant, benthos, fish and wildlife species observed at Liberty State Park, Jersey City, NJ

Appendix B. Wetland delineation data sheets for Liberty State Park, Jersey City, NJ

Appendix C. Water quality survey data from Liberty State Park, Jersey City, NJ

Appendix D. North Cove benthic assessment, Liberty State Park, Jersey City, NJ

Appendix E. Modified Highway Methodology functional assessment consideration and qualifiers and evaluation sheets for Liberty State Park, Jersey City, NJ

Appendix F. Wildlife Functional Assessment Matrix for Liberty State Park, Jersey City, NJ

Appendix G. Biobenchmarking report for Liberty State Park, Jersey City, NJ

Appendix H. Correspondence with U.S. Fish and Wildlife Service, and New Jersey Department of Environmental Protection Endangered Species Program regarding endangered and threatened species in Liberty State Park, Jersey City, NJ

LIST OF ACRONYMS

CRIP	Comprehensive Restoration Implementation Plan
CRM	Common Reed/Mugwort
CRRNJ	Central Railroad of New Jersey Terminal
CRW	Common Reed-dominated Wetlands
DEM	Deep Emergent Marsh
ERC	Ecosystem Restoration Consultants
FFW	Floodplain Forest Wetland
HRE	Hudson-Raritan Estuary Environmental Restoration study
IC	Interpretive Center
LOI	Letter of Interpretation
LSC	Liberty Science Center
LSP	Liberty State Park
MF	Maritime Forest
MG	Maritime Grassland
MHW	Mean High Water
ML	Mowed Lawn
MLW	Mean Low Water
MS	Maritime Shrubland
NAVD	North American Vertical Datum
NJDEP	New Jersey Department of Environmental Protection
NJDPF	New Jersey Division of Parks and Forestry
NY/NJ Harbor	New York and New Jersey Harbor
PANYNJ	Port Authority of New York/New Jersey
RCRA	Resource Conservation and Recovery Act
ROAD	Unpaved/Paved Road
SEM	Shallow Emergent Marsh
SNH	Successional Northern Hardwood
SOF	Successional Old Field
SSB	Successional Shrubland
SSW	Shrub Swamp Wetland
TI	Texas Instruments, Inc.
USACE	United States Army Corps of Engineers
WET	Wetland Evaluation Technique
WRDA	Water Resources Development Act

EXECUTIVE SUMMARY AND CONCLUSIONS:

1. The Hudson-Raritan Estuary Environmental Restoration Study (HRE) was authorized by the U.S. House of Representatives Committee on Transportation and Infrastructure, and was designed to investigate the feasibility of environmental restoration opportunities that relate to water resources and sediment quality within the port district of New York and New Jersey. The HRE has two elements that are currently underway: the development of a Comprehensive Restoration Implementation Plan (CRIP) and the implementation of restoration opportunities where there is existing public support and potential for a cost share sponsor.

2. Liberty State Park (LSP), in Jersey City, New Jersey is one of the first restoration opportunities undertaken by the HRE. The NY District of the U.S. Army Corps of Engineers (USACE) is currently conducting an integrated Environmental Impact Assessment and Feasibility Study for the implementation of a habitat restoration project within the park.

3. Liberty State Park consists of 1,122 acres on the western bank of Upper New York Bay. The site offers waterfront views of the Manhattan skyline, the Statue of Liberty and Ellis Island. The park was once an intertidal mud flat and salt marsh that was filled and used as a railroad yard. The soils consist of historic fill materials that were deposited to stabilize the surface between 1860 and 1919 (MacFarlane 2001). These historic fill materials (e.g. debris from construction projects and refuse from New York City) overlie native marine clay. Between 1864 and 1967 the Central Railroad of New Jersey Terminal (CRRNJ) used the site as a rail yard for both freight and passenger service. In 1967 CRRNJ discontinued operations at the site, and the land was abandoned until it was acquired by the New Jersey Division of Parks and Forestry (NJDPF) (LSP 2003). LSP opened on July 4, 1976 (LSP 2003). NJDPF has improved the degraded site substantially since the acquisition by creating recreational and educational features in the park. The 215-acre area in the center of the park has remained undeveloped and is currently inaccessible to the public due to the presence of hydrocarbons, pesticides and metals that exceed New Jersey Department of Environmental Protection (NJDEP) clean up criteria (MacFarlane 2001).

4. Existing information from recent ecological surveys and the results of a 2003 sampling program were used to develop an Environmental Resources Inventory for LSP. This inventory provides a baseline on the plant and animal communities that can be used for environmental impact prediction for proposed habitat restoration activities, and for the design of post-implementation monitoring to evaluate the level of restoration attained.

5. Because of the presence of contaminants at levels that exceed limits established for New Jersey under the Resource Conservation and Recovery Act (RCRA), the NJDEP has entered into a Consent Decree that stipulates how these contaminated soils must be handled to prevent exposure to the public. These measures, such as capping and fencing any development or restoration that poses the opportunity for public exposure, must take place in such a manner that is consistent with the requirements of the Consent Decree.

6. The man-induced disturbances (primarily filling) which created the current landscape of the undeveloped portion of LSP are the dominant factors shaping the existing plant and animal communities and will be major factors in future ecological conditions with or without the proposed restoration. The existing plant communities can be expected to change over time with a corresponding change in animal communities. The rate of succession in plant communities will depend primarily on the timing of former disturbances among various areas of the site and the limiting factors associated with the substrates (nutrients and physical characteristics) and hydrology (water table) created by the filling. Intervention by man to correct adverse impacts associated with previous disturbances has the potential to direct future changes in an ecologically positive direction, and to accelerate the rate of positive change in existing plant and animal communities.

7. USACE has proposed a major ecological restoration effort for degraded habitats within Liberty State Park. There are four main restoration elements proposed for the LSP restoration site, including: (1) the restoration/creation of a 42-acre salt marsh within a dredged material storage area, along with a tidal connection; (2) the creation of a deep water emergent marsh system including treatment wetlands; (3) the enhancement of a complex of existing shallow water wetlands, and (4) the creation a berm grassland system for wildlife habitat in the southwestern portion of the site.

8. The recent ecological investigations by LSP staff and the current study confirms the ecological influences of former disturbances and documents changes in the plant and animal communities since 1996, when a major survey was conducted. Many vegetative communities are now dominated by invasive species and the animal population reflects the disturbed nature of available habitats and the isolation of the site from natural habitats which could serve as a source of species recruitment. Birds are well represented which reflects their ability to disperse across areas of unsuitable habitat, while amphibians, reptiles and mammals are poorly represented, presumably because there are no major corridors of natural habitat which could provide access for species with limited powers of dispersal.

9. The occurrence of threatened and endangered species on the site, particularly the northern harrier (*Circus cyaneus*), provides not only a focus for ecological management, but also a potentially limiting factor for diversifying the habitat on the site. The specialized habitat needs for foraging and breeding, and the large spatial requirements of the northern harrier relative to the size of the site, could be an impediment to comprehensive site restoration. Sensitive design and construction techniques should permit continued use of the site by the northern harrier.

10. The aquatic habitat in the North Cove contains typical invertebrate and fish assemblages found in adjacent harbor waters, with relatively low abundance and diversity. Invertebrate species known to be tolerant of polluted conditions occur in relatively high abundance in the cove. The aquatic life in North Cove would be expected to make use of a new wetland with a connection through the cove, and fish in the cove and nearby waters would benefit from the production of invertebrates and juvenile fish as a source of food.

11. A functional analysis of the existing habitats and habitats resulting from the proposed restoration plan was conducted to evaluate potential changes in ecosystem functional values throughout the site. A modified Federal Highway Administration methodology was used in order to tailor the analysis to the unique features of the site and the availability of recent site specific data. The analysis found a substantial increase in functional values with the restoration plan and an increase in cumulative functional values across all community types. This evaluation suggests that ecological value could be added to the site, both with new community types (tidal wetland complex and deep emergent marsh) and enhancement of functional values associated with existing communities.

12. A biobenchmarking study and tidal data analysis were used to establish optimum elevations for the vegetative communities proposed for the new tidal wetland. Existing, nearby, representative stands of key species were located and surveyed to provide discrete, species-specific elevations for this area of the estuary.

1. INTRODUCTION

The U.S. Army Corps of Engineers' (USACE) planning process for the Hudson-Raritan Estuary Environmental Restoration Study (HRE) was authorized under the Water Resources Development Act of 2000 (WRDA 2000) Section 905 (b) Preliminary Analysis and advanced with the "Needs and Opportunities Report". These studies identified potential restoration sites for which there is existing public support and the potential for a cost share sponsor.

With the New Jersey Department of Environmental Protection (NJDEP) as a cost share sponsor and immense public support for the project, Liberty State Park (LSP), in Jersey City, New Jersey is one of the first sites identified by the Needs and Opportunities Report for which an ecosystem restoration is planned. Under the HRE, USACE New York District (the District), along with its co-sponsor the Port Authority of New York and New Jersey (PANYNJ), is conducting an integrated Feasibility Study and Environmental Impact Statement for the restoration of a 225-acre portion of LSP (the LSP Restoration site). The restoration will include creation of a new tidal wetland habitat with a hydraulic connection to Upper New York Bay via the North Cove of LSP, enhancements to existing freshwater wetlands, enhancements to existing upland communities, and a managed public access program.

This Environmental Resources Inventory has been prepared under contract DACW51-01-D-0014, for the Implementation of Environmental Sampling for the Liberty State Park Draft Feasibility Report delivery order. The inventory includes a report of existing information, an Ecological Communities Report, and a discussion of the ecological communities functional assessment based on a survey conducted within the LSP Restoration site. This document is intended to be an appendix to the integrated Feasibility Report and Environmental Impact Statement (FR/EIS) being prepared by the District to support the restoration planned at LSP.

1.1 OVERVIEW OF THE HRE

The HRE is being carried out by the United States Army Corps of Engineers New York District under the General Investigations program, with the Port Authority of New York and New Jersey as a non-Federal study sponsor. The study was authorized by the Congress, and was designed to investigate the feasibility of environmental restoration opportunities that relate to water resources and sediment quality within the port district of New York and New Jersey. The two elements of the HRE that are currently underway

are: 1. the development of a Comprehensive Restoration Implementation Plan (CRIP); and 2. the implementation of restoration opportunities where there is existing public support and potential for a cost share sponsor.

The CRIP will be used as a framework to coordinate the restoration of degraded sites within the port district on a watershed basis. It will provide a set of goals and objectives to maximize the contribution of ecological value of HRE and non-HRE restoration initiatives covering the entire HRE project area. Technical guidance for implementing and maximizing ecological benefit will be provided in the CRIP. Environmental issues that exceed local and regional boundaries, such as water and sediment quality, will be addressed by the CRIP on a watershed-wide basis. The plan will be designed to ensure that the implementation of large and small environmental restorations within the port district will contribute to the accomplishment of the overall goals of improving sediment and water quality, and the restoration and creation of wetland, upland and shallow water habitat.

1.2 PROJECT OBJECTIVES

The Environmental Resources Inventory (ERI) was designed to result in a comprehensive description of the existing biological conditions within the LSP Restoration site, and to assess the change in ecosystem functions provided by the existing ecological communities that may result from the project. This effort included compiling existing biological information, and filling data gaps with biological sampling. The functions served by the regulated wetland communities were assessed for existing conditions and for proposed restoration conditions. Results of the investigations are presented in this ERI report. This document is intended to set the stage for the Liberty State Park FR/EIS by providing background and baseline information for the future impact assessment. Information in the report will also assist in the development of a post-implementation monitoring plan for the restoration effort.

1.3 LIBERTY STATE PARK

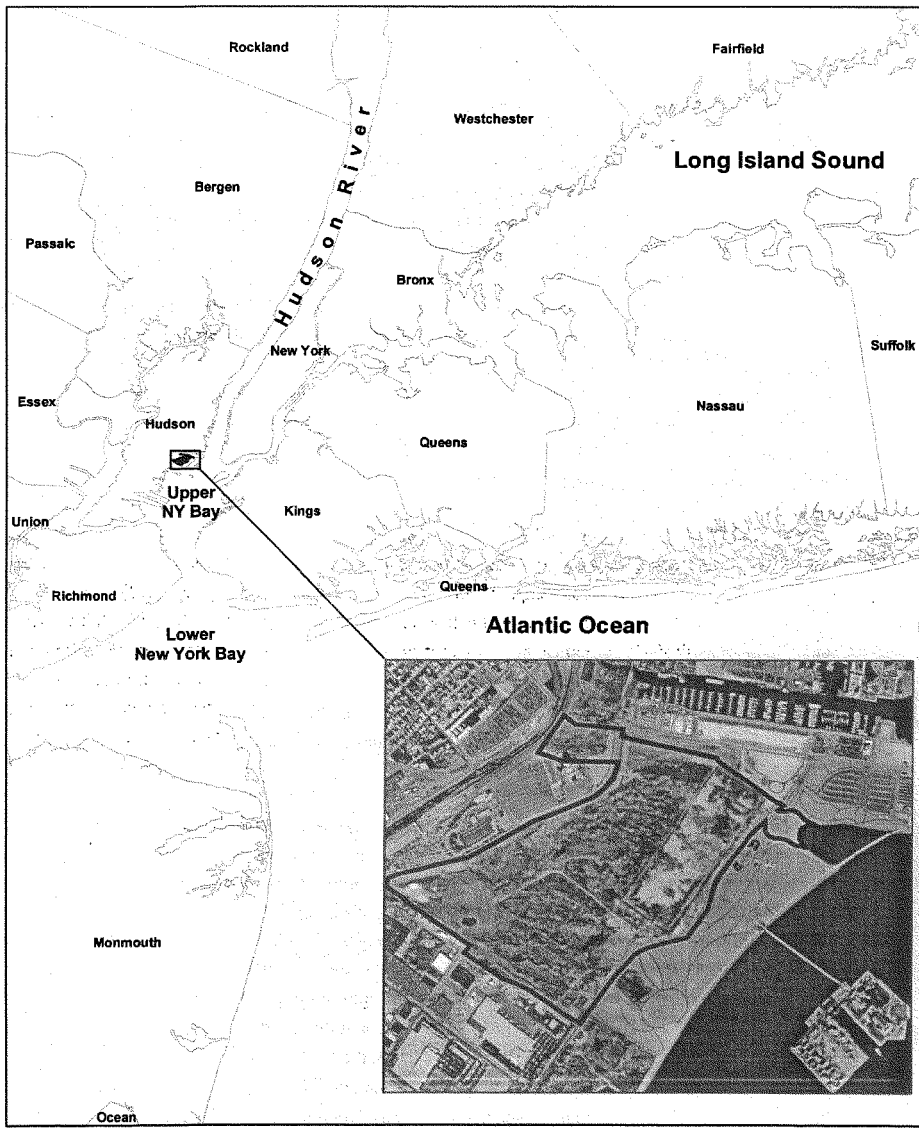
Liberty State Park is located on a 1,122-acre site on the west bank of Upper New York Bay (Figure 1-1). The site offers waterfront views of the Manhattan skyline, the Statue of Liberty and Ellis Island. Historically, the park was an intertidal mud flat and salt marsh that was filled and used as a railroad yard. The soils consist of historic fill materials that overlie the native marine clay. The materials, which consist primarily of

debris from construction projects and refuse from New York City, were deposited to stabilize the surface between 1860 and 1919 (MacFarlane 2001). Between 1864 and 1967 the Central Railroad of New Jersey (CRRNJ) used the site as a rail yard for both freight and passenger service. In 1967 CRRNJ discontinued operations at the site, and over the next few years the land was abandoned until it was acquired by the New Jersey Division of Parks and Forestry (NJDPF) (LSP 2003).

LSP opened on July 4, 1976 (LSP 2003). NJDPF has improved the degraded site substantially since the acquisition by creating recreational and educational features in the park. Park features include an 88-acre Green Park, four miles of paved walkways, the historic Central Railroad of New Jersey Terminal building, an Interpretive Center, Liberty Landing Marina, the Liberty Science Center, Caven Point Pier, and ferry service to the Statue of Liberty and Ellis Island. It is estimated that 4.3 million people visit the park annually (MacFarlane 2001).

In addition to the recreational and educational features, much of the park consists of undeveloped, vegetated and open water areas. Extensive subtidal and intertidal areas (523 acres) occur within the park boundary, including a 36-acre cord grass (*Spartina* sp.) dominated tidal wetland located behind the Interpretive Center, and the North Cove, a shallow open water cove located south of the railroad terminal building. In the center of the park is a 212-acre undeveloped area containing upland and freshwater wetland environments, which is currently inaccessible to the public, due to contaminated sediments containing levels of hydrocarbons, pesticides and metals that exceed the NJDEP clean up criteria (MacFarlane 2001).

Within the LSP Restoration site is a 42-acre dredged material storage area that is surrounded by associated containment structures (also referred to as "the impoundment"). The impoundment consisted of a series of 8-foot high earthen berms constructed from existing fill materials excavated on-site. In 1981, during the construction of the southern section of the seawall of the LSP causeway, approximately 93,000 cubic yards of dredged materials were placed in the impoundment. During the spring of 1987, an additional 255,000 cubic yards of dredged materials were placed into the impoundment, with this material obtained from an area between the South Cove and the Middle Cove during the completion of the Liberty Walk seawall project. In 1993, the NJDEP hired a contractor to excavate and regrade the berms surrounding the impoundment over the dredge spoil to form a cap over the material, and vegetative cover was subsequently established (From draft report, AMEC 2002).



US Army Corps of Engineers®
New York District

Map Source: ESRI
Aerial Photo Source: USACE

THE PORT AUTHORITY OF NY & NJ

Location of
Liberty State Park
Restoration Site
Jersey City, NJ

Figure 1-1

1.4 PROPOSED RESTORATION PROJECT DESCRIPTION

The environmental restoration effort planned for Liberty State Park includes the creation of a tidal marsh in the center of the park, and enhancements to the uplands and freshwater wetlands within the undeveloped area. Materials will be excavated from the future marsh area, capped and used to create a grassland berm in the southwestern section of the park. A narrow channel will connect the tidal marsh to the North Cove. Storm water will be collected from adjacent areas and will be diverted to feed freshwater wetlands on the site, creating shallow and deep emergent marshes. Nuisance plant species will be controlled, and native grasslands, shrublands and forests will be planted.

For this study, the LSP Restoration site (Figure 1-2) is defined as:

1. The 212-acre undeveloped parcel in the center of the park, bounded by Millennium Park to the north, Freedom Way to the east, Thomas McGovern Drive to the south and Phillips Street to the west. This area includes a soil stockpile area, a dredged material storage area, a forest/wetland complex, and a successional shrubland/forest complex.
2. A 4-acre portion of the Green Park between the undeveloped parcel and the North Cove, which is the proposed location for the tidal inlet and channel.
3. The 9-acre wetland and forested area located north of the Liberty Science Center, and generally bounded by Audrey Zapp Drive to the north, Phillips Street to the east, Liberty Science Center to the south, and Wilson Street to the west.

1.5 THE ENVIRONMENTAL RESOURCES INVENTORY

A comprehensive inventory of the existing environmental resources on the LSP Restoration site is necessary to evaluate potential impacts to these resources that may result from restoration efforts. A pre-restoration activity inventory with reproducible survey methodologies is also required to establish a baseline for the future monitoring program. This document presents the results of environmental investigations performed at Liberty State Park in 2003. The results of these surveys establish the existing conditions of the LSP Restoration site, and the protocols utilized can be replicated during the monitoring program.

US Army Corps of Engineers
New York District

Map Source: LMS
Aerial Photo Source: USACE

THE PORT AUTHORITY OF NY & NJ

Liberty State Park Restoration Site

Figure 1-2

The following sections describe the existing conditions of the environmental resources on the proposed LSP Restoration project site:

Section 2.	Terrestrial and Wetland Vegetation Communities
Section 3.	Wildlife
Section 4.	Endangered and Threatened Species
Section 5.	North Cove Aquatic Communities

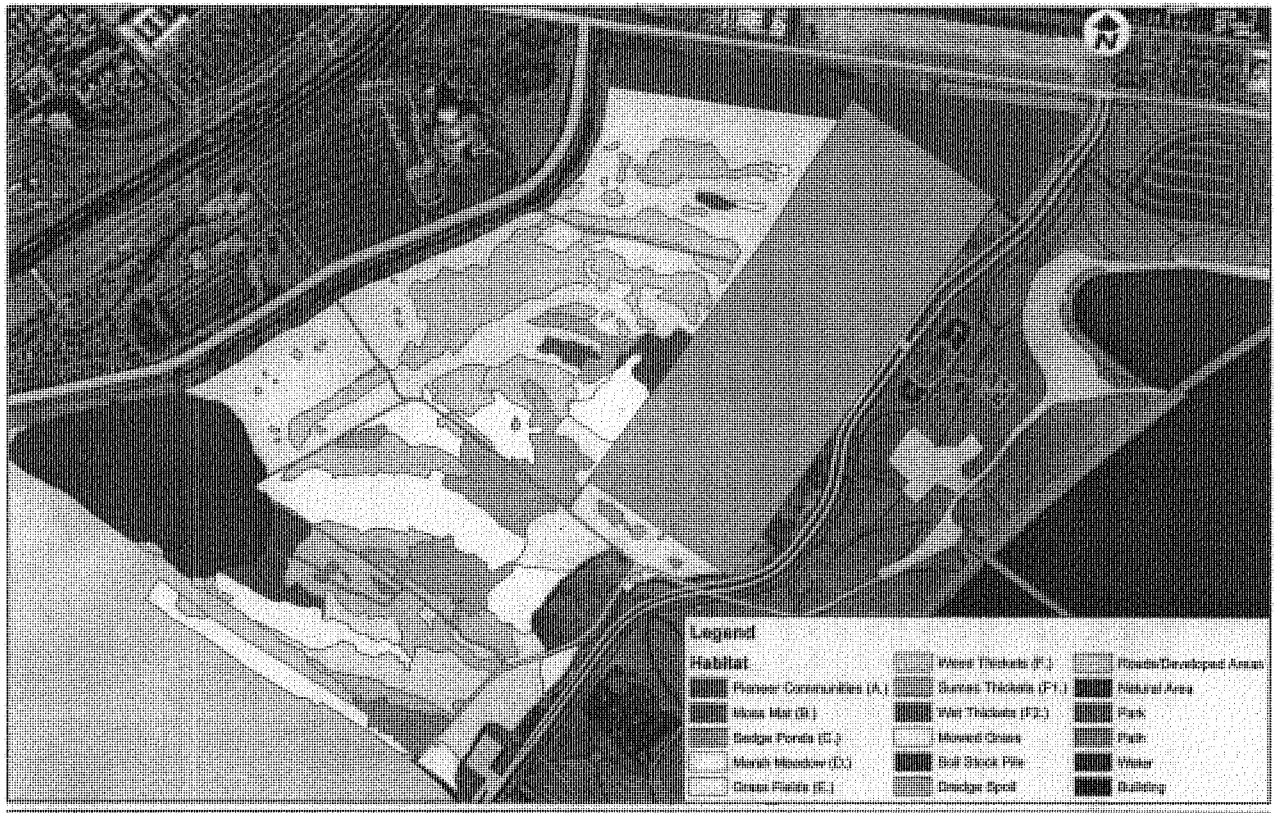
2. TERRESTRIAL AND PALUSTRINE VEGETATION COMMUNITITES

The vegetation communities within the LSP Restoration site were identified and categorized based on the descriptions and associations provided in *Ecological Communities of New York State* (Edinger *et al.* 2002). The community descriptions were slightly modified from Edinger *et al.* (2002) to more accurately characterize the disturbed and urban conditions found within the LSP Restoration site. Because of their special significance and regulation by USACE and NJDEP, wetland communities are discussed both here and in Section 2.2 Regulated Wetland Communities.

The LSP Restoration site is covered by vegetation communities that reflect decades of human alteration. The substrate is composed of fill material that was deposited on the site during the 19th and 20th centuries, when the site functioned as a rail yard. When the rail yard was closed in 1967, no site restoration was performed. Through natural succession and in response to an assortment of differing physical and chemical conditions, a variety of habitats have developed over a period of 36 years. Past construction has created compacted depressions with poor drainage, allowing for the formation of small isolated wetlands. Variability in substrate materials has created patchy distribution of soils and cinders, which has controlled the colonization of the substrate by plants. Vegetation grows sparsely in areas with cinder substrate, while trees and shrubs grow in dense stands over soil substrates. As a result, vegetation communities have developed on the fill material at different rates due to the varying soil and hydrologic conditions, and the timing of fill placement. This created a mosaic of community types within the LSP Restoration site. The community types present range from bare soil or lichens on coal ash to pioneer tree communities growing on soil deposits. Thus, the site displays variable stages of successional colonization, and provides habitat for a variety of terrestrial animal species.

2.1 COMMUNITY COMPOSITION

A natural resources inventory and vegetation community mapping were conducted in 1996, depicted in Figure 2-1 (MacFarlane 2001). This survey documented that the vegetation within the LSP Restoration site was in early successional stages at that time. An analysis of the communities present in 2003 was performed and is described in this section.



US Army Corps of Engineers®
New York District

Map Source: MacFarlane (2001)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Liberty State Park
Vegetation Communities
Maped in 1996 by MacFarlane (2001)

Figure 2-1

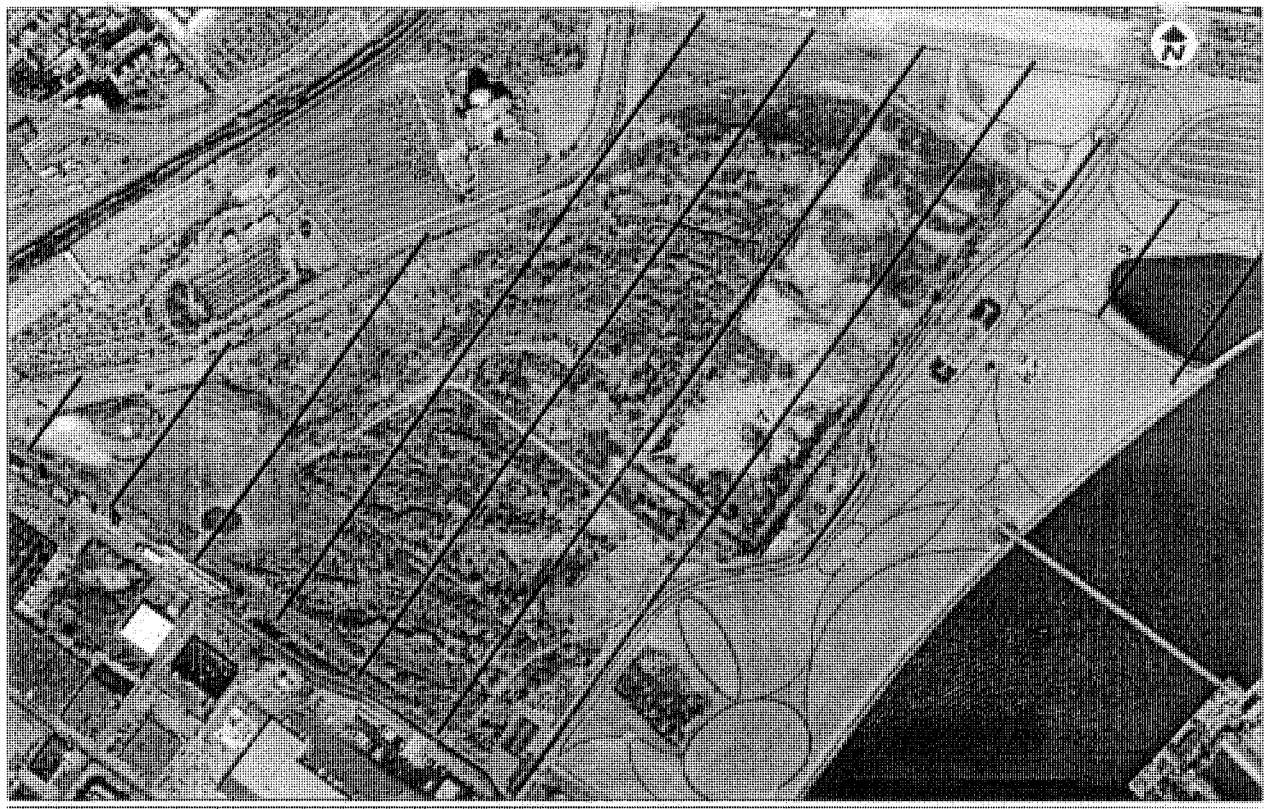
2.1.1 Methodology

The vegetation sampling program was conducted within the LSP Restoration site between 3 August 2003 and 21 August 2003 to determine the composition and coverage of plant communities. Previous vegetation surveys, wetland maps, and aerial photographs were used to plan the field effort.

Ten transects set 500 feet apart were established parallel to the shoreline in a north-south direction in an effort to intersect the maximum number of vegetative communities (Figure 2-2). A field crew walked the transects, noting distinct changes in vegetation composition, and noting the presence or absence of plant species that had been previously observed within the LSP Restoration site by MacFarlane (2001). At each transect segment where there was a vegetation community change, field crews attached colored flagging with notations at transect entry and exit points. Additional flagging was used to delineate the perimeter boundary of each community encountered along a transect. Field crews also traversed the area between each transect in an effort to insure that smaller communities between the transects were flagged in the same manner. The locations of the flags were later determined by GPS surveying methods to delineate the current vegetation community types within the LSP Restoration site.

2.1.2 Community Descriptions

Twelve vegetation community types were identified within the LSP Restoration site, consisting of eight terrestrial community types and four wetland community types. Four of the communities identified are characterized as "cultural communities" that are the result of substantial human alteration. This is the result of the site's extensive substrate alterations and land use patterns. Although largely altered by human activity and colonized by non-native invasive plant species, the site supports a minimum of 184 plant species of 125 genera and provides suitable habitat for a variety of wildlife species (Appendix A). Each vegetation community type and its dominant vegetation is described below, dominant species are presented in Table 2-1, and its aerial extent within the LSP Restoration site is shown in Figure 2-3.



US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Locations of Transects Set for 2003 Community Mapping Effort

Figure 2-2

Table 2-1. Dominant vegetation by community type within the Liberty State Park Restoration site, Jersey City, NJ.

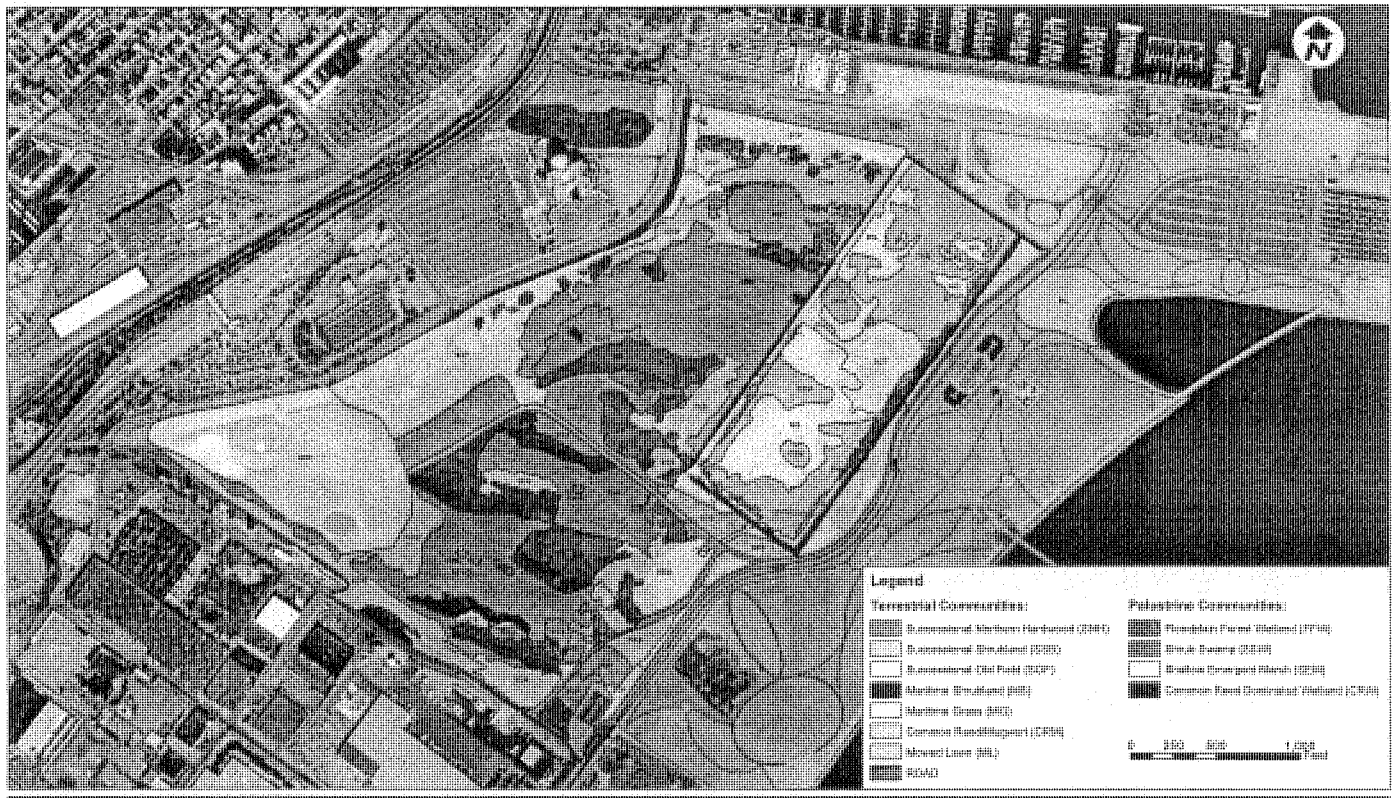
Community Type	Common Name	Scientific Name
ERRESTRIAL COMMUNITIES		
Successional Northern Hardwood		
	quaking aspen	*Populus tremuloidies*
	eastern cottonwood	*Populus deltoides*
	gray birch	*Betula populifolia*
	winged sumac	*Rhus copallina*
	steeplebush	*Spiraea tomentosa*
Successional Shrubland		
	cut-leaved blackberry	*Rubus laciniata*
	smooth sumac	*Rhua glabra*
	northern bayberry	*Myrica pensylvanica*
	Canada goldenrod	*Solidago canadensis*
	common reed	*Phragmites australis*
	Japanese knotweed	*Polygonum cuspidatum*
Successional Old Field		
	Chee reed grass	*calamagrostis epigeios*
	common mullein	*Verbascum thapsus*
	spotted knapweed	*Centauria maculosa*
	butter and eggs	*Linaria vulgaris*
	Canada goldenrod	*Solidago canadensis*
	staghorn sumac	*Rhus typhina*
	quaking aspen	*Populus tremuloidies*
	eastern cottonwood	*Populus deltoides*
Maritime Shrubland		
	winged sumac	*Rhus copallina*
	smooth sumac	*Rhus glabra*
	staghorn sumac	*Rhus typhina*
	Canada goldenrod	*Solidago canadensis*
	common reed	*Phragmites australis*
	mugwort	*Artemisia vulgaris*
	gray birch	*Betula populifolia*
	quaking aspen	*Populus tremuloidies*

Table 2-1. (Page 2 of 3). Dominant vegetation in the vegetation communities at Liberty State Park, Jersey City, NJ.

Community Type	Common Name	Scientific Name
Maritime Grassland		
	saltmeadow cordgrass	*Spartina patens*
	butter and eggs	*Linaria vulgaris*
	common reed	*Phragmites australis*
	purple loosestrife	*Lythrum salicaria*
	eastern baccharis	*Baccharis halimifolia*
	marsh elder	*Iva frutescens*
	winged sumac	*Rhus copallina*
	staghorn sumac	*Rhus typhina*
	quaking aspen	*Populus tremuloidies*
	eastern cottonwood	*Populus deltoidies*
Common Reed/Mugwort		
	mugwort	*Artemisia vulgaris*
	common reed	*Phragmites australis*
	hemp dogbane	*Apocyanum cannibinum*
	common mullein	*Verbascum thapsus*
	purple loosestrife	*Lythrum salicaria*
	winged sumac	*Rhus copallina*
	quaking aspen	*Populus tremuloidies*
Mowed Lawn		
	annual bluegrass	*Poa annua*
Unpaved/Paved Road		
	mugwort	*Artemisia vulgaris*
	white sweet clover	*Melilotus alba*
	common mullein	*Verbascum thapsus*
	wild carrot	*Daucus carota*
	spotted knapweed	*Centauria maculosa*

Table 2-1. (Page 3 of 3). Dominant vegetation in the vegetation communities at Liberty State Park, Jersey City, NJ.

Community Type	Common Name	Scientific Name
PALUSTRINE COMMUNITIES		
Floodplain Forest Wetland		
	gray birch	*Betula populifolia*
	eastern cottonwood	*Populus deltoides*
	sensitive fern	*Onoclea sensibilis*
Shrub Swamp Wetland		
	cut-leaved blackberry	*Rubus laciniata*
	winged sumac	*Rhus copallina*
	staghorn sumac	*Rhus typhina*
	common reed	*Phragmites australis*
	purple loosestrife	*Lythrum salicaria*
	sensitive fern	*Onoclea sensibilis*
	quaking aspen	*Populus tremuloidies*
Shallow Emergent Marsh		
	purple loosestrife	*Lythrum salicaria*
	common reed	*Phragmites australis*
	wool grass	*Scirpus cyperinus*
	steeplebush	*Spiraea tomentosa*
	gray birch	*Betula populifolia*
Common Reed-dominated Wetland		
	common reed	*Phragmites australis*
	purple loosestrife	*Lythrum salicaria*
	sensitive fern	*Onoclea sensibilis*



US Army Corps of Engineers New York District

Map Source: LIBS (2005)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

Existing Liberty State Park Vegetation Communities

Figure 2-3

2.1.2.1 Terrestrial Communities

Terrestrial Forested Upland Communities

Forested upland communities are defined as those communities with more than 60% tree canopy cover that grow on a substrate that is made up of less than 50% rocky outcrop or shallow soil over bedrock (Edinger *et al.* 2002). Only one type of terrestrial forest community, Successional Northern Hardwoods, was identified within the LSP Restoration site.

Successional Northern Hardwoods (SNH) is defined by Edinger *et al.* (2002) as a forest community located on previously disturbed or cleared sites where shrubs represent less than 50% of the vegetative cover. Successional forests are those where the canopy is dominated by light-requiring, wind-dispersed species, while the seedlings and sapling species are more shade tolerant. SNH tree communities are among the most widespread community type within the LSP Restoration site, being located throughout the site, and covering approximately 62.7 acres (Figure 2-3).

The dominant tree species in LSP Restoration site SNH communities are quaking aspen (*Populus tremuloides*), eastern cottonwood (*P. deltoides*), and gray birch (*Betula populifolia*). Less dominant tree species included tree-of-heaven (*Ailanthus altissima*), big-toothed aspen (*P. grandidentata*), black locust (*Robinia pseudoacacia*), white pine (*Pinus strobus*), red maple (*Acer rubrum*), lombardy poplar (*Populus nigra*), and black oak (*Quercus velutina*). The shrub layer was dominated by winged sumac (*Rhus copallina*), smooth sumac (*R. glabra*), northern bayberry (*Myrica pensylvanica*), and staghorn sumac (*Rhus typhina*). Typical representatives of the herbaceous understory include Canada goldenrod (*Solidago canadensis*), cut-leaved blackberry (*Rubus laciniata*), common reed (*Phragmites australis*), mugwort (*Artemisia vulgaris*), and steeplebush (*Spiraea tomentosa*) (Table 2-1).

The tree species present represent early successional stages. Poplars and gray birch are referred to as pioneer species, which often colonize disturbed areas because they generally have high light requirements, can colonize bare mineral soils, are tolerant of poor soil conditions and can adapt to a variety of different growing habitats (MacFarlane 2001). Pioneer hardwood species are usually succeeded by species such as red maple and black oak that require less light and can establish themselves below the pioneer species' canopy. The shade-tolerant species eventually outcompete the pioneer trees for resources such as sunlight and water. The few maple saplings identified within the LSP

Restoration site suggest that shade-tolerant hardwoods may become more widespread in years to come.

This forest community provides breeding and foraging habitat for several species of year-round resident birds, including the American robin (*Turdus migratorius*), downy woodpecker (*Picoides pubescens*), and northern flicker (*Colaptes auratus*) (Bull and Farrand 1977). The edges of forest communities, especially when bounded by grasslands, are particularly good foraging habitat for birds. Raptors, such as Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*) and red-tailed hawk (*Buteo jamaicensis*) were observed foraging along the edges of the forest communities within the LSP Restoration site in 2003.

Terrestrial Open Upland Communities

Open upland communities are defined as those that have less than 25% tree canopy cover. Dominant vegetation types in these communities are shrubs, herbs and/or mosses and lichens (Edinger *et al.* 2002). Four open upland communities were identified within the LSP Restoration site, Maritime Shrubland, Successional Shrubland, Successional Old Field and Maritime Grassland.

Successional Shrubland (SSB) is defined by Edinger *et al.* (2002) as a shrubland community located on sites that have been cleared and are dominated by at least 50% shrub species. SSB communities in the LSP Restoration site have similar species as maritime shrublands, but are dominated by cut-leaved blackberry, and Japanese knotweed (*Polygonum cuspidatum*). Northern bayberry, present in maritime shrublands, is absent from the SSB communities. The herbaceous understory is dominated by Canada goldenrod and common reed (Table 2-1).

SSB communities covering approximately 4.2 acres are located in the Wetland/Forest Complex and the Dredged Material Storage Area of the LSP Restoration site (Figure 2-3). SSB communities within the site have likely developed from old fields and will probably succeed into SNH communities with the introduction of wind dispersed seeds.

Successional shrublands offer nesting and foraging habitat for many of the same bird species as maritime shrublands, and in addition, Cooper's hawk and downy woodpecker forage in these communities (Bull and Farrand 1977).

Successional Old Field (SOF) is defined by Edinger *et al.* (2002) as a meadow community located in areas that have been cleared and abandoned. These communities are dominated by non-woody herbs and grasses. SOF communities are the most diverse community type within the LSP Restoration site, with 67 identified plant types. Dominant species include Chee reed grass (*calamagrostis epigeios*), common mullein (*Verbascum thapsus*), Canada goldenrod, spotted knapweed (*Centauria maculosa*), mugwort, and butter and eggs (*Linaria vulgaris*). Other species identified included wild carrot (*Daucus carota*), hyssop-leaved boneset (*Eupatorium hyssopifolium*), hemp dogbane (*Apocyanum cannibinum*), common ragweed (*Ambrosia artemisiifolia*), and white sweet clover (*Melilotus alba*) (Table 2-1).

The SOF communities are located along the northern boundary of the LSP restoration site, and in the Soil Stockpile Area, and cover approximately 49.6 acres (Figure 2-3). Typical characteristics of plants found in SOF communities are annuals and biennials that establish and reproduce rapidly. SOF communities are early successional communities that gradually evolve into SSB areas with the introduction of new seeds.

SOF communities are important foraging grounds for most of the bird species observed within the LSP Restoration site. The seeds of many species provide a food source for wildlife species. An abundance of insects that inhabit SOF communities provide a source of food for insectivorous bird and small mammal species. The dense herbaceous vegetation also provides nesting and roosting cover, however, the lack of a tree/shrub canopy enables predatory birds to easily locate prey species such as the songbirds and small mammal species that frequent the SOF communities.

Maritime Shrubland (MS) is defined by Edinger *et al.* (2002) as a shrub community located near the ocean that is exposed to onshore winds and spray. These shrublands are usually located in shallow depressions and are typically dominated by shrubs between 6 and 9 feet tall and trees are sparse or absent (less than 25% canopy cover). While exposure to onshore salt spray is minimal within the LSP Restoration site, MS vegetation communities are present throughout the area. The MS community is represented by a diverse mix of species, but is largely dominated by winged and smooth sumac shrubs. Subdominant species include northern bayberry, Canada goldenrod, common reed, cut-leaved blackberry, gray birch, and quaking aspen (Table 2-1). Maritime Shrubland communities cover approximately 22.0 acres of the LSP Restoration site (Figure 2-3).

Succession of MS communities is dependent upon soil moisture. With adequate soil moisture, MS communities may succeed into wetland shrub communities, whereas drier MS communities are more likely to support successional upland forest species.

Several summer, winter and year-round resident birds use shrubland communities for foraging and breeding. American goldfinch (*Carduelis tristis*), yellow warbler (*Dendroica petechia*), eastern towhee (*Pipilo erythrophthalmus*) and red-winged blackbird (*Agelaius phoneiceus*) are likely to breed within these shrublands of LSP. Summer residents, such as the tree swallow (*Tachycineta bicolor*) and yellow warbler, and year-round residents including the American woodcock (*Scolopax minor*), chimney swift (*Chaetura pelagica*) and American kestrel (*Falco sparverius*), forage in or over the shrubland communities (Bull and Farrand 1977). Maritime shrublands also provide foraging habitat for winter residents.

Maritime Grassland (MG) is defined by Edinger *et al.* (2002) as a grassland community dominated by more than 50% grasses and few shrubs located near the ocean where onshore winds and spray are present. Although onshore winds and spray are minimal within the LSP Restoration site, MG communities developed near the trenches that are connected to drainage culverts in the North Cove and Morris Canal. These trenches may be tidally influenced, and saltwater from the harbor may be introduced, allowing for the development of adjacent MG communities. These communities are located primarily in the Dredged Material Storage Area, and the northwestern section of the site (Figure 2-3).

MG communities in the LSP Restoration site are dominated by grasses, mostly saltmeadow cordgrass (*Spartina patens*). Solitary and clustered shrubs identified in these herb-dominated were eastern baccharis (*Baccharis halimifolia L.*) and marsh elder (*Iva frutescens*). Other common species included common reed, mugwort, common mullein, Canada goldenrod, and hemp dogbane (Table 2-1).

All of the MG communities are located adjacent to monocultures of common reed, and it is likely that the reed stands will eventually expand and outcompete the grasses. These grasslands cover approximately 14.6 acres.

MG communities offer valuable nesting and foraging habitat for the northern harrier and several other wildlife species, many of which are also found in Successional Old Field habitat.

Terrestrial Cultural Communities

Terrestrial Cultural Communities are defined as systems that have been substantially altered by human activities and the resulting substrate and/or composition of the biological community is substantially different than before human influence. These communities include both areas that have been created and are maintained by human activities (e.g. mowed lawns), and communities where the physical properties of the substrate or the vegetation have been substantially altered but not maintained (e.g. dredged material deposits) (Edinger *et al.* 2002). Four terrestrial cultural community types were found within the LSP Restoration site, Common Reed/Mugwort, Mowed Lawn, Unpaved/Paved Road communities. The community descriptions are presented below.

Common Reed/Mugwort Communities (CRM) are characterized by more than 75% cover of the invasive herbs, mugwort, common reed, and/or Japanese knotweed. Although these communities are largely dominated by mugwort and common reed, twenty-five plant species were identified in CRM communities. The most frequently occurring subdominant species were purple loosestrife, hemp dogbane, and common mullein (Table 2-1).

CRM communities are among the most common type within in LSP Restoration site, covering approximately 38.7 acres. These communities are located throughout the Dredged Material Storage Area and along the boundaries of the site (Figure 2-3). Succession will most likely be repressed in these communities because the plant types within the community are invasive species that have adaptations that allow them to outcompete native herbaceous plants. Unlike most native herbaceous species that reproduce through seed dispersion, common reed primarily spreads through rhizomal colonization. Once a common reed community is established, it easily outcompetes neighboring plant communities by expansion of its rhizome system. Mugwort accumulates toxic allelochemicals in its roots, which inhibits the growth of other plant species (Inderjit 2001, Inderjit and Foy 1999).

Because mugwort, common reed and Japanese knotweed grow as monocultures in several areas, CRM communities provide little habitat diversity for wildlife. A relatively small number of birds forage and nest in these communities as preferred habitat.

Mowed Lawn (ML) is defined by Edinger *et al.* (2002) as a residential, recreational or commercial land in which the groundcover is dominated by clipped grasses and there is less than 30% cover of trees. The LSP Restoration site includes 5.6 acres of ML around the fringes of the site, in Millennium Park, and adjacent to the North Cove (Figure 2-3). This community provides foraging habitat for species such as the American robin, ring-billed gull (*Larus delawarensis*), and rock dove (*Columbia livia*).

Unpaved/Paved Road (ROAD) is defined by Edinger *et al.* (2002) as vegetation rooted in a road or path made of the parent material of the site and is maintained by regular trampling of the land surface. While in most locations no vegetation is present, common species identified in ROAD communities included mugwort, ragweed, white sweet clover, common mullein, tree-of-heaven, wild carrot, clovers and spotted knapweed (Table 2-1). This community is represented by two roads within the LSP Restoration site, one along the southern boundary of the Dredged Material Storage Area, and one bisecting the Wetland/Forest Complex, covering a total of 3.1 acres (Figure 2-3). Plant species that grow on roads are typically tolerant of compacted soil conditions and frequent trampling.

2.1.2.2 Wetland Communities

Forested Mineral Soil Communities

Forested Mineral Soil wetlands includes seasonally flooded forests, and permanently flooded or saturated swamps that are shaded by a minimum of 50% canopy cover. Only one type of Forested Mineral Soil Wetland, a Floodplain Forest, was identified within the LSP Restoration site.

Floodplain Forest Wetland (FFW) is a broadly-defined community type that consists (Edinger *et al.* 2002) of hardwood forests that grow in the low terraces of river floodplains and river deltas. This community type is flooded either regularly (lower areas) or irregularly (higher areas). The entire LSP Restoration site is located in the 100-year floodplain of the Upper New York Bay. One 0.3 acre FFW was identified in the Wetland/Forest Complex (Figure 2-3). Cottonwood, gray birch and sensitive fern (*Onoclea sensibilis*) are the dominant plant species (Table 2-1).

Similar to other forested communities, FFWs provide foraging and breeding habitat for a number of passerine and predatory birds. These forested wetlands also provide habitat

for the Fowler's toad (*Bufo woodhousii fowleri*), raccoons (*Procyon lotor*), and cottontail rabbits (*Sylvilagus floridanus*).

Palustrine Open Mineral Soil Wetland Communities

Palustrine Open Mineral Soil Wetland Communities are defined by Edinger *et al.* (2002) as non-tidally influenced perennial wetlands that have less than 50% tree canopy cover. The substrate of these communities ranges from mineral soils to mucky organic soils. Water levels fluctuate in these wetlands, allowing aeration of the soils and decomposition of organic matter. There is little peat accumulation. Two types of open mineral soil wetland, shrub swamp and shallow emergent marsh, were found within the LSP Restoration site.

Shrub Swamp Wetland (SSW) Edinger *et al.* (2002) defines this community as an inland wetland located on mineral soil or muck substrate, dominated by tall shrubs (2002). Within the LSP Restoration site, SSW communities are dominated by winged sumac shrubs and common reed. Other species commonly associated with SSW are purple loosestrife and cut-leaved blackberry. Gray birch, sensitive fern, quaking aspen, mugwort and Canada goldenrod were also present in some of the SSW wetlands (Table 2-1).

Two small SSW communities, covering a total of 0.1 acres, are located within the Wetland/Forest Complex (Figure 2-3). Common reed and purple loosestrife, two of the common species in SSW, are typically very aggressive during establishment. Eventually, they may outcompete shrubs and other species in the community, thus succeeding into a Common Reed-dominated Wetland (described below).

SSW communities provide valuable breeding and foraging habitat for the same species of birds as the MS communities. Nine bird species that have been observed within the LSP Restoration site may breed within SSW communities, and 16 observed bird species use shrub swamps as foraging grounds (Bull and Farrand 1977).

Shallow Emergent Marsh (SEM) This community is defined by Edinger *et al.* (2002) as a wetland growing on mineral or mucky soils that are seasonally flooded, and saturated throughout the year. Within the LSP Restoration site, these wetlands are dominated by purple loosestrife, common reed, gray birch, wool grass (*Scirpus cyperinus*), and

steeplebush (Table 2-1). Nine SEM communities that cover a total of 10.2 acres were identified; all of which are located in the Wetland/Forest Complex (Figure 2-3).

Emergent marsh communities provide foraging habitat for several of the bird species present within the LSP Restoration site, including the northern harrier, chimney swift, American kestrel, tree swallow, and killdeer (*Charadrius vociferous*). Emergent marshes also provide potential breeding habitat for the bobolink (*Dolichonyx oryzivorous*) and the northern harrier.

Palustrine Cultural Communities

Palustrine Cultural Communities are defined as wetlands that have been created and maintained by human activity, or are modified by humans to such a degree that the substrate, hydrology and/or biological communities are substantially different than prior to human disturbance (Edinger 2002). One cultural wetland type, Common Reed-dominated wetlands was found in Liberty State Park.

Common Reed-dominated Wetlands (CRW) are located on dredged material substrate, and are dominated by common reed and/or purple loosestrife. Other subdominant species include winged sumac, sensitive fern, steeplebush and Canada goldenrod (Table 2-1).

Fifteen CRW communities, covering a total of 13.0 acres, were identified throughout the LSP Restoration site (Figure 2-3). Two of the CRWs are located on drainage ditches, one surrounding the Dredged Material Storage Area, and one along the western boundary of the site. Eleven of the CRW communities are located in the Wetland/Forest Complex.

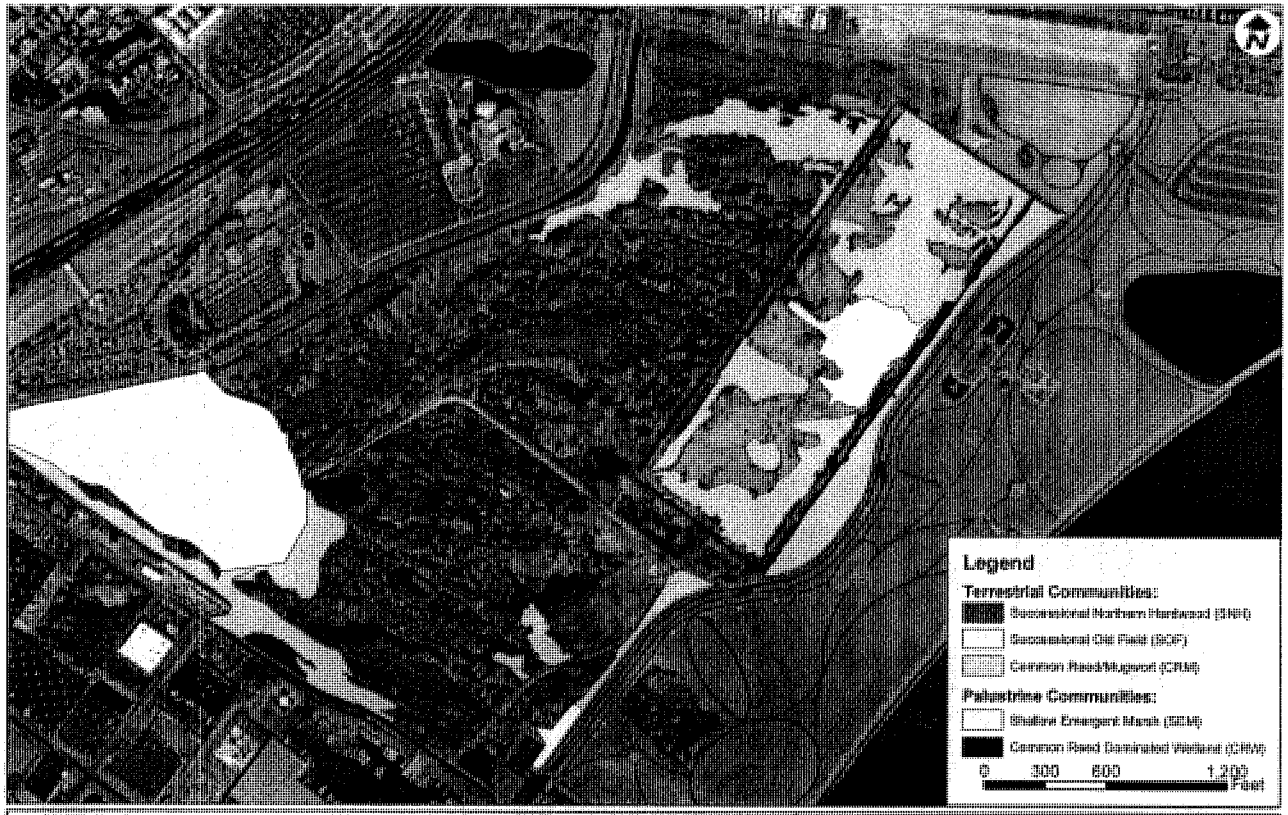
Typically, it is difficult for other plant species to establish and reproduce in dense common reed communities and succession of such communities into a more diverse wetland community is unlikely without human intervention. Although common reed and purple loosestrife are not considered a preferred habitat because they do not provide a variety of food sources for wildlife, some wildlife species are able to use CRW wetlands as cover, nesting or roosting habitat. Within the LSP Restoration site, song sparrows (*Melospiza melodia*) and red-winged blackbirds (*Agelaius phoneiceus*) were infrequently observed utilizing CRW communities.

2.1.3 Summary

Thirty-seven years have passed since the area that is now Liberty State Park was an active rail yard and terminal. In this time period early successional vegetation communities have established on the undeveloped portion of the park defined as the LSP Restoration site. While some of these communities that have experienced the longest period to develop represent late successional types (e.g. northern hardwood forest), much of the area is vegetated with terrestrial open upland communities and open mineral soil wetland communities. This is likely due to the slower successional revegetation process that is occurring on areas that have poorer soils or other growth inhibitors, or due to interim disturbances that have occurred. The latter includes the use of a 42-acre area of the LSP Restoration site for disposal of dredged materials between 1981 and 1993, which eliminated the vegetation present at that time and reverted the surface back to an unvegetated state. Considering that the development of vegetation communities is an ongoing process, it is likely that there will be changes in their extent and composition without the implementation of any active restoration.

Forest communities will be dominated by native poplars and birches, with further growth of slow-growing maple and oak saplings under the tree canopy. Forest boundaries will continue to expand slowly into areas that are now covered by shrublands or grasslands. Maritime and successional shrubland communities are likely to expand over the successional old fields. Maritime shrubs are located throughout the old field communities, and the grasses acreage is likely to decrease as the shrubs become dominant. Existing native maritime grassland communities are located adjacent to monocultures of the invasive species common reed and mugwort (Figure 2-4). The invasive species will likely encroach upon the grasslands and eventually outcompete them for resources, and the maritime grasslands will likely be rare or non-existent within the LSP Restoration site in as little as ten years.

Wetlands within the LSP Restoration site may increase in area due to the accumulation of organic matter, but will likely decrease in value over the next ten years without the proposed restoration project. Common reed and/or purple loosestrife are common in most of the freshwater wetlands. It is likely that, with the exception of the floodplain forested wetland, existing wetlands will develop into monocultures of these invasive species.



US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Liberty State Park Communities Dominated by Invasive Species (>75%)

Figure 2-4

2.2 REGULATED WETLAND COMMUNITIES

In New Jersey, freshwater wetlands and their adjacent areas are regulated by New Jersey Department of Environmental Protection Land Use Regulation Program under the New Jersey Freshwater Wetlands Protection Act (N.J.S.A. 13:9B). Any work that is proposed near a freshwater wetland should not be performed without receiving a Letter of Interpretation (LOI) from NJDEP to verify whether the project takes place within the regulated wetland boundary or its regulated transition area. Because the boundaries of wetlands can shift over time due to changes in hydrology, plant dominance, or land use patterns, LOIs are issued by NJDEP for 5 year periods.

Obtaining an LOI from NJDEP requires the submittal of data defining the basis for establishing the boundaries of the freshwater wetlands. Within the LSP Restoration site, wetland boundaries were defined using the methodologies described in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands of 1989 (1989 manual) (USFWS *et al.* 1989). In New Jersey, the Freshwater Wetland Regulatory Program has been determined to meet or exceed the requirements established under Section 404 of the Federal Clean Water Act, and the USACE regulatory program has thus been delegated to NJDEP for most wetlands. The New Jersey Freshwater Wetlands Protection Act requires wetland delineations be completed following the methodology outlined by the 1989 manual. The U.S. Army Corps of Engineers Wetlands Delineation Manual of 1987 (Environmental Laboratory 1987) is used by USACE to make a similar Jurisdictional Determination (JD) when required. USACE retains jurisdiction over wetlands within 1,000 feet of tidal waters; these wetlands would be jointly regulated by USACE and NJDEP. In addition, since the LSP restoration project would disturb tidal waters or wetlands, USACE would regulate all wetland impacts associated with the project, including freshwater wetland impacts within 1,000 feet of the high tide line.

Because the restoration planned at LSP will fall under the jurisdiction of two regulatory agencies (NJDEP and USACE New York District) that require wetland delineations be completed in accordance with different versions of the wetland delineation manual, both the 1987 and 1989 manuals were utilized in delineating the extent of regulated wetlands within the LSP Restoration site. Both manuals require a thorough investigation of vegetation, soil and hydrology in determining a wetland boundary. Both utilize a "three parameter" approach for defining wetlands, and define an area as wetland if the following criteria are present:

1. The land supports vegetation that is dominated (> 50%) by hydrophytes (wetland vegetation).
2. The substrate is a hydric soil being at least periodically saturated or inundated during a portion of the growing season.
3. The area shows signs of hydrology (i.e. indications of past or present hydrologic events).

Hydrophytes are plants that have the ability to grow in water or in a substrate that is at least periodically deficient in oxygen, due to periodic or permanent flooding of soils. The U.S. Fish and Wildlife Service (USFWS) prepared a list of plant species for the Northeast Region (Region I) to be used in determining the presence of a wetland (Reed 1988). The plant species listed in this publication are classified based on their affinity for wetlands, and percent likelihood that they will occur in wetlands.

The USACE and NJDEP definition of hydrophytes is based on the USFWS classification system. In general, any plant species that is found growing in wetlands more than 50% of the time is considered a hydrophyte. These plants include those classified by the USFWS as "facultative", "facultative wetland", or "obligate".

Hydric soils are poorly drained soils that either are inundated or have the seasonal high water table within 6 inches of the surface for a portion of the growing season (Environmental Laboratory 1987). The subsoils are typically predominantly gray and mottled immediately below the "A" horizon and have thick, dark colored surface layers. A hydrogen sulfide odor, resulting from anaerobic respiration, is another diagnostic characteristic of hydric soils.

Hydrologic Indicators are evidence of periodic or permanent inundation. Morphological adaptations on trees such as buttressed or fluted trunks, or multiple trunks indicate that the trees spend part of their growing season under flooded conditions. Physical evidence of flooding is also considered indicative of wetland hydrology. Examples of physical hydrologic indicators include water stained leaves and drift lines on trees.

2.2.1 Methodology

The wetland delineation for the LSP Restoration site first involved a desktop review of existing maps, wetland boundary flagging and descriptions of mapped wetland community types based on the classification system described by Cowardin *et al.* (1979). The maps reviewed included the U.S. Department of the Interior National Wetland Inventory (NWI) map (Jersey City, NJ USGS Quad), the NJDEP Freshwater Wetland Map, and previous wetland delineation data.

The wetland field investigation was based on the three-parameter Routine Onsite Determination Method Plant Community Assessment Procedure described in the 1989 manual. This procedure involves the establishment of representative sampling points along the wetland line and at representative locations within each plant assemblage on the site. At each sampling point, data regarding the vegetation, soil and hydrology of the area was collected to determine whether the area met the definition of a wetland. In some areas, it was not possible to collect soil samples due to deep standing water or an unsuitable substrate. In these cases, wetland determination was based upon the presence of wetland vegetation and hydrological indicators. Wetland delineation data sheets are presented in Appendix B.

Twenty-five wetlands were identified within the LSP Restoration site. The wetlands are described below and their locations are presented in Figure 2-5.

2.2.2 Wetland Community Descriptions

The wetlands within the LSP Restoration site were described using the classification system presented in the USFWS publication, Classification of Wetlands and Deepwater Habitats of the United States (Cowardin *et al.* 1979). This hierarchical system was designed to describe every aquatic system within the United States, including waterbodies and the wetlands that are associated with those waterbodies. The systems are divided into subsystems and classes that relate to tidal regime, substrate and/or vegetation type. The wetland classes are further divided by their flooding patterns.

All of the wetlands within the LSP Restoration site fall under the palustrine system, because the wetlands are not subject to tidal influence. Palustrine wetlands can be found on the fringes of lakes or rivers as well as in isolated situations. The palustrine system includes several classes of wetland types. Palustrine wetlands of the emergent, scrub-

shrub and forested classes were identified within the LSP Restoration site. Table 2-2 provides a description of individual wetlands.

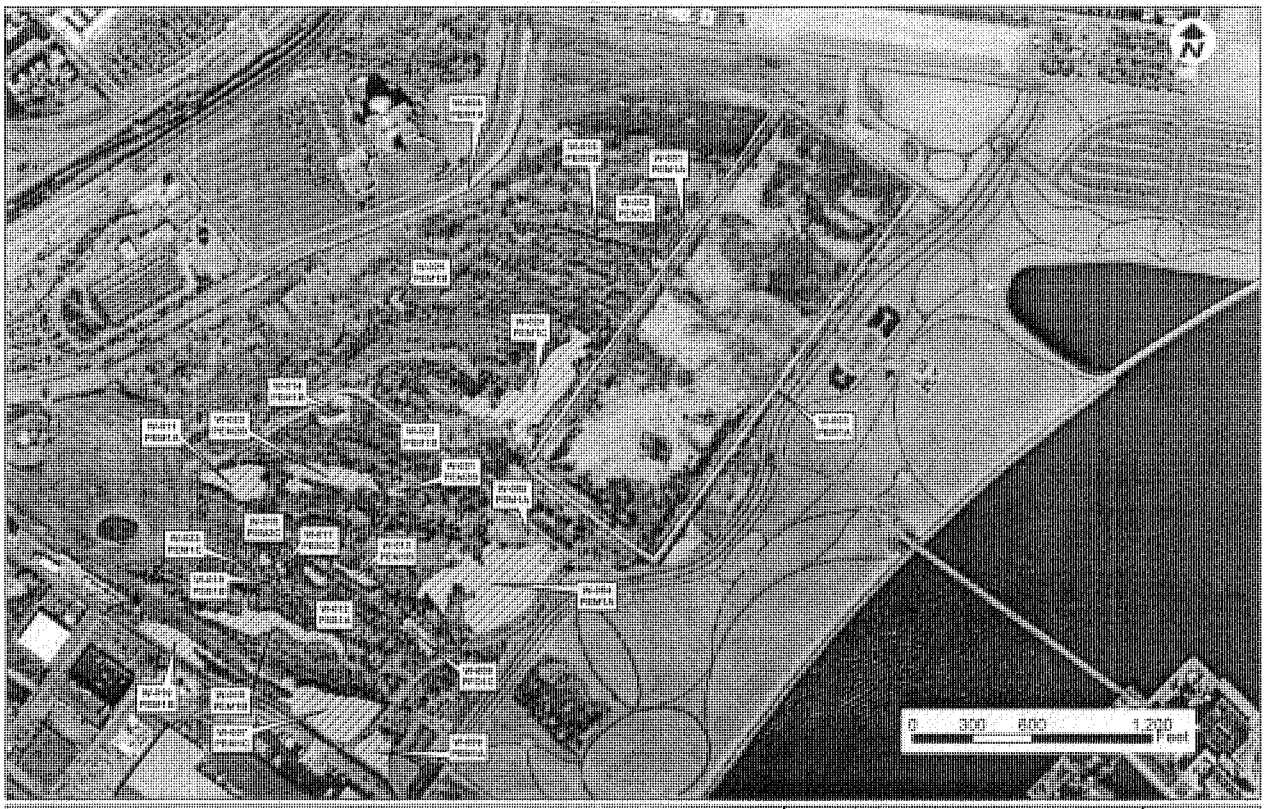
Palustrine Forested Wetlands

Palustrine forested wetlands are dominated by woody vegetation that is a minimum of 18 feet tall. One palustrine forested wetland that is dominated by broad-leaved deciduous tree species was identified within the LSP Restoration site (W-6 in Figure 2-5). This wetland type is further defined as a Temporarily-Flooded Broad-leaved Deciduous Palustrine Forested Wetland (PFO1C). The PFO1C wetland is located in the Wetland/Forest Complex, and covers approximately 0.26 acres. The wetland is significantly shaded by a canopy of cottonwood with an understory of gray birch saplings. Both species are classified as facultative species, indicating that their distribution is divided nearly evenly between wetland and upland habitats. The dominant plant in the herbaceous layer is purple loosestrife, a plant that is found most commonly in wetlands. The wetland is flooded during a portion of the growing season as a result of the accumulation of surface runoff into a depressional area (Table 2-2).

Palustrine Scrub-Shrub Wetlands

Palustrine scrub-shrub wetlands include areas dominated by woody vegetation less than 20 feet tall. Cowardin *et al.* (1979) defined PSS1A wetlands as those palustrine scrub-shrub wetlands that are dominated by broad-leaved deciduous species, such as alders (*Alnus* spp.), willows (*Salix spp.*) and red osier dogwood (*Cornus stolonifera*), and are flooded for a portion of the growing season. Two of the freshwater wetlands within the LSP Restoration site are in this category. An isolated 0.12-acre Temporarily-Flooded Palustrine Scrub-Shrub Wetland with Broad-leaved Deciduous Plants (PSS1A) (W-12 in Figure 2-5) dominated by red maple saplings, purple loosestrife and steeplebush is flooded by surface runoff that collects in a depressional area with a high water table (Table 2-2).

A nearby small, isolated 0.02-acre saturated Palustrine Scrub-Shrub Wetland with Broad-leaved Deciduous Plants (PSS1B) (W-18 in Figure 2-5) is dominated by silky dogwood (*Cornus amomum*) and has saturated soils that result from a high water table within a depressional area (Table 2-2).



US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Regulated Wetlands in Liberty State Park Jersey City, NJ

Figure 2-5

Table 2-2. Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ.

Wetland Number	Type	Ecological Community	Size (Acres)	Substrate	Wetland Indicators	Dominant Vegetation
W-1	PEM1A	Common Reed-dominated Wetland	0.01	Cinders	Standing Water; Surface water depth 2"; mottling present	Purple loosestrife (*Lythrum salicaria*): FACW+; Steeplebush (*Spiraea tomentosa*): FACW
W-2	PEM2C	Common Reed-dominated Wetland	0.06		Saturated soils at surface; Water table 4" below surface; Low chroma soils with mottling; Water stained leaves and shallow root sytsems	Sensitive fern (*Onoclea sensibilis*): FACW; Common reed (*Phragmites australis*): FACW; Gray birch (*Betula populifolia*): FAC
W-3	PEM1C	Common Reed-dominated Wetland	2.91		Saturated soils at surface; Water table 5" to 10" below surface; Low chroma soils with mottling	Common reed: FACW; Sensitive fern: FACW; Steeplebush: FACW; Purple loosestrife: FACW+; Peachleaf willow (*Salix nigra*): FACW+; Soft rush (*Juncus effuses*): FACW+
W-4	PEM1A	Common Reed-dominated Wetland	4.21		Standing water; Surface water depth 2" to 12"+	Common reed: FACW; Sensitive fern: FACW; Purple loosestrife: FACW+; and Cattails (*Typha spp.*): OBL; Reed canary grass (*Phalaris arundinacea*): FACW+

Table 2-2 (page 2 of 6). Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ.

Wetland Number	Type	Ecological Community	Size (Acres)	Substrate	Wetland Indicators	Dominant Vegetation
W-5	PEM1A	Common Reed-dominated Wetland	0.06		Saturated soils at surface	Common reed: FACW; Reed canary grass: FACW+
W-6	PFO1C	Floodplain Forest Wetland	0.26		Standing water; surface water depth 2"; Water table 6" below surface Buttressed tree trunks; Low chroma soils	Eastern cottonwood (*Populus deltoides*): FAC; Gray birch (*Betula populifolia*): FAC; Purple loosestrife: FACW+; Poison ivy (*Toxicodendron radicans*): FAC
W-7	PEM1C	Shallow Emergent Marsh	2.10	Disturbed sandy soils	Surface soil saturated; Water table 6" to 16" below surface Low chroma soils; Water stained leaves	Common reed: FACW; Purple loosestrife: FACW+; Steeplebush: FACW; Eastern cottonwood: FAC
W-8	PEM1A	Common Reed-dominated Wetland	1.56	Gravel	Standing water; Surface water depth from 0" to 12"	Common reed: FACW; Purple loosestrife: FACW+; Swamp rosemallow (*Hibiscus moschuetos*): OBL; Curlytop knotweed (*Polygonum lapathifolium*): FACW+

Table 2-2 (page 3 of 6). Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ.

Wetland Number	Type	Ecological Community	Size (Acres)	Substrate	Wetland Indicators	Dominant Vegetation
W-9	PEM1A	Common Reed-dominated Wetland	0.59		Surface soils saturated; Water table 6" below surface; Low chroma soils with mottling	Common reed: FACW; Purple loosestrife: FACW+; Eastern cottonwood: FAC
W-10	PEM1B	Common Reed-dominated Wetland	1.20	Disturbed sand and clay soils	Surface soils saturated; Water table 5" below surface; Low chroma soils with mottling	Common reed: FACW; Purple loosestrife: FACW+; Eastern cottonwood: FAC
W-11	PEM1A	Common Reed-dominated Wetland	0.90		Standing water; Surface water depth 2"; Water table 4" below surface; Low chroma soils	Common reed: FACW; Sensitive fern: FACW; Marsh fern (*Thelypteris palustris*): FACW+; Purple loosestrife: FACW+
W-12	PSS1A	Shrub Swamp	0.12	Gravel; sand; shell	Standing water; Surface water depth 1" in some areas; Water table 4" below soil surface; Water stained leaves, shallow root systems and buttressed trees	Red maple (*Acer rubrum*): FAC; purple loosestrife: FACW+; Steeplebush: FACW; Sensitive fern: FACW; Marsh fern: FACW+; Swamp azalea (*Rhododendon viscosum*): OBL; Gray birch (*Betula populifolia*): FAC

Table 2-2 (page 4 of 6). Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ.

Wetland Number	Type	Ecological Community	Size (Acres)	Substrate	Wetland Indicators	Dominant Vegetation
W-13	PEM1B	Common Reed-dominated Wetland	0.18	Coarse sand	Saturated soils; Water table 2" below soil surface; Low chroma soils	Common reed: FACW; Marsh fern: FACW+; Poison ivy: FAC; Gray birch: FAC
W-14	PEM1B	Common Reed-dominated Wetland	0.29	Debris and soil	Low chroma soils with mottling	Common reed: FACW; Canadian clearweed (*Pilea pumila*): FACW
W-15	PEM2B	Common Reed-dominated Wetland	0.01	Cinders	Standing water; Surface water depth 2"	Common reed: FACW; Sensitive fern: FACW; Gray birch: FAC
W-16	PEM2C	Shallow Emergent Marsh	0.06		Standing water; Surface water depth 12"+; water stained leaves	Woolgrass (*Scirpus cyperinus*): OBL; Common reed: FACW; Northern bayberry (*Myrica pensylvanica*): FAC; Gray birch: FAC; Red maple: FAC
W-17	PEM2C	Shallow Emergent Marsh	0.04		Standing water; Surface water depth 8"	Purple loosestrife: FACW+; Woolgrass: OBL; Northern bayberry: FAC; Gray birch: FAC; Red maple: FAC

Table 2-2 (page 5 of 6). Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ.

Wetland Number	Type	Ecological Community	Size (Acres)	Substrate	Wetland Indicators	Dominant Vegetation
W-18	PSS1B	Shrub Swamp	0.02		Saturated soils; Water table 16" below surface; Low chroma soils with mottling	Silky dogwood (*Cornus amomum*): FACW; Purpl loosestrife: FACW+; Yellow nutsedge (*Cyperus esculentus*): FACW; Gray birch: FAC; Northern bayberry: FAC
W-19	PEM1B	Common Reed-dominated Wetland	0.72		Saturated soils; Low chroma soils with mottling; Water stained leaves	Common reed: FACW; Purple loosestrife: FACW Marsh fern: FACW+
W-20	PEM2B	Shallow Emergent Marsh	0.99		Saturated soils; Water table 16" below surface; Low chroma soils with mottling	Marsh fern: FACW+; Sensitive fern: FACW; Roy fern (*Osmunda regalis*): OBL; Narrowleaf cattail (*Typha angustifolia*): OBL; Steeplebush: FACW; Purple loosestrife: FACW+; Common reed: FAC Canadian clearweed: FACW
W-21	PEM2B	Shallow Emergent Marsh	0.08		Saturated soils; Water stained leaves and water marks	Sensitive fern: FACW; Steeplebush: FACW; Pur loosestrife: FACW+; Common reed: FACW

Table 2-2 (page 6 of 6). Wetland indicators for regulated wetlands in Liberty State Park, Jersey City, NJ.

Wetland Number	Type	Ecological Community	Size (Acres)	Substrate	Wetland Indicators	Dominant Vegetation
W-22	PEM1B	Shallow Emergent Marsh	0.03		Saturated soils; Water stained leaves and water marks; Low chroma soils	Reed canary grass: FACW; Steeplebush: FACW; Eastern cottonwood: FAC; Gray birch: FAC
W-23	PEM1C	Common Reed-dominated Wetland	0.02		Standing water observed on several occasions.	Phragmites australis, FACW; Onoclea sensibilis, FACW.
W-24	PEM1A	Shallow Emergent Marsh	2.68		Saturated soils at surface;	Wool grass (*Scirpus cyperinus*): OBL; Soft rush: FACW+; Red maple (*Acer rubrum*): FAC; Common reed: FACW; purple loosestrife: FACW+
W-25	PEM1B	Common Reed-dominated Wetland	0.08		Frost in soil – soil saturated.	Phragmites australis, FACW; Onoclea sensibilis, FACW.

Palustrine Emergent Wetlands

Cowardin *et al.* (1979) defines emergent wetlands as those that are characterized by erect, rooted, herbaceous vegetation, excluding mosses and lichens, and that are usually dominated by perennial plants. This class is further divided into subclasses (depending upon vegetation type) and dominance types (depending upon flooding regimes). Most (22 of the 25) wetlands identified within the LSP Restoration site are palustrine emergent wetlands, and most of these wetlands are dominated by common reed and/or purple loosestrife (Figure 2-5). Descriptions of these wetlands by Cowardin, *et al.* (1979) category are described below.

Temporarily-Flooded Palustrine Emergent Wetlands with Persistent Vegetation (PEM1A)

PEM1A wetlands are dominated by herbaceous vegetation that persists (usually as dead standing stems) after the growing season. Surface water is present during some part of the growing season, but the water table is typically well below the soil surface.

Seven wetlands, covering 10.01 acres are classified as PEM1A wetlands (W-1, W-4, W-5, W-8, W-9, W-11 and W-24 on Figure 2-5). These wetlands are dominated by common reed and purple loosestrife, both species that have non-living stems that persist throughout the year (Table 2-2). These wetlands represent a range of hydrologic regimes including ditches that convey surface runoff, and isolated wetlands where water ponds due to a high water table. Standing water was observed in these wetlands in August 2003, but the water table had dropped below the soil surface by October 2003.

Saturated Palustrine Emergent Wetlands with Persistent Vegetation (PEM1B)

PEM1B wetlands are defined by Cowardin *et al.* (1979) as those that are dominated by herbaceous vegetation that stays erect throughout the year, where the surface soils are saturated at the surface for extended periods during the growing season, and where surface water is rare.

Six isolated wetlands totaling 4.12 acres are classified as PEM1B (W-10, W-13, W-14, W-19, W-22 and W-25 in Figure 2-5). Like the PEM1A wetlands, they are dominated by common reed and purple loosestrife (Table 2-2). These wetlands occur in topographic depressions or where drainage is restricted by roads or other impediments to flow. Surface soil permeability may be sufficient to prevent ponding, but saturated soils do occur.

Seasonally-Flooded Palustrine Emergent Wetlands with Persistent Vegetation (PEM1C)
PEM1C wetlands are defined by Cowardin *et al.* (1979) as being dominated by herbaceous vegetation that persists after the growing season, and have standing water for most of the growing season.

Three wetlands, (W-3, W-7 and W-23 in Figure 2-5) totaling 5.03 acres are classified as PEM1C. W-3 is located adjacent to the drainage ditch surrounding the Dredged Material Storage Area, and it is dominated by common reed. Drainage to this ditch maintains the presence of standing water in the W-3 ditch through much of the growing season. W-7, located in the southern portion of the site, is dominated by purple loosestrife, common reed, and steeplebush (Table 2-2). Surface drainage is contained by a roadway at the eastern end of W-7, creating water depths that exceed 3 feet following significant rain events, but drains to the extent that no water was present during the fall season. W-23, also located in the southern portion of the site, is dominated by common reed.

Saturated Palustrine Emergent Wetlands with Non-Persistent Vegetation (PEM2B)
Cowardin *et al.* (1979) defined PEM2B wetlands as those dominated by non-persistent herbaceous vegetation that falls to the soil surface after the growing season, where the soils are saturated at the surface for some part of the growing season. For much of the year the water table is below the soil surface.

Three small PEM2B wetlands (W-15, W-20, and W-21 on Figure 2-5) dominated by non-persistent ferns, specifically sensitive fern, marsh fern (*Thelypteris palustris*) and royal fern (*Osmunda regalis*), cover a total of 1.08 acres (Table 2-2). Two of these are located in proximity and may reflect topographic depressions related to the prior railyard layout (W-20 and W-21). The other, W-15, is adjacent to a linear drainage feature within the successional forest/shrub complex.

Seasonally-Flooded Palustrine Emergent Wetlands with Non-Persistent Vegetation (PEM2C)
PEM2C wetlands are defined by Cowardin *et al.* (1979) as being dominated by herbaceous vegetation that falls to the soil surface after the growing season, and have standing water for a large part of the growing season.

Three PEM2C wetlands covering 0.16 acre were identified within the LSP Restoration site (W-2, W-16 and W-17 on Figure 2-5). Wool grass and other hydrophytic herbaceous

vegetation dominated these wetlands (Table 2-2). One of these wetlands (W-16) is located in an isolated depression where water ponds for periods of the growing season, creating conditions suitable for these emergent species.

3. WILDLIFE

Many types of wildlife have been reported to utilize the vegetation communities documented within the LSP Restoration site. The mix of habitat types may provide suitable migratory, foraging, nesting and overwintering territories for a variety of birds including raptors, songbirds, waders, shorebirds and waterfowl. Mammals that inhabit the LSP Restoration site are typically small mammals that provide abundant prey for raptor species. The methodologies used to inventory each wildlife group and the results of the surveys conducted during 2003 are presented in the following sections.

3.1 AMPHIBIANS AND REPTILES

Amphibian and reptile surveys were designed to document the presence and habitat usage within the LSP Restoration site. Previous surveys (Texas Instruments [TI] 1976) suggested that amphibian and reptile use of the LSP Restoration site was minimal; only one amphibian (Fowler's toad) and one reptile (eastern painted turtle [*Chrysemys p. picta*]) were observed by TI in their 1976 surveys.

3.1.1 Methodology

Potential amphibian and reptile habitats were surveyed to determine habitat use by these groups. Possible turtle nesting sites included well-drained embankments, berms, and sand/gravel areas. Pools were surveyed with dip nets for amphibian eggs, larvae, and adults, and turtles and snakes. Throughout the surveys, rocks, logs and debris piles were overturned and checked for the presence of amphibians and reptiles. Amphibian and reptile populations were surveyed during April and August 2003. During April 2003 two evening surveys were conducted to identify calling frogs and toads.

3.1.2 Results

Three species of amphibians and four species of reptiles were identified in Liberty State Park. Amphibian species observed were Fowler's toad, green frog (*Rana clamitans melanota*) and wood frog (*Rana sylvatica*). Reptiles observed were the northern brown snake (*Storeria d. dekayi*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), and northern diamondback terrapin (*Malaclemys t. terrapin*).

Although the LSP Restoration site appears to have suitable habitat for several amphibians and reptiles, many expected species were not found. As in the 1976 TI study, regionally

common wetland frogs, such as northern spring peeper (*Hyla crucifer crucifer*) were not observed. No salamanders were found, although northern redback salamander (*Plethodon c. cinereus*) is common in northern New Jersey. Reptiles were also under-represented, with only three snake species identified. No regionally-common northern ringneck snakes (*Diadophis punctatus edwardsi*), or eastern milk snakes (*Lampropeltis t. triangulum*) were found. Common turtles (e.g. snapping turtle [*Chelydra serpentina*], eastern painted turtle and eastern box turtle [*Terrapene carolina*]) were not observed.

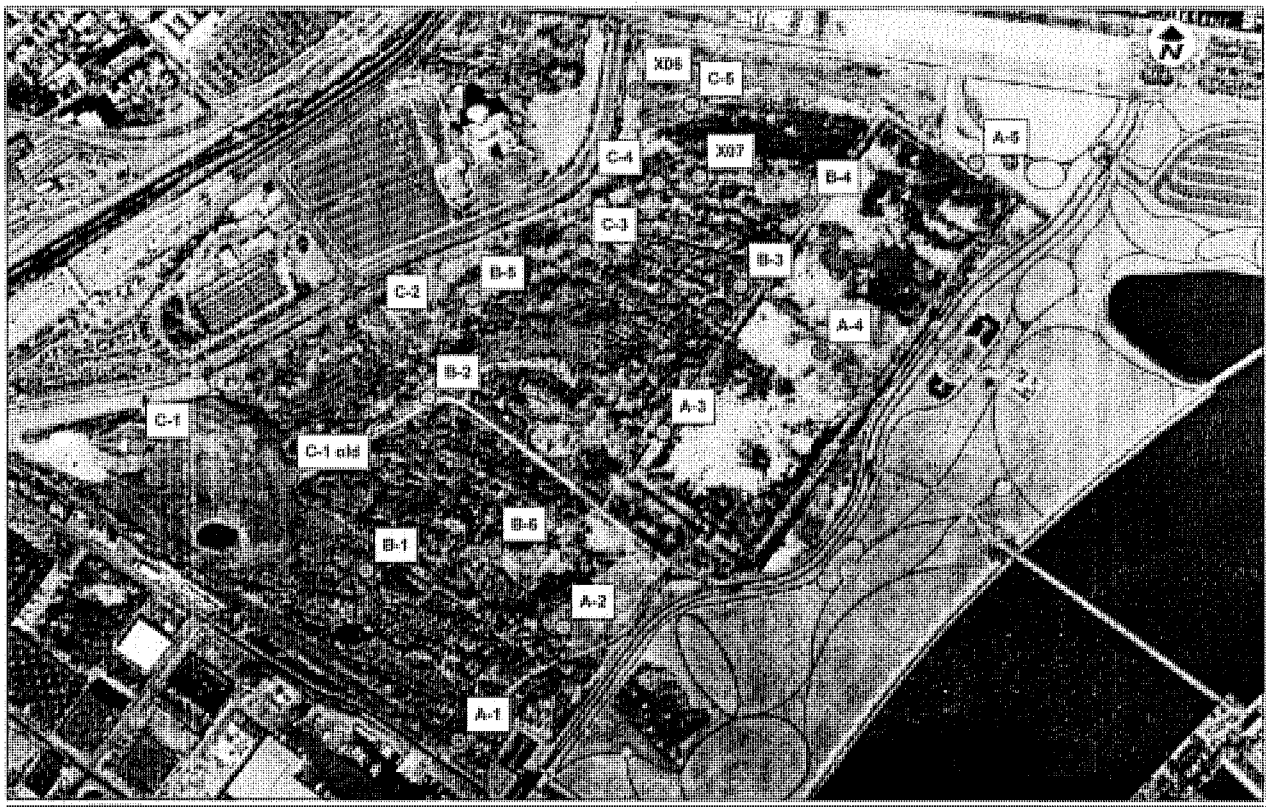
3.2 BIRDS

Avian surveys were conducted to determine species richness, relative abundance, and habitat use by birds in the vegetative community types and open water areas within the LSP Restoration site.

3.2.1 Methodology

Early morning (sunrise to 3-4 hrs after) surveys conducted at observation (point count) stations for birds and other wildlife were conducted weekly from 4 to 30 August 2003. Three transects, oriented roughly southwest-northeast, were established, and seventeen observation stations were selected along these transects. Point count stations were selected to obtain a view of all habitat types on the LSP Restoration site. Each station was established in an area from which it would be possible to see multiple habitat types (Figure 3-1). At each station, observations (species, numbers, distance and habitat) of birds/wildlife were recorded over a five-minute survey period. In addition, weekly wildlife surveys were conducted at the North and South Coves at or near low water periods. Playback recordings were used to survey for raptors and marsh birds on an opportunistic schedule.

Additional observations of bird use of the LSP Restoration site were made by the project team during northern harrier surveys (described in Section 4, Endangered and Threatened Species), the April 2003 amphibian surveys, the October 2003 mammal surveys, and by Liberty Science Center (LSC) staff between 3 January and 6 June 2003. In addition, records of bird sighting within LSP were obtained from the LSP Interpretive Center (IC). These records date back to 2001.



US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Liberty State Park Wildlife Observation Stations

Figure 3-1

3.2.2 Survey Results

During the August 2003 wildlife surveys (point counts and surveys at the North and South Coves), 758 individual bird observations representing 54 species were recorded (Table 3-1). Passerine species (songbirds) were the largest group represented by 24 species, and making up 61.7% of individual birds counted. Observations of rock and mourning doves and several species of gulls also represented a large number of the individual bird observations made during the surveys (13.1% and 10.8% respectively) (Table 3-1).

The majority (52.4%) of the individual observations were birds flying over the point count stations, and thus not associated with any specific habitat. Of the 343 observations of individual birds counted using a specific vegetative community, most were sighted in low lying upland habitats, (e.g. shrublands and forests). Of these, 18.7% of observations were of birds on Mowed Lawns, 5.5% were observed in Maritime Grasslands, 8.5% were observed in Successional Old Fields, 23.6% were observed in Maritime Shrubland habitat and its edges, and 28.3% were observed using Successional Northern Hardwood vegetation community and forest edges (including forest/shrub edge) (Table 3-2).

A limited number of the point stations encompassed freshwater wetland habitats and thus relatively few observations were made of birds utilizing freshwater wetlands; however, many birds were observed using wetlands and other aquatic habitats. Of the individual birds observed using upland and wetland habitats, 9.9% were seen using the Salt Marsh from the South Cove point station. Nine birds (2.6%) were seen in the shallow ponds in the Soil Stockpile Area. An additional 4.7% birds were counted in Shallow Emergent Wetlands, or in the edge habitat between these wetlands and forest or shrubland. Only 3.4% were observed using the upland areas covered by the invasive species, common reed and mugwort, despite the fact that these habitats were visible from several observation points. An additional 1.7% were recorded using the edges of Common Reed/Mugwort communities (Table 3-2). The seasonal use of the LSP Restoration site, and the foraging and breeding habitat requirements for bird species observed during the August 2003 wildlife surveys are presented in Table 3-3. This table includes species recorded during point counts as well as incidental sightings recorded by wildlife and vegetation survey crews.

Supplemental observations recorded during the northern harrier, amphibian and vegetation surveys, and by LSC staff yielded an additional 76 bird species, bringing the total to 131 species observed on or near the LSP Restoration site. Of the 131 species, 70 were observed on the LSP Restoration site and 61 were observed on open water or the South Cove Salt

Marsh, or in other habitats outside the proposed LSP Restoration site. A comprehensive list of birds observed in LSP habitats during the August 2003 point count, northern harrier, vegetation and spring amphibian surveys and supplemental sightings by LSC and IC staff is presented in Appendix A.

The point count bird surveys were conducted only during the month of August, and it is assumed that the observations do not represent all of the species that use the site. Additional sightings of migratory and overwintering populations during fall, winter and spring months are presented in Appendix A. A detailed discussion of the major groups of birds that have been observed on, or are expected to use, the LSP Restoration site follows.

Raptors

Migratory corridors tend to funnel raptors into the NY/NJ Harbor area (USFWS 1998). Raptors that are often observed within the vicinity of LSP include osprey (*Pandion haliaetus*), northern harrier, red-tailed hawk, common barn owl (*Tyto alba*), and peregrine falcon (*Falco peregrinus*). The small mammal and songbird populations of the area provide prey for resident and migratory raptor populations (USFWS 1998). Several raptors are known to utilize foraging, nesting and overwintering habitat within the NY/NJ Harbor area. Red-tailed hawk, northern harrier, osprey, common barn owl, and peregrine falcon are the most common species observed during the breeding season. Common winter residents include northern harrier, rough-legged hawk (*Buteo lagopus*), American kestrel, common barn owl, short-eared owl (*Asio flammeus*), long-eared owl (*Asio otus*), and peregrine falcon (USFWS 1998).

Twelve individuals of four raptor species were observed in Liberty State Park during the point count surveys (Table 3-1). One species of falcon (American kestrel), and three species of hawk (northern harrier, Cooper's hawk and red-tailed hawk) were observed flying over the point stations. Eight additional raptor species were sighted on or near the LSP Restoration site by LSC staff. Osprey and peregrine falcon were observed flying over or near the LSP Restoration site. Long-eared owls, short-eared owls and great horned owls (*Bubo virginianus*) were observed within or near the LSP Restoration site during the winter of 2003. Turkey vultures (*Cathartes aura*) and sharp-shinned hawks (*Accipiter striatus*) were sighted in the South Cove Salt Marsh. LSC staff have also observed merlin (*Falco columbarisus*) and snowy owl (*Nyctea scaniaca*) near the LSP Restoration site (Appendix A).

Table 3-1. Avian abundance during the August 2003 point count and North and South Cove surveys at Liberty State Park, Jersey City, NJ

Common Name	Scientific Name	No. of Individuals	Percent of Total Observed
Raptors			
American Kestrel	*Falco sparverius*	1	0.1%
Cooper's Hawk	*Accipiter cooperii*	1	0.1%
Northern Harrier	*Circus cyaneus*	5	0.7%
Red-tailed Hawk	*Buteo jamaicensis*	5	0.7%
	Total	**12**	**1.6%**
Passerines			
American Goldfinch	*Carduelis tristis*	20	2.6%
American Robin	*Turdus migratorius*	75	9.9%
Barn Swallow	*Hirundo rustica*	44	5.8%
Blue Jay	*Cyanocitta cristata*	1	0.1%
Brown Thrasher	*Toxostoma rufum*	2	0.3%
Brown-headed Cowbird	*Molothrus ater*	1	0.1%
Cedar Waxwing	*Bombycilla cedrorum*	6	0.8%
Common Grackle	*Quiscalu quiscula*	1	0.1%
Common Yellowthroat	*Geothlypis trichas*	12	1.6%
Eastern Kingbird	*Tyrannus tyrannus*	13	1.7%
Eastern Towhee	*Pipilo erythrophthalmus*	28	3.7%
European Starling	*Sturnus vulgaris*	93	12.3%
Field sparrow	*Spizella pusilla*	6	0.8%
Flycatcher	*Empidonax sp.*	1	0.1%
Gray Catbird	*Dumetella carolinensis*	77	10.2%
House Sparrow	*Passer domesticus*	2	0.3%
Northern Mockingbird	*Miimus polyglottos*	7	0.9%
Northern Oriole	*Icterus spurius*	1	0.1%
Red-winged Blackbird	*Agelaius phoneiceus*	15	2.0%
Song Sparrow	*Melospiza melodia*	49	6.5%
Sparrows unid.	*Melospiza sp.*	5	0.7%
Tree Swallow	*Tachycineta bicolor*	3	0.4%
Willow Flycatcher	*Empidonax traillii*	3	0.4%
Yellow Warbler	*Dendroica petechia*	3	0.4%
	Total	**468**	**61.7%**
Long-legged Waders			
Black-crowned Night Heron	*Nycticorax nycticorax*	2	0.3%
Great Blue Heron	*Ardea herodias*	3	0.4%
Great Egret	*Casmerodius albus*	1	0.1%

Table 3-1 (page 2 of 2). Avian abundance during the August 2003 wildlife surveys at Liberty State Park, Jersey City, NJ

Common Name	Scientific Name	No. of Individuals	Percent of Total Observed
Green Heron	*Butorides virescens*	2	0.3%
Snowy Egret	*Egretta thula*	1	0.1%
	Total	**9**	**1.2%**
Dabbling Ducks and Geese			
American Black Duck	*Anas rubripes*	10	1.3%
Canada Goose	*Branta canadensis*	12	1.6%
Mallard	*Anas platyrhynchos*	5	0.7%
	Total	**27**	**3.6%**
Shorebirds			
Greater Yellowlegs	*Tringa melanoleuca*	2	0.3%
Killdeer	*Charadrius vociferus*	5	0.7%
Lesser Yellowlegs	*Tringa flavipes*	4	0.5%
Sandpiper sp.		3	0.4%
Shorebirds unid		5	0.7%
	Total	**19**	**2.5%**
Gulls and Terns			
Greater Black Backed Gull	*Larus marinus*	1	0.1%
Herring Gull	*Larus argentatus*	19	2.5%
Laughing Gull	*Larus atricilla*	9	1.2%
Black Skimmer	*Rynchops niger*	1	0.1%
Common Tern	*Sterna hirundo*	1	0.1%
Least Tern	*Sterna antillarum*	1	0.1%
Ring-billed Gull	*Larus delawarensis*	53	7.0%
	Total	**85**	**11.2%**
Cormorants			
Double-crested Cormorant	*Phalacrocorax auritus*	11	1.5%
	Total	**11**	**1.5%**
Doves/Pigeons			
Rock Dove	*Columbia livia*	80	10.6%
Mourning Dove	*Zenaida macroura*	19	2.5%
	Total	**99**	**13.1%**
Swifts			
Chimney Swift	*Chaetura pelagica*	21	2.8%
	Total	**21**	**2.8%**
Woodpeckers			
Downy Woodpecker	*Picoides pubescens*	6	0.8%
Northern Flicker	*Colaptes auratus*	1	0.1%
	Total	**7**	**0.9%**

Table 3-2. Habitat use by birds at Liberty State Park, Jersey City, NJ

Community Type	No. Individuals Observed	Percent of Total
Successional Northern Hardwood	49	14.3%
Forest/Emergent Wetland Edge	9	2.6%
Forest/Field Edge[b]	21	6.1%
Forest/Common Reed/Mugwort Edge	3	0.9%
Forest/Shrub Edge[c]	15	4.4%
Maritime Shrubland	55	16.0%
Shrub[c]/Field Edge[b]	10	2.9%
Shrub[c] /Emergent Wetland Edge	3	0.9%
Shrub[c] /Common Reed/Mugwort Edge	3	0.9%
Successional Old Field	29	8.5%
Maritime Grassland	19	5.5%
Field[b]/Common Reed-dominated Wetland Edge	1	0.3%
Mowed Lawn	64	18.7%
Common Reed/Mugwort	12	3.5%
Salt Marsh	34	9.9%
Shallow Emergent Marsh	4	1.2%
Common Reed-dominated Wetland	3	0.9%
Open Water (shallow ponds)	9	2.6%
	343	**100.0%**

Notes:

[a] – Shrub edge includes the edges of Maritime and Successional Shrublands, and Shrub Swamp Wetlands.

[b] – Field edge includes the edges of Successional Old Field and Maritime Grassland communities.

- No point count stations were in view of the Forest Floodplain Wetland

Table 3-3. Habitat requirements of birds observed using the LSP restoration area during ERC surveys conducted in August and September 2003 at Liberty State Park, Jersey City, NJ.

Common Name (*Scientific Name*)	Seasonal Use[a]	Forest/ Woodland[b]	Emergent Wetland[c]	Shrubland[d]	Successional Shrubland	Successional Field[e]	Forest / Field Edge	Shrubland /Field Edge	North Cove
American Crow (*Corvus brachyrhynchos*)	R	F,B	F	F	F	F	F.B,O	F	
American Goldfinch (*Carduelis tristis*)	R		F	B, F	B,F,O	F	B	B,F,O	
American Kestrel (*Falco sparverius*)	R		F	F		F,O	B	F	
American Redstart (*Setophaga ruticilla*)	V	F,O		F	F,O	F		F	
American Robin (*Turdus migratorius*)	R	B,F		B, F	B,F	F,O	B,F	B,F	
American Woodcock (*Scolopax minor*)	R			F,O	F,B,O	F,O	f	F	
Barn Swallow (*Hirundo rustica*)	SR		F,O		F,O	F,O			
Bobolink (*Dolichonyx oryzivorus*)	V		F,B			F,B,O			
Brown Thrasher (*Toxostoma rufum*)	S				F,B,O	F		F,B,O	
Brown-headed Cowbird (*Molothrus ater*)	R	B		B	F,B	F,B	B	B,F,O	
Canada Goose (*Branta canadensis*)	R		F,B			F,B,O			
Cedar Waxwing (*Bombycilla cedrorum*)	W	F		F,O	B,O		F	F	
Chimney Swift (*Chaetura pelagica*)	SR		F,O	F	F,O	F,O		F	
Common Yellowthroat (*Geothlypis trichas*)	SR		B	F		F,B,O		F,B,O	

Table 3-3 (page 2 of 4). Habitat requirements of birds observed using the LSP restoration area during ERC surveys conducted in August and September 2003 at Liberty State Park, Jersey City, NJ.

Common Name (*Scientific Name*)	Seasonal Use[a]	Forest/ Woodland[b]	Emergent Wetland[c]	Shrubland[d]	Successional Shrubland	Successional Field[e]	Forest / Field Edge	Shrubland /Field Edge	North Cove
Cooper's Hawk (*Accipiter cooperii*)	R	F,B,O			F	F	F,B	F	
Downy Woodpecker (*Picoides pubescens*)	R	F,B			F		F, B		
Eastern kingbird (*Tyrannus tyrannus*)	SR					F,B,O	F, B	F	
Eastern Towhee (*Pipilo erythrophthalmus*)	SR-M	F,O		F,B,O	F,O	F,B	F,O	F,O	
European Starling (*Sturnus vulgaris*)	R					F			
Field Sparrow (*Spizella pusilla*)	SR					F,B,O		F	
Flycatcher sp. (*Empidonax sp.*)	V					F,O	F		
Gray Catbird (*Dumetella carolinensis*)	SR			F,B,O	F,B,O	F,B,O	F,O	F,B,O	
Greater Yellowlegs (*Tringa melanoleuca*)	M		F,O						
Herring Gull (*Larus argentatus*)	R								F,O
House Sparrow (*Passer domesticus*)	R					F,O			
Killdeer (*Charadrius vociferous*)	R		F,O			F,O			
Lesser Yellowlegs (*Tringa flavipes*)	M		F,W,O						

Table 3-3 (page 3 of 4). Habitat requirements of birds observed using the LSP restoration area during ERC surveys conducted in August and September 2003 at Liberty State Park, Jersey City, NJ.

Common Name (*Scientific Name*)	Seasonal Use[a/]	Forest/ Woodland[b/]	Emergent Wetland[c/]	Shrubland[d/]	Successional Shrubland	Successional Field[e/]	Forest / Field Edge	Shrubland /Field Edge	North Cove
Mallard (*Anas platyrhynchos*)	R		F,B			F,O			F
Mourning Dove (*Zenaida macroura*)	R			B		F,O		B,O	
Northern Flicker (*Colaptes auratus*)	R	F,B			F		F,B,O		
Northern Harrier (*Circus cyaneus*)	R		F,B,O			F,B,W,O	O		
Northern Mockingbird (*Mimus polyglottos*)	R			F,B,O		F,B,W,O		F,B,O	
Baltimore Oriole (*Icterus galbula*)	S						F,O	F,O	
Red-tailed Hawk (*Buteo jamaicensis*)	R	B	F,O	F,O		F.O	F,B,O	F	
Red-winged Blackbird (*Agelaius phoeniceus*)	R		F,B,O	F,B		F,B,O		B	
Ring-necked Pheasant (*Phasianus colchicus*)	R			F	F	F,B,O		F,B,O	
Song Sparrow (*Melospiza melodia*)	R		F			F,B,W,O		F,B,O	
Spotted Sandpiper (*Actitus macularia*)	V		F						F,O
Tree swallow (*Tachycinta bicolor*)	SR		F,O	F	F	F,O	B		

Table 3-3 (page 4 of 4). Habitat requirements of birds observed using the LSP restoration area during ERC surveys conducted in August and September 2003 at Liberty State Park, Jersey City, NJ.

Common Name (*Scientific Name*)	Seasonal Use[a/]	Forest/ Woodland[b/]	Emergent Wetland[c/]	Shrubland[d/]	Successional Shrubland	Successional Field[e/]	Forest / Field Edge	Shrubland /Field Edge	North Cove
Willow Flycatcher (*Empidonax traillii*)	M				F	F,O	F	F	
Yellow Warbler (*Dendroica petechia*)	SR			F,B	F	F,O	F	F,B,O	

Key: F= Foraging habitat; B= Breeding habitat; W= winter habitat; O= Species observed in habitat type

Notes:
Species listed in this table are species recorded using the LSP restoration area during August – September 2003 (point counts, incidental sightings, and northern harrier surveys). Species flying over the site, using the South Cove Salt Marsh, or mowed lawn areas are not included.
a/ Seasonal use: R= Resident (may breed on-site); SR = Summer Resident (may breed on-site); M = Migrant (occurs in spring and fall); W = winter visitor (includes spring and fall); V = Visitor (occasionally occurs on-site). Source: Birds of Liberty State Park list.
b/ Forest/woodland includes successional northern hardwood and floodplain forest vegetative communities.
c/ Emergent wetland includes deep emergent marsh, shallow emergent marsh, and common reed dominated wetland vegetative communities.
d/ Shrubland includes maritime shrubland, successional shrubland, and shrub swamp vegetative communities.
e/ Successional field includes maritime grassland, successional old field, and common reed/mugwort vegetative communities.

Observations of the State-listed endangered and threatened raptors within the LSP Restoration site (northern harrier, short-eared owl, long-eared owl and Cooper's hawk) are discussed in Section 4, Endangered and Threatened Species.

Passerines

The New York and New Jersey Harbor (NY/NJ Harbor) area occupies a key location for migrating songbirds, as evidenced by the large number and variety of birds seen throughout the LSP Restoration site. Both short and long distance migrant songbirds pass through the Liberty State Park area; some of the species that nest in the NY/NJ Harbor area could nest in the LSP Restoration site, provided suitable habitat exists. Others may overwinter in the LSP Restoration site.

Breeding Bird Atlas data from New York and New Jersey indicate that up to 92 species of passerines are present in the NY/NJ Harbor area during the nesting season. The USFWS (1998) identified and described songbird species that are common breeders in urban areas near the Harbor. Nesting species include song sparrow (*Melospiza melodia*), American robin, gray catbird (*Dumatella carollinensis*), yellow warbler, and red-winged blackbird. Grassland birds such as grasshopper sparrow (*Ammodramus savannarum*), savannah sparrow (*Passerculcus sandwichensis*), and bobolink migrate through but rarely breed in the region. Because the NY/NJ Harbor area generally lacks large expanses of forest habitat forest interior species rarely breed in the region, but may pass through the area during migration.

Passerines were the most common group of birds observed during the August point count surveys. Observations of 24 species of passerines made up 61.7% of all bird observations. Most common species were European starling (*Sterna vulgaris*) (n = 93), American robin (n = 75), and gray catbird (n = 77). Other common species were song sparrow (n = 49), barn swallow (*Hirundo rustica*) (n = 44), eastern towhee (n = 26) and American goldfinch (n = 20) (Table 3-1). An additional 16 passerine species were identified on the LSP Restoration site by LSC staff, and 11 were sighted nearby.

Long-legged Waders

Breeding colonies of herons, egrets, and ibises exist in the Arthur Kill, Kill van Kull and Lower New York Bay (on Hoffman Island). Individuals from these colonies forage in shallow waters and marshes of the NY/NJ Harbor area. The most common waders in the Harbor are black-crowned night-heron (*Nycticorax nycticorax*), snowy egret (*Egretta*

thula), glossy ibis (*Plegadis falcinellus*), cattle egret (*Bubulcus ibis*), and great egret (*Casmerodius albus*) (USFWS 1998).

Although no wading birds were observed in the LSP Restoration site, yellow-crowned night heron (*Nyctanassa violacea*) (NJ threatened) black-crowned night heron (listed as threatened breeding populations), great egrets, snowy egrets, and green herons (*Butorides virescens*) were observed foraging in the South Cove Salt Marsh reference site during the August point count surveys (Table 3-1). In addition to the wading birds sighted during the August survey, LSC staff reported glossy ibis using the South Cove Salt Marsh.

Waterfowl

Thirty-two species of waterfowl utilize estuarine, riverine, palustrine wetlands and adjacent uplands of the NY/NJ Harbor area (USFWS 1998). The primary use of the harbor shoreline by waterfowl is for resting and feeding during the fall migration, which peaks in November, and as a wintering area. Waterfowl migrate down the Hudson River and/or along the Atlantic coast, stopping to rest and feed or to overwinter in the NY/NJ Harbor area. The northward migration from the NY/NJ Harbor estuary begins as early as February for some species, but for most occurs in March.

Common waterfowl species in the harbor area include: American black duck (*Anas rubripes*), mallard (*Anas platyrhynchos*), Atlantic brant (*Branta bernicla*) greater scaup (*Aythya marila*), canvasback (*Aytha valisneria*), and Canada goose (*Branta canadensis*), along with lesser numbers of bufflehead (*Bucephala albeola*), oldsquaw (*Clangula hyemalis*), red-breasted merganser (*Mergus serrator*), common goldeneye (*Bucephala clangula*), and American wigeon (*Anas americana*). Concentrations of waterfowl occur along the Staten Island shoreline, in Caven's Cove (Liberty State Park), in the Kill van Kull, and along the lower Hudson River. Up to 12 waterfowl species, including mallard and American black duck, nest in the NY/NJ Harbor area.

Although it is likely that several species of waterfowl use Liberty State Park as a resting stop during fall migration and as overwintering grounds, only three waterfowl species were observed during the August point count surveys. During the winter of 2003, LSC staff observed 10 species of waterfowl using the waters surrounding the LSP. In August 2003, mallard, American black duck, and Canada goose were observed flying over the point stations, as well as foraging in a ponded area in the southwestern portion of the LSP Restoration site, on the Mowed Lawn areas and in the South Cove Salt Marsh habitat.

Waterfowl are further discussed in two groups, based on feeding techniques, divers and dabblers.

Diving Ducks – Large overwintering rafts of diving ducks forage and rest within the NY/NJ Harbor area. About 15 species of diving ducks can be expected to pass through and use portions of the NY/NJ Harbor area for migration stopovers and for overwintering (Nichols 1995). Concentrations are composed primarily of canvasbacks, greater scaup, and buffleheads, with lesser numbers of mergansers (TI 1976; LMS 1984a, 1984b, 1987). These species and others are found along the mid-Atlantic Coast during winter with breeding occurring farther north and west in the Northeast, Midwest, Canada, and Alaska (Bellrose 1980).

LSC staff observed seven species of diving ducks in the winter of 2003. Bufflehead, canvasback, common goldeneye, mergansers (hooded and red-breasted), ruddy duck (*Oxyura jamaicensis*) and white-winged scoters (*Melanitta fusca*) were observed in the open waters surrounding the LSP Restoration site between January and April 2003 (Appendix A).

Dabbling Ducks breed and overwinter in the NY/NJ Harbor estuary. Mallards and American black ducks are common nesters in this area, and gadwall (*Anas strepera*), green-winged teal (*Anas crecca*), and blue-winged teal (*Anas discors*) are occasionally found nesting there (Andrle and Carroll 1988). Overwintering species include gadwalls, American black ducks, northern pintails (*Anas acuta*), and mallards (TI 1976; LMS 1984a, 1984b, 1987).

At least three species of dabbling ducks use the NY/NJ Harbor area to overwinter, and are expected to use the waters of the North and South Coves. Canada goose, American black ducks, and mallards are common species identified during the winter in the NY/NJ Harbor area (TI 1976; LMS 1984a, 1984b, 1987, 1996b), and were observed on the LSP Restoration site and/or the South Cove Salt Marsh during the August surveys. These species prefer marshes, bays, and estuaries for overwintering (Howe *et al.* 1978).

Twenty-seven observations of mallards and American black ducks made up 3.6% of all the bird sightings during the August 2003 point count surveys (Table 3-1). Five mallards were observed flying over the point count stations during the August wildlife surveys. Seven American black ducks were observed utilizing the Salt Marsh habitat of the South Cove of Liberty State Park during the point count surveys, and 3 were observed flying over point

stations. Several other species of dabbling ducks and geese were observed by LSC staff between January and March 2003, including American wigeon, brant, and gadwall.

Shorebirds

Up to 30 species of shorebirds migrate through the NY/NJ Harbor area. During migration, these shorebird species feed and rest in the marshes, mudflats, and shallow water areas of the Harbor. Migration of shorebirds occurs throughout much of the year; spring migration occurs between March and June, and fall migration begins in July and lasts through November (USFWS 1998). The most abundant shorebird species in the Harbor area are semipalmated sandpiper (*Calidris pusilla*), semipalmated plover (*Charadrius semipalmatus*), sanderling (*Calidris alba*), ruddy turnstone (*Arenaria interpres*), black-bellied plover (*Pluvialis squatarola*), dunlin (*Calidris alpina*), short-billed dowitcher (*Limnodromus griseus*), greater and lesser yellowlegs (*Tringa melanoleuca* and *T. flavipes*), and least sandpiper (*Calidris minutilla*).

Shoreline areas within the vicinity of the LSP Restoration site are characterized by a mixture of rip-rap shorelines, intertidal marsh, and mud flats. These areas provide foraging and resting habitat for shorebirds. The South Cove provides a relatively undisturbed intertidal mud flat, shoreline and marsh. The North Cove consists of hardened shoreline with a small mudflat area that is exposed at low tide. Four species of shorebirds (greater yellowlegs, lesser yellowlegs, spotted sandpiper, and least sandpiper) were recorded in the Salt Marsh habitat of the South Cove. Suitable habitat for shorebirds in the interior of the LSP Restoration site includes freshwater wetlands and shallow puddles in the Soil Stockpile Area. These shallow freshwater habitats are used for resting and foraging. Nineteen observations of shorebirds made up 2.5% of all birds observed during the point counts and northern harrier surveys (Table 3-1). Greater yellowlegs, lesser yellowlegs, and killdeer were sighted using the shallow puddles in the Soil Stockpile Area. Killdeer also used the Mowed Lawn areas.

LSC staff observed three additional shorebird species in LSP between April and June 2003, including black-bellied plover, Baird's sandpiper (*Calidris bairdii*), and spotted sandpiper (*Actitis macularia*) (Appendix A).

Gulls and Terns

Gulls are a common group in the NY/NJ Harbor area, where they nest, forage and overwinter. The shallow water shorelines of the North and South Coves of Liberty State

Park provide foraging habitat for gulls, while the Mowed Lawn picnic areas provide an additional food source. Gulls were commonly observed flying over the LSP Restoration site, and in the mowed lawn areas of the park. Four species of gulls were recorded during the wildlife surveys. Observations of herring gulls (*Larus argentatus*), greater black-backed gull (*Larus marinus*), ring-billed gull and laughing gull (*Larus atricilla*) comprised 10.8% of all individual bird observations during the avian surveys. Of these species, ring-billed gull was the most commonly observed (Table 3-1).

No terns were observed on the LSP Restoration site during the August 2003 point count surveys. Three species, common tern (*Sterna hirundo*), least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*), were observed using the off-site habitat of the South Cove. The least tern was sighted flying over the South Cove Salt Marsh, and the black skimmer was observed in the open water. Common terns were observed roosting on walkway railings and other structures and foraging over open water areas.

Cormorants

Observations of cormorants in the LSP Restoration site during the point count surveys were limited to 10 sightings of the double-crested cormorant (*Phalacocorax cardo*) flying over the point stations, and one double-crested cormorant observed in the South Cove Salt Marsh. Great cormorants (*Phalacocorax auritus*) were observed by LSC staff in March 2003.

Rails and Coots

Three species of rails (clapper rail [*Rallus longirostris*], Virginia rail [*Rallus limicola*], and sora [*Porzana carolina*]) and the American coot (*Fulica Americana*) may breed in the NY/NJ Harbor area (Andrle and Carroll 1988). No rails were observed during the point count surveys, but LSC staff sighted an American coot in March 2003 and heard clapper rails calling in May 2003 in the South Cove Salt Marsh (Appendix A).

Other Birds

Several other birds not falling under the major categories were observed on the LSP Restoration site and in the North and South Coves of Liberty State Park during the point count surveys and supplemental observations. During the August surveys, downy woodpeckers were observed on six occasions, five of which were in Successional Northern Hardwood habitat. Chimney swifts were observed on 21 occasions, most of which were flying over the site. LSC staff recorded observations of wild turkey (*Melegris gallopavo*) and ring-necked pheasant (*Phasianus colchicus*). Northern flicker

Ten mammal species were observed within several habitat types on the LSP Restoration site during August, September, and October 2003 (Table 3-4). During the small mammal trapping survey 99 individuals of four species were captured. White-footed mice (*Peromyscus leucopus*) were the most frequently encountered species, with 93 (0.9/100 TNs) individuals collected. Four meadow voles (*Microtus pennsylvanicus*) (0.04/100 TNs), one Norway rat (*Rattus norvegicus*) (0.01/100 TNs), and one house mouse (*Mus musculus*) (0.01/100 TNs) were also captured.

Meadow voles were less common than expected based on the available habitat and the prior TI study. Their numbers may fluctuate greatly as they are a primary prey species for many predators including northern harriers, red-tailed hawks, and barn owls, which forage within the LSP Restoration site year-round. Other species such as feral cats (*Felis catus*) and raccoons may also prey upon meadow voles. A second possible explanation for the low numbers of captures is that meadow voles may be a trap-shy species that is less likely to be caught in live traps; therefore, their numbers per 100 TNs may be under represented.

3.4 SUMMARY

Seventy species of birds have been observed in the LSP Restoration site during this study and by staff of the Liberty Science Center, and an additional 61 species were observed in the South Cove Salt Marsh, or in other LSP habitats outside of the proposed restoration site.

Relatively few amphibian, reptile and mammal species were found on the LSP Restoration site, despite the availability of suitable habitat. This is likely the result of the ecological communities forming in a highly urbanized area. A lack of habitat corridors from other ecological communities most likely impedes colonization of the LSP Restoration site.

Table 3-4. Mammals observed at Liberty State Park during the August 2003 wildlife survey and October small mammal trapping survey.

Common Name	Scientific Name	Relative Abundance In Liberty State Park
Eastern Cottontail	*Sylvilagus floridanus*	Uncommon
Woodchuck	*Marmota monax*	Uncommon
Gray Squirrel	*Sciurus carolinensis*	Uncommon
White-footed Mouse	*Peromyscus leucopus*	Very Common
Meadow Vole	*Microtus pennsylvanicus*	Common
Muskart	*Ondatra zibethicus*	Uncommon
Norway Rat	*Rattus norvegicus*	Uncommon
House Mouse	*Mus musculus*	Uncommon
Raccoon	*Procyon lotor*	Uncommon
Domestic Cat	*Felis catus*	Common
Feral Dog	*Canis familiaris*	Common

4. ENDANGERED AND THREATENED SPECIES

The use of the undeveloped portion of Liberty State Park (LSP) by species listed by the New Jersey Department of Environmental Protection (NJDEP) as threatened or endangered has been evaluated as a component of this ERI. This section presents the results of these evaluations.

4.1 ENDANGERED AND THREATENED VEGETATION

One New Jersey state-endangered plant, Torrey's rush (*Juncus torreyi*), was observed on the LSP Restoration site. This species was observed on vegetation Transect 6 in a maritime grassland community. Although the species was found in an upland plant community, Torrey's rush is a FACW plant that prefers wet habitats and is intolerant of shade. Shallow emergent marshes within the LSP Restoration site may provide suitable habitat for this species. This species is present in relatively low numbers on the LSP Restoration site.

4.2 ENDANGERED AND THREATENED WILDLIFE

Past documentation of endangered and threatened species (ETS) necessitated further investigations of ETS use of the LSP Restoration site. Five ETS bird species have been observed on the site by the staff of the Liberty State Park Interpretive Center (IC) and the Liberty Science Center (LSC). LSC staff provided a summary of bird observations for the period extending from January through June 2003 (Britt 2003). These records included: northern harrier, Cooper's hawk, long-eared owl (*Asio otus*), short-eared owl (*Asio flammeus*), and savannah sparrow (*Passerculus sandwichensis*) during the winter and spring of 2003. IC staff provided a summary of northern harrier sightings from 2001-2003. The status, habitat requirements and a summary of habitat use for ETS within the LSP Restoration site between 2001 and 2003 are presented in Table 4-1.

The following text describes the habitat requirements and the diets of the ETS that are known to use the LSP Restoration site.

Table 4-1. Status, habitat requirements, and records of sightings for New Jersey State-listed threatened and endangered species observed within the 225-acre study area at Liberty State Park.

Common name (*Scientific name*)	Status[1/]	Habitat requirements	Habitat use/sighting information for 225-acre study area
Northern harrier (*Circus cyaneus*)	NJ T/U	Forage, nest, and roost in marshes (freshwater and saltwater), wet meadows, grasslands, agricultural fields, shrublands, and riparian corridors (NJDEP 1995; Macwhirter and Bildstein 1996; Banner and Schaller 2001). Small rodents, particularly voles, and birds are the primary prey of adult northern harriers (Dechant et al. 2001). Nests on the ground in patches of dense vegetation, generally dominated by grasses. Preferred nesting habitat has few shrubs or with shrubs <1 foot tall (Banner and Schaller 2001). Habitat value may be reduced in areas with shrubs and trees >7 feet tall because this vegetation could provide habitat for predators (Banner and Schaller 2001). Patch size for nesting habitat ranges from 20 to 297 acres (Banner and Schaller 2001; Dechant et al. 2001).	• Nesting attempts within early successional habitat types in 2001, 2002, and 2003. • Winter 2003 - used fenced Dredge Material Storage Area as winter roost. • Summer/Fall 2003 – observed foraging or flying over early successional habitats numerous times.
Cooper's hawk (*Accipiter cooperii*)	NJ T/T	Forage, nest, and roost in deciduous forest, often near a field edge (Bull and Farrand 1977; Baicich and Harrison 1997). Commonly nest in open forests rather than those with dense stands of trees (Cornell Lab of Ornithology 1997). Nests generally located in deciduous trees 20-60 feet above the ground. During migration, documented using a wide variety of habitat types and can be associated with any habitat containing trees or shrubs (NJDEP 1995).	• Winter/spring 2003 - observed within 250-acre study area. • August/September 2003 – observed flying from forested floodplain habitat within 250-acre site. Also seen foraging at South Cove. • October 2003 – observed in successional hardwoods/maritime shrubland, near Wildlife Survey Point B-05.
Long-eared Owl (*Asio otus*)	NJ T/T	Nests in dense forest stands. In NJ, nesting habitat is commonly associated with hedgerows and woodlots interspersed with agricultural fields and forest openings. Winter roosts often in dense pines surrounded by fallow fields, Shrub habitat, and deciduous woodlots. Primary prey is voles; therefore, foraging habitat is generally fields and brushy habitats (NJDEP 1995).	• January 2003 – observed foraging over Dredge Material Storage Area. • Reported to roost in planted pines in southwestern corner of 250-acre site.
Short-eared Owl (*Asio flammeus*)	NJ E/U	Unconfirmed or possibly extant breeder in NJ (ENSP 2002a). Occurs widely as a winter resident. Breed, forage, and roost in freshwater and saltwater marshes, bogs, and old fields. Roosting has been documented in NJ at abandoned dumps, quarries, gravel pits, storage yards, dunes, and thickest. Often roosts communally with northern harriers (Schneider and Pence 1992; Dechant et al. 2001). May require areas >125 acres for foraging (NJDEP 1995).	• February 2003– one observed foraging over and flying high over fenced Dredge Material Storage Area.

Table 4-1 (page 2 of 2). Status, habitat requirements, and records of sightings for New Jersey State-listed threatened and endangered species observed within the 225-acre study area at Liberty State Park.

Common name (*Scientific name*)	Status[1/]	Habitat requirements	Habitat use/sighting information for 225-acre study area
Bobolink (*Dolichonyx oryzivorus*)	NJ T/T	Breed in hayfields, meadows, and marshes with taller grasses and forbs. Prefer moist to dry habitats for foraging and breeding. In northern NJ, breeding populations primarily found in Hunterdon, Warren, and Sussex Counties (NJDEP 1995).	• September 2003 – observed in dredge material mugwort/ maritime grassland community.
Savannah Sparrow (*Passerculus sandwichensis*)	NJ T/T	Open fields, meadows, pastures, salt marshes, and vegetated landfills dominated by grasses and forbs (Baicich and Harrison 1997; ENSP 2002b). Tolerant of early woody growth. Sometimes shares nesting habitat with bobolinks (Wander 1999). NJ is at southern limits of the species' breeding range (ENSP 2002b). Nesting habitat and non-breeding season habitat are similar.	• April 2003 – 14-16 individuals observed in dredge material mugwort community in northwest corner of 250-acre study area (in vicinity of Wildlife Observation Point C-01).
Torrey's rush (*Juncus torreyi*)	NJ E	Wet prairies, meadows, and sandy or muddy banks of rivers and streams (USGS undated). This species has a wetland indicator status of FACW[2/] and is intolerant of shade. It is also intolerant of saline environments (NRCS 2003).	• August 2003 – observed in maritime grassland community along Segment 6 of Transect 6.

1/ NJ State Status Descriptions: E – Endangered. T – Threatened. U – Undetermined. Status for animals separated by a slash (/) indicates dual status. The first status refers to the species breeding population. The second status refers to the species migratory or winter population.
2/ FACW: Facultative Wetland Species. The probability of this species being found in wetlands is 67-99%.

301

Northern Harrier

The northern harrier usually nests and forages in open marsh, field, or other early successional habitats. Northern harriers nest in large patches of grassland or old field habitat that are generally between 20 and 300 acres (Banner and Schaller 2001; Dechant et al. 2001) in size. Foraging and winter roosting habitat are similar to nesting habitat (NJDEP 1995; Dechant *et al.* 2001); but, uplands may be preferred over wetlands as winter roosts (Banner and Schaller 2001). Northern harriers are opportunistic feeders that typically forage over marshes and low vegetation such as grass meadows (Aslop 2001, Beans and Niles 2003, Conn. DEP 2003, Mass. DFW 2003). Common food items vary with season and availability but include small rodents such as voles and mice, as well as small birds, amphibians, reptiles, insects, crayfish, and carrion (Aslop 2001, Beans and Niles 2003, Conn. DEP 2003, Mass. DFW 2003). Northern harriers exhibit sexual dimorphism in prey selection, with the larger females able to secure larger prey, such as waterfowl, than the males (Beans and Niles 2003).

Vegetative communities within the LSP Restoration site that provide the most suitable foraging and nesting habitat for northern harriers include Shallow Emergent Marshes, Maritime Grassland, Successional Old Field, Common Reed-dominated Wetlands, and Common Reed/Mugwort.

Northern harriers are believed to nest in the 42-acre Dredged Material Storage Area, a block of early-successional habitat, which is within the estimated minimum nesting patch size. The Successional Old Field community in the Soil Stockpile Area also provides a block of suitable nesting habitat. Although the LSP Restoration site offers suitable nesting habitat, its value is somewhat diminished due to the presence of less than optimal habitat characteristics. Within the LSP Restoration site, potential northern harrier nesting habitat contains patches of shrubs and trees, which are believed to reduce the value of nesting habitat because they provide habitat for potential nest predators (e.g., American crows (*Corvus brachyrhynchos*) and great horned owls) (Macwhirter and Bildstein 1996; Banner and Schaller 2001).

Northern harriers may choose to roost on the LSP Restoration site because of the scarcity of nearby early-successional upland habitats in the region. Additionally, the fencing that surrounds the LSP Restoration site may make it less susceptible to human disturbance. The scattered cottonwood trees on the site serve as resting and vantage points for the harriers.

Cooper's Hawk

Cooper's hawks nest in woodlots and forests interspersed with fields and other open habitats (Bull and Farrand 1977). Nests are commonly located in deciduous trees, 20-60 feet off the ground, often near a field/forest edge (Cornell Lab of Ornithology 1997). During migration, they have been documented using a wide variety of habitat types and can be associated with any habitat containing trees or shrubs (NJDEP 1995).

The Cooper's hawk generally resides in wooded areas where they forage (Beans and Niles 2003). The Cooper's hawk diet consists primarily of birds such as thrushes, jays, woodpeckers or sparrows, while small mammals, fish, poultry, reptiles and amphibians are occasionally eaten (Aslop 2001, Beans and Niles 2003). The Cooper's hawk, like the northern harrier, exhibit sexual dimorphism in prey selection with the larger females able to secure larger prey.

The patchy environment of the LSP Restoration site and surrounding lands are consistent with literature descriptions of suitable Cooper's hawk foraging and nesting habitat; however, nesting attempts at LSP have not been documented.

Long-eared Owl

Long-eared owls are generally associated with field and meadow habitat interspersed by woodlots that are often dominated by dense conifers. This species usually nests in dense forests, but in New Jersey nesting most often occurs in hedgerows or woodlots associated with agricultural land (NJDEP 1995). Roosting habitat is similar to nesting habitat.

Long-eared owls' primary foraging habitat is open fields characterized by low-growing vegetation where they hunt for small mammalian prey (NJDEP 1995). The diet consists primarily of voles and small rodents, and includes small birds, snakes and insects (Aslop 2001, Beans and Niles 2003, Conn. DEP 2003, Lawrence 2001). Over forty species of mammals, some as large as snowshoe hares, have been identified in the diet of long-eared owls (Lawrence 2001).

Long-eared owls are associated with wooded and early-successional habitats within the LSP Restoration site. Conifers that were planted in the southern corner of the LSP Restoration site serve as a winter roost for long-eared owls (Gallagher 2003). Although

habitat within the LSP Restoration site may be suitable nesting habitat for long-eared owls, only wintering individuals have been observed.

Short-eared Owl

Short-eared owls inhabit coastal tidal and brackish marshes, fallow fields, pastures, and grasslands. The species nests and roosts on the ground (NJDEP 1995; Baicich and Harrison 1997). Short-eared owls commonly share winter roosts with northern harriers (Dechant *et al.* 2001). Published studies on short-eared owls suggest this species prefers large blocks of undisturbed habitat greater than 125 acres for foraging, roosting, and nesting (NJDEP 1995). Breeding has been documented in habitat patches ranging from 60 to over 300 acres (ENSP 2002a).

The short-eared owl preys mainly on small mammals such as voles, mice, shrews, rats and rabbits (Aslop 2001, Beans and Niles 2003, Conn. DEP 2003, Lawrence 2001, NYSDEC 2003). Voles are considered a large portion of the short-eared owl diet and consumption of two meadow voles per day has been recorded (Beans and Niles 2003, Lawrence 2001). The diet also includes insects and small birds (Aslop 2001, Beans and Niles 2003, Conn. DEP 2003, Lawrence 2001).

Although suitable nesting, foraging, and roosting habitat for short-eared owl is present in the interior portion of the LSP Restoration site, only one foraging individual was observed using the LSP Restoration site during the winter of 2003.

Bobolink

The bobolink is a Neotropical migrant that breeds from New Jersey west to Colorado and north to Newfoundland and British Columbia (Bull and Farrand 1977). In New Jersey, most breeding occurrences have been documented in northern and western portions of the state (NJDEP 1995). This species is generally associated with open agricultural, grass, forb or hay fields and wet meadows (Aslop 2001, Beans and Niles 2003).

The bobolink's diet varies with season and availability, but typically consists of seeds and invertebrates, including caterpillars, beetles, ants, spiders, centipedes and grasshoppers during summer, and seeds, corn and other grains during migration (Aslop 2001, Beans and Niles 2003).

At LSP, bobolinks are classified as migrants that may visit the park during the spring and fall (NJDEP 2003). Suitable foraging and resting habitat for bobolinks exists in the emergent wetlands and early-successional upland habitats on the LSP Restoration site.

Savannah Sparrow

Savannah sparrows inhabit open lands including fallow fields, grasslands, upland meadows, salt marshes, and vegetated landfills (Bull and Farrand 1977; Baicich and Harrison 1997; ENSP 2002b). The species is relatively tolerant of succession and will occupy fields that contain woody growth. Nests are located on the ground. During the non-breeding season, savannah sparrows use drier habitats including coastal dunes, roadside edges, pastures, and golf courses (ENSP 2002b). This species is a common migrant in New Jersey (Wander 1997).

The savannah sparrow feeds on seasonally abundant seeds, snails, and insects, such as beetles, grasshoppers, ants, butterflies/moths, dragonflies, and spiders (Aslop 2001, Beans and Niles 2003).

Savannah sparrows were observed using the Successional Old Field within the Soil Stockpile Area during April 2003. Although savannah sparrows were only seen in one vegetative community type within the LSP Restoration site, the Successional Shrubland, Shrub Swamp Wetland, Maritime Grassland, and Common Reed/Mugwort, communities also provide suitable habitat for this species.

4.2.1 Endangered and Threatened Bird Survey Methodology

Because the northern harrier has been documented using the LSP Restoration site throughout the year and has unsuccessfully attempted nesting for two consecutive years (Britt 2003, Gallagher 2003), it is the ETS bird species of particular concern for this project. The ETS survey methodology was designed to determine habitat use by northern harriers within the LSP Restoration site. Information collected from these surveys will help to determine minimization and avoidance strategies for the long- and short-term impacts to the northern harriers within the LSP Restoration site from the habitat restoration project. The design of the restoration effort will also be tailored to maximize habitat value for the northern harrier.

To assess the use of the LSP Restoration site, site-specific field surveys were conducted during the summer of 2003. Weekly surveys for northern harriers were conducted from

seven permanent survey stations between August 4 and September 5, 2003 (Figure 4-1). Six of these stations were located within the 225-acre LSP Restoration site, and two were located outside the perimeter. Station locations were selected within or adjacent to large blocks of suitable habitat where northern harrier activity had been previously reported. These stations allowed for longer observations of larger blocks of habitat while providing observers with different vantage points. Five stations offered observations of the Dredged Material Storage Area and two stations were located within the Soil Stockpile Area.

Surveys were conducted a minimum of once per week from each survey location over the five week survey period. Surveys began 15 minutes before sunrise. At each point, two observers watched for northern harriers and other wildlife over a 15-minute survey period. During this survey period, wildlife species that were seen or heard were identified to species and numbers of individuals were recorded.

4.2.2 Results of Endangered and Threatened Species Surveys

Cooper's hawks, bobolinks and northern harriers were observed on the LSP Restoration site during the ETS surveys. Cooper's hawks were seen flying to and from wooded portions of the LSP Restoration site. Bobolinks were observed in the Dredged Material Storage Area in September 2003 (Table 4-1).

Observations of northern harrier foraging were common during the ETS surveys; harriers were observed on twelve occasions. Field crews conducting vegetation surveys also sighted northern harriers regularly. A minimum of three individuals were observed on-site during the survey period: one male, one female, and one juvenile. Northern harriers were most frequently sighted in the Dredged Material Storage Area (the location of the proposed Salt Marsh restoration) and the Soil Stockpile Area (the location of the proposed Grassland Berm). On two occasions, individual birds were seen perched in trees (Table 4-2).

US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Liberty State Park Northern Harrier Observation Stations

Figure 4-1

Table 4-2. Summary of northern harrier observations during the August 2003 ETS surveys at Liberty State Park, Jersey City, NJ.

Date	Observation Location	Number of Individuals Observed	Notes
5 Aug.	Dredged Material Storage Area	2	Male and juvenile perched in tree near northwest limits of dredge spoil area.
6 Aug	Soil Stock Pile Area	1	Over field, flying east
6 Aug	Center wetland (near Wildlife Observation Point A-02)	1	Male perched in tree
6 Aug	Road edge (near Wildlife Observation Point B-02)	1	Antagonistic encounter between Northern Harrier (NOHA) and Red-tailed Hawk (RTHA). Male NOHA chased RTHA from tree.
12 Aug	Dredged Material Storage Area	1	Female, flying over fenced Dredged Material Storage Area
12 Aug	Fenced area between Dredged Material Storage Area and Freedom Way	1	Male, foraging
13 Aug	Soil Stock Pile Area (from Wildlife Observation Point C-01)	1	Female, foraging
19 Aug	Flyover	1	Female observed flying east to west over site in vicinity of Wildlife Observation Point A-02 towards Wildlife Observation Point C-01.
20 Aug	South Cove	1	Flying towards Caven Cove
21 Aug	Soil Stock Pile Area (from Wildlife Observation Point C-01)	1	Female, foraging
21 Aug	Dredged Material Storage Area	1	Male, flying low
3 Sept	Dredged Material Storage Area	1	One individual flew from fenced Dredge Material Storage Area towards south cove.
29 Oct	Wildlife Observation Point A-04	1	Female, flying over maritime grassland/dredge material mugwort.

Table 4-2 (Page 2 of 2). Summary of northern harrier observations during the August 2003 ETS surveys at Liberty State Park, Jersey City, NJ.

Date	Observation Location	Number of Individuals Observed	Notes
29 Oct	Mammal Trapping Site X-06	1	Juvenile, flying over successional old-field adjacent to Millennium Park
31 Oct	Wildlife Observation Point B-04	1	Juvenile, foraging in successional old-field near Audrey Zapp Drive
31 Oct	Parking Lot Across from Interpretive Center	2	1 juvenile, 1 adult flying from north to south. Adult remained within 225-acre site. Juvenile continue south towards South Cove.

4.3 SUMMARY

Six state-listed bird species and one state-listed plant species have been documented within the LSP Restoration site. Of the six state-listed birds, only the northern harrier has been documented as having recently nested within the LSP Restoration site. However, the nesting success during the summer of 2003 is uncertain. Northern harriers are year-long residents of LSP, and along with long-eared owls, use the site as a winter roosting and/or foraging site. Short-eared owls have been observed foraging on the LSP Restoration site during the winter but have not been documented using the area for nesting or roosting. Cooper's hawks are considered potential year-round residents at LSP; however, their presence within the LSP Restoration site has only been documented during migration and winter. Savannah sparrows and bobolinks are known to use the LSP Restoration site during migration.

5. NORTH COVE AQUATIC COMMUNITIES

Estuaries are typically highly productive ecological systems, characterized by vegetated shorelines and tidal wetlands. However, intense coastal development with increasing urbanization and industrial use, often result in modification of estuaries as in the case of the Hudson–Raritan Estuary. This loss of marginal wetlands and shallows along with a variety of urban and industrial inputs has impacted the estuarine systems. Aquatic biotic communities associated with watersheds with high urban land use are generally characterized by lower species diversity, altered community composition and reduced habitat diversity (Dauer et al 2000). NY/NJ Harbor demonstrates the impacts of urbanization within an estuarine system. Despite extensive changes and urbanization of NY/NJ Harbor it is still a productive estuary supporting diverse communities of fish and invertebrates (Woodhead *et al.* 1999).

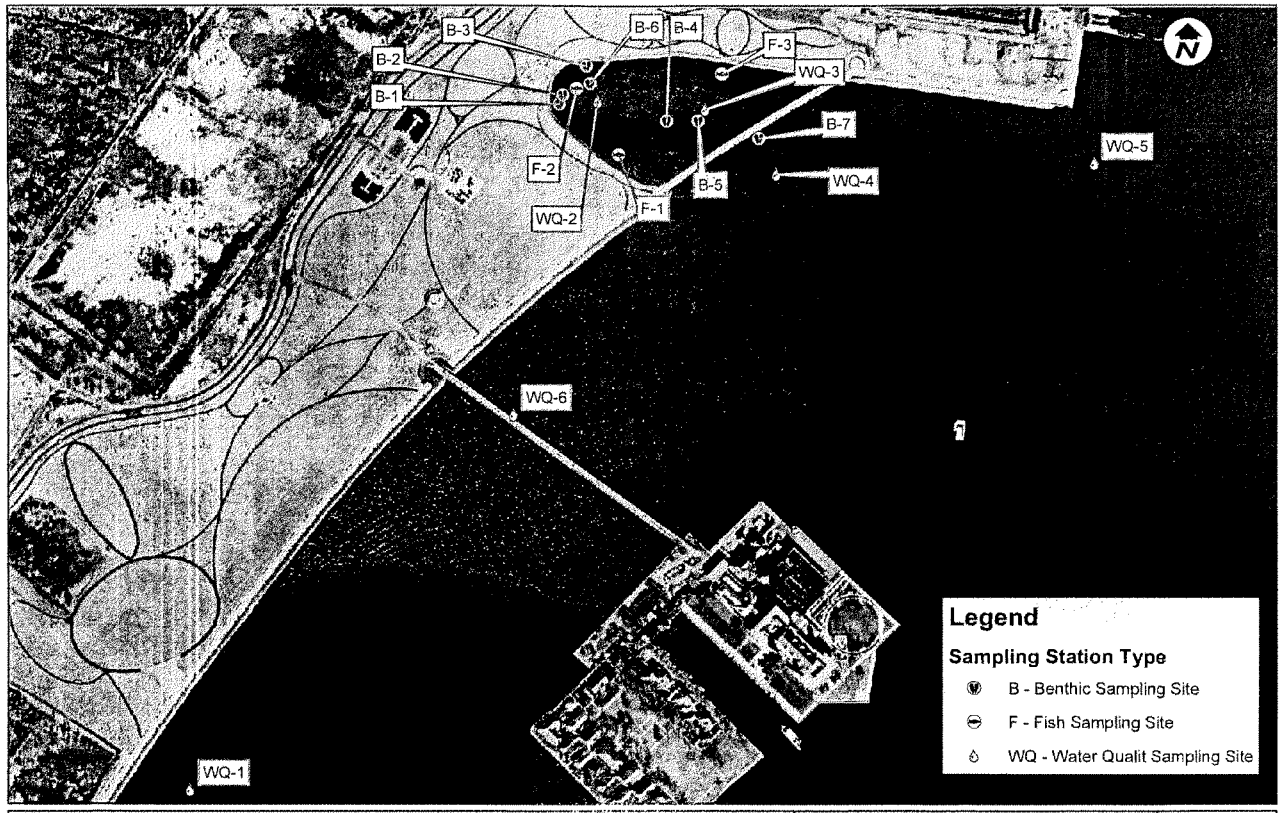
The North Cove is located in the northeast corner of Liberty State Park. The cove is approximately 800 feet long and is 850 feet at its widest point, with depths ranging from five to nine feet in the center of the Cove (Figure 5-1). The North Cove is characterized by a riprap shoreline, steep slopes and areas of unconsolidated sediments.

5.1 WATER QUALITY

The water quality data for both baseline conditions and wet weather conditions can be found in Appendix C. Additional water quality data is being collected by USACE from both surface water and ground water locations. The water quality data summarized in Appendix C will be analyzed with the additional data when it becomes available.

5.2 BENTHIC INVERTEBRATES

Benthic invertebrate communities are important links in the flow of energy and cycling of nutrients between the sediment and the water column in marine environments. The lower trophic levels in an estuary influence fish populations through their role as a major food source. The infaunal community (benthos) is composed of suspension and deposit feeders, represented by polychaete worms, crustaceans and bivalves. The benthos life strategies and sediment characteristics are tightly coupled with grain size, chemistry and physical properties of the sediment, which control benthic organism colonization. Benthic organisms can serve as bioindicators, because some organisms are more tolerant of pollution and poor water quality conditions than others. Community composition may be indicative of water and sediment quality.



US Army Corps of Engineers®
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Sampling Stations in the North Cove of Liberty State Park

Figure 5-1

5.2.1 Methodology

The benthic invertebrate sampling program was designed to: (1) characterize the existing conditions of the benthic community in the North Cove of Liberty State Park; (2) collect baseline data to use in assessing the level of success attained in the restoration; (3) establish a benthic baseline for predicting bottom environments that may be created in the proposed tidal creek; and (4) assess possible impacts to the benthic environment that may result from the construction of the creek. The program included benthic grab sampling for both organisms and sediments, identifying the organisms to the lowest taxonomic level practicable, and sediment analysis for grain size distribution and organic content.

Twenty one samples were collected from seven stations (3 replicates at each station) within the North Cove using a standard Ponar grab ($0.05m^2$) on August 18, 2003. Four stations were located along a transect that began at the proposed mouth of the tidal creek and ended outside of the promenade. The remaining three stations were located in the shallowest water possible at the edge of the Cove and were taken in the intertidal zone at low tide (Figure 5-1). Sample station locations were documented with Global Positioning System (GPS).

In the field, the sediment collected in the benthic grabs was characterized at each station. The sediment texture and/or shell hash was recorded, and obvious odors such as hydrogen sulfide or petroleum or lack of odor were noted. The sediment from the grab samples was then washed through a 500-micron sieve, and the remaining organisms were collected and preserved for laboratory analysis.

Additional grab samples were taken from each of the stations to obtain sediments, which were collected and sent to Advance Testing Laboratory, Campbell Hall, NY for analysis of grain size distribution and organic content.

The benthic organism samples were sorted, enumerated and identified to the lowest practicable taxon at the LMS Nyack, NY laboratory. Only whole organisms or parts of organisms with heads were counted, but all identifiable fragments were saved.

The following indices were calculated to compare the benthic community sampled at each location:

1. Organism density – the number of organisms collected per meter square of sediment.

2. Organism biomass – the weight (g) of the organisms collected per meter square of sediment.
3. Taxa richness – the number of individual taxa collected in each sample
4. Diversity (Shannon-Weiner Function H') - This order is characterized by the number of individuals found for each species/category, and is calculated with the equation:

$$H' = -\sum P_i \ln P_i$$

where P_i = the # of individuals of species i ÷ the total # of individuals in the community

5.2.2 Results of Benthic Community Sampling

The sediment grain size and benthic community characteristics varied greatly between the seven stations in the North Cove. A summary of the sediment characteristics and the abundance, diversity, and biomass of major groups is presented in Table 5-1.

Coarse, odorless sediments were found close to the shoreline at stations B-1 and B-2, and in the center of the cove at Station B-5. Finer sediments were collected from stations B-7, B-6, B-4 and B-3. These fine-grained sediments were black soft muds containing a strong petroleum odor and oily globules. Organic content of the sediments ranged from 3.1% at Station B-2 to 10.2% at Station B-1 (Table 5-1).

The variability of sediment characteristics and wave energy within the North Cove has created a patchy distribution of organisms based on differing habitat requirements. The mean density of organisms from all samples (n=7) taken in the cove was 737 organisms/m^2. Density was highest at stations B-4 and B-7, located approximately 400 and 700 feet from the shoreline, respectively. The grab sample at Station B-4 collected 1,300 organisms, and the sample at Station B-7 collected 1,320 organisms. The fewest organisms were collected from the stations located nearest to the shoreline; both stations B-1 and B-3 contained 340 organisms.

Samples containing fine-grained sediment tended to contain a more diverse assemblage of organisms than those from coarse-grain substrates. The most diverse assemblage was collected from the fine-grain sediments at stations B-6 (located along the transect approximately 150 feet from the shoreline) and B-7. Ten taxa were collected at each of these stations. Only one type of organism was collected from the coarse sediments at Station B-2, located close to the shoreline. A complete list of the organisms collected in the North Cove is presented in Appendix A.

Table 5-1. Summary Data for Benthic Grab samples at the North Cove of Liberty State Park, Jersey City, NJ.

Station	Density (animals/m^2)	Biomass (g/m^2)	Richness (# taxa)	Diversity	Dominant Group (by biomass)	Dominant Group (by density)	Particle Size Distribution[1]		Organic Content (by Weight)
							Coarse	Fine	
1	320	0.59	3	1.01	Arthropoda	Arthropoda	98.0%	2.0%	10.2%
2	520	26.58	1	0.00	Arthropoda	Arthropoda	99.8%	0.2%	3.1%
3	340	177.59	6	2.42	Annelida	Arthropoda	25.9%	74.1%	8.6%
4	1300	38.08	6	0.87	Annelida	Annelida	11.0%	89.0%	6.8%
5	620	12.53	5	1.34	Annelida	Annelida	89.0%	11.0%	9.8%
6	740	133.17	10	2.58	Mollusca	Annelida	23.9%	76.1%	8.8%
7	1320	21.73	10	2.44	Annelida	Annelida	16.0%	84.1%	7.3%

[1] - "Coarse" includes Gravel and Sand particles; "Fine" includes Silt and Clay particles

Fine-grained sediments also contained greater biomass than coarse sediments. The mean biomass of infaunal communities from all seven stations in the North Cove was 59.0 g/m^2, but the biomass ranged from 0.6 g/m^2 at Station B-1, where gravel and sand made up 98% of the substrate, to 177.6 g/m^2 at Station B-3, where 74% of the substrate was composed of silt and clay (Table 5-1). A discussion of the benthic communities collected at each station is presented below.

Station B-1

The benthic community collected from the coarse sediments at Station B-1 contained the lowest density, 320 animals/m^2, and the lowest biomass, 0.6 g/m^2 (Figure 5-1) Two of the three replicate samples contained no organisms, and only three taxa were collected from the third sample. Two taxa of amphipods (Melitidae and *Gammarus* sp.) represented 67% of the infaunal community. Small polychaete worms (*Capitella* sp.) were also collected in low numbers. The sediments collected from Station B-1 had the highest content of organic materials, 10.2% by weight.

Station B-2

The coarse sediments collected from Station B-2 contained only horseshoe crabs (*Limulus polyphemus*). When compared to other North Cove stations, the infaunal community was low in abundance (520 animals/m^2), biomass (26.6 g/m^2), and diversity (0.0). The organic content of the sediments was the lowest for all stations, 3.1% by weight.

Station B-3

The sample collected from Station B-3 was low in organism abundance, 340 animals/m^2, however species diversity was highest among the seven stations. Polychaetes worms (*Capitella* sp., *Leitoscoloplos* sp., and *Glycera* sp.) dominated the benthic community. Low numbers of gastropods and hermit crabs were also present. The mean infaunal biomass was high due in part to gastropod shells, 177.6 g/m^2. Polychaetes comprised 12% of the biomass. The substrate was fine grain sediments, predominately silt and clay. The organic content of these sediments was one of the highest, 8.6% by weight.

Station B-4

At Station B-4, the fine-grained sediments contained low densities (340 animals/m^2) of several different groups. Polychaete worms (mainly *Leitoscoloplos* sp. and *Capitella sp*) made up about 83% of the catch. The bivalve, *Mulinia lateralis* and other polychaetes were also present in low numbers. The mean biomass contained in the replicate samples

was 38 g/m^2. The benthic community from this station was approximately four times more abundant than sites along the beach at the back end of the cove. The substrate was silt and clay particles that contained a strong petroleum odor. The organic content of the sediments was 6.8%, by weight.

Station B-5

The coarse sediments collected at Station B-5 contained only polychaete worms, with *Leitoscoloplos* sp. and *Capitella* sp. making up 96% of the organisms. The sample contained relatively low organism densities (620 animals/m^2) and biomass (13 g/m^2). The organic content of the sediments at Station B-5 was the second highest for all stations, 9.8%, by weight.

Station B-6

Polychaetes and oligochaetes dominated the benthic community collected from the fine-grained sediments at Station B-6. The infaunal community had the highest species diversity, 2.58 and the biomass was relatively high, 133 g/m^2. Three taxa of polychaete worms (*Leitoscoloplos* sp., *Capitella* sp., and Paraonidae) were most abundant, comprising 70% of the infaunal community. Gastropods (*Illynassa obsoleta*), mysid (*Neomysis americana*) and amphipods (Melitidae) were also present. The mean abundance of the community was 740 animals/m^2. The organic content of the sediments was 8.8%, by weight.

Station B-7

The benthic community collected from the fine grain sediments at Station B-7 contained the highest density of organisms, 1320 animals/m^2, and diversity with 10 taxa. Eight taxa of polychaetes (including the bioindicators *Leitoscoloplos* sp., *Capitella* sp., and *Streblospio benedicti*) were the most abundant organisms, comprising 80% of the infaunal community. Other infaunal organisms present in small numbers included amphipods (Melitidae) and shrimp (*Crangon septemspinosa*). The mean biomass was 22 g/m^2. The sediments collected from Station B-7 had the second lowest content of organic materials, 7.3%, by weight.

5.2.3 Summary

The Hudson-Raritan Estuary has undergone intense urbanization; nevertheless, it supports a productive invertebrate community. The physical characteristics of the North Cove are typical of low energy coastal environments where settling of silt and organic matter occurs near the shoreline and wave action re-suspends fine particles in the water

column on which zooplankton can feed. The high organic content in the sediments near the shoreline of the North Cove (10.2%) could be attributed to runoff and/or sewage from nearby combined stormwater outfalls.

The samples were dominated by polychaete worms, which were collected at all seven sampling sites. Polychaetes are bioindicators of environmental stress due to their ability to tolerate poor environmental conditions such as low dissolved oxygen and high turbidity. Different species of polychaetes exhibit different levels of tolerance to environmental stress. Several of the polychaetes found in the North Cove (*Capitella* sp., *Leitoscoloplos* sp., *Streblospio benedicti* and *Nephtys* sp.) are often found in sediments associated with impacted environments impacted by petroleum hydrocarbons or other stressors (Llanso 1991, NOAA 2003). *Capitella* sp., *Leitoscoloplos* sp., *Streblospio benedicti* and *Nephtys sp* are often found in environments with low oxygen levels, high organic matter and sewage content. *Capitella* sp. are also tolerant to petroleum pollution; they are often one of the first groups to recolonize an area impacted by dredging or an oil spill (Llanso 1991, NOAA 2003).

Amphipods were present in two of the seven stations. *Gammarus* sp. and Melitid amphipods feed on detritus and are found in muddy and sandy substrates. They are an important food source for fish. The absence of the amphipod *Ampelesca abdita* is an environmental indicator, because this species is reported to be sensitive to pollutants such as petroleum compounds and are typically not found in highly polluted sediments (NOAA 2003).

Horseshoe crabs were collected at Station B-2, in the shallow water along the western edge of North Cove (Figure 5-1). They are environmental generalists and can survive within a wide range of environmental conditions including variations in salinity and oxygen levels (Shuster 1982). Currently, there is little information to suggest unusual sensitivity by horseshoe crabs to low dissolved oxygen, high turbidity or urban pollution (Botton 1995).

In surveys of benthic habitats found in NY/NJ Harbor, Iocco *et al.* (1995) found that sediments were dominated by opportunistic or pollution tolerant species. The organisms Iocco *et al.* (1995) reported were similar to those found in the North Cove. Common infaunal species of Upper New York Bay include capitellid worms, *Streblospio benedicti* and the bivalve *Mulinia lateralis*. Species diversity and relative abundance for the North Cove are consistent with the species found at other Upper New York Bay locations with

similar environmental conditions. Organism density was greater in samples collected by Iocco *et al.* (1995) throughout the harbor, than in the samples collected at the North Cove. A possible explanation for this difference is that organism densities vary with season, with low densities typically recorded during the summer when bottom dissolved oxygen levels are lowest. Also when comparing studies, one has to take into account the different physical properties, wave action and currents, that could effect sedimentation in a cove versus a bay.

Colonization of the seabed by macrobenthos in stressed habitats (such as polluted sediments) typically follows the Pearson – Rosenberg paradigm (Pearson – Rosenberg 1978). For infauna distributed along a gradient of decreasing organic input, this paradigm suggests that an area of sediments with no organisms is followed by an assemblage of small opportunistic organisms (worms and tube dwelling amphipods). Further from the source of organic input, the opportunists are gradually replaced by larger burrowing species (Zappala 2001). The open seabed in the North Cove consisted of unconsolidated fine black mud, which contained oily globules. The predominate organisms found living in the black mud were small, opportunistic polychaete worms. The sediments close to the back of the cove were coarser and there was no apparent petroleum odor. The colonization of the sediments in the North Cove appears to resemble the early opportunistic stage in the Pearson-Rosenberg stress gradient model.

5.3 VERTEBRATES

The North Cove (the Cove) at LSP was surveyed during late summer to early fall 2003 to determine the fish species that use the Cove. Baseline data were needed to identify the species that use the tidal creek habitat proposed to extend from the base of the Cove into the 42-acre Dredged Material Storage Area. These data will also be used to determine how the species composition in the cove may change with construction of tidal creek habitat.

5.3.1 Methodology

To collect adequate representation of the fish communities that use the North Cove, active and passive gear types were used to sample three stations in the cove (Figure 5-1). Seining was conducted as an active method of fish capture to collect species that may inhabit shallow areas of the Cove as short-term residents. Trap nets were set as a passive capture method to target predatory species that move in and out of the Cove during the crepuscular period (i.e., dawn and dusk) and during the night.

The three sampling stations were located along the shoreline of the North Cove. Station F-2 is located on the small beach area at the west end of the Cove. This area represents the only shallow beach habitat in the cove at low tide. Station F-1 was located along the south shoreline of the Cove and F-3 was located along the north shoreline. At the time of sampling, the shoreline at these two stations was characterized by steep sloping banks covered with riprap. Details of the sampling dates and sampling locations for each method are provided in Table 5-2.

Seine hauls were conducted during daylight hours with a 50-foot bag seine (1/4-inch mesh). The depth of the Cove required the hauls to be conducted by fixing one end of the seine on shore and working the other end out from shore and enclosing a semicircular area along the shoreline. The North Cove fish community was sampled via seine on 28 August, 8 September and 24 September 2003 (Table 5-2). A total of five seine hauls were conducted during the program. Seine hauls were conducted on each date (n=3) at the F-2 sampling location. Seine hauls at the other two sample locations (F-1 and F-3) were not attempted after 28 August because riprap on the shoreline caused the seine to snag, prohibiting effective seining. Although fish were collected on the first sample date at F-1 and F-3, the catch must be interpreted with caution because snagging potentially allowed fish to escape from the net.

Three 20-foot long trap nets (3x6-ft box frame, ¼ -in. mesh, and 40- ft long lead) were set perpendicular to the shoreline for approximately 14-hours from dusk to dawn. All fish were identified to species level, enumerated and an unbiased selection of up to 30 specimens from each species was measured for total length (nearest mm). Trap nets were not set on the first sampling date. Trap nets were set at all three sampling locations during the September sampling dates. The nets sampled for a total of 84 trap nets hours over the two sample dates. On the 8 September sampling date, no fish were collected in the trap nets set at F-2 or F-3. During the 24 September sampling date, fish were collected at all three sample locations.

Table 5-2. Description of fish sampling effort during August and September 2003 at Liberty State Park North Cove, Jersey City, NJ.

Date	Gear	Station	Station Depth	Start Latitude	Start Longitude	Number of Fish Caught	Number of Species Caught
8/28/2003	50-ft Beach Seine	F-2	3.7	40 42.32	74 02.54	50	3
8/28/2003	50-ft Beach Seine	F-3	3.5	40 42.36	74 02.57	32	6
8/28/2003	50-ft Beach Seine	F-5	8	40 42.36	74 02.43	53	4
9/8/2003	Trap Net	F-2	6	40 42.31	74 02.53	0	0
9/8/2003	50-ft Beach Seine	F-3	4.9	40 42.36	74 02.57	52	2
9/8/2003	Trap Net	F-3	5	40 42.36	74 02.57	19	8
9/8/2003	Trap Net	F-5	10	40 42.37	74 02.43	0	0
9/24/2003	Trap Net	F-2	7	40 42.31	74 02.53	5	3
9/24/2003	50-ft Beach Seine	F-3	4	40 42.36	74 02.57	18	3
9/24/2003	Trap Net	F-3	4	40 42.36	74 02.57	21	7
9/24/2003	Trap Net	F-5	9	40 42.37	74 02.43	7	5

5.3.2 Results of Vertebrate Community Sampling

At total of 257 fish representing 15 species were collected during the beach seine hauls and trap net surveys (Table 5-2). Nine species were collected via seine, while 12 species were collected in the trap nets. Bay anchovy (*Anchoa mitchilli*) and Atlantic menhaden (*Brevoortia tyrannus*) were the most common species collected by number during the seine survey. White perch (*Morone americana*) and striped bass (*Morone saxatilis*), both temperate basses, were the most common species collected in the trap nets, followed closely by winter flounder (*Pseudopleuronectes americanus*). Six species (alewife, [*Alosa pseudoharengus*]; hogchocker, [*Trinectes maculates*]; oyster toadfish, [*Opsanus tau*]; scup, [*Stenotomus chrysops*]; summer flounder, [*Paralichthys dentatus*]; and tautog, [*Tautoga onitis*]) were each represented by only one fish.

Total lengths were measured from 207 fish during the sampling program (Table 5-3). Total lengths varied by species and life stage. In general, juvenile fish were most common in the catch. Bay anchovy ranged in lengths from 65 mm to 92 mm with an average length of 81 mm. Several other species were represented primarily by juveniles, including Atlantic menhaden (average length = 48 mm), striped bass (82 mm) and winter flounder (67 mm). Several species were collected primarily as adults, notably white perch (244 mm), summer flounder (359 mm) and American eel (*Anguilla rostrata;* 395 mm). Only one yearling striped bass (205 mm) was collected; the remainder of the striped bass ranged in length from 56 mm to 97 mm. Several species were represented by only one fish, thus there was no interpretation of length data. The following sections provide a brief description of the spatial and temporal occurrence as well as the life history of the most common species collected in the Cove.

<u>Bay Anchovy</u>

The bay anchovy, the dominant species collected during the survey, range widely from temperate to subtropical waters along the Atlantic and Gulf coasts between Maine and Mexico (Hildebrand and Schroeder 1928). In most estuaries within their range, bay anchovy are an important trophic link between plankton and piscivores (Dorsey *et al.* 1996). The importance of anchovies as forage for larger coastal fishes and birds has been recognized in estuarine and coastal ocean systems over wide geographic range (Allen *et al.* 1995). Adults are found in a variety of habitats that include near-shore waters off sandy beaches, seagrass beds, freshwater rivers, and shallow to deep onshore waters (Morton 1989). Bay anchovy are particularly abundant in estuaries, near-shore coastal waters and bays (Springer and Woodburn 1960). The bay anchovy is an invertebrate feeder (Winemiller and Rose 1992), with the principal food source being zooplankton.

Table 5-3. Total length (mm) of species collected during August and September 2003 from Liberty State Park North Cove, Jersey City, NJ

Common Name	Number of Individuals Captured	Minimum Total Length (mm)	Maximum Total Length (mm)	Average Total Length (mm)
Alewife	1	85	85	85
American Eel	5	251	645	395
Atlantic Menhaden	71	37	74	48
Atlantic Silverside	7	82	103	92
Bay Anchovy	116	65	92	81
Hogchocker	1	106	106	106
Northern Pipefish	3	122	171	146
Oyster Toadfish	1	157	157	157
Scup	1	71	71	71
Striped Bass	19	56	205	82
Summer Flounder	1	359	359	359
Tautog	2	38	42	40
Weakfish	7	65	140	110
White Perch	14	220	260	244
Winter Flounder	8	55	86	67

Atlantic Menhaden

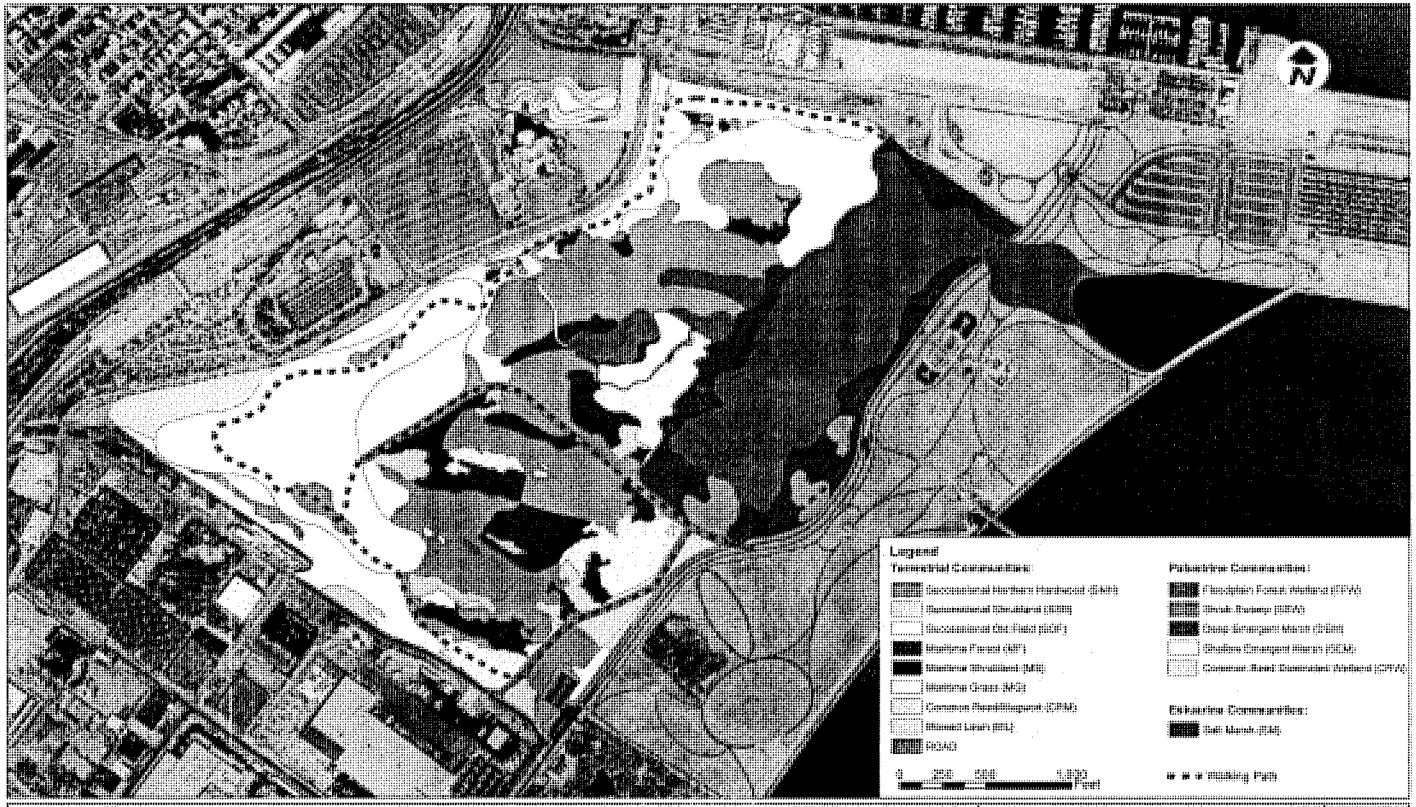
The Atlantic menhaden was also common in the North Cove vertebrate survey, is a polyhaline species that utilizes habitats along the entire eastern seaboard and adjacent shelf waters throughout its life cycle (Rogers and Van Den Avyle 1989; Hall 1995). Distributed from Nova Scotia to Florida, Atlantic menhaden undertake extensive north-south seasonal migrations and inshore-offshore movements along the eastern seaboard. Adult menhaden form large schools during feeding migrations, which often take them into nearshore coastal waters (ASMFC 1992). Juveniles use estuaries as nurseries for the first year of their lives (Curley *et al.* 1974). Most juveniles remain in their nursery estuaries until they attain a total length of 55–140 mm (2.2–5.5 in), after which time they begin migrating toward the adjacent shelf waters.

Striped Bass

The striped bass is an anadromous species that ranges along the Atlantic Coast from the St. Lawrence River, Canada, to the St. Johns River, FL, and in the Gulf of Mexico from Florida to Louisiana (Bigelow and Schroeder 1953). Major spawning populations exist in the Hudson River, Chesapeake Bay, and the Roanoke River-Albemarle Sound system. Descriptions of movements of striped bass during their first year in the Hudson River (McFadden *et al.* 1978; Dovel 1992), Delaware River, and Potomac River (Mihursky *et al.* 1976) generally are consistent. During their first summer, striped bass generally move shoreward and downstream of their natal spawning area to shallow-water nursery areas in the lower tidal river. In the fall, they move to deeper waters, and they may overwinter in the lower tidal river or leave the river completely to overwinter in bays or adjacent sounds. The following spring, yearling striped bass generally leave the overwintering areas, moving downstream toward the ocean. In summer, they are distributed throughout the tidal river and lower bays of their respective estuaries and are most abundant in the shore zone.

White Perch

White perch are endemic to estuaries along the Atlantic coast. The species has also been introduced or has invaded freshwater systems, including the lower Great Lakes and some mid-western reservoirs (Stanley and Danie 1983). White perch occur predominantly in fresh and brackish water from the Pee Dee River, South Carolina, to Cape Breton Island, Nova Scotia (Scott and Crossman 1973; Burgess 1980). They are most abundant between the Hudson River and the Chesapeake Bay region (Scott and Crossman 1973) where they are commonly distributed from the lower tidal reaches into the non-tidal portions of rivers and creeks. A semi-anadromous species, white perch undertakes seasonal



US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USAGS (2003)

THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

Maximum Habitat Plan

Figure 6-1

Adjacent to the channels will be mudflats that will go from around MLW to approximately the mean tide level. The next highest zone would be Low Salt Marsh that will extend from mean high water (MHW) to mean tide or about 0.2 feet (NAVD, Liberty Park). This will be the largest and most productive area and will cover the majority of the 42-acre area. The preliminary conceptual plan includes a High Marsh area above MHW, which will grade into upland areas. The details of all these features will be established in the design phase of the project.

The wetland communities of the Salt Marsh restoration are as follows:

1. Tidal creek – open water channels below the mean tide level. Creek bottoms will be permanently flooded but the banks will be exposed at low tide; water will be brackish to saline (salinity between 0.5 and 30.0 ppt). Plants may include widgeon grass (Ruppia maritima) and various cyannobacteria.
2. Mudflat – semi-permanently flooded areas between midtide and MLW. Plants may include spongy arrowhead (Sagitaria calycina var. spongiosa) and tapegrass (Vallisneria americana).
3. Low marsh – intertidaly inundated areas between MHW and mid-tide. Plant community will be dominated by cordgrass (Spartina alterniflora)
4. High marsh – located between spring high tide and MHW. Plant community will be dominated by salt-meadow grass.
5. Maritime shrub – located in the transition zone between upland and high marsh. Plant community will be dominated with groundsel tree and saltmarsh elder.

The purpose of these salt marsh communities is to replace the mostly phragmites and mugwort dominated upland habitat, as well as to recreate habitat lost over the last 100 years as the underlying open water, mudflat and salt marsh were filled Therefore, the Salt Marsh restoration/creation area will consist primarily of tidal marsh and open water. Some restoration goals include:

- Restore functional values to the Hudson – Raritan Estuary, lost through the filling of the historic estuary, particularly: aquatic habitat function, wildlife habitat function and water quality treatment.
- Create a diverse pattern of tidal plant communities that, when added to the surrounding variety of communities will support a diverse wildlife community.
- Provide educational, recreational and aesthetic values to what is presently a fenced off area dominated by invasive species.

6.1.2 Freshwater Wetland System.

The freshwater wetland system, including a new Deep Emergent Marsh (DEM) will be located adjacent to the restored salt marsh. A sequence of wetlands will be created in an effort to bring additional freshwater to the interior zone. This deep, freshwater wetland will be constructed by grading upland areas of the site to elevations that will allow the diversion of freshwater from parking areas into the interior. Treatment wetlands will receive direct parking lot runoff and will be hydrologically connected to additional wetland areas. Final elevation of the downstream area will also be slightly below groundwater elevations. Groundwater elevations are being documented using monitoring data collected from the site (USACE – NYD 2004). Since the site is very flat, as a means of getting positive flow to the wetland, a sequence of treatment and freshwater wetlands will be designed as a series of slightly descending depressions, directing the water from the western NJ Transit parking area to the eastern deep water wetland. Runoff from the NJ Transit parking lot flows east toward the Liberty Science Center wetland (elevation approximately 6 feet). Groundwater elevation here is between 3 and 4 feet. The surface water elevation of the Liberty Science Center wetland varies form 5.5 to 6.6 feet. Flowing east, the water will pass through another biofiltering wetland and eventually be delivered to the permanently inundated DEM at an elevation between 4 and 5 feet. These wetlands will also receive surface flow directed from NJ Transit and Liberty Science Center parking areas west of the Liberty Blvd. via pipes and/or drainage swales that run along the road.

The sequence of wetlands will be graded to allow water to flow from one depression to the next. Log dikes, rock water falls, grass swales and or pipes will connect these wetlands and provide a natural appearance to the sequence. If groundwater contamination is detected, the pools and channels will be lined with a clay layer to prevent contamination to the wetland system. The deep water wetland will most likely have a weir for its outlet and will create a number of wetland zones. Below mean groundwater level will be a semi-permanently flooded zone; the zone between groundwater and the weir inlet will be seasonally flooded, and the zone between the invert and the overflow will be temporarily flooded. Above the overflow elevation will be a transition to upland areas.

<u>*Freshwater Wetland Plant Communities.*</u> Four wetland communities will be established among the sequence of wetlands leading to the DEM. These wetland communities will enhance existing habitat on the site that consists of uplands and shallow emergent wetlands that dry out at the end of the growing season. The DEM will provide a

permanent water supply for wildlife. Water depths within each community will vary spatially and seasonally.

From the wetter to the drier zones the four vegetation communities will include:

1. Palustrine emergent marsh – a semi-permanently flooded wetland excavated below the groundwater level
2. Wet meadow – a seasonally flooded community between groundwater level and invert
3. Scrub-shrub wetland – temporarily flooded wetland located between invert and overflow
4. Scrub-shrub or forested transition zone – located above overflow elevation
5. Upland (above top of weir)

6.1.3 Shallow Wetland Enhancement Area

The existing shallow wetlands will be enhanced to provide a greater diversity of habitats and a more dynamic hydrology. Some regrading may occur; however enhancement will primarily consist of vegetation management, such as invasive species control. Enhancements will allow more diverse communities and provide greater habitat functional value, particularly for amphibians which are not well represented in the area. Enhanced wetland plant communities will likely include: (1) emergent marshes, (2) open water depressions and (3) wet meadows. In addition, upland hummocks could be incorporated to provide topographic diversity and potential habitat for small mammals, amphibians and birds.

6.1.4 Upland Enhancement Area

Materials excavated from the creation of the Salt Marsh will be placed on the existing Soil Stockpile Area to create a berm that will buffer the noise from industrial development, will direct runoff to the existing wetlands and will enhance the visual aesthetics of the southern section of the park. Maritime Grassland species with small pockets of maritime trees will be planted to provide additional foraging and nesting habitat to the northern harrier and other grassland species. Existing SNH communities in the northern section of the LSP Restoration site will be managed to promote the succession of native hardwood species, and Maritime Forest species will be planted near the created Salt Marsh. Invasive species (i.e. tree-of-heaven) will be controlled in the

northern forested sections. In the southern section of the LSP Restoration site, existing forests will remain a mixture of successional northern hardwood and invasive species. A walking trail will be established around the perimeter and through the interior section of the LSP Restoration site, to allow public access for recreational and educational purposes.

6.2 METHODOLOGY

A functional analysis was performed on each Liberty State Park ecological community type for both the existing scenario and future project conditions scenario. Proposed project conditions were defined as the restoration of a salt marsh within the 42-acre Dredged Material Storage Area, along with the enhancement of on-site freshwater wetlands and the creation of deep emergent marshes. The analysis was developed to quantify impacts to community functions and values resulting from the proposed project. This evaluation had three major objectives: (1) identify the functions and values provided by the existing communities; (2) evaluate potential functions and values of the proposed restoration plan; and (3) compare the change in functional value of the proposed plan compared to existing conditions.

6.2.1 Evaluation Methodology Selection

There are a number of methodologies available for functional assessment of wetlands. The project team reviewed a number of wetland functional assessment systems, including the Federal Highway Administration (FHWA) system; USFWS Habitat Evaluation Procedure (USFWS 1980); the Hollands-Magee method (Hollands and Magee 1986, Brinson 1993); the USACE wetland evaluation technique (WET 2.0); the hydrogeomorphic (HGM) approach developed by USACE Waterways Experiment Station (WES); and the New England USACE Highway Methodology.

Because relatively detailed field data was available for the LSP site, the project team wanted a methodology that would enable the assessment of wetland functions and values by utilizing a combination of professional opinion and an interpretation of the data collected in the field. The Highway Methodology recommended by the US Army Corps of Engineers – New England Division was selected as the most appropriate methodology. This "Descriptive Approach" to wetland functions and values incorporates both wetland science and human judgment of values. It was ideally suited to Liberty State Park since of it incorporates field data into the assessment of both wetland and upland functions and values. It also enabled the ability to synthesize the information and develop habitat units for each ecological community as described below.

Other methods were evaluated and discarded for a variety of reasons. The HGM Approach (Smith *et al.* 1995) takes the lead as technically the most progressive and frequently applied methodology. The hydrogeomorphic approach has the greatest potential to improve the precision, consistency, reliability, and timeliness of functional assessments. The HGM approach was developed to satisfy the requirements of the 404 Program, but was also intended for use in a wide range of assessment situations. However, other than for riparian wetlands and tidal wetlands (Expert HGM) the system is still being developed. HGM Approach was not adequately tested for other communities (e.g. upland habitats). The use of this approach for Liberty State Park which requires the analysis of both tidal and freshwater wetlands along with an upland assessment would not be the most cost effective approach.

Initially, ERC applied the USACE Wetland Evaluation Technique (WET) to each of the ecological communities on the site. WET was developed by Adamus, et al. (1987) and revised by 17 federal agencies and the National Wetland Technical Council. While accepted by most federal agencies, the methodology has fallen out of favor and has now been replaced by other methods. WET was the first comprehensive approach to wetland assessment and uses "predictors" of physical, chemical or biological processes (ie. functions) and assigns value to function in terms of Social Significance.

WET has been specifically developed for wetlands, using features of a wetland's watershed, topography, vegetation, and other factors to estimate a probability rating of "High", "Moderate", or "Low" for each function. The team applied this approach to both wetlands and uplands on the site, but the standard questions are not relevant to upland conditions and the estimated functions were not realistic, thus the system was unusable.

The functional evaluation method selected utilized a modified version of the "Highway Methodology" recommended by the New England Division of USACE. Using the assessment teams best professional judgment in applying the "Highway Methodology", a functional analysis was prepared for each ecological community type within the LSP Restoration site. The analyzed wetland functions, and the rating criteria are described in Table 6-1.

Table 6-1. Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology[1]

Function/Value	
Groundwater Recharge/Discharge	
Description	This function considers the potential for a habitat to serve as a groundwater recharge and/or discharge area. It refers to the fundamental interaction between habitats and aquifers, regardless of the size or importance of either.
Considerations & Qualifiers	Downstream wells, impervious "substrate", water course association, signs of recharge, discharge or variable water levels, water temperature, piezometer data.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 3 qualifiers met; "Moderate" (2) = 4 to 8 qualifiers met; "High" (3) > 8 qualifiers met.
Floodflow Alteration	
Description	(Storage and Desynchronization) - This function considers the effectiveness of the habitat in reducing flood damage by water retention for prolonged periods following precipitation events and the gradual release of floodwaters. It adds to the stability of the habitat/wetland ecological system or its buffering characteristics and provides social or economic value relative to erosion and/or flood prone areas.
Considerations & Qualifiers	Location, size, capacity, flood storage potential of habitat, impervious surface area in watershed, downstream development and flooding history, water course association, vegetation and soils of habitat.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 5 qualifiers met; "Moderate" (2) = 6 to 9 qualifiers met; "High" (3) > 9 qualifiers met.

Table 6-1 (Page 2 of 7). Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology

Function/Value	
Freshwater Fish/Shellfish Habitat	
Description	This function considers the effectiveness of seasonal or permanent watercourses associated with the habitat in question for fish and shellfish habitat.
Considerations & Qualifiers	Forest cover in watershed, cover objects/shade vegetation present, width and depth of water body and watercourses, food, spawning habitat, water velocity and persistence able to support fish.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 4 qualifiers met; "Moderate" (2) = 5 to 9 qualifiers met; "High" (3) > 9 qualifiers met.
Sediment/Toxicant/Pathogen Retention	
Description	This function reduces or prevents degradation of water quality. It relates to the effectiveness of the habitat as a trap for sediments, toxicants, or pathogens in runoff water from surrounding uplands, or upstream eroding wetland areas.
Considerations & Qualifiers	Sources of sediment, toxicants and pathogens in watershed, slow moving water, fine grained or organic soils with aerobic areas present, wells present downstream, wetlands 50+ years old with no drainage ditches.
Ranking Criteria	"None" (0) < 2 qualifiers met; "Low" (1) = 2 to 5 qualifiers met; "Moderate" (2) = 6 to 10 qualifiers met; "High" (3) > 10 qualifiers met.

Table 6-1 (Page 3 of 7). Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology

Function/Value	
Nutrient Removal/Retention/Transformation	
Description	This function considers the effectiveness of the habitat as a trap for nutrients in runoff water from the surrounding uplands of contiguous habitats, and the ability of the habitat to process these nutrients into other forms of trophic levels. One aspect of this function is to prevent ill effects of nutrients entering aquifers or surface waters such as ponds, lakes, streams, rivers or estuaries.
Considerations & Qualifiers	Habitat size, excess nutrients in watershed, potential to trap sediments, presence of open water, saturated soils and organic/fine grained sediment deposits present, vegetation density, ability of biota to use nutrients.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 5 qualifiers met; "Moderate" (2) = 6 to 10 qualifiers met; "High" (3) > 10 qualifiers met.
Production Export (Nutrient)	
Description	This function evaluates the effectiveness of the habitat to produce food or useable products for man and living organisms.
Considerations & Qualifiers	Food sources, detritus and economic or commercial products present, wildlife and vegetation diversity and abundance, water course association, evidence of export, presence of flowering plants.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 5 qualifiers met; "Moderate" (2) = 6 to 9 qualifiers met; "High" (3) > 9 qualifiers met.

Table 6-1 (Page 4 of 7). Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology

Function/Value	
Sediment/Shoreline Stabilization	
Description	This function considers the effectiveness of a habitat to stabilize stream banks and shorelines against erosion.
Considerations & Qualifiers	Sediment sources present, indications of erosion, siltation, gradient and sharp banks, type and density of vegetation, high flow velocity, channelized flow, fetch and boating activity present.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 4 qualifiers met; "Moderate" (2) = 5 to 7 qualifiers met; "High" (3) > 7 qualifiers met.
Wildlife Habitat (Including Breeding, Foraging and Dependancey) based on Wildlife Matrix	
Description	These functions consider the ability of a habitat to support a diverse, native wildlife community.
Considerations & Qualifiers	Number of local wildlife species known to breed and/or forage in the habitat type, and number of species that depend upon that habitat type for survival.
Ranking Criteria	"None" (0) = Habitat type ranked below the 10th percentile in supporting large numbers of valuable species; "Low" (1) = Ranked between 10th and 40th percentile; "Moderate" (2) = Ranked between 40th and 70th percentile; "High" (3) = Ranked in the top 30th percentile.

Table 6-1 (Page 5 of 7). Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology

Function/Value	
Recreation (Consumptive and Non-Consumptive)	
Description	This value considers the suitability of the habitat to provide recreational opportunities such as hiking, canoeing, boating, fishing, hunting or other passive or active recreational activities. Consumptive opportunities consume or diminish the plants, animals or other resources that are intrinsic tot he habitat. Non-consumptive opportunities do not consume or diminish these resources.
Considerations & Qualifiers	Location in the watershed and community, ongoing recreational activities, wildlife habitat, watercourse association, open water present, visual/aesthetic quality, access, parking.
Ranking Criteria	"None" (0) < 2 qualifiers met or if no public access exists; "Low" (1) = 3 to 5 qualifiers met; "Moderate" (2) = 6 to 9 qualifiers met; "High" (3) > 9 qualifiers met.
Educational/Scientific Value	
Description	This value considers the suitability of the habitat as a site for an "outdoor classroom" or as a location for scientific study or research.
Considerations & Qualifiers	Disturbance level, threatened, endangered, rare species present, biota diversity, habitat value, location, habitat enhancement, watercourse association, open water present, safety hazards, access, parking, current uses.
Ranking Criteria	"None" (0) < 2 qualifiers met; "Low" (1) = 2 to 7 qualifiers met; "Moderate" (2) = 8 to 9 qualifiers met; "High" (3) > 8 qualifiers met.

Table 6-1 (Page 6 of 7). Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology

Function/Value	
Uniqueness/Heritage	
Description	This value considers the effectiveness of the habitat to provide certain special values. These may include archeological sites, critical habitat for endangered species, its overall health and appearance, its role in the ecological system of the area, its relative importance as a typical habitat for this geographic location. These functions are clearly valuable habitat attributes relative to aspects of public health, recreation, and habitat diversity.
Considerations & Qualifiers	Open water, flowering plants, critical habitat and unique features present, nearby development, location, access, parking, habitat variety, safety hazards, water quality, visual aspects, archeological sites, hydrology.
Ranking Criteria	"None (0)", 2 qualifiers met; "Low" (1) = 3 to 8 qualifiers met; "Moderate" (2) = 8 to 13 qualifiers met; "High" (3) > 13 qualifiers met.
Visual Quality/Aesthetics	
Description	This value considers the visual and aesthetic quality or usefulness of the habitat.
Considerations & Qualifiers	Habitat variety, vegetation and animal diversity, visible local land use, noise levels, odors, sight lines within the habitat, access, presence of trash, debris and signs of disturbance, development.
Ranking Criteria	"None" (0) = No qualifiers met; "Low" (1) = 1 to 4 qualifiers met; "Moderate" (2) = 5 to 7 qualifiers met; "High" (3) > 7 qualifiers met.

Table 6-1 (Page 7 of 7). Description of Functions Evaluated with the Modified Highway Methodology Based on the Federal Highway Methodology

Function/Value	
Endangered Species Habitat	
Description	This value considers the suitability of the habitat to support threatened or endangered species.
Considerations & Qualifiers	Threatened and/or endangered species present and/or area contains critical habitat for listed species.
Ranking Criteria	0 and "Low" (1) = No qualifiers met; "Moderate" (2) = 1 or 2 qualifiers met based on usage and observations; "High" (3) = 2 qualifiers met based on usage and observations.
Fish and Shellfish Habitat (Marine)	
Description	This function considers the effectiveness of the habitat to support marine resources such as fish, shellfish, marine mammals, and sea turtles.
Considerations & Qualifiers	Presence of special aquatic sites, spawning habitat, presence of commercially and/or recreationally important species or suitable habitat exists, prey for higher trophic levels present, migratory habitat for anadromous fish.
Ranking Criteria	"None" (0) = No qualifiers met: "High" (3) > 3 qualifiers met. No Ranking Criteria of 1 or 2 awarded.

Note: [1] – For details on the considerations and qualifiers, and for functional assessment evaluation sheets for the evaluated communities see Appendix F.

The Highway Methodology relies primarily on existing data to evaluate the functionality of wetlands. In an effort to tailor the analysis to the LSP Restoration site, which includes both upland and wetland ecosystems, additional emphasis was placed on habitat functions for wildlife. An additional analysis technique for wildlife habitat was developed using observations from the August 2003 wildlife surveys and published literature on habitat requirements for birds of the NY/NJ Harbor area. The following wildlife habitat functions were analyzed:

- Wildlife Breeding Habitat
- Wildlife Foraging Habitat
- Habitat Dependency (i.e. habitats that are required by local species)

6.2.2 Existing Data

Before conducting the functional assessment, the team reviewed existing data and regional ecological information. This effort included obtaining maps, aerial photographs, and other information necessary for evaluation of the wetlands and other ecological communities within a 5-mile radius. For this site, it included piecing together a total of six quads from the USGS (topography and drainage), NWI maps, and NJDEP freshwater wetland maps to allow regional analysis of other wetlands. The existing Natural Resource Inventory of Liberty State Park was also reviewed.

6.2.3 Modified Highway Methodology

Based on the field delineation, there are 12 existing ecological community types that cover 251.5 acres (Figure 2-3). It is anticipated that the final proposed plan will include all of these, and three additional community types.

The ecological communities evaluated include the following:

A. Wetland Communities:
   1. Floodplain Forest Wetland (FFW)
   2. Shrub Swamp (SSW)
   3. Shallow Emergent Marsh (SEM)
   4. Common Reed Dominated Wetland (CRW)
   5. Deep Emergent Marsh (DEM)*
   6. Salt Marsh (SM)*

B. Upland Communities:
   1. Successional Northern Hardwoods (SNH)
   2. Successional Shrublands (SS)
   3. Successional Old Fields (SOF)
   4. Common Reed/Mugwort (CRM)
   5. Maritime Forest (MF)*
   6. Maritime Shrubland (MS)
   7. Maritime Grassland (MG)
   8. Mowed Lawn (ML)
   9. Road (ROAD)

   * - Proposed conditions only

Each community was evaluated for the functions and values by the study team, which included ERC wetland scientists, wildlife biologists, and aquatic biologists. The methodology lists a number of statements (or "considerations/qualifiers") that are true for communities that perform each function. The decision concerning the ability of an ecological community to perform a function is related to the number of considerations/qualifiers that are true for that community. As a means to quantify these functions and generate scores for each community, a number was assigned to each function based on the number of considerations that were true. A range of 0 ("none") to 3 ("high") was assigned for each function. A list of the considerations/qualifiers for each function is presented in Appendix F along with the Wetland Function-Value Evaluation forms that were prepared for each community.

Each ecological community was assessed in terms of the functions and values according to the methodology explained above. Numerical scores were assigned to each of the 13 functions and values listed in the "Highway Method". These were then combined with the three additional wildlife functions.

6.2.4 Wildlife Functional Assessment

The functional values of each community type for wildlife were determined based on the number and type of species that use that community for foraging and breeding, and whether it is critical for the survival of one or more species. Using existing information on wildlife habitat requirements, a matrix was developed to quantify three functional habitat values for existing and proposed community types: wildlife breeding value, foraging value, and habitat dependency. The approach required ranking the relative

importance of wildlife species, identifying the ecological community types used by each species, and calculating functional values for each community type.

A comprehensive list of wildlife species known to exist near NY/NJ Harbor, including all species documented using the LSP Restoration site and species that may potentially use the site, was compiled. A total of 10 mammals, 145 birds, 2 amphibians and 4 reptiles were the basis for this analysis. Each species was assigned a rank for several biological characteristics, based on Brooks and Croonquist (1990) *Wetland, habitat, and trophic response guilds for wildlife species in Pennsylvania.*

Of the biological characteristics described by Brooks and Croonquist (1990), trophic level, habitat specificity and regulatory status were selected to determine relative species' importance. Table 6-2 provides a summary of the selected Brooks and Croonquist (1990) biological characteristics and rank designations, and the number of evaluated species that fall within each rank. A rank between 1 and 5 was assigned for trophic level, with higher numbers indicating species with specialized diets, and all carnivores, and lower ranks assigned to omnivores and herbivores. Habitat specificity ranks ranged from 1 to 5 with higher ranks assigned to species with specialized habitat requirements, and lower ranks assigned to species that are able to exist in degraded areas, or on the edges of communities. Endangered and threatened species were assigned a regulatory status rank of 5, commercially or recreationally valuable species were assigned a rank of 3, and other indigenous species were assigned a value of 1. The mean value of the ranks is the species value. Non-native species were considered to have no value.

Community types were evaluated as potential foraging or breeding grounds for each of the listed species. For each species that used a community for foraging, the community was assigned a score of 1 multiplied by the species value. The sum of this product for all evaluated species is considered a community's foraging value. Because breeding habitat is more critical than foraging habitat for many species, the communities were assigned a score of 2 multiplied by the species value for each of the species known to breed in that habitat type (breeding value). If a community type was considered obligate habitat for a species it was assigned a score of 2 multiplied by the species value of each species that requires the habitat (habitat specificity value). Table 6-3 shows an example of the functional analysis for wildlife in Maritime Shrubland communities within the LSP Restoration site, and Appendix F shows the data for all communities.

Table 6-2. Brooks and Croonquist (1990) biological characteristics and rank designations, and the number of evaluated wildlife species that fall under the ranks.

Trophic Level			Habitat Specificity			Regulatory Status		
Description	**Rank**	**No. of Species**	**Description**	**Rank**	**No. of Species**	**Description**	**Rank**	**No. of Species**
Carnivore, Specialist	5	5	Alpha species (Specialist)	5	24	Endangered/ Threatened	5	18
Carnivore, Generalist	4	85	Gamma species (Landscape dependent)	3	58	Commercial, Recreational value	3	17
Herbivore, Specialist	3	5	Beta species (Generalist)	1	77	Other Native species	1	116
Herbivore, Generalist	2	10				Exotics	0	8
Omnivore	1	54						

To standardize the results to fit within the Modified Highway Methodology used to evaluate the other vegetative community functions, the foraging, breeding and habitat specificity functional values were translated into rankings between 0 ("none") to 3 ("high"). Community types that ranked in the lowest 10th percentile for a function were considered to have no habitat value for that function. Communities that ranked between the 10th and 40th percentile were considered to have low value, and those that ranked between the 40th and 70th were considered to have moderate value. High functional values were assigned to communities that ranked higher than 70th percentile.

6.2.5 Evaluation

The results of the analysis were evaluated in two ways, for two purposes: (1) to determine the cumulative functional values for the existing and proposed conditions, in an effort to estimate whether implementation of the proposed restoration plan will change the effectiveness of the LSP Restoration site in performing any of the 16 evaluated functions; and, (2) to calculate the relative value of each community type, in order to assign a number of "habitat units".

The cumulative functional values of the LSP Restoration site (for both existing conditions and the proposed conceptual plan), were calculated by multiplying each functional score for a community by its acreage, and summing the products for each of the 16 functional categories.

The relative value of each community type was calculated by summing the 16 functional values for that community type, which provided the number of habitat units per acre of habitat. The total number of habitat units for each community type is the product of the score per acre and the number of acres. The number of habitat units for existing and proposed conditions can be calculated as the sum of the total habitat units for each community type.

6.3 EVALUATION RESULTS

Hydrologically isolated wetlands and several drainage ditches (see section 2.2 Regulated Wetland Communities) are the most common wetland communities on the site. Results from the analysis indicate that the functional value of the existing conditions will be improved from a total of 3,568.8 habitat units within the LSP Restoration site to 5,601.2 habitat units if the proposed restoration plan is implemented.

Table 6-3. Example of wildlife functional analysis for Maritime Shrubland communities at Liberty State Park[1], Jersey City, NJ.

Community Type: Maritime Shrubland

Common Name	Habitat Specificity[2]	Trophic Level[2]	Status[2]	Species. Value	Breeding	Foraging	Hab. Dep.[3]
Cottontail Rabbit	1	2	3	2.00	--	2.00	--
Feral Cat	1	4	0	0.00	--	0.00	--
Feral Dog	1	4	0	0.00	--	0.00	--
Meadow Vole	1	2	1	1.33	2.67	1.33	--
White-footed Mouse	1	1	1	1.00	2.00	1.00	--
American Crow	1	1	1	1.00	--	1.00	--
American Goldfinch	1	2	1	1.33	2.67	1.33	--
American Redstart	1	4	1	2.00	--	2.00	--
American Robin	1	1	1	1.00	2.00	1.00	--
American Tree Sparrow	1	2	1	1.33	--	1.33	--
American Woodcock	3	5	3	3.67	7.33	3.67	--
Brown-headed Cowbird	1	1	1	1.00	2.00	--	--
Cedar Waxwing	1	3	1	1.67	--	1.67	--
Common Yellowthroat	1	4	1	2.00	4.00	2.00	--
Cooper's Hawk*	3	4	5	4.00	--	4.00	--
Downy Woodpecker	1	4	1	2.00	--	2.00	--
Golden-crowned Kinglet	3	4	1	2.67	--	2.67	--
Gray Catbird	1	1	1	1.00	2.00	1.00	--
Mourning Dove	1	2	1	1.33	2.67	--	--
Savannah Sparrow*	1	1	5	2.33	--	2.33	--
Sharp-shinned Hawk	3	4	1	2.67	--	2.67	--
Snowy Owl	3	4	1	2.67	--	2.67	--
Song Sparrow	1	1	1	1.00	2.00	1.00	--
Tree swallow	5	4	1	3.33	--	3.33	--
Wild Turkey	3	1	3	2.33	--	2.33	--
Yellow Warbler	1	4	1	2.00	4.00	2.00	--
Eastern Garter Snake	1	4	1	2.00	4.00	2.00	--
Northern Brown Snake	1	4	1	2.00	4.00	2.00	--
Additional species							
Total Functional Value ($\sum$ of functional values for all species)					**49.33**	**95.33**	**0.00**

Notes: [1] – List does not represent total species list for Maritime Shrubland communities

[2] – Based on Brooks and Croonquist (1990): *Wetland, habitat, and trophic response guilds for wildlife species in Pennsylvania.*

[3] – Habitat Dependency

* - New Jersey State Endangered or Threatened Species

Each of the evaluated functions will improve under the proposed maximum habitat plan. Public access will be allowed, increasing the recreation functional score from 5.6 habitat units under existing conditions to 390.6 under the proposed plan. Sediment and toxicant reduction, marine fish habitat, and shoreline stabilization will also be increased substantially under the proposed plan. The change in functional values for the existing and proposed conditions is illustrated in Figure 6-2.

In general, results from the analysis indicate that wetlands score higher than uplands for most functions. The number of habitat units (per acre) ranges from 0 for roadways to 41 for Salt Marsh. Emergent marshes scored among the communities with the most value; Deep Emergent Marsh communities have 39 habitat units per acre. Shallow Emergent Marshes have 27 habitat units per acre under the existing conditions, and with improved access and invasive species control, will have 38 habitat units per acre under the proposed conditions. Cultural communities scored the lowest of all community types. Mowed Lawn and Common Reed/Mugwort communities have 6 and 7 habitat units per acre, respectively. Common Reed-dominated Wetlands have 14 habitat units per acre. Results of the Highway Methodology and wildlife functional assessment are summarized in Table 6.4, and are discussed below.

6.3.1 Wetland Communities

Floodplain Forest Wetland (FFW). The principal FFW functions are flood flow alteration and groundwater recharge. The flood flow alteration function is reasonably significant due to the absence of a downstream outlet, and the presence of small ponded areas throughout the wetland. Effective flood storage is small or non-existent upslope of or above the wetland. The wetland loses water to the underlying strata via infiltration and contributes to groundwater recharge. Secondary functions of FFW communities are production export, and wildlife habitat. Because this community is unique on the site, once the park is open to the public it would provide passive recreation, educational and scientific value, and visual quality and local uniqueness.

The functional score of FFW was 24 habitat units (per acre), however since the area is so small, the total score for existing conditions was only 6.2. Under the proposed conditions, however, increased public access, recreational and scientific value will increase the functional score slightly to 25 habitat units per acre, and the FFW will have a total of 6.4 habitat units (Table 6-4).

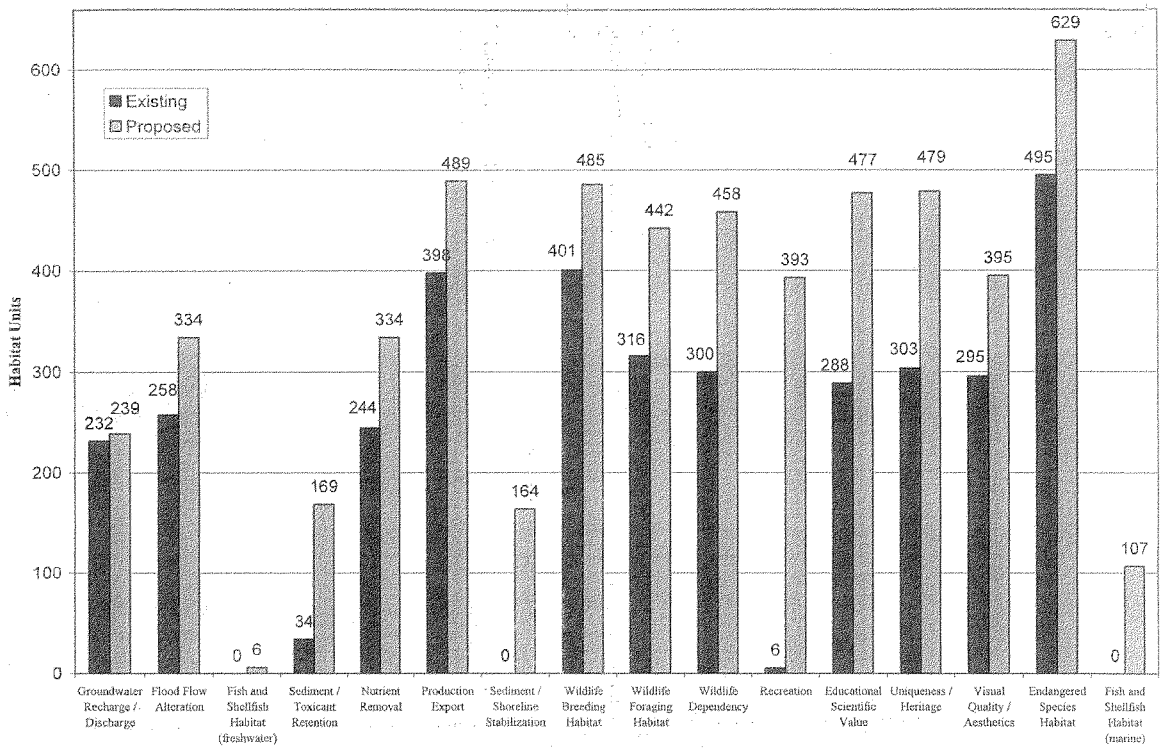


Figure 6-2. Cumulative functional values for existing conditions and the proposed habitat restoration plan at the Liberty State Park Restoration site, Jersey City, NJ.

Table 6-4. Functional assessment scores for existing and proposed conditions at Liberty State Park, Jersey City, NJ

Evaluated Ecological Community	Acreage	Groundwater Recharge / Discharge	Flood Flow Alteration	Fish and Shellfish Habitat (freshwater)	Sediment / Toxicant Retention	Nutrient Removal	Production Export	Sediment / Shoreline Stabilization	Wildlife Breeding Habitat	Wildlife Foraging Habitat
Existing Conditions										
Terrestrial Communities										
Successional Northern Hardwood (SNH)	62.62	1	1	0	0	1	2	0	2	2
Successional Shrubland (SSB)	4.22	1	1	0	0	1	2	0	1	2
Successional Old Field (SOF)	49.60	1	1	0	0	1	2	0	3	2
Common Reed/Mugwort (CRM)	38.69	1	1	0	0	1	1	0	0	0
Mowed Lawn (ML)	5.63	1	1	0	0	1	1	0	0	0
Maritime Forest (MF)	0.00	--	--	--	--	--	--	--	--	--
Maritime Grassland (MG)	14.55	1	1	0	0	1	2	0	3	2
Maritime Shrubland (MS)	22.03	1	1	0	0	1	2	0	2	1
Road (ROAD)	3.06	0	0	0	0	0	0	0	0	0
Palustrine Communities										
Forested Floodplain Wetland (FFW)	0.26	2	2	0	1	1	2	0	3	3
Shrub Swamp Wetland (SSW)	0.13	2	1	0	1	1	2	0	2	1
Shallow Emergent Marsh (SEM)	10.23	2	2	0	2	2	2	0	2	3
Deep Emergent Marsh (DEM)	0.00	--	--	--	--	--	--	--	--	--
Common Reed Wetland (CRW)	13.04	1	3	0	1	2	2	0	1	0
Estuarine Communities										
Salt Marsh (SM)	0.00	--	--	--	--	--	--	--	--	--
Total	224.06									

Table 6-4 (page 2 of 4). Functional assessment scores for existing and proposed conditions at Liberty State Park, Jersey City, NJ.

Evaluated Ecological Community	Acreage	Wildlife Dependency	Recreation	Educational Scientific Value	Uniqueness Heritage	Visual Quality / Aesthetics	Endangered Species Habitat	Fish and Shellfish Habitat (marine)	Habitat Units per Acre	Total Habitat Units
Existing Conditions										
Terrestrial Communities										
Successional Northern Hardwood (SNH)	62.62	2	0	2	2	1	3	0	**19**	**1189.78**
Successional Shrubland (SSB)	4.22	0	0	1	1	1	1	0	**12**	**50.64**
Successional Old Field (SOF)	49.60	2	0	1	1	2	3	0	**19**	**942.38**
Common Reed/Mugwort (CRM)	38.69	0	0	1	1	1	0	0	**7**	**270.80**
Mowed Lawn (ML)	5.63	0	1	0	0	1	0	0	**6**	**33.78**
Maritime Forest (MF)	0.00	--	--	--	--	--	--	--	**0**	**0.00**
Maritime Grassland (MG)	14.55	3	0	1	2	2	3	0	**21**	**305.55**
Maritime Shrubland (MS)	22.03	0	0	1	1	1	3	0	**14**	**308.46**
Road (ROAD)	3.06	0	0	0	0	0	0	0	**0**	**0.00**
Palustrine Communities										
Forested Floodplain Wetland (FFW)	0.26	3	0	2	2	1	2	0	**24**	**6.20**
Shrub Swamp Wetland (SSW)	0.13	2	0	1	2	1	2	0	**18**	**2.41**
Shallow Emergent Marsh (SEM)	10.23	3	0	2	2	2	3	0	**27**	**276.21**
Deep Emergent Marsh (DEM)	0.00	--	--	--	--	--	--	--	**0**	**0.00**
Common Reed Wetland (CRW)	13.04	0	0	1	1	1	1	0	**14**	**182.56**
Estuarine Communities										
Salt Marsh (SM)	0.00	--	--	--	--	--	--	--	**0**	**0.00**
Total	224.06								**Number of Existing Habitat Units**	**3,568.77**

Table 6-4 (Page 3 of 4). Functional assessment scores for existing and proposed conditions at Liberty State Park, Jersey City, NJ

Evaluated Ecological Community	Acreage	Groundwater Recharge / Discharge	Flood Flow Alteration	Fish and Shellfish Habitat (freshwater)	Sediment / Toxicant Retention	Nutrient Removal	Production Export	Sediment / Shoreline Stabilization	Wildlife Breeding Habitat	Wildlife Foraging Habitat
Proposed Conditions										
Terrestrial Communities										
Successional Northern Hardwood (SNH)	50.83	1	1	0	0	1	2	0	2	2
Successional Shrubland (SSB)	1.53	1	1	0	0	1	2	0	1	2
Successional Old Field (SOF)	9.21	1	1	0	0	1	2	0	3	2
Common Reed/Mugwort (CRM)	1.96	1	1	0	0	1	1	0	0	0
Mowed Lawn (ML)	5.45	1	1	0	0	1	1	0	0	0
Maritime Forest (MF)	2.61	1	1	0	0	1	2	0	3	3
Maritime Grassland (MG)	55.42	1	1	0	0	1	2	0	3	2
Maritime Shrubland (MS)	34.58	1	1	0	0	1	2	0	2	1
Road (ROAD)	3.06	--	--	--	--	--	--	--	--	--
Palustrine Communities										
Forested Floodplain Wetland (FFW)	0.26	2	2	0	1	1	2	0	3	3
Shrub Swamp Wetland (SSW)	0.82	2	1	0	1	1	2	0	2	1
Shallow Emergent Marsh (SEM)	17.04	2	3	0	3	3	3	3	2	3
Deep Emergent Marsh (DEM)	2.02	1	3	3	3	3	3	3	0	3
Common Reed Wetland (CRW)	3.62	1	2	0	1	2	2	0	1	0
Estuarine Communities										
Salt Marsh (SM)	35.64	1	3	0	3	3	3	3	2	3
Total	224.05									

Table 6-4 (page 4 of 4). Functional assessment scores for existing and proposed conditions at Liberty State Park, Jersey City, NJ.

Evaluated Ecological Community	Acreage	Wildlife Dependency	Recreation	Educational Scientific Value	Uniqueness / Heritage	Visual Quality / Aesthetics	Endangered Species Habitat	Fish and Shellfish Habitat (marine)	Habitat Units per Acre	Total Habitat Units
Proposed Conditions										
Terrestrial Communities										
Successional Northern Hardwood (SNH)	50.83	2	2	3	2	1	3	0	**22**	**1118.26**
Successional Shrubland (SSB)	1.53	0	1	1	1	1	1	0	**13**	**19.83**
Successional Old Field (SOF)	9.21	2	2	2	2	2	3	0	**23**	**211.83**
Common Reed/Mugwort (CRM)	1.96	0	1	1	1	1	0	0	**8**	**15.72**
Mowed Lawn (ML)	5.45	0	1	0	0	1	0	0	**6**	**32.70**
Maritime Forest (MF)	2.61	2	2	2	2	1	3	0	**23**	**60.03**
Maritime Grassland (MG)	55.42	3	2	2	2	2	3	0	**24**	**1330.08**
Maritime Shrubland (MS)	34.58	0	1	1	2	1	3	0	**16**	**553.28**
Road (ROAD)	3.06	--	--	--	--	--	--	--	**0**	**0.00**
Palustrine Communities										
Forested Floodplain Wetland (FFW)	0.26	3	1	2	2	1	2	0	**25**	**6.46**
Shrub Swamp Wetland (SSW)	0.82	2	0	1	2	1	2	0	**18**	**14.76**
Shallow Emergent Marsh (SEM)	17.04	3	2	2	3	3	3	0	**38**	**647.52**
Deep Emergent Marsh (DEM)	2.02	3	2	3	3	3	3	0	**39**	**78.78**
Common Reed Wetland (CRW)	3.62	0	1	1	1	1	1	0	**14**	**50.68**
Estuarine Communities										
Salt Marsh (SM)	35.64	3	2	3	3	3	3	3	**41**	**1461.24**
Total	224.05								**Number of Proposed Habitat Units**	**5,601.17**

Shrub Swamp Wetland (SSW). Primary SSW functions are groundwater recharge and wildlife breeding habitat. The physical configuration of the wetlands confirms the groundwater recharge function. The wetlands have no defined inlet, but trap precipitation and some runoff with steep sloping areas adjacent to the wetlands; when water level raises they overflow and water moves laterally into the adjacent pervious soil. This recharges the groundwater.

The functional score of SSW was 18 habitat units (per acre), and the 0.1 acre of SSW in the existing plan have a total number of 2.4 habitat units. Under the proposed conditions, the acreage of SSW will increase to 0.8, and the functional value will be 14.8 (Table 6-4).

Deep Emergent Marsh (DEM). The principal DEM functions are wildlife habitat, flood flow alteration and nutrient removal. There is no existing DEM habitat on the site; however, a DEM system is proposed for the restoration. Wildlife function is the primary reason for adding this wetland community to the proposed restoration plan. Creating a permanent pool of water where presently none exists will result in a significant increase in wildlife function throughout the year. Both wildlife foraging habitat and wildlife dependency functions will increase due to the addition of a range of hydrologic conditions and habitat diversity to the site.

The flood flow alteration function is reasonably significant due to the restricted outlet to the downstream side of the wetland created by a spillway. The area of the wetland is large relative to its watershed (+22 acres watershed to +5 acres wetland), and detention will occur in small ponded areas included in the wetland design, and in the well-saturated hydric soils. The wetland will receive and retain overland or sheet flow runoff from the surrounding uplands and two catchment areas (NJ Transit lot and Liberty Science Center). Effective flood storage is small or non-existent for the catchment areas that will be diverted to this system.

Nutrient removal is another principal function of the DEM, because of its relative size within the watershed, the presence of open water, and its potential to trap sediments. The physical configuration of the wetland, such as the various zones and the presence of a spillway, gives this wetland high potential to trap nutrients that are currently being discharged directly into the bay.

Secondary functions of this wetland include groundwater discharge, sediment and toxicant removal, production export, passive recreation, educational and scientific value, visual quality and local uniqueness.

The functional score of DEM communities is 39 habitat units per acre. The proposed plan will include a 2.0-acre DEM, which will receive a total functional score of 78.8 habitat units (Table 6-4).

Shallow Emergent Marsh (SEM). SEMs perform several of the same wetland functions as DEM wetlands. SEMs support a large abundance of breeding ducks and other waterfowl because complexes of depressional wetlands and surrounding uplands provide these birds with the diverse habitat they need for feeding, breeding, nesting, and brood-rearing. SEM wetlands are also important stopovers and staging areas for migratory species.

Many depressional wetlands, like SEM, are vernal pools that experience temporal variation in hydrology, drying out for a part of the year. Annual drying precludes organisms that require permanent water and favors species adapted to fluctuating water levels. These conditions are favorable for breeding amphibians.

Shallow Emergent Marshes also perform some groundwater recharge. Detention occurs in small ponded areas throughout the wetland and in the well-saturated hydric soils. Field observation with hand augers indicates that some of these wetlands are underlain by impervious layer that may restrict water loss to the deeper ground water system. In the absence of surface water outlets and ground water connections, water loss is primarily through evapotranspiration. However, water removal can occur through shallow flows, even when movement to deeper groundwater system is restricted. Additional data is required to determine whether groundwater plays a role in SEM wetlands within the LSP Restoration site.

The functional score for existing SEM wetlands is 27 habitat units per acre under existing conditions. Approximately 10.2 acres of SEM exists within the LSP Restoration site, and the total habitat units are 276.2. Increased public access, recreational and scientific value, and improved hydrological regime in the proposed future conditions increases the functional score for SEM to 38 habitat units per acre. The proposed plan increases the

acreage of SEM wetlands to 17.0, and the total number of habitat units to about 647.5 (Table 6-4).

Salt Marsh (SM). The proposed salt marsh system will be the largest wetland system on the site. It will be located in the Dredged Material Storage Area. Primary functions of SM communities are production export, flood flow alteration, water quality, wildlife habitat and aquatic habitat. These functions in conjunction with its large proposed acreage make this the most significant system within the restored plan. It has been frequently asserted that salt marshes are amongst the world's most productive ecosystems (Whittaker 1975). Important values to this system will include primarily education/scientific value and visual quality/aesthetics. A secondary value will be passive recreation considering its proximity to and access from the nearby Interpretive Center.

Salt Marsh communities received a functional score of 41 habitat units per acre, and the proposed 35.6 acre marsh will have a total of 1,461.2 habitat units. This habitat rating is the highest for any community as is the accrued total habitat units.

Common Reed-dominated Wetland (CRW). The principal function and values associated with these wetlands are flow alteration and retention transformation. The flat nature of the site and low runoff gives these wetlands a limited potential for trapping sediment and only a limited capacity for nutrient removal. The hydric soils have some ability for absorbing and retaining water, giving the wetlands a limited function of flood flow alteration.

Of all wetlands, CRW received the lowest functional score of 14 habitat units per acre in both the existing and the proposed restored conditions. The 13.0 existing acres of CRW have a total 182.6 habitat units. The proposed restoration plan calls for the removal of 9.4 CRW acres, and the total number of habitat units will be reduced to 50.7 (Table 6-4).

6.3.2 Upland Communities

Successional Northern Hardwoods (SNH). The principal functions of SNH communities are habitat value, production export and endangered species habitat. The total functional value of this community type under existing conditions is 19 habitat units per acre, and the total value is 1,189.8 habitat units for the 62.6 acres. Under the proposed plan, public access, recreational and scientific values are increased, resulting in the increased score of 22 habitat units per acre. Acreage of the SNH communities will decrease under the

proposed restoration plan, and the 50.8 acres will have a total of 1,118.3 habitat units (Table 6-4).

Successional Shrublands (SSB). Relatively small areas of SSB are currently located along the southeast boundary of the LSP Restoration site. Based on functional assessment results, these areas provide production export, wildlife foraging habitat including some endangered species' habitat. Contributing reasons for these functions are: they provide a source of food for wildlife, detritus development is present, vegetation density is high, and evidence of wildlife, including endangered species was documented.

Under existing conditions, SSB communities have a total of 50.6 habitat units for the 4.2 acres. Implementation of the proposed restoration plan will decrease the size of SSB to 1.5 acres and the functional score to 19.8 habitat units (Table 6-4).

Successional Old Field (SOF). SOF communities provide several functions at a moderate level, including production export, wildlife foraging habitat and dependency, and aesthetics. SOF also provides quality Endangered and Threatened Species (ETS) and wildlife breeding habitat. Grassland obligate species, such as the northern harrier, breed in SOF communities.

The functional score for SOF communities is 19 habitat units per acre under existing conditions, and the total score for the existing 49.6 acres of SOF is 942.4 habitat units. Under the proposed restoration plan, increased recreational and scientific value will result in an increased functional score of 23 habitat units per acre. Implementation of the restoration plan will decrease the habitat units assigned to SOF, because the plan calls for a reduction in SOF acreage. The total functional score of SOF will be 211.8 habitat units (Table 6-4).

Maritime Forest (MF). The principal functions of MF communities are wildlife breeding habitat, wildlife foraging habitat and endangered species habitat. Secondary functions include production export and uniqueness and heritage.

This community type will have a score of 23 habitat units per acre. Under the proposed restoration plan, approximately 2.6 acres of MF will be created, resulting in a total of 60.0 habitat units (Table 6-4).

Maritime Shrubland (MS). Primary functions of MS communities are production export and wildlife breeding habitat at a moderate level and endangered species habitat at a high level. Contributing factors for these functions and values are the same as those identified for SSB above. In the future, MS communities could offer a moderate level of heritage function based on the opportunity for wildlife observation, scientific research and proximity to and access from the nearby Interpretive Center.

Existing MS communities have a moderately low functional score of 14 habitat units per acre. The total score for the 22.0 acres of MS communities on the site is 308.5 habitat units. Proposed restoration implementation will increase the size of MS communities to 34.6 acres. Increased recreational and scientific value of these communities will increase the score to 16 habitat units per acre, and the total score under the proposed restoration will be 553.3 habitat units (Table 6-4).

Maritime Grassland (MG). Primary functions of MG communities include wildlife breeding habitat, wildlife dependency and endangered species habitat. Secondary functions include production export, wildlife foraging habitat, uniqueness and heritage, and aesthetics. As with SOF, the presence of wildlife including ETS and the identification of critical breeding habitat for northern harrier in these communities are the primary reason for its high rating for these functions.

The functional score for existing MG communities is 21 habitat units per acre, and the total score for the 14.6 acres is 305.6 habitat units. Under the proposed restoration plan, increased public access, recreational and scientific values will increase the score to 24 habitat units per acre of MG. Because Maritime Grassland is critical breeding habitat for the northern harrier, the proposed plan calls for an increase in the size of MG communities to 55.4 acres, resulting in a total score of 1,330.1 habitat units (Table 6-4).

Common Reed/Mugwort (CRM). CRM was identified throughout the LSP Restoration site with large areas concentrated in the northern portion of the site and the Dredged Material Storage Area. This community type provides limited functions (groundwater recharge and discharge, flood flow alteration, nutrient removal, aesthetics and production export) at a low level. None of the remaining functions assessed are provided by CRM communities.

The functional score for existing and future CRM communities is 7 habitat units per acre, and the total functional score for the existing 38.7 acres is 270.8 habitat units. The proposed restoration plan calls for the removal of most of these communities, leaving only about 2 acres. Increased public access will raise the functional value of CRM to 8 habitat units per acre. The total functional value for the proposed plan is 15.7 habitat units (Table 6-4)

Mowed Lawn (ML). ML, which is found along the northern boundary of the LSP Restoration site and surrounding the North Cove, provides six functions at a low level including ground water recharge, flood flow alteration, nutrient removal, production export, recreation and aesthetics.

The functional score for existing and future ML is 6 habitat units per acre, and the 5.6 existing acres have a functional score of 33.8 habitat units. The proposed plan calls for a decrease in ML acreage of ML to 5.5 acres, resulting in an increase functional score of 32.7 habitat units.

Road (ROAD). The roadways in the LSP Restoration site provide no functional value. The existing 3.1 acres of roadway will be converted to a walking trail under the proposed restoration plan (Table 6-4).

6.4 SUMMARY

The project's restored, created and enhanced wetlands are proposed to restore historic losses of wetland functions and values while enhancing the developing upland communities and their associated wildlife. The salt marsh will add an entirely new host of functions and values that are not currently present on the LSP Restoration site, particularly aquatic habitat. The deep emergent marsh will provide new habitat functions and values that presently do not exist, including deep water habitat for waterfowl. The shallow persistent open water depressions will provide the important function of groundwater recharge and habitat value. The palustrine emergent marsh will provide bird, mammal and amphibian habitat value. The wet meadow community along the salt marsh will assist important wetland functions of wildlife habitat and flood storage. The scrub-shrub wetland will provide flood flow attenuation to adjacent areas wildlife habitat value. The entire restoration plan provides upland, and wetland complex that will be a mosaic of habitats similar to what is present with two additional important ecosystems, the

saltmarsh system and deep water marsh system. Opening the site to the public with a system of walkways and observation platforms will add both aesthetic and educational value to the Liberty State Park interior that does not exist today. Table 6-4 and Figure 6-2 provide a graphic representation of changes in vegetation community functions and values between existing conditions and the proposed ecological restoration plan.

7. REFERENCES

Able, K.W. and F.P. Fahay. 1998. The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight. Rutgers Univ. Press, New Brunswick, NJ 400 p.

Adamus, P.R., E.J. Clairain, Jr., R.O. Smith, and R.E. Young. 1987. Wetland Evaluation Technique (WET): Volume II: Methodology. Operational Draft Technical Report FHWA-IP-88-029. US Army Waterways Experiment Station. Vicksburg, MI. 279pp.

Allen, D.M., W.S. Johnson and V. Ogburn-Matthews. 1995. Trophic relationships and seasonal utilization of salt-marsh creeks by zooplanktivorous fishes. Environmental Biology of Fishes. 42:37-50.

Andrle, R.F., and J.R. Carroll. 1988. The Atlas of Breeding Birds in New York State. Cornell University Press. 550 pp.

Aslop, Fred J. III. 2001. Smithsonian Birds of North America. DK Publishing, Inc. New York, NY. 1008p.

ASMFC (Atlantic States Marine Fisheries Commission). 1992. Fishery management plan for Atlantic menhaden. 1992 revision. September 1992.

Baicich, P.J., and C.J.O. Harrison. 1997. A guide to the nests, eggs, and nestlings of North American Birds. Academic Press, New York, NY.

Banner, A., and S. Schaller. 2001. USFWS Gulf of Maine Watershed Habitat Analysis. Gulf of Maine Program. Retrieved July 31, 2003, from

http://r5gomp.fws.gov/gom/habitatstudy/Gulf_of_Maine_Watershed_Habitat_Analysis.htm

Beans, Burce E. and Larry Niles. 2003. Endangered and threatened wildlife in New Jersey. Rutgers University Press. New Brunswick, NJ. 303p.

Beck, S. 1995. White perch. Pages 235-243. in L.E. Dove and R.M. Nyman. editors. Living resources of the Delaware estuary. The Delaware Estuary Program.

Bellrose, F.C. 1980. Ducks, Geese, and Swans of North America. Harrisburg, PA: Stackpole Books. 540 pp.

Bigelow, H. B., and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. Bull. U.S. Fish Wildl. Serv., Fish. Bull. 74.

Botton, M. L. 1995. "Horseshoe crab." In Living Resources of the Delaware Estuary, edited by L. E. Dove and R. M. Nyman, 51–57. Philadelphia: U.S. Environmental Protection Agency

Brinson, M.M. 1993. "A Hydrogeomorphic Classification for Wetlands," Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Britt, M. 2003. Half-year report summarizing bird observations at Liberty State Park. Unpublished report submitted to F. Gallagher, NJDEP, Division of Parks and Forestry.

Bull, J. 1974. Birds of New York State. Comstock Publishing, Ithaca, NY.Bull, J., and J. Farrand, Jr. 1977. The Audubon Society field guide to North American Birds. Alfred A. Knopf, New York, NY.

Bull, J., and J. Farrand, Jr. 1977. The Audubon Society field guide to North American Birds. Alfred A. Knopf, New York, NY.

Burgess, G. H. 1980. Morone americana (Gmelin), white perch. Page 573 in D.S. Lee, et al., editors. Atlas of North American freshwater fishes. N.C. State Mus. Nat. Hist., Raleigh.

Clark, K.E., and L.A. Gelvin-Innvaer. 1995. Migratory shorebirds. Pages 441-447 in L.E. Dove and R.M. Nyman (eds.), Living Resources of the Delaware Estuary. The Delaware Estuary Program.

Connecticut Department of Environmental Protection. 2003. Wildlife in Connecticut Endangered and Threatened Species Series: Long-Eared Owl (Asio otus). Bureau of Natural Resources, Wildlife Division. Hartford, CT. http://dep.state.ct.us/burnatr/wildlife/factshts/leowl.htm. January 2000.

Connecticut Department of Environmental Protection. 2003. Wildlife in Connecticut Endangered and Threatened Species Series: Northern Harrier (Circus cyaneus). Bureau of Natural Resources, Wildlife Division. Hartford, CT. http://dep.state.ct.us/burnatr/wildlife/factshts/harrier.htm. January 2000.

Connecticut Department of Environmental Protection. 2003. Wildlife in Connecticut Endangered and Threatened Species Series: Short-Eared Owl (Asio flammetus). Bureau of Natural Resources, Wildlife Division. Hartford, CT. http://dep.state.ct.us/burnatr/wildlife/factshts/searowl.htm. January 2000.

Cornell Lab of Ornithology. 1997. Birds in forested landscapes. Cornell Lab of Ornithology, Ithaca, NY.

Curley, J.H., R.P. Lawton, D.L. Chawick, K. Reback, and J.M. Hickey. 1974. A study of the marine resources of the Taunton River and Mount Hope Bay. Monograph Series Number 15. Division of Marine Fisheries, Massachusetts Department of Natural Resources.

Dauer D.M., J.A. Ranasinghe, and S.B. Weisberg. 2000. Relationship between benthic community condition, water quality, sediment quality, nutrient loads and land use patterns in Chesapeake Bay. Estuaries 23(1):80-96.

Dechant, J.A., M.L. Sondreal, D.H. Johnson, L.D. Igl, C.M. Goldade, M.P. Nenneman, and B.R. Euliss. 2001. Effects of management practices on grassland birds: Northern Harrier. Northern Prairie Wildlife Research Center, Jamestown, ND. Northern Prairie Wildlife Research Center Home Page.

http://www.npwrc.usgs.gov /resource/literatr/grasbird/harrier/harrier.htm (Version 17FEB2000).

Dorsey, S. E., E. D. Houde, and J. C. Gamble. 1996. Cohort abundances and daily variability in mortality of eggs and yolk-sac larvae of bay anchovy, Anchoa mitchilli, in Chesapeake Bay. Fishery Bulletin 94:257-267.

Dovel, W.L. 1992. Movements of immature striped bass in the Hudson estuary. Pages 276-300 in C.L. Smith, editor. Estuarine research in the 1980s: the Hudson River Environmental Society Seventh Symposium on the Hudson River Ecology. State Univ. of New York Press, Albany, NY.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. (Draft for review).

ENSP. 2002b. Savannah sparrow, Passerculus sandwichensis. New Jersey Division of Fish and Wildlife, Conserve Wildlife Webpage. Retrieved 10/14/03 from http://www.state.nj.us/dep/fgw/tandespp.htm.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. Prepared for the U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Gallagher, F. 2003. Personal communication between R. Zwier of URS and F. Gallagher of NJDEP, Division of Parks and Forestry on 9/25/03.

Garbish, E. W. 1986. Highways and wetlands: Compensating for Wetland Losses. US DOT, FHA Report No. FHA Report No. FHWA-IP-86-22, 60 pp.

Garbish, E. W. 1989 Wetland enhancement, restoration, and construction. Pages 261-275 in S.K. Majuday, R.P. in Brooks, F.J. Brenner, and R.W. Tiner (eds.) Wetland ecology and conservation: Emphasis in Pennsylvania. The Pennsylvania Academy of Science, Philadelphia.

Garbish, E.W. and Garbish, J.L. 1994. Control of Upland Bank Erosion Through Tidal Marsh Construction of Restored Shores: Application in the Maryland Portion of Cheasepeake Bay.

GretagMacbeth. 2000. Munsell Soil Color Charts: Year 2000 Revised, New Windsor, CT. Hall, W.R. 1995. Atlantic Menhaden. pp 219 - 226. In: L.E. Dove and R.M. Nyman [eds.], Living Resources of the Delaware Estuary. Report of the Delaware Estuary Program. July 1995.

Hardy, J.D., Jr. 1978. Development of fishes of the Mid-Atlantic Bight: An atlas of the egg, larval and juvenile stages, volume III. Aphredoderidae through Rachycentridae. FWS/OBS-78/12. U.S. Fish Wildl. Serv., Biol. Serv. Prog.

Hildebrand, S. F. 1963. Family: Clupeidae. Pages 152-249 in Fishes of the western North Atlantic. Mem. Sears Found., Mar. Res. Mem. 1(3):1-630.

Hollands, G.H. and McGee, D.W. 1985. A Method for Assessing the Functions of Wetlands, Proceedings of the National Wetlands Assessment Symposium, J.A. Kusler (Ed.) Association of State Wetland Managers, Berne, New York (1985) pp. 108-118.

Howe, M.A., R.B. Ciapp, and J.S. Weske. 1978. Marine and Coastal Birds. New York Sea Grant Institute. MESA N.Y. Bight Atlas Monograph 31. 87 pp.

Iocco L., p. Wilbur, R. Diaz, D. Clarke and B. Will. 2000. Benthic Habitats of New York/ New Jersey Harbor: 1995 Survey of Jamaica, Upper, Newark, Bowery and Flushing Bays. Final Report for United States Army Corps.

Inderjit. 2001. Soil: environmental effects on allelochemical activity. Agron. J. 93:79-84.

Inderjit and C. L. Foy. 1999. Nature of the interference mechanism of mugwort (Artemisia vulgaris). Weed Technol. 13:176-182.

Kelso, D.P. 1994. Spatial and seasonal variation in fish communities in the tidal freshwater Potomac River. Bulletin of the Ecological Society of America 75 (2):108.

Kennard, W.C., M.W. Lefor, and D. L. Civco. 1983. Analysis of Coastal Marsh Ecosystems: Effect of Tides on Vegetational Change. Univ. of Connecticut, Institute of Water Resources, Storrs, CT. Res. Proj, Tech. Completion Rept. B-014 CONN. 140pp.

Lawler, Matusky Skelly Engineers LLP (LMS). 1996. Biological survey of Newark Bay shoal areas and adjacent Kill Van Kull and Arthur Kill Channels. Prepared for the Port Authority of New York and New Jersey.

Lawler, Matusky Skelly Engineers (LMS). 1987. Preliminary draft environmental impact statement, River Walk. Prepared on behalf of Related Properties, Inc., for the City of New York Environmental Quality Review.

Lawrence, R.D. 2001. Owls: the silent fliers. Revised edition. Firefly Books, Canada 176 p.

Liberty State Park (LSP) 2003. History of Liberty State Park.

http://www.libertystatepark.com/1/lsp_history/history.htm

Llanso Roberto J. 1991. Tolerance of low dissolved oxygen and hydrogen sulfide by the polychaete Streblospio benedicti. Journal of Experimental Marine Biology Ecology. 153:165-178.

MacFarlane, D.W. 2001. The Ecology of Liberty State Park: A Historical Perspective

Macwhirter, R.B., and K.L. Bildstein. 1996. Northern Harrier, Circus cyaneus. In A. Poole and F. Gill (eds.) The Birds of North America, No. 210. The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C.

Mansueti, R.J. 1964. Eggs, larvae, and young of the white perch, Roccus americanus with comments on its ecology in the estuary. Ches. Sci. 5:3-45.

Massachusetts Division of Fisheries & Wildlife. 2003. Massachusetts Threatened Wildlife: Northern Harrier (Circus cyaneus). Natural Heritage & Endangered Species Program. Westborough, MA.

http://www.state.ma.us/dfwele/dfw/nhesp/nhfacts/Circya.pdf. January 2003.

McFadden, J.T., Texas Instruments, Inc., and Lawler, Matusky & Skelly Engineers. 1978. Influence of the proposed Cornwall pumped storage project and steam electric generating plants on the Hudson River estuary with emphasis on striped bass and other fish populations. Prepared for Consolidated Edison Co. of NY, Inc.

Mihursky, J.A., W.R. Boynton, E.M. Setzler, K.R. Wood, H.H. Zion, E.W. Gordon, L.Tucker, P. Pulles, and J. Leo. 1976. Final report on Potomac estuary fisheries study: ichthyoplankton and juvenile investigations. Univ. of Maryland CEES Ref. No. 76-12-CBL.

Morton, T. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)-Bay Anchovy. U.S. Fish and Wildlife, Biological Report 82(11.97), TR EL-82-4. 13 p.

New York Natural Heritage Program, New York Department of Environmental Conservation, Albany, NY.ENSP. 2002a. Short-eared owl, Asio flammeus.

New York State Department of Environmental Conservation. 2003. Short-eared owl fact sheet. Endangered Species unit, Albany, NY. Retrieved March 2003 from:

http://www.dec.state.ny.us/website/dfwmr/wildlife/endspec/seowfs.html.

New Jersey Department of Environmental Protection (NJDEP). 2003. Birds of Liberty State Park. NJDEP, Division of Parks and Forestry, Trenton, NJ.

New Jersey Department of Environmental Protection (NJDEP). 2001. Liberty State Park General Management Plan for the Parks Interior Section. New Jersey Department of Protection – Division of Parks and Forestry. 29pp.

New Jersey Department of Environmental Protection (NJDEP). 1995. Protocols for the establishment of exceptional resource value wetlands pursuant to the freshwater wetlands protection act (N.J.S.A. 13:9B-1 et seq.) based on the documentation of state or federal endangered or threatened species. A cooperative effort between the Land Use Regulation Program, Office of Natural Lands Management, Division of Parks, and Forestry, and the Endangered and Nongame Species Program, Division of Fish, Game, and Wildlife. Trenton, NJ.NOAA. 2003. Mudworms. Capitella sp..

www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgstrebl.html

New Jersey Division of Fish and Wildlife, Conserve Wildlife Webpage. Retrieved 10/10/03 from

http://www.state.nj.us/dep/fgw/tandespp.htm.

Nichols, T.C. 1995. Diving ducks. Pages 353-358 in C.E. Dove and R.M. Nyman, (eds.), Living Resources of the Delaware Estuary. The Delaware Estuary Program.

NOAA. 2003. Mudworms. Streblospio benedicti.

www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgstrebl.html

NOAA. 2003. Other benthos: Amphipod.

www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgstrebl.html

NRCS. 2003. Conservation plant characteristics for Torrey's rush. Retrieve 10/10/03 from http://plants.usda.gov/cgi_bin/plant_attributes.cgi?symbol=JUTO

Pearson T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology: an Annual Review. 16:229-311.

Ralph, J.C., G.R. Geupel, P. Pyle, T.E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Dept. of Agriculture.

Reed, Porter B. 1988. National List of Plant Species that Occur in Wetlands: Northeast (Region 1). Biological Report 88(26.1). Prepared for the National Wetlands Inventory, U. S. Fish and Wildlife Service (USFWS), Washington, DC.

Reschke, C. 1990. Ecological Communities of New York State. New York Natural Heritage Program, NYS DEC, Latham, New York.

Rogers, S.G., and M.J. Van Den Avyle. 1989. Species Profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic) - Atlantic Menhaden. U.S. Fish & Wildlife Service Biological Report 82 (11.108). U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS. Technical Report EL-82-4.

Schneider, K.J. and D.M. Pence, eds. 1992. Migratory Nongame birds of management concern in the Northeast. US Dept. of the Interior, Fish and Wildlife Service, Newtown Corner, MA.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. Can. Bull. 184.

Shuster, C. N. Jr. 1982. "A pictorial review of the natural history and ecology of the horseshoe crab, Limulus polyphemus, with reference to other Limulidae." In Physiology and biology of horseshoe crabs: Studies on normal and environmentally stressed animals, edited by J. Bonaventura et al. New York: Alan R. Liss, Inc.

Springer, V. G. and D. D. Woodburn. 1960. An ecological study of the fishes of the Tampa Bay area. Florida Board Conserv. Mar. Lab. Prof. Pap. Ser.1. 104 p.

Stanley, J.G. and D.S. Danie. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—white perch. U.S. Fish and Wildlife Service Publication No. FWS/OBS-82/11.7.

Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L. Andreasen. 1994. Distribution and abundance of fishes and invertebrates in Mid-Atlantic estuaries. ELMR Rep. No. 12. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 280 pp.

Texas Instruments (TI). 1976. Liberty State Park ecological study. Prepared for the Port Authority of New York and New Jersey.

Tiner, R. W., Jr. 1985. Wetlands of New Jersey. U.S. Fish and Wildlife Service, National Wetlands Inventory, Newton Center, MA. 117 pp.

U.S. Army Corps of Engineers (USACE). 2004. Liberty State Park Hydrology and Hydraulics of Freshwater Wetlands.

U.S. Army Corps of Engineers (USACE). 1995. Wetlands Delineation Manual. (Revised November 16 1995) http://www.wetlands.com/coe/87manp3b.htm Environmental Technical Services Co., 834 Castle Ridge Rd., Austin, TX 78746-5152

U.S. Army Corps of Engineers (USACE). 1993. The Highway Methodology Workbook, US Army Corps of Engineers New England Division. 28 pp. NEDEP-360-1-30

U.S. Department of Agriculture, Soil Conservation Service (SCS). 1989. New York Hydric and Soils with Potential Hydric Inclusions. SCS: Syracuse, NY.

U.S. Fish and Wildlife Service (USFWS). 1998. Assessment of the dredged material management plan for the port of New York and New Jersey. Draft Fish and Wildlife Coordination Act Section 2(b) Report.

U. S. Fish and Wildlife Service, U. S. Army Corps of Engineers. 1989. Federal Manual for Delineating Jurisdictional Wetlands: An Interagency Cooperative Publication, Washington, DC.

U.S. Fish and Wildlife Service 1980. Habitat Evaluation Procedures (HEP) Manual (102 ESM), Washington, D.C. (1980) Paginated variously.

Wander, W. 1999. Grassland birds. Presentation at the course on Threatened and Endangered Species in New Jersey. Cook College Office of Continuing Education, New Brunswick, NJ March 15-16, 1999.

Wang, J.C.S., and R.J. Kernehan. 1979. Fishes of the Delaware estuaries: a guide to early life histories. Ecological Analysts, Inc.

Whittaker, R.H. 1970. Communities and Ecosystems. Macmillan, New York. 162 p. illus.

Winemiller, K.O., and K.A. Rose. 1992. Patterns of life-history diversification in North American fishes: implications for population regulation (Includes Database). Can. J. Fish. Aquat. Sci. 49: 2196-2218.

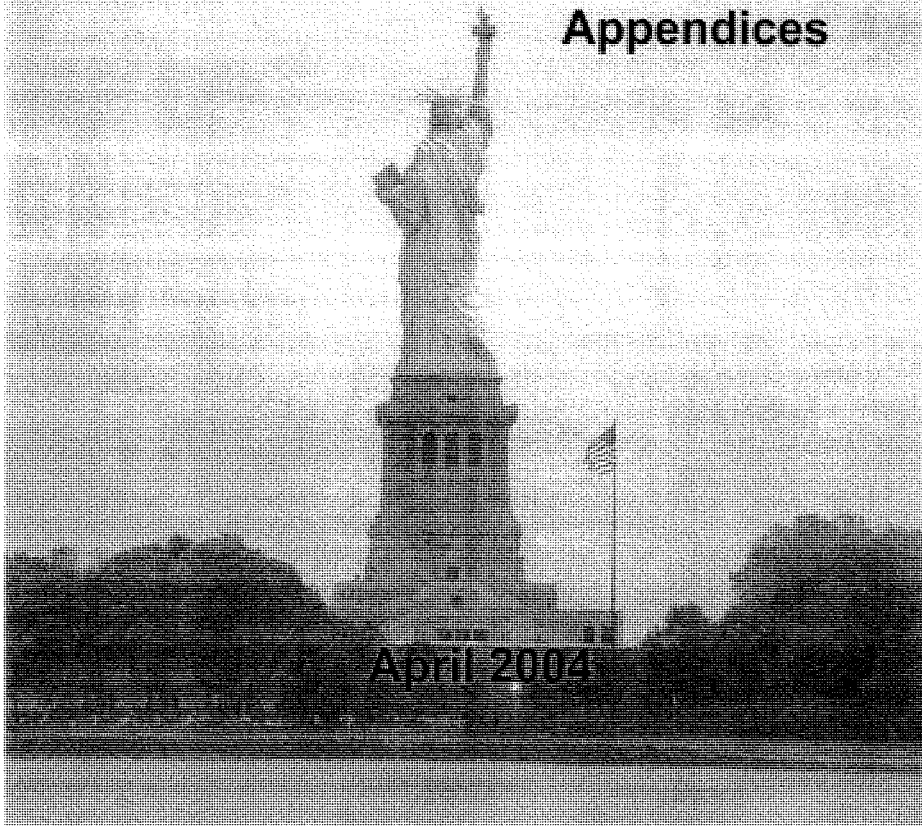
Woodhead PMJ, T. Rotunno and S. Zappala. 1999. New York Harbor Habitat Assessment Project. Biological assessment of fish habitat associated with shipping piers in New York Harbor. State University of New York, Stony Brook, NY.

Zappala, Sarah. 2001. The growth and development of epibenthic and benthic communities associated with waterfront shipping piers in New York Harbor. Masters Thesis. State University of New York, Stony Brook.

US Army Corps
of Engineers®
New York District

THE PORT AUTHORITY OF NY & NJ

Liberty State Park
Environmental Resources Inventory
Appendices



April 2004

Appendix A

Inventory of Plants, Benthic Macroinvertebrates, Fish and Wildlife Species Observed in Liberty State Park Jersey City, NJ

Table A-1 (Page 1 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Abutilon theophrasti	velvetleaf			X	N
Acer Rubrum	red maple	X		X	Y
Acer spp.	maple species		X		--
Achillea millefolium	yarrow	X	X	X	N
Agrostis hyemalis	bentgrass	X			Y
Agrostis sp.	bentgrass species			X	--
Ailanthus altissima	tree-of-heaven		X	X	N
Alliaria petiolata	garlic mustard			X	N
Ambrosia atremesifolia	common ragweed	X		X	Y
Ambrosia sp.	ragweed species			X	--
Amelanchier sp.	shadbush			X	--
Amorpha sp.	indigo species			X	--
Ampelopsis brevipedunculata	porcelainberry		X		N
Anaphalis margaritcea	pearly everlasting	X	X		Y
Andropogon sp.	beardgrass species			X	--
Andropogon virginianus	broomsedge	X	X		Y
Anthemis cotula	mayweed			X	N
Apocyanum cannibinum	hemp dogbane		X	X	Y
Apocyanum medium	intermediate dogbane	X			N
Arabis sp.	rock-cress species			X	--
Arctium lappa	great burdock	X			N
Arctium minus	annual wormwood	X			N
Aristida oligantha	prairie three-awn			X	Y
Aristida sp.	three-awn grass species			X	--
Artemesia vulgaris	mugwort	X	X	X	N
Asclepias syrica	common milkweed	X	X	X	Y
Asclepias tuberosa	butterfly weed		X		Y
Asclepias variegata	white milkweed			X	Y
Asparagus officinalis	asparagus	X			N
Aster sp.	aster species	X	X	X	Y
Atriplex sp.	orache species	X			--
Baccharus halimifolia	eastern baccharis			X	Y
Barbarea vulgaris	winter cress	X		X	N
Betula papyrifera	paper birch	X			Y
Betula pendula	white birch			X	N
Betula populifolia	gray birch		X	X	Y
Betula sp.	birch species			X	--
Bidens aristosa	tickseed sunflower	X			Y
Boehmeria cylindrica	false nettle			X	Y
Brassica sp.	mustard species			X	--
Bulbostylis capillaris	hairgrass		X		Y
Bulbostylis sp.	bulbostylis species			X	--
Calamagrostis canadensis	bluejoint	X			Y
Calamagrostis epigeios	reed steppe grass		X	X	N
Cardaria draba	pepperweed			X	N

Table A-1 (Page 2 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Carex sp.	sedge species	X		X	--
Cassia nictitans	wild sensitive plant			X	Y
Celtis occidentalis	hackberry	X			Y
Centaurea sp.	knapweed species	X			--
Centauria maculosa	spotted knapweed		X	X	NL
Cerastium sp.	mouse-ear chickweed species			X	--
Cerastium vulgatum	mouse-ear chickweed	X			N
Chenopodium album	lambsquarters	X		X	N
Chichorium intybus	chickory	X			NL
Chrysanthemum luecanthemum	oxe-eye daisy	X	X		NL
Cinna sp.	woodreed species			X	--
Cirsium altissimum	tall thistle			X	Y
Cirsium arvense	Canada thistle	X	X	X	N
Cirsium discolor	field thistle			X	Y
Cirsium muticum	swamp thistle			X	Y
Cirsium vulgare	bull thistle	X			N
Cladonia cristatella	british soldier lichen		X	X	Y
Commelina communis	asiatic dayflower	X			N
Convolvulus arvensis	field bindweed	X			N
Convolvulus sp.	bindweed species			X	--
Cornus alterniflora	alternate-leaf dogwood			X	NL
Crepis sp.	hawksbeard species	X			--
Cyperus esculentus	yellow nutsedge			X	N
Cyperus odoratus	galingale	X			Y
Cyperus ovularis	ball sedge		X		Y
Cyperus ovularis	spike-ball sedge		X		Y
Cyperus strigosus	straw-colored cyperus		X	X	NL
Danthonia sp.	wild oat grass	X			--
Datura stramonium	jimsonweed	X		X	N
Daucus carota	wild carrot	X	X	X	N
Desmodium sp.	beggar's tick species			X	--
Dianthus sp.	pink species			X	--
Digitaria sanguinalis	large hairy crabgrass	X			Y
Dipsacus sp.	teasel species			X	--
Echium vulgare	vipers bugloss			X	N
Elaeagnus sp.	olive species			X	--
Elaeagnus umbellata	autumn olive			X	N
Eleocharis obtusa	blunt spike rush		X		Y
Eleocharis parvula	dwarf spike rush		X		Y
Eleocharis sp.	spike rush species	X		X	--
Equisetum arvense	horsetail		X	X	Y
Equisetum sp.	scouring rush species	X		X	--
Eragrostis pectinacea	nees pink grass			X	Y
Erigeron annuus	daisy fleabane			X	Y

Table A-1 (Page 3 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Erigeron philadelphicus	common fleabane			X	Y
Eupatorium hyssopifolium	hyssop-leaved boneset		X	X	Y
Eupatorium perfoliatum	boneset	X			Y
Eupatorium pilosum	hairy boneset		X		Y
Eupatorium rugosum	white snakeroot	X		X	Y
Eupatorium sp.	thoroughwort			X	--
Euphorbia supina	milk purslane			X	Y
Festuca elatior	meadow fescue	X			N
Festuca sp.	fescue species			X	--
Fragaria virginiana	wild strawberry	X			Y
Fraxinus americana	white ash		X		Y
Geranium carolinianum	Carolina cranesbill	X			Y
Graminae sp.	grass species			X	--
Habernaria sp.	orchis species			X	--
Helianthus tuberosus	Jerusalem artichoke	X			Y
Heterotheca subaxillaris	camphor weed		X		Y
Hibiscus palustris	marsh mallows		X	X	Y
Hieracium canadensis	Canada hawkweed	X			NL
Hieracium sp.	hawkweed species		X	X	--
Hydrangea sp.	hydrangea species			X	--
Hypericum gentianoides	orange grass		X	X	Y
Hypericum perforatum	common St. Johnswort	X		X	N
Hypericum punctatum	spotted St. Johnswort			X	Y
Hypericum sp.	St. Johnswort species			X	--
Juncus acuminatus	sharp-fruited rush		X		Y
Juncus effusus	common rush		X		Y
Juncus tennis	path rush			X	NL
Juncus torreyi	torrey's rush		X	X	Y
Juniperus virginiana	eastern red cedar			X	Y
Lactuca canadensis	prickly lettuce			X	Y
Lactuca sp.	lettuce species	X			--
Larix sp.	larch species			X	--
Lepidium sp.	peppergrass species			X	--
Lepidium virginicum	peppergrass	X			Y
Lespedeza sp.	bush clover species			X	--
Leucobryum glaucum	white cushion moss		X		Y
Lichen sp.	lichens species			X	--
Linaria vulgaris	butter and eggs	X		X	N
Linum sp.	flax species			X	--
Liquidambar sp.	sweetgum species			X	--
Lonicera japonica	Japanese honeysuckle			X	N
Lonicera morrocui x Bella	bella honeysuckle			X	NL
Lycopdium complantanum	running ground pine		X		NL
Lycopodium alopecuroides	fox-tail clubmoss		X		Y
Lycopus sp.	waterhorehound			X	--
Lythrum salicaria	purple loosestrife	X	X	X	N

Table A-1 (Page 4 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Malve moschata	musk mallow			X	NL
Marshallia sp.	marshallia species			X	--
Matricaria matricarioides	pineapple-weed	X			N
Medicago lupulina	black medik	X			NL
Medicago sativa	alfalfa	X			N
Melilotus alba	white sweet clover	X	X	X	N
Melilotus officianale	yellow sweet clover		X		NL
Melilotus sp.	sweet clover species			X	--
Mirabilis nyctaginea	4-o'clock	X			Y
Mirabilis sp.	4-o'clock species			X	--
Morella cerifera	common waxmyrtle			X	Y
Morus alba	white mulberry			X	N
Morus sp.	mulberry species			X	--
Moss sp.	moss species			X	--
Muhlenbergia sp.	muhly grass species			X	--
Myrica pensylvanica	northern bayberry		X	X	Y
Oenothera biennis	common evening primrose	X			Y
Onoclea sensibilis	sensitive fern	X	X	X	Y
Oxalis stricta	yellow wood sorrel	X			Y
Panicum dichotomiflorum	spreading witch grass	X		X	Y
Panicum sp.	panicum species	X		X	--
Panicum virgatum	switchgrass		X	X	Y
Parthenocissus quinquefolia	virginia creeper	X	X	X	Y
Parthenocissus tricuspidata	Boston ivy	X			N
Paspalum sp.	paspalum	X			--
Pastinaca sativa	wild parsnip	X	X	X	N
Phalaris arundinacea	reed canary grass			X	Y
Phlox paniculata	garden phlox			X	Y
Phragmites australis	common reed	X	X	X	Y
Phytolacca americana	American pokeweed	X			Y
Phytolacca sp.	pokeweed species			X	--
Picea glauca	white spruce			X	Y
Pinus strobus	white pine			X	Y
Pinus sylvestris	scotch pine			X	N
Plantago lanceolata	narrow-leaved plantain	X		X	N
Plantago major	common plantain	X			Y
Plantago sp.	plantain species			X	--
Platanus occidentalis	American sycamore			X	Y
Poa palustris	fowl meadow grass			X	Y
Poa pratensis	Kentucky bluegrass	X			N
Poa sp.	poa species			X	--
Poltrichum commune	hair-cap moss		X		NL
Polygonum aviculare	prostrate knotweed	X			N

Table A-1 (Page 5 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Polygonum cespitosum	lady's thumb	X		X	N
Polygonum cuspidatum	Japanese knotweed	X	X	X	N
Polygonum prolificum	knotweed	X			NL
Polygonum scandens	climbing false buckwheat	X		X	Y
Polygonum sp.	smartweed species			X	--
Polyporaceae sp.	bracket fungi species			X	--
Populus alba	white poplar	X	X	X	N
Populus deltoides	eastern cottonwood	X	X	X	Y
Populus grandidentata	big-toothed aspen		X	X	Y
Populus nigra	lombardy poplar			X	N
Populus sp.	poplar species			X	--
Populus tremuloidies	quaking aspen		X	X	Y
Potentilla intergrifolia	downy cinquefoil			X	NL
Potentilla recta	rough-fruited cinquefoil	X		X	N
Potentilla simplex	common cinquefoil	X			Y
Potentilla sp.	cinquefoil species			X	--
Prunus serotina	black cherry	X		X	Y
Prunus sp.	wild cherry species		X	X	--
Pyrola sp.	wintergreen species			X	--
Quercus palustris	pin oak			X	Y
Quercus sp.	oak species		X	X	--
Quercus velutina	black oak			X	Y
Ranunculus sp.	buttercup species			X	--
Rhododendron sp.	rhododendron species			X	--
Rhus copallina	winged sumac	X	X	X	Y
Rhus glabra	smooth sumac		X	X	Y
Rhus typhina	staghorn sumac	X	X	X	Y
Robinia pseudoacacia	black locust	X	X	X	Y
Rosa multiflora	multiflora rose	X			N
Rubus laciniata	cut-leaved blackberry			X	NL
Rubus ostryifolius	highbush blackberry			X	Y
Rubus sp.	blackberry species	X		X	--
Rudbeckia hirta	black-eye susan	X		X	Y
Rumex acetosella	field sorrel	X		X	N
Rumex crispus	curled dock	X		X	N
Salix alba	white willow			X	N
Salix discolor	pussywillow		X	X	Y
Salix sp.	salix species			X	--
Sambucus canadensis	elderberry	X	X	X	Y
Saponaria officinalis	bouncing bet	X	X	X	N
Scirpus americana	three-square		X		Y
Scirpus cyperinus	woolgrass		X		Y
Scirpus sp.	bulrush species	X			--
Scutellaria intergrifolia	larger skullcap			X	NL
Scutellaria sp.	skullcap species			X	--
Senecio vulgaris	groundsel tree	X		X	N

Table A-1 (Page 6 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Setaria sp.	foxtail	X			--
Setaria viridis	green foxtail			X	N
Silene antirrhina	sleepy catchfly		X		Y
Silene cucubalus	bladder campion	X			N
Silene latifolia	white champion			X	N
Silene sp.	champion species			X	--
Sisymbrium altissimum	tumble mustard	X			N
Sisyrinchium sp.	blue-eyed grass species	X			--
Solanum interius	deadly nightshade			X	Y
Solanum nigrum	common nightshade	X			N
Solanum sp.	nightshade species	X		X	--
Solidago altissima	tall goldenrod	X		X	Y
Solidago arguta	sharp-leaved goldenrod			X	Y
Solidago canadensis	Canada goldenrod			X	Y
Solidago gigantea	late goldenrod			X	Y
Solidago gramnifolia	narrow-leaved goldenrod	X		X	NL
Solidago juncea	early goldenrod			X	Y
Solidago microcephala	slender goldenrod			X	Y
Solidago odora	sweet goldenrod			X	Y
Solidago patula	rough leaved goldenrod			X	Y
Solidago semervirens	seaside goldenrod	X			Y
Solidago sp.	goldenrod species		X	X	--
Solidago speciosa	showy goldenrod			X	Y
Solidago tenuifolia	slender-leaved goldenrod			X	Y
Spartina alterniflora	smooth cordgrass	X			Y
Spartina patens	saltmeadow cordgrass			X	Y
Sphagnum spp.	sphagnum moss		X		--
Spiraea tomentosa	steeplebush	X	X	X	Y
Spiranthes cernua	nodding ladies tresses		X		Y
Stellaria sp.	chickweed species			X	--
Strophostyles helvola	wild bean			X	NL
Symphyotrichum ericoides	heath aster	X		X	Y
Syntherisma sanguinale	large crabgrass			X	NL
Taraxacum officinale	common dandelion	X			N
Thelypteris palustris	marsh fern		X	X	Y
Tilia americana	American basswood			X	Y
Toxicodendron radicans	poison ivy		X	X	Y
Tradescantia virginiana	spiderwort	X			Y
Tragopogon pratensis	yellow goat's-beard	X			N
Trichostema dichotomum	blue curls		X	X	Y
Tridens sp.	purple-top species			X	--
Trifolium hybridum	Alsike clover	X			N
Trifolium pratense	red clover	X		X	N
Trifolium repens	white clover	X			N
Trifolium sp.	clover species			X	--
Typha angustifolia	narrow-leaved cattail	X		X	N

Table A-1 (Page 7 of 7). Plant species observed at Liberty State Park, Jersey City, N.J. during 1975-1976, 2001 and 2003 biological surveys.

Scientific Name	Common Name	Texas Instruments (1976)	MacFarlane (2001)	ERC (2003)	U.S. Nativity (Yes/No)[1]
Typha latifolia	broad-leaved cattail	X			Y
Verbascum blattaria	moth mullein	X			N
Verbascum thapsus	common mullein	X	X	X	N
Verbena hastata	blue vervain			X	Y
Viburnum sp.	viburnum species			X	--
Vitis palmata	red grape			X	Y
Vitis sp.	grape species			X	--
Vitis vulpina	frost grape		X	X	Y

[1] USDA, NRCS. 2004. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Ecosystem Restoration Consultants (ERC). 2003. – August – September 2003 Vegetation surveys

MacFarlane, D.W. 2001. The Ecology of Liberty State Park: A Historical Perspective

Texas Instruments (TI). 1976. Liberty State Park ecological study. Prepared for the Port Authority of New York and New Jersey.

Table A-2 (Page 1 of 4). Benthos collected at Liberty State Park, Jersey City, NJ during the 1975-1976 and 2003 biological surveys.

Phyllum	Group	Lowest Taxa (Family/Genus/Species)	TI (1976)	ERC (2003)
Annelida	Bryozoa	Electra sp.	X	
Annelida	Bryozoa	Pedicellina sp.	X	
Annelida	Bryozoa	Unidentified sp.	X	
Annelida	Chordata-Tunicata	Ascidiacea	X	
Annelida	Chordata-Tunicata	Molgula sp.	X	
Annelida	Chordata-Tunicata	Unidentified sp.	X	
Annelida	Cirripedia	Balanus sp.	X	
Annelida	Copepoda	Calanoida	X	
Annelida	Copepoda	Cyclopoida	X	
Annelida	Copepoda	Cyclops sp.	X	
Annelida	Copepoda	Harpacticoida	X	
Annelida	Crustacea	Chiridotea sp.	X	
Annelida	Crustacea	*Corophium insidiosum*	X	
Annelida	Crustacea	Cyathura sp.	X	
Annelida	Crustacea	*Edotea montosa*	X	
Annelida	Crustacea	Gammaridae	X	
Annelida	Crustacea	Gammarus sp.	X	
Annelida	Crustacea	Melita nitida	X	
Annelida	Cumacea	Cyclapsis sp.	X	
Annelida	Cumacea	*Leucon americana*	X	
Annelida	Cumacea	Oxyyrostylis sp.	X	
Annelida	Decapoda	*Callinectes sapidus*	X	
Annelida	Decapoda	*Crangon septemspinosus*	X	

Table A-2 (Page 2 of 4). Benthos collected at Liberty State Park, Jersey City, NJ during the 1975-1976 and 2003 biological surveys.

Phyllum	Group	Lowest Taxa (Family/Genus/Species)	TI (1976)	ERC (2003)
Annelida	Decapoda	*Neopanope texana*	X	
Annelida	Decapoda	*Palaemonetes pugio*	X	
Annelida	Decapoda	*Rhithropanopeus harrisi*	X	
Annelida	Gastropoda	Amnicolidae	X	
Annelida	Gastropoda	Calliostoma sp.	X	
Annelida	Gastropoda	Corambella sp.	X	
Annelida	Gastropoda	*Crepidula fornicata*	X	
Annelida	Gastropoda	*Ilyanarsa (Nassarius) obsolita*	X	
Annelida	Gastropoda	Nudibranchia	X	
Annelida	Insecta	Ceratopogonidae	X	
Annelida	Insecta	Chaoborus sp.	X	
Annelida	Insecta	Chrionomidae	X	
Annelida	Insecta	Coleoptera	X	
Annelida	Insecta	Cricotopus sp.	X	
Annelida	Insecta	Culicidae	X	
Annelida	Insecta	Psychoda sp.	X	
Annelida	Insecta	Psychodidae	X	
Annelida	Insecta	Stenelmis sp.	X	
Annelida	Insecta	Telmatoscopus sp.	X	
Annelida	Insecta	Unidentified sp.	X	
Annelida	Mollusca	*Crassostrea virginica*	X	
Annelida	Mollusca	*Macoma balthica*	X	
Annelida	Mollusca	*Mulinia lateralis*	X	
Annelida	Mollusca	*Mya arenaria*	X	

Table A-2 (Page 3 of 4). Benthos collected at Liberty State Park, Jersey City, NJ during the 1975-1976 and 2003 biological surveys.

Phyllum	Group	Lowest Taxa (Family/Genus/Species)	TI (1976)	ERC (2003)
Annelida	Mollusca	Pelecypoda	X	
Annelida	Mollusca	Tellina sp.	X	
Annelida	Mysidacea	*Neomysis americana*	X	
Annelida	Oligochaeta	Unidentified (probably *Limnodrilus Nais* sp.)	X	
Annelida	Oligochaete	Oligochaeta		X
Annelida	Polychaete	Capitella sp.		X
Annelida	Polychaete	*Cirratulidae tharyx*	X	
Annelida	Polychaete	*Diopatra cuprea*		X
Annelida	Polychaete	*Eteone heteropoda*	X	
Annelida	Polychaete	Eteone sp.		X
Annelida	Polychaete	*Glycera americana*	X	
Annelida	Polychaete	Glycera sp.		X
Annelida	Polychaete	Glycera sp.	X	
Annelida	Polychaete	Leitoscolopios sp.		X
Annelida	Polychaete	Nephtys sp.		X
Annelida	Polychaete	Nereis sp.	X	
Annelida	Polychaete	Nereis virens		X
Annelida	Polychaete	Paraonidae		X
Annelida	Polychaete	*Pectinaria gouldii*		X
Annelida	Polychaete	*Pectinaria gouldii*	X	
Annelida	Polychaete	Phyllodoce sp.		X
Annelida	Polychaete	*Polydora ligni*	X	X
Annelida	Polychaete	*Sabellaria vulgaris*	X	

Table A-2 (Page 4 of 4). Benthos collected at Liberty State Park, Jersey City, NJ during the 1975-1976 and 2003 biological surveys.

Phyllum	Group	Lowest Taxa (Family/Genus/Species)	TI (1976)	ERC (2003)
Annelida	Polychaete	*Scoloplos robustus*	X	
Annelida	Polychaete	Spirorbis sp.	X	
Annelida	Polychaete	*Streblospio benedicti*	X	X
Annelida	Polychaete	Streblospio sp.	X	
Annelida	Polychaete	Unidentified sp.	X	
Annelida	Polychaete	Unidentified sp.	X	
Annelida	Polychaete	Unidentified sp.	X	
Annelida	Xiphosura	*Limulus polyphemus*	X	
Arthropoda	Amphipod	Gammarus sp.		X
Arthropoda	Amphipod	Melitidae		X
Arthropoda	Decapod	*Crangon septemspinosa*		X
Arthropoda	Decapod	*Neomysis americana*		X
Arthropoda	Merostomata	*Limulus polyphemus*		X
Arthropoda	Pagurid	Pagurus sp.		X
Mollusca	Bivalve	*Mulinia lateralis*		X
Mollusca	Gastropod	*Ilyanassa obsoleta*		X
Nematoda	Nemertina	Cerabratulus sp.	X	
Nematoda	Nemertina	Unidentifed sp.	X	
Cnidaria	Anthozoa	Unidentifed sp.	X	
Platyhelminthes	Turbellaria	Unidentifed sp.	X	

Data Sources:

Ecosystem Restoration Consultants (ERC). 2003. Benthic Macroinvertebrate surveys

Texas Instruments (TI). 1976. Liberty State Park ecological study. Prepared for the Port Authority of New York and New Jersey.

Table A-3 (Page 1 of 3). Gear type and fish species collected at Liberty State Park, Jersey City, N.J. during 1975-1976 and 2003 biological surveys.

Scientific Name	Common Name	Gear Type	TI (1976)	ERC (2003)
Alosa aestivalis	Blueback herring	Beach Seine	X	
		Fyke Net	X	
		Otter Trawl	X	
Alosa pseudoharengus	Alewife	Beach Seine	X	X
		Fyke Net	X	
		Otter Trawl	X	
Alosa sapidissima	American shad	Beach Seine	X	
		Otter Trawl	X	
Anchoa mitchilli	Bay Anchovy	Beach Seine	X	X
		Fyke Net	X	
		Otter Trawl	X	
Anguilla rostrata	American Eel	Trap Net		X
		Beach Seine	X	X
		Fyke Net	X	
Apeltes quadracus	Fourspine stickleback	Fyke Net	X	
Astroscopus guttatus	Northern stargazer	Beach Seine	X	
Brevoortia tyrannus	Atlantic Menhaden	Beach Seine	X	X
		Otter Trawl	X	
		Trap Net	X	X
Caranx hippos	Crevalle jack	Beach Seine	X	
Clupea harengus	Atlantic herring	Beach Seine	X	
Cynoscion regalis	Weakfish	Beach Seine	X	X
		Trap Net		X
Fundulus heteroclitus	Common mummichog	Beach Seine	X	
Fundulus majalis	Striped killifish	Beach Seine	X	
		Fyke Net	X	

Table A-3 (Page 2 of 3). Gear type and fish species collected at Liberty State Park, Jersey City, N.J. during 1975-1976 and 2003 biological surveys.

Scientific Name	Common Name	Gear Type	TI (1976)	ERC (2003)
Gasterosteus aculeatus	Threespine stickleback	Beach Seine	X	
		Fyke Net	X	
Gobiosoma bosci	Naked goby	Beach Seine	X	
Leiostomous xanthurus	Spot	Beach Seine	X	
Membras martinica	Rough silverside	Beach Seine	X	
Menidia beryllina	Tidewater silverside	Beach Seine	X	
Menidia menidia	Atlantic Silverside	Beach Seine	X	X
		Trap Net		X
Menticirrhus saxatilis	Northern kingfish	Beach Seine	X	
Merluccius bilinearis	Silver hake	Fyke Net	X	
		Otter Trawl	X	
Microgadus tomcod	Atlantic tomcod	Beach Seine	X	
		Fyke Net	X	
		Otter Trawl	X	
Morone americana	White Perch	Beach Seine	X	X
		Fyke Net	X	
		Trap Net		X
Morone saxatilis	Striped Bass	Beach Seine	X	X
		Fyke Net	X	
		Otter Trawl	X	
		Trap Net		X
Mugil curema	White mullet	Beach Seine	X	
Myoxocephalus aeneus	Little sculpin	Fyke Net	X	
Opsanus tau	Oyster Toadfish	Trap Net		X
Osmerus mordax	Rainbow smelt	Fyke Net	X	

Scientific Name	Common Name	Gear Type	TI (1976)	ERC (2003)
Paralichthys dentatus	Summer Flounder	Trap Net		X
Pomatomus saltatrix	Bluefish	Beach Seine	X	
		Otter Trawl	X	
Prionotus carolinus	Common searobin	Beach Seine	X	
Pseudopleuronectes americanus	Winter Flounder	Beach Seine	X	
		Fyke Net	X	
		Trap Net		X
Stenotomus chrysops	Scup	Trap Net		X
Strongylura marina	Atlantic needlefish	Beach Seine	X	
Syngnathus fuscus	Northern Pipefish	Beach Seine	X	X
		Fyke Net	X	
		Otter Trawl	X	
Tautoga onitis	Tautog	Trap Net		X
Trinectes maculatus	Hogchocker	Trap Net		X

Data Sources:

Ecosystem Restoration Consultants (ERC). 2003. North Cove fish surveys

Texas Instruments (TI). 1976. Liberty State Park ecological study. Prepared for the Port Authority of New York and New Jersey.

Appendix B

Wetland Delineation Data Sheets for Liberty State Park
Jersey City, NJ

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): C. Robbins/D. Fargo Date: 8/5/2003
Project/Site: Liberty State Park State: NJ County: Hudson
Applicant/Owner: ACOE Plant Community #/Name: Wetland I
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes [✓] No [ ] (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes [✓] No [ ] (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. Lythrum salicaria	FACW+	Herb	11.		
2. Rubus argutus	FACU	Shrub	12.		
3. Apocynum cannabinum	FACU	Herb	13.		
4. Spiraea tomentosa	FACW	Herb	14.		
5.			15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

Percent of dominant species that are OBL, FACW, and/or FAC 50%
Is the hydrophytic vegetation criterion met? Yes [✓] No [ ]
Rationale: 50% vegetation is hydrophytic vegetation

SOILS

Series/phase: *See remarks Subgroup:[2]
Is the soil on the hydric soils list? Yes [ ] No [ ] Undetermined [✓]
Is the soil a Histosol? Yes [ ] No [ ] Histic epipedon present? Yes [ ] No [ ]
Is the soil: Mottled? Yes [✓] No [ ] Gleyed? Yes [ ] No [✓]
Matrix Color: See remarks Mottle Colors: See remarks
Other hydric soil indicators:
Is the hydric soil criterion met? Yes [✓] No [ ]
Rationale: Soils were disturbed however mottling was present

HYDROLOGY

Is the ground surface inundated? Yes [✓] No [ ] Surface water depth: 2"
Is the soil saturated? Yes [✓] No [ ]
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.
none
Is the wetland hydrology criterion met? Yes [✓] No [ ]
Rationale: Primary hydrologic indicators present

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes [✓] No [ ]
Rationale for jurisdictional decision: Hydrology and vegetation parameters satisfied. See remarks

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

Soil Profile Description

Depth (inches)	Horizon	Matrix Color	Mottle Colors	Mottle Abundance %

Remarks:

Soil pit contained black cinder material to a depth of 12". At 12" a color change to gray is apparent however no Munsell color match was made. Soils beyond 12" contained muddy soils. Standing water in pit at 6". Wetland determination was heavily based on hydrology and vegetation parameters due to the presence of disturbed soils at the site. *According to the Bergen Area, New Jersey soil survey (1925), the soils are classified as "Unclassified City Land." Unclassified city land is defined as the land "within or adjacent to boundaries of numerous towns and cities in the eastern and northeastern parts of the area. This district, separated from New York City only by Hudson River, is used entirely as building sites and is so densely populated that DETERMINATION OF VARIOUS SOIL TYPES IS NOT PRACTICAL."

Appendix C

Water Quality Survey Data From the North Cove of Liberty State Park, Jersey City, NJ

Table C-1: Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey #1

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO_3/ NO_2 (mg/L)	P (Total) (mg/L)
1	7-Aug	1015	17	9	Ebb	23.8	4.1	29,720	18.5	7.4	2.30	11.7	<1.00	1.40	110	0.160
2	7-Aug	1030	4	2	Ebb	24.2	4.3	27,770	17.0	7.5	<2.00	21.9	<1.00	1.44	112	0.150
3	7-Aug	1040	6	3	Ebb	24.2	4.3	28,710	17.6	7.5	5.00	17.7	<1.00	1.53	0.500	0.140
4	7-Aug	1055	7	3.5	Ebb	23.9	4.1	29,460	18.3	7.5	<2.00	16.3	<1.00	1.53	0.550	0.230
5	7-Aug	1120	15	7.5	Ebb	24.8	4.8	22,060	13.3	7.5	<2.00	24.1	<1.00	1.49	152	0.150
1	7-Aug	1150	13	1	Ebb	24.4	4.7	25,290	15.4	7.5	NA	NA	NA	NA	NA	NA
1	7-Aug	1150	13	6	Ebb	24.0	4.4	27,910	17.0	7.5	NA	NA	NA	NA	NA	NA
1	7-Aug	1150	13	12	Ebb	23.4	4.0	31,220	19.4	7.5	NA	NA	NA	NA	NA	NA
2	7-Aug	1220	4	2	Ebb	24.7	4.9	27,610	17.0	7.5	NA	NA	NA	NA	NA	NA
3	7-Aug	1225	7	1	Ebb	24.4	4.8	25,640	15.6	7.5	NA	NA	NA	NA	NA	NA
3	7-Aug	1225	7	6	Ebb	24.4	4.6	27,240	16.7	7.5	NA	NA	NA	NA	NA	NA
4	7-Aug	1236	8	1	Ebb	24.4	4.6	25,290	15.4	7.5	NA	NA	NA	NA	NA	NA
4	7-Aug	1236	8	7	Ebb	24.3	4.5	25,870	15.8	7.5	NA	NA	NA	NA	NA	NA
5	7-Aug	1247	15	1	Ebb	25.0	5.1	20,310	12.1	7.5	NA	NA	NA	NA	NA	NA
5	7-Aug	1247	15	7	Ebb	24.7	4.8	22,910	13.8	7.5	NA	NA	NA	NA	NA	NA
5	7-Aug	1247	15	14	Ebb	24.5	4.7	24,000	14.6	7.5	NA	NA	NA	NA	NA	NA
1	7-Aug	1340	19	1	Flood	24.4	4.8	26,140	16.0	7.5	NA	NA	NA	NA	NA	NA
1	7-Aug	1340	19	9	Flood	24.2	4.5	27,930	17.2	7.5	NA	NA	NA	NA	NA	NA
1	7-Aug	1340	19	18	Flood	23.8	4.0	30,250	18.8	7.5	NA	NA	NA	NA	NA	NA
2	7-Aug	1400	6	1	Flood	24.6	4.9	25,620	15.9	7.5	NA	NA	NA	NA	NA	NA
2	7-Aug	1400	6	5	Flood	24.6	4.8	25,780	15.7	7.5	NA	NA	NA	NA	NA	NA
3	7-Aug	1410	9	1	Flood	24.5	4.8	25,850	15.8	7.5	NA	NA	NA	NA	NA	NA
3	7-Aug	1410	9	8	Flood	24.5	4.6	26,270	16.1	7.5	NA	NA	NA	NA	NA	NA
4	7-Aug	1430	11	1	Flood	24.7	5.1	23,730	14.4	7.5	NA	NA	NA	NA	NA	NA
4	7-Aug	1430	11	5	Flood	24.4	4.8	25,980	15.9	7.5	NA	NA	NA	NA	NA	NA

Table C-1 (Page 2 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey #1 (cont'd)

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO_3/ NO_2 (mg/L)	P (Total) (mg/L)
4	7-Aug	1430	11	10	Flood	24.4	4.6	26,660	16.3	7.5	NA	NA	NA	NA	NA	NA
5	7-Aug	1455	18	1	Flood	25.0	5.2	20,800	12.4	7.6	NA	NA	NA	NA	NA	NA
5	7-Aug	1455	18	9	Flood	24.6	5.0	24,460	14.8	7.5	NA	NA	NA	NA	NA	NA
5	7-Aug	1455	18	17	Flood	24.4	4.7	26,360	16.1	7.5	NA	NA	NA	NA	NA	NA
1	7-Aug	1545	19	9.5	Flood	24.6	5.0	24,840	15.1	7.6	<2.00	12.4	<1.00	1.35	206	0.140
2	7-Aug	1605	9	4.5	Flood	24.7	5.1	25,040	15.2	7.7	<2.00	7.87	<1.00	1.52	0.510	0.130
3	7-Aug	1615	11	5.5	Flood	24.7	5.1	24,960	15.2	7.7	2.41	10.1	<1.00	1.55	0.590	0.130
4	7-Aug	1630	14	7	Flood	24.8	5.1	24,510	14.8	7.6	<2.00	13.7	<1.00	1.34	0.580	0.130
5	7-Aug	1650	20	10	Flood	24.6	5.0	24,800	15.1	7.6	<2.00	18.0	<1.00	1.47	0.580	0.120

NA = Not Analyzed

Table C-1 (Page 3 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey #2

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/ NO2 (mg/L)	P (Total) (mg/L)
1	20-Aug	0725	17	1	Ebb	24.8	5.3	19,770	11.8	7.8	NA	NA	NA	NA	NA	NA
1	20-Aug	0725	17	8	Ebb	24.5	4.5	25,330	15.4	7.6	<2.00	16.4	<1.00	1.64	0.430	0.130
1	20-Aug	0725	17	16	Ebb	23.9	3.5	29,000	17.9	7.4	NA	NA	NA	NA	NA	NA
2	20-Aug	0745	3	1.5	Ebb	24.4	5.0	19,880	11.9	7.6	<2.00	14.8	<1.00	1.50	0.460	0.120
3	20-Aug	0800	6	1	Ebb	24.6	5.4	18,950	11.3	7.7	NA	NA	NA	NA	NA	NA
3	20-Aug	0800	6	3	Ebb	24.8	5.3	19,610	11.6	7.5	<2.00	9.00	<1.00	1.68	0.440	0.100
3	20-Aug	0800	6	5	Ebb	24.7	4.9	21,490	13.1	7.5	NA	NA	NA	NA	NA	NA
4	20-Aug	0815	8	1	Ebb	24.8	5.3	19,960	11.9	7.6	NA	NA	NA	NA	NA	NA
4	20-Aug	0815	8	4	Ebb	24.7	5.3	20,150	12.1	7.6	<2.00	26.8	<1.00	1.48	0.390	0.140
4	20-Aug	0815	8	7	Ebb	24.4	4.6	23,450	14.2	7.5	NA	NA	NA	NA	NA	NA
5	20-Aug	0835	12	1	Ebb	25.2	5.9	17,130	9.8	7.7	NA	NA	NA	NA	NA	NA
5	20-Aug	0835	12	5	Ebb	25.1	5.9	16,430	9.7	7.5	7.64	11.0	<1.00	<1.00	0.420	<0.100
5	20-Aug	0835	12	11	Ebb	23.5	3.8	30,000	18.6	7.4	NA	NA	NA	NA	NA	NA
1	20-Aug	0900	16	1	Ebb	24.9	5.3	19,770	11.7	7.6	NA	NA	NA	NA	NA	NA
1	20-Aug	0900	16	8	Ebb	24.5	4.7	24,230	14.7	7.4	NA	NA	NA	NA	NA	NA
1	20-Aug	0900	16	15	Ebb	23.7	3.6	29,170	18.0	7.4	NA	NA	NA	NA	NA	NA
2	20-Aug	0915	4	1	Ebb	24.9	5.5	19,470	11.5	7.6	NA	NA	NA	NA	NA	NA
2	20-Aug	0915	4	3	Ebb	24.8	5.6	19,650	11.7	7.6	NA	NA	NA	NA	NA	NA
3	20-Aug	0930	6	1	Ebb	25.2	5.6	19,150	11.4	7.6	NA	NA	NA	NA	NA	NA
3	20-Aug	0930	6	5	Ebb	24.9	5.5	19,670	11.7	7.6	NA	NA	NA	NA	NA	NA
4	20-Aug	0936	7	1	Ebb	25.2	5.9	18,820	11.1	7.6	NA	NA	NA	NA	NA	NA
4	20-Aug	0936	7	6	Ebb	24.7	5.1	21,470	12.8	7.6	NA	NA	NA	NA	NA	NA
5	20-Aug	0945	12	1	Ebb	25.5	5.9	16,900	9.8	7.7	NA	NA	NA	NA	NA	NA

Table C-1 (Page 4 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey #2 (cont'd)

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
5	20-Aug	0945	12	5	Ebb	25.1	5.6	18,310	10.9	7.6	NA	NA	NA	NA	NA	NA
5	20-Aug	0945	12	11	Ebb	24.5	4.6	22,810	13.9	7.5	NA	NA	NA	NA	NA	NA
1	20-Aug	1005	17	1	Ebb	25.1	5.7	20,790	12.4	7.6	NA	NA	NA	NA	NA	NA
1	20-Aug	1005	17	8	Ebb	24.8	5.3	21,480	12.9	7.6	NA	NA	NA	NA	NA	NA
1	20-Aug	1005	17	16	Ebb	23.9	3.6	28,800	17.8	7.5	NA	NA	NA	NA	NA	NA
2	20-Aug	1020	4	1	Ebb	25.5	5.6	19,210	11.4	7.6	NA	NA	NA	NA	NA	NA
2	20-Aug	1020	4	3	Ebb	25.0	5.7	19,530	11.6	7.6	NA	NA	NA	NA	NA	NA
3	20-Aug	1025	6	1	Ebb	25.6	5.9	18,500	11.0	7.6	NA	NA	NA	NA	NA	NA
3	20-Aug	1025	6	5	Ebb	25.1	6.0	19,500	11.6	7.6	NA	NA	NA	NA	NA	NA
4	20-Aug	1035	7	1	Ebb	25.4	6.0	18,410	10.9	7.7	NA	NA	NA	NA	NA	NA
4	20-Aug	1035	7	6	Ebb	25.0	5.5	20,500	12.2	7.6	NA	NA	NA	NA	NA	NA
5	20-Aug	1055	12	1	Ebb	26.2	7.0	12,740	7.2	7.8	NA	NA	NA	NA	NA	NA
5	20-Aug	1055	12	5	Ebb	25.6	6.2	16,950	10.1	7.7	NA	NA	NA	NA	NA	NA
5	20-Aug	1055	12	11	Ebb	24.7	4.9	21,590	12.9	7.6	NA	NA	NA	NA	NA	NA
1	20-Aug	1140	17	1	Ebb	26.3	6.9	16,710	9.8	7.6	NA	NA	NA	NA	NA	NA
1	20-Aug	1140	17	8	Ebb	25.3	5.9	19,810	11.7	7.4	NA	NA	NA	NA	NA	NA
1	20-Aug	1140	17	16	Ebb	24.1	4.0	27,800	17.1	7.4	NA	NA	NA	NA	NA	NA
2	20-Aug	1205	5	1	Ebb	26.4	6.7	17,150	10.1	7.8	NA	NA	NA	NA	NA	NA
2	20-Aug	1205	5	4	Ebb	26.1	6.9	17,780	10.5	7.8	NA	NA	NA	NA	NA	NA
3	20-Aug	1215	7	1	Ebb	26.4	6.7	15,950	9.2	7.8	NA	NA	NA	NA	NA	NA
3	20-Aug	1215	7	6	Ebb	25.6	6.2	19,510	11.5	7.6	NA	NA	NA	NA	NA	NA
4	20-Aug	1220	9	1	Flood	26.2	7.0	16,430	9.6	7.8	NA	NA	NA	NA	NA	NA
4	20-Aug	1220	9	4	Flood	25.8	7.0	17,330	10.2	7.8	NA	NA	NA	NA	NA	NA
4	20-Aug	1220	9	8	Flood	25.1	5.9	20,820	12.5	7.6	NA	NA	NA	NA	NA	NA
5	20-Aug	1240	13	1	Flood	27.0	7.4	11,610	6.6	7.8	NA	NA	NA	NA	NA	NA

Table C-1 (Page 5 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey #2 (cont'd)

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
5	20-Aug	1240	13	6	Flood	26.8	7.5	12,170	6.8	7.8	NA	NA	NA	NA	NA	NA
5	20-Aug	1240	13	12	Flood	25.3	6.1	20,110	12.0	7.7	NA	NA	NA	NA	NA	NA
1	20-Aug	1330	15	1	Flood	26.3	9.3	18,920	11.1	7.9	NA	NA	NA	NA	NA	NA
1	20-Aug	1330	15	7	Flood	25.2	8.1	21,910	13.2	7.7	<2.00	13.0	<1.00	<1.00	0.420	<0.100
1	20-Aug	1330	15	14	Flood	24.6	6.2	23,770	14.4	7.6	NA	NA	NA	NA	NA	NA
2	20-Aug	1345	6	1	Flood	27.1	9.6	16,270	9.5	8.0	NA	NA	NA	NA	NA	NA
2	20-Aug	1345	6	3	Flood	26.5	9.3	16,730	9.8	8.0	<2.00	8.00	<1.00	1.13	0.420	<0.100
2	20-Aug	1345	6	5	Flood	26.0	8.5	18,600	10.9	7.9	NA	NA	NA	NA	NA	NA
3	20-Aug	1405	9	1	Flood	27.1	10.0	16,530	9.7	8.1	NA	NA	NA	NA	NA	NA
3	20-Aug	1405	9	4	Flood	26.2	8.8	17,650	10.4	7.9	<2.00	8.60	<1.00	<1.00	0.420	<0.100
3	20-Aug	1405	9	8	Flood	25.1	6.6	21,390	12.8	7.8	NA	NA	NA	NA	NA	NA
4	20-Aug	1415	11	1	Flood	26.6	9.9	17,910	10.5	8.0	NA	NA	NA	NA	NA	NA
4	20-Aug	1415	11	5	Flood	26.0	9.4	19,140	11.4	7.9	<2.00	7.60	<1.00	<1.00	0.420	0.100
4	20-Aug	1415	11	10	Flood	25.1	7.5	21,160	12.7	7.8	NA	NA	NA	NA	NA	NA
5	20-Aug	1425	16	1	Flood	26.8	10.1	17,540	10.3	8.0	NA	NA	NA	NA	NA	NA
5	20-Aug	1425	16	7	Flood	26.3	10.4	17,920	10.5	7.9	<2.00	7.40	<1.00	1.06	0.430	0.100
5	20-Aug	1425	16	15	Flood	24.5	6.6	22,530	13.5	7.8	NA	NA	NA	NA	NA	NA

NA = Not Analyzed

Table C-1 (Page 6 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey # 3

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
1	3-Sep	0745	17	1	Ebb	20.8	4.2	33,870	21.3	7.6	NA	NA	NA	NA	NA	NA
1	3-Sep	0745	17	8	Ebb	20.9	4.1	34,020	21.3	7.4	<2.00	23.9	<1.00	1.94	0.310	0.140
1	3-Sep	0745	17	16	Ebb	20.7	3.6	37,250	23.6	7.4	NA	NA	NA	NA	NA	NA
2	3-Sep	0805	4	2	Ebb	20.3	4.3	34,510	21.7	7.4	<2.00	28.1	<1.00	<1.00	0.350	0.160
3	3-Sep	0815	6	2	Ebb	20.7	4.1	34,390	21.6	7.4	NA	NA	NA	NA	NA	NA
3	3-Sep	0815	6	3	Ebb	NA	NA	NA	NA	NA	<2.00	13.1	<1.00	1.37	0.300	0.130
3	3-Sep	0815	6	5	Ebb	20.6	4.0	34,990	22.4	7.4	NA	NA	NA	NA	NA	NA
4	3-Sep	0830	7	2	Ebb	20.7	4.0	34,450	21.7	7.4	NA	NA	NA	NA	NA	NA
4	3-Sep	0830	7	3.5	Ebb	NA	NA	NA	NA	NA	<2.00	13.4	<1.00	1.64	0.310	0.130
4	3-Sep	0830	7	5	Ebb	20.7	3.6	38,060	24.1	7.4	NA	NA	NA	NA	NA	NA
5	3-Sep	0840	11	1	Ebb	21.4	4.5	29,440	18.3	7.5	NA	NA	NA	NA	NA	NA
5	3-Sep	0840	11	5	Ebb	21.4	4.4	30,450	19.0	7.4	<2.00	85.4	<1.00	1.49	0.340	0.210
5	3-Sep	0840	11	10	Ebb	21.1	3.7	34,650	21.7	7.4	NA	NA	NA	NA	NA	NA
1	3-Sep	0855	17	1	Ebb	21.0	4.1	33,450	21.0	7.4	NA	NA	NA	NA	NA	NA
1	3-Sep	0855	17	8	Ebb	21.0	3.9	33,940	21.3	7.4	NA	NA	NA	NA	NA	NA
1	3-Sep	0855	17	16	Ebb	20.8	3.7	36,650	23.2	7.4	NA	NA	NA	NA	NA	NA
2	3-Sep	0910	3	1	Ebb	20.6	3.9	34,410	21.7	7.4	NA	NA	NA	NA	NA	NA
3	3-Sep	0920	6	1	Ebb	20.7	4.0	34,710	21.8	7.4	NA	NA	NA	NA	NA	NA
3	3-Sep	0920	6	5	Ebb	20.7	3.8	35,570	22.8	7.4	NA	NA	NA	NA	NA	NA
4	3-Sep	0930	8	2	Ebb	20.8	4.2	33,700	21.2	7.3	NA	NA	NA	NA	NA	NA
4	3-Sep	0930	8	6	Ebb	20.8	3.9	35,360	22.6	7.2	NA	NA	NA	NA	NA	NA
5	3-Sep	0940	11	1	Ebb	21.7	4.5	27,280	16.7	7.3	NA	NA	NA	NA	NA	NA
5	3-Sep	0940	11	5	Ebb	21.6	4.3	28,470	17.4	7.1	NA	NA	NA	NA	NA	NA

Table C-1 (Page 7 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey # 3 (cont'd)

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
5	3-Sep	0940	11	10	Ebb	20.9	3.9	33,660	21.5	7.1	NA	NA	NA	NA	NA	NA
1	3-Sep	0955	19	1	Ebb	21.0	4.0	32,790	20.5	7.1	NA	NA	NA	NA	NA	NA
1	3-Sep	0955	19	10	Ebb	20.8	3.7	36,110	22.9	7.1	NA	NA	NA	NA	NA	NA
1	3-Sep	0955	19	18	Ebb	20.8	3.6	36,510	23.1	7.0	NA	NA	NA	NA	NA	NA
2	3-Sep	1015	4	2	Ebb	20.4	4.2	34,280	21.6	7.2	NA	NA	NA	NA	NA	NA
3	3-Sep	1030	7	1	Ebb	21.0	4.0	32,110	20.1	7.6	NA	NA	NA	NA	NA	NA
3	3-Sep	1030	7	6	Ebb	21.0	4.0	32,800	20.4	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1035	9	1	Ebb	21.1	4.3	31,070	19.3	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1035	9	4	Ebb	21.2	4.2	32,170	20.1	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1035	9	8	Ebb	21.0	4.2	32,870	20.5	7.6	NA	NA	NA	NA	NA	NA
5	3-Sep	1045	13	1	Ebb	21.6	4.3	27,810	17.0	7.6	NA	NA	NA	NA	NA	NA
5	3-Sep	1045	13	6	Ebb	21.5	4.2	29,090	17.9	7.6	NA	NA	NA	NA	NA	NA
5	3-Sep	1045	13	12	Ebb	21.1	4.1	32,130	20.1	7.7	NA	NA	NA	NA	NA	NA
1	3-Sep	1200	16	1	Flood	20.9	4.4	32,280	20.1	7.6	NA	NA	NA	NA	NA	NA
1	3-Sep	1200	16	8	Flood	21.0	4.3	32,800	20.5	7.3	NA	NA	NA	NA	NA	NA
1	3-Sep	1200	16	15	Flood	20.8	4.1	34,330	21.6	7.6	NA	NA	NA	NA	NA	NA
2	3-Sep	1210	7	1	Flood	21.0	4.2	31,780	19.8	7.6	NA	NA	NA	NA	NA	NA
2	3-Sep	1210	7	6	Flood	21.1	4.1	31,780	19.8	7.6	NA	NA	NA	NA	NA	NA
3	3-Sep	1215	10	1	Flood	21.0	4.3	31,590	19.7	7.6	NA	NA	NA	NA	NA	NA
3	3-Sep	1215	10	5	Flood	21.1	4.1	32,100	20.1	7.6	NA	NA	NA	NA	NA	NA
3	3-Sep	1215	10	9	Flood	21.1	4.1	32,280	20.3	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1225	11	1	Flood	21.2	4.5	30,550	19.0	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1225	11	5	Flood	21.2	4.4	31,740	19.8	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1225	11	10	Flood	21.1	4.0	33,010	20.7	7.6	NA	NA	NA	NA	NA	NA

Table C-1 (Page 8 of 8): Liberty State Park North Cove 2003 Weekly Water Quality Data

Survey # 3 (cont'd)

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
5	3-Sep	1235	10	1	Flood	21.2	4.5	31,360	19.5	7.7	NA	NA	NA	NA	NA	NA
5	3-Sep	1235	10	5	Flood	21.2	4.5	31,410	19.6	7.6	NA	NA	NA	NA	NA	NA
5	3-Sep	1235	10	10	Flood	21.1	4.2	32,220	20.0	7.6	NA	NA	NA	NA	NA	NA
1	3-Sep	1320	16	1	Flood	21.2	4.6	31,150	19.4	7.6	NA	NA	NA	NA	NA	NA
1	3-Sep	1320	16	8	Flood	21.1	4.5	31,930	19.8	7.6	<2.00	20.6	<1.00	2.50	0.340	0.140
1	3-Sep	1320	16	15	Flood	21.0	4.1	32,670	20.4	7.6	NA	NA	NA	NA	NA	NA
2	3-Sep	1330	7	1	Flood	21.1	4.3	31,380	19.6	7.6	NA	NA	NA	NA	NA	NA
2	3-Sep	1330	7	3.5	Flood	NA	NA	NA	NA	NA	<2.00	28.4	<1.00	2.09	0.380	0.150
2	3-Sep	1330	7	6	Flood	21.1	4.3	31,560	19.7	7.6	NA	NA	NA	NA	NA	NA
3	3-Sep	1340	10	1	Flood	21.1	4.2	31,380	19.6	7.6	NA	NA	NA	NA	NA	NA
3	3-Sep	1340	10	5	Flood	21.2	4.1	31,390	19.6	7.6	<2.00	21.1	<1.00	1.82	0.350	0.140
3	3-Sep	1340	10	9	Flood	21.1	3.9	31,820	19.9	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1355	10	1	Flood	21.2	4.4	30,950	19.3	7.6	NA	NA	NA	NA	NA	NA
4	3-Sep	1355	10	5	Flood	21.3	4.4	30,980	19.3	7.6	<2.00	13.9	<1.00	1.05	0.330	0.140
4	3-Sep	1355	10	9	Flood	21.3	4.4	31,040	19.3	7.7	NA	NA	NA	NA	NA	NA
5	3-Sep	1410	16	1	Flood	21.2	4.4	31,350	19.5	7.6	NA	NA	NA	NA	NA	NA
5	3-Sep	1410	16	8	Flood	21.2	4.4	31,320	19.5	7.7	<2.00	14.4	<1.00	1.60	0.330	0.150
5	3-Sep	1410	16	15	Flood	21.2	4.3	31,380	19.5	7.7	NA	NA	NA	NA	NA	NA

NA = Not Analyzed

Table C-2: Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/ NO2 (mg/L)	P (Total) (mg/L)
1	10-Sep	0755	20	2	Flood	21.0	4.5	33,440	21.0	7.2	NA	NA	NA	NA	NA	NA
1	10-Sep	0806	20	10	Flood	21.0	4.8	33,520	21.0	7.3	<2.00	16.7	<1.00	<1.00	0.400	0.130
1	10-Sep	0821	20	18	Flood	21.1	4.8	33,730	21.2	7.3	NA	NA	NA	NA	NA	NA
6	10-Sep	0833	14	2	Flood	21.0	4.8	33,540	21.1	7.3	NA	NA	NA	NA	NA	NA
6	10-Sep	0835	14	7	Flood	21.0	4.6	33,760	21.2	7.3	<2.00	21.7	<1.00	<1.00	0.400	0.130
6	10-Sep	0837	14	12	Flood	21.1	4.6	33,730	21.2	7.3	NA	NA	NA	NA	NA	NA
2	10-Sep	0846	7	2	Flood	21.1	4.4	33,750	21.2	7.2	NA	NA	NA	NA	NA	NA
2	10-Sep	0848	7	4	Flood	NA	NA	NA	NA	NA	<2.00	18.4	<1.00	<1.00	0.420	0.120
2	10-Sep	0850	7	5	Flood	21.2	4.2	33,930	21.3	7.2	NA	NA	NA	NA	NA	NA
3	10-Sep	0858	9	2	Flood	21.1	4.4	33,610	21.1	7.2	NA	NA	NA	NA	NA	NA
3	10-Sep	0900	9	5	Flood	NA	NA	NA	NA	NA	<2.00	10.4	<1.00	<1.00	0.430	0.120
3	10-Sep	0902	9	7	Flood	21.1	4.2	34,000	21.4	7.3	NA	NA	NA	NA	NA	NA
4	10-Sep	0909	10	2	Flood	20.9	4.6	33,560	21.1	7.5	NA	NA	NA	NA	NA	NA
4	10-Sep	0911	10	5	Flood	NA	NA	NA	NA	NA	<2.00	20.4	<1.00	1.29	0.400	0.130
4	10-Sep	0913	10	8	Flood	21	4.5	33,560	21.1	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	0923	14	2	Flood	21.1	4.7	33,810	21.2	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	0925	14	7	Flood	21.1	4.8	33,800	21.2	7.5	<2.00	19.5	<1.00	<1.00	0.400	0.130
5	10-Sep	0927	14	12	Flood	21.1	4.7	33,810	21.2	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	0939	20	2	Slack	21.1	4.7	33,870	21.3	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	0941	20	10	Slack	21.2	4.7	34,030	21.4	7.5	<2.00	13.0	<1.00	1.47	0.410	0.120
1	10-Sep	0943	20	18	Slack	21.2	4.7	34,100	21.5	7.5	NA	NA	NA	NA	NA	NA
2	10-Sep	0955	6	2	Slack	21.5	4.4	33,870	21.2	7.5	NA	NA	NA	NA	NA	NA
2	10-Sep	0957	6	3	Slack	NA	NA	NA	NA	NA	<2.00	17.5	<1.00	<1.00	0.410	0.130
2	10-Sep	0959	6	4	Slack	21.3	4.3	33,970	21.4	7.5	NA	NA	NA	NA	NA	NA
4	10-Sep	1005	11	2	Ebb	21.2	4.7	33,700	21.2	7.5	NA	NA	NA	NA	NA	NA
4	10-Sep	1007	11	5	Ebb	21.2	4.6	33,800	21.2	7.5	<2.00	31.4	<1.00	1.53	0.380	0.140

Table C-2 (Page 2 of 7): Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/ NO2 (mg/L)	P (Total) (mg/L)
4	10-Sep	1009	11	9	Ebb	21.1	4.4	33,850	21.3	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	1014	9	2	Ebb	21.3	4.5	33,610	21.1	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	1016	9	5	Ebb	NA	NA	NA	NA	NA	<2.00	9.10	<1.00	<1.00	0.420	0.120
3	10-Sep	1018	9	7	Ebb	21.1	4.4	33,740	21.2	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1027	13	2	Ebb	21.7	4.5	31,540	19.7	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1029	13	6	Ebb	21.2	4.6	33,760	21.2	7.5	<2.00	14.3	<1.00	1.45	0.420	0.130
5	10-Sep	1031	13	11	Ebb	21.2	4.6	34,090	21.4	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1039	14	2	Ebb	21.3	4.8	33,770	21.2	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1041	14	7	Ebb	21.2	4.6	34,050	21.4	7.5	<2.00	12.3	<1.00	<1.00	0.400	0.130
6	10-Sep	1043	14	12	Ebb	21.2	4.6	34,110	21.4	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	1211	21	2	Ebb	22.3	4.9	33,030	20.7	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	1213	21	10	Ebb	21.7	4.7	33,640	21.1	7.5	<2.00	11.5	<1.00	NA	NA	NA
1	10-Sep	1215	21	19	Ebb	21.4	4.6	33,800	21.3	7.5	NA	NA	NA	NA	NA	NA
2	10-Sep	1226	4	2	Ebb	22.1	5.5	33,640	21.1	7.7	<2.00	15.8	<1.00	NA	NA	NA
4	10-Sep	1235	9	2	Ebb	21.7	4.7	34,160	21.5	7.5	NA	NA	NA	NA	NA	NA
4	10-Sep	1237	9	5	Ebb	NA	NA	NA	NA	NA	<2.00	15.6	<1.00	NA	NA	NA
4	10-Sep	1239	9	7	Ebb	21.5	4.2	35,740	22.6	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	1305	6	2	Ebb	22.2	4.7	33,650	21.0	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	1307	6	4	Ebb	21.7	4.1	35,330	22.3	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1312	10	2	Ebb	22.1	4.6	31,960	20.1	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1314	10	8	Ebb	21.6	4.1	35,610	22.5	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1320	10	2	Ebb	22.0	4.3	34,530	21.6	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1322	10	8	Ebb	21.6	4.1	35,510	22.4	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	1502	16	2	Ebb	22.4	4.5	32,890	20.6	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	1504	16	8	Ebb	22.1	4.5	33,490	21.1	7.5	<2.00	18.0	<1.00	NA	NA	NA
1	10-Sep	1506	16	14	Ebb	22.1	4.6	33,950	21.3	7.5	NA	NA	NA	NA	NA	NA

Table C-2 (Page 3 of 7): Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/ NO2 (mg/L)	P (Total) (mg/L)
2	10-Sep	1524	2	1	Ebb	23.7	5.9	33,200	20.8	7.7	2.3000	41.0	<1.00	NA	NA	NA
4	10-Sep	1534	7	2	Ebb	22.6	4.6	33,930	21.3	7.5	NA	NA	NA	NA	NA	NA
4	10-Sep	1536	7	3	Ebb	NA	NA	NA	NA	NA	<2.00	19.5	<1.00	NA	NA	NA
4	10-Sep	1538	7	5	Ebb	21.7	4.1	35,610	22.5	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	1605	5	3	Ebb	22.5	4.6	34,090	21.3	7.5	<2.00	18.2	<1.00	NA	NA	NA
5	10-Sep	1620	8	2	Ebb	22.4	4.6	30,460	18.9	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1622	8	4	Ebb	NA	NA	NA	NA	NA	<2.00	48.8	<1.00	NA	NA	NA
5	10-Sep	1624	8	6	Ebb	21.7	4.1	35,210	22.3	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1631	11	2	Slack	22.3	4.5	31,630	19.7	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1633	11	6	Slack	22.1	4.3	32,740	20.5	7.5	<2.00	31.2	<1.00	NA	NA	NA
6	10-Sep	1635	11	9	Slack	22.1	4.4	32,850	20.6	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	1800	19	2	Flood	22.6	4.7	33,570	21.1	7.5	NA	NA	NA	NA	NA	NA
1	10-Sep	1802	19	10	Flood	22.3	4.7	33,930	21.3	7.5	<2.00	28.0	<1.00	NA	NA	NA
1	10-Sep	1804	19	17	Flood	22.2	4.8	34,190	21.5	7.5	NA	NA	NA	NA	NA	NA
2	10-Sep	1814	5	3	Flood	22.4	4.7	32,600	20.4	7.5	<2.00	19.6	<1.00	NA	NA	NA
4	10-Sep	1821	10	2	Flood	22.2	4.7	32,840	20.6	7.5	NA	NA	NA	NA	NA	NA
4	10-Sep	1823	10	5	Flood	NA	NA	NA	NA	NA	<2.00	25.4	<1.00	NA	NA	NA
4	10-Sep	1825	10	8	Flood	22.1	4.5	33,530	21.0	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	1903	9	2	Flood	22.1	4.5	33,140	20.8	7.6	NA	NA	NA	NA	NA	NA
3	10-Sep	1905	9	7	Flood	22.1	4.3	33,490	21.0	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1912	20	2	Flood	22.1	4.7	33,210	20.7	7.5	NA	NA	NA	NA	NA	NA
5	10-Sep	1914	20	10	Flood	22.1	4.6	33,270	20.9	7.6	NA	NA	NA	NA	NA	NA
5	10-Sep	1916	20	18	Flood	22.1	4.5	33,270	20.9	7.6	NA	NA	NA	NA	NA	NA
6	10-Sep	1922	13	2	Flood	22.1	4.7	30,360	19.1	7.6	NA	NA	NA	NA	NA	NA
6	10-Sep	1924	13	6	Flood	22.1	4.7	31,540	19.6	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	1926	13	11	Flood	22.1	4.7	31,830	19.8	7.5	NA	NA	NA	NA	NA	NA

Table C-2 (Page 4 of 7): Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/ NO2 (mg/L)	P (Total) (mg/L)
1	10-Sep	2030	16	2	Flood	21.9	4.8	32,400	20.2	7.4	NA	NA	NA	NA	NA	NA
1	10-Sep	2030	16	8	Flood	21.9	4.9	32,490	20.4	7.3	<2.00	29.6	<1.00	NA	NA	NA
1	10-Sep	2030	16	14	Flood	21.9	4.9	33,280	20.9	7.4	NA	NA	NA	NA	NA	NA
2	10-Sep	2050	7	2	Flood	21.9	4.5	31,490	19.6	7.4	NA	NA	NA	NA	NA	NA
2	10-Sep	2050	7	3.5	Flood	NA	NA	NA	NA	NA	<2.00	14.8	<1.00	NA	NA	NA
2	10-Sep	2050	7	5	Flood	21.9	4.5	31,940	20.0	7.4	NA	NA	NA	NA	NA	NA
4	10-Sep	2100	11	2	Flood	21.8	4.7	31,210	19.4	7.4	NA	NA	NA	NA	NA	NA
4	10-Sep	2100	11	5	Flood	21.8	4.7	31,190	19.4	7.5	<2.00	14.4	<1.00	NA	NA	NA
4	10-Sep	2100	11	9	Flood	21.9	4.7	31,240	19.5	7.4	NA	NA	NA	NA	NA	NA
6	10-Sep	2130	15	2	Flood	21.8	4.8	32,550	20.3	7.5	NA	NA	NA	NA	NA	NA
6	10-Sep	2130	15	7	Flood	21.9	4.9	32,520	20.3	7.5	<2.00	13.0	<1.00	NA	NA	NA
6	10-Sep	2130	15	13	Flood	21.9	4.9	32,530	20.4	7.5	NA	NA	NA	NA	NA	NA
3	10-Sep	2145	10	2	Flood	21.8	4.4	31,350	19.5	7.6	NA	NA	NA	NA	NA	NA
3	10-Sep	2145	10	5	Flood	21.9	4.3	31,330	19.5	7.6	<2.00	13.0	<1.00	NA	NA	NA
3	10-Sep	2145	10	8	Flood	21.9	4.3	31,890	19.9	7.6	NA	NA	NA	NA	NA	NA
5	10-Sep	2205	15	2	Flood	21.7	4.7	31,900	19.9	7.6	NA	NA	NA	NA	NA	NA
5	10-Sep	2205	15	7	Flood	21.8	4.7	32,210	20.1	7.6	<2.00	13.8	<1.00	NA	NA	NA
5	10-Sep	2205	15	13	Flood	21.6	4.2	35,880	22.3	7.6	NA	NA	NA	NA	NA	NA
1	10-Sep	2330	19	2	Ebb	21.4	5.0	32,510	20.3	7.6	NA	NA	NA	NA	NA	NA
1	10-Sep	2330	19	9	Ebb	21.8	4.4	33,030	20.7	7.5	<2.00	6.80	<1.00	<1.00	0.410	0.120
1	10-Sep	2330	19	17	Ebb	21.8	4.3	33,130	20.8	7.6	NA	NA	NA	NA	NA	NA
2	10-Sep	2340	6	2	Ebb	21.5	4.5	31,420	19.6	7.6	NA	NA	NA	NA	NA	NA
2	10-Sep	2340	6	3	Ebb	NA	NA	NA	NA	NA	<2.00	13.6	<1.00	<1.00	0.440	0.130
2	10-Sep	2340	6	4	Ebb	21.8	4.7	32,190	20.1	7.6	NA	NA	NA	NA	NA	NA
4	10-Sep	2355	10	2	Ebb	21.7	4.9	32,210	20.1	7.6	NA	NA	NA	NA	NA	NA
4	10-Sep	2355	10	5	Ebb	21.8	4.5	33,810	21.1	7.6	<2.00	6.57	<1.00	<1.00	0.410	0.110

Table C-2 (Page 5 of 7): Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
4	10-Sep	2355	10	8	Ebb	21.7	4.8	34,400	21.6	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0030	12	2	Ebb	21.7	4.8	33,030	20.6	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0030	12	6	Ebb	21.8	4.5	33,700	21.1	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0030	12	10	Ebb	21.8	4.5	33,760	21.2	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0045	12	2	Ebb	21.9	4.7	31,020	19.4	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0045	12	5	Ebb	21.7	4.5	34,470	22.1	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0045	12	10	Ebb	21.5	4.3	37,080	23.6	7.6	NA	NA	NA	NA	NA	NA
3	11-Sep	0055	6	2	Ebb	21.8	4.7	32,180	20.1	7.6	NA	NA	NA	NA	NA	NA
3	11-Sep	0055	6	4	Ebb	21.8	4.5	33,690	21.1	7.6	NA	NA	NA	NA	NA	NA
1	11-Sep	0230	19	2	Ebb	21.5	4.4	34,040	21.2	7.7	NA	NA	NA	NA	NA	NA
1	11-Sep	0230	19	9	Ebb	21.6	4.4	35,030	22.1	7.6	<2.00	9.60	<1.00	NA	NA	NA
1	11-Sep	0230	19	17	Ebb	21.6	4.3	35,270	22.3	7.5	NA	NA	NA	NA	NA	NA
2	11-Sep	0240	3	1.5	Ebb	21.3	4.4	33,290	20.5	7.6	<2.00	7.00	<1.00	NA	NA	NA
4	11-Sep	0255	6	2	Ebb	21.3	4.6	33,190	20.8	7.6	NA	NA	NA	NA	NA	NA
4	11-Sep	0255	6	3	Ebb	NA	NA	NA	NA	NA	<2.00	17.0	<1.00	NA	NA	NA
4	11-Sep	0255	6	4	Ebb	21.6	4.3	34,800	21.9	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0330	10	2	Ebb	21.5	4.4	33,740	21.2	7.7	NA	NA	NA	NA	NA	NA
6	11-Sep	0330	10	5	Ebb	21.6	4.4	35,480	22.5	7.4	<2.00	33.2	<1.00	NA	NA	NA
6	11-Sep	0330	10	8	Ebb	21.6	4.4	35,650	22.5	7.6	NA	NA	NA	NA	NA	NA
3	11-Sep	0340	5	2.5	Ebb	21.5	4.4	34,410	21.7	7.7	<2.00	12.8	<1.00	NA	NA	NA
5	11-Sep	0350	10	2	Ebb	21.7	4.5	31,690	19.8	7.8	NA	NA	NA	NA	NA	NA
5	11-Sep	0350	10	5	Ebb	21.7	4.3	33,310	20.5	7.8	<2.00	54.8	<1.00	NA	NA	NA
5	11-Sep	0350	10	7	Ebb	21.7	4.3	33,400	20.7	7.8	NA	NA	NA	NA	NA	NA
1	11-Sep	0530	17	2	Slack	21.1	4.5	33,160	20.7	7.6	NA	NA	NA	NA	NA	NA
1	11-Sep	0530	17	8	Slack	21.6	4.3	33,700	21.1	7.6	<2.00	8.93	<1.00	NA	NA	NA
1	11-Sep	0530	17	15	Slack	21.6	4.2	34,470	21.6	7.6	NA	NA	NA	NA	NA	NA

Table C-2 (Page 6 of 7): Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
2	11-Sep	0535	4	2	Slack	21.1	4.4	34,400	21.5	7.6	<2.00	6.80	<1.00	NA	NA	NA
4	11-Sep	0545	8	2	Slack	21.6	4.3	32,720	20.5	7.6	NA	NA	NA	NA	NA	NA
4	11-Sep	0545	8	4	Slack	NA	NA	NA	NA	NA	<2.00	12.2	<1.00	NA	NA	NA
4	11-Sep	0545	8	6	Slack	21.5	4.3	33,340	20.8	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0630	11	2	Flood	21.3	4.4	33,840	21.1	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0630	11	5	Flood	21.5	4.4	33,860	21.3	7.6	NA	NA	NA	NA	NA	NA
6	11-Sep	0630	11	9	Flood	21.5	4.3	34,180	21.3	7.6	NA	NA	NA	NA	NA	NA
3	11-Sep	0635	7	2	Flood	21.4	4.4	32,960	20.5	7.6	NA	NA	NA	NA	NA	NA
3	11-Sep	0635	7	5	Flood	21.3	4.3	33,960	21.3	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0645	12	2	Flood	21.8	4.5	27,270	17.1	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0645	12	5	Flood	21.5	4.5	31,410	21.1	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0645	12	10	Flood	21.5	4.4	33,690	21.1	7.6	NA	NA	NA	NA	NA	NA
1	11-Sep	0830	15	2	Flood	21.5	4.8	31,250	19.5	7.6	NA	NA	NA	NA	NA	NA
1	11-Sep	0830	15	7	Flood	21.3	4.4	33,450	21.0	7.8	<2.00	16.8	<1.00	<1.00	0.420	0.140
1	11-Sep	0830	15	13	Flood	21.4	4.4	33,830	21.3	7.8	NA	NA	NA	NA	NA	NA
6	11-Sep	0840	12	2	Flood	21.5	4.6	31,600	19.8	7.7	NA	NA	NA	NA	NA	NA
6	11-Sep	0840	12	6	Flood	21.5	4.6	32,450	20.2	7.6	<2.00	12.4	<1.00	1.34	0.440	0.130
6	11-Sep	0840	12	10	Flood	21.4	4.5	32,740	20.5	7.6	NA	NA	NA	NA	NA	NA
2	11-Sep	0850	7	2	Flood	21.4	4.5	32,300	20.2	7.9	NA	NA	NA	NA	NA	NA
2	11-Sep	0850	7	3.5	Flood	NA	NA	NA	NA	NA	<2.00	13.9	<1.00	<1.00	0.460	0.130
2	11-Sep	0850	7	5	Flood	21.3	4.6	32,570	20.4	7.9	NA	NA	NA	NA	NA	NA
3	11-Sep	0900	9	2	Slack	21.4	4.5	32,160	20.0	8.0	NA	NA	NA	NA	NA	NA
3	11-Sep	0900	9	4	Slack	NA	NA	NA	NA	NA	<2.00	14.0	<1.00	<1.00	0.460	0.130
3	11-Sep	0900	9	7	Slack	21.3	4.3	33,060	20.7	7.8	NA	NA	NA	NA	NA	NA
4	11-Sep	0910	12	2	Slack	21.6	4.8	31,830	19.9	7.7	NA	NA	NA	NA	NA	NA
4	11-Sep	0910	12	6	Slack	21.5	4.6	32,360	20.2	7.6	<2.00	17.4	<1.00	<1.00	0.440	0.130

Table C-2 (Page 7 of 7): Liberty State Park North Cove 2003 Dry Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
4	11-Sep	0910	12	10	Slack	21.5	4.5	32,370	20.2	7.6	NA	NA	NA	NA	NA	NA
5	11-Sep	0920	15	2	Ebb	21.6	4.7	32,000	19.9	7.8	NA	NA	NA	NA	NA	NA
5	11-Sep	0920	15	7	Ebb	21.5	4.3	32,750	20.5	7.7	<2.00	25.3	<1.00	1.23	0.440	0.150
5	11-Sep	0920	15	13	Ebb	21.4	4.3	32,830	20.6	7.6	NA	NA	NA	NA	NA	NA

NA = Not Analyzed

400

Table C-3: Liberty State Park North Cove 2003 Wet Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/ NO2 (mg/L)	P (Total) (mg/L)
1	19-Nov	1536	NDA	4	Flood	12.7	8.6	22,760	13.7	7.7	<2.00	34.0	<1.00	1.01	0.390	0.150
6	19-Nov	1645	10	5	Flood	12.0	8.3	25,560	15.6	7.9	<2.00	44.2	<1.00	<1.00	0.420	0.140
4	19-Nov	1720	12	2	Flood	11.5	8.6	22,370	13.5	7.8	NA	NA	NA	NA	NA	NA
4	19-Nov	1720	12	6	Flood	11.3	8.1	23,010	13.8	7.8	<2.00	21.4	<1.00	<1.00	0.390	<0.100
4	19-Nov	1720	12	10	Flood	11.5	7.4	29,330	18.1	7.9	NA	NA	NA	NA	NA	NA
3	19-Nov	1742	12	2	Flood	11.6	8.6	22,210	13.4	7.9	NA	NA	NA	NA	NA	NA
3	19-Nov	1742	12	6	Flood	11.5	7.7	28,050	17.3	7.9	<2.00	21.8	<1.00	<1.00	0.410	<0.100
3	19-Nov	1742	12	10	Flood	11.4	7.7	28,330	17.5	7.9	NA	NA	NA	NA	NA	NA
5	19-Nov	1805	7	2	Flood	11.6	7.7	29,040	18.3	7.9	NA	NA	NA	NA	NA	NA
5	19-Nov	1805	7	3.5	Flood	NA	NA	NA	NA	NA	<2.00	50.8	<1.00	<1.00	0.370	<0.100
5	19-Nov	1805	7	5	Flood	11.6	7.4	30,620	19.0	7.9	NA	NA	NA	NA	NA	NA
2	19-Nov	1820	NA	2	Flood	12.1	8.5	21,200	12.7	7.9	<2.00	17.6	<1.00	<1.00	0.460	0.110
1	19-Nov	1930	NDA	3	Ebb	14.4	6.3	27,210	16.8	7.8	<2.00	53.0	<1.00	<1.00	0.440	0.130
4	19-Nov	2005	10	2	Ebb	11.8	8.3	22,960	14.1	7.9	NA	NA	NA	NA	NA	NA
4	19-Nov	2005	10	5	Ebb	11.6	7.1	29,650	17.9	7.9	<2.00	25.1	<1.00	<1.00	0.350	0.100
4	19-Nov	2005	10	8	Ebb	11.6	6.7	33,430	20.9	7.9	NA	NA	NA	NA	NA	NA
2	19-Nov	2015	NDA	2	Ebb	11.9	8.4	21,880	13.2	7.8	<2.00	53.6	<1.00	<1.00	0.480	0.210
6	19-Nov	2045	NDA	5	Ebb	12.3	7.8	27,730	17.1	7.8	<2.00	23.2	<1.00	<1.00	0.460	0.100
3	19-Nov	2055	9	2	Ebb	11.8	7.9	24,070	14.4	7.9	NA	NA	NA	NA	NA	NA
3	19-Nov	2055	9	4.5	Ebb	NA	NA	NA	NA	NA	<2.00	22.0	<1.00	1.19	0.330	0.100
3	19-Nov	2055	9	7	Ebb	11.7	6.4	35,410	22.3	7.8	NA	NA	NA	NA	NA	NA
5	19-Nov	2110	5	2	Ebb	11.7	7.1	31,600	19.4	7.9	<2.00	43.4	<1.00	<1.00	0.350	0.130
1	19-Nov	2300	NDA	2	Ebb	12.5	5.8	27,660	17.0	7.7	<2.00	27.9	<1.00	NA	NA	NA
4	19-Nov	2310	8	2	Ebb	11.8	6.8	34,130	21.3	7.9	NA	NA	NA	NA	NA	NA
4	19-Nov	2310	8	4	Ebb	NA	NA	NA	NA	NA	<2.00	28.2	<1.00	NA	NA	NA

NDA = No Depth Available
NA = Not Analyzed

Table C-3 (Page 2 of 5): Liberty State Park North Cove 2003 Wet Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
6	19-Nov	2353	4	2	Ebb	11.9	7.3	29,030	17.9	7.7	NA	NA	NA	NA	NA	NA
3	20-Nov	0010	8	2	Ebb	11.8	7.1	31,900	19.1	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	0010	8	6	Ebb	11.7	6.4	34,740	21.8	7.9	NA	NA	NA	NA	NA	NA
5	20-Nov	0025	4	2	Ebb	11.7	7.2	29,990	18.6	7.8	NA	NA	NA	NA	NA	NA
4	19-Nov	2310	8	6	Ebb	11.7	6.2	34,660	21.8	7.8	NA	NA	NA	NA	NA	NA
2	19-Nov	2320	NDA	2	Ebb	12.6	8.1	14,100	8.2	7.7	2.17	28.2	<1.00	NA	NA	NA
1	20-Nov	0145	NDA	2	Flood	12.4	5.9	27,400	16.4	7.9	<2.00	12.8	<1.00	NA	NA	NA
4	20-Nov	0200	12	2	Flood	11.7	7.6	30,770	19.2	7.8	NA	NA	NA	NA	NA	NA
4	20-Nov	0200	12	6	Flood	11.7	7.5	30,820	19.2	7.8	<2.00	28.4	<1.00	NA	NA	NA
4	20-Nov	0200	12	10	Flood	11.6	7.6	30,950	19.2	7.8	NA	NA	NA	NA	NA	NA
2	20-Nov	0230	4	2	Flood	11.6	7.2	32,280	20.1	7.8	<2.00	11.7	<1.00	NA	NA	NA
6	20-Nov	0245	NDA	2	Flood	11.5	7.2	30,870	19.2	7.8	<2.00	10.0	<1.00	NA	NA	NA
3	20-Nov	0300	12	2	Flood	11.3	7.4	31,290	19.2	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	0300	12	6	Flood	11.5	7.4	31,400	19.5	7.8	<2.00	15.3	<1.00	NA	NA	NA
3	20-Nov	0300	12	10	Flood	11.5	7.5	31,470	19.3	7.8	NA	NA	NA	NA	NA	NA
5	20-Nov	0315	12	2	Flood	11.5	7.6	29,880	18.5	7.9	NA	NA	NA	NA	NA	NA
5	20-Nov	0315	12	6	Flood	11.6	7.6	29,700	18.4	7.9	5.01	14.4	<1.00	NA	NA	NA
5	20-Nov	0315	12	10	Flood	11.5	7.6	29,700	18.4	7.9	NA	NA	NA	NA	NA	NA
1	20-Nov	0445	7	2	Flood	11.8	7.2	30,960	19.2	7.8	NA	NA	NA	NA	NA	NA
1	20-Nov	0445	7	3.5	Flood	NA	NA	NA	NA	NA	<2.00	11.6	<1.00	NA	NA	NA
1	20-Nov	0445	7	5	Flood	12.2	5.8	28,890	17.8	7.8	NA	NA	NA	NA	NA	NA
4	20-Nov	0500	13	2	Flood	11.4	7.6	31,620	19.7	7.8	NA	NA	NA	NA	NA	NA
4	20-Nov	0500	13	6	Flood	11.5	7.4	31,480	19.5	7.8	<2.00	9.87	<1.00	NA	NA	NA
4	20-Nov	0500	13	11	Flood	11.5	7.3	31,650	19.7	7.8	NA	NA	NA	NA	NA	NA

NDA = No Depth Available
NA = Not Analyzed

Table C-3 (Page 3 of 5): Liberty State Park North Cove 2003 Wet Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
2	20-Nov	0520	5	2	Flood	11.3	7.2	30,790	19.2	7.9	<2.00	8.20	<1.00	NA	NA	NA
6	20-Nov	0545	7	2	Slack	11.5	7.3	30,280	18.8	7.8	NA	NA	NA	NA	NA	NA
6	20-Nov	0545	7	5	Slack	11.5	7.2	31,480	19.6	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	0600	14	2	Ebb	11.4	7.5	31,590	19.7	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	0600	14	7	Ebb	11.4	7.6	31,440	19.5	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	0600	14	12	Ebb	11.5	7.1	32,210	20.2	7.8	NA	NA	NA	NA	NA	NA
5	20-Nov	0615	7	2	Ebb	11.6	7.3	26,580	16.2	7.9	NA	NA	NA	NA	NA	NA
5	20-Nov	0615	7	5	Ebb	11.7	7.1	31,210	19.4	7.9	NA	NA	NA	NA	NA	NA
1	20-Nov	0745	NDA	2	Ebb	12.3	5.4	31,980	19.9	7.8	<2.00	26.6	<1.00	NA	NA	NA
4	20-Nov	0800	8	2	Ebb	11.5	7.5	32,340	20.2	7.9	NA	NA	NA	NA	NA	NA
4	20-Nov	0800	8	4	Ebb	NA	NA	NA	NA	NA	<2.00	30.1	<1.00	NA	NA	NA
4	20-Nov	0800	8	6	Ebb	11.7	7.3	33,530	21.0	7.9	NA	NA	NA	NA	NA	NA
2	20-Nov	0815	4	2	Ebb	11.5	7.1	32,550	20.3	7.8	3.21	89.6	<1.00	NA	NA	NA
6	20-Nov	0845	NDA	2	Ebb	11.7	6.9	34,140	21.4	7.9	<2.00	31.0	<1.00	NA	NA	NA
3	20-Nov	0900	6	2	Ebb	11.2	7.4	33,030	21.2	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	0900	6	3	Ebb	NA	NA	NA	NA	NA	<2.00	15.4	<1.00	NA	NA	NA
3	20-Nov	0900	6	4	Ebb	11.4	7.2	33,770	21.1	7.9	NA	NA	NA	NA	NA	NA
5	20-Nov	0910	5	3	Ebb	11.5	7.6	30,280	18.8	7.9	2.43	47.0	<1.00	NA	NA	NA
1	20-Nov	1045	NDA	3	Slack	12.2	5.6	31,720	19.8	7.9	<2.00	15.0	<1.00	<1.00	0.490	0.120
4	20-Nov	1055	8	2	Slack	11.5	7.1	32,180	20.0	7.9	NA	NA	NA	NA	NA	NA
4	20-Nov	1055	8	4	Slack	NA	NA	NA	NA	NA	2.99	26.6	<1.00	1.28	0.380	0.110
4	20-Nov	1055	8	6	Slack	11.7	7.2	31,810	19.8	7.9	NA	NA	NA	NA	NA	NA
2	20-Nov	1105	4	2	Slack	11.6	6.8	34,200	21.5	7.9	4.07	78.0	<1.00	1.50	0.390	0.210
6	20-Nov	1145	NDA	3	Flood	11.3	7.7	29,090	17.9	7.9	NA	NA	NA	NA	NA	NA
3	20-Nov	1155	7	2	Flood	11.4	7.6	28,600	17.7	7.9	NA	NA	NA	NA	NA	NA

NDA = No Depth Available
NA = Not Analyzed

Table C-3 (Page 4 of 5): Liberty State Park North Cove 2003 Wet Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
3	20-Nov	1155	7	5	Flood	11.4	7.7	29,500	18.3	7.9	NA	NA	NA	NA	NA	NA
5	20-Nov	1210	5	3	Flood	11.3	7.9	25,300	15.5	7.9	NA	NA	NA	NA	NA	NA
1	20-Nov	1352	NDA	2	Flood	13.2	5.8	29,060	18.0	7.7	<2.00	14.2	<1.00	NA	NA	NA
4	20-Nov	1412	8	2	Flood	11.5	7.5	27,490	16.9	7.7	NA	NA	NA	NA	NA	NA
4	20-Nov	1412	8	4	Flood	NA	NA	NA	NA	NA	<2.00	20.6	<1.00	NA	NA	NA
4	20-Nov	1412	8	6	Flood	11.5	7.0	30,190	18.7	7.7	NA	NA	NA	NA	NA	NA
2	20-Nov	1417	NDA	2	Flood	11.5	7.9	27,600	16.9	7.7	<2.00	18.4	<1.00	NA	NA	NA
6	20-Nov	1446	NDA	2	Flood	11.5	7.4	28,440	17.5	7.7	<2.00	18.8	<1.00	NA	NA	NA
3	20-Nov	1505	8	2	Flood	11.2	7.5	27,480	16.9	7.7	NA	NA	NA	NA	NA	NA
3	20-Nov	1505	8	4	Flood	NA	NA	NA	NA	NA	<2.00	21.0	<1.00	NA	NA	NA
3	20-Nov	1505	8	6	Flood	11.4	7.1	29,480	18.2	7.7	NA	NA	NA	NA	NA	NA
5	20-Nov	1520	7	2	Flood	10.8	8.4	18,740	11.1	7.7	NA	NA	NA	NA	NA	NA
5	20-Nov	1520	7	3.5	Flood	NA	NA	NA	NA	NA	<2.00	24.2	<1.00	NA	NA	NA
5	20-Nov	1520	7	5	Flood	10.9	8.3	18,780	11.2	7.7	NA	NA	NA	NA	NA	NA
1	20-Nov	1646	NDA	2	Flood	12.0	6.0	30,930	19.2	7.7	<2.00	20.8	<1.00	NA	NA	NA
4	20-Nov	1700	9	2	Flood	11.1	7.5	28,740	17.7	7.7	NA	NA	NA	NA	NA	NA
4	20-Nov	1700	9	4.5	Flood	NA	NA	NA	NA	NA	<2.00	17.4	<1.00	NA	NA	NA
4	20-Nov	1700	9	7	Flood	11.5	7.2	29,560	18.3	7.7	NA	NA	NA	NA	NA	NA
2	20-Nov	1710	NDA	2	Flood	10.8	8.0	29,360	18.1	7.7	<2.00	28.8	<1.00	NA	NA	NA
6	20-Nov	1755	NDA	2	Flood	10.8	7.7	30,990	19.3	7.7	NA	NA	NA	NA	NA	NA
3	20-Nov	1805	9	2	Flood	10.9	8.0	22,560	13.3	7.8	NA	NA	NA	NA	NA	NA
3	20-Nov	1805	9	7	Flood	11.3	7.2	29,750	18.6	7.7	NA	NA	NA	NA	NA	NA
5	20-Nov	1815	6	2	Flood	10.8	8.2	20,620	12.4	7.7	NA	NA	NA	NA	NA	NA
5	20-Nov	1815	6	4	Flood	10.9	8.0	21,190	12.7	7.7	NA	NA	NA	NA	NA	NA

NDA = No Depth Available
NA = Not Analyzed

Table C-3 (Page 5 of 5): Liberty State Park North Cove 2003 Wet Weather CSO Water Quality Data

Station	Date	Time	Station Depth (ft)	Sample Depth (ft)	Tide	Temp (°C)	DO (mg/L)	SPC @ 25°C (µS)	Salinity (ppt)	pH	BOD5 (mg/L)	TSS (mg/L)	NH3 (mg/L)	TKN (mg/L)	NO3/NO2 (mg/L)	P (Total) (mg/L)
1	20-Nov	1945	NDA	2	Ebb	10.9	5.8	24,040	14.5	7.6	<2.00	18.6	<1.00	<1.00	0.490	0.110
6	20-Nov	2000	NDA	2	Ebb	10.6	8.0	25,780	15.7	7.7	<2.00	25.2	<1.00	<1.00	0.490	0.140
4	20-Nov	2005	8	2	Ebb	10.8	7.9	25,400	15.4	7.7	NA	NA	NA	NA	NA	NA
4	20-Nov	2005	8	4	Ebb	NA	NA	NA	NA	NA	<2.00	28.0	<1.00	<1.00	0.430	0.130
4	20-Nov	2005	8	6	Ebb	11.2	7.2	28,040	17.3	7.7	NA	NA	NA	NA	NA	NA
3	20-Nov	2020	8	2	Ebb	10.6	7.6	25,770	15.7	7.7	NA	NA	NA	NA	NA	NA
3	20-Nov	2020	8	4	Ebb	NA	NA	NA	NA	NA	<2.00	20.6	<1.00	<1.00	0.430	0.120
3	20-Nov	2020	8	6	Ebb	11.3	6.7	29,140	18.0	7.7	NA	NA	NA	NA	NA	NA
5	20-Nov	2030	4	2	Ebb	11.0	7.8	22,100	13.3	7.7	<2.00	36.2	<1.00	<1.00	0.440	0.160
2	20-Nov	2040	NDA	2	Ebb	10.4	7.5	25,510	15.5	7.7	9.30	233	<1.00	4.93	0.460	0.640

NDA = No Depth Available
NA = Not Analyzed

Appendix D

North Cove Benthic Assessment for Liberty State Park
Jersey City, NJ

North Cove Benthic Assessment
Liberty State Park, Jersey City, NJ

Hudson-Raritan Estuary Ecosystem Restoration Project

REPORT

September 16, 2003

For:

U.S. Army Corps of Engineers
New York District
Planning Division – Environmental Analysis Branch
26 Federal Plaza
New York, NY 10278-0090

Submitted by:

Ecosystem Restoration Consultants
1 Blue Hill Plaza
Pearl River, NY 10965

TABLE OF CONTENTS

LIST OF TABLES D-2
LIST OF FIGURES D-3
I. INTRODUCTION D-4
1. BACKGROUND D-4
2. STUDY AREA D-4
II. OBJECTIVES D-4
III. METHODS D-5
1. FIELD PROCEDURES D-5
2. LABORATORY PROCEDURES D-5
2.1. Sorting D-5
2.2. Sub- sampling D-6
2. 3. Identification D-6
3. QUALITY CONTROL PROCEDURES D-6
IV. RESULTS D-7
1. SEDIMENT D-7
2. BIOLOGICAL D-7
2.1. Abundance, Biomass and Species Diversity D-7
2.1.1. Station 1 ..... D-7
2.1.2. Station 2 ..... D-7
2.1.3. Station 3 ..... D-7
2.1.4. Station 4 ..... D-8
2.1.5. Station 5 ..... D-8
2.1.6. Station 6 ..... D-8
2.1.7. Station 7 ..... D-8
V.DISCUSSION D-8
VI REFERENCES 11

LIST OF TABLES

Table 1. Benthos mean abundance (animals/m2) and species diversity (H) at Liberty State Park North Cove, Jersey City, NJ.....D-12

Table 2. Benthos Biomass (g/m2) for Liberty State Park North Cove, Jersey City, NJ.....D-13

LIST OF FIGURES

Figure 1. Benthic survey sampling stations.....D-14

Figure 2. Percent composition and biomass for infaunal communities in North Cove, Liberty State Park, Jersey City, NJ.....D-15

I. INTRODUCTION

1. BACKGROUND

Natural estuaries are typically biologically highly productive ecological systems which are characterized by vegetated shorelines and tidal wetlands. However, intense coastal development with increasing urbanization and industrial use, often result in modification of estuaries as in the case of the Hudson – Raritan Estuary. The loss of marginal wetlands and shallows and a variety of urban and industrial inputs may impact estuarine systems. Aquatic biotic communities associated with watersheds with high urban land use are generally characterized by lower species diversity, altered community composition and reduced habitat diversity (Dauer et al 2000). New York/New Jersey Harbor is a well demonstrated example of the impacts of urbanization within an estuarine system. Despite extensive changes and urbanization of NY/NJ Harbor it is still a productive estuary supporting diverse communities of fish and invertebrates (Woodhead et al. 1999).

The invertebrate communities are an important part of the marine environment in the Harbor. Benthic organisms are important links in the flow of energy and cycling of nutrients between the sediment and the water column. It is important to examine the lower trophic levels of the food web in the Estuary because the benthos influences the fish population through their role as a food source for fish. The infaunal community (benthos) is composed of suspension and deposit feeders. They include polychaetes, crustaceans and bivalves. Their life strategies and sediment characteristics are tightly coupled. The grain size, chemistry and physical properties of the sediment limit which benthic organisms colonize an area.

2. STUDY AREA

The North Cove Benthic Assessment is part of the larger Environmental Sampling Program for the Liberty State Park Draft Feasibility Report and the USACE Hudson Raritan Estuary Ecosystem Restoration Project. The North Cove is located in the north east corner of Liberty State Park. The cove is approximately 800 feet long and at its widest point 850 feet wide, with depths ranging from 5 to 9 feet in the center of the Cove. The North Cove is characterized by a rip-rap shoreline, steep slopes and areas of unconsolidated sediments.

II. OBJECTIVES

The objectives of the North Cove Benthic Assessment are:

- To establish a benthic baseline for predicting what types of bottom environment may be possible to create in the proposed tidal creek;
- To predict the environmental impact of the proposed tidal marsh;
- To collect baseline data to use in assessing the level of restoration attained in the post construction of the tidal portion of the project.

III. METHODS

1. FIELD PROCEDURES

LMS collected twenty one (21) benthic grab samples from seven proposed stations (3 replicate samples at each station) within North Cove using a standard Ponar grab ($0.05m^2$). Four (4) stations were located along a transect that began at the proposed mouth of the tidal creek and ended outside of the promenade. The remaining three (3) stations were located in the shallowest water possible at the edges of the Cove and were taken in the intertidal zone at low tide (Figure 1). Sample stations were located by Global Positioning System (GPS).

STATION	LOCATION
1	Back of the North Cove at the southwestern shore.
2	Back of the North Cove at western shore.
3	Back of the North Cove at the northwestern shore.
4	Middle of the cove.
5	Middle of the cove towards the promenade
6	Middle of the cove towards the back of the cove
7	Outside the promenade

The boat was brought on station and the YSI meter probes were lowered over the side of the sampling vessel to approximately 1-foot above the bottom. Measurements for temperature, salinity, and dissolved oxygen were recorded on the field data sheet. A Niskin water sampling bottle was lowered to approximately 1 foot above bottom to collect a water sample for measuring pH with a calibrated pHtester2 pH pen.

The sediment was characterized as being coarse, fine, gravel, clay or mixed type. Also the presence of petroleum and shell hash was recorded. Obvious odors such as hydrogen sulfide or petroleum or lack of odor were recorded.

After the sample description was completed, the sediment was washed through a 500 micron sieve. The remaining material transferred from the 500-micron sieve into a labeled sample container and preserved with a solution of 10% formalin with rose bengal stain.

The samples were brought to the LMS Nyack laboratory to be sorted, enumerated and identified to the lowest practical taxon.

2. LABORATORY PROCEDURES

2.1. Sorting

Each sample was washed through a 500-μ sieve in a sink under a fume hood to remove all traces of formalin. The samples were sorted in a glass laboratory pan, which was placed on a light box. The organisms were removed and enumerated. Only whole organisms or parts of organisms with heads were counted, but all identifiable fragments were saved. The enumerated organisms were preserved in 10% formalin, placed in labeled vials, and stored with the other samples from the survey.

2.2. Sub- sampling

Samples containing excessive sand and detritus, or organisms in significant number, were split using a Caton Macroinvertebrate Subsampler. This subsampler consists of a rectangular screen (~380-μ mesh) and has sets of grid coordinates, which allows for as many as 30, 6 x 6-cm subsamples. Actual organism densities will determine the number of subsamples sorted.

The preservative-free washed sample was transferred to the subsampler screen, which had been placed in a tray on a level surface. A sufficient quantity of water was added to the tray to ensure thorough mixing and dispersal of the sample across the entire subsampler screen. Initially, more cells were selected than the anticipated number of sub-samples. The selected subsamples were lifted off of the sampling screen using a subsample square and a scoop. Subsamples were then transferred directly to sorting pans for analysis. The process of selecting and sorting subsamples continued until the total number of organisms removed and sorted was at least 100, or the entire sample had been sorted. Selected squares were sorted in their entirety, even after the 100-organism count had been reached.

2. 3. Identification

After sorting, the organisms were identified to the lowest practical taxon and counted. Organisms such as barnacles, calanoid copepods, bryozoan statoblasts and hydroids, which could not be quantitatively sampled with the dredge, were not counted. However, their presence was noted. All organisms were then preserved in 10% formalin.

3. QUALITY CONTROL PROCEDURES

3.1 *Sorting.*

Sorting was checked using a continuous sampling plan (CSP-1) that required that each batch of samples pass the required level of QC before continuing the analysis of the next batch. This plan required that the first eight (f = 8) samples that were analyzed by the laboratory be resorted and meet a 90% accuracy level before continuing the sorting of subsequent samples. After this criterion was met, one randomly selected sample out of the next seven (i=7) samples was resorted to determine if the 90% accuracy level had been attained. As long as this criterion was met, one random sample out of every seven was checked for the remainder of the program. If there was a failure to meet this criterion, the next eight samples were resorted to reestablish a 90 % accuracy level.

3.2 Identification.

Quality control of the identification phase of the analysis was done by an individual taxonomist, and followed the CSP-1 format outlined above for sorting.

IV. RESULTS

1. SEDIMENT

Sediment samples were collected at all seven sites in the North Cove. Grab samples collected at the back end of the cove were odorless and consisted of a mix of coarse and fine grain size sediments. Particle size varied from 0.075 – 9.5 mm. Site 1 had the highest organic content, 10.2 percent. Site 2 had the lowest organic content, 3.1 percent. The samples collected along a transect in the middle of North Cove (the back of the cove to outside the promenade) were black soft muds containing a strong petroleum odor. Particle size varied from 0.002 – 4.75mm.

2. BIOLOGICAL

2.1. Abundance, Biomass and Species Diversity

The overall mean density of organisms from the open seabed samples (N=7) taken in the North Cove was 737 animals/m^2. The infaunal community collected from Station 1 contained the lowest mean density (320 animals/m^2). Faunal densities were the greatest at Station 7, 1,320 animals/m^2 (Table 1). The overall mean biomass of infaunal communities located in the North Cove was 59 g/m^2. Sediment infaunal communities at Station 1 had the lowest biomass, 0.6 g/m^2. Species diversity was greatest at Stations 6 (middle of the cove) and 7 (outside the cove). Each station contained 10 taxa (Table 2).

2.1.1. Station 1

In sediment at Station 1, the infaunal communities were comprised of small polychaete worms and amphipods in low densities, 320 animals/m^2. Species diversity was also low. Amphipods dominated by Melitidae and *Gammarus sp.* were the most abundant organisms, comprising 67% of the infaunal community. Polychaetes, *Capitella sp.*, were also present in low numbers. The infaunal biomass was also low, 0.58 g/m^2. Two of the three replicate samples resulted in no catches. The samples were valid grabs.

2.1.2. Station 2

At Station 2, the horseshoe crab, *Limulus polyphemus*, comprised 100% of the infaunal composition. The infaunal community was low in abundance (540 animals/m^2) and biomass (26.6 g/m^2). One of the three replicates resulted in a no catch. It was a valid grab sample.

2.1.3. Station 3

Worms (polychaetes and oligochaetes) comprised about 67% of the infaunal community. Gastropods (*Illynassa obsoleta*, 17%) and hermits crabs (*Pagurus* sp., 17%) were also present but in lower numbers. The most abundant polychaetes were *Capitella sp.*, *Leitoscoloplos sp.*, and *Glycera* sp. The mean density of the infaunal community was 340 animals/m^2. Species diversity was among the highest out of the seven sites. The mean infaunal biomass was high due to the shells of the hermit crabs and the gastropods, 177.586 g/m^2. Polychaetes comprised of 12% of the infaunal biomass.

2.1.4. Station 4

At station 4, the infaunal community was comprised of several different organisms living in the sediment but in low densities, 340 animals/m^2. Polychaete worms comprised about 83% of the infaunal community; *Leitoscoloplos sp.* and *Capitella sp* were the most abundant species. The bivalve, *Mulinia lateralis* and polychaetes, Nephtys *sp.*, *Diopatra cuprea* and *Paraonidae* were also present in low numbers. The mean overall biomass of the infaunal community is 38 g/m^2. Overall, the faunal community from this station was approximately four times more abundant than sites along the beach at the back end of the cove.

2.1.5. Station 5

In sediment at Station 5, the infaunal community was comprised solely of polychaetes, 620 animals/m^2. *Leitoscoloplos sp.* and *Capitella sp.* were the most abundant polychaetes. These species comprised 96% of the infaunal community. Other polychaete species included *Pectinaria gouldii, Eteone sp.* and *Glycera sp.* The overall mean biomass for the infaunal community was 13 g/m^2

2.1.6. Station 6

At station 6 polychaetes and oligochaetes comprised 70% of the infaunal community. *Leitoscoloplos sp., Capitella sp.*, and Paraonidae worms were most abundant species. Gastropods (*Illynassa obsoleta*), mysid (*Neomysis americana*) and amphipods (Melitidae) comprised 30% of the infaunal population. The overall mean abundance of the community was 740 animals/m^2. Faunal diversity was relatively high with 10 taxa. Mean biomass was relatively high, 133 g/m^2. Polychaetes comprised 30% of the biomass weighing 40 g/m^2. The gastropods comprised 70% of the biomass, 93 g/m^2.

2.1.7. Station 7

Polychaetes comprised about 80% of the infaunal community. Principle polychaetes included *Leitoscoloplos sp., Capitella sp., Streblospio benedicti, Polydora ligni, Phyllodoce sp., Pectinaria Gouldii, Nephtys sp.* and *Paraonidae*. Other infaunal organisms present in small numbers included amphipods (Melitidae) and shrimp (*Crangon septemspinosa*). Faunal diversity was relatively high with 10 taxa. The mean biomass was 22 g/m2.

V.DISCUSSION

The Hudson-Raritan Estuary has undergone intense urbanization. Natural estuarine habitat characterized by sunlit shallows and submerged vegetation have been modified; nevertheless the Hudson-Raritan Estuary still supports a large invertebrate community. This invertebrate community is important in an estuary because it is the source of food for the fish population.

In the North Cove of Liberty State Park, NJ, grab and sediment samples were collected to determine existing benthic communities and sediment type. This evaluation was conducted to provide the physical and biological information necessary to evaluate the potential for creating a tidal creek at the back of North Cove. Overall, the faunal communities increased in species diversity and abundance from the back of North Cove station 2 (520 animals/m^2) to outside the

promenade station 7 (1,320 animals/m^2). The infaunal community at station 2 was comprised solely of horseshoe crabs. In contrast to this, the infaunal community living in the seabed at station 7 consisted of polychaetes, amphipods and decapods (Figure 2.).

Sediment

The characteristics of North Cove are typical of low energy habitats where settling of silt and organic matter occurs. These sediment conditions promote the accumulation of detritus in the water column for zooplankton to feed. Typically, the organic content for unpolluted coastal sediments can range between 1% for clean sand and 8% for fine mud. The high organic content found in North Cove sediments (102%) could be from groundwater, runoff, or sewage from nearby CSOs.

Biology

Polychaetes were collected at all 7 sampling sites. They comprised the majority of all species. Polychaetes are used as bioindicators due to their direct contact with the sediment, thus showing sensitivity to anthropogenic compounds. *Capitella sp.*, *Leitoscoloplos sp.*, *Streblospio benedicti* and *Nephtys sp.* are considered environmental indicator species because they are tolerant of degraded habitat conditions. They are often found in sediments characterized by high organic matter, petroleum contamination, sewage, and in waters with low dissolved oxygen levels. *Capitella sp.* are often one of the first groups to recolonize an area impacted by dredging or oil spill (Llanso 1991, NOAA 2003).

Amphipods were present in two of the seven stations. *Gammarus sp.* and Melitid amphipods feed on detritus and are found in muddy and sandy substrates. They are an important food source for fish. The absence of the amphipod *Ampelesca abdita* is an environmental indicator. *A. abdita* is reported to be sensitive to pollutants such as petroleum compounds and are typically not found in highly polluted sediments (NOAA 2003).

Horseshoe crabs were collected at site 2, which is at the back of North Cove. They are environmental generalists and can survive within a wide range of environmental conditions including variations in salinity and oxygen levels (Shuster 1982). Currently, there is little information to suggest unusual sensitivity by horseshoe crabs to low dissolved oxygen, high turbidity or urban pollution (Botton 1995).

In surveys of benthic habitats Iocco et al. (1995) found that sediments were dominated by opportunistic or pollution tolerant species. Common infaunal species of the Upper Bay included capitellid worms, *Streblospio benedicti* and the bivalve *Mulinia lateralis*. Abundance, biomass and species richness were used as indicators of benthic community health. Abundant species and species diversity for the Upper Bay are consistent with the species found in the North Cove.

Comparable studies of benthic communities in New York/New Jersey Harbor, (Zappala 2001) found that open seabed areas were comprised of fine black mud and contained rather low densities (1,500 animals/m^2) of macrobenthic infauna. Polychaetes were the dominant taxa. The common species were *Leitoscoloplos sp*, *Capitella sp.*, *Heteromastus sp.*, *Polydora sp.*, *Neries sp.*, and *Streblospio benedicti*. Other infaunal organisms present in small numbers included, gastropods and a few amphipods (*Ampelesca abdita,* Melitidae and *Gammarus sp.*)

Colonization of the seabed by macrobenthos in stressed habitats (such as polluted sediments) typically follows the Pearson – Rosenberg paradigm (Pearson – Rosenberg 1978). For infauna distributed along a gradient of decreasing organic input, this paradigm suggests that an area of azoic sediments is followed by an assemblage of small opportunistic organisms (worms and tube dwelling amphipods). Further from the source of organic input, the opportunists are gradually replaced by larger burrowing species (Zappala 2001). The open seabed in the North Cove consisted of unconsolidated fine black mud, which contained oily globules. The predominant organisms found living in the black mud were small opportunistic capitellid worms and *Leitoscoloplos sp.* The seabed close to the back of the cove was coarser and there was no apparent petroleum odor. The colonization of the sediments in the North Cove appears to resemble the early opportunistic stage in the Pearson-Rosenberg stress gradient model.

VI REFERENCES

Botton, M. L. 1995. "Horseshoe crab." In *Living Resources of the Delaware Estuary*, edited by L. E. Dove and R. M. Nyman, 51–57. Philadelphia: U.S. Environmental Protection Agency

Dauer D.M., J.A. Ranasinghe, and S.B. Weisberg. 2000. Relationship between benthic community condition, water quality, sediment quality, nutrient loads and land use patterns in Chesapeake Bay. *Estuaries* 23(1):80-96.

Iocco L., p. Wilbur, R. Diaz, D. Clarke and B. Will. 2000. Benthic Habitats of New York/ New Jersey Harbor: 1995 Survey of Jamaica, Upper, Newark, Bowery and Flushing Bays. Final Report for United States Army Corps.

Llanso Roberto J. 1991. Tolerance of low dissolved oxygen and hydrogen sulfide by the polychaete *Streblospio benedicti. Journal of Experimental Marine Biology Ecology.* 153:165-178.

NOAA. 2003. Mudworms. *Capitella sp.*. www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgstrebl.html

NOAA. 2003. Mudworms. *Streblospio benedicti.* www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgstrebl.html

NOAA. 2003. Other benthos: Amphipod. www.csc.noaa.gov/lcr/nyharbor/html/gallery/sgstrebl.html

Pearson T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: an Annual Review.* 16:229-311.

Shuster, C. N. Jr. 1982. "A pictorial review of the natural history and ecology of the horseshoe crab, *Limulus polyphemus*, with reference to other Limulidae." In *Physiology and biology of horseshoe crabs: Studies on normal and environmentally stressed animals*, edited by J. Bonaventura et al. New York: Alan R. Liss, Inc.,.

Woodhead PMJ, T. Rotunno and S. Zappala. 1999. New York Harbor Habitat Assessment Project. Biological assessment of fish habitat associated with shipping piers in New York Harbor. State University of New York, Stony Brook, NY.

Zappala, Sarah. 2001. The growth and development of epibenthic and benthic ocmmunities associated with waterfront shipping piers in New York Harbor. Masters Thesis. State University of New York, Stony Brook.

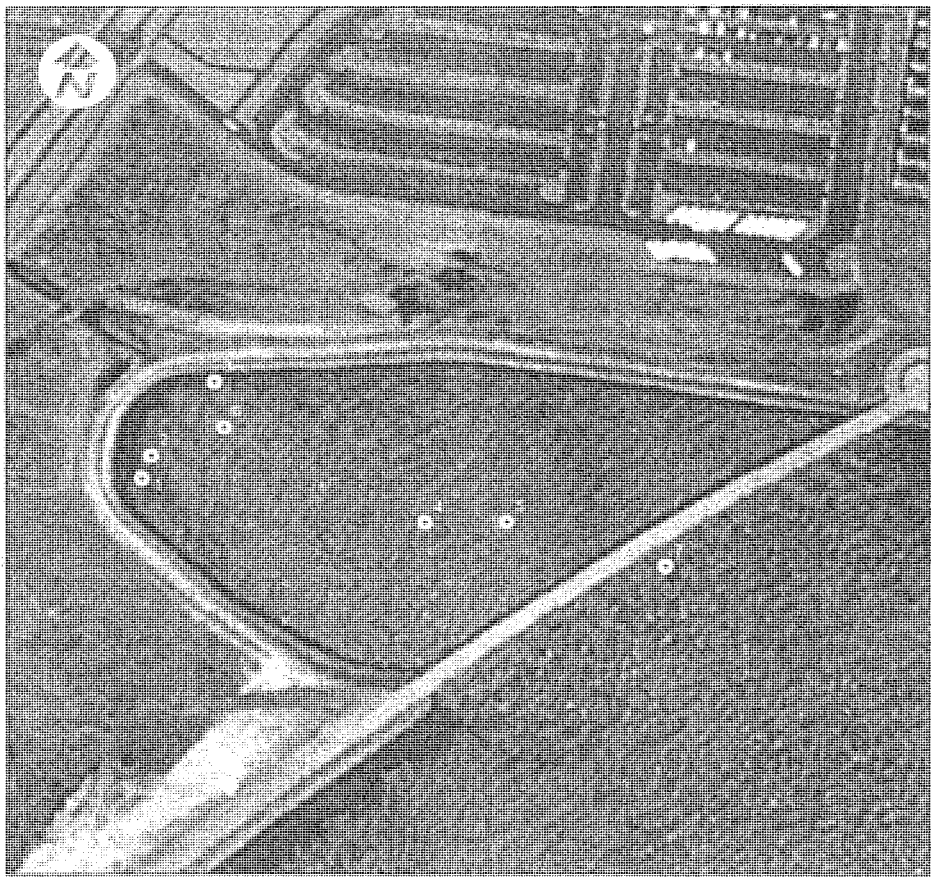
Table 1. Benthos mean abundance (animals/m2) and species diversity (H) at Liberty State Park North Cove, Jersey City, NJ.

			Mean Abundance (animals/m2)						
Family	**Group**	**Species**	**NC 1**	**NC 2**	**NC 3**	**NC 4**	**NC 5**	**NC 6**	**NC 7**
Arthropoda	Amphipod	*Melitidae*	240	0	0	0	0	20	220
Arthropoda	Amphipod	*Gammarus sp.*	20	0	0	0	0	0	0
Annelida	Polychaete	*Capitella sp.*	60	0	100	80	140	100	140
Arthropoda	Merostomata	*Limulus polyphemus*	0	520	0	0	0	0	0
Annelida	Oligochaete	*Oligochaeta*	0	0	20	0	0	20	0
Annelida	Polychaete	*Glycera sp.*	0	0	80	0	20	20	0
Arthropoda	Pagurid	*Pagurus sp.*	0	0	40	0	0	0	0
Annelida	Polychaete	*Leitoscoloplos sp.*	0	0	60	1120	420	280	600
Mollusca	Gastropod	*Ilyanassa obsoleta*	0	0	40	0	0	40	0
Mollusca	Bivalve	*Mulinia lateralis*	0	0	0	20	0	0	0
Annelida	Polychaete	*Paraonidae*	0	0	0	40	0	180	20
Annelida	Polychaete	*Nephtys sp.*	0	0	0	20	0	20	140
Annelida	Polychaete	*Diopatra cuprea*	0	0	0	20	0	0	0
Annelida	Polychaete	*Eteone sp.*	0	0	0	0	20	0	0
Annelida	Polychaete	*Pectinaria gouldii*	0	0	0	0	20	0	20
Arthropoda	Decapod	*Neomysis americana*	0	0	0	0	0	20	0
Annelida	Polychaete	*Nereis virens*	0	0	0	0	0	40	0
Annelida	Polychaete	*Phyllodoce sp.*	0	0	0	0	0	0	20
Annelida	Polychaete	*Polydora ligni*	0	0	0	0	0	0	40
Annelida	Polychaete	*Streblospio benedicti*	0	0	0	0	0	0	100
Arthropoda	Decapod	*Crangon septemspinosa*	0	0	0	0	0	0	20
			NC 1	**NC 2**	**NC 3**	**NC 4**	**NC 5**	**NC 6**	**NC 7**
	Species Richness (total number of taxa)		3	1	6	6	5	10	10
	TRUE Species Richness (total # of taxa)		3	1	6	6	5	10	10
	Mean Density (individuals/m2)		320	520	340	1300	620	740	1320
	Diversity (Shannon-Wiener Function, H')		1.01	0	2.41	0.86	1.34	2.57	2.43
	H' max		1.58	0	2.584	2.58	2.32	3.32	3.32
	Evenness (E)		0.63	1	0.93	0.33	0.57	0.77	0.73
			NC 1	**NC 2**	**NC 3**	**NC 4**	**NC 5**	**NC 6**	**NC 7**
# Taxa occurring	Annelida	#	1	0	4	5	5	7	8
		%	33%	0%	67%	83%	100%	70%	80%
	Arthropoda	#	2	1	1	0	0	2	2
		%	67%	100%	17%	0%	0%	20%	20%
	Mollusca	#	0	0	1	1	0	1	0
		%	0%	0%	17%	17%	0%	10%	0%
# Individuals occurring	Annelida	#	60	0	260	1280	620	660	1080
		%	19%	0%	76%	98%	100%	89%	82%
	Arthropoda	#	260	520	40	0	0	40	240
		%	81%	100%	12%	0%	0%	5%	18%
	Mollusca	#	0	0	4	20	0	40	0
		%	0%	0%	1%	2%	0%	5%	0%

Table 2. Benthos Biomass (g/m2) for Liberty State Park North Cove, Jersey City, NJ.

	Biomass (g/m2)								
	Family	**Group**	**NC 1**	**NC 2**	**NC 3**	**NC 4**	**NC 5**	**NC 6**	**NC 7**
	Arthropoda	Amphipods	0.5	0	0	0	0	0.08	0.626
	Annelida	Polychaetes	0.086	0	21.922	35.056	12.532	39.538	20.146
	Arthropoda	Merostomata	0	26.58	0	0	0	0	0
	Annelida	Oligochaetes	0	0	0.024	0	0	0.064	0
	Mollusca	Gastropods	0	0	60.982	0	0	93.492	0
	Arthropoda	Paguridae	0	0	94.658	0	0	0	0
	Mollusca	Bivalves	0	0	0	3.028	0	0	0
	Arthropoda	Crustaceans	0	0	0	0	0	0	0.958
		TOTAL	0.586	26.58	177.586	38.084	12.532	133.174	21.73

			NC 1	**NC 2**	**NC 3**	**NC 4**	**NC 5**	**NC 6**	**NC 7**
Biomass	Annelida	g/m2	0.086	0	21.946	35.056	12.532	39.602	20.146
		%	15%	0%	12%	92%	100%	30%	93%
	Arthropoda	g/m2	0.5	26.58	94.658	0	0	0.08	1.584
		%	85%	100%	53%	0%	0%	0.06%	7%
	Mollusca	g/m2	0	0	60.982	3.028	0	93.492	0
		%	0%	0%	34%	8%	0%	70%	0%



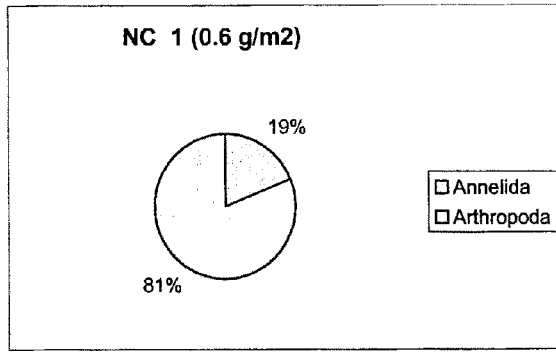
Legend

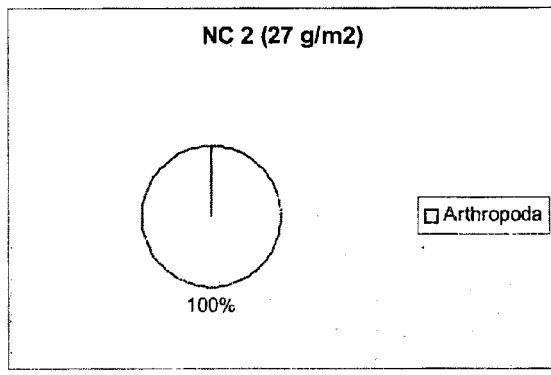
Sampling Point

0 50 100 200 Feet

Benthyic Survey Sampling Stations

FIGURE 1





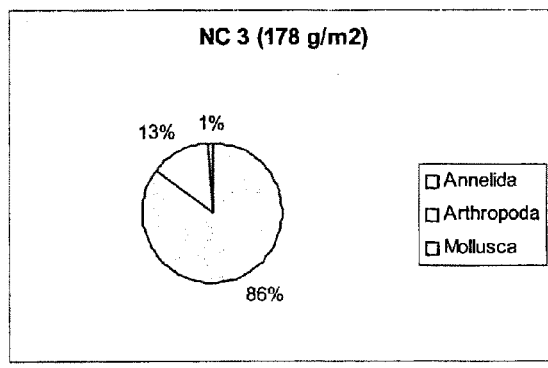


Figure 2: Percent composition and biomass for infaunal communities in North Cove, Liberty State Park, Jersey City, NJ.

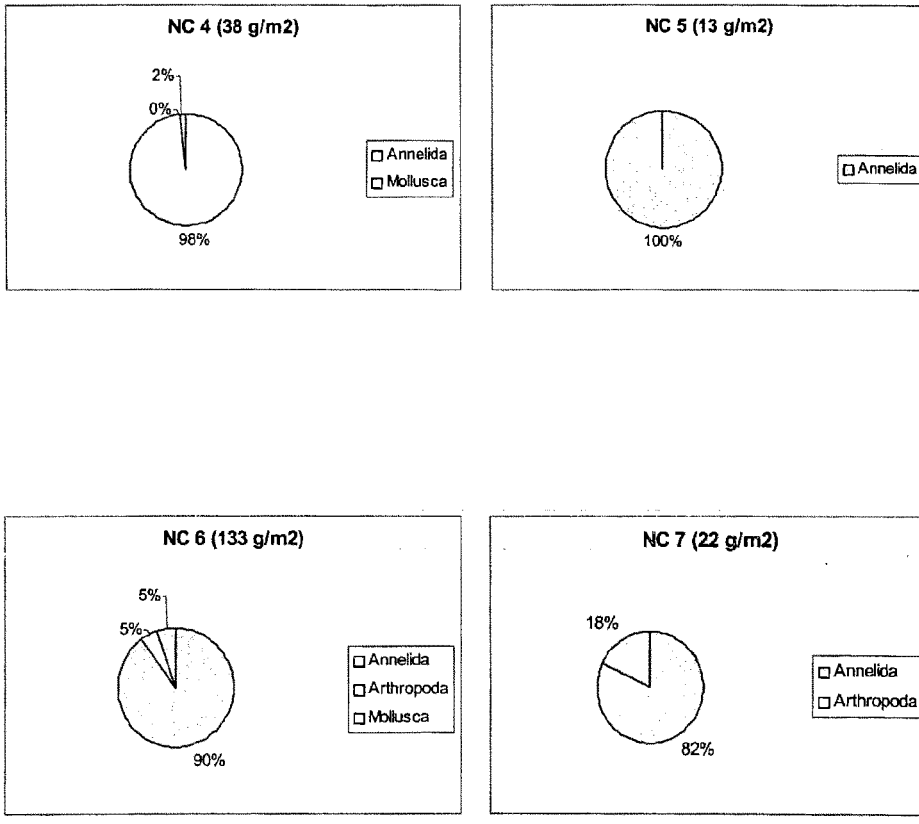


Figure 2 (page 2 of 2). Percent composition and biomass for infaunal communities in North Cove, Liberty State Park, Jersey City, NJ.

Appendix E

Modified Highway Functional Assessment Considerations and Qualifiers and Evaluation Sheets for Liberty State Park Jersey City, NJ

Functional Evaluation
The Highway Methodology (New England Division; USACE)

Wetland Evaluation supporting Documentation

- **Groundwater Recharge/Discharge:**

This function considers the potential for a wetland to serve as a groundwater recharge and or discharge area. It refers to the fundamental interaction between wetlands and aquifers, regardless of the size or importance of either.

Considerations/Qualifiers:

1. Public or private wells occur downstream from wetland.
2. Potential exists for public or private wells downstream of the wetland.
3. Wetland is underlain with stratified drift
4. Gravel or sandy soils present in/or adjacent to the wetland.
5. Fragipan does not occur in the wetland.
6. Fragipan, impervious soils, or bedrock does occur in the wetland.
7. Wetland is associated with a perennial or intermittent watercourse.
8. Signs of groundwater recharge are present.
9. Wetland is associated with a watercourse.
10. Wetland contains only an outlet.
11. Groundwater quality of stratified drift aquifer within or downstream of wetland meets drinking water standards.
12. Quality of water associated with the wetland is high.
13. Signs of groundwater discharge are present. (E.g. springs).
14. Water temperature suggests it is a discharge site.
15. Wetland shows signs of variable water levels.
16. Gravel or sandy soils present in or adjacent to wetland.
17. Piezometer data demonstrates discharge.
18. Other.

- **Floodflow Alteration (Storage and Desynchronization)**

This function considers the effectiveness of the wetland in reducing flood damage by water retention for prolonged periods following precipitation events and the gradual release of floodwaters. It adds to the stability of the wetland ecological system or its buffering characteristics and provides social or economic value relative to erosion and/or flood prone areas.

Considerations/Qualifiers:

1. Area of this wetland is large relative to its watershed.
2. Wetland occurs in the upper portions of the watershed
3. Effective flood storage is small or non-existent upslope of or above the wetland.
4. Wetland watershed contains a high degree of impervious surfaces.

5. Wetland contains hydric soils which are able to absorb and detain water.
6. Wetland exists in relatively flat area that has flood storage potential.
7. Wetland has an intermittent outlet, ponded water, or signs are present of variable water level.
8. during flood events, this wetland can retain higher volumes of water than under normal or average rainfall conditions
9. Wetland receives and retains overland or sheet flow runoff from surrounding uplands.
10. In the event of a large storm, this wetland may receive and detain excessive flood water from a nearby watercourse.
11. Valuable properties, structures or resources are located in or near the floodplain downstream from the wetland.
12. The watershed has a history of economic loss due to flooding
13. The wetland is associated with one or more watercourses.
14. This wetland watercourse is sinuous or diffuse.
15. This wetland outlet is restricted
16. Channel flow velocity is affected by this wetland.
17. Land uses downstream are protected by this wetland.
18. This wetland contains a high density of vegetation.
19. Other.

- **Fish and Shellfish Habitat**

This function considers the effectiveness of seasonal or permanent watercourses associated the wetland in question for fish and shellfish habitat.

Considerations/Qualifiers:

1. Forest land dominant in the watershed above this wetland
2. Abundance of cover objects present.

- **Sediment/Toxicant/Pathogen Retention**

This function reduces or prevents degradation of water quality. It relates to the effectiveness of the wetland as a trap for sediments, toxicants, or pathogens in runoff water from surrounding uplands, or upstream eroding wetland areas.

Considerations/Qualifiers:

1. Potential sources of excess sediment are in the watershed above the wetland.
2. Potential or known sources of toxicants are in the watershed above the wetland.
3. Opportunity for sediment trapping by slow moving water or deepwater habitat is present in this wetland.
4. Mineral, fine grained or organic soils are present.
5. Long duration water retention time is present in this wetland.
6. Public or private water sources occur downstream.
7. The wetland edge is broad and intermittently aerobic.
8. The wetland is known to have existed for more than 50 years.
9. Drainage ditches have not been constructed in the wetland.

- **Nutrient Removal/Retention/Transformation**

This function considers the effectiveness of the wetland as a trap for nutrients in runoff water from surrounding uplands or contiguous wetlands, and the ability of the wetland to process these nutrients into other forms of trophic levels. One aspect of this function is to prevent ill effects of nutrients entering aquifers or surface waters such as ponds, lakes, streams, rivers or estuaries.

Considerations/Qualifiers:

1. Wetland is large relative to the size of its watershed.
2. Deep water or open water habitat exists.
3. Overall potential for sediment trapping exists in the wetland.
4. Potential sources of excess nutrients present in the watershed above the wetlands.
5. Wetland saturated for most of the season. Ponded water is present in the wetland.
6. Deep organic/sediment deposits are present.
7. Slowly drained mineral, fine grained, or organic soils, are present.
8. Dense vegetation is present
9. Emergent vegetation and/or dense woody stems are dominant.
10. Aquatic diversity/abundance sufficient to utilize nutrients.
11. Opportunity of nutrient attenuation exists.
12. Vegetation diversity/abundance sufficient to utilize nutrients.

- **Production Export (Nutrient)**

This function evaluated the effectiveness of the wetland to produce food or usable products for man or other living organisms.

Considerations/Qualifiers:

1. Wildlife food sources grow within this wetland.
2. Detritus development is present within this wetland.
3. Economically or commercially used products found in this wetland.
4. Evidence of wildlife use found within the wetland.
5. Higher trophic level consumers are utilizing this wetland.
6. Fish or shellfish develop or occur in this wetland.
7. High vegetation density is present
8. Wetland exhibits a high degree of plant community structure/species diversity.
9. High aquatic diversity/abundance is present.
10. Nutrients exported in wetland watercourses (permanent outlet present).
11. "Flushing" of relatively large amounts of organic plant materials occurs from this wetland.
12. Wetland contains flowering plants which are used by nectar-gathering insects.
13. Indications of export are present.
14. High production levels occurring however, no visible signs of export (assumes export is attenuated).
15. Other.

- **Sediment/Shoreline Stabilization**

This function considers the effectiveness of a wetland to stabilize stream banks and shorelines against erosion.

Considerations/Qualifiers:

1. Indications of erosion, siltation present.
2. Topographic gradient is present in wetland.
3. Potential sediment sources are present up-slope.
4. No distinct shoreline or bank is evident between the waterbody and the wetland or upland.
5. A distinct step between the open waterbody or stream and the adjacent land exists (i.e. sharp bank) with dense roots throughout.
6. Wide wetland (>10') bordering watercourse, lake or pond.
7. High flow velocities in the wetland.
8. Potential sediment sources present upstream.
9. The watershed is of sufficient size to produce channelized flow.
10. Open water fetch is present.
11. Boating activity is present.
12. Dense vegetation is bordering watercourse, lake or pond.
13. High percentage of energy absorbing emergents and/or shrubs bordering watercourse, lake or pond.
14. Vegetation comprised of large trees and shrubs which withstand major flood events or erosive incident and stabilize the shoreline on a large scale (feet).
15. Vegetation comprised of dense resilient herbaceous layer which stabilizes sediments and the shoreline on a small scale (inches) during minor flood events or potentially erosive events.
16. Other.

- **Wildlife Habitat**

This function considers the effectiveness of the wetland to provide habitat for various types and populations of animals typically associated with wetlands and the wetland edge. Both resident and/or migrating species must be considered. Species lists of observed and potential animals should be included in the wetland assessment report.2

Considerations/Qualifiers:

1. Wetland is not degraded by human activity.
2. Water quality of the watercourse, pond, or lake associated with this wetland meets or exceeds Class A or B standards.
3. Wetland is not fragmented by development.
4. Upland surrounding this wetland is undeveloped.
5. More than 40% of this wetland edge is bordered by upland wildlife habitat (e.g. brushland, woodland, active farmland, or idle land) at least 500 feet in width.
6. Wetland contiguous with other wetland systems connected by watercourse or lake.
7. Wildlife overland access to other wetlands is present.
8. Wildlife food sources are within this wetland or are nearby.
9. Wetland exhibits a high degree of interspersion of vegetation classes and or open

water.
10. Two or more islands or inclusions of upland within the wetland are present.
11. Dominant wetland class includes deep or shallow marsh or wooded swamp.
12. More than three acres of shallow permanent open water (less than 6.6 feet deep) including streams in or adjacent to wetland are present.
13. Density of the wetland vegetation is high.
14. Wetland exhibits a high degree of plant species diversity.
15. Wetland exhibits a high degree of diversity in plant community structure (e.g. tree/shrub/vine/grasses/mosses/etc.).
16. Plant/animal indicator present.
17. Animal signs observed (tracks, scats, nesting areas, etc.).
18. Seasonal uses vary for wildlife, and wetland appears to support varied population diversity/abundance during different seasons.
19. Wetland contains or has potential to contain a high population of insects.
20. Wetland contains or has potential to contain large amphibian populations.
21. Wetland has a high avian utilization or its potential.
22. Indications of less disturbance-tolerant species present.
23. Sighs of wildlife habitat enhancement present (birdhouses, nesting boxes, food sources, etc.)
24. Other:

- **Recreation (Consumptive and Non-Consumptive)**

This value considers the suitability of the wetland and associated watercourses to provide recreational opportunities such as hiking, canoeing, boating fishing, hunting or other passive or active recreational activities. Consumptive opportunities consume or diminish the plants, animals or other resources that are intrinsic to the wetland. Non-consumptive opportunities do not consume or diminish these resources of the wetland.

Considerations/Qualifiers:
1. Wetland is part of a recreation area, park, forest, or refuge.
2. Fishing is available within or from the wetland.
3. Hunting is permitted in the wetland.
4. Hiking occurs or has potential to occur within the wetland.
5. Wetland is a valuable wildlife habitat.
6. The watercourse, pond, or lake, associated with the wetland is unpolluted.
7. High visual/aesthetic quality of this potential recreation site.
8. Access to water is available at this potential recreation site.
9. The watercourse associated with this wetland is wide and deep enough to accommodate canoeing and/or non-powered boating.
10. Off-road public parking available at the potential recreation site.
11. Accessibility and travel ease is present at this site.
12. The wetland is within a short drive or safe walk from highly populated public and private areas.
13. Other

- **Educational/Scientific Value**

This value considers the suitability of the wetland as a site for an "outdoor classroom" or as a

location for scientific study or research.

Considerations/Qualifiers:

1. Wetland contains or is known to contain threatened, rare, or endangered species.
2. Little or no disturbance is occurring in this wetland.
3. Potential educational site contains a diversity of wetland classes which are accessible or potentially accessible.
4. Potential educational site is undisturbed and natural.
5. Wetland is considered to be a valuable wildlife habitat.
6. Wetland is located within a nature preserve or wildlife management area.
7. Signs of wildlife habitat enhancement present (bird houses, nesting boxes, food sources, etc.).
8. Off-road parking at potential educational site suitable for school bus access in or near wetland.
9. Potential educational site is within safe walking distance or a short drive to schools.
10. Potential educational site within safe walking distance to other plant communities.
11. Direct access to perennial stream at potential educational site available.
12. Direct access to pond or lake at potential educational site available.
13. No known safety hazards within the potential educational site.
14. Public access to the potential educational site is controlled.
15. Handicap accessibility is available.
16. Site is currently used for educational or scientific purposes.
17. Other

- **Uniqueness/Heritage**

This value considers the effectiveness of the wetland or its associated waterbodies to provide certain special values. These may include archaeological sites, critical habitat for endangered species, its overall health and appearance, its role in the ecological system of the area, its relative importance as a typical wetland class for this geographic location. These functions are clearly valuable wetland attributes relative to aspects of public health, recreation, and habitat diversity.

Considerations/Qualifiers:

1. Upland surrounding wetland primarily urban.
2. Upland surrounding wetland developing rapidly.
3. More than 3 acres of shallow permanent open water occur in wetlands (less than 6.6 feet deep) including streams
4. Three or more wetland classes present.
5. Deep and/or shallow marsh, or wooded swamp dominated.
6. High degree of interspersion of vegetation and/or open water occurring in this wetland.
7. Well-vegetated stream corridor (15 feet on each side of the stream) occurs in this wetland.
8. Potential educational site is within a short drive or a safe walk from schools.
9. Off-road parking at potential educational site is suitable for school buses.
10. No known safety hazards exist within this potential educational site.
11. Direct access to perennial stream or lake at potential educational site.
12. Two or more wetland classes visible from primary viewing locations.

13. Low-growing wetlands (marshes, scrub-shrub, bogs, open water) visible from primary viewing locations.
14. Half an acre of open water or 200 feet of stream is visible from the primary viewing locations.
15. Large area of wetland is dominated by flowering plants, or plants which turn vibrant colors in different seasons.
16. General appearance of the wetland visible from primary viewing locations is unpolluted and/or undisturbed.
17. Overall view of the wetland is available from the surrounding upland.
18. Quality of the water associated with the wetland is high.
19. Opportunities for wildlife observations are available.
20. Historical buildings occur within the wetland.
21. Presence of pond or pond site and remains of a dam occur within the wetland.
22. Wetland within 50 yards of the nearest perennial watercourse.
23. Visible stone or earthen foundations, berms, dams, standing structures or associated features occur within the wetland.
24. Wetland contains critical habitat for a state or federally listed threatened or endangered species.
25. Wetland is known to be a study site for scientific research.
26. Wetland is a natural landmark or recognized by the state natural heritage inventory authority as an exemplary natural community.
27. Wetland has local significance because it serves several functional values.
28. Wetland has local significance because it has biological, geological, or other features which are locally rare or unique.
29. Wetland is known to contain an important archaeological site.
30. Wetland is hydrologically connected to a state or federally designated scenic river.
31. Wetland is located in an area experiencing a high wetland loss rate.
32. Other

- **Visual Quality/Aesthetics**

This value considers the visual *and* aesthetic quality or usefulness of the wetland.

Considerations/Qualifiers:

1. Multiple wetland classes visible from primary viewing locations.
2. Emergent marsh and/or open water visible from primary viewing locations.
3. Diversity of vegetation species visible from primary viewing locations.
4. Wetland dominated by flowering plants, or plants which turn vibrant colors in different seasons.
5. Land use surrounding the wetland is undeveloped as seen from primary viewing locations.
6. Visible surrounding land use form contrasts with wetland.
7. Wetland views absent of trash, debris, and signs of disturbance
8. Wetland is considered to be a valuable wildlife habitat.
9. Wetland is easily accessed.
10. Low noise level at primary viewing locations.
11. Unpleasant odors absent at primary viewing locations.
12. Relatively unobstructed sight line exists through wetland.

13. Other

- **Endangered Species Habitat**

This value considers the suitability of the wetland to support threatened or endangered species.

Considerations/Qualifiers:

1. Wetland contains or is known to contain threatened or endangered species.
2. Wetland contains critical habitat for a state or federally listed threatened or endangered species.
3. Other

Although the above example refers to freshwater wetlands, it can also be adapted for marine ecosystems. Below is an example of an adaptation for the fish and shellfish function provided by the National Marine Fisheries Service.

- **Fish and Shellfish Habitat**

This function considers the effectiveness of wetlands, embayments, tidal flats, vegetated shallows, and other environments in supporting marine resources such as fish, shellfish, marine mammals, and sea turtles.

Considerations/Qualifiers: (Marine)

1. Special aquatic sites (tidal marsh, mud flats, and eelgrass beds) are present.
2. Suitable spawning habitat is present at the site or in the area.
3. Commercially or recreationally important species are present or suitable habitat exists.
4. The wetland/waterway supports prey for higher trophic level marine organisms.
5. The waterway provides migratory habitat for anadromous fish.
6. Other

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: CRDW

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	2,5,8		*3 have no [illegible]
Floodflow Alteration					
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention					
Nutrient Removal					
Production Export					
Sediment/Shoreline Stabilization					
Wildlife Breeding Habitat					
Wildlife Foraging Habitat					
Wildlife Dependency					
Recreation	0*	1	1,4,10,11,12		*No Public Access
Educational Scientific Value	1	1	2,8,9,10,14		
Uniqueness/Heritage					
Visual Quality/Aesthetics					
Endangered Species Habitat	0	0			
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: FFW

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	2	2	4, 5, 8, 15		
Floodflow Alteration	2	2	3, 5, 6, 7, 8, 9, 10, 18		
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	1	1	1, 2, 3, 4, 9		
Nutrient Removal	1	1	7, 8, 9, 11, 12		
Production Export	2	2	1, 2, 4, 5*, 7, 8, 12, 14		*-Check Matrix
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	3	3			* See Appendix - Wdlife Matrix
Wildlife Foraging Habitat	3	3			
Wildlife Dependency	3	3			
Recreation	0*	1	1, 5, 10, 11, 12		*No Public Access
Educational Scientific Value	2	2	1, 2, 3, 5, 8, 9, 10, 14, 16*		* Future only
Uniqueness/Heritage	2	2	1, 5, 6, 8, 9, 15, 19, 24, 25*, 27, 28		* Future only
Visual Quality/Aesthetics	1	1	4, 8, 9*, 11		
Endangered Species Habitat	2	2	1, 2		2 non-observed Listed Sp. Breed. Canada
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: SSW

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	2	2	4, 5, 8, 15		
Floodflow Alteration	-1	1	3, 5, 6, 9, 10,		*Minimal Flood Storage
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	1	1	1, 2, 4, 9		
Nutrient Removal	1	1	7, 8, 9, 11, 12		
Production Export	2	2	1, 2, 4, 7, 8, 12, 14		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	2	2			* See Appendix - Wildlife Matrix
Wildlife Foraging Habitat	1	1			
Wildlife Dependency	2	2			
Recreation	0*	0	1, 5		*No Public Access; No Future Access
Educational Scientific Value	1	1	2, 8, 9, 10, 14		
Uniqueness/Heritage	2	2	1, 5, 6, 8, 9, 15, 19, 24, 25*, 27, 28		*Future only
Visual Quality/Aesthetics	1	1	4, 8, 9*, 11		
Endangered Species Habitat	2	2	1, 2		Foraging For Cooper's Hawk + Swainson
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: SEM

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	2	2	4, 5, 7*, 8, 12*, 15		*Future condition only, W-3 will have improved WQ
Floodflow Alteration	2	3	3, 5, 6, 7, 8, 9, 10, 13, 16*, 18		*Future only
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	2	3	1, 2, 3, 4, 7, 9, 10*, 11*, 12*, 13*, 14*, 15*, 16*		*Future only
Nutrient Removal	2	3	2, 3, 4*, 5, 7, 8, 9, 10, 11, 12, 13*, 14*, 15*		*Future only, increased wetlands size
Production Export	2	3	1, 2, 4, 5, 7, 8, 10*, 11*, 12, 14		*Future only, *A Can't answer until Final PLAN
Sediment/Shoreline Stabilization	0	3	3*, 4*, 6*, 8*, 12*, 13*, 14*, 15*		*Future only
Wildlife Breeding Habitat	2	2			* See Appendix - Wildlife Matrix
Wildlife Foraging Habitat	3	3			
Wildlife Dependency	3	3			
Recreation	0*	2	1, 4, 5, 8, 10, 11, 12		*No Public Access; Future Condition W-3 will have improved WQ
Educational Scientific Value	2	2	1, 2, 3, 5, 8, 9, 10, 14, 16*		* Future only
Uniqueness/Heritage	2	3	1, 4*, 5, 6, 7*, 8, 9, 11, 12, 14*, 19, 22*, 24*, 25*, 27, 28		* Future only
Visual Quality/Aesthetics	3	3	1*, 2*, 3*, 4*, 6, 7, 8, 9*, 11, 12		* Future only
Endangered Species Habitat	3	3	1, 2		Bobolink Breeding
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: DEM

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	X	1	4,5,7,15		
Floodflow Alteration	X	3	3,5,6,7,8,9,10,13,16,18		
Fish and Shellfish Habitat (freshwater)	X	3	2,4,5,7,8,10,12,13,16,17		
Sediment/Toxicant Retention	X	3	1,2,3,4,7,9,10,11,12,13,14,15,16		
Nutrient Removal	X	3	2,3,4,5,7,10,11,12,13,14,15		
Production Export	X	3	1,2,4,5,6,9,10,11*,12,13		* Check Final Design
Sediment/Shoreline Stabilization	X	3	3,4,6,8,12,13,14,15		
Wildlife Breeding Habitat	X	0			* See Wildlife Matrix
Wildlife Foraging Habitat	X	3			
Wildlife Dependency	X	3			
Recreation	X	2	1,4,5,10,11,12		
Educational Scientific Value	X	3	1,2,3,5,7,8,9,10,13,14,16		
Uniqueness/Heritage	X	3	1,3,4,5,6,7,8,9,11,12,14,19,22,24,25,27,28		
Visual Quality/Aesthetics	X	3	1*,2*,3,4*,6,7,8,9*	11,12	* Future Only
Endangered Species Habitat	X	3	1,2		Night Herons Breeding
Fish and Shellfish Habitat (marine)	X	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: SNH

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	4,5,17?		Waiting on DATA from Proponent
Floodflow Alteration	1	1	3*,6,10,18		*Flood Storage better in Future
Fish and Shellfish Habitat (freshwater)	0	0	N/A		
Sediment/Toxicant Retention	0	0	2,4		
Nutrient Removal	1	1	8,9,12		
Production Export	2	2	1,2,4,5,7,12, 14		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	2	2			See Appendix — Wildlife Matrix
Wildlife Foraging Habitat	2	2			
~~Wildlife~~ Dependency (Habitat Dependency)	2	2			
Recreation	0*	2	1,4,5,10,11,12		*No Existing Access to Site.
Educational Scientific Value	2	2	1,2,3,5,6,8,9,14 16*		*Future will have Sci. Purpose #16
Uniqueness/Heritage	2	2	1,8,9,15,19,24,27,28, 25*,27		*Future only
Visual Quality/Aesthetics	1	1	4,8,9*,11		*Future only
Endangered Species Habitat	3	3	1,2		Cooper's Hawk Breeding
Fish and Shellfish Habitat (marine)	0	0	N/A		
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Habitat Code: SSB

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	4,5,17?		Waiting on DNTA flow [illegible]
Floodflow Alteration	1	1	3,6,10,18		
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	0	0			
Nutrient Removal	1	1	8,9,12		
Production Export	2	2	1,2,4,5,7,12,14		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	1	1			* See Appendix — Wildlife Matrix
Wildlife Foraging Habitat	2	2			
Wildlife Dependency	0	0			
Recreation	0*	1	1,4,5,10,11,12		* No access permitted
Educational Scientific Value	1	1	2,8,9,13,14,16*		*Future only
Uniqueness/Heritage	1	1	1,8,9,19,24,25*,27,28		*Future only scientific research
Visual Quality/Aesthetics	1	1	6,8,~~#~~ 9*,11		*Future only
Endangered Species Habitat	2	2	1		
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: SOF

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	4,5,		
Floodflow Alteration	1	1	3,6,10,18*		* Veg will be more dense in Future
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	0	0			
Nutrient Removal	1	1	8,9,12		
Production Export	2	2	1,2,4,5,7,8,12,14		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	3	3			* See Appendix – Wildlife Matrix
Wildlife Foraging Habitat	2	2			
Wildlife Dependency	2	2			
Recreation	0*	2	1,4,5,10,11,12		* No Public Access
Educational Scientific Value	1	2	1,2,5,8,9,10,14,16*		* Future Only
Uniqueness/Heritage	1	2	1,8,9,15,19,24,25*,27,28		
Visual Quality/Aesthetics	2	2	3,4,8,9*,12,6		* Future only
Endangered Species Habitat	3	3	1,2		N. Harrier Breed
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: ML

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	4,5		
Floodflow Alteration	1	1	3,6,10,18		
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	0	0			
Nutrient Removal	1	1	8,9		
Production Export	1	1	1,4,7		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	0	0			* See Appendix – Wildlife Matrix
Wildlife Foraging Habitat	0	0			
Wildlife Dependency	0	0			
Recreation	1	1	1, 10, 11, 12		
Educational Scientific Value	0	0	13,		
Uniqueness/Heritage	0	0	1,19		
Visual Quality/Aesthetics	1	1	6, 9, 11, 12		
Endangered Species Habitat	0	0			
Fish and Shellfish Habitat (marine)					
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: MF

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	T	1	4,5,		
Floodflow Alteration	—	1	3,6,10,18		
Fish and Shellfish Habitat (freshwater)	Ø	0			
Sediment/Toxicant Retention	—	0	2		
Nutrient Removal	—	1	8,9,12		
Production Export	—	2	1,2,4,5,7,12,14		
Sediment/Shoreline Stabilization	—	0	N/A		
Wildlife Breeding Habitat	—	3			
Wildlife Foraging Habitat	—	3			
Wildlife Dependency	—	2			
Recreation	Ø*	2	1,4,5,10,11,12		* No Public Access
Educational Scientific Value	—	3	1,2,5,8,9,10,13,14,16		
Uniqueness/Heritage	—	2	1,8,9,15,19,24,27,28,25*,27		* Future Only
Visual Quality/Aesthetics	—	1	4,8,9,11		
Endangered Species Habitat	—	3	1,2		Cooper's Hawk Breeding
Fish and Shellfish Habitat (marine)	Ø	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: MG

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	4, 5		
Floodflow Alteration	-	1	3, 6, 10, 18		
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	0	0	2		
Nutrient Removal	1	1	8, 9, 12		
Production Export	2	2	1, 2, 4, 5, 7, 8, 12, 14		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	3	3			
Wildlife Foraging Habitat	2	2			
Wildlife Dependency	3	3			
Recreation	0*	2	1, 4, 5, 10, 11, 12		* No Public Access
Educational Scientific Value	1	2	1, 2, 5, 8, 9, 10, 14, 16*		* Future Only
Uniqueness/Heritage	2	2	1, 8, 9, 15, 19, 24, 25*, 27, 28		
Visual Quality/Aesthetics	2	2	3, 4, 8, 9*, 12, 6		*Future only
Endangered Species Habitat	3	3	1, 2		N. Harrier
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: MS

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	1	1	4,5		
Floodflow Alteration	1	1	3,6,10,18		
Fish and Shellfish Habitat (freshwater)	0	0			
Sediment/Toxicant Retention	0	0	2		
Nutrient Removal	1	1	8,9,12		
Production Export	2	2	1,2,4,5,7,12,14		
Sediment/Shoreline Stabilization	0	0	N/A		
Wildlife Breeding Habitat	2	2			
Wildlife Foraging Habitat	1	1			
Wildlife Dependency	0	0			
Recreation	0*	1	1,4,10,11,12		* No Public Access
Educational Scientific Value	1	1	2,8,9,10,11,14,16		* Future only
Uniqueness/Heritage	1	2	1,8,9,15,19,24,25*,27,28		* Future only
Visual Quality/Aesthetics	1	1	6,8,9*,11		* Future
Endangered Species Habitat	3	3	1,2		Savannah Sparrow + Cooper's Obligate
Fish and Shellfish Habitat (marine)	0	0			
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Wetland Function-Value Evaluation Form

Total area of existing habitat _____ acres.

Total area of proposed habitat _____ acres.

Wildlife & vegetation diversity/abundance (see Appendix --)

Habitat Code: SM

Prepared by: ERC Date _____

Evaluation based on:
Office √ Field √

Function /Value	Occurrence* E	Occurrence* P	Rationale (reference #)*	Principal Function(s) Value(s)	Comments
Groundwater Recharge/Discharge	~~0~~	1	4,5,7		
Floodflow Alteration	~~0~~	3	1,3,5*,8,9,10,13,14,16,18**		*SAND will turn Organic. **excluding Mud Flats
Fish and Shellfish Habitat (freshwater)	~~0~~	~~0~~	N/N		
Sediment/Toxicant Retention	~~0~~	3	1,2,3,4,7,9,10,11,12,14,15,16		
Nutrient Removal	~~0~~	3	1,2,3,4,5,7,8*,9*	10,11,12,13,14,15	*Excluding Mud Flats
Production Export	~~0~~	3	1,2,3,4,5,6,7*,9,	10,11,13	*Excluding Mud Flats
Sediment/Shoreline Stabilization	~~0~~	3	1,3,5,6,7,8,12,	13,15	
Wildlife Breeding Habitat	~~0~~	2			* See Matrix
Wildlife Foraging Habitat	~~0~~	3			
Wildlife Dependency	~~0~~	3			
Recreation	~~0~~*N	1	1,4,5,10,11,12		
Educational Scientific Value	~~0~~	3	1,2,3,5,8,9,10,13,14,16		
Uniqueness/Heritage	~~0~~	3	1,4,5,6,8,9,10,12,13,14,16,17,19,24,25,27,28		
Visual Quality/Aesthetics	~~0~~	3	1,2,3,6,7,8,9,12		
Endangered Species Habitat	~~0~~	3	1,2		Night Herons Foraging
Fish and Shellfish Habitat (marine)	~~0~~	3	1,2,3,4		
Total Functional Habitat Value					

Notes:* H= 3; M=2; L=1; No function = 0; *Wetland assessment is relatively indicative of functions and values present in both Existing (E) and Proposed (P) conditions.*

Appendix F

Wildlife Matrix Developed for Liberty State Park
Jersey City, NJ

					Successional Northern Hardwood			Successional Shrubland		
	Habitat Specificity	Trophic Level	Regulatory Status	Species Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
American Black Duck	3	1	3	2.33	--	--	--	--	--	--
American Coot	1	1	4	2.00	--	--	--	--	--	--
American Crow	1	1	1	1.00	2.00	1.00	--	--	1.00	--
American Goldfinch	1	2	1	1.33	--	--	--	2.67	1.33	--
American Kestrel	5	4	1	3.33	--	--	--	--	--	--
American Redstart	1	4	1	2.00	--	--	--	--	2.00	--
American Robin	1	1	1	1.00	2.00	1.00	--	2.00	1.00	--
American Tree Sparrow	1	2	1	1.33	--	--	--	--	1.33	--
American Wigeon	3	1	3	2.33	--	--	--	--	--	--
American Woodcock	3	5	3	3.67	--	--	--	7.33	3.67	--
Bairds Sandpiper	3	4	1	2.67	--	--	--	--	--	--
Baltimore Oriole*	1	1	5	2.33	4.67	2.33	--	--	--	--
Barn Swallow	1	4	1	2.00	--	--	--	--	2.00	--
Belted Kingfisher	5	5	1	3.67	--	--	--	--	--	--
Black crowned Night Heron*	5	4	1	3.33	--	--	--	--	--	--
Black Skimmer*	5	4	5	4.67	--	--	--	--	--	--
Bobolink*	1	1	5	2.33	--	--	--	--	--	--
Brant	5	3	3	3.67	--	--	--	--	--	--
Brown Thrasher	1	1	1	1.00	--	--	--	2.00	1.00	--
Brown-headed Cowbird	1	1	1	1.00	2.00	--	--	2.00	1.00	--
Bufflehead	3	4	3	3.33	--	--	--	--	--	--
Canada Goose	1	2	1	1.33	--	--	--	--	--	--
Canvasback	5	3	3	3.67	--	--	--	--	--	--
Cedar Waxwing	1	3	1	1.67	--	1.67	--	--	1.67	--
Chimney Swift	1	4	1	2.00	--	--	--	--	2.00	--
Clapper Rail	3	1	1	1.67	--	--	--	--	--	--
Common Goldeneye	5	1	3	3.00	--	--	--	--	--	--
Common Tern	3	4	1	2.67	--	--	--	--	--	--
Common Yellowthroat	1	4	1	2.00	--	--	--	--	--	--
Cooper's Hawk*	3	4	5	4.00	8.00	4.00	--	--	4.00	--
Doubled-crested Cormorant	1	5	1	2.33	--	--	--	--	--	--
Downy Woodpecker	1	4	1	2.00	4.00	2.00	--	--	2.00	--
Eastern Kingbird	1	1	1	1.00	--	--	--	--	--	--
Eastern Meadowlark	1	1	1	1.00	--	--	--	--	1.00	--
Eastern Phoebe	1	4	1	2.00	--	2.00	--	--	--	--

					Successional Northern Hardwood			Successional Shrubland		
	Habitat Specificity	Trophic Level	Regulatory Status	Species Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Eastern Towhee	1	1	1	1.00	2.00	1.00	--	--	1.00	--
European Starling	3	1	--	1.33	--	1.33	--	--	--	--
Field Sparrow	1	1	1	1.00	--	--	--	--	--	--
Flycatcher sp.				--	--	--	--	--	--	--
Gadwall	3	1	3	2.33	--	--	--	--	--	--
Glossy Ibis	5	4	4	4.33	--	--	--	--	4.33	--
Golden-crowned Kinglet	3	4	1	2.67	--	2.67	--	--	2.67	--
Gray Catbird	1	1	1	1.00	--	--	--	2.00	1.00	--
Great Black-backed Gull	1	1	1	1.00	--	--	--	--	--	--
Great Blue Heron	5	4	1	3.33	--	--	--	--	--	--
Great Egret	5	4	1	3.33	--	--	--	--	--	--
Great Horned Owl	1	4	1	2.00	--	2.00	--	--	2.00	--
Greater Yellowlegs	3	4	1	2.67	--	--	--	--	--	--
Herring Gull	1	1	1	1.00	--	--	--	--	--	--
Hooded Merganser	5	4	3	4.00	--	--	--	--	--	--
Horned Grebe	1	4	1	2.00	--	--	--	--	--	--
Horned Lark	1	1	1	1.00	--	--	--	--	--	--
House Sparrow	1	1	--	0.67	--	--	--	--	0.67	--
House Wren	1	4	1	2.00	--	--	--	4.00	2.00	--
Killdeer	1	4	1	2.00	--	--	--	--	--	--
Laughing Gull	1	4	1	2.00	--	--	--	--	--	--
Lesser Yellowlegs	3	4	1	2.67	--	--	--	--	--	--
Long-eared owl*	3	4	5	4.00	--	4.00	--	--	--	--
Mallard	1	1	3	1.67	--	--	--	--	--	--
Marsh Wren*	3	4	1	2.67	--	--	--	--	--	--
Merlin	3	4	1	2.67	--	2.67	--	--	2.67	--
Mourning Dove	1	2	1	1.33	--	--	--	--	--	--
Northern Cardinal	1	2	1	1.33	--	1.33	--	2.67	1.33	--
Northern Flicker	3	1	1	1.67	3.33	1.67	--	--	1.67	--
Northern Harrier*	3	4	5	4.00	--	--	--	--	--	--
Northern Mockingbird	1	1	1	1.00	--	--	--	2.00	1.00	--
Osprey*	5	5	5	5.00	--	--	--	--	--	--
Pied-billed Grebe*	1	4	5	3.33	--	--	--	--	--	--
Red-breasted Merganser	3	4	3	3.33	--	--	--	--	--	--
Red-tailed Hawk	1	4	1	2.00	4.00	--	--	--	--	--
Red-throated Loon	3	5	1	3.00	--	--	--	--	--	--
Red-winged Blackbird	1	1	1	1.00	--	--	--	--	--	--

					Successional Northern Hardwood			Successional Shrubland		
	Habitat Specificity	Trophic Level	Regulatory Status	Species Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Ring-billed Gull*	1	1	5	2.33	--	--	--	--	--	--
Ring-necked Pheasant	1	1	--	0.67	--	--	--	--	0.67	--
Rock Dove	1	2	--	1.00	--	--	--	--	--	--
Ruddy Duck	3	2	3	2.67	--	--	--	--	--	--
Savannah Sparrow*	1	1	5	2.33	--	--	--	--	--	--
Short-eared Owl *	3	4	5	4.00	--	--	--	--	--	--
Snowy Egret	3	4	1	2.67	--	--	--	--	--	--
Snowy Owl	3	4	1	2.67	--	--	--	--	--	--
Song Sparrow	1	1	1	1.00	--	--	--	2.00	1.00	--
Spotted Sandpiper	3	4	4	3.67	--	--	--	--	--	--
Tree swallow	5	4	1	3.33	--	--	--	--	3.33	--
White-throated Sparrow	1	1	1	1.00	--	--	--	--	1.00	--
Wild Turkey	3	1	3	2.33	4.67	2.33	--	--	2.33	--
Willow Flycatcher	1	4	1	2.00	--	--	--	--	2.00	--
Yellow crowned Night Heron*	5	4	5	4.67	--	--	--	--	--	--
Yellow Warbler	1	4	1	2.00	--	--	--	--	2.00	--
Peregrine Falcon*	5	4	5	4.67	--	--	--	--	--	--
Black-bellied Plover	3	4	1	2.67	--	--	--	--	--	--
Hermit Thrush	3	1	1	1.67	--	1.67	3.33	--	1.67	--
Palm Warbler	3	3	1	2.33	--	--	--	--	--	--
Yellow-rumped Warbler	3	1	1	1.67	--	1.67	--	--	1.67	--
Dark-eyed Junco	1	1	1	1.00	--	1.00	--	--	1.00	--
Least Tern*	3	4	5	4.00	--	--	--	--	--	--
Sharp-shinned Hawk	3	4	4	3.67	7.33	3.67	7.33	--	3.67	--
Barn Owl*	3	4	5	4.00	--	--	--	--	--	--
Ruby-Crowned Kinglet	3	1	1	1.67	--	1.67	--	--	1.67	--
Least Sandpiper	3	4	1	2.67	--	--	--	--	--	--
Wood Thrush*	3	1	5	3.00	--	3.00	--	--	--	--
Rough-legged Hawk	3	4	1	2.67	--	--	--	--	--	--
White-eyed vireo	1	4	1	2.00	--	--	--	--	2.00	--
Yellow-throated vireo	3	4	1	2.67	--	--	--	--	--	--
Warbling vireo	1	4	1	2.00	--	2.00	--	--	--	--
Rey-eyed vireo	1	4	1	2.00	--	2.00	--	--	--	--
Philadelphia vireo	1	4	1	2.00	--	2.00	--	--	2.00	--
Black & white warbler	3	4	1	2.67	--	2.67	--	--	2.67	--
Tennessee warbler	1	4	1	2.00	--	2.00	--	--	2.00	--

					Successional Northern Hardwood			Successional Shrubland		
	Habitat Specificity	Trophic Level	Regulatory Status	Species Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Nashville warbler	1	4	1	2.00	--	2.00	--	--	2.00	--
Northern Parula	5	4	1	3.33	--	3.33	--	--	3.33	--
Magnolia warbler	1	4	1	3.00	--	2.00	--	--	2.00	--
Cape May Warbler	5	4	1	3.33	--	3.33	--	--	3.33	--
Black-throated Blue Warbler	3	4	1	2.67	--	2.67	--	--	--	--
Chestnut-sided Warbler	1	4	1	2.00	--	2.00	--	--	2.00	--
Black-throated Green Warbler	3	4	1	2.67	--	2.67	--	--	--	--
Blackburnian Warbler	5	4	1	3.33	--	3.33	--	--	--	--
Bay-breasted Warbler	3	4	1	2.67	--	2.67	--	--	--	--
Blackpoll Warbler	3	4	1	2.67	--	2.67	--	--	--	--
Pine Warbler	3	4	1	2.67	--	2.67	--	--	2.67	--
Prairie Warbler*	1	4	1	2.00	--	2.00	--	--	2.00	--
Ovenbird	3	4	1	2.67	--	--	--	--	--	--
Northern Waterthrush	3	4	1	2.67	--	2.67	--	--	--	--
Louisiana Waterthrush	3	4	1	2.67	--	--	--	--	--	--
Yellow-breasted Chat	3	1	1	1.67	--	--	--	--	1.67	--
Wilson's Warbler	3	4	1	2.67	--	--	--	--	--	--
Canada Warbler *	1	4	1	2.00	--	--	--	--	--	--
Scarlet Tanager	1	1	1	1.00	--	--	--	--	--	--
Black-capped Chickadee	1	1	1	1.00	--	1.00	--	--	--	--
Tufted Titmouse	3	1	1	1.67	3.33	1.67	--	--	--	--
White-breasted Nuthatch	5	1	1	2.33	--	--	--	--	--	--
Red-breasted Nuthatch	5	1	1	2.33	--	--	--	--	--	--
Brown Creeper	5	4	1	3.33	--	3.33	--	--	--	--
Winter Wren	3	4	1	2.67	--	2.67	--	--	--	--
Carolina Wren	1	4	1	2.00	--	--	--	--	--	--
Blue-Gray Gnatcatcher	3	4	1	2.67	--	2.67	--	--	--	--
Veery	3	1	1	1.67	--	--	--	--	--	--
Gray-cheeked Thrush	3	1	1	1.67	--	--	--	--	--	--
Swainson's Thrush	3	1	1	1.67	--	1.67	--	--	--	--
Yellow-billed Cuckoo	1	1	1	1.00	2.00	1.00	--	--	--	--
Acadian Flycatcher	3	4	1	2.67	--	--	--	--	--	--
Least Flycatcher	1	4	5	3.33	--	3.33	--	--	3.33	--
Hairy Woodpecker	3	4	1	2.67	--	--	--	--	--	--
Yellow-bellied Sapsucker	5	1	5	3.67	--	3.67	--	--	--	--
Red-bellied Woodpecker	3	1	1	1.67	--	1.67	--	--	--	--

					Successional Northern Hardwood			Successional Shrubland		
	Habitat Specificity	Trophic Level	Regulatory Status	Species Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Meadow Vole	1	2	1	1.33	--	--	--	--	1.33	--
White-footed Mouse	1	1	1	1.00	--	--	--	2.00	1.00	--
House Mouse	1	1	--	0.67	--	--	--	1.33	0.67	--
Norway Rat	1	1	--	0.67	--	--	--	--	0.67	--
Gray Squirrel	5	3	3	3.67	7.33	3.67	7.33	--	3.67	--
Muskrat	1	2	3	2.00	--	--	--	--	--	--
Raccoon	1	1	3	1.67	3.33	1.67	--	--	1.67	--
Cottontail Rabbit	1	2	3	2.00	4.00	2.00	--	4.00	2.00	--
Feral Dog	1	4	--	1.67	--	1.67	--	--	1.67	--
Feral Cat	1	4	--	1.67	--	--	--	--	1.67	--
Northern Water Snake	1	4	1	2.00	--	--	--	--	--	--
Northern Brown Snake	1	4	1	2.00	--	--	--	4.00	2.00	--
Green Frog	1	4	1	2.00	--	--	--	--	--	--
Fowler's Toad*	1	4	1	2.00	--	2.00	--	4.00	2.00	--
Eastern Garter Snake	1	4	1	2.00	--	--	--	4.00	2.00	--
Northern Diamond-backed Terrapin	5	1	1	2.33	--	--	--	--	--	--
Total Habitat Value					**64.00**	**124.00**	**18.00**	**48.00**	**118.67**	**0.00**

	Successional Old Field			Common Reed/ Mugwort			Mowed Lawn		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
American Black Duck	--	--	--	--	--	--	--	--	--
American Coot	--	--	--	--	--	--	--	--	--
American Crow	--	1.00	--	--	1.00	--	--	1.00	--
American Goldfinch	--	1.33	--	--	1.33	--	--	--	--
American Kestrel	--	3.33	--	--	3.33	--	--	--	--
American Redstart	--	2.00	--	--	2.00	--	--	--	--
American Robin	--	1.00	--	--	--	--	--	1.00	--
American Tree Sparrow	--	1.33	--	--	--	--	--	--	--
American Wigeon	--	--	--	--	--	--	--	--	--
American Woodcock	7.33	3.67	--	7.33	3.67	--	--	3.67	--
Bairds Sandpiper	--	--	--	--	--	--	--	--	--
Baltimore Oriole*	--	--	--	--	--	--	--	--	--
Barn Swallow	--	2.00	--	--	2.00	--	--	2.00	--
Belted Kingfisher	--	--	--	--	--	--	--	--	--
Black crowned Night Heron*	--	--	--	--	--	--	--	--	--
Black Skimmer*	--	--	--	--	--	--	--	--	--
Bobolink*	4.67	2.33	4.67	--	2.33	--	--	--	--
Brant	--	--	--	--	--	--	--	3.67	--
Brown Thrasher	2.00	1.00	--	--	1.00	--	--	--	--
Brown-headed Cowbird	2.00	1.00	--	2.00	1.00	--	--	1.00	--
Bufflehead	--	--	--	--	--	--	--	--	--
Canada Goose	2.67	--	--	--	--	--	--	1.33	--
Canvasback	--	--	--	--	--	--	--	--	--
Cedar Waxwing	--	--	--	--	--	--	--	--	--
Chimney Swift	--	2.00	--	--	2.00	--	--	2.00	--
Clapper Rail	--	--	--	--	--	--	--	--	--
Common Goldeneye	--	--	--	--	--	--	--	--	--
Common Tern	--	--	--	--	--	--	--	--	--
Common Yellowthroat	4.00	2.00	--	4.00	2.00	--	--	--	--
Cooper's Hawk*	--	4.00	--	--	4.00	--	--	--	--
Doubled-crested Cormorant	--	--	--	--	--	--	--	--	--
Downy Woodpecker	--	2.00	--	--	2.00	--	--	--	--
Eastern Kingbird	2.00	1.00	--	2.00	1.00	--	--	--	--
Eastern Meadowlark	--	1.00	2.00	--	1.00	--	--	--	--
Eastern Phoebe	--	--	--	--	--	--	--	--	--

	Successional Old Field			Common Reed/ Mugwort			Mowed Lawn		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Eastern Towhee	2.00	1.00	--	--	--	--	--	--	--
European Starling	--	1.33	--	--	--	--	--	1.33	--
Field Sparrow	2.00	1.00	--	--	--	--	--	--	--
Flycatcher sp.	--	--	--	--	--	--	--	--	--
Gadwall	--	--	--	--	--	--	--	--	--
Glossy Ibis	--	--	--	--	--	--	--	--	--
Golden-crowned Kinglet	--	2.67	--	--	--	--	--	--	--
Gray Catbird	--	1.00	--	--	1.00	--	--	--	--
Great Black-backed Gull	--	--	--	--	--	--	--	--	--
Great Blue Heron	--	--	--	--	--	--	--	--	--
Great Egret	--	--	--	--	--	--	--	--	--
Great Horned Owl	--	2.00	--	--	2.00	--	--	--	--
Greater Yellowlegs	--	--	--	--	--	--	--	--	--
Herring Gull	--	--	--	--	--	--	--	--	--
Hooded Merganser	--	--	--	--	--	--	--	--	--
Horned Grebe	--	--	--	--	--	--	--	--	--
Horned Lark	--	1.00	--	--	--	--	--	1.00	--
House Sparrow	--	--	--	--	0.67	--	--	0.67	--
House Wren	4.00	2.00	--	--	--	--	--	--	--
Killdeer	--	2.00	--	--	--	--	4.00	2.00	--
Laughing Gull	--	--	--	--	--	--	--	--	--
Lesser Yellowlegs	--	--	--	--	--	--	--	--	--
Long-eared owl*	--	4.00	--	--	4.00	--	--	--	--
Mallard	3.33	--	--	--	--	--	--	1.67	--
Marsh Wren*	--	--	--	--	--	--	--	--	--
Merlin	--	--	--	--	--	--	--	--	--
Mourning Dove	--	1.33	--	--	--	--	--	1.33	--
Northern Cardinal	--	1.33	--	--	--	--	--	--	--
Northern Flicker	--	--	--	--	--	--	--	1.67	--
Northern Harrier*	8.00	4.00	8.00	8.00	4.00	--	--	--	--
Northern Mockingbird	2.00	1.00	--	--	1.00	--	--	--	--
Osprey*	--	--	--	--	--	--	--	--	--
Pied-biled Grebe*	--	--	--	--	--	--	--	--	--
Red-breasted Merganser	--	--	--	--	--	--	--	--	--
Red-tailed Hawk	--	2.00	--	--	2.00	--	--	--	--
Red-throated Loon	--	--	--	--	--	--	--	--	--
Red-winged Blackbird	2.00	1.00	--	2.00	1.00	--	--	--	--

	Successional Old Field			Common Reed/ Mugwort			Mowed Lawn		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Ring-billed Gull*	--	--	--	--	--	--	--	2.33	--
Ring-necked Pheasant	1.33	0.67	--	1.33	0.67	--	--	0.67	--
Rock Dove	--	--	--	--	--	--	--	1.00	--
Ruddy Duck	--	--	--	--	--	--	--	--	--
Savannah Sparrow*	4.67	2.33	4.67	4.67	2.33	--	--	--	--
Short-eared Owl *	8.00	4.00	8.00	--	4.00	--	--	--	--
Snowy Egret	--	--	--	--	--	--	--	--	--
Snowy Owl	--	2.67	--	--	2.67	--	--	--	--
Song Sparrow	2.00	1.00	--	2.00	1.00	--	--	--	--
Spotted Sandpiper	--	--	--	--	--	--	--	--	--
Tree swallow	--	3.33	--	--	--	--	--	3.33	--
White-throated Sparrow	--	1.00	--	--	1.00	--	--	--	--
Wild Turkey	4.67	2.33	--	--	--	--	--	--	--
Willow Flycatcher	--	2.00	--	--	2.00	--	--	--	--
Yellow crowned Night Heron*	--	--	--	--	--	--	--	--	--
Yellow Warbler	--	2.00	--	--	2.00	--	--	--	--
Peregrine Falcon*	--	--	--	--	--	--	--	--	--
Black-bellied Plover	--	--	--	--	--	--	--	--	--
Hermit Thrush	--	--	--	--	--	--	--	--	--
Palm Warbler	--	2.33	--	--	--	--	--	--	--
Yellow-rumped Warbler	--	1.67	--	--	1.67	--	--	--	--
Dark-eyed Junco	--	1.00	--	--	1.00	--	--	--	--
Least Tern*	--	--	--	--	--	--	--	--	--
Sharp-shinned Hawk	--	3.67	--	--	3.67	--	--	--	--
Barn Owl*	--	4.00	--	--	4.00	--	--	4.00	--
Ruby-Crowned Kinglet	--	--	--	--	--	--	--	--	--
Least Sandpiper	--	--	--	--	--	--	--	--	--
Wood Thrush*	--	--	--	--	--	--	--	--	--
Rough-legged Hawk	--	2.67	--	--	2.67	--	--	--	--
White-eyed vireo	--	--	--	--	--	--	--	--	--
Yellow-throated vireo	--	--	--	--	--	--	--	--	--
Warbling vireo	--	--	--	--	--	--	--	--	--
Rey-eyed vireo	--	--	--	--	--	--	--	--	--
Philadelphia vireo	--	--	--	--	--	--	--	--	--
Black & white warbler	--	2.67	--	--	--	--	--	2.67	--
Tennessee warbler	--	--	--	--	--	--	--	--	--

	Successional Old Field			Common Reed/ Mugwort			Mowed Lawn		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Nashville warbler	--	--	--	--	--	--	--	--	--
Northern Parula	--	3.33	--	--	--	--	--	3.33	--
Magnolia warbler	--	--	--	--	--	--	--	--	--
Cape May Warbler	--	--	--	--	--	--	--	3.33	--
Black-throated Blue Warbler	--	--	--	--	--	--	--	--	--
Chestnut-sided Warbler	--	--	--	--	--	--	--	--	--
Black-throated Green Warbler	--	--	--	--	--	--	--	--	--
Blackburnian Warbler	--	--	--	--	--	--	--	--	--
Bay-breasted Warbler	--	--	--	--	--	--	--	--	--
Blackpoll Warbler	--	--	--	--	--	--	--	--	--
Pine Warbler	--	--	--	--	--	--	--	--	--
Prairie Warbler*	--	--	--	--	--	--	--	--	--
Ovenbird	--	--	--	--	--	--	--	--	--
Northern Waterthrush	--	--	--	--	--	--	--	--	--
Louisiana Waterthrush	--	--	--	--	--	--	--	--	--
Yellow-breasted Chat	--	--	--	--	--	--	--	--	--
Wilson's Warbler	--	--	--	--	--	--	--	--	--
Canada Warbler *	--	--	--	--	--	--	--	--	--
Scarlet Tanager	--	--	--	--	--	--	--	--	--
Black-capped Chickadee	--	--	--	--	--	--	--	--	--
Tufted Titmouse	--	--	--	--	--	--	--	--	--
White-breasted Nuthatch	--	--	--	--	--	--	--	--	--
Red-breasted Nuthatch	--	--	--	--	--	--	--	--	--
Brown Creeper	--	--	--	--	--	--	--	--	--
Winter Wren	--	--	--	--	--	--	--	--	--
Carolina Wren	--	--	--	--	--	--	--	--	--
Blue-Gray Gnatcatcher	--	--	--	--	--	--	--	--	--
Veery	--	--	--	--	--	--	--	--	--
Gray-cheeked Thrush	--	--	--	--	--	--	--	--	--
Swainson's Thrush	--	--	--	--	--	--	--	--	--
Yellow-billed Cuckoo	--	--	--	--	--	--	--	--	--
Acadian Flycatcher	--	--	--	--	--	--	--	--	--
Least Flycatcher	--	--	--	--	--	--	--	--	--
Hairy Woodpecker	--	--	--	--	--	--	--	--	--
Yellow-bellied Sapsucker	--	--	--	--	--	--	--	--	--
Red-bellied Woodpecker	--	--	--	--	--	--	--	--	--

	Successional Old Field			Common Reed/ Mugwort			Mowed Lawn		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Meadow Vole	2.67	1.33	2.67	2.67	1.33	--	--	--	--
White-footed Mouse	2.00	1.00	--	2.00	1.00	--	--	--	--
House Mouse	1.33	0.67	--	--	--	--	--	--	--
Norway Rat	--	0.67	--	--	--	--	--	--	--
Gray Squirrel	--	--	--	--	--	--	--	--	--
Muskrat	--	--	--	--	--	--	--	--	--
Raccoon	--	--	--	--	--	--	--	--	--
Cottontail Rabbit	--	2.00	--	--	--	--	--	--	--
Feral Dog	--	1.67	--	--	--	--	--	--	--
Feral Cat	--	1.67	--	--	1.67	--	--	--	--
Northern Water Snake	--	--	--	--	--	--	--	--	--
Northern Brown Snake	4.00	2.00	--	--	--	--	--	--	--
Green Frog	--	--	--	--	--	--	--	--	--
Fowler's Toad*	--	--	--	--	2.00	--	--	--	--
Eastern Garter Snake	--	2.00	--	--	2.00	--	--	--	--
Northern Diamond-backed Terrapin	--	--	--	--	--	--	--	--	--
Total Habitat Value	**78.67**	**116.33**	**30.00**	**38.00**	**82.00**	**0.00**	**4.00**	**46.00**	**0.00**

	Floodplain Forest Wetland			Shrub Swamp			Shallow Emergent Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
American Black Duck	--	--	--	--	--	--	4.67	2.33	4.67
American Coot	--	--	--	--	--	--	--	--	--
American Crow	2.00	1.00	--	--	1.00	--	--	--	--
American Goldfinch	--	--	--	2.67	1.33	--	--	1.33	--
American Kestrel	--	--	--	--	--	--	--	3.33	--
American Redstart	--	--	--	--	2.00	--	--	--	--
American Robin	2.00	1.00	--	2.00	1.00	--	--	--	--
American Tree Sparrow	--	--	--	--	1.33	--	--	--	--
American Wigeon	--	--	--	--	--	--	--	2.33	4.67
American Woodcock	--	--	--	7.33	3.67	--	--	3.67	--
Bairds Sandpiper	--	--	--	--	--	--	--	2.67	5.33
Baltimore Oriole*	4.67	2.33	--	--	--	--	--	--	--
Barn Swallow	--	--	--	--	--	--	--	2.00	--
Belted Kingfisher	--	--	--	--	--	--	--	--	--
Black crowned Night Heron*	--	--	--	--	--	--	--	--	--
Black Skimmer*	--	--	--	--	--	--	--	--	--
Bobolink*	--	--	--	--	--	--	4.67	2.33	4.67
Brant	--	--	--	--	--	--	--	3.67	--
Brown Thrasher	--	--	--	--	1.00	--	--	--	--
Brown-headed Cowbird	2.00	--	--	2.00	--	--	--	--	--
Bufflehead	--	--	--	--	--	--	--	--	--
Canada Goose	--	--	--	--	--	--	2.67	1.33	--
Canvasback	--	--	--	--	--	--	--	--	--
Cedar Waxwing	--	1.67	--	--	1.67	--	--	--	--
Chimney Swift	--	--	--	--	2.00	--	--	2.00	--
Clapper Rail	--	--	--	--	--	--	--	1.67	3.33
Common Goldeneye	--	--	--	--	--	--	--	--	--
Common Tern	--	--	--	--	--	--	--	--	--
Common Yellowthroat	--	--	--	4.00	2.00	--	4.00	2.00	--
Cooper's Hawk*	8.00	4.00	--	--	4.00	--	--	4.00	--
Doubled-crested Cormorant	--	--	--	--	--	--	--	--	--
Downy Woodpecker	4.00	2.00	--	--	2.00	--	--	2.00	--
Eastern Kingbird	--	--	--	--	--	--	--	--	--
Eastern Meadowlark	--	--	--	--	--	--	--	1.00	--
Eastern Phoebe	--	2.00	--	--	--	--	--	2.00	--

	Floodplain Forest Wetland			Shrub Swamp			Shallow Emergent Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Eastern Towhee	--	1.00	--	--	1.00	--	--	--	--
European Starling	2.67	--	--	--	--	--	--	--	--
Field Sparrow	--	--	--	--	--	--	--	--	--
Flycatcher sp.	--	--	--	--	--	--	--	--	--
Gadwall	--	--	--	--	--	--	--	2.33	--
Glossy Ibis	--	--	--	--	--	--	--	4.33	8.67
Golden-crowned Kinglet	--	2.67	--	--	2.67	--	--	--	--
Gray Catbird	--	--	--	2.00	1.00	--	--	--	--
Great Black-backed Gull	--	--	--	--	--	--	--	--	--
Great Blue Heron	6.67	--	--	--	--	--	--	3.33	6.67
Great Egret	--	--	--	--	--	--	--	3.33	6.67
Great Horned Owl	4.00	2.00	--	--	--	--	--	2.00	--
Greater Yellowlegs	--	--	--	--	--	--	--	2.67	5.33
Herring Gull	--	--	--	--	--	--	--	--	--
Hooded Merganser	--	--	--	--	--	--	--	--	--
Horned Grebe	--	--	--	--	--	--	--	--	--
Horned Lark	--	--	--	--	--	--	--	--	--
House Sparrow	--	--	--	--	--	--	--	--	--
House Wren	--	--	--	--	--	--	--	--	--
Killdeer	--	--	--	--	--	--	--	2.00	4.00
Laughing Gull	--	--	--	--	--	--	--	--	--
Lesser Yellowlegs	--	--	--	--	--	--	--	2.67	5.33
Long-eared owl*	--	4.00	--	--	--	--	--	--	--
Mallard	--	--	--	--	--	--	--	1.67	3.33
Marsh Wren*	--	--	--	--	--	--	5.33	2.67	5.33
Merlin	--	2.67	--	--	--	--	--	--	--
Mourning Dove	--	--	--	2.67	--	--	--	--	--
Northern Cardinal	--	1.33	--	--	1.33	--	--	--	--
Northern Flicker	3.33	1.67	--	--	--	--	--	--	--
Northern Harrier*	--	--	--	--	--	--	--	4.00	--
Northern Mockingbird	--	--	--	2.00	1.00	--	--	1.00	--
Osprey*	--	--	--	--	--	--	--	--	--
Pied-biled Grebe*	--	--	--	--	--	--	--	--	--
Red-breasted Merganser	--	--	--	--	--	--	--	--	--
Red-tailed Hawk	4.00	--	--	--	2.00	--	--	2.00	--
Red-throated Loon	--	--	--	--	--	--	--	--	--
Red-winged Blackbird	--	--	--	2.00	1.00	--	2.00	1.00	--

	Deep Emergent Marsh			Common Reed-Dominated Wetland			Maritime Forest		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Eastern Towhee	--	--	--	--	--	--	--	1.00	--
European Starling	--	--	--	--	--	--	2.67	1.33	--
Field Sparrow	--	--	--	--	--	--	--	--	--
Flycatcher sp.	--	--	--	--	--	--	--	--	--
Gadwall	--	2.33	4.67	--	--	--	--	--	--
Glossy Ibis	--	--	--	--	--	--	--	--	--
Golden-crowned Kinglet	--	--	--	--	--	--	--	2.67	--
Gray Catbird	--	--	--	--	--	--	--	--	--
Great Black-backed Gull	--	1.00	--	--	--	--	--	--	--
Great Blue Heron	--	3.33	6.67	--	--	--	6.67	--	--
Great Egret	--	3.33	6.67	--	--	--	--	--	--
Great Horned Owl	--	2.00	--	--	2.00	--	4.00	2.00	--
Greater Yellowlegs	--	--	--	--	--	--	--	--	--
Herring Gull	--	1.00	--	--	--	--	--	--	--
Hooded Merganser	--	4.00	8.00	--	--	--	--	--	--
Horned Grebe	--	2.00	4.00	--	--	--	--	--	--
Horned Lark	--	--	--	--	--	--	--	--	--
House Sparrow	--	--	--	--	--	--	--	--	--
House Wren	--	--	--	--	--	--	--	--	--
Killdeer	--	--	--	--	2.00	--	--	--	--
Laughing Gull	--	2.00	--	--	--	--	--	--	--
Lesser Yellowlegs	--	--	--	--	--	--	--	--	--
Long-eared owl*	--	--	--	--	--	--	8.00	4.00	--
Mallard	--	1.67	3.33	--	--	--	--	--	--
Marsh Wren*	--	--	--	5.33	2.67	--	--	--	--
Merlin	--	--	--	--	--	--	--	2.67	--
Mourning Dove	--	--	--	--	--	--	--	--	--
Northern Cardinal	--	--	--	--	--	--	--	1.33	--
Northern Flicker	--	--	--	--	--	--	3.33	1.67	--
Northern Harrier*	--	4.00	--	--	4.00	--	--	--	--
Northern Mockingbird	--	1.00	--	--	1.00	--	--	--	--
Osprey*	--	5.00	--	--	--	--	--	--	--
Pied-billed Grebe*	--	3.33	6.67	--	--	--	--	--	--
Red-breasted Merganser	--	3.33	6.67	--	--	--	--	--	--
Red-tailed Hawk	--	--	--	--	2.00	--	4.00	--	--
Red-throated Loon	--	3.00	6.00	--	--	--	--	--	--
Red-winged Blackbird	2.00	1.00	--	2.00	1.00	--	--	--	--

	Deep Emergent Marsh			Common Reed-Dominated Wetland			Maritime Forest		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Ring-billed Gull*	--	2.33	--	--	--	--	--	--	--
Ring-necked Pheasant	--	--	--	--	--	--	--	--	--
Rock Dove	--	--	--	--	--	--	--	--	--
Ruddy Duck	--	2.67	5.33	--	--	--	--	--	--
Savannah Sparrow*	--	--	--	--	2.33	--	--	--	--
Short-eared Owl *	--	--	--	--	4.00	--	--	--	--
Snowy Egret	--	2.67	5.33	--	--	--	--	--	--
Snowy Owl	--	--	--	--	--	--	--	--	--
Song Sparrow	--	--	--	--	1.00	--	--	--	--
Spotted Sandpiper	--	3.67	--	--	--	--	--	--	--
Tree swallow	--	3.33	--	--	3.33	--	--	--	--
White-throated Sparrow	--	--	--	--	--	--	--	--	--
Wild Turkey	--	--	--	--	--	--	4.67	2.33	--
Willow Flycatcher	--	2.00	--	--	2.00	--	--	--	--
Yellow crowned Night Heron*	--	4.67	9.33	--	--	--	--	--	--
Yellow Warbler	--	--	--	--	--	--	--	--	--
Peregrine Falcon*	--	--	--	--	--	--	--	--	--
Black-bellied Plover	--	--	--	--	--	--	--	--	--
Hermit Thrush	--	--	--	--	--	--	--	1.67	3.33
Palm Warbler	--	--	--	--	2.33	--	--	--	--
Yellow-rumped Warbler	--	--	--	--	--	--	--	1.67	--
Dark-eyed Junco	--	--	--	--	--	--	--	1.00	--
Least Tern*	--	4.00	8.00	--	--	--	--	--	--
Sharp-shinned Hawk	--	--	--	--	--	--	7.33	3.67	--
Barn Owl*	--	--	--	--	--	--	--	--	--
Ruby-Crowned Kinglet	--	--	--	--	--	--	--	1.67	--
Least Sandpiper	--	--	--	--	--	--	--	--	--
Wood Thrush*	--	--	--	--	--	--	--	3.00	--
Rough-legged Hawk	--	--	--	--	--	--	--	--	--
White-eyed vireo	--	--	--	--	--	--	--	--	--
Yellow-throated vireo	--	--	--	--	--	--	--	2.67	--
Warbling vireo	--	--	--	--	--	--	--	2.00	--
Rey-eyed vireo	--	--	--	--	--	--	--	2.00	--
Philadelphia vireo	--	--	--	--	--	--	--	2.00	--
Black & white warbler	--	--	--	--	--	--	--	2.67	--
Tennessee warbler	--	--	--	--	--	--	--	2.00	--

	Deep Emergent Marsh			Common Reed-Dominated Wetland			Maritime Forest		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Nashville warbler	--	--	--	--	--	--	--	2.00	--
Northern Parula	--	--	--	--	--	--	--	3.33	--
Magnolia warbler	--	--	--	--	--	--	--	2.00	--
Cape May Warbler	--	--	--	--	--	--	--	3.33	--
Black-throated Blue Warbler	--	--	--	--	--	--	--	2.67	--
Chestnut-sided Warbler	--	--	--	--	--	--	--	--	--
Black-throated Green Warbler	--	--	--	--	--	--	--	2.67	--
Blackburnian Warbler	--	--	--	--	--	--	--	3.33	--
Bay-breasted Warbler	--	--	--	--	--	--	--	2.67	--
Blackpoll Warbler	--	--	--	--	--	--	--	2.67	--
Pine Warbler	--	--	--	--	--	--	--	2.67	--
Prairie Warbler*	--	--	--	--	--	--	--	--	--
Ovenbird	--	--	--	--	--	--	--	2.67	5.33
Northern Waterthrush	--	--	--	--	--	--	--	2.67	--
Louisiana Waterthrush	--	--	--	--	--	--	--	--	--
Yellow-breasted Chat	--	--	--	--	--	--	--	--	--
Wilson's Warbler	--	--	--	--	--	--	--	--	--
Canada Warbler *	--	--	--	--	--	--	--	--	--
Scarlet Tanager	--	--	--	--	--	--	--	1.00	2.00
Black-capped Chickadee	--	--	--	--	--	--	2.00	1.00	--
Tufted Titmouse	--	--	--	--	--	--	3.33	1.67	--
White-breasted Nuthatch	--	--	--	--	--	--	4.67	2.33	--
Red-breasted Nuthatch	--	--	--	--	--	--	--	2.33	--
Brown Creeper	--	--	--	--	--	--	--	3.33	--
Winter Wren	--	--	--	--	--	--	5.33	2.67	--
Carolina Wren	--	--	--	--	--	--	4.00	2.00	--
Blue-Gray Gnatcatcher	--	--	--	--	--	--	--	2.67	--
Veery	--	--	--	--	--	--	--	1.67	--
Gray-cheeked Thrush	--	--	--	--	--	--	--	1.67	3.33
Swainson's Thrush	--	--	--	--	--	--	--	--	3.33
Yellow-billed Cuckoo	--	--	--	--	--	--	--	--	--
Acadian Flycatcher	--	--	--	--	--	--	--	--	--
Least Flycatcher	--	--	--	--	--	--	--	--	--
Hairy Woodpecker	--	--	--	--	--	--	5.33	2.67	--
Yellow-bellied Sapsucker	--	--	--	--	--	--	--	3.67	--
Red-bellied Woodpecker	--	--	--	--	--	--	3.33	1.67	--

	Deep Emergent Marsh			Common Reed-Dominated Wetland			Maritime Forest		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Meadow Vole	2.67	1.33	--	2.67	1.33	--	--	--	--
White-footed Mouse	--	--	--	--	--	--	--	--	--
House Mouse	--	--	--	--	--	--	--	--	--
Norway Rat	--	--	--	--	--	--	--	--	--
Gray Squirrel	--	--	--	--	--	--	7.33	3.67	--
Muskrat	--	2.00	4.00	--	2.00	--	--	--	--
Raccoon	--	1.67	--	--	1.67	--	3.33	1.67	--
Cottontail Rabbit	--	--	--	--	--	--	4.00	2.00	--
Feral Dog	--	--	--	--	--	--	--	1.67	--
Feral Cat	--	--	--	--	--	--	--	--	--
Northern Water Snake	--	2.00	--	--	2.00	--	--	--	--
Northern Brown Snake	--	2.00	--	--	2.00	--	--	--	--
Green Frog	4.00	2.00	4.00	--	--	--	--	--	--
Fowler's Toad*	4.00	2.00	--	4.00	2.00	--	--	2.00	--
Eastern Garter Snake	--	2.00	--	--	2.00	--	--	--	--
Northern Diamond-backed Terrapin	--	--	--	--	--	--	--	--	--
Total Habitat Value	**17.33**	**130.00**	**159.33**	**22.67**	**69.67**	**0.00**	**116.00**	**138.00**	**17.33**

	Maritime Shrubland			Maritime Grassland			Salt Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
American Black Duck	--	--	--	--	--	--	4.67	2.33	4.67
American Coot	--	--	--	--	--	--	--	2.00	4.00
American Crow	--	1.00	--	--	1.00	--	--	1.00	--
American Goldfinch	2.67	1.33	--	--	1.33	--	--	--	--
American Kestrel	--	--	--	--	3.33	--	--	3.33	--
American Redstart	--	2.00	--	--	2.00	--	--	--	--
American Robin	2.00	1.00	--	--	1.00	--	--	--	--
American Tree Sparrow	--	1.33	--	--	1.33	--	--	--	--
American Wigeon	--	--	--	--	--	--	--	2.33	4.67
American Woodcock	7.33	3.67	--	7.33	3.67	--	--	--	--
Bairds Sandpiper	--	--	--	--	--	--	--	2.67	5.33
Baltimore Oriole*	--	--	--	--	--	--	--	--	--
Barn Swallow	--	--	--	--	2.00	--	--	2.00	4.00
Belted Kingfisher	--	--	--	--	--	--	7.33	3.67	7.33
Black crowned Night Heron*	--	--	--	--	--	--	6.67	3.33	6.67
Black Skimmer*	--	--	--	--	--	--	9.33	4.67	9.33
Bobolink*	--	--	--	4.67	2.33	4.67	--	--	--
Brant	--	--	--	--	--	--	--	3.67	--
Brown Thrasher	--	1.00	--	2.00	1.00	--	--	1.00	2.00
Brown-headed Cowbird	2.00	--	--	2.00	1.00	--	--	--	--
Bufflehead	--	--	--	--	--	--	--	3.33	6.67
Canada Goose	--	--	--	2.67	--	--	2.67	1.33	2.67
Canvasback	--	--	--	--	--	--	--	3.67	--
Cedar Waxwing	--	1.67	--	--	--	--	--	--	--
Chimney Swift	--	2.00	--	--	2.00	--	--	2.00	--
Clapper Rail	--	--	--	--	--	--	3.33	1.67	3.33
Common Goldeneye	--	--	--	--	--	--	--	3.00	6.00
Common Tern	--	--	--	--	--	--	--	2.67	5.33
Common Yellowthroat	4.00	2.00	--	4.00	2.00	--	--	--	--
Cooper's Hawk*	--	4.00	--	--	4.00	--	--	4.00	--
Doubled-crested Cormorant	--	--	--	--	--	--	--	2.33	4.67
Downy Woodpecker	--	2.00	--	--	--	--	--	--	--
Eastern Kingbird	--	--	--	2.00	1.00	--	--	1.00	--
Eastern Meadowlark	--	--	--	--	1.00	2.00	--	--	--
Eastern Phoebe	--	--	--	--	2.00	--	--	--	--

	Maritime Shrubland			Maritime Grassland			Salt Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Eastern Towhee	--	1.00	--	2.00	1.00	--	--	--	--
European Starling	--	--	--	--	1.33	--	--	1.33	--
Field Sparrow	--	--	--	2.00	1.00	--	--	--	--
Flycatcher sp.	--	--	--	--	--	--	--	--	--
Gadwall	--	--	--	--	--	--	--	2.33	--
Glossy Ibis	--	--	--	--	--	--	8.67	4.33	8.67
Golden-crowned Kinglet	--	2.67	--	--	2.67	--	--	--	--
Gray Catbird	2.00	1.00	--	--	1.00	--	--	--	--
Great Black-backed Gull	--	--	--	--	--	--	--	1.00	2.00
Great Blue Heron	--	--	--	--	--	--	--	3.33	6.67
Great Egret	--	--	--	--	--	--	--	3.33	6.67
Great Horned Owl	--	--	--	--	2.00	--	--	2.00	--
Greater Yellowlegs	--	--	--	--	--	--	--	2.67	5.33
Herring Gull	--	--	--	--	--	--	--	1.00	2.00
Hooded Merganser	--	--	--	--	--	--	--	4.00	8.00
Horned Grebe	--	--	--	--	--	--	--	2.00	--
Horned Lark	--	--	--	--	1.00	--	--	--	--
House Sparrow	--	--	--	--	--	--	--	--	--
House Wren	--	--	--	4.00	2.00	--	--	--	--
Killdeer	--	--	--	--	2.00	--	--	2.00	--
Laughing Gull	--	--	--	--	--	--	--	2.00	4.00
Lesser Yellowlegs	--	--	--	--	--	--	--	2.67	5.33
Long-eared owl*	--	--	--	--	4.00	--	--	--	--
Mallard	--	--	--	3.33	--	--	3.33	1.67	3.33
Marsh Wren*	--	--	--	--	--	--	5.33	2.67	5.33
Merlin	--	--	--	--	2.67	--	--	2.67	--
Mourning Dove	2.67	--	--	--	1.33	--	--	1.33	--
Northern Cardinal	--	1.33	--	--	1.33	--	--	--	--
Northern Flicker	--	--	--	--	--	--	--	--	--
Northern Harrier*	--	--	--	8.00	4.00	8.00	8.00	4.00	--
Northern Mockingbird	2.00	1.00	--	2.00	1.00	--	--	--	--
Osprey*	--	--	--	--	--	--	--	5.00	1--
Pied-biled Grebe*	--	--	--	--	--	--	6.67	3.33	6.67
Red-breasted Merganser	--	--	--	--	--	--	--	3.33	6.67
Red-tailed Hawk	--	2.00	--	--	2.00	--	--	2.00	4.00
Red-throated Loon	--	--	--	--	--	--	--	3.00	6.00
Red-winged Blackbird	2.00	1.00	--	2.00	1.00	--	--	--	--

	Maritime Shrubland			Maritime Grassland			Salt Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Ring-billed Gull*	--	--	--	--	--	--	--	2.33	4.67
Ring-necked Pheasant	--	0.67	--	1.33	0.67	--	--	0.67	1.33
Rock Dove	--	--	--	--	--	--	--	1.00	--
Ruddy Duck	--	--	--	--	--	--	--	2.67	5.33
Savannah Sparrow*	--	2.33	--	4.67	2.33	4.67	--	2.33	--
Short-eared Owl *	--	--	--	8.00	4.00	8.00	--	4.00	--
Snowy Egret	--	--	--	--	--	--	--	2.67	5.33
Snowy Owl	--	2.67	--	--	2.67	--	--	2.67	--
Song Sparrow	2.00	1.00	--	2.00	1.00	--	--	1.00	--
Spotted Sandpiper	--	--	--	--	--	--	--	3.67	7.33
Tree swallow	--	3.33	--	--	3.33	--	--	3.33	--
White-throated Sparrow	--	1.00	--	--	1.00	--	--	--	--
Wild Turkey	--	2.33	--	4.67	2.33	--	--	--	--
Willow Flycatcher	--	2.00	--	--	2.00	4.00	--	--	--
Yellow crowned Night Heron*	--	--	--	--	--	--	--	4.67	9.33
Yellow Warbler	4.00	2.00	--	--	2.00	--	--	--	--
Peregrine Falcon*	--	--	--	--	--	--	--	4.67	--
Black-bellied Plover	--	--	--	--	--	--	--	2.67	5.33
Hermit Thrush	--	--	--	--	--	--	--	--	--
Palm Warbler	--	2.33	--	--	2.33	--	--	2.33	--
Yellow-rumped Warbler	--	1.67	--	--	1.67	--	--	--	--
Dark-eyed Junco	--	1.00	--	--	1.00	--	--	--	--
Least Tern*	--	--	--	--	--	--	--	4.00	8.00
Sharp-shinned Hawk	--	3.67	--	--	--	--	--	3.67	--
Barn Owl*	--	--	--	--	4.00	--	--	4.00	--
Ruby-Crowned Kinglet	--	1.67	--	--	--	--	--	--	--
Least Sandpiper	--	--	--	--	--	--	--	2.67	5.33
Wood Thrush*	--	--	--	--	--	--	--	--	--
Rough-legged Hawk	--	--	--	--	2.67	--	--	--	--
White-eyed vireo	--	2.00	--	--	--	--	--	--	--
Yellow-throated vireo	--	--	--	--	--	--	--	--	--
Warbling vireo	--	--	--	--	--	--	--	--	--
Rey-eyed vireo	--	--	--	--	--	--	--	--	--
Philadelphia vireo	--	2.00	--	--	--	--	--	--	--
Black & white warbler	--	2.67	--	--	2.67	--	--	--	--
Tennessee warbler	--	2.00	--	--	--	--	--	--	--

	Maritime Shrubland			Maritime Grassland			Salt Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Nashville warbler	--	2.00	--	--	--	--	--	--	--
Northern Parula	--	3.33	--	--	3.33	--	--	--	--
Magnolia warbler	--	2.00	--	--	--	--	--	--	--
Cape May Warbler	--	3.33	--	--	--	--	--	--	--
Black-throated Blue Warbler	--	--	--	--	--	--	--	--	--
Chestnut-sided Warbler	--	2.00	--	--	--	--	--	--	--
Black-throated Green Warbler	--	--	--	--	--	--	--	--	--
Blackburnian Warbler	--	--	--	--	--	--	--	--	--
Bay-breasted Warbler	--	--	--	--	--	--	--	--	--
Blackpoll Warbler	--	--	--	--	--	--	--	--	--
Pine Warbler	--	2.67	--	--	--	--	--	--	--
Prairie Warbler*	--	2.00	--	--	--	--	--	--	--
Ovenbird	--	--	--	--	--	--	--	--	--
Northern Waterthrush	--	--	--	--	--	--	--	--	--
Louisiana Waterthrush	--	--	--	--	--	--	--	--	--
Yellow-breasted Chat	--	--	--	--	--	--	--	--	--
Wilson's Warbler	--	--	--	--	--	--	--	--	--
Canada Warbler *	--	--	--	--	--	--	--	--	--
Scarlet Tanager	--	--	--	--	--	--	--	--	--
Black-capped Chickadee	--	--	--	--	--	--	--	--	--
Tufted Titmouse	--	--	--	--	--	--	--	--	--
White-breasted Nuthatch	--	--	--	--	--	--	--	--	--
Red-breasted Nuthatch	--	--	--	--	--	--	--	--	--
Brown Creeper	--	--	--	--	--	--	--	--	--
Winter Wren	--	--	--	--	--	--	--	--	--
Carolina Wren	4.00	2.00	--	--	--	--	--	--	--
Blue-Gray Gnatcatcher	--	--	--	--	--	--	--	--	--
Veery	--	--	--	--	--	--	--	--	--
Gray-cheeked Thrush	--	--	--	--	--	--	--	--	--
Swainson's Thrush	--	--	--	--	--	--	--	--	--
Yellow-billed Cuckoo	--	--	--	--	--	--	--	--	--
Acadian Flycatcher	--	--	--	--	--	--	--	--	--
Least Flycatcher	--	--	--	--	--	--	--	--	--
Hairy Woodpecker	--	--	--	--	--	--	--	--	--
Yellow-bellied Sapsucker	--	--	--	--	--	--	--	--	--
Red-bellied Woodpecker	--	--	--	--	--	--	--	--	--

	Maritime Shrubland			Maritime Grassland			Salt Marsh		
	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value	Breeding Value	Foraging Value	Habitat Dependency Value
Meadow Vole	2.67	1.33	--	2.67	1.33	2.67	2.67	1.33	--
White-footed Mouse	2.00	1.00	--	2.00	1.00	--	--	--	--
House Mouse	--	--	--	1.33	0.67	--	--	--	--
Norway Rat	--	--	--	--	0.67	--	--	0.67	--
Gray Squirrel	--	--	--	--	--	--	--	--	--
Muskrat	--	--	--	--	--	--	4.00	2.00	4.00
Raccoon	--	--	--	--	--	--	--	1.67	--
Cottontail Rabbit	--	2.00	--	--	2.00	--	--	--	--
Feral Dog	--	1.67	--	--	1.67	--	--	--	--
Feral Cat	--	1.67	--	--	1.67	--	--	1.67	--
Northern Water Snake	--	--	--	--	--	--	--	2.00	--
Northern Brown Snake	4.00	2.00	--	4.00	2.00	--	--	2.00	--
Green Frog	--	--	--	--	--	--	--	--	--
Fowler's Toad*	--	--	--	--	--	--	--	--	--
Eastern Garter Snake	4.00	2.00	--	--	2.00	--	--	2.00	--
Northern Diamond-backed Terrapin	--	--	--	--	--	--	4.67	2.33	4.67
Total Habitat Value	**49.33**	**100.33**	**0.00**	**78.67**	**115.33**	**34.00**	**77.33**	**190.67**	**228.00**

* New Jersey State Engangered or Threatened Species

467

Appendix G

Biobenchmarking Report for Liberty State Park
Jersey City, NJ

Biological Benchmarking

BACKGROUND

Salt marsh vegetation communities are tightly coupled with the tidal regime. Water levels fluctuate over the daily and monthly tidal cycle, flooding the shoreline for different periods of time. The period of inundation is dictated by elevation contours, and zonation among plant species occurs along these contours. The location of plant species along the gradient is determined by the species' tolerance to salinity and water (frequency, duration, and/or depth of inundation). Species that are tolerant to water and salinity occur at lower elevations in the intertidal zone, between the Mean High Water (MHW) level and the Mean Low Water (MLW) level. Less tolerant species occur at higher elevations, which are inundated only during spring-tide high water levels.

The success of a salt marsh restoration effort greatly depends upon the location of the planted vegetation along the shoreline gradient. Since local conditions vary (salinity, tidal amplitude etc), biological benchmarks measured from surrounding local marsh vegetation and local tidal information should be used as a guide for determining the elevations for vegetation replanting. Elevation ranges of plant communities in reference wetlands can be duplicated in the restored salt marsh.

PURPOSE

To assist in the development of conceptual plans for the Liberty State Park salt marsh restoration, bio-benchmarking and hydraulic geometry data was collected from two reference wetlands. Based on initial bio-benchmarking investigations (soil characteristics and tidal elevations), local tide data and geomorphic indices were developed for the reference wetlands. Table G-1 provides definitions for the collected tidal data. This information was used to supplement the regional tide analyses and the tide gauges placed in the Morris Canal and the South Cove of Liberty State Park.

METHODOLOGY

In order to supplement tidal information, existing vegetation communities were used as indicators of local tidal elevation. This information along with nearby tidal record plus newly installed tide gauges provided the information needed to determine proposed target elevations for the new restoration salt marsh and helped establish the best range of elevations for new plantings.

The use of indicator species on or near the project site often enables the establishment of the best elevations for the project site (Garbish 1994; Garbish 1989; Garbish 1986). Since plant zonation and abundance is the result of a series of complex environmental gradients, using existing vegetation markers allows the design team to mimic the remnant patches of the original marsh

Two nearby salt marshes were selected as reference wetlands. One was in the South Cove of Liberty State Park and the second was just south west of the site in Port Liberte. Reference plant communities were located in nearby tidal wetlands and their characteristics were documented by Ecosystem Restoration Consultants (ERC) on 17 and 25th September 2003 and 14 October 2003.

To evaluate local tide condition, indicator species were selected and homogeneous stands of these species located. The elevation range of *Spartina alterniflora*, *Spartina patens*, and key high marsh plants, (e.g., *Baccharis halimifolia*, *Iva frutescens*) were located in nearby salt marshes. Selected reference vegetation boundaries were staked in the field and representative observation points located using differential GPS. In most cases the lowest elevations of these communities were surveyed. In addition, measurements of hydraulic geometry and soil samples were collected to assist in salt marsh design. Soil samples were sent to an outside laboratory, where soil texture, nutrient, and hydrocarbon analyses were conducted.

RESULTS

Locations of the elevations of surveyed plant community boundaries are shown on Figures G-1 and G-2. When discussing these communities, it is useful to refer to their locations in terms of tidal datums. Table G-1 provides definitions of measured tidal datums. Table G-2 summarizes existing regional tide data from the Battery, Governor's Island and Con Rail Railroad Ferry. This data was interpolated for the South Cove and

adjusted to the 1988 NAVD datum. Significant elevations are shown in the last column of Table G-2. The elevations of a number of communities on the two sites are indicated in Table G-3 below. Based on this bio-benchmarking data, the elevation ranges for these tidal communities is as follows:

1. Low Marsh Plants

- *Spartina alterniflora* Lowest elevation = -0.87

2. High Marsh Plants

- *Spartina Patens* – Range of Lowest elevation = 1.69 to 2.77
- *Distichlis spicata* – Range of lowest elevation =1.74 to 2.44

3. Shrubs:

- *Baccharis halimifolia* – Range of Lowest elevation = 2.42 to 3.77
- *Iva frutescens* – Range of Lowest elevation = 2.21 to 2.58

Tide gauges were installed by the Engineering Division of the New York District in the Morris Canal and the South Cove and monitored for a few months. The restoration team analyzed the information from the regional tide gauges, the biobenchmarking field effort and the in-situ tide gauges. Table G-4 shows this data reconstructed for the South Cove tidal datums.

IMPLICATIONS FOR RESTORATION DESIGN

Regional tide data, bio-benchmarking and the examination of tide gauges can be used as guides to planting elevations. Table G-5 indicates that the three methods yield a very close correlation. The average elevations of the existing biobenchmarking plant communities are presented in Table G-6.

The restored salt marsh should replicate natural salt marshes that dominate saline (polyhaline) reaches of New Jersey estuaries. They contain distinct vegetation zones resulting from tidal flooding and frequency of inundation. The major two zones are shown in Figure G-4 and are identified as (1) low marsh and (2) high marsh. Below this is mudflat and open water and above these salt marsh zones is often a maritime scrub shrub zone.

The low marsh is flooded at least once daily by the tides (regularly flooded zone) and extends from approximately mean sea level to the mean high water level (MHW). The tall form of smooth cordgrass (*Spartina alterniflora*) is often an accurate indictor of the landward extent of mean high tide (elevation 1.75) (Kennard, et al. 1983.). The short form of smooth cordgrass forms extensive stands just above the low marsh (Tiner, 1985) and therefore we are recommending planting of the smooth cordgrass to elevation 2.0 ft above MHW. Some authors recommend planting to one foot above MHW (Garbish and Garbish, 1994). For convenience we will call the low marsh from -1.0 to + 2.0.

The high marsh zone begins above the low marsh and is flooded less often (irregularly flooded zone) and is exposed to drying for much greater periods. This zone is usually much less homogeneous than the low marsh, and is often a mosaic of a number of species including salt hay grass (*Spartina patens*), spike grass (*Distichlis spicata*), a short form of smooth cordgrass, black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), high-tide bush (*Iva frutescens*) and common reed (*Phragmites australis*) (Tiner, 1985).

Spartina patens grows at a minimum to mean high water spring (elev. 2.29) but often occurs up to the extreme high tide. This upper boundary may be inundated infrequently, in some locations as little as once or twice annually. Such inundation usually occurs during the spring tide cycle (highest annual tides or MHWS) and during the severe storm events. This is confirmed for New Jersey salt marshes by Tiner, (1985), who states "The upper margins of the high marsh may be flooded only during storm tides which are more frequent in winter". "Extreme high tide" is not specifically recorded in the regional tide data. While, the highest observed water level was actually over 4 feet above MHWS, about one foot above MHWS or an elevation of 3.3 ft is a reasonable estimate of "Extreme high tide" and a possible upper limit for the high marsh.

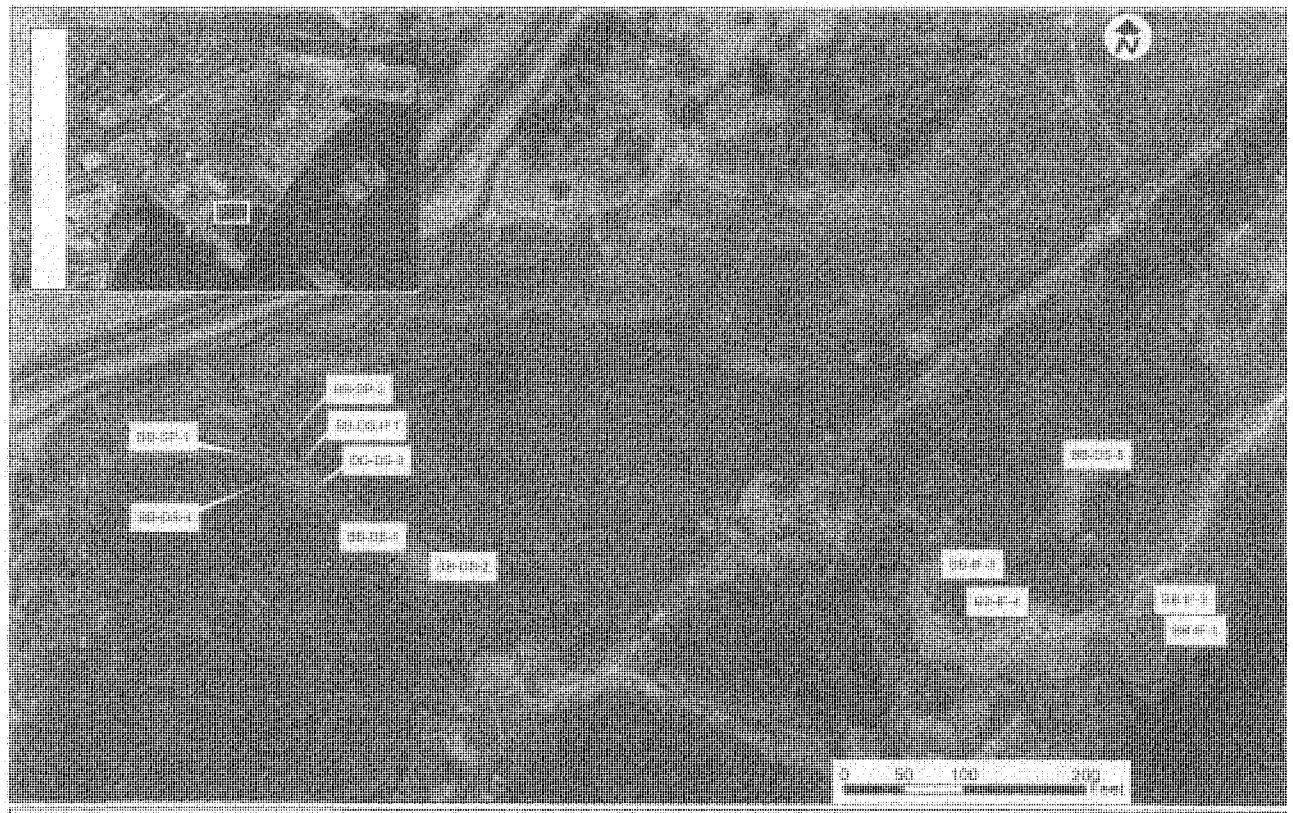
If the final design will contain a high marsh community, we recommend the planting of *Spartina patens* between 1.75 (MHW) and about 3.0. However the area above elevation 2.3 ft, salt hay grass may grow poorly and may be susceptible to invasion of common reed. Consequently, this zone should also be planted with companion species such as high-tide bush and black grass.

Above high marsh is the marsh-upland border or shrub-scrub wetland. This would be planted with sea myrtle (*Baccharis halimifolia*), rose mallow (*Hibiscus moscheutos*), seaside goldenrod (*Solidago sempervirens*) and switchgrass (*Panicum virgatum*). These would be planted above elevation 3.0 as a transition zone between the high marsh and the upland areas.

Figures G-3 and G-4 summarize the recommended elevations for each tidal community and they are as follows:

1. Open Water (-3.5 to -1.0)
2. Low Marsh (-1.0 to 2.00 ft)
    a. Mud Flat (-1.00 to -0.50 ft)
    b. *Spartina alterniflora* (-0.50 to 1.75 ft)
3. Mixed Marsh* (1.75 to 2.00 ft)
    a. *Spartina alterniflora* (-0.50 to 1.75 ft)
    b. *Spartina patens* (2.00 to 3.00 ft)
4. High Marsh (2.00 to 3.00 ft)
    a. *Spartina patens* (2.00 to 3.00 ft)
    b. *Distichlis spicata* (1.75 to 3.00 ft)
5. Maritime Shrubs (>3.0)
    a. *Baccharis halimifolia,*
    b. *Iva frutescens)*

*This zone would be an overlap area between low marsh and high marsh planted with both species.



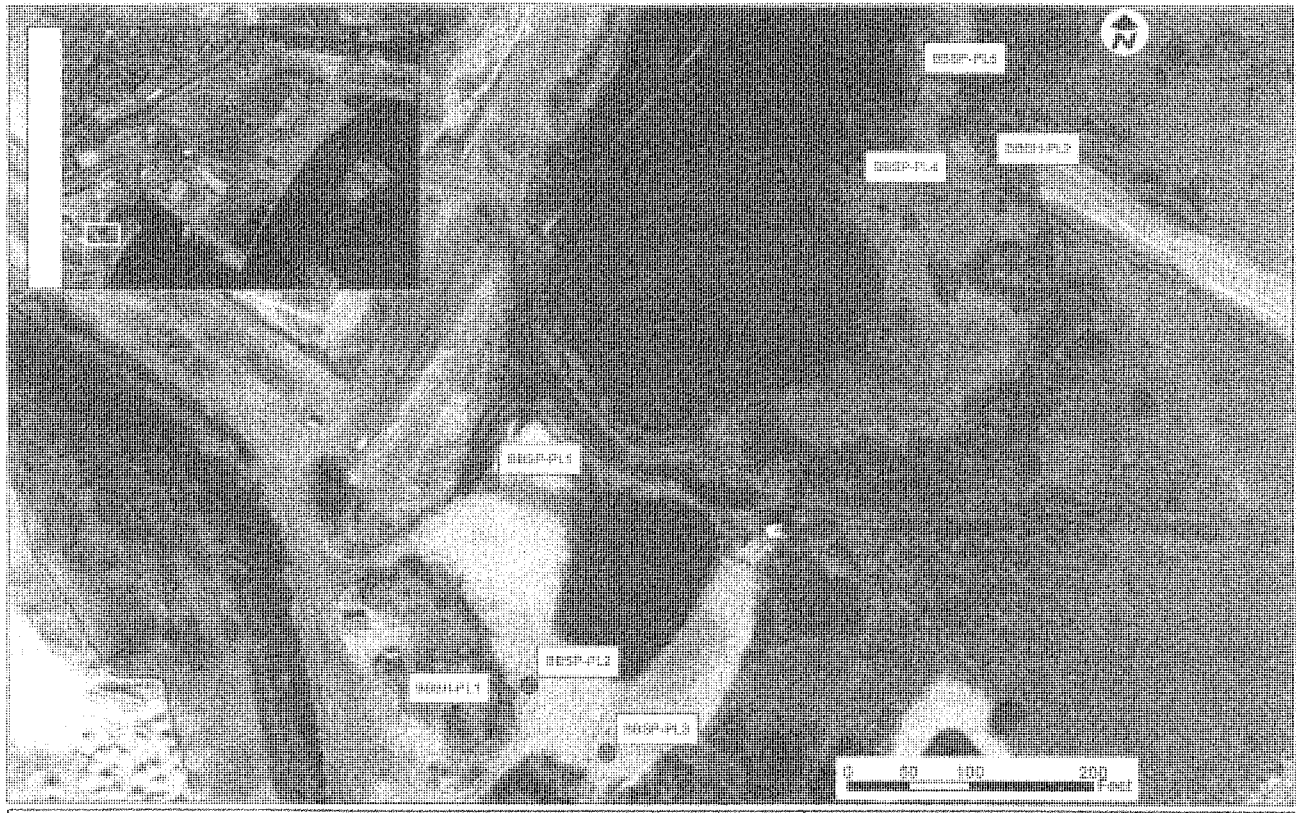
US Army Corps of Engineers
New York District

Map Source: LMS (2005)
Aerial Photo Source: USACE (2005)

THE PORT AUTHORITY OF NY & NJ

South Cove Wetland With Reference Elevation Locations

Figure G - 1



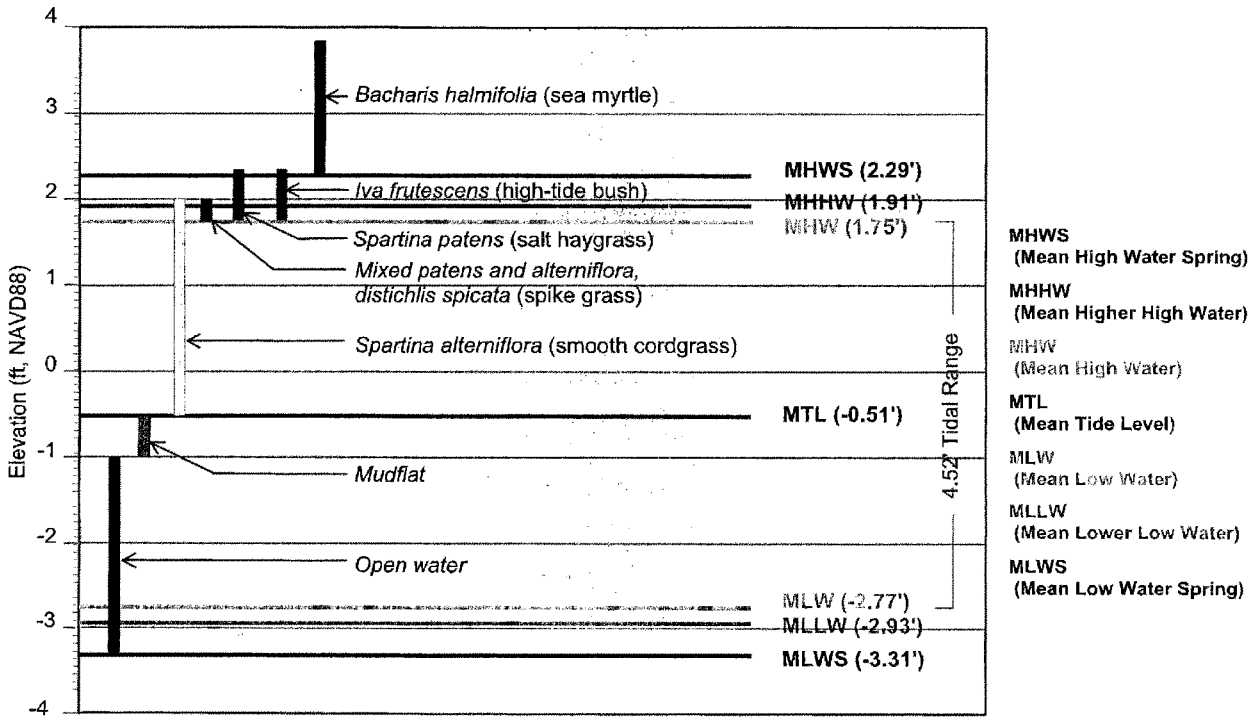
US Army Corps of Engineers
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Port Liberte Wetland With Reference Elevation Locations

Figure G - 2



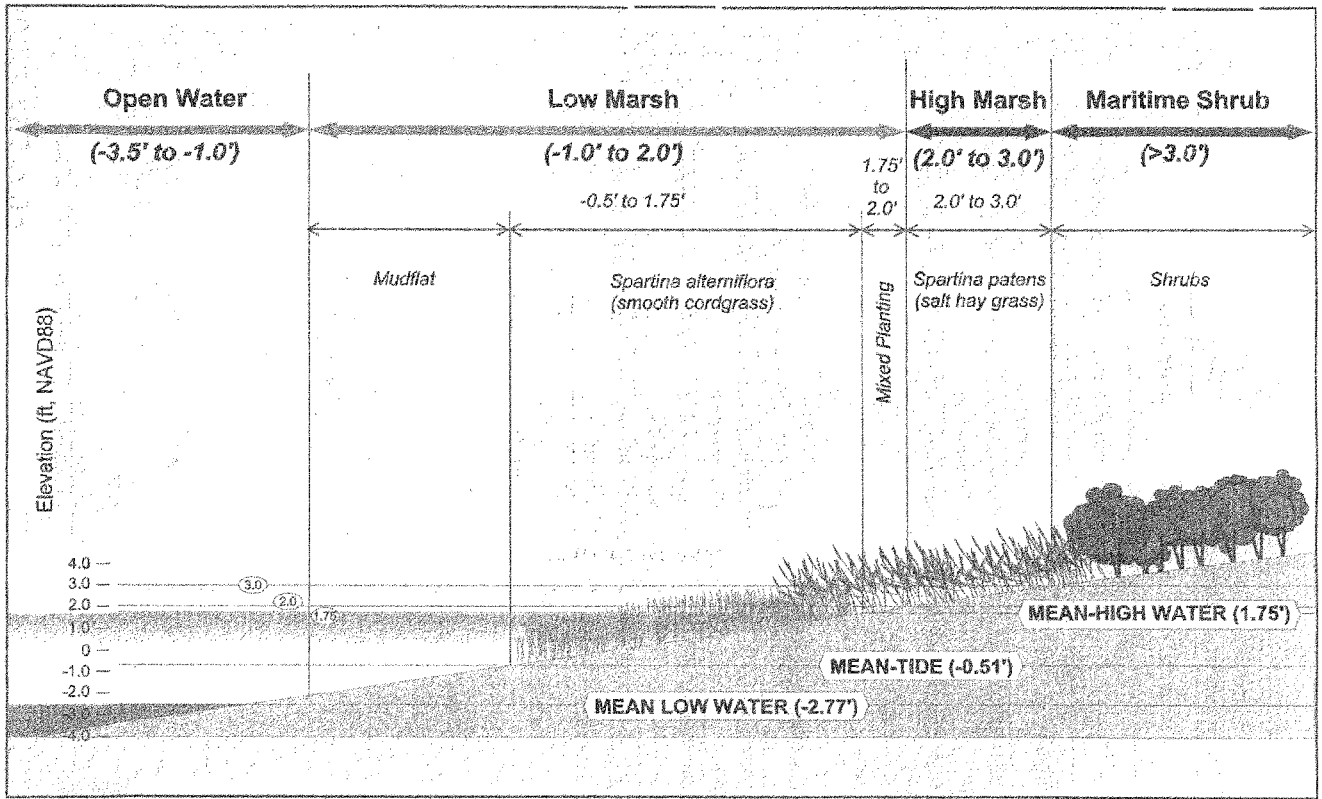
Elevations from Reconstructed South Cove Elevations from 1983 to 2001 Battery Tidal Epoch.

US Army Corps of Engineers®
New York District

THE PORT AUTHORITY OF NY & NJ

Benchmarking and Tidal Datums Liberty State Park

Figure G-3



US Army Corps of Engineers®
New York District

THE PORT AUTHORITY OF NY & NJ

Salt Marsh Profile
Liberty State Park

Figure G-4

Table G-1. Definitions of tidal datums

Term	Definition
High Water	Maximum water level reached during a tidal cycle
Mean High Water (MHW)	The average height of the maximum water level reached in a tidal cycle over a 19-year period
Mean Higher High Water (MHHW)	The average height of the highest annual water level over a 19-year period
Mean High Water Spring (MHWS)	The average height of the high waters occurring at the time of spring tide.
Low Water	Minimum water level reached in a tidal cycle
Mean Low Water (MLW)	The average height of the minimum water level reached in a tidal cycle over a 19-year period
Mean Lower Low Water (MLLW)	The average height of the lowest annual water level, over a 19-year period
Mean Low Water Spring (MLWS)	The average height of the low waters occurring at the time of spring tide.
Mean Tide level	Average of all hourly water levels over the available period of record.

Table G-2. Tidal elevations in the New York/New Jersey Harbor area.

	Abbreviation	Battery (1983-2001)	Governors Island	Con Rail RR Ferry	Liberty State Park (MLLW)	Liberty State Park (NAVD)
Highest Observed Water Level (09/12/1960)	HOWL	10.01	n/a	n/a	n/a	n/a
Mean High Water Spring	MHWS	5.22	5.01	5.01	5.01	2.34
Mean Higher High Water	MHHW	5.06	4.80	4.80	4.80	2.13
Mean High Water	MHW	4.73	4.57	4.57	4.57	1.90
North American Vertical Datum-1988	NAVD	2.78	2.67	2.67	2.67	0.00
Mean Sea Level	MSL	2.57	2.47	2.47	2.47	-0.20
Mean Tide Level	MTL	2.47	2.37	2.37	2.37	-0.30
Mean Low Water	MLW	0.21	0.17	0.17	0.17	-2.50
Mean Lower Low Water	MLLW	0.00	-0.05	-0.05	-0.05	-2.72
Mean Low Water Spring	MLWS	-0.28	-0.27	-0.27	-0.27	-2.94
Lowest Observed Water Level (02/02/1976)	LOWL	-4.29	n/a	n/a	n/a	
Mean Range	MHW-MLW	4.53	4.40	4.40	4.40	1.73
Diurnal Range	MHHW-MLLW	5.06	4.85	4.85	4.85	2.18
Spring Range	MHWS-MLWS	5.50	5.28	5.28	5.28	2.61

Note: Elevations of tidal datums for the Battery referred to Mean Lower Low Water (MLLW), in feet, based on the 19 year tidal epoch January 1983 - December 2001.

Other stations*	Mean Range	Spring Range	MTL
Governors Island	4.4	5.3	2.4
Battery	4.56	5.52	2.5
Jersey City, Con Rail RR. Ferry, N.J	4.4	5.3	2.4

*Based on conversions. Data source: www.co-ops.nos.noaa.gov

Table G-3. Elevation data from reference wetlands at Liberty State Park South Cove, Jersey City, NJ and Port Liberte, Caven Point, NJ.

Species		Spot Elevations (ft)		Mean Elevation (ft)		Range (ft.)
		South Cove	Port Liberte	SC	PL	
S. alterniflora	Lowest Elevations	0.87		0.87		
S. patens	Lowest Elevations	2.04, 2.12	2.77, 2.63, 2.73, 1.69, 1.84	2.08	2.332	1.69-2.77
Distichlis spicata	Lowest Elevations	1.81, 1.74, 1.88, 2.01, 2.44		1.97		1.74-2.44
Baccharis halimifolia	Lowest Elevations		2.42, 3.77		3.09	2.42-3.77
Iva frutescens	Lowest Elevations	2.21, 2.42, 2.58, 2.38		2.39		2.21-2.58

Note: Points were surveyed by BET and elevations were based on NAVD88 datum.
Elevations of tidal datums for the Battery referred to Mean Lower Low Water (MLLW), in feet, based on the 19 year tidal epoch January 1983 - December 2001.

Table G-4. Liberty State Park Water Level Observations: Summer and Fall 2003

	Location	Morris Canal	South Cove	NOAA-NOS Battery, NY	Morris Canal	NOAA-NOS Battery, NY	NOAA-NOS Battery, NY	Reconstructed* South Cove
Period of Record	Start:	31-Jul	31-Jul	31-Jul	31-Jul	31-Jul	1983 to	1983 to
	Finish:	11-Sep	11-Sep	11-Sep	21-Nov	21-Nov	2001	2001
Mean High Water Spring	**MHWS**	3.01	2.72	3.14	3.17	3.28	2.44	2.29
Mean Higher High Water	**MHHW**	2.36	1.96	2.58	2.24	2.43	2.28	1.91
Mean High Water	**MHW**	2.25	1.84	2.24	2.19	2.12	1.95	1.75
Mean Tide Level	**MTL**	-0.06	-0.51	-0.11	-0.08	-0.08	-0.31	-0.51
Mean Low Water	**MLW**	-2.37	-2.85	-2.46	-2.34	-2.27	-2.57	-2.77
Mean Lower Low Water	**MLLW**	-2.39	-2.86	-2.46	-2.36	-2.47	-2.78	-2.93
Mean Low Water Spring	**MLWS**	-3.20	-3.67	-3.14	-3.26	-3.24	-3.06	-3.31
Diurnal Tide Range	**RangeM**	4.62	4.69	4.70	4.53	4.39	4.52	4.51
Great Diurnal Tide Range	**RangeGD**	4.75	4.82	5.04	4.60	4.90	5.06	4.84
Spring Tide Range	**RangeS**	6.21	6.39	6.28	6.43	6.52	5.50	5.60

* Reconstructed South Cove Tidal Datums were used for the design of the tidal wetland. They were obtained by comparing the South Cove and Battery datums from 31-Jul-2003 to 11-Sep-2003, and reconstructing them to the 1983-2001 tidal epoch, using the Battery as the primary record.

Table G-5. Comparison of tide and bio-benchmarking data at Liberty State Park, Jersey City, NJ.

Vegetation Communities	Edge	Elevation Range (Bio-benchmarking [ft])	Tide Data (ft)	On-site Tide Gauges (ft)
Spartina alterniflora	Low edge	-0.87	-0.30 (MT)	-0.51
	High edge	2.00-2.40 (2.20)	1.90 (MHW)	+1.75
Spartina patens	Low edge	2.00	1.90 (MHW)	+1.75
	High edge	2.30	2.34 (MHWS)	+2.29
Shrubs	Low edge	2.40-3.00 (2.70)	2.34 (MHWS)	+2.29

Note: **S. alterniflora* is usually planted 1.00 ft above MHW

Table G-6. Existing Plant Communities (averages of the biobenchmarking)

	Low Elevation	High Elevation	Elevation Range	Mean Elevation	Range + or -
Spartina alterniflora	-1.0	2.5	3.5	0.75	1.75
Spartina patens	2.0	3.00	1.0	2.0	0.5

Note: *S. alternifolia* could be planted a low as –1.5 however survival at this elevation may be low, the team wanted mudflat areas and felt the *S. alternifolia* will eventually spread in this direction.

Appendix H

Correspondence with U.S. Fish and Wildlife Service, and New Jersey Department of Environmental Protection Endangered Species Unit Regarding Endangered and Threatened Species in Liberty State Park Jersey City, NJ

Agency Correspondence Regarding Endangered and Threatened Species and Species of Concern for the Liberty State Park Ecosystem Restoration Project

The following section documents the correspondence between the U.S. Army Corps of Engineers (USACE) N.Y. District with interested agencies regarding endangered, threatened wildlife species and species of special concern for the Liberty State Park (LSP) ecosystem restoration project. Wendy Walsh from the U.S. Fish and Wildlife Service (USFWS) attended two Liberty State Park project development team (PDT) meetings, and attended a field visit to the LSP project site. Representatives from the New Jersey Department of Environmental Protection (NJDEP) Endangered and Nongame Species Program (ENSP) attended a field visit to the LSP project site. USACE requested that the USFWS and NJDEP provide a list of wildlife species that may be of concern in the project area, and both agencies complied.

Included in this appendix are:

1. Memo for Record for the LSP PDT meetings that were attended by USFWS (25 September 2003; and 11 December 2003)
2. An email from Wendy Walsh (USFWS) documenting the input she provided during the PDT meeting, and during the LSP field visit
3. A memo summarizing the input USFWS provided during the 9 December 2003 wildlife meeting and field visit, and the 11 December 2003 LSP PDT meeting
4. An email from Kim Korth providing a list of target species that ENSP would like to see established or enhanced in the LSP project site

USFWS provided comments on the conceptual plan for the LSP Restoration site in terms of wildlife habitat enhancement. Of particular concern was the creation of large patches of contiguous vegetation cover types to maximize the area of interior habitat. The conceptual plan was revised to address this concern. The grassland berm in the southwest portion of the LSP Restoration site was expanded, and the forest boundaries have been expanded to create a larger interior core.

MEMORANDUM FOR RECORD

SUBJECT: HRE – Liberty State Park Meeting; 25 September 2003

Bob Will (USACE)
Olivia Ng (USACE)
Kerry Anne Donohue (USACE)
Bethany McClanahan (USACE)
Webster Shipley (USACE)
Jack Berezniak (USACE)
Frank Gallagher (NJDEP)
David Bean (NJDEP)
John Staples (USFWS)
Wendy Walsh (USFWS)
John Roebig (ERC/LMS)
Jennifer Curran (ERC/LMS)
John Dromsky-Reed (ERC/URS)
Ray Hinkle (ERC/URS)
Roberta Zwier (ERC/URS)

1.0 SUMMARY

The Liberty State Park (LSP) restoration project team met at the LSP Railroad Building to discuss project status and for a presentation of the preliminary results of the Geotech and Biological Survey Investigations.

2.0 INTRODUCTION

Frank Gallagher described the history of Liberty State Park. The substrate for most of the park, a former marsh, was created from fill from New York City (trash, etc.) for the establishment of a railroad. The substrate in the 45-acre rectangle is dredged material that was excavated during the construction of the visitor center.

3.0 PRESENTATION OF PRELIMINARY BIOLOGICAL SURVEY DATA

ERC presented the preliminary findings of the biological surveys. John Roebig described the vegetation surveys, Jennifer Curran summarized the preliminary findings of the North Cove Benthos, Fish, and Water Quality surveys, and Roberta Zwier discussed the preliminary findings of the wildlife (including threatened and endangered species [TES]) surveys. A summary of the findings is presented below.

3.1 Vegetation

The process of mapping the vegetation communities within the park is nearly complete. The community boundaries have been identified and marked with flagging throughout the site, and BET survey crews have located the flags. Wetlands were delineated using the three-parameter approach described in the 1989 USACE wetland delineation manual.

Each community has been characterized as one of the types listed in the "Ecological Communities of New York State." The following community types are present in the park: Successional Northern Hardwoods, Successional Shrubland, Successional Old Field, Maritime Shrubland, Maritime Grassland, Dredge Material, and Paved Path/Road.

Twenty wetlands have been identified on the restoration site. The wetlands have been categorized as: Shallow Emergent Marsh (sedges), Shrub Swamp (winged sumac,

phragmites), Vernal Pool (spikerush), Open water, Dredge Material Wetland (sensitive fern, blackberry) or Reedgrass/Purple Loostrife Wetland.

3.2 Benthos

Replicate grab samples were collected from three North Cove Stations with a 0.5 m^2 Standard Ponar Grab. The replicate samples were composited and brought back to the lab for analysis. Organisms were identified to the lowest practical level.

Overall, the samples were low in diversity and abundance of organisms, and most of the species collected were tolerant polychaete worms, indicating high pollution levels. Two of the six grab samples had no organisms in them. Diversity and abundance were lowest in the shallow areas of the southwest North Cove, where the samples were composed 320-520 individuals/m^2 of 1-3 species. Samples from the deeper waters of the eastern cove contained more individuals (620 – 1320/m^2) of 6-10 species.

Although comparisons of benthic studies are difficult because of seasonal variation in species composition and patchy distribution, it is interesting to note that when compared to other studies in NY/NJ Harbor, the abundance of organisms in the North Cove seems low. Zappala 2001 (A Master's Thesis from SUNY Stony Brook) reported an average abundance of 1,017 organisms/m^2 in shallow open waters. Iocco et al. 2000 reported average harborwide abundance of 7,783 organisms/m^2.

3.3 Fish

Fish communities in the North Cove were sampled with 50-ft beach seines and 3' X 6' box frame trap nets set at three stations. Fish were counted, ID'd to species level and released.

Preliminary results suggest that, although most of the species of fish were collected at early life stages, several species of fish at different life stages utilize the North Cove. Eight fish species were collected with a beach seine, and bay anchovy and juvenile Atlantic menhaden dominated the catch, with 30 or more individuals of one of these species in each sample. Less abundant species included juvenile striped bass, weakfish, northern pipefish, American eel and white perch.

No fish were collected in two of the three trap nets; only the trap nearest to the western shore of the North Cove captured fish. The trap net collected 19 fish of 8 species. Unlike

the beach seine catch, demersal fish that feed on benthic organisms dominated the trap net catch. Juvenile white perch, winter flounder, tautog, and scup, and one adult summer flounder and American eel were collected.

3.4 Water Quality

Surface and Bottom water samples were collected bi-weekly from 5 stations for a period of 5 weeks, between 7 August and 3 September 2003. At stations where the depth exceeded 11 feet, samples were also collected from the middle of the water column. The samples were analyzed for temperature, dissolved oxygen, salinity, total suspended solids, biological oxygen demand, ammonia, TKN, nitrate/nitrite, and total phosphorus. Laboratory analysis was incomplete for several of the parameters, so the discussion was limited to temperature, dissolved oxygen pH and salinity.

The temperature ranged from 20.3°C to 27.1°C, with an average of 23.5°C for all stations and samples combined. Salinity ranged from 6.6 ppt to 24.1 ppt, with the higher values recorded for bottom samples. Overall, the average salinity was 16.0 for all stations and samples. Dissolved oxygen ranged from 3.5 mg/L to 10.4 mg/L, averaging 5.4 mg/L for all samples. The pH ranged from 7.0 to 8.1.

3.5 Wildlife

Fifty species of birds were observed during the wildlife surveys at Liberty State Park. Within restoration area, most species were associated with field/meadow, edge, or successional habitats (e.g., brown thrasher, yellow warbler, American woodcock, song sparrow). Six State-listed threatened/endangered species of birds were observed in the site.

Three northern harriers were observed in the park. An adult male and female were observed on several occasions, and a juvenile was observed once. It is probable that the juvenile was not a resident of the park.

Incidental sightings of mammals and reptiles include: meadow vole, eastern cottontail, raccoon, feral cat, common garter snake and northern brown snake

3.6 Biobenchmarking

The team has identified two nearby wetlands that will be used as reference sites during the design of the tidal wetland in the restoration site. Transition zones between vegetation communities (e.g. Spartina alterniflora and Spartina patens/Phragmites) and open water have been staked.

4.0 GEOTECHNICAL INVESTIGATION

Webster Shipley and Jack Berezniak from USACE discussed progress of the geotechnical work at LSP. The team bored 38 holes down to native marine clay (at 12-15'). Two samples will be analyzed for each hole. The team will also measure in situ permeability. WS said that there was less debris in the soil than expected. The North Cove still needs to be sampled.

Eight 2' diameter temporary piesometers were installed for 30 – 60 day monitoring of groundwater conditions (flow and direction).

The analytical work is on hold because the laboratory was damaged during the hurricane, but results should be expected for the November or December meeting.

5.0 WILDLIFE CONCERNS

Wendy Walsh (WW) initiated a discussion about the formulation of wildlife criteria to ensure that additional wildlife will not be attracted to contaminated areas within the site. The current geotechnical sampling plan does not call for analytical testing on surface sediments, only samples at depths of 17' and 28'.

Bob Will will check about the possibility of additional testing of surface sediments.

WW also spoke about the possibility of wildlife (esp. amphibian) impacts due to the low pH cinder substrate. Since the restoration project calls for excavation of the rectangle, WW suggested that the team should coordinate with USFWS and NJ's Endangered and Nongame Species Program (ENSP) to determine impacts to the threatened and endangered species on the site, to avoid impacts and enhance habitat on the site. She suggested that actions such as predator control, enhancing freshwater wetlands and Phragmites control should be considered.

THE NEXT LSP MEETING IS SCHEDULED FOR 10:00 A.M. THURSDAY, NOVEMBER 6TH AT THE INTERPRETIVE CENTER

CENAN-PL-F 11 December 2003
Memorandum for Record

SUBJECT: Liberty State Park (LSP) Project Delivery Team (PDT) Meeting

1) Liberty State Park PDT members met at 10 AM on 11 December 2003 at the LSP Interpretive Center to review the available data and discuss how the information affected the conceptual plans. The following were present:

Name	Organization	Phone	Email
Bob Will	USACE	212.264.2165	robert.j.will@usace.army.mil
Bethany McClanahan	USACE	212.264.9074	bethany.m.mcclanahan@usace.army.mil
Daniel Kriesant	USACE	212.264.9117	daniel.j.kriesant@usace.army.mil
Richard Dabal	USACE	212.264.5746	richard.p.dabal@usace.army.mil
Bob Hass	USACE	212.264.0146	robert.a.hass@usace.army.mil
Olivia Cackler	USACE	212.264.9088	olivia.n.cackler@usace.army.mil
Jack Berezniak	USACE	410.962.4450	john.n.berezniak@usace.army.mil
Wendy Walsh	USFWS	609.383.3938 x48	wendy_walsh@fws.gov
David Bean	NJDEP/ONRR	609.984.0599	david.bean@dep.state.nj.us
John Roebig	ERC (LMS)	845.735.8300	jroebig@lmseng.com
Jennifer Curran	ERC (LMS)	845.735.8300	jcurran@lmseng.com
John Dromsky-Reed	ERC (URS)	973.785.0700	john_dromsky-reed@urscorp.com
Roberta Zwier	ERC (URS)	973.785.0700	roberta_zwier@urscorp.com
Ray Hinkle	ERC (URS)	973.812.6886	ray_hinkle@urscorp.com

2) Geotechnical presentation (Jack Berezniak).
   a. Samples were collected from 38 drills holes. The soils were dominated by silty sand and fat clay, which accounted for roughly 90% of the total volume of samples. Geotechnical data indicates that the soils on the site are generally fine-grained and mostly impervious.
   b. The geotechnical characterization of the soil as mostly impervious needs to be reconciled with the high infiltration rates observed at the park.
   c. A synoptic ground water reading was also taken from piezometers on 15 November 2003. At present, the readings suggest that ground water is closest to the surface in the northeast corner of the park by North Cove and lowest in the southwest corner underneath the proposed berm. However, these readings were taken over a period of two hours and need to be adjusted to account for tidal fluctuations.

3) HTRW presentation (Richard Dabal).
Samples were taken from the bottom of the 38 drill samples (28.5 feet below surface) collected for geotechnical analysis. In summary, they were less contaminated than the history of the site would lead us to believe. Samples were screened for metals, pesticides, acid base neutrals, and especially for hexavalent chrome, in response to the Consent Decree. Two criteria were used:

Effects Range-Low (ER-L), which is the concentration of a chemical (in parts per million) in sediment below which toxic effects are rarely observed among sensitive species; and NJDEP Non-Residential Direct Contact Soil Clean-up Criteria (NRDCSCC). Samples were also taken from the midpoint of 12-15 feet and are currently in storage. However, due to the time that has elapsed, these samples can only be tested for the presence of metals.

a. It was clarified by NJDEP that ER-L is a screening measure for presence and does not always accurately reflect danger to species. The true concern is bio-availability.
b. Hot spots: Sample Point 20 (close to the proposed inlet for the tidal creek) and Sample point 37 (close to the proposed berm). Additional testing around point 20, to the depth of proposed excavation, 15 ft, has been proposed.
c. Need for additional collections: The PDT believes more sampling is required at the midpoint depth of 15 ft in the proposed excavation areas, especially the tidal creek in the fenced-off 45 acres.
d. The importance of screening the groundwater for contaminants was discussed, as it could affect the sides of the proposed tidal creek. If the groundwater is clean, it would eliminate the need for a clay liner for the sides of the tidal creek.

4) Topographic & bathymetric surveys (John Dromsky-Reed). Draft survey results are in and are in the process of being finalized. The draft version is complete enough to use as the basis for the Hydraulic and Hydrologic modeling. They are also available in a 3-D version.

5) H&H Modeling presentation (Dan Kriesant). The entrance to the tidal creek has been modeled using HEC-RAS. At present, the recommendation is have a straight eco-channel as wide as possible as the entrance. This design ensures the necessary velocity to get water into the tidal creek and the wideness maximizes area to support species. Concerns about the closeness of the inlet to the boundary conditions were noted and will be addressed. The next step is to model the portion of the creek within the 45-acre area, using RMA. In this second phase of modeling, the first concern is to determine how far the water can go inland, then how much sinuosity will be possible given the sustainable length, and then finding the right design for proper flooding and draining.

6) Water budget (John Roebig). These are four options for the freshwater wetland sources, and their calculated acre-ft run-off, based on annual average precipitation from 1993-2003:

1 = Wetland catchment (no action)	4.07
2 = 1 + Liberty Science Center	32.94
3 = 2 + NJ Transit Property	67.03
4 = 3 + pumps	TBD

Taken on a monthly base, Plan 2 generates the minimum amount of water necessary to sustain a wetland on a year round basis. It should be noted that this water budget only takes surface water into account. Ground water levels were not factored into the budget. The PDT recommended moving the proposed freshwater deep pool to the north and west of its current location in the conceptual plans because this would bring it closer to freshwater sources and protect it from salt-

water intrusion from the tidal creek. Also, the berm could be contoured to direct more fresh water into the site.

7) Wildlife survey (Roberta Zwier, Ray Hinkle). Additional wildlife data has been collected since the last briefing on wildlife surveys was provided in September 2003. Small mammal trapping was completed from October 28-November 1, 2003. White-footed mice were the most frequently captured species and they occurred in all habitat types. Meadow voles were captured in old-field/meadow habitat. One Norway rat and one house mouse were also captured. Northern harriers and Cooper's hawks were seen foraging within the 250 acres during the small mammal surveys. A long-eared owl was observed in Liberty State Park on Tuesday December 9, 2003.

8) Harbor Herons meeting briefing (Roberta Zwier). The Harbor Herons meeting was discussed in terms of how it could fit with the CRIP and LSP. Predators and a loss of suitable nest trees thought to be the primary factors causing herons to abandon established colonies such as Shooter's Island and Pralls Island. As wading birds are a group of species that require alternate habitats across the larger landscape, it is possible that they may find new nesting areas in potential HRE projects. For instance, Liberty State Park could provide nesting areas for wading birds in its upland habitats. The Harbor Herons Subcommittee is in favor of ecosystem restoration projects but expressed some concerns because projects in the Hudson-Raritan Estuary have the potential to attract wading birds to forage in areas that could expose them to contaminants.

9) Effects on Conceptual Plans

a. Moving the deep freshwater pool to the west, as discussed in item 6.
b. Less smaller, fragmented habitats scattered throughout the site and more larger, contiguous habitats.
c. Instead of sinuous entrance to tidal creek, or culverts, there should be a straight, wide eco-channel (Item 5).

10) Still need:

Ground water screening
Incorporation of tidal information
Mid-depth HTRW samples, 15 ft
Schedule Planning Committee Meeting in January

11) Next meeting on **Tuesday, 13 January 2003, at NJDEP Offices in Trenton, NJ, 10 AM.**

12) Comments and questions can be directed to Olivia Ng Cackler, Project Planner, at 212.264.9088.

Wendy_Walsh@fws.gov To: Robert.J.Will@nan02.usace.army.mil
cc: roberta_zwier@urscorp.com, jroebig@lmseng.com, fgallagher@dep.state.nj.us, John_Staples@fws.gov
12/12/2003 11:37 AM
Subject: meeting follow-up

Hi Bob:

Thanks very much for arranging Tuesday's wildlife meeting, and including me in yesterday's PDT meeting. I thought these were very informative and productive. I really appreciate the opportunity to provide input while the conceptual plan is still in development. I jotted down a summary of the recommendations I made at the meetings (attached); these are just preliminary based on the preliminary info we reviewed at the meetings. I'll look forward to future iterations of the conceptual plan.

Regarding my suggestion for monitoring to get a better handle on the harrier (before, during, and after construction), I think it would be great if Michael Britt could be involved in the effort. I think his knowledge and enthusiasm would be a real asset. I don't think this harrier work would be a huge or expensive effort.

On my LSP "to do" list, I've got:
- Get in touch with Kim Korth to see if Larry Niles is interested in some pass-through funding so that ENSP can dedicate staff to provide input as I prepare the draft 2(b) report.
- Get in touch with John Roebig the re: habitat evaluation now in progress.
- Next PDT meeting January 13.
- Planning Committee meeting sometime in January.

Here's a list of info I've requested, as it becomes available:
- GIS files of existing cover types, invasive species, and proposed plans;
- North Cove sediment contaminants testing and water quality results;
- full soil testing results;
- sampling plans for any additional contaminants testing;

- preliminary wildlife (terrestrial & aquatic) and vegetation reports;
- Liberty State Park management plan; and
- draft SOW and request for cost estimate.

I'll be looking at March 15 as the target date for the draft 2(b) report.
Please let me know if that changes.

Thanks again.
Happy holidays!
Wendy

(See attached file: USFWS_Dec_meeting_input.doc)
(See attached file: USFWS_Dec_meeting_input.doc)

Summary of U.S. Fish and Wildlife Service Preliminary Input provided at the December 9 and 11, 2003 Liberty State Park Meetings

- The Service strongly supports the general design concept that would provide various tidal marsh and shrub communities, freshwater wetlands and pools (if a water source is available), upland grasslands, and upland forest.

- The Service recommends the Corps:

    - test existing water quality of parking lot runoff proposed as a freshwater source, and design treatment basins to ensure that water directed into the restoration area is sufficiently clean to support diverse aquatic communities; and
    - test North Cove sediments, groundwater, and soils in the excavation areas at depths to be excavated for environmental contaminants. (Based on preliminary review, the Service supports the proposed use of ERLs as screening levels with bioavailability of contaminants as the final determinant of the need for remedial actions (*i.e.*, clay liner). Appropriate wildlife endpoints should be specifically considered.)

- The Service recommends the Corps and the NJDEP:

    - consolidate planned cover types (particularly grassland and forest) into larger patches, designed to maximize the area of interior habitat;
    - test salinity and pH of groundwater and vernal pools as possible limiting factors in amphibian abundance;
    - in accordance with any recommendations from ENSP, conduct or fund northern harrier monitoring before, during, and after construction, including nest site location, nest success, a tagging program, and (if birds are present year-round) contaminants testing;
    - design and schedule construction to minimize disturbance to nesting harriers;
    - plant trees along the interior road to minimize fragmentation effects and control invasive species;
    - plant trees in small patches of "old field" cover types that are too small to support grassland species and that fragment the developing forest;
    - plant a diverse array of native warm season grasses in the grassland areas, with a large "butterfly garden" (native wildflowers) located in an area of high visibility;
    - preserve orchid and moss mat areas; and
    - design construction to avoid impacts to known occurrences of State-listed plants.

- The Service concurs with the NJDEP's plan to generally leave upland shrub and forest communities to succeed with minimal to moderate interference, and recommends that the NJDEP:

    - develop a long-term habitat management plan (control invasive species, grassland mowing regime); and
    - develop a long-term species monitoring program (e.g., State-listed birds, amphibians), including management actions as appropriate (e.g., predator control, nest platforms).

-----Original Message-----
From: Kim Korth [mailto:Kim.Korth@dep.state.nj.us]
Sent: Tuesday, February 17, 2004 2:40 PM
To: Wendy_walsh@fws.gov; Will, Robert J
Cc: Larry Niles; jroebig@lmseng.com; smetzger@lmseng.com; Henn, Roselle E
Subject: Re: Request for lists of preferred species for habitat enhancement @ Liberty State Park

Hi Bob!

Here is the informal list of species of birds, herps and inverts that ENSP would like to see established or enhanced at LSP. Some are currently using the site and groups/suites of some species would benefit from the similar habitat management plans.

American bittern
Henslow's sparrow
Least Tern
Northern harrier
Peregrine falcon
Vesper sparrow
Black-crowned night-heron
Grasshopper sparrow
Savannah sparrow
Osprey
Yellow-crowned night-heron
American kestrel
Colonial waterbird nesting habitat
Spotted sandpiper
Tricolored heron
Migratory songbird habitat
Eastern box turtle
Fowler's toad
Frosted Elfin
Arogos skipper

Let me know if you have any questions

Kim

>>> "Will, Robert J NAN02" <Robert.J.Will@nan02.usace.army.mil>
02/06/04 07:31PM >>>
Wendy/Kim. If you remember from our December LSP meeting when we discussed
T&E species, we had asked for an informal list of species of plants, herps,
birds & mammals that your agencies would prefer to see established or
enhanced at LSP. We were discussing this in-house yesterday & think that we
would very much like to reference any species lists your agencies may
provide for use in our biological inventory (you have, or will have copies
of this draft report next week). So if you could send us those lists
("off-the-shelf" lists or reports are fine) we talked about, it would help
to move this project forward significantly at this point. No need to wait
for official FWCA communication or any official letters. That will come
later, we just need to see whatever you have available ASAP so we can warp
up this biological inventory for the site. Thanks again for the help.
Bob

PS. We can always amend the biological inventory later in the feasibility
study if additional significant data and/or priorities surface.

HUDSON RARITAN RESTORATION
LIBERTY STATE PARK
PUBLIC SCOPING MEETING - OCTOBER 16, 2002

The following comments were received at the October 16, 2002 Public Scoping Meeting for the United States Army Corps of Engineers (USACE) restoration plans for Liberty State Park (LSP). The comments have been categorized and summarized.

COORDINATION WITH LSP STAFF AND NJDEP

1. USACE should continue to coordinate with Liberty State Park staff and NJDEP to ensure that all efforts comply with the Park's master plan.[1,9]

PUBLIC ACCESS

1. Access to the restored areas should have trails, boardwalks and interpretive displays.[1,11]

2. The proposed walkway should be confined to the current space between the current fence line and roadside, which is almost uniformly 37 feet, to protect the endangered species (northern harriers). The areas where the northern harriers are nesting should definitely not be accessible to the public. With all due respect, this is not a request but a duty. On the dredge spoil site, where you want to implement salt marsh restoration, anything that could possibly displace the harriers should not be done.[5]

3. Walkways and viewing areas must not interfere with nesting and protection of young.[10]

4. It is possible to construct walkways that avoid sensitive areas.[8]
5. Although access is important, all access will impact the species here, so we have to plan accordingly.[7]

6. Fencing off a portion of the park may be a danger to wildlife that will not be able to travel in and out of the fence (i.e. rabbits).[10]

7. There should be an entrance and exit at the north side of the park. We should build a roadway from the north area, bring in a rail behind the restaurant and take it out again.[12]

8. The marina should be filled, under State law the Governor and the commissioner have the power to terminate the marina on 30 days notice.[12,13]

9. A walkway and bridge should be built in the north part of the park to have access in and out at the north end.[12]

10. The canal should only be used for rowboats.[12]

PERIMETER/RECREATIONAL PORTION OF THE PARK

1. It is important to complete the restoration of the perimeter upland portions of the park to allow for recreation. There is a need for both local and statewide active recreation forums. Let's continue the dialogue to ensure that all departments are involved so that the recreational areas work within the overall plan.[2]

2. There are 3 appropriate places in the park for a dog show field, ball fields, and bocce courts. The interior of the park should be a natural center.[9]

3. Constructing a swimming pool or anything to block the view of the industrial area will block views of the skyline from the harbor. It's a two-way street.[10]

4. Any sports to be developed should be on the outside of the perimeter as far as possible so as not to disturb wildlife during nesting, resting or migration.[10]

RESTORATION DESIGNS

1. The Liberty State Park Science Center prefers the complete through-going channel to introduce a richer variety of habitat and bio-diversity.[3, 9]

2. The through-channel would provide a focal point that is possibly lacking now for the trail network within the interior 251 acres.[3]

3. If the project is adopted with one outlet and that outlet faces the downstream direction of the Hudson it will fill and require maintenance, whereas a through-channel will have a natural flushing.[3]

4. How successful in the past have you been in converting upland habitats to wetland habitats? I know you have lots of success with wetland restoration, but it is mostly reintroducing spartina and other desirable species to phragmite-dominated marshes.[5,a]

5. We need substantially more information on this restoration system, including what habitats will be the most crucial before implementation of these restoration designs. The restoration plans are generic and we need more specifics, especially with regard to species performance (I have concerns about the northern harrier, and also aquatic communities).[7]

6. There is concern that bringing saltwater inland may lead to the contamination of the many fresh water ponds in the upland areas. There is such little fresh water for the wildlife during their migrations and during their nesting. Saltwater intrusion would destroy crucial freshwater habitats that already exist in the park. Any plans made for the inland site should be kept specifically for the wildlife.[10,15]

7. We need more information on scale and hierarchy of channel size for any wetlands considered here. It may or may not be possible to look at a greater length of smaller channels as well. Integration and relationship of freshwater inflows and the salt-water marsh are crucial mixing processes. System hierarchy will lend itself to phasing.[7]

8. These projects typically happen in very short time frames. However, phasing a restoration project over time reduces the amount of disturbance and is especially crucial to a single generation of species. A large-scale modification in a single event is worthy of reconsideration.[7]

9. There should be bold action, and we should not cut corners.[11]

10. Concentrating totally on wetland extension into the interior is a bad decision. This was a former landfill; wetland creation would leach materials out.[14]

11. The middle of the park should be a habitat for wildlife and people. It should rise up around 30 feet, because the shoreline is the concentration of the view of NY. A stepped-up upland ecology with good viewing areas would be an additional concentration of human activity, and would also support wildlife.[14]

12. Is there a system that will ensure that there is no saltwater intrusion into freshwater wetlands?[a]

13. The uplands have returned to a forest ecosystem that relies on fresh, not saltwater. How will the bringing in of saltwater affect the underground freshwater streams? You can not bring water into a forest that is primarily funded by freshwater.[a]

14. If salt marshes are created, will there be places for harriers to nest?[a]

COMMUNITY PARTICIPATION

1. Phasing the project will also allow for community participation as well as job training and involvement on the site if we spread the dollars out over time. This type of project would be more adaptable as it is implemented because observations could be made throughout the process.[7]

2. The long-term effort must include the involvement of local citizens and school kids in planting and monitoring. As Leslie Sauer says in her book Once and Future Forest, involving local citizens in the planting, monitoring and celebration of the work leads to local empowerment and knowledge. A world-class restoration calls for a world-class interpretive facility. We should not spend all of the money on the habitat, we need high-quality visitor experience that is properly interpreted with high-class educational materials.[8]

DREDGE SPOIL AREA

1. If remediation in a dredge spoil site must be performed, therefore making it necessary to restore the habitat, it should be grassland and not salt marsh. There is already a great deal of salt marsh preserved in the state, mostly the southern area of the state, LSP already has a private salt marsh. Grassland is more cost-effective. Grasslands are easier to install than salt marshes and you do not have to worry about digging channels and building bridges over the channels. God forbid they ever flooded the road. The success of salt marsh restoration is questionable.

Grassland habitat has more threatened & endangered species (TES) in NJ than any other habitat. Nine TES species in NJ require grassland habitat. Harriers, I admit, use salt marsh as nesting sites, but there is no guarantee they will be able to use this one. Therefore, the site should be left alone or converted to a grassland for remediation. Salt marsh is too risky. The only thing these birds need besides protection is minimal annual maintenance. Preventing fields from fully succeeding as a forest and cutting trees down.[5]

2. Removal of the dredged material prior to salt marsh creation is a concern.[10]

HABITAT

1. The Phragmites on the site has been described as a nuisance species on one of the Army Corps panels. Although it is not native to America, it is useful to wildlife. Over 30 species of birds next in it or use it as nesting material. If habitat diversity is important we should not totally eliminate the Phragmites.[5]

2. We have lost a significant amount of acreage over the past 10 years. The green park replaced approximately 100 acres of natural habitat. It is crucial that the last-remaining natural acreage in this park be retained for non-human inhabitants. Over 200 species of birds depend on this urban refuge for some point in the year as a refueling station, a wintering site or a foraging area. The iste is especially important for birds of prey throughout the year. Year-round residents include the State-endangered peregrine falcon, the State-endangered northern harrier and red-tailed hawks, and others.[5]

3. It is important to remember that bird wintering areas are equally important as nesting areas. Wintering species include State-threatened coopers hawks, an occasional Maryland rough-legged hawk, Snowy owls, State-endangered short-eared owls, State-threatened long-eared owls, and others.[5]

4. The 251 acres must provide high quality habitat for wildlife; mowed lawns are not acceptable. The following habitat goals should be met:
    - 10 acres of Wet Thickets
    - 1 acre of Moss Mat
    - 18 acres of Freshwater Wetlands

- 9 acres of Marsh Meadow
- 14 acres of Park Enhancement
- 80 acres of Soil Stockpile
- 28 acres of Native Grasslands[8]

5. Removal of vegetation and trees should be minimized. Smaller trees should not be totally removed from the site because without small trees the forest dies.[10]

6. We should consider the possibility of bringing back wildlife that we have lost (i.e. pigeon hawks and pheasants).[10]

7. LSP is a natural flyway for over 230 species of birds, and this should remain a priority.[12]

NORTHERN HARRIERS

1. In the spring/summer of 2001 a nesting pair of northern harriers were discovered in the rectangular area in Liberty State Park where the Army Corps would like to implement salt marsh restoration. The Harriers successfully fledged two young. The information was accepted by the NJ Fish & Wildlife Service and put into the State's database. This year, harriers were found nesting in the park. A male paired up with a young female. Although the nesting attempt failed, it is the second attempt in two successive years. These birds warrant protection, and because they are on the Endangered species list, protection is mandatory.[5]

2. I want to ensure that the Harriers are given sufficient space and comfort so that the park can continue to be a nest site for these magnificent birds. An important foraging area that needs to be protected in connection with the dredged site is the grassy field that runs along Cobblestone Drive and fencing should be up for the birds' safety.[5]

3. It is important to take into account to protect northern harriers, and any plan should include the terms of acreage requirements and type of preferred habitat so that these birds can continue to be part of the natural landscape.[6,11]

OTHER COMMENTS

1. Focus on getting additional funding for the park from companies responsible for Chromium toxicity (i.e. Allied Single and PBG), and companies that profited from the contamination by using the Chromium (i.e. GM and GE).[12]

2. We should have a public meeting to discuss the discontinuation of the contract with the Liberty State Park Development Corporation (who have not responded to the NJDEP's claim that financial irregularities were discovered).[13]

3. The alternative plans should be posted on the Internet so that people can evaluate them.[15]

4. Until the scoping meeting, the people were not asked if they believed that habitat restoration was necessary in LSP. The USACE has not showed any evidence that the restoration is necessary at all.[a]

5. Will there be a bridge open between LSP and Ellis Island?[a]

6. Have you looked at the siltation and stagnation of Morris Island?[a]

SPEAKERS

[1] – Desiree Ramos, on behalf of Congressman Menendez
[2] – Maryann Bucci-Carter - City of Jersey City – Division of City Planning
[3] – Emlyn Koster, Phd. - President of Liberty Science Center
[4] – Connie Clayman – Liberty Science Center
[5] – Michael Britt – Liberty Science Center
[6] – Wayne Greenstone
[7] – Leslie Sauer – Audubon Society and Restoration Practitioner
[8] – Eric Styles – NJ Audubon Society
[9] – Sam Pesin – President of Friends of Liberty State Park
[10] – Catherine Grimm – LSP Conservancy
[11] – Greg Remorig -President of LSP Conservancy ** Check on spelling of name
[12] – Gregory Giordano – Friends of LSP
[13] – Howard Moskovitz
[14] – Joe Chesonis - Urban Systems Concept Group
[15] – Bill Ambruster
[a] – The question was brought up during the question and answer period following the speakers.

Liberty State Park Public Scoping Meeting

Sponsored by
U.S. Army Corps of Engineers-New York District
October 16, 2002

7:00-7:45pm Sign In and Informal Discussion of Program
(Those wishing to speak are asked to complete an ID card. Nineteen (19) people chose to speak)

**

7:45pm Welcome to Liberty State Park by Frank Gallagher, Administrator, Division of Parks and Forestry, NJ Department of Environmental Protection

**

Presentation of the Scoping Process and Proposed Project – Joseph Redican, Project Planner, U.S. Army Corps of Engineers

1st Speaker – Desiree Ramos from the Office of Congressman Robert Menendez

Thank you for the opportunity to be here today and share Congressman Menendez's views on the Liberty State Park portion of the Hudson-Raritan Estuary Ecosystem Restoration Study.

Mr. Menendez has worked diligently to make the Hudson-Raritan Estuary Ecosystem Restoration Study possible. As the senior New Jersey member of the House Committee on Transportation, Mr. Menendez shepherded the Study through the authorization process. Since that time, he has taken the lead among the New Jersey delegation to garner full funding of the Study. Although Congress has not yet completed funding for Corps programs, both the House and Senate demonstrated their commitment to this Study by providing funding above the President's request.

Mr. Menendez commends the Corps, New Jersey DEP – including the Liberty State Park employees, and the Port Authority for their hard work in coming up with the preliminary conceptual plan. The Congressman understands that you tried to come up with a plan that enhances and restores habitat in the most cost-effective manner possible while balancing the need for public green space. He also wanted me to encourage you to move forward with plans to improve public access to the enhanced habitat areas through the use of trails, boardwalks and interpretive displays. Finally, as a member of the Liberty State Park interdisciplinary planning committee, the Congressman was instrumental in developing the Park's Master Plan and urges The Corps to continue to coordinate with Liberty State Park staff and NJDEP and to ensure that all efforts comply with the Park's Master Plan.

Mr. Menendez will continue to seek full funding for the Study and use his position on the Transportation Committee to garner construction funding in the next Water Resources Development Act.

2nd Speaker – Maryann Bucci-Carter - City of Jersey City – Division of City Planning

I have no prepared speech today, but we can support habitation restoration in the park. There are many things proposed but what stands out most and what we all can agree upon is that we want to see the park completed—we want the environment restored and the recreation areas completed. This park is a very special place for everyone—including its immediate neighbors, Jersey City. The residents count on it. Portions of the park came from the city. We look to The State, The Army Corps and the Port Authority to come together to make all the pieces fall into place.

Right now we focus on habitat restoration, but I want to bring out one thing insofar as the Scoping meeting: we don't want to ignore the perimeter portions of the park and not bring that to completion. Still undone. Keep that in our sights. Upland recreation. Let's not preclude.

There are no longer people pushing for commercial recreation but there is a need for both local & statewide active recreation forums. Let's continue the dialogue. This is the first and let's be sure all departments are involved so that it works within the overall plan.

3rd Speaker - Emlyn Koster, Phd. - President of Liberty Science Center

I'd like to speak in three professional capacities: my PhD. Is in geology. I studied rivers and estuaries for my doctoral thesis and I stand also as a public educator devoted to the public awareness of science and technology sort of with a social and environmental stance and I am the President of the LSC since 1996, and have been an active member of the Park Planning Committee standing strongly, along with my colleagues, for holistic planning of the park—that is not piecemeal planning of the park --- and trying to look forward to the day that projects like this would happen.

For the Science Center, and me personally in those capacities, the plan is urgently needed because the park is approaching its 30th anniversary in 2006. There has been a lot of patience in this community, long before I came, waiting for the park to realize its completion according to the mission of the park and in accordance with the park planning study. I think the Hudson, which is one of the mighty rivers of the country and one of its

estuaries, almost completely lacks any remaining shoreline. We don't appreciate the tides in the river because it's always against vertical walls. By reintroducing habitat of this nature, and its given shallow shorelines, you will be able to appreciate the 7.2 foot tidal range from its spring tides to its knee tides and appreciate the tidal form that happens in those environments and the flowing of the tidewater itself.

I would make a comment that the Science Center under my stewardship and me personally from that professional angle as geologist would much prefer to see the complete through-going channel to introduce a richer variety of habitat and bio-diversity and provide a focal point which is possibly lacking now for the trail network within the interior 251 acres. It would give it a focal point for people to walk down across the interior woodlands w/all of its rich bird resources and able to approach the edge of this channel from the exterior or interior side. And to appreciate the rich bird habitat that would be recreated. After all, this was inter-tidal land until the early 1800's and we are bringing back that which was there.

I would also comment that if the project is adopted with one outlet it will require more maintenance if it faces the downstream direction of the Hudson. It will fill and require maintenance, whereas if there is a thru channel it will have a natural flushing. That is my professional opinion. But I defer to the model of the US Army Corps of Engineers.

So I would be anxious to see this project happen and be a catalyst. As the city has said and as Congressman Menendez has said, I believe, for this to be a catalyst to the onward completion of the planning, to draw attention and be able to accelerate the vision of the park.

4th Speaker – Connie Clayman - Liberty Science Center

I am here as the VP of Finance & Facilities for the Center. I've been here for 12 yeas. As well as a member of the LSP planning and I want to say we very much support one of these two estuary plans. As part of expansion on what LSC is doing, we are having a large exhibit called "Our Hudson Home" which is physically about the Hudson River estuary and being able to have walkways that come down to an estuary. The walkways will show all of the inner-city children that we have nature in the most populated county in the country and will give them an opportunity to see something they

now can't. Even though they are living on the Hudson River but have no estuary to go down to see.

So I think it will be a wonderful addition to the educational mission of the LSC and a perfect fit with what our new exhibit area will be.

5th Speaker – Michael Britt - Liberty Science Center

I also work at the Science Center but all my views tonight are as an individual. I don't necessarily reflect the Science Center as an institution.

First thing I want to comment on is that I've heard a few people call the park incomplete. This park is definitely not incomplete. Also on one of the Army Corps panels Phragmites is described as a nuisance species. It is not native to North America – is European – but does have some wildlife uses. Over 30 species of birds nest in it or use it as nesting material.

The problem with Phragmites is that it crowds out other species and becomes a monolith. Habitat diversity is important but we should not totally eliminate Phragmites.

I am a member of the NJ Audubon Society. I've been coming to LSP for 10 years to observe birds, and over that period we have lost a significant amount of acreage here. The green park replaced approx. 100 acres of natural habitat. We can still not access the only sandy beach in Jersey City that is adjacent to that heavy metal dust. That said it's crucial that the last-remaining natural acreage in this park be retained for non-human inhabitants. Over 200 species of birds at some point in the year depend on this urban refuge for resting, refueling station, a wintering site or a foraging area. The 251 acres is especially important for birds of prey throughout the year. The year-round residents include American kestrel which is a small falcon, the state-endangered peregrine falcon, red-tailed hawks, and the state-endangered northern harrier which I will focus primarily on. Wintering species include State-threatened coopers hawks, an occasional Maryland rough-legged hawk, State-endangered short-eared owls, state-threatened long-eared owls, etc.

Now it is very important to remember that wintering areas are as equally important as nesting areas like the north woods in Canada. Snowy owls migrate almost

1200 miles and spend the winter in places like Liberty State Park. They cannot survive the winters if they cannot return to their breeding grounds.

If anyone in the audience wonders what these birds feed upon, it is the many rodents and pheasants that reside here. An important note moving on: as far as breeding is concerned, northern harriers are a State-endangered species. The bulk occupy the salt marshes of the outer coastal plains of the Delaware bay shore. In contrast, there are relatively few pairs in Northern New Jersey, so this fact – coupled with state law – makes protection of this site beyond mandatory.

You might not know which site I'm talking about yet, but in the spring/summer of 2001 I discovered a nesting pair of fenced off northern harriers in the rectangular area there where the Army Corps would like to implement salt marsh restoration. The harriers successfully fledged two young and I sent the information to the Record of NJ birds and the NJ Fish & Wildlife Service. The record was accepted and put into the State's data base and I rec'd a letter of confirmation.

This year the results were not as successful, but still somewhat positive. What do I mean by not as successful? Probably because the male paired up with a young female and sometimes young females do not lay viable eggs.

Other possible sources of nesting failure include ground predators such as raccoons, possums and feral cats that thrive in the park. For comparison, 28 of the 34 pairs of bald eagles that were nesting in NJ had successful incubation of young this year. That shows that 100% of nesting attempts are not successful.

In any event, this is the 2nd successive year that harriers nested in the park. Failed or successful, harriers are an endangered species and warrant protection. What I want to ensure is that the harriers are given sufficient space and comfort so the park can continue to be a nest site for these magnificent birds. An important foraging area that needs to be protected in connection with the dredged site is the grassy field that runs along Cobblestone Drive and fencing should be up for the birds' safety.

I am fully aware there needs to be a walkway that connects the rest of Jersey City with the Science Center and park. However, the proposed walkway should be confined to the current space between the current fence line and roadside (which is almost uniformly 37 feet). I have gone down there and measured along the road. I realize that most of the

wooded areas will be open to the public, but these two areas should definitely not be accessible. The Army Corps of Engineers, with all due respect-- this is not a request but a duty. Looking at this map and the dredge-spoiled site where you want to implement the salt marsh restoration, anything that could possibly displace the harriers should not be done.

I'll bring up a question that I'll restate later: how successful in the past have you been in converting upland habitats to wetland habitats? I know you have lots of success with wetland restoration but it is mostly reintroducing spartina and other desirable species to Phragmites-dominated marshes. But how successful at converting uplands to wetlands?

Also, if remediation in a dredge-spoiled site must be performed therefore making it necessary to restore the habitat, it should be a grasslands and not a salt marsh. The reason being there is already a great deal of salt marsh preserved in the state, mostly the southern area of the state, LSP already has a private salt marsh. Grassland is more cost-effective. It is easier to install and you don't have to worry about digging channels and building bridges over the channels. God forbid they ever flooded the road. The success of such a conversion is questionable. Grassland habitat has more threatened & endangered species in NJ than any other habitat. I have the list and I have the species highlighted. There are nine. Harriers, I admit, use salt marsh as nesting sites. But there is no guarantee they will or be able to use this one. Therefore, the site should be left alone or converted to grassland for remediation. Salt marsh is too risky. The only thing these birds need besides protection is minimal annual maintenance, for example, preventing fields from fully succeeding as a forest and cutting trees down.

Just because harriers are not as well-known as Bald Eagles does not mean they don't deserve the same protection by the law, not to mention that special accommodations have made a species like the Osprey. People build platforms in salt marsh areas and they build their nest on the platform. And also ( ) packing for Harriers & Falcons. Special accommodations were made for those species and the same should be done for the northern harriers.

6th Speaker – Wayne Greenstone

I'm from Cranston, N.J. and Director of the New Jersey Audubon Society, and am not here speaking on behalf of The Audubon Society.

I have a special affection for this park and have been coming here for 30 years to observe the wildlife that still exists here and the beauty of the park. The park has become a refuge and haven for people from all over the world—this city, people from many countries who visit here. It is a very special legacy and, hopefully, the Army Corps will get a flavor from you at this meeting and in the future. This park has to be preserved as an open and free space for both the people, for the history, the culture and the environment.

This marsh was an incredible estuary before millions of people came thru Ellis Island and the goal of trying to restore it and the wildlife that everyone can enjoy is significant. The northern harriers that the previous people talked about protecting are very special. If any of you have not had the opportunity to see the birds that winter here, perhaps you can come back in the spring to enjoy the beauty of these birds.

In terms of what the corps has proposed, it is important to take into account to protect these species and that any plan include the terms of acreage and type of habitat so that these birds can continue to be part of the natural landscape and for everyone to enjoy. It only takes one to mess things up but it takes us all with shared and common vision to preserve the values we hold dearly. I hope that this responsibility and charge you have will be fulfilled thru the participation of the citizens here, and the park will be a place both for nature and the people who come here.

7th Speaker – Ms. Leslie Sauer – Andropogen Associates

I've been a restoration practitioner for 33 years and am here now with the Audubon Society and want to make a few comments based on my previous experience.

We need substantially more information than we have now on this restoration system, including what habitats will be most crucial. I find that the restoration plans are generic and we need more specifics, especially with regard to species performance. I would reiterate concerns about the northern harrier, but also am concerned about the aquatic communities, stages, performance criteria and the relationship between that and the ongoing monitoring.

I would also suggest that, given the nature of this park, we are not just looking at wetlands restoration but the entire park. Access and how we view the wetlands, but all

access will impact the species here. Therefore, we have to plan in concert. More info on scale and hierarchy of channel size for any wetlands considered here should be collected. It may or may not be possible to look at a greater length of smaller channels as well. Integration and relationship of freshwater inflows and the saltwater marsh is crucial mixing. System hierarchy will lend itself to phasing.

I think my biggest concern is the way these projects happen in general. The timeframe over which things are supposed to happen is very short. I realize you have certain contractual limitations but I think the phasing over time reduces the amount of disturbance and is especially crucial to a single generation of species and a large scale modification at a single swoop is worthy of reconsideration.

Another important rationale for phasing is to move away from a short-term fix it/ maintain it mentality and allow for community participation as well as job training and involvement on the site if we spread the dollars out over time. I'm looking for a process that is more adaptable as we move along and observe what is going on.

8th Speaker - Eric Stiles - NJ Audubon Society - Conservation

I want to celebrate the fact that bad ideas lead to good visions and that is the people here tonight galvanized by a process to defeat other peoples' ideas of commercial interest that do not belong in this world-class park.

We should remember the birthing process and local cities and champions of LSP as we have a conversation that represents the broader interests of Jersey City and LSC, and we are pleased with this administration. And, we are no longer speaking to a brick wall. Congressman Menendez and his terrific support—again I want to celebrate this multi-tier approach. Dr. Koster's quote: "a vision with no funding is an hallucination." I want to thank the Army Corp of Engineers, and the Port Authority. We have some terrific partners in this effort. I want to throw out the idea that if Gov. Whitman can spend $300M on casinos on Barrier Islands and on Atlantic City casinos that we can spend the money here for our national heritage.

I want to reiterate that the 251 acres must provide high quality habitat for wildlife and plants. Mowed lawns are not acceptable. The following habitat laws should be sufficient for wildlife and associated recreation. Goals should be met: wet thickets 10 acres, 1

acre – moss mat, fresh water wetlands 18 acres, marsh meadow 9 acres, park enhancement 14 acres, soil stock pile 800 acres and native grasslands 28 acres.

A common vision that was celebrated by many people in this room is what I reiterate is our target. The layout of the habitat should be done to maximize the quality of the habitat wildlife and the experience of the recreational users. The existing inter-disciplinary planning committee overseen by the Dept. of Environmental Protection of which NJ Audubon is a member should continue to direct the planning process with the Army Corps of Engineers. We feel strongly that the DEP that has really spearheaded this to hire expert restoration ecologists and landscape restoration architects to draft plans and provide critical guidance. The restoration effort and long-term effort must include the involvement of local citizens and school kids in planting and monitoring. As Leslie Sauer says in her book (Once & Future Forest), you must involve local citizens in the planting, monitoring and celebration of the work. There must be local empowerment and knowledge.

A world-class restoration calls for a world-class interpretive facility. We should not spend all of the money on the habitat. This is our national park. We need high quality visitor experience that is property interpreted with high-class educational materials.

9TH Speaker - Mike Anderson - NJ Audubon Society

I don't represent the New Jersey Audubon Society tonight. I don't come here tonight as a representative.

Being in the education department, it means a great deal to me that my grandparents came thru Ellis Island. It is important to preserve native habitat and go through restoration process. I would like to thank Mike and others who talk about all the good reasons to do this project.

10th Speaker - Sam Pesin - President of Friends of Liberty State Park

I'd like to thank the folks who are here—Congressman Menendez' Desiree Ramos on behalf of The Congressman who has gotten millions of dollars to get this feasibility study started and he will be a crucial person for the future of this interior. And

the DEP has been so great and supportive with going forward. Assistant Commissioner Mark N( ) with his tremendous expertise and dedication, John ( ), and from the DEP, Frank Gallagher who has been the chair of this inter-disciplinary planning. In addition, Bahonee who has tremendous knowledge and commitment to LSP, from Trenton (Paul Siegler) Steve Ellis who is fantastic super at LSP. Representing the friends of LSP with its over 700 members.

I speak as a member of the planning committee and the son of the father of the park whose vision in 1957 was of people and nature. His spirit is here tonight along with the spirit of the very much alive Audrey, who has been the greatest champion of nature in this park. This is a historic meeting because this plan in its infancy. 190 acres of the natural area and the 60-acre open space perimeter will be an international model of urban nature restoration.

It is exciting to be involved at this early stage and in this democratic process of guiding the 251-acre public piece of land behind the Statue of Liberty and in this densely populated region and the park being on the Atlantic flyway. We have a rare opportunity to do something really special for the people of today and future generations.

We are fully supportive of this general management Plan to which Frank Gallagher referred. There is consensus. We had a 2-year process and going back many years based upon what people said at public meetings since 1976.

We had two major public hearings and the public supported the plan. The committee is made up of constituents, conservancy, city, Audubon, and others. I am also thanking those here representing Mayor Cunningham. The Mayor has been represented and has been supportive and knows very well the meaning of LSP. I do want to point out the President of Liberty Park Conservancy standing in back. My mentor as far as the interior and other aspects of the park and is a great advocate for this estuary.

The essence of the general management, as a lay person, sounds great as well as the acreage suggestions Eric Stiles talked about. The forest is for people's enjoyment and education. I grew up in Jersey City with no real experience of nature beyond raking leaves and setting them on fire. To have a trail through the forest and the meadows will affect children for the rest of their lives.

I agree with Dr. Koster's idea that a channel should emit from the river thru the interior and enrich the diversity and then channel back out to the Hudson. Salt marsh seems to be a spectacular opportunity to recreating the way it was hundreds of years ago. I would hope that the Army Corps and DEP work closely with NJ Audubon who have been in the forefront of fighting for the park for northern harriers and other endangered species and have been working on observation points & trails and other aspects of this plan. No— Liberty State Park is not as sacred as the Gettysburg battlefield but it is sacred land – rare, open urban space across from lower Manhattan, and people have been inspired.

The park has tremendous spiritual value and we owe it to the people who fought for this park from the beginning and all who use it and future generations to come up with a visionary and inspiring plan. This center of the park has great potential, and with our partners (including The Army Corps of Engineers, the public and elected officials) staying involved to give our views as the plan moves forward. Regarding recreation, Miriam mentioned three appropriate places in the park for dog show fields, ball fields and bocce courts. The interior should be natural center. The park should also include a cultural center to make this an all-round great park.

11th Speaker – Michel Cuillerier - VP of Friends of LSP (Sierra Club)

Finally a public hearing w/no protest! Cumulative effort. I want to acknowledge the people who have participated. Every one of you plus I welcome the Army Corps of Engineers & other players. This is an important, delicate project. You people are the reasons it happened. Write in your comments-- don't be shy. This is the result of all of our efforts. Acknowledge yourselves. The 2nd concept is too uncertain. We have to stay as natural as we can within the park.

12th Speaker – Michael Stringer – LSP Conservancy

It's good to see this project gaining momentum on the Jersey side of the Harbor. I'd like to express my support for this project and the goals of maintaining the diversity with minimum disturbance.

13th Speaker - Kathleen McLean - NJ Audubon

I'm a member. Thank Eric Stiles. LSP is a jewel that should be developed properly and not become a golf course.

14th Speaker - Catherine Grimm – LSP Conservancy

Tonight I am representing myself. Many of you know I've been coming to this park since before it was even a park. I have seen spectacular wildlife pictures that you'd never expect. I like the idea of the wetlands restoration but it concerns me that the area where the dredged material from the river has been dumped—they will have to come in there and dig everything out. They never should have put it there in the first place. Now they are talking about another area where they would put a swimming pool and other things to block view of industrial area but when you come in it blocks view of skyline from Harbor. It's a two-way street.

I am concerned geologically that with bringing water inland, there are so many fresh water ponds in the uplands that mostly – that bringing salt water in whether it will underground contaminate fresh water ponds—and destroy habitats we already have.

Whether this has been considered or looked into, I do not know. But it should be by the Corps of Engineers. There is so little fresh water for the wildlife during their migrations, during their nesting that any plans made for the inland site should be kept specifically for the wildlife. Any sports to be developed should be on the outside of the perimeter as far as possible so as not to disturb wildlife during nesting, resting or migration and just leave it developed naturally. We have to watch what they will do—how much vegetation removed, how many trees destroyed because they said something about the big trees but w/out little trees the forest dies.

We also have to look at bringing back wildlife because, since the development of the park started, the pigeon hawk has disappeared and the pheasants have decreased. They fenced off the whole interior wildlife area. The rabbits in there were locked in. Rabbits outside were locked out. Rabbits have to go back and forth in order to maintain their own life. The pheasant, the cormorant, the monarch butterflies—we are on the migration route for the monarch butterflies coming down the East Coast.

Years ago, I walked into a field at the railroad yard and it became alive with the flowers – the butterflies were resting on this field of eight-foot sunflowers and to walk in there and have hundreds of butterflies around you. I know what it felt like when the scientists walked into the valley and found where the monarchs go.

These are things children should be able to see. In the development, we have to protect wildlife and vegetation and keep serene for wildlife. So, any walkways and viewing areas must not interfere with nesting and protecting the young.

Mainly I'm concerned about the feed water infecting the fresh water and destroying the uplands.

15th Speaker – Greg Remorig -President of LSP Conservancy

I am glad not to need my formal comment. I will ramble a bit—a while back the press said people were fighting and that the press didn't want to talk with you/them.

But, people will be thanking you for generations to come. What Sam & Audrey are doing and when we have rational discourse and good plans and not the crap the development organization kept pushing down our throats, then we will have conversation where everyone will contribute the wealth of knowledge and understanding. And that's what happened. It's phenomenal! Yes, there are slight disagreements and differing ideas about what could happen with the flow of water and other things, but we are discussing it and there has not been anything heated. We are working with agencies and sometimes we butted heads with and sometimes we didn't and the Corps has been fantastic—Joel Redican, Bob and ...it's a new day. It's not surprising us—we worked hard for it but it happened quickly and the right plan and right people came together.

I have 3 main points about the interior. One thing that was left out was that this project came at two levels: people at the grass roots led by Frank Gallagher and inter-disciplinary planning committee led by Frank Gallagher but at the same time the Corps, Habitat Estuary program and Mark, before he came over was Chair of the Habitat Work Group, very productive. So, we had ideas and people on a larger level to implement, and it's all coming together. One thing we should do is to think boldly –as Dr. Koster says over and over again: noting should skimped. Don't cut corners. We have to look at cost benefit alternatives; but most importantly, that this is a grand park that combines natural

attributes with social & human attributes. Judging from the support of Congressman Menendez who was there back in the quiet days—bring me a good plan—I will champion it – Desiree has done a phenomenal job.

Quick points: The general management plan came out of years of people coming down here. It is flexible but has a plain point and I don't want to lose that. It has room, flexibility and I want to be sure that it came out of strong work by the city and the inter-disciplinary committee. The other thing is – and I know it puts stress on the staff and you don't always have control over it – about what the Assistant Commissioner said about three/two years ago: we are going to drive that and provide you with clear information and vision. We will push you to move quickly and do things you haven't done before. Be responsive to local partners and ask for whatever it takes to move it along; even if we need to talk to Congress it has to move or we may lose it.

Be sure that the barrier has buffer sufficient to be sure not disturbed.

Also, it is important that we have trails that are aligned correctly. It should be done right but I am a strong advocate that the public gets to enjoy the park.

From the point of interpretation, there is a wonderful interpretive program here at LSP. Gina, Lorie, Diane—they take folks to beach on southern part of the park and will make sure that nature interpretation is part of the center park as well.

16th Speaker - Gregory Giordano – Friends of LSP

I'm a member of the *Friends of Liberty State Park*. The park is fundamentally a park for all people, and a golf course would have violated basic principal of social justice. It would have given a great deal to a few. The natural habitat is important. You cannot separate social justice from the environmental issue. The basic philosophy is that this is for the people as well as for nature. You have a natural fly-a-way for over 230 species of birds and we are only a couple miles from New York City so this should maintain a priority.

The other aspect is that the park was developed without a foundation—meaning they addressed the park first insofar as building and haphazardly focused on toxicity. They

built without a foundation to continue in this vein. By focusing on toxicity you focus on three major players responsible for it: Allied Single, PBG and (___). Chromium history goes back to 1887 by Lawrence Wells. He was a sector of industry—back to Scotland and Germany – over 100 years. Now why the EPA has not been able to focus on this and make these major players responsible for this is a small mystery. However, we still need money to build this park and the idea of focusing on the Corps of Engineers-this is tax-payers' money. This money should be coming from major players and the international corporations that also profited from this by getting rid of chromium as they did throughout Hudson County made their product cheaper to those who were using it like GM and GE.

The development corporation should reach out to all the corps for funding for this park. Now, regarding the aspect of the building of the park, there is one thing we are not focusing on. There has to be an exit and entrance from North side of park. It is built on a peninsula. We have access from the West with access and ingress. The marina should not be there. Your Army Corps can be doing this. We can do. Fill in the marina and build a walkway and bridge in the north part of the park to have access in and out at the north end.

The marina, if you look at it—check the base and go into the soil you will see the silky quality that is a harbinger for disease. I liken it to a Chinese village, with the problem of spilling toxins with body waste is like what you will have going into that marina. If you have any remnants of a canal, all it should have is rowboats. It is important that we build a roadway from the north area, bring in a rail behind that restaurant and take it out again. At the same time, you have a walkway. Focus on the aspect of the park for all people. We have in the southeast corner a memorial to the holocaust and that has always been a focal point—a sign of the park at the memorial is for the fact that occurred because of arrogance, greed and quest for power. The same indifference has been developing the park and we must avoid this.

17th Speaker - Howard Moskovitz

There is a whole generation of people responsible for this park who cannot be here today. What we have been hearing from certain agencies is what we have been fighting for over a quarter of a century. I prevented the Department of EP from spreading 40 acres of blankety-blank dredge soil with 6" of dirt to be put above it. I looked at the assistant NJ

attorney general and asked "Ma'am would you allow your child to play under those conditions?" That is why those dredge spoils were never spread, but why they haven't been removed in over 20 years is another...

Among the 10 agencies involved in the 2- year process, only two agencies supported the plan we put forth. The NJ DEP and the Army Corps of Engineers. It is so refreshing to hear such a different perspective as tonight. I won't name the other agencies, but you can see their comments and their opposition. It's very good there is an inter-governmental process gong on here. I would like to commend Mr. Ramon; this could be a new day for LSP, it depends on us and on the officials in government. I'd like to also say this park is owned by the State of New Jersey. There are many actions the State can take, but it should not have waited these 25 years. I'd like to say that the gentleman representing the project manager for the Army Corps should urge that individual be assigned specifically and a staff be assigned because the number of issues concerning the LSP is lengthy.

There has been passing reference to the LP Development Corp. In the spring the Dept of EP announced that it had found significant financial irregularities and the Development Corp spent their time fighting these last 2.5 years to have our questions answered. Nothing happened. Why can't we have a public meeting as to the continuation of the contract, which can be terminated by the St. of NJ with the Lib St Park Dev which is by far and away the entity that has prevented the incredible promise this park held. It was people like us, not the bureaucrats who had it officially founded in1976. The time has come for an end to the Liberty St. Park Development Corp. It is now five months since the June deadline that the Commissioner gave, to his credit, for the corporation to respond and we have not heard anything. But, there is much more than the financial irregularities. I won't go into detail here. Let us hold a public meeting with the NJ Dept of EP. I just want to respond, as I've been taking notes tonight:

What scientists of all type refer to as the most important ecological feature of LPS and NY Harbor is Haven Point Cove, which has been a designated natural area – it was the #3 designated natural area for 25 years. A 1/2 mile sand beach.

There is no access unless you know the secret. It is not on the map of LSP. Ten years of fighting to prevent its desecration, and it is cleaned 2 times per year. The Haven Point Pier that is part of LSP and by a minority vote – split – 4-3 whether to include the pier as part of the designated natural area. It has been allowed to deteriorate. I don't know if it

can be saved. *("It's gone?" he asked. "As of when?")* The pier has been torn down in the last six months. The pier goes to the middle of the Harbor—it is a spiritual experience. But the DEP has allowed it to be a terrible situation.

I see there is a Jersey Central Railroad Heritage Festival later this month. Half of the National & State historic sites have been allowed to deteriorate. A year and a half ago the consultants hired by the DEP made recommendations as to what could be done. We realized the finances are not available now for any of those 3 alternatives—at a minimum a cover can be placed over that historic shed to prevent its further deterioration. Twenty-five years ago the track and shed area was in better shape before the State of NJ took it over.

I'm just going to mention other issues to the Assistant Commissioner – under State law the commission and Governor have power to terminate the despicable marina on 30 days notice. I'll be happy to point to the statue that sets that forth.

18th Speaker– Joe Chesonis - Urban Systems Concept Group

I live in No. Bergen. Lets talk about wildlife habitat and allowing all wildlife to have three propagations. I would like to discuss a problem I have with LSP and I've been working with Sam for many years along with the other groups. Instead of the middle of the park—the park has to be a habitat for wildlife and people. I've talked to Sam many times about the middle of park, that it has to rise up around 30 feet. Because all of the concentration – the shoreline is concentration of the view of NY but back farther the concentration of all this human activity is on the water edge. What I'm saying is to develop a stepped up uplands ecology as well as a wetlands ecology. It is extremely important in the inland area mounted 30' high with types of vegetation and good viewing areas, it gives concentration of human activity as well as wildlife that could be there also.

Concentrating totally on wetland extension into the interior is a bad decision. This was a former landfill. It is sort of another landfill from dredged material. Get out of that mentality and talk bout uplands for people, different vegetation and wildlife. Rather than wetlands migration because this was an old landfill -- so you are leaching materials out of many years. Go into a different eco system that was in this area long ago that everyone destroyed. But developing this 30' hi eco system could be beautiful w/elevation rather than migrating wetlands in a soggy former landfill. Also, I would like to say we wish to

have your cooperation with another idea—a nice idea –which is called 2 Rivers Meadow Bay—organizing the Hackensack & Passaic tidal areas and the Newark Bay as one entity. Development pressures are on there to build and we have to have something to say about it.

19th Speaker - Bill Armbruster

Dr. Koster's concept regarding ingress and egress, and lady in back preserving freshwater habitat and being mindful of possible contamination and, finally, I suggest that the different alternative plans be on a website so that people can evaluate them.

***

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://njfieldoffice.fws.gov

FP-04/35

JUL 14 2005

Colonel Richard J. Polo, Jr.
District Engineer, New York District
U.S. Army Corps of Engineers
Jacob K. Javits Federal Building
New York, New York 10278-0090

Dear Colonel Polo:

The U.S. Fish and Wildlife Service (Service) has reviewed preliminary project information for the U.S. Army Corps of Engineers, New York District's (Corps) Liberty State Park ecosystem restoration project located in Jersey City, Hudson County, New Jersey. The Liberty State Park restoration is part of the Corps' Hudson-Raritan Estuary (HRE) restoration study. The Service participated in Planning Development Team (PDT) meetings for Liberty State Park on September 25, 2003, December 9, 2003, and January 13, 2004, as well as a specific wildlife meeting on December 11, 2003. The Service provides this Planning Aid Letter (PAL) pursuant to a Scope of Work dated June 15, 2004. The Service has also reviewed the most current conceptual design for proposed restoration.

The focus of the Corps project is an approximate 225-acre undeveloped site in the interior of Liberty State Park, including a roughly 45-acre dredge spoil disposal area. Potential ecosystem enhancement measures in the park interior include creation of tidal marsh in the dredge spoil disposal area, protection and enhancement of freshwater wetlands, and upland management to control the encroachment of invasive species. The proposed enhancements would be carried out in cooperation with the New Jersey Department of Environmental Protection (NJDEP) Division of Parks and Forestry (DPF), the non-federal sponsor for the post-Feasibility phases of the Liberty State Park project. The Service appreciates the Corps' efforts in the planning stages for this highly visible restoration project that will benefit fish and wildlife and provide opportunities for public outreach and education.

AUTHORITY

The following comments are provided as planning aid and do not constitute the report of the Secretary of Interior pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*) (FWCA). Comments are also provided under the authority of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA) and

the Migratory Bird Treaty Act (MBTA) (40 Stat. 755;16 U.S.C. 703-712), and are consistent with the intent of the Service's Mitigation Policy (Federal Register, Vol. 46, No. 15, Jan. 23, 1981).

SERVICE COMMENTS

To assist in project planning and the preparation of environmental documents, the Service provides the following summary of preliminary comments and recommendations that were previously offered in our November 8, 2002 letter (or log no. FP-02/47) and verbally at meetings.

General Comments

Recent studies of compensatory mitigation in New Jersey (Balzano *et al.*, 2002) and across the country (National Research Council, 2001) have found that the success of wetland restoration and creation projects is far from guaranteed. However, the science of environmental restoration has progressed considerably over the past two decades, and many lessons may be learned from earlier wetland restoration efforts. Consistent with the findings of these studies, the Service offers the following general recommendations:

- design the restored habitats to become self-sustaining and avoid over-engineered structures (*i.e.*, artificial structures requiring long-term maintenance);
- consider a phased approach to project implementation to allow for correction of problems in establishing target plant communities, and conduct early monitoring as part of adaptive management;
- thoroughly evaluate and address environmental contaminants concerns;
- avoid impacts to protected and sensitive species (*e.g.*, State-listed species) during construction, and include project features to enhance conditions for such species;
- develop a water budget and design the restoration to provide naturally variable hydrologic conditions;
- provide appropriately heterogeneous topography;
- coordinate closely with the contractors responsible for actual project construction, and conduct post-grading on-site meetings and inspections to ensure consistency with construction plans;
- incorporate design features to avoid re-establishment of invasive species, and incorporate invasive and nuisance species vegetative control and herbivore management into project planning;
- consult the scientific literature and use the best available information regarding planting

elevation, depth, soil type, and seasonal timing, and subsurface conditions to include soil and sediment geochemistry and physics, groundwater quantity and quality, and infaunal communities;

- implement a monitoring plan adequate to evaluate success of the subject project, inform the larger HRE restoration planning effort, and contribute to the science of wetland restoration, particularly in urban settings; and

- continue close coordination with existing public and private environmental protection efforts in the HRE throughout project planning, implementation, and monitoring.

Specific Comments

The Service supports the general design concept that would provide various tidal marsh and shrub communities, freshwater wetlands and pools (if a water source is available), upland grasslands, and upland forest.

The Service recommends the Corps:

- test existing water quality of parking lot runoff proposed as a freshwater source, and design treatment basins to ensure that water directed into the restoration area is sufficiently clean to support diverse aquatic communities; and

- test North Cove sediments, groundwater, and soils for environmental contaminants in the excavation areas at the depths to be excavated. Based on a preliminary review, the Service supports the proposed use of invertebrate Effects Range - Low (ERLs) guidelines as one screening tool, but notes that ERLs do not address potential acute or chronic toxicity to species in upper trophic levels, or the potential for contaminants to bioaccumulate or biomagnify. Bioavailability of contaminants to appropriate wildlife endpoints (*e.g.* northern harrier (*Circus cyaneus*) reproduction) should be the ultimate determinant of the need for remedial actions (*e.g.*, clay liner). The Service requests an opportunity to review proposed methodologies for assessing bioavailability, including the selection of upper-trophic-level endpoints.

The Service recommends the Corps and the DPF:

- consolidate planned cover types (particularly grassland and forest) into larger patches, designed to maximize the area of interior habitat;

- test salinity and pH of groundwater and vernal pools as possible limiting factors in amphibian abundance;

- conduct or fund in accordance with any recommendations from NJDEP Endangered and Nongame Species Program (ENSP), northern harrier monitoring before, during, and after construction, including nest site location, nest success, a tagging program, and (if birds

are present year-round) contaminants testing;

- design and schedule construction to minimize disturbance to nesting harriers;
- plant trees along the interior road to minimize fragmentation effects and control invasive species;
- plant trees in small patches of "old field" cover types that are too small to support grassland species and that fragment the developing forest;
- plant a diverse array of native warm season grasses in the grassland areas, with a large "butterfly garden" (native wildflowers) located in an area of high visibility to the public;
- preserve orchid and moss mat areas; and
- design construction to avoid impacts to known occurrences of State-listed plants.

The Service concurs with the DPF's plan to generally leave upland shrub and forest communities to succeed with minimal interference, and recommends that the DPF:

- develop a long-term habitat management plan (to include control of invasive species and a grassland mowing regime); and
- develop a long-term species monitoring program (*e.g.*, State-listed birds, amphibians), including management actions as appropriate (*e.g.*, predator control, nest platforms).

The Service appreciates the opportunity to provide input into the Corps' Liberty State Park environmental restoration project. Should you have any questions, please contact John Staples or Wendy Walsh of my staff at (609) 646-9310 extensions 18 and 48, respectively.

Sincerely,

Clifford G. Day
Supervisor

REFERENCES

Balzano, S., A. Ertman, L. Brancheau, and W. Smejkal. 2002. Creating Indicators of Wetland Status (Quantity and Quality) Freshwater Wetland Mitigation in New Jersey. New Jersey Department of Environmental Protection, Division of Science, Research and Technology. Trenton, New Jersey.

National Research Council. 2001. Compensating for Wetland Losses Under the Clean Water Act. National Academy Press. Washington, D.C.

LIBERTY STATE PARK
JERSEY CITY, HUDSON COUNTY, NEW JERSEY
SUB-SURFACE SOIL CHARACTERIZATION
AUGUST 2003 – FEBRUARY 2004

In August of 2003, The Army Corps of Engineers, New York District (the District) initiated an extensive sub-surface soil characterization within Liberty State Park. This fieldwork was in collaboration with the New Jersey Department of Environmental Protection (DEP), Division of Parks and Forestry (Parks). The District is partnering with the DEP on the planning and reintroduction of tidal wetlands and the enhancement of fresh water wetlands and upland habitat. The purpose of this fieldwork was to define the vertical and lateral extent of any existing contamination. The entire park is comprises fill placed there over the decades starting back in the late 1800's. The area(s) to be characterized were mostly in the middle third part of the park and further concentrated in an area presently fenced off. Within this 45-acre fenced off area are dredged sediments placed there in the late 1980's by New York District during construction of the bulkhead for the walkway. Information obtained from this sampling will be used to direct the planning, design and construction of tidal wetlands within that central area of the park.

The drilling was conducted by the Corps of Engineers – Baltimore District drill crew with laboratory analyses conducted by the US Army Environmental Lab at Fort Monmouth, NJ. Samples were collected, described and shipped by District personnel. There were two phases of drilling. The first phase took place over 22 days from 11 August through 7 September 2003. The second phase occurred over 4 days from 2 February through 5 February 2004.

Background:

Prior to the start of placing fill in that area that eventually would be come Liberty State Park (LSP) was primarily shallow open water and mud flats. Starting in the late 1800's the shallows/mud flats were covered over by dumping of fill. Over the next several decades the area was completely covered over with debris, excavated soil from other construction projects, demolition debris, blasted stone from construction sites, obsolete wooden barges filled with stone and coal ash and sunk in place. Eventually the filled in area extended outward over one mile from the historic shoreline. The dominant activity on this filled in area was railroad. There were locomotive repair shops, fuel oil storage tanks, rail sidings, docks for rail ferries to New York City and a passenger terminal.

In the early to mid 1900's quantities of chromium laced waste tailings, from nearby chromium (chrome) ore processing plants, was used as fill. This fill was subsequently built on by the railroads. In the mid to late 1960's railroad activity ceased and the site evolved into an abandoned area. By the mid 1970's the NJDEP started buying up the land that eventually became the state park. At the time of this purchase, the characterization of the fill material started. What the early sub-surface soil sampling showed was how extensive the chrom laced back fill was. Further studies over the years determined concentration levels, depths and areal extent of the chrome fill.

In the late 1980's dredged sediment from the area immediately adjacent the present day walkway was placed in the center third of the park and fenced off within a 45 acres parcel from the general public. This dredged sediment is managed as hazardous and signs placed on the fence warn of such. To ensure the containment of this material is was capped with presumably clean sand. This area is isolated from the main areas of public activity within the park. Long

range plans by park management show this area as wetlands and habitat restoration thus turning this area into a focal point for wildlife habitat. The sub-surface soil characterization conducted in August, September 2003 is the first step in bringing that plan to fruition.

In February 2003, AMEC, New York District conducted a Phase One Site Assessment on Liberty State Park. Considering the already extensive files and reports already in existence, the purpose of the Phase One was to physically locate and review those documents. The report concisely summarizes the site's history leading up to it becoming a state park. The Phase One report is part of this document as an attachment.

Field Sampling Methodology:

To conduct the sub-surface characterization a CME drill rig all terrain vehicle (ATV) was utilized. This type drill rig has the capability of drilling through the type of fill anticipated to be within the study area. A total of forty (40) borings were planned and thirty-eight (38) were completed in the first phase. Two of the forty borings were planned for the sediments in North Cove. A barge mounted drill rig from the Baltimore District was used to accomplish that part of the project. Planned boring depths were twenty-eight to thirty feet (28 – 30) below ground surface (bgs). This depth was picked as the proposed new bottom elevation for the proposed tidal channels. Soil samples were collected at two locations within the boring, at the halfway point (13 – 17 feet below ground surface) and bottom. Samples were placed in clear eight-ounce glass jars; there were three jars of soil per set. A total of six sample jars per boring were collected. Samples collected from the bottom were analyzed; samples collected at the midway point of the boring were archived. Once a boring was completed its location was marked with a Global Positioning System (GPS).

In the second phase, seventeen (17) samples were collected at a depth of 12-15 feet below ground surface. Two of the samples were collected from North Cove. The sampling, storage and analysis techniques were identical to that of the first phase.

Samples were collected using a stainless steel two-inch diameter "split spoon". The split spoon was advanced into the ground inside a four-inch hollow stem auger. There was continuous split spoon sampling, in two foot increments, from surface to bottom of boring. After a spoon was pushed down to depth and retrieved, an auger was advanced down to the depth of the previous spoon. Once a spoon was retrieved, it was opened, its contents described and written down into a field log book, with time of day, soil boring number, depth collected from, percent recovery within the spoon (recovery was listed in 10, 20, 30 percent, etc.), color, noticeable odors, grain size/texture, moisture content (saturated, moist, etc.), changes in lithology (clay to sand, loam to sand, etc.), amount of roots, stone and other material. When a sample was collected it was given a unique identifier code, time and date of collection, initials of the person collecting the sample, analyses required, preserving agents added or not and who the sample was collected for, in this case the sample was collected for the New York District Corps of Engineers. All that information would be written on a label fixed onto the sample jar.

Once a split spoon was used it was set aside, washed of loose soil, then put through a decontamination process: washed in an alconox detergent and rinsed off, rinsed again with de-ionized water, air dried, then a final rinse with laboratory grade acetone and air dried.

All samples collected each day were documented on a form called a Chain of Custody (C of C). This form would list the samples collected that day, initials of the person collecting the samples, types of analyses requested, sample type (solid, liquid) and name of the person signing off on the transfer of the samples. All samples were placed in a cooler packed in ice to chill them down to four degrees centigrade. Ice was placed in small zip lock bags to minimize free water in the bottom of the cooler and to further pack the sample jars in place. All samples were placed in zip lock bags as well. The C of C was placed in a zip lock bag and put inside the cooler with the samples. All coolers were sealed for transit with duct tape. Baltimore District personnel delivered all samples to the Fort Monmouth Environmental Lab, Fort Monmouth, NJ.

The lab analyzed for the following constituents: Volatile Organics +15 Library Search (VOA+15), Acid Base Neutrals + 25 Library Search (ABN+25), Pesticide/PCBs, Total Petroleum Hydrocarbons (TPHC), RCRA Metals, Percent Solids. Turn-around time was the standard three weeks. Archived samples will stay at Fort Monmouth until further notice. All samples were soil no water samples were collected.

Laboratory Methodology Summary:

EPA SW-846 Method 8260
Gas Chromatographic Determination of Volatiles in Soil.

EPA SW-846 Method 8270
Gas Chromatographic Determination of Semi-volatiles in Soil

EPA SW-846 Method 8081/8082
Gas Chromatographic Determination of Pesticides and PCB's in Soil

EPA SW-846 Method 3051, 3rd Edition Base Manual with Final Updates I, II, IIA, IIB and III: Digestion of Priority Pollutants Metals

Milestone MLS and 1200 MEGA

EPA SW-846 Method 6010, 3rd Edition Base Manual With Final Updates I, II, IIA, IIB, and III: ICP Priority Pollutant Metals

Perkin Elmer OPTIMA 3000 DV

EPA SW-846 Method 7471A, 3rd Edition Base Manual With Final Updates, I, II, IIA, IIB and III: Mercury

Varian SpectrAA-640, VGA-77

NJDEP Method OQA-QAM-025 10/97
Gas Chromatographic Determination of Total Petroleum Hydrocarbons in Soil.

Data Review:

The following categories of constituents were analyzed by the Fort Monmouth Environmental Laboratory and Lionville Lab, Inc. (hexavalent chromium):

- Volatile Organics plus 15 (VOA + 15)
- Acid Base Neutral plus 25 (ABN + 25)
- Pesticides/PCBs (Pest/PCBs)
- Total Petroleum Hydrocarbons (TPHC)
- Priority Pollutant Metals
- Percent Solids (% solids)
- Total Hexavalent Chromium

Effects Range Criteria for Sediment:

Effects Range (ER) criteria used to gauge potential impact of contaminated sediment. The purpose is to quantify how much contamination is present and it's potential for being released into the food chain, thus ingested by the native fauna and potentially affected by that contamination. The ER criteria has three levels; Low, Medium, Severe. The threshold levels for exceeding ER levels are more conservative than, for example the Non-Residential Direct Contact Soil Cleanup Criteria. Those areas of the park that will excavated and potentially made part of the planned wetlands the ER criteria may be implemented on the now exposed lower layers of sediment

Non-Residential Direct Contact Soil Cleanup Criteria:

Non-Residential Direct Contact Cleanup Criteria (NRDCSCC) is a NJDEP guideline used to manage the cleanup of impacted soils, impacted areas that will not be residential in its final designed use. This guideline would be used to manage the restoration of those areas excavated during construction but not part of the planned wetlands.

Volatile Organics plus 15:

Of the 38 samples there were no significantly measurable quantities of VOAs found. The parameter of measurement was Part Per Billion (ppb). There were 33 samples with measurable amounts of acetone and 2-butanone. Their presence is explained by the use of acetone in the field as a decon agent and 2-butanone is a solvent very similar to acetone, present in laboratories and it's presence here is not at all surprising. Neither of these VOAs was present in any quantity exceeding threshold limits for the NJDEP's Non Residential Direct Contact Soil Clean Criteria (NRDCSCC), or Impact to Groundwater Soil Cleanup Criteria (IGWSCC). Both VOAs are not on the DEP's Effects Range for Marine/Estuarine Sediment Screening Guidelines.

All 38 samples had VOAs listed as Tentatively Identified Compounds (TICs), they left a distinct mark on the gas chromatograph analysis, but their exact identification could not be determined. Hexane did appear several times on the TIC list, with one sample as high as 220 ppb (or .220 ppm). The reason for hexane being listed in the TIC is its presence was suspected but not confirmed. Its presence is explained as lab influence plus it did not exceed any NJDEP criteria and thus a non-issue. Other TICs had readings as high as 276 ppb (or .276 ppm) and as low as 10 ppb (.0.010 ppm). The high TIC number, like the 276 ppb is the total of the several TICs present in that one sample.

Acid Base Neutrals plus 25:

All 38 samples had TICs. The number of TICs per sample ranged from two to eleven and ranged from 1990 to 93,300 ppb (1.99 to 93.3 ppm). Those numbers are the total of all TICs present in that

one sample. Compared to the NRDCSCC the ABN levels are below thresholds in the identified ABNs and the TIC ABNs. When compared to the Effects Range – Low criteria (ERL), the guidelines referred to thresholds established for freshwater sediment screening. Bear in mind the sediment analyzed in this came from a tidal estuary, not a freshwater environment.

There were three ABNs that exceeded the ERL, they are pyrene, fluoranthene and phenanthrene. Pyrene was 3300 ppb (3.300 ppm), the ERL is .490 ppm. Phenanthrene was 2100 ppb (2.100 ppm), ERL is .560 ppm. Fluoranthrene was 3500 ppb (3.500 ppm), ERL is .750 ppm. These three ABNs add up to 8900 ppb or 8.900 ppm. If the total amount of TICs in a sample added together exceed 4.00 ppm (4000 ppb) then these are a flagged sample location. There are over six samples exceeding this threshold. Sample LSP-03-20 which has a TIC number of 93,300 ppb or 93.300 ppm, has the highest exceedence. The next lowest TIC exceedence is 64,800 ppb or 64.800 ppm. The numbers range down from there to 5010 ppb or 5.010 ppm.

Pesticides:

No pesticides exceeded the NRDCSCC, IGWSCC or ERL thresholds. Only one pesticide was detected, Dieldrin at 1.60 ppb (or 0.0016 ppm). The ERL threshold is 0.002 ppm.

PCBs:

There were no PCBs detected.

TPHC:

Only one sample came up positive for TPHC, sample LSP-03-20. The number was 549.31 ppm. There are no threshold limits for TPHC in the NRDCSCC, IGWSCC or ERL.

Metals Priority Pollutant List:

Of the 38 samples, fourteen (14) exceeded the ERL. No samples exceeded the NRDCSCC or IGWSCC. Nickel was the most prevalent (twelve samples) metal exceeding the ERLs. The threshold is 21 ppm, the highest exceedence was 31.9 ppm. Next was cadmium with seven samples exceeding threshold of 1.2 ppm, the highest number was 1.74 ppm. Next was arsenic, with four samples exceeding threshold. ERL threshold is 8.2 ppm, the highest number was 10.0 ppm. Next is mercury with two samples exceeding threshold. ERL limit is 0.15 ppm, the highest sample was 3.22 ppm. The last metal was lead, with one exceedence. The ERL is 47 ppm, the highest number was 74.3 ppm. All of the highest metal numbers came from one sample…LSP-03-20. Other samples with exceedences were generally barely above threshold.

Hexavalent Chromium:

Hexavalent Chromium was detected in only nine samples. The numbers ranged from 0.45 ppm up to 9.4 ppm. Interestingly enough sample LSP-03-20, which had the highest numbers in metals and TPHC did not have the highest number.

Summation for Round 1:

All things considered, the bottom sediment layer (28 – 30 feet) is not as impacted as previously thought. The surprisingly low numbers in hexavalent chrome can lead one to conclude the metal did not leach all that much downward to the depths drilled to (thirty feet). Considering the amount of chromium-laced backfill dumped on what is now Liberty State Park this is unexpected. The rest of the Priority Pollutant metals analyzed for were unexpectedly low considering the history of the site. Even

when there were numbers above threshold, those numbers were not that high. In many samples the exceedences were only a fraction above threshold. Reviewing the TPHC analyses it was equally surprising to see only one sample to come up with detectable limits. For the pesticides and VOAs no new information on what is in the sub-soil came out of this. The level of ABNs was unexpected. Even though only three ABNs exceeded threshold it was still unexpected considering the site's history. What was expected was a series of samples exceeding thresholds for metals, TPHC and hexavalent chromium. That was not the case. In fact only sample, LSP-03-20 came up with any significant numbers in the aforementioned categories. The analytical information from LSP-03-20 points to a concentrated pocket of contaminants in that vicinity of the park. This information will be used to plan accordingly on how best to excavate and manage the handling of this material.

Date Review for Round 2:
A second phase was conducted in February 2004, based on results of the August 2003 investigations. This round focused on the route of the proposed tidal creek and collected 17 continuous samples from the surface to 15 feet bgs (Figure 7 in Geotechnical Appendix, Vol. 1). Sampling and analysis procedures for this round were identical to the procedures used in Round 1.

Volatile Organics plus 15:
Of the 17 samples there were no significantly measurable quantities of VOAs found. The results are similar to those of Round 1, which took samples from a depth of 30 feet bgs.

Acid Base Neutrals plus 25:
Over all, the numbers were low across all the samples, except for three: NC04-04 with 52 ppm, NC04-03 with 636 ppm, and CA04-03 with 66 ppm. NC04-4 and NC04-3 are close to LSP-03-20, and CA04-03 is in the center of the containment area.

Pesticides:
No pesticides were detected.

PCBs:
No PCBs were detected.

TPHC:
Three samples came up positive for TPHC: NC04-3 with 600 ppm, NC04-3 with 2896 ppm, and CA04-03 with 2284 ppm. The result for CA04-03 is similar to that of other samples from round one in the same area, and is to be expected given the history of the site. There are no threshold limits for TPHC in the NRDCSCC, IGWSCC or ERL. These are the same samples of concern from the Acid Base Neutrals analysis.

Metals Priority Pollutant List:
Of the 17 samples, three (3) exceeded the NRDCSCC. Lead was the most prevalent (three samples) metal exceeding the NRDCSCC. The threshold is 600 ppm, and the highest exceedence was 2400 ppm. One sample, NC04-03 in North Cove, had the highest concentration of metals exceeding the NRDCSCC. Below is a table listing the metals, NRDCSCC limits, and NC04-03 results for that metal:

Metal	NRDCSCC(ppm)	NC04-03(ppm)
Arsenic	40	68
Copper	600	1600
Lead	600	2400
Zinc	1500	5760

It is worth noting sample NC04-03 is in close proximity to Sample LSP-03-20, which yielded the highest concentrations of metals in round one, reinforcing the need to implement precautionary measures in working with this material.

Hexavalent Chromium:

Hexavalent Chromium was detected in only three samples. The numbers ranged from 0.36 ppm up to 2.0 ppm. Two of the samples were from the containment area (CA04-06 AND CA04-01). The highest concentration of hexavalent chromium came from sample NC04-03 in the North Cove at 2.0 ppm. As the NJDEP guideline for hexavalent chromium is 20 ppm, levels of this metal will not be a major concern in any work done within the project area.

Recommendations:

In two rounds of sampling, only 2 sample points, LSP-03-20 and CA-04-03 came up with significant levels of contaminants. As these two samples are in close proximity to each other, it would be reasonable to assume that the sub-soil in the vicinity would be equally impacted with decreasing levels as one moves outward from these two points. When time comes for excavation of areas adjacent to this, additional engineering controls will have to be implemented. Estimates can be prepared on potential volume of material to be excavated. Exact controls can be specified at a later time but at a minimum there will be strict segregation of excavated material and placement of that same material in the park's designated disposal area. It may be this sub-soil is too impacted to be secured within the park's area and must be hauled off site for final disposal. Plans to manage this should be drawn up and funds dedicated to that task. When plans for construction are drawn up, there must be protocols and procedures written out on how to address pockets of concentrated chrome impacted waste, drums, remnants of drums, pockets of oil. These plans will include health and safety protocols, procedures for isolating the area(s), collecting soil/sediment/water samples, personal protective equipment to wear, level of air quality monitoring to maintain, decon procedures to follow, chain of command in notification and managing the impacted soils, debris, etc. These health and safety plans will be fully detailed and presented to the NJDEP for review and comment before actual construction starts.

As for the remaining sample locations it appears the extent of impacted sub-soil is not as pervasive as previously thought. It looks entirely feasible that only simple dust suppression procedures may be adequate, that straightforward excavation methods be employed and equally straightforward placement/containment of the excavated sub-soil in the park's southwest corner.

Fort Monmouth Environmental Laboratory
NYSDOH Certification # 11699
Laboratory Director: Daniel Wright
Telephone Number: 732 532-4359

Fort Monmouth Environmental Laboratory follows approved EPA SW-846 and NYSDOH methodology. The list below is a summary of the methods that are followed:

Method Summary

EPA SW-846 Method 8260
Gas Chromatographic Determination of Volatiles in Soil

A 5-gram volume of soil sample is added to a 5-ml aliquot of water. Surrogates and internal standards are added and the sample is placed on a purge and trap concentrator. The sample as purged and desorbed into a GC/MS system. Volatiles are identified and quantitated. The final concentration is calculated using soil weight, percent moisture and concentration.

EPA SW-846 Method 8270
Gas Chromatographic Determination of Semi-volatiles in Soil

Surrogates are added to a 10-gram soil sample that has been dried with sodium sulfate. The sample is then extracted using a soxtherm extractor. The extract is concentrated to 1 ml. Internal standards are added and the sample is injected into a GC/MS system. Semi-volatiles are identified and quantitated. The final concentration is calculated using soil weight, percent moisture and concentration.

EPA SW-846 Method 8081/8082
Gas Chromatographic Determination of Pesticides and PCB's in Soil

Surrogates are added to a 10-gram soil sample, which has been dried with sodium sulfate. The sample is then extracted using a soxtherm extractor. The extract is concentrated to 10 ml. Internal standards are added and the extract is injected into a GC/ECD system. Pesticide and PCB's are identified and quantitated. The final concentration is calculated using soil weight, percent moisture and concentration.

EPA SW-846 Method 3051, 3rd Edition base manual with final Updates I, II, IIA, IIB and III: Digestion of RCRA Metals

Milestone MLS 1200 MEGA
A representative sample of 1.0 to 5.0 grams is digested in 10 ml of concentrated nitric acid for 10 minutes heating with a suitable laboratory microwave unit. The sample and acid are placed in a fluorocarbon (TFM) microvessel. This vessel is capped and heated in the microwave unit. After cooling the vessel contents are filtered and then diluted to a 100-ml volume and analyzed by ICP.

EPA SW-846 Method 6010B, 3rd Edition Base Manual with Final Updates I, II, IIA, IIB and III: ICP RCRA Metals

Perkin Elmer OPTIMA 3000 DV
The method measures element-emitted light by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Radio-frequency inductively coupled plasma produces element-specific atomic-line emission spectra. The spectra are dispersed by a grating spectrometer and a Segmented-array Charged-coupled-device Detector (SCD) monitors the intensities of the lines. Background and interelemental correction is used for trace element determinations.

EPA SW-846 Method 7471A, 3rd Edition Base Manual with Final Updates I, II, IIA, IIB and III: Mercury

Varian SpectrAA-640, VGA-77
The flameless AA procedure is a physical method based on the absorption of radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrometer. Absorbency (peak height) is measured as a function of mercury concentration and recorded in the usual manner.

EPA SW-846 Method 9045C, 3rd Edition Base Manual with Final Updates I, II, IIA, IIB, and III: pH

20 mL of reagent grade water is added to 20 grams of soil in a 50 mL beaker. Cover the beaker and continuously stir the suspension for 5 minutes. Let the soil suspension stand and then measure the pH with a glass electrode.

Chain of Custody Instructions

1. Fill out the customer name, phone number and type of project (DERA OMA other).
2. Include project number, if known and the location where the samples were taken.
3. Include samplers' name and company if different than above.
4. To be filled out by the laboratory.
5. Fill out the sample location for each sample and blank submitted to the laboratory. **IMPORTANT!** This will determine how your samples are identified in the results and reports.
6. Report the date each sample was collected.
7. Report the time each sample was collected.
8. Record sample type: Aqueous (AQ), Soil, sludge (S), Drinking water (DW), Oil, etc.
9. Include the total amount of containers for each sample.
10. Record the types of analyses required. Then check the corresponding boxes for each sample.
11. Signature of person relinquishing the samples to the laboratory.
12. Date and time the samples were relinquished to the laboratory.
13. Signature of person at the laboratory accepting the samples.
14. Fill out the type of report required and the turn around time. **IMPORTANT!** This will make sure your regulatory requirements are met and that your data will be reported when it is needed.
15. To be filled out by the laboratory.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
HTRW CENTER OF EXPERTISE
12565 WEST CENTER ROAD
OMAHA, NEBRASKA 68144-3869

REPLY TO
ATTENTION OF:

February 14, 2002

Hazardous, Toxic and Radioactive Waste
Center of Expertise

Lionville Laboratory Inc.
ATTN: Carol Schrenkel
208 Welsh Pool Road
Lionville, PA 19341

Gentlemen:

This correspondence addresses the recent evaluation of Lionville Laboratory of Lionville, PA by the U.S. Army Corps of Engineers (USACE) for chemical analysis in support of the USACE Hazardous, Toxic and Radioactive Waste Program.

Your laboratory is now validated for the parameters listed below:

METHOD	PARAMETERS	MATRIX(1)
300 series	Anions(4)	Water(2)
9010B/9012A	Cyanide	Water(2)
9013/9012A	Cyanide	Solids
8280	Dioxins/Furans(5)	Water
8280	Dioxins/Furans(5)	Solids
8330	Explosives	Water(2)
8330	Explosives	Solids(2)
8151A	Herbicides	Water(2)
8151A	Herbicides	Solids
7196A	Hexavalent Chromium(5)	Water
3060A/7196A	Hexavalent Chromium(5)	Solids
413.1	Oil & Grease	Water(2)
9071	Oil & Grease	Solids
8081A	Organochlorine Pesticides	Water(2)
8081A	Organochlorine Pesticides	Solids
8082	Polychlorinated Biphenyls	Water(2)
8082	Polychlorinated Biphenyls	Solids(2)
8310	Polynuclear Aromatic Hydrocarbons	Water(2)
8310	Polynuclear Aromatic Hydrocarbons	Solids

8270C	Semivolatile Organics	Water[2]
8270C	Semivolatile Organics	Solids[2]
6010B/7000A	TAL Metals[3]	Water[2]
6010B/7000A	TAL Metals[3]	Solids[2]
9060	Total Organic Carbon	Water[2]
Mod 8015	TPH - DRO/GRO[5]	Water
Mod 8015	TPH - DRO/GRO[5]	Solids
8021B	Volatile Organics	Water[2]
8021B	Volatile Organics	Solids
8260B	Volatile Organics	Water[2]
8260B	Volatile Organics	Solids

Remarks:

1) 'Solids' includes soils, sediments, and solid waste.

2) The laboratory has successfully analyzed a performance evaluation sample for this method/matrix.

3) TAL Metals: Aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

4) Anions: Chloride, fluoride, sulfate, nitrate, nitrite, and ortho-phosphate.

5) Approval for this parameter is based on review of SOPs only.

Enclosed for your information is a copy of the Laboratory Inspection and Evaluation Report. Your laboratory has responded to the deficiencies as noted in the report. No further responses are necessary.

Based on the successful analysis of the performance evaluation samples, the results of the laboratory inspection, and your Corrective Action Report, your laboratory will be validated for sample analysis by the methods listed above. The period of validation is 24 months and expires on February 14, 2004.

The USACE reserves the right to conduct additional laboratory inspections or to suspend validation status for any or all of the listed parameters if deemed necessary. It should be noted that your laboratory may not subcontract USACE analytical work to any other laboratory location without the approval of this office. This laboratory validation does not guarantee the delivery of any analytical samples from a USACE Contracting Officer Representative.

Any questions or comments can be directed to Cheryl Groenjes at (402) 697-2568. General questions regarding laboratory validation may be directed to the Laboratory Validation Coordinator at (402) 697-2574.

Sincerely,

Marcia C. Davies, Ph.D.
Director, USACE Hazardous,
Toxic and Radioactive Waste
Center of Expertise

Enclosure

STANDARD OPERATING PROCEDURE

SOP No.: SAM-0200
Revision No.: 1
Date Revised: 7/28/99
Page 1 of 4

CATEGORY: Sample Handling
TITLE: Sample Containers, Preservation and Holding Times

1 PURPOSE: To document the sample containers, preservation and holding times requirements.

2 RESPONSIBILITY: Quality Assurance shall be responsible for maintaining and updating the sample containers, preservation and holding times SOP. These updates will occur annually at a minimum or as the methods' requirements change.

3 REFERENCES: Field Sampling Procedures Manual, May 1992. New Jersey Department of Environmental Protection.

4 SUMMARY: The following table is a summary of the sample containers, method required preservation and holding times of various analytical parameters. The summary will provide information to field sampling personnel and laboratory analysts. Additionally, this summary will aid individuals involved with data validation, quality assurance and sample receiving.

Table 1

Parameter	Container	Preservation	Holding Time*	Method
VOA AQ	2-40 ml septum, G Teflon lined cap	HCL, to pH <2 Cool, 4°C	14 days	624 (4), 8260 (2)
VOA Non-AQ	2 oz wide, G Teflon lined cap	Methanol, Cool, 4°C	14 days	8260 (2)
BNA AQ	1 L amber, G Teflon lined cap	Cool, 4°C	Extraction. 7 days Analysis 40 days	625 (4), 8270 (2)
BNA Non-AQ	4 oz wide, G Teflon lined cap	Cool, 4°C	Extraction. 14 days Analysis 40 days	8270 (2)

Prepared By _____ Date_____

Approved By _____ Date_____
QA Manager / Laboratory Director

CATEGORY: Sample Handling
TITLE: Sample Containers, Preservation and Holding Times

Parameter	Container	Preservation	Holding Time*	Method
Pest/PCB AQ	1 L amber, G Teflon lined cap	Cool, 4°C	Extraction. 7 days Analysis 40 days	608 (4), 8080 8081/8082 (2)
Pest/PCB Non-AQ	4 oz wide, G Teflon lined cap	Cool, 4°C	Extraction. 7 days Analysis 40 days	8081/8082 (2)
Herbicides AQ	1 L amber, G Teflon lined cap	Cool, 4°C	Extraction. 7 days Analysis 40 days	8151 (2)
TPHC AQ	1 L amber, G Teflon lined cap	Cool, 4°C	Extraction. 7 days Analysis 40 days	OQA-QAM-25
TPHC Non-AQ	4 oz wide, G Teflon lined cap	Cool, 4°C	Extraction. 14 days Analysis 40 days	OQA-QAM-25
Metals AQ Minus Hg, Cr^{+6}	500ml Plastic	HNO_3 to pH <2	6 Months	600 Series(4), SW846 (2)
Metals Non-AQ Minus Hg, Cr^{+6}	4 oz wide, G Teflon lined cap	None	6 Months	SW846 (2)
Hg AQ	500ml Plastic	HNO_3 to pH <2	28 Days	600 Series(4), SW846 (2)
Hg Non-AQ	4 oz wide, G Teflon lined cap	None	28 Days	SW846 (2)
Cr^{+6} AQ	250 ml Plastic	Cool, 4°C	24 Hours	7196A (2)
Cr^{+6} Non-AQ	4 oz wide, G Teflon lined cap	Cool, 4°C	1 Month	3060A/7196A (2)
TSS AQ	100 ml Plastic	Cool, 4°C	7 Days	160.2 (1)
TS AQ	100 ml Plastic	Cool, 4°C	7 Days	160.3 (1)
DO AQ	300 ml BOD bottle	Fix on Site Store in Dark	8 Hours	405.1 (1)
COD AQ	100 ml Plastic	Cool, 4°C H_2SO_4 to pH <2	28 Days	410.4 (1)
BOD_5 AQ	1 L Plastic	Cool, 4°C	48 Hours	5210B (5)
pH AQ	25 ml Plastic or Glass	None	Immediately	9040 (2) 150.1 (1)

*Holding time begins at time of sample collection.

STANDARD OPERATING PROCEDURE

SOP No.: SAM-0200
Revision No.: 1
Date Revised: 7/28/99
Page 3 of 4

CATEGORY: Sample Handling
TITLE: Sample Containers, Preservation and Holding Times

Parameter	Container	Preservation	Holding Time*	Method
pH Non-AQ	4 oz wide, G Teflon lined cap	None	Immediately	9045 (2)
Total Organic Carbon (TOC) AQ	Glass Teflon lined cap	Cool, 4°C H_2SO_4 to pH <2	28 Days	415.1 (1)
Total Organic Carbon (TOC) Non AQ	4 oz Glass Teflon lined cap	Cool, 4°C	28 Days	9060 (2)
Ammonia AQ	1 L Plastic	Cool, 4°C H_2SO_4 to pH <2	28 Days	350.3 (1)
Chemical Oxygen Demand (COD) AQ	1 L Glass	Cool, 4°C H_2SO_4 to pH <2	28 Days	410.2 (1)
Cyanide, Total AQ	1 L Plastic	Cool, 4°C NaOH to pH>12	14 Days	335.2 (1)
Cyanide, Total Non-AQ	4 oz Glass Teflon lined cap	Cool, 4°C	14 Days	9010 (2)
Hardness as $CaCO_3$ AQ	100 ml Plastic	HNO_3 to pH<2	6 Months	130.2 (1)
Kjeldahl, Total AQ	1 //l Plastic	Cool, 4°C H_2SO_4 to pH <2	28 Days	351.3 (1)
Nitrate/Nitrite AQ	100 ml Plastic	Cool, 4°C H_2SO_4 to pH <2	28 Days	353.3 (1)
Nitrate AQ	100 ml Plastic	Cool, 4°C	48 Hours	352.1 (1)
Nitrite AQ	100 ml Plastic	Cool, 4°C	48 Hours	354.1 (1)
Phenolics AQ	1 L Amber	Cool, 4°C H_2SO_4 to pH <2	28 Days	420.1 (1)
Phosphorus, Total AQ	100 ml Plastic	Cool, 4°C H_2SO_4 to pH <2	28 Days	365.2 (1)
Sulfate AQ	100 ml Plastic	Cool, 4°C	28 Days	375.4 (1)
Specific Conductivity AQ	100 ml Plastic	Cool, 4°C	28 Days	120.1 (1)
Turbidity AQ	500 ml Plastic	Cool, 4°C	48 Hours	180.1 (1)

*Holding time begins at time of sample collection.

Parameter	Container	Preservation	Holding Time*	Method

Surfactants, MBAS AQ	500 ml Plastic	Cool, 4°C	48 Hours	425.1 (1)
Ignitability	P, G	None	NA	1010 (2)
Reactivity - (HCN)	P, G	Cool, 4°C	14 Days	7.3.3 (2)
Reactivity- (H_2S)	P, G	Cool, 4°C	7 Days	7.3.4 (2)
Paint Filter Test	P, G	None	NA	9095 (2)

*Holding time begins at time of sample collection.

(1)-"Methods of Chemical Analysis of Water and Wastes", Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, March 1983, EPA-600 4-79-020.

(2)-"Test Methods for Evaluating Solid Waste", Physical/Chemical Methods, SW-846, 3rd Edition.

(3)-Code of Federal Regulations, Title 40, Part 136.

(4)-"Methods for the Determination of Organic Compounds in Drinking Water", EPA-600/4-88/039, EMSL, USEPA, Cincinnati, OH 45268.

(5)-"Standard Methods for Water and Wastewater", 16th Edition.

STANDARD OPERATING PROCEDURE

SOP No.: SAM-0201
Revision No.: 2
Date Revised: 7/28/99
Page 1 of 6

CATEGORY: Sample Handling
TITLE: Sample Receiving, Log-In and Disposal

1 PURPOSE: To document the procedure for the handling of coolers, logging in samples and disposal within the laboratory.

2 RESPONSIBILITY: Designated laboratory or administrative personnel who have been properly instructed and trained in the log-in procedure shall be responsible for checking in samples.

3 REFERENCE: Standard Methods for the Examination of Water and Wastewater, 18th Ed., 1989.

4 SUMMARY:

4.1 Using the Master Logbook, assign the next consecutive number as the FMETL project number for the samples.

4.1.1 Open the cooler and immediately check and record the cooler temperature by measuring the temperature of the cooler blank (bottle of water transported with samples).

4.1.2 Record the cooler temperature on the SAMPLE RECEIPT FORM, (Attachment 1).

4.1.3 Inspect the cooler contents by completing the top section of the SAMPLE RECEIPT FORM - Preliminary Examination Phase.

4.1.3.1 Remove samples and verify against the chain of custody to insure documentation accuracy and completeness.

4.1.3.2 Verify field identification numbers against the CHAIN OF CUSTODY FORM, (Attachment 2).

4.1.3.3 Assign each individual sample an FMETL ID # which is designated by the project number with a hyphenated suffix beginning with -.01, and increasing consecutively for each sample in the project.

4.2 Inspect the samples for breakage, preservation, and overall condition by completing the center portion of the SAMPLE RECEIPT FORM - Log-In Phase.

Prepared By _____ Date _____

Approved By _____ Date _____
QA Manager / Laboratory Director

4.2.1 Any individual sample that requires acidic or basic preservation methods, determine its pH using pH paper.
4.2.2 Record the sample ID# and pH on the SAMPLE RECEIPT FORM.

4.3 In the event of any discrepancies with either the coolers or the samples, complete the laboratory corrective action memo in the lower section of the SAMPLE RECEIPT FORM.
4.3.1 Reference any discrepancies and document the corrective action taken (e.g. pH adjustment or re-attaching loose label).
4.3.2 Where corrective action requires notifying appropriate persons of the problem (e.g. for incorrect sample volumes or broken bottles that would require resampling), contact client or appropriate person immediately to resolve any discrepancies. Record the time and date of the notification on the lower section of the SAMPLE RECEIPT FORM and initiate a Corrective Action Report.

4.4 Record the required information on the CHAIN OF CUSTODY FORM:
4.4.1 Lab Sample ID#.
4.4.2 Date and time received.
4.4.3 Project information (e.g. number of samples received, type of analyses).

4.5 Information on all samples received will then be entered into a bound logbook. This logbook will be of ledger type with columns and numbered pages. Each sample logbook will be sequentially numbered and on the outside cover, the starting date and sample numbers will be indicated. All entries will be made using a ballpoint pen with permanent ink. All errors will be crossed out with a single line and initialed. The following will be entered into the logbook:
4.5.1 Sample ID#
4.5.2 Site
4.5.3 Location
4.5.4 Sample Date/Time
4.5.5 Matrix
4.5.6 Sampler
4.5.7 Analysis
4.5.8 Comments

4.6 A job folder will then be created. The job folder will be kept, sequentially, in a designated filing cabinet. The folder will contain the original chain of custody, sample receipt form and any field notes or maps. Data will be inserted into the folder, as it becomes available.

4.7 Deliver the logged-in samples to the proper storage areas (designated refrigerators). Proper storage of all samples prior to preparation and analysis is critical to the determination of accurate and high quality analytical results. Samples that are not properly stored may suffer degradation, volatilization, or reaction.

Refrigerator #	Samples
1	Volatiles
2	Semivolatiles
3	Extractions
4	Sample Receipt
5	Extracts
6	Metals/Wet Chemistry

4.8 Store samples that may easily be contaminated by other samples (such as drinking water samples) in a refrigerator separate from one where more highly contaminated samples are stored.

4.8.1 Monitor the temperatures of storage refrigerators daily to ensure sample integrity (see OQC-0303).

4.9 Deliver a copy of the CHAIN OF CUSTODY FORM to the various departments to notify analysts of the presence of the samples.

4.10 Each analysis has specified limits on Holding Times (see SAM-0200).

4.10.1 For samples received within 72 hours of sampling or before one-half of the holding time period is expired (whichever is less), the analyst will initiate sample preparation and/or analysis within the prescribed holding times.

4.10.2 For samples arriving after this, the client will immediately be informed of the status of the sample and told whether preparation and/or analysis can still be performed within established holding times. If preparation or analysis within the designated holding times is impossible, the client will be contacted for further instructions.

4.11 Due to limited refrigerator space, samples will be removed after a 90-day period or when analysis is complete.

4.11.1 Soil samples are emptied and returned to the site location.

4.11.2 Unpreserved aqueous samples are returned to their effluent discharge.

4.11.3 Preserved aqueous samples are disposed of into a 55-gallon acid/aqueous drum.

4.12 All waste materials classified as hazardous are managed in accordance with the Fort Monmouth Hazardous Waste Management Plan.

Attachment 1

SAMPLE RECEIPT FORM

Date Received: _____ Lab Project ID#: _____

Site/Project Name: _____ Cooler Temp (d. C): _____

Received By: _____ Sign: _____
(print name)

Circle the appropriate answer

1. Did the samples come in a cooler?	yes	no
2. Were the chain of custody papers filled out correctly and legibly?	yes	no
3. Did you sign the chain of custody in the appropriate place?	yes	no
4. Did all the labels agree with the chain of custody and in good condition?	yes	no
5. Were the correct containers and/or preservatives used for the tests indicated?	yes	no
6. Was a sufficient amount of sample sent for the tests indicated?	yes	no
7. Were bubbles absent from aqueous VOC sample containers?	yes	no

Fill out the following table for each sample bottle

Sample ID	pH	Preservative	Sample ID	pH	Preservative

Comments: _____

Attachment 2

CHAIN OF CUSTODY FORM

Fort Monmouth Environmental Testing Laboratory

Bldg. 173, SELFM-PW-EV, Fort Monmouth, NJ 07703
Tel (732)532-4359 Fax (732)532-3484 EMail:appleby@doim6.monmouth.army.mil
NJDEP Certification #13461

Chain of Custody Record

Customer:	Project No:	Analysis Parameters	**Comments:**
Phone #:	Location:		
( )DERA ( )OMA ( )Other:_____			
Samplers Name / Company :			

Lab Sample I.D.	Sample Location	Date	Time	Sample Type	# bottles								Remarks / Preservation Method

Relinquished by (signature):	Date/Time:	Received by (signature):	Relinquished by (signature):	Date/Time:	Received by (signature):
Relinquished by (signature):	Date/Time:	Received by (signature):	Relinquished by (signature):	Date/Time:	Received by (signature):

Report Type: (_)Full, (_)Reduced, (_)Standard, (_)Screen / non-certified Turnaround time: (_)Standard 4 wks, (_)Rush ____ Days, (_)ASAP Verbal ____Hrs.	Remarks:

US ARMY FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
BUILDING 173 RIVERSIDE AVENUE
FORT MONMOUTH, NEW JERSEY 07703
(732) 532-4359

QUALITY ASSURANCE / QUALITY CONTROL MANUAL

LABORATORY DIRECTOR
DANIEL K. WRIGHT

QUALITY ASSURANCE OFFICER
JACQUELINE HAMER

REVISION: 6
DATE PREPARED: JANUARY 2003

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

NEW JERSEY DEP CERT # 13461
NEW YORK DOH CERT # 11699
PENNSYLVANIA DEP CERT # 68-561
MARYLAND DOH CERT # G-1047
AIHA ACCREDITATION # 102771

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
U.S. ARMY

TABLE OF CONTENTS

		PAGE#
SECTION 1.	INTRODUCTION	3
SECTION 2.	POLICY STATEMENT 4	
SECTION 3.	PERSONNEL AND TRAINING	5-9
SECTION 4.	QUALITY ASSURANCE OBJECTIVES	10-20
SECTION 5.	LABORATORY PROCEDURES	21-26
SECTION 6.	CALIBRATION PROCEDURES	27-37
SECTION 7.	METHOD CONFORMANCE CHARTS	38-48
SECTION 8.	DATA	49-52
SECTION 9	INTERNAL QUALITY CONTROL CHECKS	53-55
SECTION 10.	PERFORMANCE AND SYSTEM AUDITS	56-57
SECTION 11.	PROCEDURES USED TO ACCESS DATA PRECISION AND ACCURACY	58-59
SECTION 12.	CORRECTIVE ACTION	60-61
SECTION 13.	QUALITY ASSURANCE REPORTS TO MANAGEMENT	62
SECTION 14.	ACCREDITED METHODOLOGY SUMMARY	63-71
SECTION 15.	LABORATORY EQUIPMENT	72-78
APPENDIX 1 (CHAIN OF CUSTODY RECORD)		79
APPENDIX 2 (SAMPLE RECEIPT FORM)		80
APPENDIX 3 (ETHICS AND DATA INTEGRITY AGREEMENT)		81
APPENDIX 4 (CONFIDENTIAL FAX COVER SHEET)		82

SECTION 1

1.0 INTRODUCTION

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY QUALITY ASSURANCE POLICIES AND PROCEDURES

The Fort Monmouth Environmental Testing Laboratory is operated by the base Operations Contractor (currently, TECOM-Vinnell Inc.) under the direct supervision of the Directorate of Public Works Environmental Office. Fort Monmouth Environmental Testing Laboratory was first established for the purpose of providing potable water sampling and analysis. Prior to that, the DPW Laboratory (pre-BASOPS contracting) activities included sampling and analysis of the sanitary treatment system at Fort Monmouth. Due to changes in environmental regulations, the removal of over 400 underground storage tanks (UST's) and the assessment of several landfills and suspected contaminated sites, the requirements of the department have expanded to include additional analyses and sampling services. The laboratory's analytical capabilities cover significantly more analytes than performed by other Army DPW Laboratories. All sampling and analyses are performed in accordance with the NJDEP and EPA regulations.

The purpose of this document is to provide a uniform set of procedures for the trace organic and inorganic analyses of samples. It provides documentation of the methods and their performance during a survey, and verification of the sample data generated. The prime function of the QC program here is the definition of procedures for the evaluation of documentation of analytical methodologies and the reduction and reporting of data. The objective is to provide a uniform basis for sample collection and handling, instrument and methods maintenance, performance evaluation and analytical data gathering and reporting.

Although it is impossible to address all analytical situations in one document, the approach taken here is to define minimum requirements for all major steps relevant to any analysis. In many instances where methodologies are available, specific quality control procedures are incorporated into the methods documentation. In instances where new methodologies must be established, a guide specifying the minimum method validation procedures, quality control and documentation requirements is presented.

SECTION 2

2.0 POLICY STATEMENT

Fort Monmouth Environmental Testing Laboratories (FMETL), provides a wide variety of year round chemical and environmental services. These services include the sampling

and analysis of ground and surface water, treated water, soils, sediments, industrial and hazardous wastes and air quality monitoring. Because it is important to measure and report pollutants accurately for contaminates in air, soil and water, FMETL maintains a thorough and monitored quality assurance program.

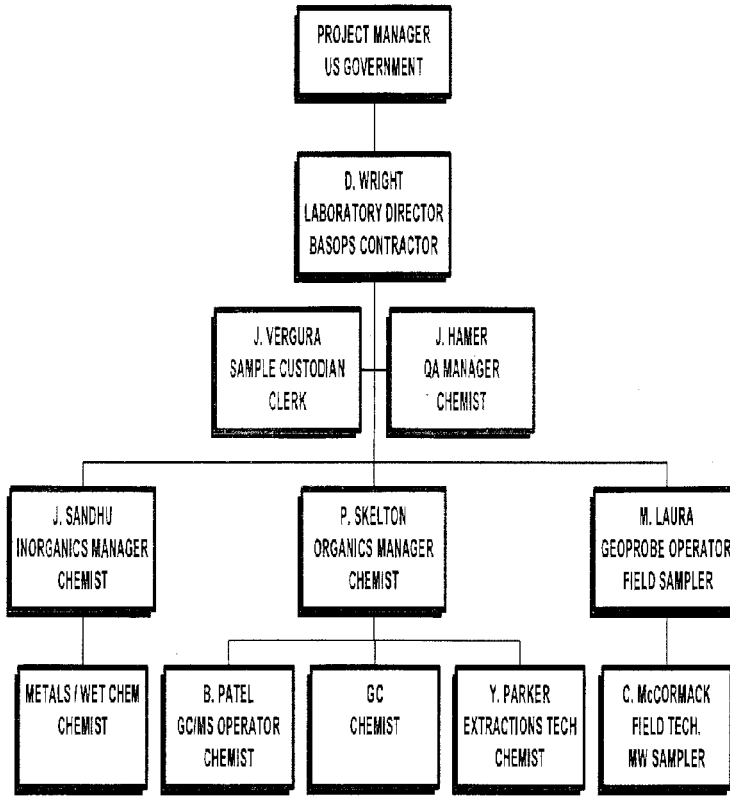
FMETL has established this Quality Assurance Policies and Procedures manual to assure a standardized quality assurance and quality control program is implemented throughout the facility. This plan is intended to comply with the best standard practices of industry and to assure the effectiveness of quality and safety programs. Any deviations from standard policies and procedures must be approved by the Laboratory Director and documented.

The Quality Assurance Manager reports directly to the Project Manager of FMETL. This direct path assures the highest visibility to management on laboratory and field operations. This organizational structure provides a mechanism for constant communications between quality assurance and senior management. Any new work that is to be received by the laboratory must undergo a review by the Technical Director and the Manager to whom the work will be assigned to insure that the laboratory possesses the means to complete the work prior to accepting the project.

All analytical results generated by the laboratory are property of the US Army or other government organizations that have contracted the laboratory for services. Laboratory personnel undergo training for their legal and ethical responsibilities in regards to client confidentiality as well as the documentation and reporting of analytical results.

FORT MONMOUTH ENVIRONMENTAL LABORATORY

JANUARY 6, 2003



3.0 PERSONNEL AND TRAINING

Laboratory personnel are given a general orientation program and then are trained in specific laboratory procedures.

The overall orientation program requires that employees become familiar with the following:

1. Laboratory equipment - Refer to Section 15.
2. Laboratory safety procedures - Refer to Safety Manual.
3. Analytical procedures - Refer to Section 5.
4. The FMETL Analytical Services - QA/QC.
5. Ethical training for legally analyzing samples and reporting data – Refer to Appendix 3 (ETHICS AND DATA INTEGRITY AGREEMENT).

This manual must be read, discussed with the laboratory supervisor and then an employee training record must be signed and dated by the employee. Employees may be trained in all items listed above or only in those that are pertinent to their specific position. Experienced personnel under the supervision of the laboratory supervisor conduct the basic orientation. Spot checks, oral quizzes and reorientation assure completeness of orientation by the laboratory supervisor. The documentation and training requirements are outlined in SOP DOC-0105.

When an individual has been fully familiarized with the above and has completed his Demonstration of Capability, he is then allowed to begin work on the samples. The laboratory supervisor directs this work..

Minimum requirements of the individual's responsibilities with respect to the QA program are as follows:

3.1 FMETL PROJECT MANAGER

The Project Manager's duties and responsibilities with respect to the environmental laboratory division include the following:

- Provide overall guidance to the laboratory's operations and quality assurance.

- Serve as liaison between the laboratory staffs and other groups.

- Approve requisitions for personnel, instrumentation and materials required for satisfying laboratory objectives.

3.2 LABORATORY DIRECTOR

- Provide supervision of all laboratory operations and quality assurance.
- Provide information to clients on sample project status, responsible for the release of preliminary data.
- Responsible for corrective actions to non-conformance observed and reported.
- Coordinate projects with Sales personnel.
- Schedule execution of projects and ensure laboratory's performance meets the client's requirements.
- Perform the final review and sign all test reports.
- Keep FMETL Project Manager abreast of all laboratory performance issues, including changes made within the QA/QC program.

The Laboratory Director reports to the Project Manager of FMETL.

3.3 QUALITY ASSURANCE MANAGER

- Implement and monitor all activities relating to the laboratory QA/QC program.
- Ensure compliance with QA/QC requirements by conducting routine audits of lab operations.
- Analyze the QA/QC data for events and trends, and incorporate in reports to management.
- Identify and respond to QA concerns of lab staff and clients.
- Review, evaluate and provide assistance in making decisions with respect to data quality.
- Prepare quarterly reports to Director and Project Manager.
- Update the Quality Assurance/Quality Control Manual on an annual basis.

SECTION 3

- Review of a certain percentage of completed laboratory reports to verify compliance with laboratory QA/QC policies.

- The Quality Assurance Manager reports to the Manager of Quality Assurance and Safety and Laboratory Director.

3.4 LABORATORY MANAGERS

- Ensure compliance with appropriate analytical methods and instrument performance specifications.
- Ensure proper application and performance of QA/QC samples.
- Consult with clients on technical issues.
- Review and verify data submitted by respective lab areas.
- Ensure all QA/QC requirements are implemented and understood.
- Keep Lab Director informed on all phases of the respective laboratories.
- The Laboratory Manager reports to the Laboratory Director.

3.5 ANALYST/TECHNICIAN

- Equipment maintenance and calibration.
- Sample preparation and analysis, including verification of regulatory holding times.
- First review of quality control data.
- Data acceptance, calculation and reporting.
- Recording of QC sample results.
- Keep supervisor and/or manager informed of all phases of their operations.
- Analysts report to their respective Laboratory Supervisor or Manager.

SECTION 3

3.6 SAMPLE CUSTODIAN

- Ensure that samples submitted and accepted into the laboratory are in accordance with NJDEP and EPA documented sample acceptance procedures.

- Reject receipt of samples which do not meet NJDEP sample handling and preservation requirements until sales staff affirms with client to proceed or re-sample.

- Sign for sample receipt on chain of custody document (see Attachment 1).

- Ensure that associated sample acceptance data is documented on the Sample Receipt form (see Attachment 2).

- Arrange for proper and secure sample transfer to respective laboratory departments and storage.

SECTION 4

4.0 QA OBJECTIVES

The primary quality assurance objective of all laboratory and field operations is to assure the accuracy and correct representation of the data. This is done with respect to the media of the samples and the actual conditions existent in the field. Whenever sample collection is to be performed by the client, and the samples are to be delivered to the laboratory, correct representation must be assumed. Suggested field procedures are included to aid in sample collection when FMETL personnel do not perform sampling. Whenever possible, samples are collected by FMETL field personnel using appropriate techniques, field equipment, sample identification, and field observations.
Analytical results in the laboratory are evaluated for defined parameters within targeted objectives as listed in the tables in section 4. As data is evaluated, the target QA objectives are updated.

4.1 ACCURACY

The degree of agreement of measurement (or an average of measurement of the same thing), x, with an accepted reference or true value, t, usually expressed as the difference between the two values, (x - t), or the difference as a percentage of the reference or true value, 100(x - t)/t, and sometimes expressed as a ratio, x/t. Accuracy is a measure of the bias in a system.

4.2 PRECISION

A measure of mutual agreement among individual measurements of the same property usually under prescribed similar conditions. Precision is best expressed in terms of the relative percent difference (RPD). RPD is the percent expression of the absolute difference of the two values divided by the average of the two values.

4.3 COMPLETENESS

A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under current normal conditions.

4.4 COMPARABILITY

The accuracy and precision measurements are monitored by comparing the results of each spike and spike duplicate recovery to the appropriate objective. The Supervisor and/or Manager review the quality control table or chart for each parameter. The Quality Assurance Manager is informed of all nonconformities and anomalies.

TABLE 4-1

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

FMETL ORGANIC QC OBJECTIVES

MATRIX SPIKE RECOVERY

FRACTION	SPIKE COMPOUND	WATER % REC.	SOIL/SED % REC
GC/MS VOLATILES			
VOA	Benzene	37-151	70-130
VOA	Bromodichloromethane	35-155	70-130
VOA	Bromoform	45-169	70-130
VOA	Bromomethane	D-242	70-130
VOA	Carbon tetrachloride	70-140	70-130
VOA	Chlorobenzene	37-160	70-130
VOA	Chloroethane	14-230	70-130
VOA	2-Chloroethylvinyl ether	D-305	70-130
VOA	Chloroform	51-138	70-130
VOA	Chloromethane	D-273	70-130
VOA	Dibromochloromethane	53-149	70-130
VOA	1,2-Dichlorobenzene	18-190	70-130
VOA	1,3-Dichlorobenzene	59-156	70-130
VOA	1,4-Dichlorobenzene	18-190	70-130
VOA	1,1-Dichloroethane	59-155	70-130
VOA	1,2-Dichloroethane	49-155	70-130
VOA	1,1-Dichloroethene	D-234	70-130
VOA	trans-1,2-Dichloropropane	54-156	70-130
VOA	1,2-Dichloropropane	D-210	70-130
VOA	cis-1,3-Dichloropropene	D-227	70-130
VOA	trans-1,3-Dichloropropene	17-183	70-130
VOA	Ethyl benzene	37-162	70-130
VOA	Methylene chloride	D-221	70-130
VOA	1,1,2,2-Tetrachloroethane	46-157	70-130
VOA	Tetrachloroethene	64-148	70-130
VOA	Toluene	47-150	70-130
VOA	1,1,1-Trichloroethane	52-162	70-130
VOA	1,1,2-Trichloroethane	52-150	70-130
VOA	Trichloroethene	71-157	70-130
VOA	Trichlorofluoromethane	17-181	70-130
VOA	Vinyl chloride	D-251	70-130

TABLE 4-1

FMETL ORGANIC QC OBJECTIVES

MATRIX SPIKE RECOVERY

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

FRACTION	SPIKE COMPOUND	WATER % REC.	SOIL/SED % REC
GC/MS EXT.			
BN	Acenaphthene	47-145	70-130
BN	Acenaphthylene	33-145	70-130
BN	Anthracene	27-133	70-130
BN	Benzo(a)anthracene	33-143	70-130
BN	Benzo(b)fluoranthene	24-159	70-130
BN	Benzo(k)fluoranthene	11-162	70-130
BN	Benzo(a)pyrene	17-163	70-130
BN	Benzo(ghi)perylene	D-219	70-130
BN	Benzyl butylphthalate	D-152	70-130
BN	Bis(2-chloroethyl)ether	12-158	70-130
BN	Bis(2-chloroethoxy)methane	33-184	70-130
BN	Bis(2-chloroisopropyl)ether	36-166	70-130
BN	Bis(2-ethylhexyl)phthalate	8-158	70-130
BN	4-Bromophenyl phenyl ether	53-127	70-130
BN	2-Chloronaphthalene	60-118	70-130
BN	4-Chlorophenyl phenyl ether	25-158	70-130
BN	Chrysene	17-168	70-130
BN	Dibenzo(a,h)anthracene	D-227	70-130
BN	Di-n-butyl phthalate	1-118	70-130
BN	1,2-Dichlorobenzene	32-129	70-130
BN	1,3-Dichlorobenzene	D-172	70-130
BN	1,4-Dichlorobenzene	20-124	70-130
BN	3,3'-Dichlorobenzidine	D-262	70-130
BN	Diethyl phthalate	D-114	70-130
BN	Dimethyl phthalate	D-112	70-130
BN	2,4-Dinitrotoluene	39-139	70-130
BN	2,6-Dinitrotoluene	50-158	70-130
BN	Di-n-octyl phthalate	4-146	70-130
BN	Fluoranthene	26-137	70-130
BN	Fluorene	59-121	70-130
BN	Hexachlorobenzene	D-152	70-130
BN	Hexachlorobutadiene	24-116	70-130
BN	Hexachloroethane	40-113	70-130

TABLE 4-1

FMETL ORGANIC QC OBJECTIVES

MATRIX SPIKE RECOVERY

FRACTION	SPIKE COMPOUND	WATER % REC.	SOIL/SED % REC
GC/MS EXT. CONT.			
BN	Indeno(1,2,3-cd)pyrene	D-171	70-130

BN	Isophorone	21-196	70-130
BN	Naphthalene	21-133	70-130
BN	Nitrobenzene	35-180	70-130
BN	N-nitroso-di-n-propylamine	D-230	70-130
BN	Phenanthrene	54-120	70-130
BN	Pyrene	52-115	70-130
BN	1,2,4-Trichlorobenzene	44-142	70-130
GC/MS EXT.			
ACID	4-Chloro-3-methylphenol	22-147	70-130
ACID	2-Chlorophenol	23-134	70-130
ACID	2,4-Dichlorophenol	39-135	70-130
ACID	2,4-Dimethylphenol	32-119	70-130
ACID	2,4-Dinitrophenol	D-191	70-130
ACID	2-Methyl-4,6-dinitrophenol	D-181	70-130
ACID	2-Nitrophenol	29-182	70-130
ACID	4-Nitrophenol	D-132	70-130
ACID	Pentachlorophenol	14-176	70-130
ACID	Phenol	5-112	70-130
ACID	2,4,6-Trichlorophenol	37-144	70-130
GC EXT.			
PEST	Aldrin	42-122	70-130
PEST	alpha-BHC	37-134	70-130
PEST	beta-BHC	17-147	70-130
PEST	delta-BHC	19-140	70-130
PEST	gamma-BHC (Lindane)	32-127	70-130
PEST	Chlordane	45-119	70-130
PEST	4,4'-DDD	31-141	70-130
PEST	4,4'-DDE	30-145	70-130
PEST	4,4'-DDT	25-160	70-130
PEST	Dieldrin	36-146	70-130
PEST	Endosulfan I	45-153	70-130
PEST	Endosulfan II	D-202	70-130

TABLE 4-1

FMETL ORGANIC QC OBJECTIVES

MATRIX SPIKE RECOVERY

FRACTION	SPIKE COMPOUND	WATER % REC.	SOIL/SED % REC
GC EXT. CONT.			
PEST	Endosulfan sulfate	26-144	70-130
PEST	Endrin	30-147	70-130
PEST	Heptachlor	34-111	70-130
PEST	Heptachlor epoxide	37-142	70-130

PEST	Toxaphene	41-126	70-130
PCB	Arochlor-1016	50-114	NR
PCB	Arochlor-1221	15-178	NR
PCB	Arochlor-1232	10-215	NR
PCB	Arochlor-1242	39-150	NR
PCB	Arochlor-1248	38-158	NR
PCB	Arochlor-1254	29-131	NR
PCB	Arochlor-1260	8-127	NR
PCB	Arochlor-1016/1260 Mixture	NR	70-130

TABLE 4-2

FMETL ORGANIC QC OBJECTIVES

RELATIVE PERCENT DIFFERENCE

FRACTION	COMPOUND	WATER RPD	SOIL/SED RPD
GC/MS VOLATILES			
VOA	Benzene	20	20
VOA	Bromodichloromethane	20	20
VOA	Bromoform	20	20
VOA	Bromomethane	20	20
VOA	Carbon tetrachloride	20	20
VOA	Chlorobenzene	20	20
VOA	Chloroethane	20	20
VOA	2-Chloroethylvinyl ether	20	20
VOA	Chloroform	20	20
VOA	Chloromethane	20	20
VOA	Dibromochloromethane	20	20
VOA	1,2-Dichlorobenzene	20	20

TABLE 4-2

FMETL ORGANIC QC OBJECTIVES

RELATIVE PERCENT DIFFERENCE

FRACTION	COMPOUND	WATER RPD	SOIL/SED RPD
GC/MS VOA CONT.			
VOA	1,3-Dichlorobenzene	20	20
VOA	1,4-Dichlorobenzene	20	20
VOA	1,1-Dichloroethane	20	20
VOA	1,2-Dichloroethane	20	20
VOA	1,1-Dichloroethene	20	20
VOA	trans-1,2-Dichloropropane	20	20

VOA	1,2-Dichloropropane	20	20
VOA	cis-1,3-Dichloropropene	20	20
VOA	trans-1,3-Dichloropropene	20	20
VOA	Ethyl benzene	20	20
VOA	Methylene chloride	20	20
VOA	1,1,2,2-Tetrachloroethane	20	20
VOA	Tetrachloroethene	20	20
VOA	Toluene	20	20
VOA	1,1,1-Trichloroethane	20	20
VOA	1,1,2-Trichloroethane	20	20
VOA	Trichloroethene	20	20
VOA	Trichlorofluoromethane	20	20
VOA	Vinyl chloride	20	20
GC/MS SEMI.		20	20
BN	Acenaphthene	20	20
BN	Acenaphthylene	20	20
BN	Anthracene	20	20
BN	Benzo(a)anthracene	20	20
BN	Benzo(b)fluoranthene	20	20
BN	Benzo(k)fluoranthene	20	20
BN	Benzo(a)pyrene	20	20
BN	Benzo(ghi)perylene	20	20
BN	Benzyl butylphthalate	20	20
BN	Bis(2-chloroethyl)ether	20	20
BN	Bis(2-chloroethoxy)methane	20	20
BN	Bis(2-chloroisopropyl)ether	20	20
BN	Bis(2-ethylhexyl)phthalate	20	20

TABLE 4-2

FMETL ORGANIC QC OBJECTIVES

RELATIVE PERCENT DIFFERENCE

FRACTION	COMPOUND	WATER RPD	SOIL/SED RPD
GC/MS SEMI. CONT.			
BN	4-Bromophenyl phenyl ether	20	20
BN	2-Chloronaphthalene	20	20
BN	4-Chlorophenyl phenyl ether	20	20
BN	Chrysene	20	20
BN	Dibenzo(a,h)anthracene	20	20
BN	Di-n-butyl phthalate	20	20
BN	1,2-Dichlorobenzene	20	20
BN	1,3-Dichlorobenzene	20	20
BN	1,4-Dichlorobenzene	20	20

BN	3,3'-Dichlorobenzidine	20	20
BN	Diethyl phthalate	20	20
BN	Dimethyl phthalate	20	20
BN	2,4-Dinitrotoluene	20	20
BN	2,6-Dinitrotoluene	20	20
BN	Di-n-octyl phthalate	20	20
BN	Fluoranthene	20	20
BN	Fluorene	20	20
BN	Hexachlorobenzene	20	20
BN	Hexachlorobutadiene	20	20
BN	Hexachloroethane	20	20
BN	Indeno(1,2,3-cd)pyrene	20	20
BN	Isophorone	20	20
BN	Naphthalene	20	20
BN	Nitrobenzene	20	20
BN	N-nitroso-di-n-propylamine	20	20
BN	Phenanthrene	20	20
BN	Pyrene	20	20
BN	1,2,4-Trichlorobenzene	20	20
GC/MS SEMI.		20	20
ACID	4-Chloro-3-methylphenol	20	20
ACID	2-Chlorophenol	20	20
ACID	2,4-Dichlorophenol	20	20
ACID	2,4-Dimethylphenol	20	20

TABLE 4-2

FMETL ORGANIC QC OBJECTIVES

RELATIVE PERCENT DIFFERENCE

FRACTION	COMPOUND	WATER RPD	SOIL/SED RPD
GC/MS SEMI. CONT.			
ACID	2,4-Dinitrophenol	20	20
ACID	2-Methyl-4,6-dinitrophenol	20	20
ACID	2-Nitrophenol	20	20
ACID	4-Nitrophenol	20	20
ACID	Pentachlorophenol	20	20
ACID	Phenol	20	20
ACID	2,4,6-Trichlorophenol	20	20
GC SEMI.			
PEST	Aldrin	20	20
PEST	alpha-BHC	20	20
PEST	beta-BHC	20	20
PEST	delta-BHC	20	20

PEST	gamma-BHC (Lindane)	20	20
PEST	Chlordane	20	20
PEST	4,4'-DDD	20	20
PEST	4,4'-DDE	20	20
PEST	4,4'-DDT	20	20
PEST	Dieldrin	20	20
PEST	Endosulfan I	20	20
PEST	Endosulfan II	20	20
PEST	Endosulfan sulfate	20	20
PEST	Endrin	20	20
PEST	Heptachlor	20	20
PEST	Heptachlor epoxide	20	20
PEST	Toxaphene	20	20
PCB	Arochlor-1016	20	20
PCB	Arochlor-1221	20	20
PCB	Arochlor-1232	20	20
PCB	Arochlor-1242	20	20
PCB	Arochlor-1248	20	20
PCB	Arochlor-1254	20	20
PCB	Arochlor-1260	20	20
PCB	Arochlor-1016/1260 Mixture	20	20

TABLE 4 - 3

FMETL ORGANIC QC OBJECTIVES

SURROGATE RECOVERY LEVELS

FRACTION	SURROGATE COMPOUND	WATER	LOW / MEDIUM SOIL
VOLATILE (GC/MS)	Toluene-d_8 4 Bromo-fluorobenzene 1,2-Dichloro-ethane-d_4	76-125 76-125 76-125	70-137 74-120 70-115
ACID (GC/MS)	Phenol-d_6 2-Fluorophenol 2,4,6-Tribromophenol	10-58 24.5-71.8 51.9-99.4	10-124 10-125.1 11.7-171
BASE NEUTRAL (GC/MS)	Nitrobenzene-d_5 2-Fluorobiphenyl Terphenyl-d_{14}	51.3-114.8 57.8-104 40.5-111.4	10-117.5 14.1-120.2 16.8-142.1
PESTICIDES (GC)	Decachlorobiphenyl (DCB) Tetrachloro-m-xylene (TCX)	10-130 10-130	10-130 10-130

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 4-4

FMETL INORGANIC QC OBJECTIVES

METHOD ACCURACY STATEMENT

PARAMETER	LCS	%RECOVERY	%RPD
WET CHEMISTRY		MATRIX SPIKE	SOIL/AQUEOUS
Alkalinity	NA	Duplicates	20
Ammonia Nitrogen	80-120	80-120	20
Biochemical Oxygen Demand (BOD)	80-120	NA	NA
Chloride	80-120	80-120	20
Chemical Oxygen Demand (COD)	80-120	80-120	20
Cyanide	90-110	80-120	20
Hardness	NA	Duplicates	20
Nitrate Nitrogen	80-120	80-120	20
Nitrite Nitrogen	80-120	80-120	20
Ortho-Phosphate	80-120	80-120	20
Phenolics	80-120	80-120	20
Phosphorus as PO_4	80-120	80-120	20
Sulfate	80-120	80-120	20
Sulfide	80-120	80-120	20
Total Organic Carbon (TOC)	80-120	80-120	20
Total Kjeldahl Nitrogen (TKN)	80-120	80-120	20
Surfactants (MBAS)	80-120	80-120	20

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 4-4

FMETL INORGANIC QC OBJECTIVES

METHOD ACCURACY STATEMENTS

PARAMETER	MATRIX SPIKE % RECOVERY	%RPD
TRACE METALS ICP		
WASTEWATER	90-110	20
DRINKING WATER	90-110	20
SOIL	75-125	20
GRAPHITE FURNACE		
WASTEWATER	80-120	20
DRINKING WATER	90-110	20
SOIL	75-125	20
FLAME AA		
WASTEWATER	80-120	20
DRINKING WATER	90-110	20
SOIL	75-125	20
MERCURY COLD VAPOR		
WASTEWATER	80-120	20
DRINKING WATER	90-110	20
SOIL	75-125	20

SECTION 5

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

5.0 LABORATORY PROCEDURES

All sampling operations are conducted to attain study objectives and maintain sample integrity. Sampling procedures, preservation, and guidelines are taken from "The NJDEP Field Sampling Procedures Manual, 1992".

The following general guidelines are used to achieve these goals.

5.1 SAMPLING PROGRAM

The actual logistics and sample locations are often determined by client needs. Field conditions and tests tend to vary with each sampling program. To meet requirements in the most efficient and effective way, sampling must be tailored to each jobs need. Field surveys are strongly recommended before any program is undertaken. Once this is complete, sample procedures and locations can be determined prior to the sampling event. All conditions and procedures, including sampling equipment, sample point clearing apparatus, collection methods, and composite procedures, as applicable, are specified, documented and included in the formal report. Maps, letters, or permits pertaining to sampling and any other information regarding sample points are helpful in conducting a successful sampling session that will yield valid, defendable data.

5.2 SAMPLE COLLECTION

Samples are collected following the guidelines in 'The NJDEP" Field Sampling Procedures Manual, 1992" or following specific procedures as defined for individual sampling locations for specific projects. All collection methods, equipment and composite procedures or any unusual conditions are thoroughly documented. Sampling should progress from least contaminated to most contaminated areas. Qualitative sample descriptions are included where applicable or unusual. In soil sampling, a complete core strata description may be required.

5.3 FIELD SAFETY

Caution must be exercised when dealing with contaminated areas. Even areas that are considered innocuous should be evaluated with regard to hazardous conditions. Technicians shall exercise discretion when sampling sites present any chemical conditions that may compromise safe collection. Any available information concerning possible compounds present is obtained, and the technician is alerted to potential hazardous reactions with preservatives. Gloves and protective clothing are available and used whenever conditions warrant extra precautions.

SECTION 5

5.4 FIELD CONDITIONS

General field conditions are noted and reported (e.g., weather, temperature, area description, water flow, etc.) Any other conditions applicable to the sample area or of particular interest to the study are noted.

5.5 FIELD DATA COLLECTION

All field data including sample identification, date, location, time of collection, measurements, field readings, observations, and comments are recorded in a bound field notebook. When required, specially prepared field summary sheets (Monitoring Well Field Sampling) are incorporated for specific projects.

5.6 FIELD LOG BOOK

Field technicians are responsible for keeping a bound field notebook with consecutively numbered pages. Sporadic or one time sampling projects must, as a minimum, include the following entries:

Date
Clients name
Project name
Job number
Project purpose or description
Name, Address, and phone number of field contact
Description of sample source (i.e. groundwater, lake)
Sample locations and sample time
Sample methodology
Collection containers and analyses required
Pertinent field observations
Reference sketches or maps where applicable

Hazardous waste sampling will also include:

Producer of waste and address if different from location
Types of waste
Suspected waste composition, including concentrations if possible

Routine, reoccurring contract jobs may have abbreviated entries provided that such entries provide a clear and understandable record of sampling. Sampling conditions and requirements vary widely and a broad range of pertinent data is entered in the field notebook. Every project record contains sufficient information so that the sampling event can be reconstructed without reliance on the collector's memory. Accompanying the field log are field sheets, which record detailed data and documentation. These sheets become a permanent part of the project file and/or report.

5.7 FIELD METER QC LOG

A bound field log is kept for detailing dates, maintenance performed, calibrations, and standard readings. Calibration and performance checks on each meter to be used are mandatory before any fieldwork requiring the use of the field meter.

5.8 BLANK SAMPLES

Two blanks are considered in the evaluation of field conditions and procedures:

1) Trip Blank: This sample is prepared with distilled water using standard containers and preservatives. It is prepared in the laboratory and accompanies the sample set throughout the field procedures and sample transportation back to the laboratory.

2) Field Blank: This control is also prepared with distilled water but is "collected" through the sampling equipment. This is accomplished in the field after standard preparation of the equipment but before the sampling begins. This sampler blank collection procedure is repeated during the sample run to check cleaning procedures.

5.9 DUPLICATE SAMPLES

The collection of duplicate samples for the purpose of precision and spike recovery data is another aspect of quality assurance sampling. Duplicates should be collected at approximately ten sample intervals. The duplicate is collected in exactly the same manner as the initial site sample and treated as a sample in its own right. The choice of the sample point duplicated is left to the technician's discretion, given field conditions and other pertinent factors.

5.10 COMPOSITE SAMPLING

Many times a representative sample can be obtained by the composite of several sample points into one analytical sample. This is particularly applicable to soil samples. When possible, composites will be a field procedure subject to the technician's discretion using approved methods. Volatile compounds present a special problem in this area since the manipulation of a sample may lead to the loss of the compounds of interest. If a composite is specified and it is not possible to accomplish this within a minimum of disturbance, it is done at the lab immediately before extraction.

5.11 PRESERVATION

Chemical preservation is controlled and documented by descriptions directly on the sample label. Icing samples and holding at 4 degrees C is standard and is omitted only when such icing would cause precipitation of certain substances in some samples such as certain hazardous and industrial wastes.

5.12 LABELS

Labels are written in permanent black ink markers and include project number, location, client, sample number, date/time collected, technicians initials, required analysis and preservation note.

5.13 FIELD SAMPLING OPERATIONS

Documentation of sample acquisition, field monitoring, sample preservation and custody transfer must be completed to ensure the integrity of the data produced.

5.14.SAMPLE STORAGE AND DELIVERY

Standard operating procedures require the sample to be iced as quickly as possible, protected from sunlight or any other adverse field condition, and delivered to the laboratory on the day of collection. Any deviation from this procedure must be cleared through the field and lab manager. Sample preservation and holding times comply with those outlined in "The NJDEP Field Sampling Procedures Manual, 1992", referenced here in section 7.

SECTION 5

5.15 SAMPLE CHAIN OF CUSTODY

Laboratory field technicians maintain records that completely and unambiguously identify all samples collected. Each sample will have a unique individual code that identifies it by sample point and workorder number. Chain of custody sheets are available for use whenever the samples are passed between different organizations or at the request of the client. If the client collects samples, it is the client's responsibility to maintain collection and custody data until the samples are delivered to the laboratory.

An example of the chain-of-custody sheets utilized by the laboratory and accompanying sample collection is shown in Appendix 1. Copies of this sheet are transferred along with the samples if shipment to another lab is necessary. Duplicate sample and blanks are included in the sample set shipment.

5.16 SAMPLE CUSTODY AND TRACKING

All sample custody data maintained by the client and laboratory personnel should be sufficient and adequate to completely identify all samples delivered to the laboratory. Upon delivery to the laboratory each group of samples receives a unique identifying wororder number and every sample of that group is assigned an individual sample identification number. Every project is permanently logged in a bound logbook with the workorder number, date of receipt, sample date, client information, matrix, sampler's initials and description of analyses. Also upon delivery a sample receipt form, (Appendix 2) is completed, which includes the following information: date received, project identification; project name; site information; cooler temperature; name of person receiving samples; condition of samples and any preservatives used with their corresponding pH (if applicable). The receipt of samples is outlined in SOP SAM-0201.

Each section of the laboratory, after it receives a group of samples, attaches a laboratory data sheet to a copy of the project chain of custody. These data sheets are used to record the following information: workorder number; date/time of extraction; date/time of analysis; initials of analyst and the sample results with the corresponding quality control. These individual data sheets become part of the permanent laboratory record of the project.

Field blanks, spikes, and duplicates are received and treated as individual samples and analyzed with the group with which they were collected.

SECTION 5

5.17 SAMPLE RETENTION AND DISPOSAL

All samples will be retained in storage for thirty days after the report has been submitted to the client unless the client requests that samples be retained for a longer period of time. Samples will be held in the refrigerator until the required analyses are complete. At that time they will be removed to the ambient storage area until they are disposed of.

SECTION 6

6.0 CALIBRATION PROCEDURES

The analytical procedures performed by FMETL personnel have been established and driven by regulatory programs. Sample collection, analysis and report generation to FMETL client's are routinely the consequence of circumstances from state or federal authorities. To ensure optimum instrument performances and accuracy, calibration procedures must comply with analytical method specifications.

6.1 ANALYTICAL INSTRUMENTATION

The laboratory makes use of a variety of instruments from different manufacturers, which have specific calibration requirements. Ultimately, the minimum calibration requirements are governed by EPA guidelines. Although calibration procedures may be more relaxed in some methods than others, FMETL when possible, selects the most stringent requirements for generating calibration curves.

Instrument Maintenance Logbooks are kept with each instrument. Documentation must be inclusive of the following minimum requirements: date, name of analyst, preventative maintenance, description of services, types of repair and name of person performing the repair.

Specific calibration procedures for laboratory instruments, including the frequency and standards used are listed in Table 6-1, CALIBRATION PROCEDURES. Laboratory Standard Operating Procedures, (SOP's) outline in detail the procedures for calibrations, standard preparation, analysis, verification, acceptability and documentation.

6.2 CALIBRATION MATERIALS

The calibration curve and verification data are only as good as the material and technique used to generate the data. For organic analysis, the highest purity EPA certified standards are purchased in blends containing numerous compounds, or individually as neat chemical material. For inorganic analysis, trace metals and selected wet chemistry parameters, standard material is made from stock solutions prepared with analytical reagent grade materials.

All chemicals, reagents and media are dated upon receipt and when the package is opened. Appropriate lot numbers of purchased materials are recorded in chemical preparation and analysis logbooks. Refer to SOP DOC-0106.

6.3 STANDARDS TRACEABILITY

Chemical Preparation Logbooks are kept in each individual laboratory section. Documentation must be inclusive of the following minimum requirements: preparation date, name of analyst, reagents' name and identification number, manufacturer, lot number of chemical and expiration date. Additionally, all weights, dilutions, and concentrations are also included in the logbooks. An adhesive label is attached to the reagent container with the following minimum information: reagent name and identification number, concentration, preparation date, initials of analyst and expiration date if applicable.

Analytical data generated by FMETL is recorded in logbooks with reference to the associated calibration curve and verification standards. The documentation of the standards preparation and the records of analytical data generated together allow a reviewer to trace the analysis back to the purchased analytical standard material.

6.4 EQUIPMENT AND MATERIAL RECORDS

All laboratory measuring equipment calibrations are recorded in the laboratory logbooks, Records are maintained for the following:

- Annual thermometer calibrations;
- Daily refrigerator, incubator, oven and waterbath temperatures;
- Daily balance checks;
- Spectrophotometer wavelength checks;
- Reagent water check:
    - Daily pH, conductivity and residual chlorine check
    - Monthly standard plate count check
    - Annual metals check
- Sterility checks for bacteriological requirements

Laboratory hoods are monitored by Preventive Medicine Services. They perform the required annual hood velocity checks.

All laboratory logbooks, QA Manuals and Standard Operating Procedures are retained for ten years and will clearly indicate the timeframe the documents were in force. Detailed procedures for the control and maintenance of documentation can be found in SOPs DOC-0100-DOC-0106.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 6

CALIBRATION PROCEDURES

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
GC/MS VOLATILE			
METHOD BLANK	Every 12 hours.	Non-detect for all Compounds.	Reanalyze once, then perform system maintenance.
BFB TUNE	Every 12 hours.	See Table 6-1	Reanalyze once, then perform system maintenance.
5 POINT CALIBRATION	Monthly or when calibration check fails.	See Table 6-3	Recalibrate until acceptable criteria are met.
CALIBRATION CHECK STANDARD	Every 12 hours.	See Table 6-3	Reanalyze, or run new 5 point.
INTERNAL STANDARD ADDITION	To all samples and standards.	Use mid-level standard for most recent ICAL.	Rerun, Correct the problem.
SURROGATE ADDITION	To all samples and standards.	See Table 4.3	Check calculations, Reanalyze, Flag outliers.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 6

CALIBRATION PROCEDURES

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
GC/MS BASE NEUTRAL ACIDS			
METHOD BLANK	With each sample batch extracted.	Non-detect for all compounds. Except less than 2 times the MDL for phthalates.	Re-extract all samples until acceptable blank is achieved.
DFTPP TUNE	Every 12 hours.	See Table 6-2	Reanalyze once, then perform system maintenance.
5 POINT CALIBRATION	Monthly or when calibration check fails.	See Table 6-3	Recalibrate until acceptable criteria are met.
CALIBRATION CHECK STANDARD	Every 12 hours.	See Table 6-3	Reanalyze, or run a new 5 point.
INTERNAL STANDARD ADDITION	To all samples and standards.	Use mid-level standard for most recent ICAL.	Rerun, Correct the problem.
SURROGATE ADDITION	To all samples and standards.	See Table 4.3	Check calculations, Reanalyze, Flag outliers.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

CALIBRATION PROCEDURES

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
GC PESTICIDES / PCB			
METHOD BLANK	With each sample batch extracted.	Non-detect for all compounds.	Re-extract all samples until acceptable blank is achieved.
5 POINT CALIBRATION	Until calibration check fails.	Calibration factor for each compound <20% RSD	Recalibrate until acceptable criteria are met.
CALIBRATION CHECK STANDARD	Every 10 samples (one representative PCB or multi-component Pesticide).	± 15% D	Reanalyze, or rerun new 5 point.
SURROGATE ADDITION	To all samples and standards.	See Table 4.3	Re-extract if 0%.
ENDRIN, DDT BREAKDOWN	Beginning of sequence.	<15 % breakdown.	Perform column maintenance, rerun.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 6

CALIBRATION PROCEDURES

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
TRACE METALS (AA)			
CCB	Beginning of each standardization.	Less than reporting limit or MDL.	Rerun or recalibrate instrument.
3 POINT CALIBRATION	Every run or when CCV fails.	Linear 0.995	Restandardize.
ICV	Following initial calibration.	± 10 %	Restandardize.
ICB	Following initial calibration.	Less than reporting limit or MDL.	Restandardize.
CCV	Every 10 samples.	± 10 %	Restandardize.
LCS	Every batch.	± 20 %	Re-prep.

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
MERCURY			
CCB	Beginning of each batch	Less than reporting limit or MDL.	Rerun.
5 POINT	Every shift or when CCV fails.	Linear 0.995	Restandardize.
ICV	Every batch.	± 10 %	Restandardize.
CCV	Every 10 samples.	± 10 %	Restandardize.
CCB	Every batch.	Less than reporting limit or MDL.	Restandardize, rerun samples.

TABLE 6

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

CALIBRATION PROCEDURES

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
TRACE METALS (ICP)			
CB	Beginning of each standardization.	Less than reporting limit or MDL.	Rerun.
1 POINT CALIBRATION	Every shift or when CCV fails.	Standardization.	Restandardize.
HIGH STANDARD	Following initial calibration.	± 5 %	Restandardize.
ICV	Following initial calibration.	± 5 %	Restandardize.
ICS	Beginning and end of each run.	± 20 %	Restandardize.
CCV	Every 10 samples.	± 5 %	Restandardize and rerun previous 10 samples.
ICB	Following initial calibration.	Less than reporting limit or MDL.	Restandardize.
PB	With each batch of samples digested.	Less than reporting limit or MDL.	Re-prep all samples and new blank.
LCS	With every batch.	± 20 %	Re-prep.
CCB	Every 10 samples.	Less than reporting limit or MDL.	Restandardize and rerun previous 10 samples.
METHOD BLANK	Every batch.	Less than reporting limit or MDL.	Re-analyze.
3 POINT CALIBRATION	Every batch	Linear 0.995	Restandardize.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 6

CALIBRATION PROCEDURES

MEASUREMENT	FREQUENCY PERFORMED	ACCEPTABLE CRITERIA	CORRECTIVE ACTION
pH METER			
2 POINT CALIBRATION	Daily with use.	Meter electrode acceptance.	Obtain fresh buffer.
CONTROL	Every batch.	± 0.04 Units.	Recalibrate.
REAGENT WATER	Every batch.	None.	None.
CONDUCTIVITY METER			
5 POINT CALIBRATION	Annually.	Determine cell constant 1 ± 2 %	Obtain fresh KCL Solution.
0.001 N KCL	Daily.	147 ± 20 %	Obtain fresh KCL Solution.
REAGENT WATER	Daily.	< 2 μMHO / CM^3	Improve water supply.

TABLE 6-1

BFB KEY M/Z ABUNDANCE CRITERIA

MASS	M/Z ABUNDANCE CRITERIA
50	15 TO 40% OF MASS 95
75	30 TO 60 % OF MASS 95
95	BASE PEAK, 100% RELATIVE ABUNDANCE
96	5 TO 9% OF MASS 95
173	< 2 % OF MASS 174
174	> 50% OF MASS 95
175	5 TO 9% OF MASS 174
176	>95% BUT < 101% OF MASS 174
177	5 TO 9% OF MASS 176

TABLE 6-2

DFTPP KEY MASSES AND ABUNDANCE CRITERIA

MASS	ION ABUNDANCE CRITERIA
51	30.0% - 60.0% OF MASS 198
68	LESS THAN 2% OF MASS 69
70	LESS THAN 2 % OF MASS 69
127	40.0 -60.0% OF MASS 198
197	LESS THAN 1.0% OF MASS 198
198	BASE PEAK, 100.0% RELATIVE ABUNDANCE
199	5.0 - 9.0% OF MASS 198
275	10.0 - 30.0% OF MASS 198
365	GREATER THAN 1.00% OF MASS 198
441	0 - 100% OF MASS 443
442	GREATER THAN 40.0% OF MASS 198
443	17.0 - 23.0 % OF MASS 442

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 6-3

THE VOLATILE CALIBRATION CHECK COMPOUNDS (CCC'S) ARE

1, 1 - Dichloroethene	Toluene
Chloroform	Ethylbenzene
1,2-Dichloropropane	Vinyl Chloride

THE SYSTEM PERFORMANCE CHECK COMPOUNDS (SPPC'S) ARE:

Chloromethane	1,1,2,2-Tetrachloroethane
1,1- Dichloroethane	Chlorobenzene
Bromoform	

INITITAL CALIBRATION CRITERIA FOR QUANTITATION OF ANALYSIS:
SPCC AVERAGE RF MUST BE 0.30 (0.25 FOR BROMOFORM)
CCC % RSD MUST BE < 30%
THE RSD OF ALL OTHER ANALYTES MUST BE <15%

CALIBRATION CHECK CRITERIA FOR VERIFYING THE INITIAL CURVE:
CCC %D MUST BE < 20 % FROM INITIAL AVERAGE RF
SPCC MINIMUM RF MUST BE 0.30 (0.25 FOR BROMOFORM)
THE %D OF ALL OTHER ANALYTES MUST BE <20 %D EXCEPT POOR PERFORMERS.

THE SEMIVOLATILE CALIBRATION CHECK COMPOUNDS (CCC'S) ARE:

BASE / NEUTRAL FRACTION	ACID FRACTION
Acenaphthene	4-Chloro-3-Methylphenol
1,4-Dichlorobenzene	2,4-Dichlorophenol
Hexachlorobutadiene	2-Nitrophenol
n-Nitroso-di-phenylamine	Phenol
Di-n-octylphthalate	Pentachlorophenol
Flouranthene	2,4,6-Trichlorophenol
Benzo (a) pyrene	

THE SYSTEM PERFORMANCE CHECK COMPOUNDS (SPCC'S) ARE:

n-Nitroso-di-propylamine	2,4-Dinitrophenol
Hexachlorocyclopentadiene	4-Nitrophenol

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

TABLE 6-3

INITIAL CALIBRATION CRITERIA FOR QUANTITATION OF ANALYSIS:
SPCC AVERAGE RF MUST BE 0.05
CCC % RSD MUST BE < 30 %
THE RSD OF ALL OTHER ANALYTES MUST BE <15%

CALIBRATION CHECK CRITERIA FOR VERIFYING THE INITIAL CURVE:
SPCC MINIMUM RF MUST BE 0.05
CC % D MUST BE < 20 % FROM INITIAL AVERAGE RF
THE %D OF ALL OTHER ANALYTES MUST BE <20 %D EXCEPT POOR PERFORMERS.

RF	= RESPONSE FACTOR
% D	= PERCENT DIFFERENCE
% RSD	= PERCENT RELATIVE STANDARD DEVIATION

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

7.0 FMETL METHOD CONFORMANCE CHARTS

GC/MS - AQUEOUS MATRICES

PARAMETER	METHOD	CONTAINER	PRESERVATION	HOLD TIME
VOLATILE	624 (3)	40 ML - VOA	Cool, 4°C HCL to pH <2	14 days
SEMI-VOLATILE	625 (3)	G, Amber	Cool, 4°C	7 days for extraction/40 day to analysis

GC / MS - SOLIDS AND WASTES

PARAMETER	METHOD	CONTAINER	PRESERVATION	HOLD TIME
VOLATILE	8260 (2)	2 OZ - VOA	Cool, 4°C Methanol	14 days
SEMI-VOLATILE	8270 (2)	G	Cool, 4°C	14 days for extraction/40 days to analysis

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

7.0 FMETL METHOD CONFORMANCE CHARTS

G/C - AQUEOUS MATRICES

PARAMETER	METHOD	CONTAINER	PRESERVATION	HOLD TIME
PESTICIDES / PCB's	608 (3)	G, Amber	Cool, 4°c	7 day for extraction/40 day to analysis
HERBICIDES	615 (3) 8151 (2)	G, Amber	Cool, 4°c	7 days for extraction/40 days to analysis
TPHC DRO - GRO	OQA-OAM-O25	G, Amber	Cool, 4°c	7 days/40 days to analysis

G/C - SOLIDS AND WASTES

PARAMETER	METHOD	CONTAINER	PRESERVATION	HOLD TIME
PESTICIDE / PCB's	8081/8082 (2)	G	Cool, 4°C	14 days for extraction/40 days to analysis
TPHC DRO - GRO	OQA-OAM-025	G	Cool, 4°C	14 days/40 days to analysis

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

7.0 FMETL METHOD CONFORMANCE CHARTS

WET CHEMISTRY - AQUEOUS MATRICES

PARAMETER	METHOD	CONTAINER	PRESERVATION	HOLD TIME
ACIDITY AS $CaCO_3$	305.1 (1)	P.G	Cool, 4°C	14 days take pH 1ST
ALKALINITY AS $CaCO_3$	310.1 (1)	P,G	Cool, 4°C	14 days take pH 1ST
AMMONIA	350.3 (1)	P,G	Cool, 4°C H_2SO_4 to pH <2	28 days
BOD	5210B (5)	G	Cool, 4°C	48 hours
COD	410.2 (1)	G	Cool, 4°C H_2SO_4 to pH <2	28 days
COD (SPEC)	410.4 (1)	G	Cool, 4°C H_2SO_4 to pH <2	28 days
CHLORIDE	325.3 (1)	P,G	None required	28 days
CHLORINE, DEMAND	407 (5)	G	None required	Analyze immediately
CHLORINE, TOTAL RESIDUAL	330.5 (1)	G	None required	Analyze immediately
CHLORINE, FREE RESIDUAL	408 (5)	G	None required	Analyze immediately
COLOR	110.2 (1)	P,G	Cool, 4°C	48 hours
CYANIDE, TOTAL	335.2 (1)	P	Cool, 4°C NaOH to pH > 12	14 days
CYANIDE, AMENABLE TO CHLORIN-ATION	335.1 (1)	P	Cool, 4°C NaOH to pH > 12	14 days
FLOURIDE	340.2 (1)	P,G	None required	28 days
HARDNESS AS $CaCO_3$	130.2 (1)	P,G	HNO_3 or H_2SO_4 to pH < 2	6 months
pH	150.1 (1)	P,G	None required	Analyze immediately

SECTION 7

FMETL METHOD CONFORMANCE CHART

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

WET CHEMISTRY - AQUEOUS MATRICES

PARAMETER	METHOD	CONTAINER	PRESERVATON	HOLD TIME
STANDARD PLATE COUNT	907 (5)	P,G STERILE	Cool, 4°C Sodium Thiosulfate	6 hours
COLIFORM, TOTAL	909 (5)	P,G STERILE	Cool, 4°C Sodium Thiosulfate	6 hours waste-water / 30 hours potable water
COLIFORM, FECAL	909 (5)	P,G STERILE	Cool, 4°C Sodium Thiosulfate	6 hours
STREPTO - COCCUS, FECAL	910 (5)	P,G STERILE	Cool, 4°C Sodium Thiosulfate	6 hours
TKN	351.3 (1)	P,G	Cool 4°C H_2SO_4 to pH < 2	28 days
NITRATE AS N (NO_3)	352.1 (1)	P,G	Cool 4°C H_2SO_4 to pH < 2	48 hours
NITRATE AS N (NO_2)	354.1 (1)	P,G	Cool 4°C H_2SO_4 to pH < 2	48 hours
ODOR	2150 (5)	G	Cool 4°C	As soon as possible.
ORGANIC CARBON (TOC)	415.1 (1)	G	Cool 4°C H_2SO_4 to pH < 2	28 days
ORTHO-PHOSPHATE AS P	365.2 (1)	G	Cool, 4°C Filter immediately.	48 hours
OXYGEN, DISSOLVED	405.1 (1)	G	None required	8 hours
PHENOLIC, TOTAL	420.1 (1)	G Amber, ONLY	Cool 4°C H_2SO_4 to pH < 2	28 days
PHOSPHORUS - TOTAL AS P	365.2 (1)	G	Cool 4°C H_2SO_4 to pH < 2	28 days

SECTION 7

FMETL METHOD CONFORMANCE CHART

WET CHEMISTRY - AQUEOUS MATRICES

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

PARAMETER	METHOD	CONTAINER	PRESERVATON	HOLD TIME
PHOSPHATE AS PO_4	365.2 (1)	G	Cool 4°C H_2SO_4 to pH < 2	28 days
REACTIVITY (HCn)	7.3.3 (2)	G	Cool, 4°C NaOH to pH > 12	14 days
REACTIVITY (H_2S)	7.3.4 (2)	G	Cool, 4°C NaOH to pH > 9	7 days
RESIDUE-FILTERABLE (TDS)	160.1 (1)	P,G	Cool, 4°C	7 days
RESIDUE - N - FILT (TSS)	160.2 (1)	P,G	Cool, 4°C	7 days
RESIDUE-TOTAL	160.3 (1)	P,G	Cool, 4°C	7 days
RESIDUE-VOLATILE	160.4 (1)	P,G	Cool, 4°C	7 days
RESIDUE-SETTLEABLE	160.5 (1)	P,G	Cool, 4°C	48 hours
SALINITY	210 (1)	G	Cool, 4°C	Immediately
SPECIFIC CONDUCT.	120.1 (1)	P,G	Cool, 4°C	Immediately
SPECIFIC GRAVITY	213 (5)	BOD BOTTLE	Cool, 4°C	Immediately
SULFATE-(TURB) as SO_4	375.4 (1)	P,G	Cool, 4°C	28 days
SULFIDE as S	376.2 (1)	P,G	Cool, 4°C Zn Acetate+NaOH to pH >9	7 days
SULFITE as SO3	377.1 (1)	G	None required	Immediate
SURFACT-ANTS (MBAS)	425.1 (1)	P,G	Cool, 4°C	48 hours
TURBIDITY	180.1 (1)	P,G	Cool, 4°C	48 hours

SECTION 7

FMETL METHOD CONFORMANCE CHART

WET CHEMISTRY - SOLID / WASTE MATRICES (MODIFIED AQUEOUS METHODS IN MG / KG UNITS)

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

PARAMETER	METHOD	CONTAINER	PRESERVATION	HOLD TIME
SOIL pH	9045 (2)	P,G	None required	Analyze immediately
IGNITABILITY	1010 (2)	P,G	Non required	
REACTIVITY (HCN)	7.3.3 (2)	P,G	Cool, 4°C	14 days
REACTIVITY (H_2S)	7.3.4 (2)	P,G	Cool, 4°C	7 days
ORGANIC CARBON (TOC)	9060 (2)	G	Cool, 4°C	28 days
PAINT FILTER LIQUIDS TEST	9095 (2)	G	Cool, 4°C	7 days
PHENOLIC, TOTAL	9065 (2)	G	Cool, 4°C	28 days
PHOSPHATE-MODIFIED	365.2 (1)	G	Cool, 4°C	28 days
RESIDUE-TOTAL	160.3 (1)	P,G	Cool, 4°C	7 days
RESIDUE-VOLATILE	160.4 (1)	P,G	Cool, 4°C	7 days
TKN-MODIFIED	351.3 (1)	G	Cool, 4°C	28 days

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

FMETL METHOD CONFORMANCE CHART

TRACE METALS

ELEMENT	METHOD	CONTAINER	PRESERVATION	HOLD TIME
SILVER-ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
ALUMINUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
ARSENIC - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
BORON - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
BARIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
BERYLLIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
CALCIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
CADMIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
COBALT - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
CHROMIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
COPPER - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
IRON - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
POTASSIUM-ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
MAGNESIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
MANGANESE - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
SODIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
NICKEL - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months

SECTION 7

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

FMETL METHOD CONFORMANCE CHART

TRACE METALS

ELEMENT	MEHTOD	CONTAINER	PRESERVATION	HOLD TIME
LEAD - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
ANTIMONY - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
SELENIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
TIN - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
THALLIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
VANADIUM - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months
ZINC - ICP	200.7 (6) 6010 (2)	P, G	HNO_3 to pH < 2	6 months

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

FMETL METHOD CONFORMANCE CHART

TRACE METALS

ELEMENT	METHOD	CONTAINER	PRESERVATION	HOLD TIME
SILVER - FLAME	272.1 (1) 7760 (2)	P, G	HNO_3 to pH < 2	6 months
CALCIUM - FLAME	215.1 (1) 7140 (2)	P, G	HNO_3 to pH < 2	6 months
CADMIUM - FLAME	213.1 (1) 7130 (2)	P, G	HNO_3 to pH < 2	6 months
CHROMIUM - FLAME	218.1 (1) 7190 (2)	P, G	HNO_3 to pH < 2	6 months
COPPER – FLAME	220.1 (1) 7210 (2)	P, G	HNO_3 to pH < 2	6 months
IRON - FLAME	236.1 (1) 7380 (2)	P, G	HNO_3 to pH < 2	6 months
POTASSIUM FLAME	258.1 (1) 7610 (2)	P, G	HNO_3 to pH < 2	6 months
MAGNESIUM - FLAME	242.1 (1) 7450 (2)	P, G	HNO_3 to pH < 2	6 months
MANGANESE - FLAME	243.1 (1) 7460 (2)	P, G	HNO_3 to pH < 2	6 months
SODIUM - FLAME	273.1 (1) 7770 (2)	P, G	HNO_3 to pH < 2	6 months
NICKEL - FLAME	249.1 (1) 7520 (2)	P, G	HNO_3 to pH < 2	6 months
LEAD - FLAME	239.1 (1) 7420 (2)	P, G	HNO_3 to pH < 2	6 months
ZINC - FLAME	289.1 (1) 7950 (2)	P, G	HNO_3 to pH < 2	6 months

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

FMETL METHOD CONFORMANCE CHART

TRACE METALS

ELEMENT	METHOD	CONTAINER	PRESERVATION	HOLD TIME
ALUMINUM - FURANCE	202.1 (1) -	P, G	HNO_3 to pH < 2	6 months
ARSENIC - FURNANCE	206.2 (1) 7060 (2)	P, G	HNO_3 to pH < 2	6 months
BARIUM - FURNACE	208.2 (1) 7081 (2)	P, G	HNO_3 to pH < 2	6 months
BERYLLIUM - FURNACE	210.2 (1) 7091 (2)	P, G	HNO_3 to pH < 2	6 months
CADMIUM - FURNACE	213.2 (1) 7131 (2)	P, G	HNO_3 to pH < 2	6 months
COBALT - FURNACE	219.2 (1) 7201 (2)	P, G	HNO_3 to pH < 2	6 months
CHROMIUM - FURNACE	218.2 (1) 7191 (2)	P, G	HNO_3 to pH < 2	6 months
MANGANESE FURNACE	243.2 (1) 7461 (2)	P, G	HNO_3 to pH < 2	6 months
LEAD - FURNACE	239.2 (1) 7421 (2)	P, G	HNO_3 to pH < 2	6 months
ANTIMONY - FURNACE	204.2 (1) 7041 (2)	P, G	HNO_3 to pH < 2	6 months
SELENIUM - FURNACE	270.2 (1) 7740 (2)	P, G	HNO_3 to pH < 2	6 months
TIN - FURNACE	282.2 (1)	P, G	HNO_3 to pH < 2	6 months
THALLIUM – FURNACE	279.2 (1) 7841 (2)	P, G	HNO_3 to pH < 2	6 months
VANADIUM - FURNANCE	286.2 (1) 7911 (2)	P, G	HNO_3 to pH < 2	6 months
MERCURY – COLD VAPOR	245.1 (1) 7470 (2)	P, G	HNO_3 to pH < 2	28 days

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 7

FMETL METHOD CONFORMANCE CHART

Method references are indicated in the second column, following the method number.

(1): "Methods for Chemical Analysis of Water and Wastes", Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, March 1983, EPA - 600 4 -79 -020

(2): "Test Methods for Evaluating Solid Waste", Physical / Chemical Methods, SW - 846, 3rd Edition

(3): Code of Federal Regulations, Title 40, Part 136

(4): "Methods for the Determination of Organic Compounds in Drinking Water", EPA - 600 / 4 - 88 / 039, EMSL, USEPA, Cincinnati, OH 45268

(5): "Standard Methods for Water and Wastewater", 18th Edition

(6): "Method 200.7 and Appendix A, Revision 1.3. Inductively Coupled Plasma - atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes", USEPA. ORD Publications, Cincinnati, OH 45268

SECTION 8

8.0 DATA

8.1 DATA REDUCTION

FMETL's data reduction format is consistent throughout the laboratory departments with respect to overall acceptance of data. The quality control data from each analytical batch is reviewed for each project. Data calculations are either performed manually or by computer programs that are limited with some of our instrumentation. The equations and acceptance criterion for data reduction is in accordance with respective methodologies.

8.2 DATA VALIDATION

The principle criteria to be used to validate data integrity during analyses will be the following:

- Reagent blank results.
- Method blank results.
- Calibration curve verification.
- Serial dilution results (metals only).
- Post-spike verification results (metals only).
- Laboratory Control Standards.
- Matrix spike/spike duplicate results.
- Quality control check sample results.
- Spiked surrogate recovery (organic only).

The analyst, using specific acceptance criteria initially makes the measurements. The analyst will either proceed with the analyses or take corrective action. The Laboratory Director and/or QA Manager may make decisions on unusual circumstances. FMETL utilizes computer programs and laboratory logbooks to ensure the integrity and legal validity of all sample analytical results.

8.3 CHEMICAL INVENTORY

The laboratory maintains a chemical inventory login/logout logbook. The log is filled out for every reagent and standard received. The following is recorded:

-Login #	-Matrix
-Chemical Name/Formula	-Mass Volume
-Supplier	-Expiration Date
-Lot #/C.A.S. #	-Login Date/Logout Date

All shipments are checked, initialed and dated upon receipt. Standards and reagents are then stored until required by individual departments.

8.4 CHEMICAL PREPARATION

A chemical preparation logbook is assigned to each section of the laboratory. All standards, reagents and solutions utilized in an analysis are documented in these logbooks. The following minimum is recorded:

- Date of Preparation.
- Analyst's name.
- Reagent or standard prepared.
- Components manufacturer and lot numbers.
- Weights and volumes of components.
- Concentration.

A code number is assigned to each chemical preparation, which is recorded with every analysis.

8.5 LABORATORY ANALYSIS LOGBOOK

All analyses are recorded on Laboratory/Analysis Logbooks, which document the raw data for each analytical parameter determined. Depending on the parameter, a logbook may be assigned to a specific method, instrument or to an individual analyst. Pertinent preparation, extraction, and instrumental data are recorded for each sample. This includes laboratory identification number, initial sample volume or weight, extraction volumes, dilution factors, instrument values, and the date and name of the responsible FMETL analyst. These logbooks may also include calculations of samples and QC data. Analysis Logbooks are document controlled by QA and maintained for ten years.

8.6 LABORATORY INSTRUMENT LOGBOOK

All laboratory analyses requiring analytical instrumentation are recorded in dedicated instrument logbooks. These logbooks record instrument settings, maintenance and performance criteria. Specifics to the analytical batch are, calibration standards, QC and sample sequence dilutions and associated comments. Laboratory Instrument Logbooks are retained for ten years.

8.7 LABORATORY QUALITY CONTROL DATA LOGS

The Quality Control Data Logs contain corresponding laboratory data generated for the Quality Control Program. These files consist of records of various laboratory quality control components including, QC spike and replicate performance data, statistical calculations of continuous method performance evaluations, surrogate spike recovery evaluations, and method blank analyses.

8.8 DATA REPORTING

Laboratory personnel enter all completed results and associated QC data onto analytical batch sheets that are then reviewed for completeness. A thorough review of the quality control data is performed prior to the package preparation. A peer review is then performed on the data. The data package is assembled by document control. After it has been completed, an administrative review is performed. This review will include a minimum of the following:

- Completeness of results.
- Verification of dates, detection limits, sample identifications and other units of measure.
- Verification of calculations.
- Adherence to method procedures.
- Comparing consistency of results:
- TDS and specific conductivity; TKN versus ammonia-nitrogen, etc.

A 5-10% full external QA/QC review is then performed on the final data packages.

The confidentiality of a Client requiring results by facsimile or other electronic means shall be maintained by including a confidentiality notice on the cover page. The cover will also state that this is a preliminary copy of the analytical results and the hard copy will follow (see Appendix 4).

8.9 DATA REPORTING FORMAT

FMETL offers a variety of reporting or data package formats to comply with various NJDEP and USEPA requirements. A data package may consist of:

- Results only
- QA/QC data summary
- Reduced deliverables
- Full data deliverables

All of the above formats include, but are not limited to the following:

- Laboratory Name, Address and Certification Number
- Laboratory Project Number and/or Workorder Number and Sample Number
- Client Name and Project
- Copy of the Chain of Custody
- Signature of Laboratory Director and Date

Additional technical information and supporting raw data can be provided if necessary.

8.10 REPORT ARCHIVING

Copies of all analytical reports are kept on file according to project number and client name. These reports are archived with the original chain of custody, analytical batch sheets, field sheets, invoice, and any additional information relating to the project. The Administration staff is responsible for the organization and completeness of the archived reports. All original records are kept for ten years unless otherwise directed by a client.

SECTION 9

9.0 INTERNAL QUALITY CONTROL CHECKS

The QA/QC program is designed to continuously document QC data as analyses are being performed. Some of the QC checks originate in the field in the form of "blind" duplicates and blanks.

On a quarterly basis FMETL performs performance checks to evaluate various sections of the laboratory. The QA/QC procedures followed by FMETL are based upon USEPA methodologies and state certification requirements.

9.1 INITIAL METHOD PERFORMANCE EVALUATION

FMETL conducts method performance evaluations of each analytical method to demonstrate the ability to achieve acceptable method accuracy and precision. The data acquired from these evaluations is compared to USEPA method criteria to determine and document acceptable performance.
Individual analysts must perform a Demonstration of Capability on each method before they can analyze samples. This information is kept in the analysts' file. The laboratory maintains precision and accuracy data and method detection studies for each method performed. Method Detection Limit's (MDL's) are established for all instruments and extraction procedures. These MDL's are updated annually.

9.2 PERFORMANCE EVALUATION SAMPLES

FMETL evaluates Certified analytical parameters several times a year to maintain its certifications. Performance samples are received from private vendors for the NJDEP Office of Quality Assurance, the New York Environmental Laboratory Approval Program and the American Industrial Hygiene Association. The purpose of these studies is to demonstrate an acceptable method performance level utilizing proper laboratory operating procedures.

9.3 LABORATORY CONTROL SAMPLES

Laboratory control samples (LCS) are analyzed to verify method performance. Methods and SOPs are followed to determine spiking levels and what compounds are actually spiked. Similar to matrix spikes, the analyte is added to reagent water instead of a sample and the source of the spike material is independent of spike and calibration standards. An LCS is performed within each analytical batch or group of twenty samples, whichever is more frequent, unless otherwise specified by method protocol.

9.4 METHOD BLANK EVALUATION

FMETL systematically prepares and analyzes method blanks with each batch of samples prepared. This is to continuously evaluate analytical system interferences and background contamination levels. A method blank consists of actual, routine method analyses, substituting reagent water or other applicable clean matrix for the actual sample. Analyses of method blanks will provide a safeguard against interfering and/or contaminated reagents, glassware, and laboratory environments. Unfavorable method blank performance will render associated data suspect and require corrective action.

9.5 FIELD BLANK EVALUATION

A field blank consists of laboratory reagent water, sent out to the sampling site and transferred on-site over and through sampling material to a clean sample container. Field blanks will be analyzed at the request of the client, for the parameters of interest. Analytical results may be used to evaluate environmental and procedural effects of the sampling event.

9.6 TRIP BLANK EVALUATIONS

The laboratory provides volatile organic free water in closed vials. These vials are taken on-site and back, but not opened. Trip blanks are required when sampling volatile organics. Trip blanks are analyzed to detect accidental or incidental contamination.

9.7 CONTINUING MATRIX SPIKE/SPIKE DUPLICATE (MS/MSD)

A matrix spike and duplicate matrix spike samples are prepared and analyzed within each group of twenty (20) samples with similar matrix for the required method. Methods and SOPs are followed to determine spiking levels and what compounds are actually spiked. This involves spiking two aliquots of a client's sample to check for sample and extract matrix effects on recovery of the known added analyte. Percent Recovery Determinations
(R) and Relative Percent Difference (RPD) from these matrix spike results are monitored to provide a continuous measure of the overall accuracy and precision of the method.

SECTION 9

9.8 SURROGATE SPIKE (ORGANIC ONLY)

FMETL conducts continuous surrogate spike recovery evaluations on all GC and GC/MS volatile, semi-volatile, pesticide, PCB and herbicide analyses to ensure acceptable method performance. Surrogate spikes consisting of non-targeted compounds are added to each GC and GC/MS sample, extract and standard. This allows continuous evaluation of acceptable method performance, and measurement of matrix effects on recovery of known added analytes. Failure of surrogate spike recovery render associated data suspect and requires corrective action. Refer to Section 3 for FMETL surrogate control limits. Corrective action procedures are addressed in each respective methodology SOP.

9.9 REAGENT WATER SYSTEM MONITORING

Water, free from interferences and other undesirable contaminants must be available to the analyst. FMETL's deionized (DI) water system is monitored for several variables. Water suitable for microbiological testing must be checked, verified and recorded accordingly:

CONDUCTIVITY	daily	<2 umhos/cm at 25° C
pH	daily	5.5-7.5 s.u.
CHLORINE RESIDUAL	daily	None detected
STANDARD PLATE COUNT	monthly	<500 Colonies/ML
HEAVY METALS: Pb, Cd, Cr, Cu, Ni, Zn	annually	Not greater than 0.05 MG/L per contaminant.
TOTAL METALS NOT LIMITED TO THOSE ABOVE.	annually	Not greater than 0.1 MG/L collectively.
BACTERIOLOGICAL QUALITY OF WATER	annually	Ratio between 0.8 to 3.0

Only satisfactorily tested laboratory pure water is permissible in preparing media, reagents, rinse and dilution water.
In addition to these mandatory requirements, DI water blanks are prepared and tested for each FMETL analytical method performed. This includes both organic and inorganic tests.

SECTION 10

10.0 PERFORMANCE AND SYSTEM AUDITS

The systems audit for each project consists of an initial evaluation of the proposed sampling. An analysis protocol to determine its applicability to the objectives of the project followed by routine checks of the data and quality control results. Then it is evaluated on the representation and applicability of the data with respect to field conditions and the usefulness of the results in answering specific questions concerning the system. The system audit will verify that SOP procedures are being followed, data reviews are complete and certified sources are traceable. For each project, a systems audit shall be conducted with each submission of written data until such audits indicate that the data are reasonably useful and representative. Any audit findings or corrective actions shall be fully documented in Quality Assurance Reports to management (QAR). The QA manager shall document that any findings or corrective actions required are verified within a reasonable time frame. Once that determination is made, additional audits shall be conducted periodically on a not less then quarterly basis for any long term and ongoing projects.

Performance audits are blind samples that are analyzed for each parameter generated to determine that the analyses used are providing the desired level of performance. After that determination has been made, internal performance audits shall be conducted periodically, but not less than monthly.
Semiannually, the NJDEP and the NYSDOH through their laboratory certification programs conduct external performance audits, evaluating the performance of the whole laboratory. In addition, NJDEP and NYSDOH personnel conduct on-site inspections of the laboratory's facilities.
Quarterly, the AIHA through its laboratory certification program conducts external performance audits. This is to evaluate the performance of the laboratory in various lead matrices. They also conduct onsite inspections of the laboratory's facility.

FMETL participates in a number of additional performance audits, both internal and external, to monitor the capability and performance of the laboratory and its operations.

10.1 INTERNAL PERFORMANCE EVALUATIONS

Representative analytical parameters are evaluated on a semi-annual basis at minimum. Sample vials containing analytes of known concentration are purchased from vendors who have demonstrated that their materials are prepared in accordance with USEPA requirements. These samples are prepared and analyzed along with unknown performance evaluation samples and routine sample batches of metals, organic, inorganic and physical parameters. Compliance with respect to recovery and precision data is

monitored and corrective actions are taken when required. Compliance is monitored within each employee's training file.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 11

11.0 PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY AND COMPLETENESS

Every project or batch of analyses is associated with a set of QC data for the respective test procedures and matrices. The first sample in each batch is used as the designated QC sample. Attention being taken that all clients and matrix types is treated equally. The results of the QC data are entered into the QA program by project number and date of analysis. Percent recovery (R) and relative percent difference (RPD) data is processed and used to generate spread sheets for each method. The acceptability of a batch of analyses is based on the performance of the Laboratory Control Sample, Matrix Spike and Matrix Spike Duplicate recoveries. These recoveries and associated data points are presented on control charts to provide a continuous indication of method performance. The control charts provide a visible comparison of the actual Quality Control limits. Laboratory method performance criteria are utilized to evaluate control data in the absence of and addition to published USEPA method performance criteria.
The calculation procedures for assessing data accuracy and precision are summarized below, and apply to all analytical parameters.

Accuracy: Percent Recovery (R) = (Observed Conc. X 100)/ Expected Conc.

Precision: Relative Percent Difference (RPD) = (C1 - C2)/(C1 + C2)/ 2 X 100

Where C1 and C2 are concentrations of duplicate spikes.

The mean value percent recovery (X) and standard deviation (S) determinations calculated from the spiked quality control results are compared to laboratory Quality Control Objectives for each analytical method performed in the laboratory. Calculations for analytical control limits are outlined below:

	ACCURACY	PRECISION
UPPER CONTROL LIMIT (UCL)	% X + 3 S	RPD + 3 S
UPPER WARNING LIMIT (UWL)	% X + 2 S	RPD + 2 S
LOWER WARNING LIMIT (LWL)	% X - 2 S	*
LOWER CONTROL LIMIT (LCL)	% X - 3 S	*

WHERE (S) is the STANDARD DEVIATION.

SECTION 11

% X - AVERAGE MEAN OF 20 CONSECUTIVE DATA POINTS.

RPD - RELATIVE % DIFFERENCE

LOWER DETECTION LIMITS ARE NOT CALCULATED FOR RPD, ZERO (0) % IS PERFECT PRECISION.

S – STANDARD DEVIATION.

X - NUMBER OF OBSERVED VALUES.

N - NUMBER OF OBSERVATIONS.

Quality Control Objectives for project parameters may be referenced in Section 3.0. All precision and accuracy statements are compared to calculated control limits from the respective lab department's Quality Control Data Logs.

SECTION 12

12.0 CORRECTIVE ACTION

FMETL routinely utilizes its quality control data to assess the need for corrective action. Frequent review of data and monitoring of operating procedures, permits rapid identification of the source of analytical or sampling error and implementation of corrective action.

Corrective actions may involve any phase of the sampling, analytical or data reporting methods including: reagent quality, sample extraction, equipment cleaning, instrument calibration, instrument performance, calculations, etc. These corrective actions must be verified complete within a reasonable time frame.

12.1 CORRECTIVE ACTIONS DETERMINED BY BATCH QC RESULTS

Precision and accuracy determinations from the spikes and duplicates must compare favorably to the published USEPA or laboratory method performance criteria outlined previously, in order to validate and approve of a corresponding batch of sample analyses.

Unacceptable values, positive method blank results or data reporting inconsistencies will render the corresponding batch of sample analyses suspect. The QC Data Reviewer will direct requests of the analyst, corrective action to be performed and documented on the QC batch sheet, and in the respective laboratory analysis notebook.

Each analyst is encouraged to immediately take corrective action when associated QC parameters fail established criteria. Department managers are informed of all unacceptable performances and repeat analyses.

Corrective action may consist of, but is not limited to sample and/or standard re-injection or re-preparation.

12.2 CORRECTIVE ACTIONS DETERMINED BY SAMPLE RESULTS

Implications due to sample matrix may require corrective action. A particular example is that of the organic surrogate failure. If recoveries of selected surrogates are outside of established control limit criteria, a sample is required to be re-extracted and reanalyzed. Additional corrective actions implemented on samples may include application of a clean-up technique or sample dilution. These corrective actions must be verified complete within a reasonable time frame.

12.3 CORRECTIVE ACTIONS DETERMINED FROM SYSTEMATIC PROBLEMS

Corrective action may also be implemented as a result of external performance and systems audits conducted by concerned clients, federal and state agencies, or other QA/QC activities.

While the Laboratory Managers, and ultimately the Laboratory Director are responsible for overall approval of corrective action on larger systematic issues, the QA Manager is included in the decision making process.

The QA department maintains various records that are kept on file for review. These records may consist of electronic mail messages documenting actions taken by respective lab departments, or formal responses to agencies summarizing corrective actions. Corrective actions are summarized in a Corrective Action logbook. At minimum, the following information is documented:

- Date and episode that situation was identified;
- Description of situation requiring corrective action;
- Associated laboratory department and technician;
- The corrective action agreed to be taken;
- The target date of implementation or outcome.

The steps taken to improve or correct laboratory operating procedures and their results are monitored and maintained by the QA staff. Outstanding Corrective Action issues are brought to the attention of the Laboratory Director and the Manager of Quality Assurance and Safety in Quality Assurance Reports to Management.

12.4 PROCEDURES FOR DEALING WITH COMPLAINTS

A complaint from a customer regarding analytical results, report format or procedures will be brought to the attention of the Laboratory Director and the QA Manager. The complaint will be investigated and documented in the same manner as a Corrective Action. A complaint dealing with laboratory personnel will be brought to the attention of the Laboratory Director. If the complaint is substantial, Human Resources will become involved to determine if disciplinary action is necessary.

SECTION 13

13.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Manager of Quality Assurance and Safety and the laboratory director shall be kept apprised of the quality control procedures and results of the operation of the laboratory on a regular basis (quarterly). Under no circumstances shall the technicians working on a particular project allow quality control issues or deficiencies to go unreported to the proper quality assurance for each project report before it is issued.

Management shall also receive quality assurance reports as they are received from the external system audits. Quality assurance reports issued as part of the project report for each client shall be retained as part of the project report for each client and with the original data for each report. Since laboratory management is directly involved in each corrective action performed in connection with the quality assurance program, additional reports to management are not necessary for those functions.

Management shall also review quality control data charts for individual parameters on a regular basis to verify overall performance of the laboratory functions. Any time deficiencies are reported through internal or external audits that have not otherwise been addressed through the quality assurance procedures, both verbal and written reports shall be prepared detailing the problem encountered, its cause, and the corrective actions taken.

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 14

SAFE DRINKING WATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Total Coliform	Membrane Filter	SM 18th-9222B	NJ
Total Coliform	Multiple-Tube	SM 18th 9221B	NJ
Fecal Coliform	MTF into EC	SM 18th 9221B & E	NJ
Fecal Coliform	Membrane Filter	SM 18th 9222B & 9221E	NJ
Escherichia Coli	EC Medium + MUG	SM 18th 9222B & 9221E+MUG	NJ
Escherichia Coli	Nutrient Agar + MUG	SM 18th 9222B & 9221B(3)a(3)+MUG	NJ
Turbidity	Nephelometric	EPA 180.1 & SM 18th 2130	NJ
Nitrate	Ion Selective Electrode	SM 18th 4500-NO3-D	NJ
Nitrite	Spectrophotometric	SM 18th 4500-NO2-B	NJ
Fluoride	Ion Selective Electrode	SM 18th 4500-F-C	NJ
Cyanide	Spec., Distill., Manual	SM 18th 4500-CN-E	NJ
Sulfate	Turbidity, Spec.	SM 18th 4500-SO_4-C or E	NJ
Sodium	ICP	EPA 200.7	NJ
Sodium	AA, Direct Aspiration	SM 18th 3111B	NJ
Total Diss. Solids	Gravimetric at 180°C	SM 18th 2540C	NJ
Calcium	ICP	EPA 200.7	NJ
Calcium	AA, Direct Aspiration	SM 18th 3111B	NJ
Hardness	ICP-Calculation	EPA 200.7 & SM 18th 3120B/3111B	NJ
Hardness	Titrimetric-EDTA	SM 18th 2340C	NJ
Alkalinity	Electrometric Indicator	SM 18th 2320B	NJ
Chloride	Argentometric	SM 18th 4500-CL-B	NJ
Color	Platinum-Cobalt	SM 18th 2120B	NJ
Foaming Agents	Methylene Blue	SM 18th 5540C	NJ
Odor	Consistent Series	SM 18th 2150B	NJ
Conductivity	Conductance	SM 18th 2510B	NJ
Orthophosphate	Colorimetric	SM 18th 4500-P-E	NJ
Chlorine (residual)	DPD, Colorimetric	SM 18th 4500-Cl-G	NJ
pH, Immediate	Electrometric	EPA 150.1	NJ
Temperature	Thermometric	SM 18th 2550B	NJ
Aluminum	ICP	SM 18th 3120B & EPA 200.7	NJ

SAFE DRINKING WATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Aluminum	AA, Direct Aspiration	SM 18th 3111B	NJ
Arsenic	ICP	SM 18th 3120B & EPA 200.7	NJ, MD
Arsenic	AA, Graphite Furnace	SM 18th 3113B	NJ, MD
Barium	ICP	SM 18th 3120B & EPA 200.7	NJ, MD
Barium	AA, Graphite Furnace	SM 18th 3113B	NJ, MD
Beryllium	ICP	SM 18th 3120B & EPA 200.7	NJ, MD
Beryllium	AA, Graphite Furnace	SM 18th 3113B	NJ, MD
Cadmium	ICP	SM 18th 3120B & EPA 200.7	NJ, MD
Cadmium	AA, Graphite Furnace	SM 18th 3113B	NJ, MD
Chromium	ICP	SM 18th 3120B & EPA 200.7	NJ, MD
Chromium	AA, Graphite Furnace	SM 18th 3113B	NJ, MD
Copper	ICP	SM 18th 3120B & EPA 200.7	NJ, MD
Copper	AA, Direct Aspiration	SM 18th 3111B	NJ, MD, PA
Iron	ICP	SM 18th 3120B & EPA 200.7	NJ
Iron	AA, Direct Aspiration	SM 18th 3111B	NJ
Lead	AA, Graphite Furnace	SM 18th 3113B	NJ, MD, PA
Manganese	ICP	SM 18th 3120B & EPA 200.7	NJ
Manganese	AA, Direct Aspiration	SM 18th 3111B	NJ
Mercury	Manual Cold Vapor	SM 18th 3112B & EPA 245.1	NJ, MD
Nickel	ICP	SM 18th 3120B & EPA 200.7	NJ
Nickel	AA, Direct Aspiration	SM 18th 3111B	NJ
Selenium	AA, Graphite Furnace	SM 18th 3113B	NJ, MD
Silver	ICP	SM 18th 3120B & EPA 200.200.7	NJ
Silver	AA, Graphite Furnace	SM 18th 3111B	NJ

SAFE DRINKING WATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Thallium	AA, Graphite Furnace	EPA 200.9	NJ, MD
Zinc	ICP	SM 18th 3120B & EPA 200.200.7	NJ
Zinc	AA, Direct Aspiration	SM 18th 3111B	NJ
Pesticides/PCBs	GC-Microextraction	EPA 505	NJ
Volatile Organics	GC/MS	EPA 524.2	NJ

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 14

WASTEWATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Coliform(Total)	Membrane Filter	SM 18th 9222B	NJ
Coliform(Fecal)	Membrane Filter	SM 18th 9222D	NJ
Ammonia	Distillation, Electrode	EPA 350.2 + 3 & SM 4500-NH_3 B,F,G	NJ
BOD, 5-Day	Diss. Oxygen Depl.	SM 18th 5210B & EPA 405.1	NJ
Boron-total	ICP	EPA 200.7 & SM 18th 3120B	NJ
Calcium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Calcium-total	Digestion-AA, Direct	SM 18th 3111B & EPA 215.1	NJ, NY
CBOD	Diss. Oxygen Depl., Nitrification Inhibitor	SM 18th 5210B	NJ
COD	Spectrophotometric	SM 18th 5220D & EPA 410.4	NJ
Chloride	Titrimetric, ($AgNO_3$)	SM 18th 4500-Cl-B	NJ
Color	Platinum-Cobalt	SM 18th 2120B & EPA 110.2	NJ
Cyanide	Distillation, Spectro., Man.	SM 18th 4500-CN-C, E	NJ
Fluoride	Distill.+Elect., Man.	SM 18th 4500-F-C	NJ
Hardness-total	ICP-Calculation	SM 18th 3120B	NJ
Hardness-total	Titrimetric,(EDTA)	SM 18th 2340B or C	NJ
Magnesium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Magnesium-total	Digestion-AA, Direct	SM 18th 3111B& EPA 242.1	NJ, NY
Nitrate-Nitrite	Cadmium Red., Man.	SM 18th 4500-NO_3-E & EPA 353.3	NJ
Orthophosphate	Ascorbic Acid	SM 18th 4500-P-E & EPA 365.2	NJ
Phosphorous-total	Persulfate Digestion	SM 18th 4500-P-B5 +E	NJ
Potassium	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ

WASTEWATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Potassium	Digestion-AA, Direct	SM 18th 3111B & EPA 258.1	NJ
Residue-Total	Gravimetric-103-105°C	EPA 160.3	NJ
Residue-Filterable	Gravimetric-180°C	EPA 160.1	NJ
Res.-Non-Filterable	Gravimetric-103-105°C	EPA 160.2	NJ
Residue-Settleable	Volumetric	EPA 160.5	NJ
Residue-Volatile	Gravimetric-500°C	EPA 160.4	NJ
Sodium	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ
Sodium	Digestion-AA, Direct	SM 18th 3111B & EPA 273.1	NJ
Specific Cond.	Wheatstone Bridge	EPA 120.1	NJ
Sulfate	Turbimetric	EPA 375.4	NJ
Turbidity	Nephelometric	EPA 180.1	NJ
Chlorine	DPD Spectro.	SM 18th 4500-Cl-G	NJ
Oxygen, Dissolved	Winkler	EPA 360.2	NJ
Oxygen, Dissolved	Electrode	EPA 360.1	NJ
pH, Hydrogen Ion	Electrometric	EPA 150.1	NJ, NY
pH, Hydrogen Ion	Cont. Electrometric	EPA 150.2	NJ
Temperature	Thermometric	EPA 170.1	NJ
Aluminum-total	Digestion-AA Direct	SM 18th 3111D	NJ, NY
Aluminum-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Antimony-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Antimony-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Antimony-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Arsenic-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Arsenic-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Barium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Barium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Barium-total	Digestion-AA Direct	SM 18th 3111D	NJ, NY

SECTION 14

WASTEWATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Beryllium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Beryllium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Beryllium-total	Digestion-AA Direct	SM 18th 3111D	NJ, NY
Cadmium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Cadmium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Cadmium-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Chromium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Chromium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Chromium-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Cobalt-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Cobalt-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Cobalt-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Copper-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Copper-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Iron-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Iron-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Lead-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Lead-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Lead-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Manganese-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Manganese-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Mercury-total	Cold Vapor, manual	SM 18th 3112B & EPA 245.1	NJ, NY
Molybdenum-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ
Nickel-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY

SECTION 14

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

WASTEWATER ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Nickel-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Selenium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Selenium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Silver-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Silver-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Silver-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Thallium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Thallium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Thallium-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Tin-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ
Vanadium-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Vanadium-total	Digestion-AA Furnace	SM 18th 3113B	NJ, NY
Vanadium-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Zinc-total	Digestion-ICP	EPA 200.7 & SM 18th 3120B	NJ, NY
Zinc-total	Digestion-AA Direct	SM 18th 3111B	NJ, NY
Pesticides/PCBs	Extract/GC (ECD)	EPA 608	NJ, NY
Purgeables (VOA)	GC/MS	EPA 624	NJ, NY
Base/Neut. & Acids	GC/MS	EPA 625	NJ, NY

SECTION 14

SOLID HAZARDOUS WASTE ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Ignitability	Pensky Martens	EPA SW846 1010	NJ, NY
Reactivity	HCN Release, Distill	EPA SW846 7.3.3.2	NJ, NY
Reactivity	H_2S Release, Distill	EPA SW846 7.3.4.2	NJ, NY
Volatile Organics	TCLP, ZHE	EPA SW846 1311	NJ, NY
Metals-Semiorganics	TCLP, Shaker	EPA SW846 1311	NJ, NY
Hydrogen Ion, pH	Electrometric	EPA SW846 9040B	NJ, NY
Temperature	Thermometric	EPA SW846 2550B	NJ, NY
Aluminum	ICP	EPA SW846 6010B	NJ, NY
Alumnium	AA, Direct Aspiration	EPA SW846 7020	NJ, NY
Antimony	ICP	EPA SW846 6010B	NJ, NY
Antimony	AA, Direct Aspiration	EPA SW846 7040	NJ, NY
Arsenic	ICP	EPA SW846 6010B	NJ, NY
Arsenic	AA, Graphite Furnace	EPA SW846 7060A	NJ, NY
Barium	ICP	EPA SW846 6010B	NJ, NY
Barium	AA, Direct Aspiration	EPA SW846 7080A	NJ, NY
Beryllium	ICP	EPA SW846 6010B	NJ, NY
Beryllium	AA, Graphite Furnace	EPA SW846 7091	NJ, NY
Cadmium	ICP	EPA SW846 6010B	NJ, NY
Cadmium	AA, Direct Aspiration	EPA SW846 7130	NJ, NY
Calcium	ICP	EPA SW846 6010B	NJ, NY
Calcium	AA, Direct Aspiration	EPA SW846 7140	NJ, NY
Chromium	ICP	EPA SW846 6010B	NJ, NY
Chromium	AA, Direct Aspiration	EPA SW846 7190	NJ, NY
Cobalt	ICP	EPA SW846 6010B	NJ, NY
Copper	AA, Direct Aspiration	EPA SW846 7210	NJ, NY
Copper	ICP	EPA SW846 6010B	NJ, NY
Iron	ICP	EPA SW846 6010B	NJ, NY
Iron	AA, Direct Aspiration	EPA SW846 7380	NJ, NY
Lead	ICP	EPA SW846 6010B	NJ, NY
Lead	AA, Direct Aspiration	EPA SW846 7420	NJ, NY
Lead	AA, Graphite Furnace	EPA SW846 7421	NJ, NY
Magnesium	ICP	EPA SW846 6010B	NJ, NY
Magnesium	AA, Direct Aspiration	EPA SW846 7450	NJ, NY
Manganese	ICP	EPA SW846 6010B	NJ, NY

SOLID HAZARDOUS WASTE ANALYSIS			
PARAMETER	**TECHNIQUE**	**METHOD**	**ACCREDITING AUTHORITY**
Manganese	AA, Direct Aspiration	EPA SW846 7460	NJ, NY
Mercury-Liquid	Manual Cold Vapor	EPA SW846 7470A	NJ, NY
Mercury-Solid	Manual Cold Vapor	EPA SW846 7471A	NJ, NY
Nickel	ICP	EPA SW846 6010B	NJ, NY
Nickel	AA, Direct Aspiration	EPA SW846 7520	NJ, NY
Potassium	ICP	EPA SW846 6010B	NJ, NY
Potassium	AA, Direct Aspiration	EPA SW846 7610	NJ, NY
Selenium	AA, Graphite Furnace	EPA SW846 7740	NJ, NY
Selenium	ICP	EPA SW846 6010B	NJ, NY
Silver	ICP	EPA SW846 6010B	NJ, NY
Silver	AA, Direct Aspiration	EPA SW846 7760A	NJ, NY
Sodium	ICP	EPA SW846 6010B	NJ, NY
Sodium	AA, Direct Aspiration	EPA SW846 7770	NJ, NY
Thallium	ICP	EPA SW846 6010B	NJ, NY
Thallium	AA, Graphite Furnace	EPA SW846 7841	NJ, NY
Vanadium	AA, Direct Aspiration	EPA SW846 7910	NJ, NY
Vanadium	AA, Graphite Furnace	EPA SW846 7911	NJ, NY
Vanadium	ICP	EPA SW846 6010B	NJ, NY
Zinc	ICP	EPA SW846 6010B	NJ, NY
Zinc	AA, Direct Aspiration	EPA SW846 7950	NJ, NY
Organochlorine Pesticides	GC, Extraction, ECD	EPA SW846 8081A	NJ, NY
PCB's	GC, Extraction, ECD	EPA SW846 8082	NJ, NY
Volatile Organics	GC/MS Purge & Trap	EPA SW846 8260B	NJ, NY
Semivolatile Organics	GC/MS Extraction	EPA SW846 8270C	NJ, NY

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 15

15.0 LABORATORY EQUIPMENT

EQUIPMENT	YEAR MANUFACTURED
GC/MS VOA	
HP Model 6890 GC	1997
HP Model 5972 MSD	1997
OI Model 4560 Concentrator	1997
OI DPM-16 Sampler	1997
OI MHC-16 Heater	1997
HP Chemstation/Enviroquant Data System	1997
HP Model 6890 GC	1998
HP Model 5973 MSD	1998
OI Model 4560 Concentrator	1998
OI Model 4552 Archon Autosampler	1998
HP Model 6890 GC	1999
HP Model 5973 MSD	1999
Tekmar 3000 Concentrator	1999
EST Model 4552 Archon Autosampler	1999
GC/MS Semi-Volatile	
HP Model 6890 GC	1997
HP Model 5972 MSD	1997
HP 91513A Tower	1997
HP 91512A Controller	1997
HP 18596C Tray	1997
HP Chemstation/Enviroquant Data System	1997
HP Model 6890 GC	1998
HP Model 5973 MS	1998
HP Model 6890 Injector Tower	1998
GC Semi-Volatile	
HP 5890 Series II GC	1995
HP FID Detector	1995
HP TCD Detector	1997
HP 18596C Tray	1995
HP 91513A Tower	1995
HP 91512A Controller	1995
HP Chemstation/Enviroquant Data System	1995

SECTION 15

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

EQUIPMENT	YEAR MANUFACTURED
GC Semi-Volatile (cont.)	
HP 5890 Series II GC	1996
HP FID Detector	2000
HP FPD Detector	2000
HP 91513A Tower	1997
HP 91512A Controller	1997
HP 18596C Tray	1997
HP 5890 Series II GC	1997
(2) HP ECD Detectors	1997
HP 91513A Tower	1997
HP 91512A Controller	1997
HP 18596C Tray	1997
HP Chemstation/Enviroquant Data System	1997
HP Model 6890 GC	1998
(2) HP Model 2397A ECD	1998
HP Model 6890 Injector Tower	1998
HP Model 6890 GC	1999
(2) HP Model 2397A ECD	1999
HP Model 6890 Injector Tower	1999
METALS ANALYSIS	
Perkin Elmer Optima 3000 DV (ICP) W/AS-91 Autosampler	1997
VARIAN SpectrAA-640Z (Furnace) w/ PDS Autosampler	1995
VARIAN SpectrAA-640 (Flame) w/ SPS-5 Autosampler	1995
VARIAN VGA-77 (Vapor Generation Accessory)	1995
MICROWAVE DIGESTIONS	
(2)MILESTONE Microwave Laboratory System MEGA Microwave Labstation Workstation MLS-1200	1995 & 1998
(2)MILESTONE Microwave Digestion Rotor HPR-1000/10S	1998

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 15

EQUIPMENT	YEAR MANUFACTURED
HOT BLOCK DIGESTIONS	
SCP Science Hot Block Digestion System	2002
EXTRACTIONS	
Organomation S-Evap Model 12169	1996
Organomation S-Evap Model 12169	2000
Organomation N-Evap Model 112	1998
Organomation N-Evap Model 112	2000
ABC Instruments Automated Sox-therm	1996
(2) OI Analytical Automated Sox-therms	1998
Gerhardt Automated Sox-therm	2002
Glas-Col 3D Separatory Funnel Shaker	1998
IEC Centra CL2 Centrifuge	1998
HAT Systems XL-2020 Series Dual Cone Sonicator	1994
DynaTech Laboratories Model 300	1994
FLASH POINT APPARATUS	
Precision Scientific Cat No: 74537	1994
Koehler Instruments	2002
MUFFLE FURNACE	
Thermolyne Type 62700 Furnace	1998
DESICCATORS	
Sanplatec Drykeeper H42056	1996
Fisher Scientific Model 08-645-6	1994
REFRIGERATED CIRCULATOR CHILLERS	
(2) Neslab RTE-111	1996
CARON Model 2052	1993
Polyscience Model 1174	1993
Polyscience Model 1172	1997
(2) Neslab CFT-33	1998
(2) Thermo Neslab	2002

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

SECTION 15

EQUIPMENT	YEAR MANUFACTURED
TCLP EXTRACTORS	
Environmental Express 12 Place Rotator LE1002	1996
EE Maxifil Pressure Filtration Device PF100	1996
EE Fluid Metering Pump TP 100	1996
(2) EE TCLP Syringes 50 ml S1050	1996
(6) EE ZHE ™ ZHE 1000	1996
(12) Nalgene EPTOX Bottles 2101	1996
WATER BATHS	
Blue-M Model MW-1120A-1	1990
Curtin Matheson Scientific Equatherm Cat. No. 392-142	1993
VWR Scientific Model 1203	1995
INCUBATORS	
Blue-M Bacteriological Incubator 2004	1990
Lab-Line Ambi-Hi-Low-Chamber	1995
MICROBIOLOGY	
Market Forge Sterilmatic Model STM-E Autoclave	1989
Millipore Filter Pump XX5500000	1990
Millipore U.V. Sterilizer XX63700 00	1990
Bausch & Lomb Microbiology Scope	1990
Bausch & Lomb Fluorescent Lamp 31-35-32	1990
UV/VIS Spectrophotometer	
Spectronic Instruments – Spectronic 401	1999
IR SPECTROPHOTOMETER	
Buck Scientific HC-404	1992
TURBIDITY METERS	
(3) Hach Turbidimeter 2100P	1999
SPECIFIC CONDUCTIVITY METER	
1 Hanna Instruments HI 8633	1993
Orion Model 105	2000

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

EQUIPMENT	YEAR MANUFACTURED
HOTPLATES STIRRERS	
Thermolyne SP-A1025B	1990
Fisher Scientific Thermix 610T	1992
Fisher Scientific 11-500-108SH	1991
(5) Mantle MA Solid State Electrothermal	2002
STIRRERS	
Fisher Scientific Magnetic Stirrer 14-511-1V2	1992
Fisher Scientific Thermix Stirrer 120M	1993
Barnstead/Thermolyne HP46825	1991
(2) Corning Magnetic Stirrer PC-210	1996
ANALYTICAL BALANCES	
Mettler-Toledo PM100	1995
Mettler-Toledo AG104	1994
OHAUS Model TS400S	1996
(2) OHAUS Model TS2K2	1998
WET CHEMISTRY	
HACH COD Reactor 45600-00	1997
ORION Ion Analyzer EA940	1993
ORION Ion Analyzer EA720A	1997
DRYING OVENS	
Fisher IOSOTEMP 500 Series	1994
Precision Scientific Economy Oven Model 25EG	1996
Precision Scientific Model 45EG	1996
Precision Scientific Model 45EG	1999
REFRIGERATORS/FREEZERS	
Fisher Scientific Isotemp 27.3 ft^3	1994
Fisher Scientific Isotemp 27.3 ft^3	1994
Fisher Scientific Isotemp 27.3 ft^3	1996
Fisher Scientific Isotemp 76.2 ft^3	1996
Fisher Scientific Explosion Proof	1997

SECTION 15

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

EQUIPMENT	YEAR MANUFACTURED
REFRIGERATORS/FREEZERS (CONT.)	
VWR Scientific Explosion Proof Refrigerator/Freezer 21.0 ft^3	1997
Fisher Scientific Isotemp 76.2 ft^3	1998
VWR Scientific Explosion Proof Freezer	1997
HOOD SPACE	
(2) MYSTAIRE Model 4850 - 4ft.	1995
(3) Air Sentry - 8ft.	1998
GLOBAL POSITIONING SYSTEMS	
(2) Trimble GPS TDC2 Dataloggers	1997
(2) Trimble GPS Receivers	1997
(2) Trimble GPS Antennae	1997
Impulse Laser Rangefinder	1998
Mapstar Systems Electronic Compass Module	1998
Trimble GPS (CM)TSC1 Datalogger	1999
Trimble GPS (CM) 4700 Receiver	1999
Trimble GPS (CM) 4800 Receiver/Radio	1999
Trimble GPS (CM) Antenna	1999
Pacific Crest Transmitter Radio (CM)	1999
WATER DEPTH/PRODUCT METERS	
Well Wizard Water Depth Meter	1996
Solinst Water Level Meter – 50ft.	1996
Fischer M-Scope Utility Tracking Probe	1996
Solinst Water Level Meter – 100ft.	1998
ORS Interface Probe	1996
LOW-FLOW MONITOR-WELL SAMPLING	
YSI 600 XL-B-O Sonde	1999
YSI 610-DM Datalogger	1999
(2)YSI 600 XL-B-O Sonde	2000
(2)YSI 610-DM Datalogger	2000
YSI 6820-C-M Sonde	2000
YSI 650 MDS Datalogger	2000

SECTION 15

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

FIELD EQUIPMENT	YEAR MANUFACTURED
MONITOR-WELL SAMPLING PUMPS	
(2) Masterflex Portable Sampling Pumps	1996
(3) Masterflex Portable Sampling Pumps	1998
(5) Masterflex Portable Sampling Pumps	2000
(2) Grundfos REDIFLO 2 Pumps	2000
(2) Grundfos REDIFLO Variable Frequency Drives	2000
(3) Solinst Peristaltic Pumps	2002
BENCH SPACE	
260 linear ft.	
FIELD METERS	
Foxboro Century OVA 128GC	1994
Foxboro Century OVA 128GC	1998
HNU Systems – HNU Photo-Ionizer	1994
HNU Systems – HNU Photo-Ionizer	1998
Foxboro TVA-1000B Toxic Vapor Analyzer	1999
Gastech, Inc. ProtechtorII Gas/Oxygen Detector	1996
Jerome 431-X Mercury Vapor Analyzer	1999
Foxboro – Miran 1BX	1996
Orion pH/Cond./Temp./DO Meter	1998
Hydac Digital – pH/Cond./Temp Meter	1998
(2) Extech – Oyster pH/Cond./Temp Meter	1999
(2) Analytical Inst.-continuous pH/Temp Recorder	1999
YSI Dissolved Oxygen (DO) Meter, Model 58	1996
YSI Dissolved Oxygen (DO) Meter, Model 95	1999
Orion DO Probe w/ 3m cable	1999
MISCELLANEOUS	
Wildco Instruments – Hand Corer	1999
Ekman Dredge	1999

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY
QUALITY ASSURANCE POLICIES AND PROCEDURES

APPENDIX 1

CHAIN OF CUSTODY RECORD

Fort Monmouth Environmental Testing Laboratory

Bldg. 173, SELFM-PW-EV, Fort Monmouth, NJ 07703
Tel (732)532-4359 Fax (732)532-6263 EMail:wrightd@mail1.monmouth.army.mil
NJDEP Certification #13461 NYDOH Certification #11699

Chain of Custody Record

Customer:		Project No:				Analysis Parameters								Comments:
Phone #:		Location:												
( )DERA ( )OMA ( )Other:_____														
Samplers Name / Company :				Sample	#									
Lab Sample I.D.	Sample Location	Date	Time	Type	bottles									Remarks / Preservation Method

Relinquished by (signature):	Date/Time:	Received by (signature):	Relinquished by (signature):	Date/Time:	Received by (signature):
Relinquished by (signature):	Date/Time:	Received by (signature):	Relinquished by (signature):	Date/Time:	Received by (signature):

Report Type: (_)Full, (_)Reduced, (_)Standard, (_)Screen / non-certified Turnaround time: (_)Standard 4 wks, (_)Rush ___ Days, (_)ASAP Verbal ___ Hrs.	Remarks:

APPENDIX 2

SAMPLE RECEIPT FORM

Date Received: _____ Lab Project ID#: _____

Site/Project Name: _____ Cooler Temp (°C): _____

Received By: _____ Sign: _____
(print name)

Circle the appropriate answer

1. Did the samples come in a cooler?	yes	no
2. Were the chain of custody papers filled out correctly and legibly?	yes	no
3. Did you sign the chain of custody in the appropriate place?	yes	no
4. Did all the labels agree with the chain of custody and in good condition?	yes	no
5. Were the correct containers and/or preservatives used for the tests indicated?	yes	no
6. Was a sufficient amount of sample sent for the tests indicated?	yes	no
7. Were bubbles absent from aqueous VOC sample containers?	yes	no

Fill out the following table for each sample bottle

Sample ID	pH	Preservative	Sample ID	pH	Preservative

Comments:

_____

_____

_____

APPENDIX 3

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY

ETHICS AND DATA INTEGRITY AGREEMENT

I. I, _____(NAME), state that I understand the high standards of integrity required of me with regard to the duties I perform and the data I report in connection with my employment at Ft. Monmouth Environmental Testing Laboratory.

II. I agree that in the performance of my duties at Ft. Monmouth Environmental Testing Laboratory:

a. I shall not intentionally report data values that are not the actual values obtained;
b. I shall not intentionally report the dates and times of data analyses that are not the actual dates and times of data analyses; and
c. I shall not intentionally represent another individual's work as my own.

III. I agree to inform Ft. Monmouth Environmental Testing Laboratory of any accidental reporting of non-authentic data by myself in a timely manner.

IV. I agree to inform Ft. Monmouth Environmental Testing Laboratory of any accidental or intentional reporting of non-authentic data by other employees.

_____
(SIGNATURE)

_____
(DATE)

APPENDIX 4

FORT MONMOUTH ENVIRONMENTAL TESTING LABORATORY

DIRECTORATE OF PUBLIC WORKS
BLDG. 173, RIVERSIDE AVE.
FT. MONMOUTH, NJ 07703
PHONE: 732 532-4359 FAX: 732 532-6263

FAX

This is a preliminary copy of your analytical results. A finalized hard copy will follow.

To:_____ Fax:_____
From:_____ Date:_____
Re:_____ Pages:_____

Comments:_____

CONFIDENTIALITY NOTICE

This fax contains information from Ft. Monmouth Environmental Laboratory and is intended for use by the individual(s) to whom it is addressed. If you are not the intended recipient, you are hereby notified that any disclosure, copying or distribution of the contents is strictly prohibited. If you have mistakenly received this fax, please notify us at 732-532-4359 and immediately destroy all copies of this document.

NEA
NORTHERN ECOLOGICAL ASSOCIATES, INC.

Maine Office:
451 Presumpscot Street
Portland, ME 04103

New York Office:
Village Square, 33 Church Street
Fredonia, NY 14063

Pennsylvania Office:
134 Broad Street
Stroudsburg, PA 18360

Phase I Environmental Site Assessment of Priority Sites

PART I
LIBERTY STATE PARK, JERSEY CITY, HUDSON COUNTY, NEW JERSEY

USACE Contract Number: DACW51-01-D-0017
Delivery Order No. 0012

Prepared for:

U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, New York 10278-0090

Prepared by:

AMEC Earth & Environmental, Inc.
Northern Ecological Associates, Inc.

FEBRUARY 2003

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, New York District (USACE-NYD) is working in partnership with several state and local agencies to assess the feasibility of restoring selected wetlands within the New York-New Jersey Harbor Complex (also known as the Hudson-Raritan Estuary). The USACE-NYD has identified three priority sites (Project Areas) for wetland restoration within the Hudson-Raritan Estuary. These are: (1) Liberty State Park, located in Jersey City, New Jersey; (2) Newtown Creek, located in the Boroughs of Brooklyn and Queens, New York; and (3) Sherman Creek, located in Manhattan Borough, New York.

Prior to implementation of the proposed wetland restoration projects, the USACE-NYD requires that a Phase I Environmental Site Assessment (ESA) of the three Project Areas be performed. The purpose of the ESA was to collect background data and review existing information concerning recognized environmental conditions at three Project Areas. The principal objectives of the ESA were to develop information about environmental conditions at the three sites, in the specific context of the planned wetland restoration projects; identify any information gaps regarding existing environmental studies; and make recommendations concerning any additional investigations that may be needed to address those gaps.

Under contract No. DACW51-01-D-0017 between Northern Ecological Associates, Inc. (NEA) and the USACE-NYD, AMEC Earth & Environmental, Inc. (AMEC) was assigned to conduct an ESA of the three priority wetland sites. The results are presented in this ESA Report, which is being submitted under Delivery Order 0012 of the referenced contract. The ESA report is comprised of three parts, of which Part I (this part) pertains specifically to the Liberty State Park (LSP) Project Area. Parts II and III concern the Sherman Creek and Newtown Creek Project Areas, respectively.

This ESA was prepared in accordance with the Scope of Work (SOW) prepared by the USACE-NYD (USACE-NYD, 2002). The SOW incorporates by reference the guidance document by the American Society for Testing and Materials (ASTM) entitled Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process (ASTM E1527-00) (ASTM, 2000). The geographic limits of each Project Area and the specific types of environmental record sources to be reviewed were determined on a site-specific basis, in consultation with the USACE-NYD Point of Contact (POC).

The limits of the LSP Project Area were defined as the park boundaries. The environmental records sources that were reviewed included those standard federal and state records listed under Section 7.2.1.1 of ASTM E1527-00. Additionally, a review was conducted of publicly accessible files at the New Jersey Department of Environmental Protection (NJDEP). Sources reviewed with respect to the physical setting (*e.g.*, topography, hydrology, geology) of the LSP Project Area included U.S. Geological Survey (USGS) Topographic Quadrangle maps, as well as site-specific information obtained from existing environmental reports. Historical land-use information was obtained from a review of Sanborn Fire Insurance Maps and historic aerial photography. Studies of historical land use and cultural resources of the LSP Project Area were also reviewed, along with historic maps and site plans obtained from state regulatory files. Information concerning historic land ownership within the LSP Project Area was provided by State of New Jersey.

Site reconnaissance of the LSP Project Area was performed on 9 December 2002 with the assistance of the POC. Site reconnaissance was restricted to the LSP Project Area (i.e., none of the adjoining properties were examined). Because the site has already been extensively investigated by the NJDEP, reconnaissance activities were limited to a general examination of major areas of interest and photographs of current site conditions.

LSP is currently owned and operated by the State of New Jersey, and is utilized as a public park and educational facility. The park is comprised of a series of irregularly shaped parcels, which were acquired by the State of New Jersey during the period from 1965 to 1993. Public facilities at LSP currently include the Liberty Science Center and Hall of Technology, Visitors Center, Interpretive Center, the railroad terminal (with ferry service to the Statue of Liberty and Ellis Island) formerly operated by the Central Railroad of New Jersey (CRRNJ), a swimming pool, hiking trails, picnic area, playground, food concession, and associated parking areas and roads. Waterfront facilities include the Liberty Landing Marina, a trailer launch, canoeing and boating facilities, and boat storage facilities. Additionally, there are park maintenance facilities and offices for park personnel. The Liberty Landing Marina and associated parking and boat storage facilities occupy most of the northern shore of the park. The eastern shore is bounded by a concrete seawall reinforced by an exterior apron of stone riprap. The southern shore of the property is bounded by wooden and steel bulkheads. Most of the interior of the property is currently undeveloped.

The ground elevation within LSP typically ranges from 0 to 10 feet above Mean Sea Level (MSL). Drainage is generally toward the waterfront (north, east, and south). There are currently no surface-water bodies in the interior of the site (although freshwater wetlands are present in some areas). The Hudson River Estuary and the Morris Canal Basin are the principal surface-water receptors. The site is underlain by a sequence of fill ranging in thickness from 10-40 feet, which consists principally of disturbed soils, dredge spoils, domestic refuse, coal ash, construction debris, and metal production waste. The fill material is underlain by recent (Holocene) shallow-marine deposits and partially consolidated Pleistocene-age glacial deposits which, in turn, overlay the Lower Paleozoic-age Manhattan Schist. The approximate elevation of the bedrock surface ranges from -43 to -134 feet MSL.

Based on a review of water-level data and ground water contour maps contained in NJDEP regulatory files, shallow (unconfined) ground water typically occurs at depths of 5 to 10 feet below grade, and hydraulic gradients are generally oriented toward the shoreline (i.e., toward the north, east, and south). Previous hydrogeological studies have shown that shallow ground water flow adjacent to the shoreline is tidally influenced.

Soils examined during the site reconnaissance visit typically contained common fill materials such as coal-ash, glass, and construction debris. The undeveloped portions of the site were heavily overgrown with trees and brush. No obvious evidence of environmental contamination was observed, other than the presence of the common fill materials described above. During the site reconnaissance visit, the Assistant Superintendent of LSP noted that an oil sheen has been observed sporadically along the eastern shore of the park, the source of which is currently under investigation by the NJDEP.

Nearly all LSP Project Area is underlain by fill. Prior to about 1860, the site consisted mostly of open water and tidal flats. In the 1860s, the CRRNJ placed over 20 million cubic yards of fill into the former Communipaw Cove to create a rail terminal complex. The fill consisted principally of domestic solid waste obtained from the City of New York. From the 1870s until approximately 1960, the CRRNJ and the Lehigh Valley Railroad (LVRR) operated shipping terminals, freight yards, railroad repair facilities, and stockyards at the site. During that period, the site was systematically filled to produce the present-day shoreline of LSP. Large-scale filling activities at the site were completed by about 1928. However, evidence from historic maps and aerial photographs suggests that localized filling may have occurred as recently as the 1960s.

Historic Sanborn Fire Insurance Maps and aerial photographs document the expansion of the CRRNJ and LVRR terminal facilities over time. The CRRNJ Terminal Building, an attached railroad depot, and an extensive network of rail facilities and piers were present by 1895. By 1911, the Terminal Building and the railroad depot were expanded to their present size, and new rail facilities were added, which included additional freight yards, coal loading facilities, a coal-fired power plant, a machine shop, a railroad turntable, cattle pens, and cement storage facilities. During this period, a brass foundry was operated within the area now occupied by the Liberty Science Center Parking Lot. A 1943 aerial photograph shows an active rail facility with numerous steam-powered engines in use. The 1950-51 Sanborn Maps show two railroad "roundhouses" operated by the CRRNJ at the site of the present-day Liberty Science Center, along with a coal-fired power-house, two 100,000-gallon above-ground oil tanks, coal pockets, conveyors, cinder pits, and a diesel locomotive servicing area. A tugboat repair facility was also present near the current site of the Interpretive Center, which included a machine shop, sheet metal shop, storage facilities, and floating dry docks. The 1966 aerial coverage shows evidence of active railroad operations. However, partial demolition of the roundhouse facilities is also evident.

The railroad operations by the CRRNJ and LVRR ceased by 1970, by which time both companies had filed for bankruptcy. Some of the properties owned by CRRNJ and LVRR were subsequently sold, while others remained vacant. In its review of historic aerial photography, the NJDEP noted evidence of dumping or filling activities at several areas during the 1970s. A 1976 aerial photograph reviewed during this investigation shows evidence of what appears to be an open burial site. In 1978, shortly after their acquisition by the State of New Jersey, two facilities formerly operated near the present site of Liberty Landing Marina area were found to have engaged in illegal dumping of hazardous materials. Approximately 250 abandoned drums were discovered at the two facilities, some of which were found to contain organic solvents. The NJDEP contracted for removal of the drums in 1980. Two other incidents involving abandoned drums at the property were identified in state environmental records, one in 1992 and another in 2000. Additionally, at least ten underground storage tanks (USTs) were formerly present at the site, which were used to store either leaded gasoline or diesel.

Coal combustion residues are widespread in soils at the site, both as a consequence of historic railroad operations and as a constituent of historic fill materials. Arsenic and heavy metals (principally lead, zinc, and copper) and polynuclear aromatic hydrocarbons (PAHs) are nearly ubiquitous in the fill, and typically occur at concentrations above the applicable NJDEP Soil Cleanup Criteria (SCC). Metals and PAHs have also been detected in ground water at concentrations above the New Jersey Ground water Quality Criteria. Various volatile organic compounds (VOCs) have also been detected locally in the soil and (or)

ground water, including, ethylbenzene, toluene, chloroform, trichloroethene, tetrachloroethene, and 1,1,1-trichloroethane. Additionally, traces of polychlorinated biphenyls (PCBs) and organochlorine pesticides (*e.g.*, dieldrin and DDT) have been detected in the soils at concentrations slightly above the NJDEP SCC.

Petroleum free-product is known to be present in subsurface soils at two different locations within the LSP Project Area. One site, known as the Middle Cove, has been extensively investigated by the NJDEP, and product-recovery efforts are currently underway. The other site, which is located beneath the Liberty Science Center parking lot, has not yet been completely characterized. Known sources of petroleum at LSP have historically included former locomotive repair and fueling facilities, the former tug and barge repair facility, and various USTs.

During the early 20th century, chromate chemical production waste (CCPW) derived from off-site chemical manufacturing facilities was used as a structural fill at several locations within the LSP Project Area. Three CCPW sites have been identified within the LSP Project Area to date, all of which have been investigated by the NJDEP. Hexavalent chromium is the principal environmental contaminant of concern at these sites. One issue of particular concern is the historic use of CCPW as backfill in the construction of underground utilities. In 1994, the NJDEP found that CCPW had been used as backfill during the construction of an 84-inch-wide brick sewer main (now abandoned), which bisects the LSP Project Area. It is has not been determined whether CCPW is associated with other underground utilities at LSP.

In 1916, a series of large explosions occurred at a munitions depot located adjacent to Black Tom Channel along what is today the southern shore of LSP (formerly Black Tom Island). Approximately 1,000 tons of explosives were detonated, which resulted in the deposition of unexploded ordnance (UXO) on the floor of the adjacent Black Tom Channel. During the course of hydraulic dredging operations 1981; it was discovered that several rounds of ordnance had been transferred into a dredge-spoil storage area located within the interior of LSP. The rounds were found to be completely saturated with water, and attempts to detonate them under controlled conditions were unsuccessful. However, the risks associated with any additional rounds that may be present in the dredge-spoils have not been evaluated.

Since its purchase by the state of New Jersey, the NJDEP has conducted numerous soil and ground water investigations within LSP, and most of the environmental concerns identified above have been thoroughly characterized. However, in the opinion of this investigator, there remains a risk of encountering previously unidentified soil and (or) groundwater contaminants during the construction of the proposed wetlands. The concentrations of PAHs and metals in common fill materials at the site are generally within the ranges listed in the NJDEP Historic Fill Database and meet the general definition of "historic fill" under Technical Rules for Site Remediation (N.J.A.C. 7:26E App. D). Thus, the common fill materials found at the site are amenable to on-site management (e.g., capping with a layer of clean soil and establishing a vegetative cover). However, in the event that heavily contaminated soils (*e.g.*, petroleum saturated soils or CCPW) are, on-site management of the contaminated soil may not be feasible, and off-site disposal could be prohibitively expensive.

Therefore, prior to initiating the proposed wetland restoration project, it is recommended that further compilation and analysis be performed of existing subsurface information (*e.g.*, soil-boring logs, test-pit logs; laboratory analytical results) pertaining specifically to the areas to be disturbed. The purpose of this analysis would be to assess the adequacy of existing environmental studies, evaluate the impact of any recognized environmental conditions, and identify specific targets for any additional subsurface characterization studies that may be required. It is also recommended that the NJDEP be consulted to determine whether any of the suspected dumping or filling sites identified in their review of historic aerial photography are located within the footprint of the proposed wetlands, and if so whether all of those sites have been adequately investigated. Further, it is recommended that historic utility plans be reviewed to identify any underground facilities that may have been installed using CCPW as backfill. Additionally, it is recommended that the potential risks associated with any UXO remaining in the dredge spoils storage area be assessed, if soils are to be disturbed in that area. Once these analysis have been completed, a determination can be made as to whether environmental conditions in the areas to be disturbed have been sufficiently well characterized and, if so, whether any environmental conditions are present that may hinder implementation of the proposed wetland restoration project. If necessary, a targeted, subsurface investigation can be implemented to supplement existing environmental studies.

Part I

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1
- 1.1 PURPOSE AND OBJECTIVES 1-1
- 1.2 SCOPE OF SERVICES 1-1
- 1.3 SIGNIFICANT ASSUMPTIONS 1-2
- 1.4 LIMITATIONS AND EXCEPTIONS 1-2
- 1.5 SPECIAL TERMS AND CONDITIONS 1-2

2.0 SITE DESCRIPTION 2-1
- 2.1 LOCAL AND LEGAL DESCRIPTION 2-1
- 2.2 SITE AND VICINITY GENERAL CHARACTERISTICS 2-1
- 2.3 CURRENT USE OF THE PROPERTY 2-1
- 2.4 STRUCTURES, ROADS AND OTHER IMPROVEMENTS ON THE SITE 2-2
- 2.5 CURRENT USES OF ADJOINING PROPERTIES 2-2

3.0 USER PROVIDED INFORMATION 3-1
- 3.1 REASON FOR PERFORMING PHASE I 3-1
- 3.2 OTHER INFORMATION 3-1

4.0 RECORDS REVIEW 4-1
- 4.1 STANDARD ENVIRONMENTAL RECORD SOURCES 4-1
  - 4.1.1 Federal Environmental Records Sources 4-1
  - 4.1.2 State Environmental Records Sources 4-2
- 4.2 ADDITIONAL ENVIRONMENTAL RECORD SOURCES 4-3
  - 4.2.1 NJDEP File Review 4-3
  - 4.2.2 Proprietary Databases 4-3
- 4.3 PHYSICAL SETTING SOURCES 4-4
- 4.4 HISTORICAL USE INFORMATION ON THE PROPERTY 4-4
- 4.5 HISTORICAL USE INFORMATION ON ADJOINING PROPERTIES 4-4

5.0 SITE RECONNAISSANCE 5-1
- 5.1 METHODOLOGY AND LIMITING CONDITIONS 5-1
- 5.2 GENERAL SITE SETTING 5-1
- 5.3 EXTERIOR OBSERVATIONS 5-1
- 5.4 INTERIOR OBSERVATIONS 5-2

6.0 INTERVIEWS 6-1

7.0 FINDINGS 7-1
- 7.1 PHYSICAL SETTING 7-1
  - 7.1.1 Topography and Drainage 7-1
  - 7.1.2 Geology and Hydrogeology 7-1
- 7.2 HISTORICAL USE INFORMATION 7-1
  - 7.2.1 Filling History 7-1

TABLE OF CONTENTS

Page

7.2.2 Sanborn Maps 7-2
7.2.3 Historic Topographic Maps 7-3
7.2.4 Historic Aerial Photography 7-4
7.3 STANDARD ENVIRONMENTAL RECORDS SOURCES 7-5
7.3.1 RCRIS-TSD Database 7-6
7.3.2 RCRIS-SQG Database 7-6
7.3.3 FINDS Database 7-6
7.3.4 Known Contaminated Site List 7-6
7.3.5 Solid Waste Facilities / Landfill Sites 7-6
7.3.6 Leaking Underground Storage Tank Incident Reports 7-7
7.3.7 Underground Storage Tank Database 7-7
7.3.8 NJ Spills List 7-7
7.3.9 NJ Release 7-8
7.4 NJDEP FILE REVIEW 7-8
7.4.1 Site-Wide Summary 7-8
7.4.2 Specific Areas of Environmental Concern 7-9
7.4.2.1 Freight Yard 7-9
7.4.2.2 Dredge Spoils Storage Area 7-10
7.4.2.3 Black Tom Channel / Dog Show Field 7-11
7.4.2.4 Liberty Science Center / Former Roundhouse 7-12
7.4.2.5 Chromate Waste Sites 7-13
7.4.2.6 Waterfront Development Area / Middle Cove 7-15
7.4.2.7 Northern Marina 7-16
7.4.2.8 Terminal Parking Lot 7-18

8.0 OPINION 8-1

9.0 CONCLUSIONS 9-1

10.0 RECOMMENDATIONS 10-1

11.0 DEVIATIONS 11-1

12.0 REFERENCES 12-1

LIST OF FIGURES

Figure 1 Project Site Location
Figure 2 Project Area Site Plan
Figure 3 NJDEP Ground water Sampling Locations 1993-1994

LIST OF APPENDICES

Appendix A Site Photographs
Appendix B Sanborn Historic Maps
Appendix C EDR Historical Topographic Map Report
Appendix D EDR Aerial Photography Print Service Report
Appendix E EDR Area Study Report
Appendix F NJDEP Executive Summary on the History of Environmental Investigations at Liberty State Park dated April 1989
Appendix G Liberty State Park Soil Sampling Report – August 1995

LIST OF ACRONYMS AND ABBREVIATIONS

AMEC	AMEC Earth & Environmental, Inc.
AST	Above-ground storage tank
ASTM	American Society for Testing and Materials
BCM	BCM Engineers/ ATC Group Services, Inc.
BUST	New Jersey Department of Environmental Protection Bureau of Underground Storage Tanks
CCPW	Chromate Chemical Production Waste
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System database
CERC-NFRAP	CERCLIS No Further Remedial Action Planned database
CONSENT	Superfund (CERCLA) Consent Decrees database
CORRACTS	RCRA Corrective Action Activity database
CRRNJ	Central Jersey Railroad
DAF	Dilution attenuation factor
DRPSR	NJDEP Division of Responsible Party Site Remediation
EDR	Environmental Data Resources, Inc.
ERNS	Emergency Response Notification System
ESA	Phase I Environmental Site Assessment
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FINDS	Federal Facility Index System database
FTTS	Federal database of pesticide enforcement and compliance activities
GIS	Geographic Information System
HMIRS	Hazardous Materials Information Reporting System
KCSL	New Jersey Know Contaminated Site List
LQG	Large Quantity Generator of hazardous waste
LSP	Liberty State Park
LUST	New Jersey Department of Environmental Protection Leaking Underground Storage Tanks incident report database
LVRR	Lehigh Valley Railroad
MINES	Mine Master Index File database
MLTS	Material Licensing Tracking System database
MSL	
NAD83	North American Datum of 1983
NEA	Northern Ecological Associates
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
NJPF	Publicly Funded Cleanup Site Status Report database
NPL	National Priority List
PADS	PCB Activity Database
PAH	Polynuclear aromatic hydrocarbons
PCB	Polychlorinated biphenyl
POC	U.S. Army Corps of Engineers Point of Contact
PPM	Parts Per Million
RAATS	RCRA Administration Action Tracking System
RCRA	Resource Conservation and Recovery Act

RCRIS	Resource Conservation and Recovery Act Information System database
RCRIS-LQG	Resource Conservation and Recovery Act Information System Large Quantity Generator database
RCRIS-SQG	Resource Conservation and Recovery Act Information System Small Quantity Generator database
RCRIS-TSD	Resource Conservation and Recovery Act Information System Treatment Storage and Disposal facilities database
ROD	Record of Decision
SARA	Superfund Amendment and Reauthorization Act
SCC	Soil Cleanup Criteria
SHWS	EDR database complied from New Jersey Known Contaminated Site List
SOW	Scope of Work
SPLP	Synthetic Precipitation Leaching Procedure
SQG	Small Quantity Generator of hazardous waste
SSTS	Federal Pesticide registration database
SVOC	Semi-Volatile Organic Compound
SWF/LS	New Jersey Solid Waste Facilities / Landfill Sites database
TCL	USEPA Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Carbon
TPHC	Total Petroleum Hydrocarbons
TRIS	Toxic Chemical Release Inventory
TSCA	Toxic Substance Control Act
TSD	Hazardous waste Treatment Storage and Disposal facility
USACE	U.S. Army Corps of Engineers
USACE-NYD	U.S. Army Corps of Engineers, New York District
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound

1.0 INTRODUCTION

The U.S. Army Corps of Engineers, New York District (USACE-NYD) is working in partnership with several state and local agencies to assess the feasibility of restoring selected wetlands within the New York-New Jersey Harbor Complex (also known as the Hudson-Raritan Estuary). The USACE-NYD has identified three priority sites (Project Areas) for wetland restoration within the Hudson-Raritan Estuary. These are: (1) Liberty State Park, located in Jersey City, New Jersey; (2) Newtown Creek located in the Boroughs of Brooklyn and Queens, New York; and (3) Sherman Creek, located in Manhattan Borough, New York. Prior to implementation of the proposed wetland restoration projects, the USACE-NYD requires that a Phase I Environmental Site Assessment (ESA) be performed of the three Project Areas.

Under contract No. DACW51-01-D-0017 between Northern Ecological Associates, Inc. (NEA) and the USACE-NYD, AMEC Earth & Environmental, Inc. (AMEC) was assigned to conduct an ESA of the three priority wetland sites. The results are presented in this ESA Report, which is being submitted under Delivery Order 0012 of the referenced contract. The report is comprised of three parts, of which Part I (this part) pertains to the Liberty State Park (LSP) Project Area. Parts II and III pertain to the Sherman Creek and Newtown Creek Project Areas, respectively.

1.1 Purpose and Objectives

The purpose of the ESA was to collect background data and review existing information concerning recognized environmental conditions at three Project Areas. The principal objectives of the ESA were to develop information about environmental conditions at the three sites, in the specific context of the planned wetland restoration projects; identify any information gaps regarding existing environmental studies; and make recommendations concerning any additional investigations that may be needed to address those gaps.

1.2 Scope of Services

This ESA was prepared in accordance with the Scope of Work (SOW) provided to AMEC by NEA on August 5, 2002 (USACE-NYD, 2002). The SOW incorporates by reference the guidance document by the American Society for Testing and Materials (ASTM) entitled Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process (ASTM E1527-00) (ASTM, 2000). The geographic limits of each Project Area and the specific types of environmental record sources to be reviewed were determined on a site-specific basis, in consultation with the USACE-NYD Point of Contact (POC).

The geographic limits of the LSP Project Area were defined as the park boundaries (Figure 1). The environmental records sources that were reviewed included those standard federal and state records listed under Section 7.2.1.1 of ASTM E1527-00, and publicly accessible files available at the New Jersey Department of Environmental Protection (NJDEP). Sources reviewed with respect to the physical setting (*e.g.*, topography, hydrology, geology) of the LSP Project Area included U.S. Geological Survey (USGS)

Topographic Quadrangle maps, as well as site-specific information obtained from existing environmental reports. Historical land-use information was obtained from a review of Sanborn Fire Insurance Maps and historic aerial photography. Existing reports on historical land use and cultural resources of the LSP Project Area were also reviewed, along with historic maps and site plans obtained from state regulatory files.

Site reconnaissance of the LSP Project Area was performed with the assistance of the POC and Assistant Superintendent of LSP. Site reconnaissance was limited to exterior observations concerning major areas of interest within the LSP Project Area.

1.3 Significant Assumptions

An important assumption underlying this ESA is that the LSP Project Area has already been sufficiently well characterized through previous environmental investigations by the State of New Jersey that an exhaustive review of local government records (*e.g.*, tax, fire and police records) was not warranted. This assumption was supported by the results of the NJDEP file review, which produced extensive background information on the site.

1.4 Limitations and Exceptions

Environmental impairment of a property may result from activities such as illegal or unreported dumping, or the spilling of hazardous substances or materials. It should be noted that the presence of contaminants at a particular property may not always be apparent, and the completion of a Phase I ESA in accordance with ASTM-E-1527-00 cannot provide a guarantee that hazardous substances or materials do not exist. The scope of services executed for this project does not constitute an audit for any of the following: regulatory compliance, cultural and historic resources, industrial hygiene, health and safety, ecological resources, endangered species, indoor air quality, or high voltage power lines. Nor does it comprise a detailed condition survey for: radon, naturally occurring hazardous materials, lead-based paint, lead in drinking water, asbestos-containing materials, or other conditions of potential hazard. The above-mentioned conditions are as outlined in Section 12.1.4 (Non-Scope Considerations) of the ASTM E1527-00.

1.5 Special Terms and Conditions

AMEC has prepared this report for the exclusive use of NEA and the USACE-NYD. AMEC will not be responsible for the use of this report by any other party, or reliance on or any decision to be made based on it without the prior written consent of AMEC. AMEC accepts no responsibility for damages, if any, by any other party as a result of decisions or actions based on this report.

This report presents an overview of issues of environmental concern, reflecting AMEC's best judgement using information reasonably available at the time of AMEC's site visit. AMEC has prepared this report using information understood to be factual and correct and shall not be responsible for conditions arising from information or facts that were concealed or not fully disclosed to AMEC at the time of the site visit.

In completing the scope of work, AMEC did not conduct any intrusive investigations such as sampling, testing or monitoring. Detailed cost estimates associated with environmental

issues discussed in this report, or activities required to bring the site into environmental compliance, were not required in the SOW.

2.0 SITE DESCRIPTION

2.1 Local and Legal Description

The park is comprised of a series of 24 land parcels, which were acquired by the State of New Jersey during the period from 1965 to 1993 (Figures 1 and 2). The LSP Project Area is located entirely within Jersey City, New Jersey, and includes the following tax Blocks and Lots[1]:

Block 60 (Lot 38A); Block 1497 (Lots 1C, 3F, 3N, 3Q, and 8-10);

Block 2048 (Lots S1, S2, J, H3, 6, 10A&B, 11, 16, and 44B);

Block 2145 (Lots 22M, 40D, 44D, 45D-F, 48J, 48L&M, 48P, 49J, 50J, 50L-Z, 51B&C, and 52); and

Block 2154 (Lots 33, 22D, 22G, 22H, 22J, 22M, 22S, 24, 40F, 40H, 47A, 49K, 48H, 48J, 48L, and 50H).

The LSP Project Area boundaries shown in Figures 1 and 2 are based on a geographic information system (GIS) layer provided by the NJDEP (1999), and a compilation of land acquisitions at LSP by the NJDEP Division of Parks and Forestry (NJDEP, 1984).

2.2 Site and Vicinity General Characteristics

The LSP Project Area occupies an area of approximately 1,200 acres, and is bounded to the north by the Morris Canal Basin and to the east and south by the Hudson River Estuary (Figure 1). Land use in the immediate vicinity of the LSP Project Area is predominantly industrial, but also includes some commercial and residential use. The land areas within the LSP Project Area consists mostly of fill material deposited within former tidal flats and wetlands. Approximately 70% of the land area within the LSP Project Area is currently undeveloped and unpaved.

2.3 Current Use of the Property

Liberty State Park is owned by the State of New Jersey, and is used principally as a public park and educational facility. Public facilities at LSP include the Liberty Science Center and Hall of Technology, Visitors Center, Interpretive Center, the former CRRNJ Terminal (with ferry service to the Statue of Liberty and Ellis Island), a swimming pool, hiking trails, picnic area, playground, food concession, and associated parking areas and roads (Figure 2). Waterfront facilities include the Liberty Landing Marina, a trailer launch, canoeing and boating facilities, and boat storage facilities. Additionally, there are temporary offices (trailers) for park personnel (a permanent office building is currently under construction).

[1] The NJDEP has advised that the City of Jersey City has revised its lot and block system since the Acquisition Map was prepared and that some of these lot and block designations may have been changed.

2.4 Structures, Roads and Other Improvements on the Site

The park is served by a network of paved roads (Figure 2). A utility plan of LSP produced by the Port Authority of New York and New Jersey (1975) shows subsurface sanitary sewer, electrical, water, and telephone service throughout the LSP Project Area. Three sewer mains operated by the Jersey City Sewerage Authority are shown passing through the site and discharging to the Hudson River: (1) a steel, 96-inch diameter, combined sewer, (2) an 84-inch brick combined sewer (now abandoned), and (3) an 80" x 80" reinforced concrete sanitary sewer.

2.5 Current Uses of Adjoining Properties

The New Jersey Turnpike is located immediately northwest of the LSP Project Area. As shown in Figure 2, the southwestern portion of the LSP Project Area consists of a series of irregularly shaped parcels enclosing a privately owned industrial park. The Jersey City Sewerage Authority operates a treatment facility (East Side Treatment Plant) immediately to the west of LSP.

As noted in Section 1.2 above, the LSP Project Area is defined on the basis of the park boundaries. Therefore, the current uses of adjoining properties were not reviewed further in connection with this ESA.

3.0 USER PROVIDED INFORMATION

3.1 Reason for Performing Phase I

The reason for performing this ESA, as stated in the SOW, was to "establish a base line" of environmental data for each Project Area so that "a more focused study can go forward in determining what level of effort would be required to implement restoration at the site" (USACE-NYD, 2002).

3.2 Other Information

The USACE-NYD POC provided guidance concerning the geographic limits of the LSP Project Area, the types of environmental record sources to be reviewed, and the level of detail required in the ESA report. Additionally, the POC provided AMEC with the names of contacts within the NJDEP for the purpose of arranging file reviews and/or interviews concerning environmental conditions within the LSP Project Area.

4.0 RECORDS REVIEW

4.1 Standard Environmental Record Sources

The standard environmental records sources specified under Section 7.1.1 of ASTM E1527-00 were searched for records that were "reasonably ascertainable", as defined under Section 3.3.30 of the Standard, using computerized database searches. The database searches were performed on behalf of AMEC by Environmental Data Resources, Inc. (EDR) of Southport Connecticut. The standard environmental record sources that were searched in connection with this ESA are described in Sections 4.1.1 and 4.1.2 of this report, and the results are discussed in Section 7.3.

The database queries were performed using the "Area Study" service available from EDR, in which records are searched relative to a geographic "corridor" specified by the client. The database searches included federal and state databases as well as EDR proprietary databases. As specified by the POC, a geographic search corridor based on the LSP Project Area boundaries was used for all of the databases queried except the Federal NPL Site List and RCRA TSD database. The geographic search limits for the Federal NPL Site List and RCRA TSD were extended 1 mile outward from the LSP Project Area boundaries, in accordance with Section 7.2.1.1 of ASTM E1527-00.

Due to the irregular shape of the LSP Project Area (Figure 2) and limitations imposed by EDR's geographic information system, it was not possible to exactly replicate the LSP Project Area boundaries in the computerized records search. Therefore, a simplified search corridor was defined which included all of the LSP Project Area, as well as some regions located outside of the Project Area boundaries. As per the scope of this ESA (Section 1.2), only the environmental records pertaining to sites located within the LSP Project Area are discussed in this report.

4.1.1 Federal Environmental Records Sources

The following federal databases (maintained by the USEPA) were searched in connection with this investigation:

CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System – listing of federally regulated sites under CERCLA.
CERC-NFRAP	Listing of CERCLIS sites where No Further Remedial Action is Planned.
CONSENT	Superfund (CERCLA) Consent Decrees.
CORRACTS	RCRA Corrective Action Activity database.
ERNS	Emergency Response Notification System database.

FINDS	Federal Index System – listing of USEPA regulated facilities and references to listings in other federal databases.
FTTS	Listing of federal administrative/enforcement actions against pesticide-producing establishments.
HMIRS	Hazardous Materials Information Reporting System.
MINES	Mine Master Index File.
MLTS	Material Licensing Tracking System.
NPL[2]	National Priority List.
Proposed NPL	Proposed National Priority List.
Delisted NPL	National Priority List Deletions database.
NPL Liens	Listing of federal Superfund Liens.
PADS	PCB Activity Database.
RAATS	RCRA Administration Action Tracking System database.
RCRIS-LQG	Provides information on facilities that are Large Quantity Generators (LQGs) of hazardous waste.
RCRIS-SQG	Provides information on facilities that are Small Quantity Generators (SQGs) of hazardous waste.
RCRIS-TSD[2]	Provides information on hazardous-waste treatment, storage, and disposal facilities (TSDs) regulated under the Resource Conservation and Recovery Act (RCRA).
ROD	Records of Decision database.
SSTS	Federally registered pesticide-producing establishments.
TRIS	Toxic Chemical Release Inventory.
TSCA	Records maintained under the Toxic Substance Control Act.

The relevant findings are reviewed in Section 7.3 of this report.

4.1.2 State Environmental Records Sources

The following state databases (maintained by the NJDEP) were searched in connection with this investigation:

LUST	Leaking Underground Storage Tank Incident Reports database.
NJ Brownfields	Listing of brownfields sites in New Jersey.
NJ Chrome	Known chromate waste contaminated sites.
NJ Major Facilities	List of Major Facilities in New Jersey.

[2] Geographic search corridor extended 1 mile outward from Project Area boundaries, as per ASTM E1527-00 Section 7.2.1.1.

NJ Release	Lists initial notification information provided to the NJDEP 24-hour Spill Hotline.
NJ Spills	Contains records of hazardous materials discharges reported to the NJDEP 24-hour Spill Hotline.
NJPDES	Permits issued New Jersey Pollution Discharge Elimination System.
NJPF	Publicly Funded Cleanup Site Status Report.
SHWS	Contains records from the NJDEP Known Contaminated Site List, excluding those regulated under the NJDEP Bureau of Underground Storage Tanks (BUST).
SWF/LS	Solid Waste Facilities / Landfill Sites List – contains an inventory of solid waste disposal facilities and landfills in New Jersey.
UST	Underground Storage Tank database – contains a list of registered USTs.

The relevant findings are reviewed in Section 7.3 of this report.

4.2 Additional Environmental Record Sources

4.2.1 NJDEP File Review

Additional information regarding recognized environmental conditions at LSP was obtained from a manual review of publicly accessible files maintained by NJDEP. These files provided a detailed record of past environmental investigations and remedial action at LSP, as well as information concerning the historic development and use of the property. The NJDEP file review was conducted during the period from October 22-29, 2002 at the NJDEP offices located at 401 and 501 East State Street, Trenton New Jersey. File review requests were directed to two divisions of the NJDEP: (1) the Site Remediation Program, which is responsible for oversight of environmental investigations and remedial work at LSP; and (2) the Division of Parks and Forestry, which has primary administrative responsibility for the operation, management, and development of the park. The principal contacts within the NJDEP were Edward Putnam, Assistant Director of the Remedial Planning & Design Element, Site Remediation Program, and Frank Gallagher, Administrator of Interpretive & Education Services, Division of Parks and Forestry. The results of the NJDEP file review are presented in Section 7.4 of this report.

4.2.2 Proprietary Databases

The database search performed by EDR included a search of a proprietary historical database of former manufactured gas (coal-gas) facilities. The information contained in the database consists of records compiled by EDR during the course of past investigations.

4.3 Physical Setting Sources

Information concerning the topography of the LSP Project Area, and its relationship to surrounding surface-water bodies, was obtained from the U.S. Geological Survey Jersey City Quadrangle (photorevised 1981). Site-specific information concerning the subsurface geology was obtained principally from: (1) a report prepared for the NJDEP by TAMS (1989b); (2) a report of geophysical investigations by the New Jersey Geological Survey (NJDEP 1988), and (3) soil-boring logs contained in NJDEP regulatory files. Information pertaining to shallow (*i.e.* unconfined) ground water conditions within the LSP Project Area was obtained from reports by the NJDEP (1994b, 2000b, 2001a, 2001b) and TAMS (1989a, 1989b).

4.4 Historical Use Information on the Property

Information concerning the historic uses of the properties within the LSP Project Area was obtained from the following sources:

1. Sanborn Fire Insurance Maps for the years 1885, 1887, 1911, 1912, 1950, 1951, and 1979;
2. Historic topographic map coverage provided by the EDR Historic Topographic Map service for the years 1955, 1967, and 1981;
3. Historic aerial photography provided through the EDR Aerial Photography Print Service for the years 1943, 1953, 1966, 1976, 1985, and 1995;
4. A report on the historic and cultural resources within the LSP Project Area by Historic Conservation and Interpretation Inc. (1977);
5. Historic maps obtained from NJDEP files;
6. An NJDEP memorandum (NJDEP, 1994a) summarizing the results of a previous aerial photographic review of the property; and
7. The 1984 Liberty State Park Acquisition Map compiled by the NJDEP.

4.5 Historical Use Information on Adjoining Properties

As described in Section 1.2, the scope of this ESA was limited to the region within the LSP Project Area boundaries. Therefore, no historical use information concerning the adjoining properties was reviewed.

5.0 SITE RECONNAISSANCE

Reconnaissance of the site was performed by AMEC on 9 December 2002, with the assistance of the POC. The Assistance Superintendent of LSP provided a guided tour of the facility and provided information about the development and operation of the park facilities.

5.1 Methodology and Limiting Conditions

Because of the size of the LSP Project Area, and the fact that it has already been extensively investigated by the NJDEP, reconnaissance activities were limited to an examination of major areas of interest and photographs of current site conditions. Site photographs are provided in Appendix A.

Limiting conditions encountered during the site reconnaissance included the presence of heavy vegetative overgrowth in undeveloped areas and the presence of approximately 5 inches of snow on the ground. The presence of landscaping, paved areas, and recently constructed buildings further limited examination of the underlying soils. Exposures of surficial materials were limited, and the ground was frozen at the time of the visit.

5.2 General Site Setting

Current usage of the property includes park facilities (e.g., Liberty Science Center, Interpretive Center, Maintenance Office, and Ferry Terminal), paved roads, and privately operated concessions such as the Liberty Landing Marina. The Liberty Landing Marina and associated parking and boat storage facilities occupy most of the northern shore of the park. The eastern shore is bounded by a concrete seawall reinforced by an exterior apron of stone (riprap). The southern shore of the property is bounded by wood and steel bulkheads. Most of the interior of LSP is currently undeveloped and is enclosed by chain-link fencing.

5.3 Exterior Observations

Exterior observations included a walking tour through the center of the former Freight Yard (Figure 2), visits to the Liberty Landing Marina, Ferry Terminal, and Liberty Walk, and driving tours of the park perimeter, interior roads, and roads enclosing the privately owned industrial park.

Exposed fill materials were examined at a construction site located at the western margin of the Liberty Landing Marina (Appendix A). The soils consisted of dark-gray to black fill materials (evidently coal ash and (or) other burned material) and construction debris (brick, concrete and metal). Within the Freight Yard, piles of soil were present in which similar anthropogenic materials were observed, along with tires and other refuse. As noted above, the Dredge Spoils Storage Area was heavily overgrown with trees and brush, as was the Freight Yard. No obvious evidence of environmental contamination was observed during the site reconnaissance, other than the common fill materials historically deposited at the site.

During the reconnaissance visit, the Assistant Superintendent of LSP noted that an oil sheen has been observed sporadically along the eastern shore of the park, the source of which is currently being investigated by the NJDEP. This condition is apparently related to the presence of petroleum free-product in the subsurface within an area known as Waterfront Development Area (refer to Section 7.4.2.6 below). No oil sheen was observed during the site visit.

5.4 Interior Observations

This ESA pertains specifically to areas in which wetlands restoration is proposed, which do not include the areas underlying existing park buildings. Further, all of the buildings at the park are located in areas that have already undergone environmental investigation and/or remedial action by the NJDEP. Therefore, other than a cursory examination of the former CRRNJ Terminal Building, no interior observations were made during the reconnaissance visit.

6.0 INTERVIEWS

Liberty State Park is owned, operated, and managed by the State of New Jersey, and the operating history and environmental conditions within the LSP Project Area have been extensively documented by the NJDEP. Therefore, publicly accessible files maintained by the NJDEP Site Remediation Program and the NJDEP Division of Parks and Forestry were the principal sources of information concerning recognized environmental conditions at LSP. The information developed through the NJDEP file reviews was supplemented with specific details provided by NJDEP personnel familiar with the site. The principal contacts within the NJDEP were those listed in Section 4.2.1 above and the Assistant Superintendent of LSP. Information developed from discussions with NJDEP personnel is included in the narrative in Section 7.0 of this report, and citations are provided, where appropriate.

All of the concessions currently operated at LSP (Liberty Landing Marina, Liberty Science Center, food concessions) are located in areas that have already undergone environmental investigation and/or remedial action (where required) during the course of their redevelopment. Because detailed records are available through the NJDEP concerning environmental conditions at these sites, formal interviews with concession operators were not conducted during this ESA.

7.0 FINDINGS

7.1 Physical Setting

7.1.1 Topography and Drainage

The topography of the site, as represented by the U.S. Geological Survey Jersey City Quadrangle is shown in Figure 1. The ground elevation within the LSP Project Area typically ranges from 0 to 10 feet above Mean Sea Level (MSL). Drainage is generally toward the waterfront (north, east, and south). There are currently no surface-water bodies in the interior of the site (a freshwater wetland is present immediately north of the Liberty Science Center). Thus, the Hudson River Estuary and the Morris Canal Basin are the principal surface-water receptors.

7.1.2 Geology and Hydrogeology

The unconsolidated deposits underlying the site consist principally of fill (*e.g.*, domestic refuse, coal ash, dredge spoils, construction debris, and chromate production waste). According to the results of a seismic reflection survey by the New Jersey Geological Survey the total fill thickness within the LSP Project Area ranges from 10-40 feet (NJDEP, 1988). The fill is underlain by Holocene-age shallow-marine deposits (organic-rich silt, clay, sand, and shells), which are in turn underlain by partially consolidated Pleistocene deposits consisting of "varved" lacustrine deposits and glacial till (TAMS, 1989b). The Pleistocene deposits overlay the Lower Paleozoic Manhattan Schist (Lovegreen, 1974). The elevation of the bedrock surface, as determined by geophysical surveys ranges from -43 to -134 feet MSL (NJDEP, 1988).

During previous ground water investigations at LSP, ground water was typically encountered at depths of 5 to 10 feet below grade (NJDEP 1994b, 2000b, 2001a, 2001b; TAMS 1989a, 1989b). As shown by TAMS (1989b), ground water in the vicinity of the Northern Marina (and probably elsewhere on site) is tidally influenced. The results of synoptic water-level measurements contained in NJDEP regulatory files suggest that hydraulic gradients within the shallow ground water are generally oriented toward the shoreline (*i.e.*, toward the north, east, and south). No information was found concerning the hydrogeology of deeper water-bearing units (*e.g.* fractured bedrock).

7.2 Historical Use Information

7.2.1 Filling History

Prior to about 1860, nearly all of the LSP Project Area consisted of open water and tidal flats (NJDEP 1989) (refer to Figures II and III of Appendix F). Filling of the LSP Project Area occurred in several stages, from north to south, beginning in 1860 and continuing until at least 1928. During the 1860s, the CRRNJ placed over 20 million cubic yards of fill into Communipaw Cove to create a rail terminal complex at the present site of CRRNJ Terminal

Building, thus forming the northern margin of LSP (Historic Conservation and Interpretation Inc. 1977). The fill consisted principally of garbage from the City of New York, which was transported to the site on scows. During the 1870s, the CRRNJ and the LVRR operated a railroad repair facility, stockyards, and various commercial shipping facilities at the site. A series of piers were also created by filling areas adjacent to the former Black Tom Island (now known as "Black Tom"). Over time, the region lying between Black Tom Island and the CRRNJ Terminal was systematically filled to produce the present-day shoreline of LSP.

Much of the filling of the central part of Communipaw Cove occurred during the period from 1900 to 1920, in order to create land for a new CRRNJ Freight Terminal (the region known today as the "Freight Yard"). Initially, a series of wood-cribbed bulkheads were constructed at the location of the present-day Waterfront Development Area (Figure 2). The area immediately outside (east) of the bulkhead line was then dredged, and the area behind the bulkhead was filled with a combination of dredge spoils (hydraulic fill) and domestic refuse. The following account of the filling methods used is taken from an article appearing in the Engineering News (1914):

> Back in 1900, when the work was started, under permission granted by the War Department in 1898, the first operation was to float in a large number of old canal boats, fill them with stone, and sink them from 400 to 500 feet back of the bulkhead line. Just back of the canal boats, an earthen dike was made by unloading (by hand) cellar dirt from scows. The dike formed by the earth-backed canal boats prevented the new fill from being washed away by the tides. At various points back of this dike, transverse dikes were built. Then general filling operations began.

Large-scale filling activities within the LSP Project Area was completed by about 1928 (NJDEP, 1995b). However, evidence form historic maps and aerial photographs suggests that localized filling may have occurred as recently as the 1960s.

7.2.2 Sanborn Maps

Copies of the Sanborn Fire Insurance Maps reviewed in connection with this investigation are provided in electronic (.pdf) file format in Appendix B.

The Sanborn Fire Insurance Maps for the years 1895-1897 shows the CRRNJ Ferry House (Terminal Building), an attached railroad depot, and an extensive network of rail facilities and piers. An "oil waste shed" and a "retort house" are shown approximately 200 feet east of the intersection of Johnson Avenue with Washington Avenue, along with a circular structure which appears to be a storage tank[3]. The area known today as "Black Tom" is shown as a narrow peninsula ("Black Tom Island"). A rail terminal and a series of warehouses are shown (National Storage Co.). Filling of the northern portion of the site (*i.e.* along the Morris Canal Basin) has been completed. Filling of the region lying between Black Tom and the CRRNJ terminal has not yet been completed.

The 1911-1912 Sanborn Map coverage shows the "H. Snooks Brass Foundry" and the "Neptune Mildew and Waterproofing Co." located approximately 600 feet north of the intersection of Communipaw Avenue and Phillip Street (within the northernmost portion of the current Liberty Science Center Parking Lot). The CRRNJ Ferry Concourse (Terminal

[3] The label shown on the Sanborn Map was only partially legible, beginning with the words "GAS..".

Building) and railroad depot have been expanded to their present size, and the rail facilities within the Freight Yard have also been expanded. The LVRR occupies the northernmost portion of the site, along the banks of the Morris Canal Basin, and has also established a coal loading facility immediately north of the CRRNJ Terminal Building. A coal-fired power and heating plant operated by CRRNJ is shown adjacent to the eastern terminus of Johnston Avenue. The Central Union Stockyard is shown in the approximate center of the Freight Yard. Associated facilities include a machine shop, coal pockets, a railroad turntable, cattle pens, and cement storage facilities. Within the area immediately east of the former Middle Cove, railroad tracks and piers are shown belonging to CRRNJ. The rail and loading facilities on Black Tom Island are shown as having expanded southward, and the shoreline along the southwestern margin of the property is shown in its current configuration. At this time, the region located immediately to the north of Black Tom Island (currently the site of the industrial park) has not yet been filled.

The 1950-51 Sanborn Maps show few changes in the area of the Terminal Building. The LVRR freight depot and loading facilities are still present. The Burns Bros. Coal Yard is shown immediately west of the intersection of Johnston Avenue and Washington Street. A "filling station" and an oil tank are shown at the east end of Johnston Avenue, which are apparently part of the CRRNJ rail complex. Within the region now occupied by the Liberty Science Center (east of Communipaw Avenue and south of Wilson Street) are railroad "roundhouses" operated by the CRRNJ (Communipaw Avenue engine terminal). Associated facilities include a coal-fired power house, two 100,000-gallon above-ground oil tanks, coal pockets, conveyors, cinder pits, storage buildings, offices, a diesel locomotive servicing area, and diesel storage facilities. The "Tug & Barge Supply Co." (a.k.a. McAllister Tug and Repair) is shown immediately to the east of the former Middle Cove, which includes a machine shop, sheet-metal shop, storage facilities, and floating dry docks. Immediately east of the Tug & Barge facility is another CRRNJ power house. The region immediately southeast of Black Tom Island (currently the site of Dog Show Field) is shown as being partially filled.

The 1979 Sanborn maps show no new railroad related facilities within the LSP Project Area. The Bond Adhesive Co. occupies a building on the north side of Johnston Avenue (approximately 600 feet west of Washington Street), which was formerly the site of a coal pocket operated by CRRNJ (shown on the 1951 Sanborn Map). The one of the railroad roundhouses at the Communipaw Avenue engine terminal has been partially demolished and one of the 100,000-gallon oil tanks shown in the 1951 Sanborn map is no longer present. The region immediately southeast of Black Tom Island has been filled. Black Tom Drive (now known as Wolf Drive), Edward Hart Drive, and Statue of Liberty Drive have been established. A bleach factory (the former Clorox facility) is shown immediately south of Edward Hart Drive. Immediately to the north of Edward Hart Drive there are warehouses and an electrical appliance repair business.

7.2.3 Historic Topographic Maps

Copies of the historic USGS Topographic Quadrangle maps reviewed in connection with this investigation are provided in Appendix C.

The 1955 topographic map shows an extensive network of rails, piers, and loading facilities within the LSP Project Area, along with the CRRNJ Terminal Building and the Communipaw Avenue engine terminal. The region lying immediately northeast of Black Tom Island has

been partially filled, and a road is shown along the present alignment of Thomas McGovern Drive. The 1967 revision shows additional roads in this area (Theodore Conrad Drive and Edward Hart Drive), along with several new buildings. In the 1981 (current) photorevision, the railroad tracks have been removed. Additional buildings are shown adjacent to Theodore Conrad Drive and Edward Hart Drive, within what is now the privately owned industrial park (Figure 2).

7.2.4 Historic Aerial Photography

Copies of the historic aerial photography provided by the EDR Aerial Photography Print Service are provided in Appendix D.

The 1943 aerial photographs shows an active rail facility with numerous steam-powered engines in use (rising plumes of steam are visible at several locations). Ships and barges are visible adjacent to the piers and loading areas. The presence of disturbed areas along the shoreline immediately north of Black Tom suggest that filling is taking place. The roundhouses associated with the Communipaw Avenue engine terminal are clearly visible and steam plumes visible over the tracks show that these facilities are active.

Numerous railroad cars are visible in the 1953 aerial photographs, suggesting that the rail facility is still active. However, the steam plumes seen in the earlier photographs are absent (suggesting a change to diesel and/or electric-powered engines). Boats and barges are visible adjacent to the McAllister Tug and Barge facility, suggesting that it is also active. Trains are visible within three distinct clusters of tracks, each leading to a major loading facility. Filling of the region southeast of Black Tom appears to have been mostly completed. However, no buildings are shown in the area now occupied by the industrial park. A narrow stream channel is visible passing though the area.

The 1966 aerial coverage shows evidence of several important changes. The railroad operations are still active. However, one of the railroad roundhouses at the Communipaw Avenue engine terminal has been partially demolished (apparently to make way for the New Jersey Turnpike). Several buildings are present in the area of the industrial park. Soils in the southeastern portion of the industrial park appear to be disturbed, suggesting recent construction and (or) filling in the area. The stream channel noted in the 1953 aerial photographs is no longer visible. Additionally, a new building complex is visible immediately to the northwest of the former Middle Cove, within the Freight Yard. This building complex is identified in the underground utilities plan by Port Authority of New York and New Jersey (1975) as a drug treatment center. The East Side Sewage Treatment Plant and an auto impoundment yard are also visible immediately west of Communipaw Avenue.

No evidence of active railroad operations was noted in the 1976 aerial coverage, nor were any changes noted concerning new buildings or construction. However, approximately 2,000 feet west of the Terminal Building and 700 feet south of the present-day marina, an elliptical feature is visible which appears to be an excavation filled with standing water. Its dimensions are approximately 200 feet in the east-west direction by 100 feet north-south. Immediately east of this feature is an area where the soil appears to have been disturbed. These features suggest the possibility of filling and/or burial activity at this location, and warrant further investigation.

The 1985 aerial photographs, the tracks, piers, loading facilities, McAllister Tug and Barge facility, and the Communipaw Avenue engine terminal are no longer visible (apparently removed). The Dredge Spoils Storage Area is clearly visible, as is an area of recent filling at the southeastern corner of the park (adjacent to South Cove). The elliptical excavation noted in the 1976 aerial photographs is no longer visible.

The 1995 image shows the site after construction of the seawall but before construction of the Liberty Landing Marina. The Middle Cove has been filled, along with some areas immediately west of the seawall. The site shows evidence of landscaping and several of the roads have been widened and/or otherwise improved.

Additionally, the NJDEP has reviewed historic aerial photography for the years 1930-32, 1940, 1951, 1953, 1961, 1972, 1974, 1978, 1979, and 1986. In a memorandum by the NJDEP (1994a), the reviewer noted that:

> The 1930-32 photo-mosaic shows the Freight Yard area to be completely filled and covered by railroad tracks with no areas of concern for biased sampling. There are no real changes to this area until the 1970's aerials when the railroads declined and removal of the tracks began. From the 1970's onward to the 1986 aerials there are a few areas where additional dumping/filling activities occurred and where some unusual features are indicated. These areas may warrant some biased sampling in future sampling events.

The memorandum stated that several of the features noted in the aerial photographic review were to be investigated, but did not identify the specific features that were to be investigated. Therefore, it is not known whether the NJDEP has identified or investigated the possible burial site noted in the 1976 aerial photograph reviewed during this ESA[4].

7.3 Standard Environmental Records Sources

A copy of the EDR Area Study Report is provided in Appendix E, which includes a map of the facility locations identified in the database search. As noted in Section 4.1, the search corridor defined for the EDR Area Study was a polygon that included some areas outside of the LSP Project Area (refer to the Area Study Map in Appendix E). Consequently, approximately 80% of sites listed in the EDR Area Study report are located outside of the LSP Project Area, and are therefore not within the scope of this ESA. Additionally, several of the facilities shown on the EDR Area Study Map as being within the LSP Project Area were determined to be outside of the Project Area boundaries, based on a review of the corresponding street addresses and (or) facility descriptions listed in Area Study Report[5]. Thus, a total of six facilities were identified within the LSP Project Area, which are shown at map location numbers 5, 6, 11, 13, 15, and 16 in the EDR Area Study Report (Appendix E). The environmental records in the Area Study Report pertaining to each of these facilities are discussed individually in Sections 7.3.1 through 7.3.9 below:

[4] The images reviewed by the NJDEP included coverage for 1974 and 1978, but not for 1976; it is not known whether this feature was visible in either the 1974 or 1978 coverage.

[5] Several privately owned facilities located on streets bordering the LSP Project Area were shown on the side of the street opposite their actual location.

7.3.1 RCRIS-TSD Database

A total of five TSDs were identified within a 1-mile radius of the LSP Project Area, which are shown at locations 1 through 4 on the EDR Area Study map (Appendix E). All of these facilities are located outside of the LSP Project Area, and are hydraulically isolated from it by the Morris Canal Basin (Figure 1 and Appendix E). Therefore, these sites are unlikely to have had a direct impact on soil or ground water conditions within the LSP Project Area.

7.3.2 RCRIS-SQG Database

The EDR Area Study Report shows two SQG facilities within the LSP Project Area (listed as NJDEP Sites 015 and 178) at map locations 13 and 15 (Appendix E, pages 49 and 66). These sites, which are also known as McAllister Tug and Barge Products and the Cabana Club, respectively, have been investigated by the NJDEP as part of a regional investigation of Chromate Chemical Production Waste (CCPW) sites in Hudson County. The results of these investigations are summarized in Section 7.4.2.5 below. There are currently no industrial facilities operating at either location, and their SQG status is apparently related to past investigative and remedial activities by the NJDEP.

7.3.3 FINDS Database

Listings were identified in the FINDS databases pertaining to the two sites described in Section 7.3.2 above (NJDEP Sites 015 and 178). No additional information was found in the FINDS records beyond that provided in the RCRIS-SQG database. As noted above, both of these sites have been the subject of investigations by the NJDEP, the results of which are summarized in Section 7.4 of this report.

7.3.4 Known Contaminated Site List

Two entries listed in the EDR Area Study Report are within the LSP Project Area boundaries. The sites are listed as "Hudson County Chromate Occidental" and "Hudson County Chromate 15" and are both shown at map location 13 (Appendix E, p. 51). Both entries appear to refer to the same site, and few details are provided in the database records. As noted above, Chromate Site 15 (a.k.a., McAllister Tug and Barge Products) has been investigated by the NJDEP and the results are summarized in Section 7.4.2.5 of this report.

7.3.5 Solid Waste Facilities / Landfill Sites

Two solid waste facilities are shown within the LSP Project Area boundaries, which are designated as "Liberty State Park Maintenance Area" and the "DEP Liberty Park SLF" (Appendix E, p. 68 and 74). The solid waste facility at the Liberty State Park Maintenance Area is a leaf composting facility operated by the NJDEP. The DEP Liberty Park SLF is a closed sanitary landfill (also operated by the NJDEP) which was formerly used for disposal of "bulky waste". No details were provided in the database records regarding the specific types of materials placed in the landfill.

7.3.6 Leaking Underground Storage Tank Incident Reports

Two LUST sites were identified in the EDR Area Study report at locations within LSP Project Area, one on Audrey Zapp Drive (site 5) and another at the Liberty State Park Maintenance Area located on Wolf Drive (site 16) (Appendix E, p. 22 and 68). The records show that a fuel-oil discharge was reported on September 7, 1994 at a construction site located on Audrey Zapp Drive, based on the discovery of a previously unknown, 10,000-gallon UST. Soil contamination was suspected and the tank was scheduled for removal. A no-further-action letter was issued by the NJDEP regarding this LUST on November 17, 1995.

The records pertaining to the Liberty State Park Maintenance Area indicate that four USTs with a total capacity of 4,000 gallons were scheduled for removal at the former landfill site described in Section 7.3.5 above. The USTs were formerly used to store leaded gasoline, and were reportedly installed in 1987. The tank construction was described as" fiberglass-reinforced plastic". The incident was initially reported on August 30, 1994. The available records to date do not show evidence of a no-further-action decision by the NJDEP with regard to this case. The current status of this case is therefore unknown.

7.3.7 Underground Storage Tank Database

Two USTs were identified in the EDR report at locations within the LSP Project Area, one adjacent to Freedom Way[6] (site 13) and another at the Liberty State Park Maintenance Area located on Wolf Drive (site 16) (Appendix E, p. 49 and 68). Four, bare-steel, single-wall, fuel-oil USTs were reportedly registered at the site on Freedom Way site in 1995, immediately prior to being removed. The records concerning the Liberty State Park Maintenance Area pertain to the same gasoline tanks described in Section 7.3.6 above.

7.3.8 NJ Spills List

Five discharges were identified at locations within the LSP Project Area, at site locations 5, 6, 11, 13, and 16 on the EDR Area Study map (Appendix E, pages 22, 34, 44, 49, and 68). Two of the sites are shown adjacent to Audrey Zapp Drive[7] (sites 5 and 6). One incident involved the same fuel-oil UST described in Sections 7.3.6 and 7.3.7 above, for which a no-further-action decision has been issued by the NJDEP. The other record concerned a report filed on December 17, 1992 regarding thirteen 55-gallon drums which were reportedly washed up along the shoreline, some of which were observed to be leaking (NJDEP Case No. 92-12-17-1047-24). The contents of the containers were not identified in the report. The incident responders included the Jersey City Fire Department and the NJDEP Division of Responsible Party Site Remediation (DRPSR). No further information was provided in the records regarding the outcome of this incident.

[6] The records list the site address as "Audrey Zapp Drive", but the location shown on the EDR Area Study Map is approximate ½ mile southwest of Audrey Zapp Drive, adjacent to Freedom Way. The address listed in the database is the business address of the responsible party, which apparently does not correspond to the location of the tanks.

[7] The second record incorrectly lists the street as "Audrey Zapp Blvd".

The records shown on page 44 of Appendix E (site 11) pertain to a fuel spill from a commercial bus in March 2000, which involved approximately 30 gallons of diesel [8]. The specific measures taken to contain or remediate the spill are not described in the report. However, based on the circumstances and the relatively small quantity of fuel involved, this incident does not appear to warrant further investigation.

The records pertaining to site 13 (Liberty State Park) and site 16 (Liberty State Park Maintenance Area) refer to incidents previously described in Section 7.3.6 and 7.3.7 above.

7.3.9 NJ Release

Three releases are listed in the EDR Area Study Report at locations within the LSP Project Area, all of which reportedly occurred at map location 6 (Appendix E, pages 24, 29, and 34). Two incidents are described as occurring at the Liberty Landing ("Liberty Park") Marina located at 80 Audrey Zapp Drive. The earliest record (dated December 17, 1992) pertains to the 13 abandoned drums described in Section 7.3.8 above. The incident was reported by an employee of the NJDEP on July 1, 2000 (Appendix E, p. 29). Under the heading "status at spill", the incident report states that eighty-seven 55-gallon drums were found in a trailer. The report provides no further details on the circumstances surrounding the release. The two other incidents both involved observations of an "oil sheen" on the water adjacent to the Liberty Landing Marina, one of which was reported by an officer of the U.S. Coast Guard (USCG). The source of the sheen is not described in the report. However, the type of release is described as "continuous".

7.4 NJDEP File Review

The NJDEP has conducted numerous environmental investigations within the LSP Project Area during the period from 1978 to the present, and additional investigations are planned. The results of environmental investigations performed during the period from 1981 to 1995 are summarized in reports by the NJDEP (1989; 1995a), copies of which are included in Appendices F and G respectively. A summary of site-wide soil and ground water conditions is provided in Section 7.4.1 below.

Several specific areas of environmental concern have been identified by the NJDEP, which are labeled in Figure 2. These areas of concern are: the Freight Yard, the Dredge Spoils Storage Area, Black Tom Channel / Dog Show Field, the Liberty Science Center, Chromate Sites 15 and 178, the Waterfront Development / Middle Cove area, the Northern Marina, and the Terminal Parking Lot. Details concerning the environmental investigations performed to date at these areas of concern is provided in Section 7.4.2.

7.4.1 Site-Wide Summary

The results of past environmental investigations within the LSP Project Area have shown evidence of relatively widespread soil contamination, but generally at levels below applicable hazardous-waste thresholds. Heavy metals (*e.g.*, arsenic, lead, zinc, and copper) and polynuclear aromatic hydrocarbons (PAHs) are nearly ubiquitous in fill materials

[8] The incident reportedly occurred in the vicinity of 251 Phillips Street (adjacent to the Liberty Science Center), however the location shown on the EDR map is within the former Freight Yard.

at the site, and commonly occur at concentrations above the applicable NJDEP Soil Cleanup Criteria (SCC). Petroleum hydrocarbons are commonly present in surface soils, probably as a result of incidental spillage during historic railroad operations, and petroleum free-product has been observed in subsurface soils at two different locations. Traces of Polychlorinated biphenyls (PCBs) and organochlorine pesticides (*e.g.*, dieldrin and DDT) have also been detected locally at concentrations above the SCC (but generally below applicable hazardous waste thresholds). Additionally, fill materials containing chromate chemical production waste (CCPW) have been identified at three sites within the LSP Project Area, in which hexavalent chromium (CrVI) was detected at concentrations above the NJDEP SCC.

Ground water quality at the site is generally reflective of the soil conditions described above. In 1994, the NJDEP Site Remediation Program conducted a site-wide reconnaissance investigation of ground water conditions at the site, during which 50 ground water samples were collected for laboratory analysis at the locations shown in Figure 3, using a Hydropunch® direct-push sampling rig. The sampling locations were targeted to specific features that were previously identified by the NJDEP during a review of historic aerial photography (NJDEP 1994b). The samples were analyzed for TCL VOCs, Metals and SVOCs. No VOCs were detected in the samples. However, metals and PAHs were detected locally at concentrations above the NJDEP Ground water Quality Criteria.

7.4.2 Specific Areas of Environmental Concern

7.4.2.1 Freight Yard

The Freight Yard is comprised of approximately 205 acres of undeveloped land within the center of LSP. It is bounded to the east by Freedom Way, to the west by Phillips Drive, to the north by Audrey Zapp Drive, and to the south by James Hamill Drive (Figure 2)[9]. The Freight Yard was created entirely from fill, which was deposited during the period from 1860 to about 1928 (refer to Section 7.2.1 above). From the time of its creation until the late 1960s, it was the site of a freight switching yard operated by the CRRNJ, which also contained stockyards and coal transportation facilities.

On February 28 and March 1 of 1990, a total of 57 soil samples were collected from 28 sample locations within the Freight Yard (NJDEP, 1990). Two samples were collected from each location, at depth intervals of 0-0.5 feet and 2-3 feet below grade. The samples were analyzed for the TCL VOC+30, TCL SVOCs, pesticides, PCBs, and metals. Trace of several VOCs were detected including, chloroform, ethylbenzene, trichloroethene, and toluene. Total PAH concentrations ranged from 8.0 to 276.2 parts per million (ppm). Traces of organochlorine insecticides were also detected including dieldrin (0.790 ppm), 4-4' DDE (0.580-0.70 ppm), and 4-4'-DDT (0.160-2.0 ppm). PCBs were detected in two samples (Aroclor 1248 at 5.9 ppm; Aroclor 1260 at 0.650 ppm).

[9] The Dredge Spoils Storage Area is geographically a part of the Freight Yard, but is addressed separately in Section 7.4.2.2 of this report.

During December 1994 and February 1995, the NJDEP collected additional soil samples within the southwest corner[10] and central portion of the Freight Yard. A total of 34 test pits were excavated within the southwest corner of the Freight Yard, from which 11 soil samples were collected for laboratory analysis. Within the central portion of the Freight Yard, 82 test pits were excavated, from which 52 samples were collected. The results are summarized in the August 1995 Liberty Park Soil Sampling Report (NJDEP 1995a; Appendix E). Arsenic, lead, and PAHs were detected at concentrations above the NJDEP Residential SCC. The NJDEP concluded that the contaminant concentrations in the central Freight Yard were "similar to those found in historic fill" and considered that capping with a 1-foot layer of clean cover would be a suitable remedy for the site (NJDEP,1995a). With respect to the southwest corner of the Freight Yard, the NJDEP concluded that arsenic, which had been detected at concentrations of up to 429 ppm, required further delineation.

Additional sampling was conducted during August 1996 to delineate the distribution of arsenic. A total of 23 test pits were excavated from which 54 samples were collected at depth intervals of 0-6 and 18-24 inches below grade. Further delineation of arsenic was performed during August and November 1996 (NJDEP 1996, 1997), during which 44 samples were collected for total arsenic analysis, four for Toxicity Characteristic Leaching Procedure (TCLP) analysis, and eight samples were collected for analysis using the Synthetic Precipitation Leaching Procedure (SPLP). The analytical results of these investigations were not reviewed during this ESA. However, an undated, draft NJDEP memorandum noted that arsenic concentrations as high as 1150 ppm have been detected locally within fill materials in the freight yard.

7.4.2.2 Dredge Spoils Storage Area

The Dredge Material Storage Area is located within the Freight Yard and consists of approximately 42 acres of dredge spoils and associated containment structures (NJDEP 2000a). The containment structure, which consisted of a series of 8-foot-high earthen berms, was constructed by the Port Authority of New York and New Jersey (Port Authority) during 1980-81 (NJDEP, 1989), using existing fill material excavated on-site (NJDEP 2000a). In 1981, approximately 93,000 cubic yards of dredge spoils were placed into the containment structure, in connection with the construction of the southern section of the seawall (Figure 2). On the basis of laboratory analyses performed in 1981, the dredged material was determined to be non-hazardous (NJDEP 2000a). However, runoff samples collected during October 1981 reportedly yielded results for oil & grease, cadmium, and lead above applicable regulatory thresholds. The NJDEP had previously stipulated that the Port Authority cover the dredge material with 2 feet of clean soil after dewatering of the material was complete (NJDEP 1987). However, no records were found of this work having been performed.

During the spring of 1987, an additional 255,000 cubic yards of dredge spoils were placed into the impoundment, which were obtained from an area between the South Cove and the Middle Cove during the completion of the Liberty Walk seawall project. Waste-classification sampling of this material during 1987 yielded results above the applicable regulatory thresholds for EP Toxicity (selenium) and reactive sulfide. However, The USEPA subsequently made a determination that the material was non-hazardous, citing

[10] Also known as the "Soil Staging Area".

inconclusive results for EP Toxicity and attributing the sulfide reactivity to naturally occurring, anaerobic biological activity (USEPA, 1984).

During the winter of 1991-92, a combination of high winds and dry weather resulted in erosion of the material. In August of 1993, the NJDEP hired a contractor to excavate and re-grade the berms surrounding the impoundment over the dredge spoils to form a cap over the material, and vegetative cover was subsequently established (NJDEP, 2000a).

The NJDEP conducted additional soil sampling within the Dredge Spoils Area in 1995, in order to confirm previous analytical results (NJDEP, 1995a) (Appendix E, pages 6-7). A total of 46 soil samples were collected along a regularly-spaced grid pattern, which were submitted for laboratory analysis. Relatively low concentrations of polychlorinated biphenyls (PCBs) and dieldrin, an organochlorine insecticide, were detected (maximum concentrations of 1.31 ppm and 0.72 ppm, respectively). Arsenic was detected at concentrations above the NJDEP Residential SCC of 20 ppm on 31 out of 46 samples, and lead was detected in six samples above the residential SCC of 400 ppm (maximum of 3,380 ppm). The NJDEP concluded that soil contaminants detected in the Dredge Spoils Area were generally similar to those found elsewhere in LSP, except for the presence of PCBs and dieldrin (NJDEP, 1995a). The NJDEP has suggested that an appropriate remedy for this area would be to maintain the current vegetative cover, possibly with the addition of a 1-foot layer of clean soil. It was concluded that additional investigation may be required to delineate PCBs and pesticides in this area, depending on the future use of the site (NJDEP, 1995a).

7.4.2.3 Black Tom Channel / Dog Show Field

The Black Tom Channel Area, which includes the Dog Show Field, occupies an area of approximately 150 acres at the southern end of Liberty State Park (Figure 3). A 35-acre portion of the site, which includes the Administration Building and the Liberation Monument, was the first area in the park to be redeveloped for public use. Prior to the turn of the century, Black Tom Channel was the site of a shallow oyster reef, which was partly filled with municipal refuse to create piers and a railroad terminal (refer to Sections 7.2.1 and 7.2.2 above). During the initial development of LSP, clean fill was used to cover debris located in the southern area, and asphalt parking lots were constructed.

In September 1992, the NJDEP tested surface soils within the Dog Show Field in response to a proposal to use the field for high-school football practice. Heavy metals and coal combustion residues (PAHs) were detected at concentrations above the NJDEP Residential SCC. On the basis of these results, the NJDEP determined that the site was not suitable for use as a football field but could safely be used for passive recreation and parking (NJDEP, 1995b).

Prior to the United States' entry into World War I, the terminal facilities at Black Tom were used to ship munitions to the Allied forces in Europe (NJDEP, 1989). In 1916, a series of explosions occurred at Black Tom, during which approximately 1,000 tons of munitions were detonated[11]. The explosions caused extensive damage to the surrounding area, and several barges containing unexploded ordnance (UXO) reportedly sank to the bottom of the adjacent Black Tom Channel (NJDEP, 1989).

[11] Allegedly as a result of sabotage by German agents.

During March of 1981, while hydraulic dredging operations were underway at the south end of the seawall (Figure 2), several rounds of "live" ordnance were reportedly discovered within the Dredge Spoils Storage Area (refer to Section 7.4.2.2 above). The rounds, which consisted of two 4-inch shrapnel rounds, two 3.25-inch shrapnel rounds, and two 35-mm cartridges, were sent to U.S. Navy Weapons Station Earle in Colts Neck, New Jersey for examination. The officer in charge noted that the powder and propellant charges in the rounds were "completely soaked with water", and that attempts to detonate them using explosives had failed (U.S. Navy, 1981). The report stated further that: "The conditions of the rounds examined to date indicates that the possibility of a detonation is remote." However, at the recommendation of the U.S. Coast Guard, a 100-yard-radius exclusionary zone was established around the dredging site and a screen was installed on the dredge-spoil line to prevent any additional ordnance from reaching the Dredge Spoils Storage Area. No further investigations have been performed to assess the possible presence of UXO within the LSP Project Area.

7.4.2.4 Liberty Science Center / Former Roundhouse

This site occupies an area of approximately 23.4 acres, of which 8 acres are currently leased to the Liberty Science Center, 10 acres are used as a parking lot, and the remainder is currently undeveloped (Figure 2). A freshwater wetland exists in the northern portion of the site.

The CRRNJ formerly operated its Communipaw Avenue engine terminal at this site, which was the main servicing and repair facility for over 300 railroad engines per day (refer to Section 7.2.2 above). The facility included a large double roundhouse, a coal-fired electric generating plant, and associated coal loading and fuel handling facilities. The facility was active from 1914 until 1967, when its operations were curtailed by the construction of the New Jersey Turnpike (NJDEP, 1989). The H. Snooks Brass Foundry and the Neptune Mildew and Waterproofing Co. facilities occupied the site prior to its acquisition by CRRNJ. The State of New Jersey purchased the property in 1978, and completed demolition of the buildings in 1980. During a site inspection by the NJDEP in 1980, petroleum product was observed within a manhole, which was subsequently removed. A USEPA Preliminary Assessment Report of the site noted that "the site was observed to be highly contaminated with an oil and grease sludge" an that due to the nature of operations at the site "PCBs may also exist" (USEPA, 1986a).

In February of 1991, during trenching activity associated with the construction of the Liberty Science Center, an unidentified "green goo" was reportedly encountered in the subsurface (NJDEP, 1991). The NJDEP sent a sampling team to the site, which found a petroleum product in the subsurface. The area was further excavated in an attempt to locate the source of the material, at which time an 18-inch-diameter "brick" pipe was encountered. The pipe was accidentally ruptured, at which time an estimated 100-450 gallons of oil leaked into the excavation. The material was sampled, and subsequent laboratory analysis showed it to consist of 62-76% petroleum hydrocarbons. PCBs were not detected in the sample. The NJDEP recommended no further action with respect to spill, providing that the area remains undisturbed. However, the NJDEP noted that if further excavation was to be performed in the area, removal of the grossly contaminated soils would be required.

During a preliminary soil investigation of the site performed by the NJDEP in 1987, arsenic, metals (antimony, cadmium, chromium, copper, lead, mercury, nickel, and selenium), PAHs,

and volatile organic compounds (VOCs) were detected in soils above the applicable NJDEP SCCs (NJDEP, 1998b). A remedial investigation was subsequently performed, during which soil samples were collected at 48 locations and three monitoring wells were installed. Sediment and surface-water samples were also collected at 13 locations within the adjacent Morris Canal Basin. The soils were analyzed for the USEPA Target Compound List (TCL) metals, TCL semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPHC) and total organic carbon (TOC), and randomly selected samples were analyzed for TCL Organics +30. The analytical results for soils confirmed earlier findings with respect to the presence of metals, PAHs, and petroleum hydrocarbons at the site. Additionally, lead, cadmium, petroleum hydrocarbons and semi-volatile organic compounds were detected in one of the monitoring wells, at concentrations exceeding the applicable NJDEP Ground water Quality Criteria. Unspecified "pesticides" were detected in all three of the monitoring wells (NJDEP 1998b).

The incident reports by the USEPA (1986a) and the NJDEP (1991) suggest that petroleum free-product may remain within subsurface piping, which has not been fully characterized. An NJDEP memorandum refers to anecdotal information provided by a previous site manager, who indicated that "free petroleum product may exist at a location beneath the parking lot" and recommended that a well be installed to investigate it (NJEP, 1998b). To date, no additional investigations are known to have been performed in this area.

Prior to redevelopment of the site, two subsurface geotechnical investigations were performed at the site of the area parking area, one by Langan Engineering Associates (Langan, 1991) and another by Warren George, Inc. of Jersey City, New Jersey (date unknown). Although the borings were performed for geotechnical rather than environmental sampling purposes, the associated boring logs may contain useful information concerning the distribution of petroleum product in subsurface soils.

7.4.2.5 Chromate Waste Sites

During the early 1900s, three chromate chemical production facilities were operated in Hudson County which produced an estimated two to three million tons of CCPW (NJDEP 1985). The CCPW was widely used as structural fill in Hudson County, and the majority of the CCPW sites identified to date are located in Jersey City. Three CCPW sites are currently known within the LSP Project Area. Two sites were identified during the course of regional remedial investigation performed in Hudson County between 1986 and 1989. These sites are known as Chromate Waste Site 15 (former McAllister Tug and Barge Products) and Chromate Waste Site 178 (Cabana Club). Additionally, in 1993, the NJDEP discovered CCPW in association with an abandoned brick sewer located adjacent to Thomas McGovern Drive (Figure 2). The results of the environmental investigations to date at these sites are described below:

Chromate Waste Site 15

Chromate Waste Site 15, which covers an area of approximately 12 acres, is bounded to the west by the Interpretive Center, to the east by Liberty Walk (Figure 2). The NJDEP initially reported the presence of "visually distinctive nodular chromate waste" on the ground surface, the identity of which was subsequently confirmed by soil and ground water sampling (BCM, 2001). The site is surrounded by a fence, to restrict public access. However, there is a paved road through the site to provide access to the Jersey City Sewer

Authority, as required for maintenance of the tide gates associated with their Combined Sewer Overflow System.

In 1994, the NJDEP engaged a private contractor, BCM Engineers/ATC Group Services Inc. (BCM), to perform a remedial investigation at the site. During the period from September 12, 1995 to April 10, 1996, BCM completed a total of 86 soil borings, 12 monitoring wells, and 8 test pits at the site. The soil borings ranged in overall depth from approximately 7 feet to 32 feet below grade. Additionally, surface-water and sediment samples were reportedly collected from an on-site "tidal pond".

Hexavalent chromium was detected in 62 of the soil borings and in one of the test pits. The analytical results for hexavalent chromium ranged from non-detectable to 1,877 mg/kg. The concentrations detected in 21 of the soil borings exceeded the NJDEP Site-Specific, Non-Residential Direct Contact Soil Cleanup Criterion of 20 mg/kg. Most of the results also exceeded the USEPA migration-to-ground water criterion of 38 mg/kg, which is based on a dilution attenuation factor (DAF) of 20. The highest total and hexavalent chromium concentrations were generally detected within 5 feet of the ground surface. However, hexavalent chromium was also detected in soils at depths of up to 25 feet below grade. Antimony, arsenic, beryllium, cadmium, lead, nickel, thallium, vanadium, and zinc were also detected locally at concentrations exceeding their respective Residential and/or Non-residential SCC. Chromate waste was identified in 37 out of the 86 soil borings. Hexavalent chromium was detected in one of the 12 monitoring wells sampled, at a maximum estimated concentration of 3,500 µg/L. No ground water quality criteria were then established by the NJDEP for hexavalent chromium. However, the results for hexavalent chromium exceeded the criterion of 100 µg/L established for total chromium. Hexavalent chromium was not detected in any of the nine surface water samples, nor in any of the 15 sediment samples analyzed. Total chromium concentrations detected in surface water were also below the human-health-based surface-water criterion of 160 µg/L. However, arsenic, copper, lead, mercury, selenium, and thallium were detected in surface water at concentrations exceeding the applicable surface-water criteria. Hexavalent chromium was not detected in any of the chip samples.

The investigators recommended that additional soil, ground water, surface-water, sediment, and chip sampling be performed to more precisely delineate the extent of contaminants associated with the CCPW at Site 15 (BCM, 2001). Specifically, 5 additional soil borings, 2 sediment sample locations, 8 surface-water sampling locations, and 5 additional monitoring wells were proposed.

Chromate Waste Site 178 (Cabana Club)

Chromate Waste Site 178 occupies an area of approximately 14.5 acres and is located in the southwest corner of Liberty State Park, between the Theodore Conrad Drive, Morris Pesin Drive, Burma Road, and Hart Drive (Figures 2 and 3). This site contains a public swimming pool, the Liberty State Park maintenance yard, an on-site residence for the Liberty State Park maintenance supervisor, and a summer camp for Jersey City Children (Camp Liberty). In 1992 the NJDEP received information from a confidential informant that CCPW might be present at the site. The NJDEP subsequently collected a series of surface-soil samples for analysis of chromium, to determine whether a potential exposure hazard existed at the site. None of the results were above the NJDEP SCC, nor was any CCPW observed at the site (NJDEP, 1995b). Further investigation of the site was proposed as of

October 1995. However, no information concerning subsequent investigations was found during the NJDEP file review.

Brick Sewer

The Underground Utility Plan prepared by the Port Authority (1975) shows an 84-inch brick sewer (now abandoned) passing through the LSP Project Area and discharging from an outfall located between South Cove and Middle Cove (Figure 2). Suspecting that CCPW might have been used as a structural fill during construction of the sewer, the NJDEP performed subsurface investigation of the adjacent soil during 1994-95. Initially, the NJDEP performed a geophysical investigation to determine the alignment of the sewer, and subsequently collected three samples of fill material at 100-foot intervals along its length (NJDEP 1995a) (Appendix E, pages 7-8). Laboratory analysis of the samples yielded results of up to 26,800 ppm total chromium and 42 ppm hexavalent chromium. All three samples yielded results above the NJDEP Residential Soil Cleanup Criterion of 10 ppm for hexavalent chromium. These results suggest that CCPW is present adjacent to the entire length of the brick sewer. The NJDEP has concluded that, due to the depth of the chromium contamination, "the risk to human health and the environment is minimal" (NJDEP 1995a). However, the presence of CCPW could be a significant factor in planning any wetland restoration projects at LSP, if chromium contaminated soils are disturbed.

7.4.2.6 Waterfront Development Area / Middle Cove

The Waterfront Development Area includes the area bounded by Liberty Walk to the east, Freedom Way to the west, and to the north and south by North Cove and Chromate Waste Site 15, respectively. The Middle Cove (Figure 2) is a former tidewater basin, which was originally created through filling and bulkhead construction (refer to Section 7.2.1). It is located within the Waterfront Development Area, immediately to the east of Chromate Waste Site 15 (Figure 2). Middle Cove was filled by the State of New Jersey during 1985, during the construction of the sea wall (Figure 2). Initially, the north eastern portion was filled using material from a bulkhead that had existed in front of the McAllister Tug and Barge Property. The remainder was subsequently filled with clean sand (NJDEP, undated).

In 1987, concerns were voiced by the public that the CCPW was present in the material used to fill Middle Cove, despite previous sampling results which did not shown any evidence of CCPW at this site (NJDEP 1995b)[12]. Accordingly, the NJDEP performed a subsurface soil investigation of the site during January 1995. The results did not show any evidence of the presence of CCPW. However, petroleum product was encountered in several of the subsurface soil borings, and TPHC concentrations of up to 6,400 ppm were detected in the soil. Noting that the contaminated soil was overlain by 6 to 8 feet of clean sand, the NJDEP concluded that "the threat to human health through exposure to the contamination is unlikely" and determined that no further action was necessary. However, the NJDEP also stated that "any future development of Middle Cove which would disturb the clean soil cover would require further remedial investigation and a remedial alternative analysis" (NJDEP, 1995b).

A report prepared by the NJDEP (2000b) presents the results of subsequent work to delineate and characterize free and residual product in the subsurface. The Handex Corp.,

[12] A lawsuit was brought against the NJDEP in connection with this matter [Interfaith Community Organization v. Shinn, *et al.*, D.N.J., Civ. Action Nos. 93-4774, 94-3434, 94-3793]

working under contract with the NJDEP, performed 31 cone-penetrometer borings, 4 test pits, 132 soil borings, 4 monitoring well installations, a free-product laboratory analysis, product bail-down tests, and a series of enhanced recovery evaluation tests. Based on the horizontal and vertical distribution of the free and residual product, it was estimated that 20,000 cubic yards of contaminated soil were present which contained approximately 35,000 to 70,000 gallons of oil. Appendix 3 of the NJDEP (2000b) report contains the result of laboratory "petroleum fingerprint" analysis of free product. The results show that the material is most likely derived from #2 heating oil.

The remedy selected by the NJDEP was "In place containment and exposure controls with periodic free product removal" (NJDEP, 1998a). Specifically, this consisted of: (1) placement of 1 foot of clean cover over the site and (2) periodic free-product extraction (via recovery wells). Placement of the clean cover and re-vegetation of the site was completed in 1999. Additionally, 5 sentinel wells were installed outside of the horizontal limits of the residual product in February 2000, with the goal of preventing any potential discharges into nearby ecosystems.

An additional investigation of the residual and free petroleum product at Middle Cove was performed on May 15, 2001, which included the drilling of 6 continuous cores to depth of 10-12 feet below grade using a Geoprobe® direct-push rig. Indications of free product were noted in 4 out of the 6 borings at depths ranging from 5 to 11 feet below grade (NJDEP, 2001a). Additionally, a "strong odor of creosote from buried wood pilings" was noted in two borings in which free-product was not observed.

In 2001, the NJDEP proposed to continue a program of "product bailing, ground water sampling, and contaminant migration assessment", but concluded that bailing "will not prove to be an effective long-term remedial option (NJDEP 2001b). Therefore the NJDEP has considered two other remedial options for product recovery: (1) multi-well pumping and collection systems with off-site disposal, and (2) trench collection with off-site disposal. The NJDEP subsequently determined that a multi-well pumping system "will best meet the long-term remedial goals" (NJDEP, 2001b).

7.4.2.7 Northern Marina

The Northern Marina area occupies a total area of approximately 72 acres (Figure 2) and is currently operated as a public concession (Liberty Landing Marina). Prior to its acquisition by the State of New Jersey, the CRRNJ owned the southern half of the site, and the LVRR owned the portion located along the northern waterfront (refer to Section 7.2.2). The LVRR developed docking facilities along the shore of the Morris Canal Basin, and the CRRNJ operated stockyards and a major coal distribution facility for the New York City market (TAMS, 1989a).

In 1978, shortly after the Northern Marina area was acquired by the State of New Jersey, two facilities formerly located on Johnston Avenue[13], known as the Bond Adhesive Company and the Globe Trucking Company, were found to have engaged in illegal dumping of hazardous materials (USEPA, 1986b). As noted in Section 7.2.2, the 1979 Sanborn Map coverage shows the Bond Adhesive Company occupying a building located on the north side of Johnston Avenue, which was formerly the site of "coal pocket" operated by CRRNJ

[13] Now known as Audrey Zapp Drive.

(refer to Appendix B). The Globe Trucking Company operated a facility approximately 1,200 feet west of the Bond Adhesive Co. (about 2,400 feet west of the Terminal Building[14] (NJDEP 1980a). During a site inspection by the NJDEP on March 17, 1980, 20 drums containing solvents were found inside of the abandoned Globe Trucking Building, and an estimated 75 to 100 drums were present outside of the building (NJDEP, 1980b). At the former Bond Adhesives Company, approximately 20 drums were found inside of the building and approximately 100 drums were observed at an outdoor loading dock, approximately 50 of which were empty (NJDEP, 1980b). The NJDEP subsequently contracted with Mid-Atlantic Refinery Services to perform a cleanup of the drums, and the work was completed in May 1980.

In 1987, the NJDEP Division of Hazardous Site Mitigation conducted a "Pre-RI Study" of the Northern Marina for the purpose of assessing off-site contaminant migration pathways that could pose a threat to human health or the environment (TAMS, 1989a). The study included a search of existing regulatory files, a soil-gas survey for VOCs, radiation monitoring, and sampling of surface-water, sediments and soils.

A remedial investigation of the Northern Marina was performed in 1989, the results of which are presented in a report by TAMS (1989b). The investigation included subsurface soil borings, installation and sampling of monitoring wells, determination of aquifer characteristics (*e.g.*, grain-size, permeability), tidal studies, and a benthic survey. The sampling points were located based on the results of the 1987 NJDEP Pre-RI Study, and a review of historic maps of the site. A total of 159 soil samples were collected from 76 locations, and a additional 38 samples were collected in connection with the installation of 11 monitoring wells. The soil samples were collected from fill materials as well as the underlying shallow marine deposits, and were analyzed for TCL Metals, TCL SVOCs, TPHC, and TOC. Samples from five randomly selected borings were analyzed for TCL organics + 30.

The organic compounds detected in soils included 1,1,1-TCA (5 ppb); TCE (1 ppb); PCE (9 ppb); PAHs (up to 288 ppm total); dieldrin (14-86 ppb), and 4,4'-DDE (35 ppm). Petroleum hydrocarbons were widely distributed at the site (TPHC >100 ppm in 63% of the samples), as metals (*e.g.*, lead, cadmium and copper) were widely detected at concentrations above the NJDEP SCC. The investigators concluded that the distribution of PAHs and metals in the fill materials at the site is essentially "random", and the TPHC results are related to incidental discharges associated with refueling, fuel spillage, etc. (TAMS 1989b).

The results of the 1989 study were used to develop a baseline public health evaluation for the Northern Marina site, the results of which are presented in a report by TAMS (1990). The carcinogenic and non carcinogenic risks were calculated in relation to 16 contaminants of concern. Exposure routes included ingestion of contaminated fish, as well as dermal contact and ingestion of soils. The estimated cancer risk to park workers and adult visitors was estimated at 9.4×10^{-3}, and the corresponding risk to children was estimated at 8.3×10^{-4}.

[14] Both buildings are visible in the 1966 and 1976 aerial photographs found in (Appendix D).

7.4.2.8 Terminal Parking Lot

The Terminal Parking Lot , which includes the area known as the "south lawn", is located west of the CRRNJ Terminal Building and occupies an area of approximately 12 acres (Figure 2). In July of 1992, soil samples were collected at 21 locations within the Terminal Parking Lot. The sampling results showed that PAHs and metals were present at concentrations above the NJDEP Residential SCC. In 1993, the NJDEP implemented a remedial action plan for the site, consisting of an asphalt cap over the parking lot and a 1-foot layer of clean fill over the south lawn area with a stable vegetative cover (grass). No further remedial action is planned by the NJDEP in this area (NJDEP, 1995b).

8.0 OPINION

In the opinion of this investigator, the environmental hazards within the LSP Project Area have been systematically characterized by the NJDEP through the environmental investigations conducted to date. However, there remains a risk of encountering previously unidentified environmental contaminants within areas designated for wetland restoration. Soils that are found to be moderately contaminated with arsenic, metals, PAHs, pesticides, or PCBs could probably be managed on-site by capping with a layer of clean soil and establishing a stable vegetative cover. However, if heavily contaminated soils (*e.g.*, petroleum-saturated soil or CCPW) were to be encountered, on-site management of the soil might not be feasible, and off-site disposal could be prohibitively expensive.

The environmental risks and uncertainties associated with the proposed wetland restoration project could be further constrained through further compilation and analysis of existing subsurface data (*e.g.*, soil-boring logs, test-pit logs, and laboratory analyses) pertaining specifically to the areas to be disturbed (*i.e.*, using information from the studies referenced in this ESA). This would require that the boundaries of the proposed wetland restoration project(s) and the relevant sample location maps be registered in a common coordinate system (*i.e.*, using a geographic information system). The environmental studies could then be analyzed to determine: (1) whether sufficient information is available concerning environmental conditions within the areas to be disturbed, and (2) whether there are any recognized environmental conditions that are likely to hinder implementation of the project. Should further characterization of the site conditions be required, a targeted subsurface investigation can then be implemented, focusing only on those areas that have not already been investigated.

9.0 CONCLUSIONS

The conclusions of this ESA regarding the LSP Project Area are as follows:

1. The soil, ground water conditions within the LSP Project Area have been extensively investigated by the NJDEP, and it is possible that sufficient information is already available with which to characterize environmental conditions in areas designated for wetland restoration. However, this cannot be verified without further review of the specific environmental sampling results pertaining to each area designated for restoration.
2. The typical soil contaminants associated with fill materials at the LSP Project Area consist of arsenic, metals, PAHs, and petroleum hydrocarbons. Hexavalent chromium is also present in association with CCPW.
3. The concentrations of PAHs and metals in common fill materials are generally within the ranges listed in the NJDEP Historic Fill Database[15], and appear to meet the general definition of "historic fill" under Technical Rules for Site Remediation (N.J.A.C. 7:26E App. D). Therefore, soils other than those containing CCPW or petroleum free-product can probably be managed on site (*e.g.*, by capping with a layer of clean soil and establishing a vegetative cover). However, soils that are saturated with petroleum or which contain CCPW would probably require either off-site disposal or on-site stabilization.
4. The petroleum free-product present beneath the site of the former Liberty Science Center parking lot (former Roundhouse) has not been fully delineated. Therefore, its potential implications on future wetland restoration projects cannot be assessed at this time. The fact that free-product was observed within an abandoned underground pipe suggests subsurface structures are serving as conduits for oil migration. An additional subsurface investigation may be required if wetland restoration projects are planned in this area.
5. The petroleum free-product present beneath the Waterfront Development Area has been delineated horizontally and vertically by the NJDEP, and product recovery efforts are underway. The additional costs associated with managing petroleum-saturated soils may preclude the implementation of wetland restoration projects in areas that contain free-product.
6. The presence of CCPW adjacent to the abandoned Brick Sewer could be an impediment to wetland restoration efforts, as it bisects the entire LSP Project Area. The question of whether CCPW is present in association with other underground utilities within the LSP Project Area has not been fully investigated.

[15] Technical Rules for Site Remediation N.J.A.C. 7:26E App. D

7. Some uncertainty remains as to whether all of the areas of concern identified by the NJDEP during its review of historic aerial photography have been investigated. Additional interviews with the NJDEP may be necessary to verify the exact nature and location of each area of concern, and to confirm whether all of the areas of concern have been investigated.
8. It is not known whether the possible burial site identified in the 1976 aerial photograph (refer to Section 7.2.4) has been identified or investigated by the NJDEP. Given the proximity of the excavation to two known illegal dumping sites (Globe Trucking Co. and Bond Adhesive Co.), it is possible that hazardous materials were disposed of in this area.
9. UXO may be present within the Dredge Spoils Storage Area as a consequence of the 1981 dredging operations. In the event that soils in this area are to be disturbed, further investigation of the associated risks will be necessary.
10. The geographic limits of the closed, sanitary landfill formerly operated by the NJDEP for disposal of "bulky waste" were not determined during this investigation. Therefore, it is not known whether it constitutes an impediment to the planned wetland restoration efforts.

10.0 RECOMMENDATIONS

Prior to implementation of the proposed wetland restoration project within the LSP Project Area, the following additional work is recommended:

1. It is recommended that the associated environmental risks be further constrained through additional review and analysis of the environmental studies identified in this ESA. A comprehensive compilation and analysis of existing subsurface information is recommended, in which the relevant environmental sampling results and the proposed wetland boundaries are registered in a common coordinate system. It is recommended the results be analyzed (a) to determine the adequacy of existing studies, (b) to assess the impact of any recognized environmental conditions, and (c) to identify specific targets for additional subsurface characterization studies (should they be required).
2. If soils in the vicinity of the Brick Sewer are to be disturbed, it is recommended that further delineation and characterization of associated CCPW be performed in this area. Historic maps and site plans should also be reviewed to identify any other subsurface structures within the proposed wetland restoration area (*e.g.*, water lines, culverts) where CCPW is likely to be present.
3. If soils in the vicinity of the Liberty Science Center parking lot (former Roundhouse), are to be disturbed, it is recommended that subsurface soil sampling be performed to determine whether free-product is present.
4. It is recommended that the USACE-NYD obtain a GIS-compatible map from the NJDEP showing the current limits of free-product in the Waterfront Development Area, and incorporate it into the project planning process.
5. It is recommended that records pertaining to the closed, sanitary landfill formerly operated by the NJDEP for disposal of "bulky waste" be reviewed to determine whether it constitutes an impediment to the wetland restoration projects under consideration.
6. It is recommended that the NJDEP be consulted to confirm whether all of the areas of concern identified in their 1994 review of historic aerial photography have been investigated, and additionally whether the excavation identified in the 1976 aerial photography during this ESA has been investigated.
7. If soils in the vicinity of the Dredge Spoils Storage Area are to be disturbed, it is recommended that the risks associated with the possible presence of UXO be further evaluated.

11.0 DEVIATIONS

This report was prepared in general accordance with the ASTM Standard E1527-00, subject to the limitations/deviations listed below:

- A land title search on the property was not performed.
- Building interiors were not inspected.
- Interviews were not conducted with tenants operating within the LSP Project Area, nor with local (*i.e.*, municipal or county) officials.

12.0 REFERENCES

ASTM. 2000. Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process. American Society for Testing and Materials, Designation E1527-00, revised July, 2000, 27 pp.

BCM. 2001. Preliminary Site Characterization (PSC) Report with FSC Recommendations Site 15 Liberty State Park, Jersey City, New Jersey, July 2, 1993, Directive, Hudson County Chromate Chemical Production Waste Sites, NJDEP Contract No. 68608, BCM Engineers/ATC Group Services Inc., Bromley Corporate Center, Three Terri lane, Burlington. NJ 08106, June 22, 2001, 26 pp. plus appendices, (2 volumes).

Engineering News. 1914. Methods of Filling and Dredging for a New Jersey City Freight Terminal. pp. 331-334.

Historic Conservation and Interpretation Inc. 1977. Cultural Resources Reconnaissance Liberty State Park 1 April, 1977, by Historic Conservation and Interpretation Inc., Van Houten Street, Paterson, NJ.

Langan. 1991. Subsurface Investigation and Geotechnical Engineering Study Liberty Science Center Parking Lot, Jersey City, New Jersey. Langan Engineering Associates, Inc., Elmwood Park, New Jersey, 4 April 1991, Project No. 1040007, 4 pp. plus attachments.

Lovegreen, J.R. 1974. Paleodrainage History of the Hudson Estuary. MA Thesis, Department of Geology, Columbia University, New York, New York.

NJDEP. (undated) Memorandum to Joseph Maher, Site Manager, Bureau of Site Management from Kris Geller, Technical Coordinator, BEECRA; Site: Case Name: Liberty State Park; Subject: Middle Cove, 2 pp.

NJDEP. 1980a. Memorandum dated April 1, 1980 to Spill File from David Henderson, New Jersey Department of Environmental Protection. Subject: Liberty Park Clean-up, 1 p.

NJDEP. 1980b. Memorandum dated March 17,1980 to Spill File from David Henderson, New Jersey Department of Environmental Protection. Subject: Liberty Park Clean-up, 1 p.

NJDEP. 1984. Liberty State Park Acquisition Map. Division of Parks and Forestry, State Park Services and the State Bureau of Planning, Engineering & Maintenance, scale 1"=400', 2 sheets, prepared 4/17/84.

NJDEP. 1985. DEP to Hold 3 Public Meetings on Chromium Study of 50 Sites. NJDEP Press Release No. 86 / 75, November 8, 1985, 4 pp.

NJDEP. 1987. Memorandum dated March 16, 1987 from Charles Van Sciver, New Jersey Department of Environmental Protection Environmental Measurements Section to Dave Barskey, Technical Coordinator Bureau of Environmental Evaluation and & Risk Assessment, Subject: Liberty State Park Seawall Boring Sample Episode Hudson County.

NJDEP. 1988. Geophysical Investigation at Liberty State Park, Northern Marina Area, Jersey City, Hudson County, New Jersey.

NJDEP. 1989. Executive Summary The History of the Environmental Investigations at the Liberty State Park. New Jersey Department of Environmental Protection Hazardous Waste Program, Division of Hazardous Site Mitigation, Bureau of Environmental Measurements & Quality Assurance, Division of Hazardous Waste Management, Bureau of Planning and Assessment. 38 pp.

NJDEP. 1990. Memorandum dated July 10, 1990 from Judith Yaskin, Commissioner to John Trela, Assistant Commissioner, Hazardous Waste Management, Subject: Report on Liberty State Park. Freight Yards Site.

NJDEP. 1991. Memorandum dated 15 April, 1991 from Catherine Drake, Assistant to the Director, Division of Parks and Forestry to Edward Putnam, Assistant Director, Hazardous Site Mitigation. Subject: Liberty State Park, 4 pp.

NJDEP. 1994a. Memorandum dated October 03, 1994 from David Barsky, New Jersey Department of Environmental Protection Technical Coordinator, BEECRA to Joseph Maher, Site Manager, BSM, Subject: Liberty State Park Clean Fill Stockpile Area/Freight Yards Area, Review of Aerial Photographs JN: J06AZAA0 AC:65F.

NJDEP. 1994b. Memorandum dated July 27, 1994 to Dave Barskey, Technical Coordinator BEECRA and George Blyskun, Geologist, BGWPA from Joseph Maher, Site manager, New Jersey Department of Environmental Protection Bureau of Site Management. Subject: Liberty State Park Phase I Ground Water Investigation Results.

NJDEP. 1995a. Liberty State Park Soil Sampling Report August 1995. New Jersey Department of Environmental Protection Site Remediation Program, 8 pp.

NJDEP. 1995b. Liberty State Park Site Status Report August 1995. New Jersey Department of Environmental Protection Site Remediation Program, 9 pp.

NJDEP. 1996. Memorandum dated October 7, 1996 from David Springer, HSMS III, New Jersey Department of Environmental Protection Environmental Measurements and Site Assessment Section, to Kris Geller, Technical Coordinator, Bureau of Environmental Evaluation and Risk Assessment, Subject: Liberty State Park Arsenic Delineation Sampling August 19, 1996.

NJDEP. 1997. Memorandum dated January 7, 1997 from David Springer, HSMS III, Environmental Measurements and Site Assessment Section, to Kris Geller, Technical Coordinator, New Jersey Department of Environmental Protection Bureau of Environmental Evaluation and Risk Assessment, Subject: Liberty State Park Arsenic Delineation Sampling November 25-27, 1996.

NJDEP. 1998a. Remedial Action Selection Report - Waterfront Development Area Liberty State Park. New Jersey Department of Environmental Protection, February 1998, 2 pp.

NJDEP 1998b. Memorandum dated December 28, 1998 from Joseph Maher, Site Manager, Bureau of Site Management, New Jersey Department of Environmental Protection, to George Blyskun, CPG/Hydrogeologist, Bureau of Ground water Pollution. Subject: Ground water Investigation Recommended Scope of Work, Job Code J06AZABO, Activity Code V65J, Referred Date May 14, 1998, Tracking 3819.

NJDEP 1999. NJDEP State Owned, Protected Open Space and Recreation Areas in New Jersey 1:12000. Vector Digital Data, NJDEP, Green Acres Program, Trenton, NJ. http://www.state.nj.us/dep/gis/digidownload/zips/statewide/newstate.zip

NJDEP. 2000a. Liberty State Park – Dredge Material Storage Area. Remedial Planning & Design Element, New Jersey Department of Environmental Protection Site Remediation Program Division of Publicly Funded Site Remediation. March 2000.

NJDEP. 2000b. Liberty State Park - Waterfront Development Area Free/Residual Oil Product Investigation/RA Selection Report. New Jersey Department of Environmental Protection, Site Remediation Program, Division of Publicly Funded Site Remediation, Remedial Planning & Design Element, March 2000.

NJDEP. 2001a. Memorandum dated May 22, 2001 to Kenneth Petrone, Section Chief, Bureau of Site Management NJDEP from David A. Springer, Environmental Measurements Section NJDEP, Subject: Liberty State Park Piezometer installation and free product investigation near Chromium Area Site 15 on May 15th, 2001.

NJDEP. 2001b. Liberty State Park – Waterfront Development Area Free/Residual Oil Product Consent Decree Report. Remedial Planning & Design Element, New Jersey Department of Environmental Protection Site Remediation Program, Division of Publicly Funded Site Remediation, December 2001.

Port Authority of New York and New Jersey. 1975. State of New Jersey Liberty Park – Engineering Report on Proposed Landfill in New York Bay. Liberty State Park Existing Utility Plan - Sketch No. SK-LSP-2, December 1, 1975.

TAMS. 1989a. Interim Feasibility Study - Liberty State Park. TAMS Consultants, Inc., 300 Broadacres Drive, Bloomfield, NJ 07003, March 1989.

TAMS. 1989b. Remedial Investigation, Northern Marina, Liberty State Park. Volume I (Report), TAMS Consultants, Inc., 300 Broadacres Drive, Bloomfield, NJ 07003, July 1989, 58 pp. Plus app.

TAMS. 1990. Baseline Public Health Evaluation for the Proposed Northern Marina Site at Liberty State Park, New Jersey, Final Report to TAMS Consultants, Inc., Gradient Corporation 44 Brattle Street, Cambridge, MA 02138, February 1990, 52 pp. plus attachments.

USACE-NYD. 2002. Scope of Work For Phase One Site Assessments Priority Sites Hudson-Raritan Estuary, 5 pp.

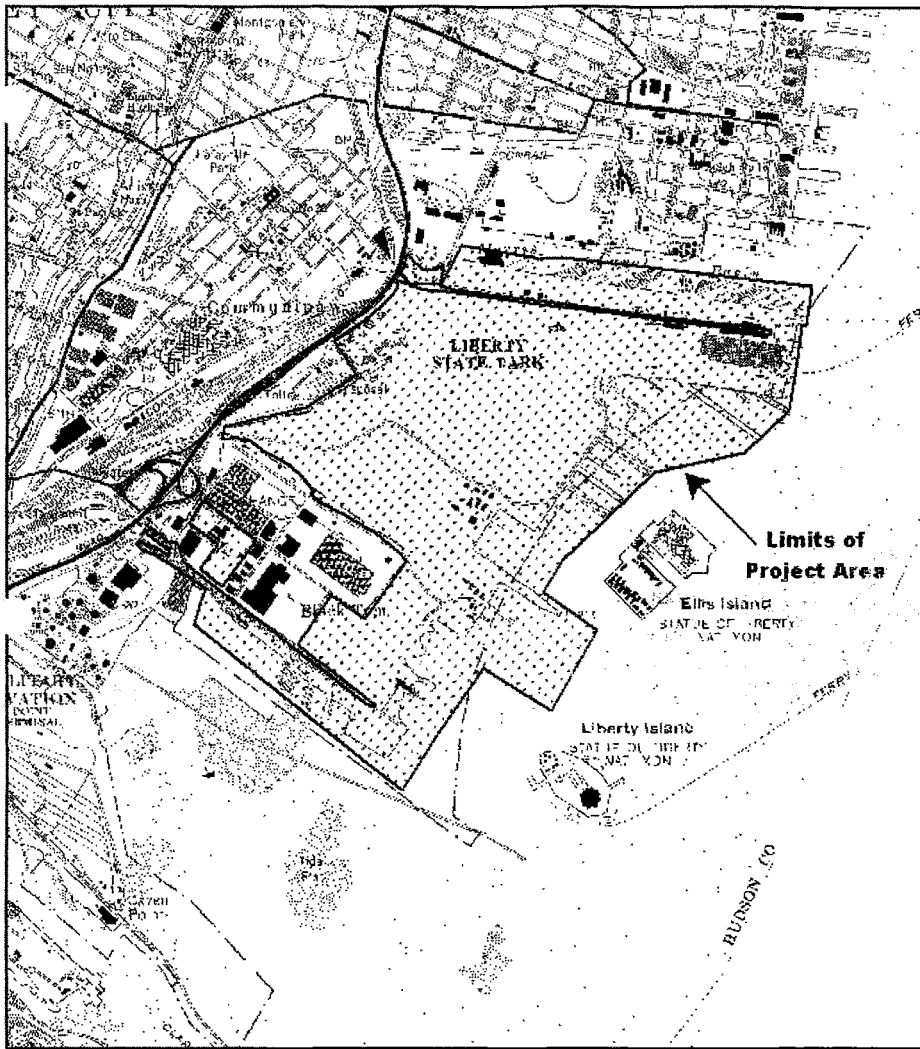
USEPA. 1984. EPA Fact Sheet - Liberty State Park. May 1994.

USEPA. 1986a. Potential Hazardous Waste Site Preliminary Assessment – Liberty State Park/Round House Site, Jersey City, Hudson County, New Jersey. 4 pp.

USEPA. 1986b. Potential Hazardous Waste Site Preliminary Assessment – Liberty State Park/Northern Marina Site, Audrey Zapp Drive, Jersey City, Hudson County, New Jersey. 4 pp.

U.S. Navy. 1981. Memorandum dated April 3, 1981 from the Explosive Ordnance Disposal Group Two at U.S. Department of the Navy Weapons Station Earle, Colts Neck New Jersey to the Division of Buildings and Construction, State of New Jersey. Subject: Liberty State Park Munition Discovery.

Figures



N
W E
S

1000 0 1000 Feet

SCALE 1:24,000

LEGEND:

limits of project area

Image Source:

USGS Jersey City Quadrangle, 1967
photorevised 1981

amec Earth & Environmental

Figure 1

Project Site Location
Phase I ESA Liberty State Park
Army Corps of Engineers, NY District
Jersey City, New Jersey

Environmental Data Resources, Inc.

"Linking Technology with Tradition"

Sanborn™ Map Transmittal

Ship to: David Mackie
AMEC Earth & Environmental
285 Davidson Street
Somerset, NJ 08873

1052441DJV 732-302-9500

Order Date: 12/4/2002 **Completion Date:** 12/04/2002
Inquiry #: 891877.1S
P.O. #: na
Site Name: Liberty State Park
Address: Liberty State Park
City/State: Jersey City, NJ 07097
Cross Streets:

Environmental Data Resources, Inc. has been instructed by AMEC Earth & Environmental to print ONLY the Sanborn Maps for the years listed below:

1885 - 4 maps
1887 - 4 maps
1911 - 8 - maps
1912 - 3 - maps
1950 - 11 - maps
1951 - 8 - maps
1979 - 18 - maps

Total Maps: 56

Limited Permission to Photocopy

AMEC Earth & Environmental (the client) is permitted to make up to THREE photocopies of this Sanborn Map Transmittal and each fire insurance map accompanying this transmittal solely for the limited use of its customer. No one other than the client is authorized to make copies. Upon request made directly to an EDR Account Executive, the client may be permitted to make a limited number of additional photocopies. This permission is conditioned upon compliance by the client, its customer and their agents with Environmental Data Resources, Inc.'s copyright policy; a copy of which is available upon request.

All maps provided pursuant to a Sanborn® Map Transmittal are currently reproducible copies of fire insurance maps owned or licensed by Environmental Data Resources, Inc. NO WARRANTY, EXPRESSED OR IMPLIED, IS MADE WHATSOEVER. ENVIRONMENTAL DATA RESOURCES, INC. SPECIFICALLY DISCLAIMS THE MAKING OF ANY SUCH WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES AS TO ACCURACY, VALIDITY, COMPLETENESS, SUITABILITY, CONDITION, QUALITY, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR USE OR PURPOSE WITH RESPECT TO THE TRANSMITTAL, THE REPORT, THE MAPS, THE INFORMATION CONTAINED THEREIN, OR THE RESULTS OF A SEARCH OR OTHERWISE. ALL RISK IS ASSUMED BY THE USER. Environmental Data Resources, Inc. assumes no liability to any party for any loss or damage whether arising out of errors or omissions, negligence, accident or any other cause. In no event shall Environmental Data Resources, Inc., its affiliates or agents, be liable to anyone for special, incidental, consequential or exemplary damages.

Copyright 2002, Environmental Data Resources, Inc. All rights reserved. Reproduction in any media or format of any map report or transmittal of Environmental Data Resources, Inc. (whether obtained as a result of a search or otherwise) may be prohibited without prior written permission from Environmental Data Resources, Inc. Sanborn and Sanborn Map are registered trademarks of Environmental Data Resources, Inc.

Electronic Sanborn Map Images
USER'S GUIDE

Thank you for your interest in electronic Sanborn Map images. The following are guidelines for accessing the images and for transferring them to your system. If you have any questions about the use of electronic Sanborn Map images, contact your EDR Account Executive at 1-800-352-0050.

Organization of Electronic Sanborn Image File

- First Page — Sanborn Map Report, listing years of coverage
- Second Page — Electronic Sanborn Map Images USER'S GUIDE
- Third Page — Oldest Sanborn Map Image
- Last Page — Most recent Sanborn Map Image

Navigating the Electronic Sanborn Image File

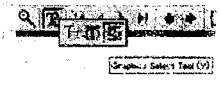
- Open file on screen.
- Identify TP (Target Property) on the most recent map.
- Find TP on older printed images.
- Using Acrobat, zoom to 250% in order to view more clearly.
  - 200-250% is the approximate equivalent scale of hardcopy Sanborn Maps.
- Zooming in on an image:
  - On the menu bar, click "View" and then zoom.
  - Use the magnifying tool and drag a box around the TP area.

Printing a Sanborn Map from the Electronic File

- EDR recommends printing all images at 300 dpi (300 dpi prints faster than 600 dpi).
- To print only the TP area, cut and paste the area from Adobe Acrobat to your word processor.

Acrobat Version 4

- Go to the Menu bar
- Press and hold the "T" button
- Choose the Graphics Select Tool
- Draw a box around the area selected
- Go to "Menu"
- Highlight "Edit"
- Highlight "Copy"
- Go to a word processor such as Microsoft Word, paste and print.

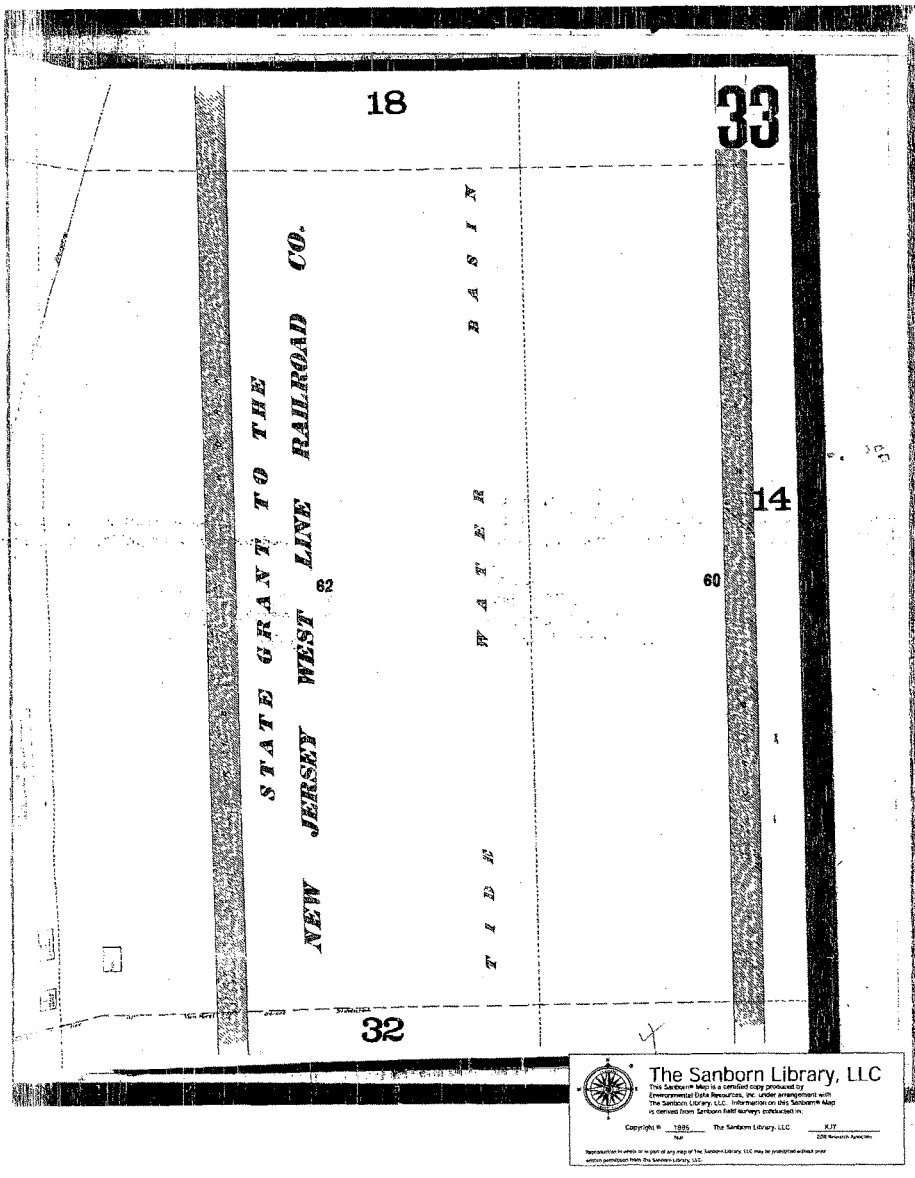


Acrobat Version 5

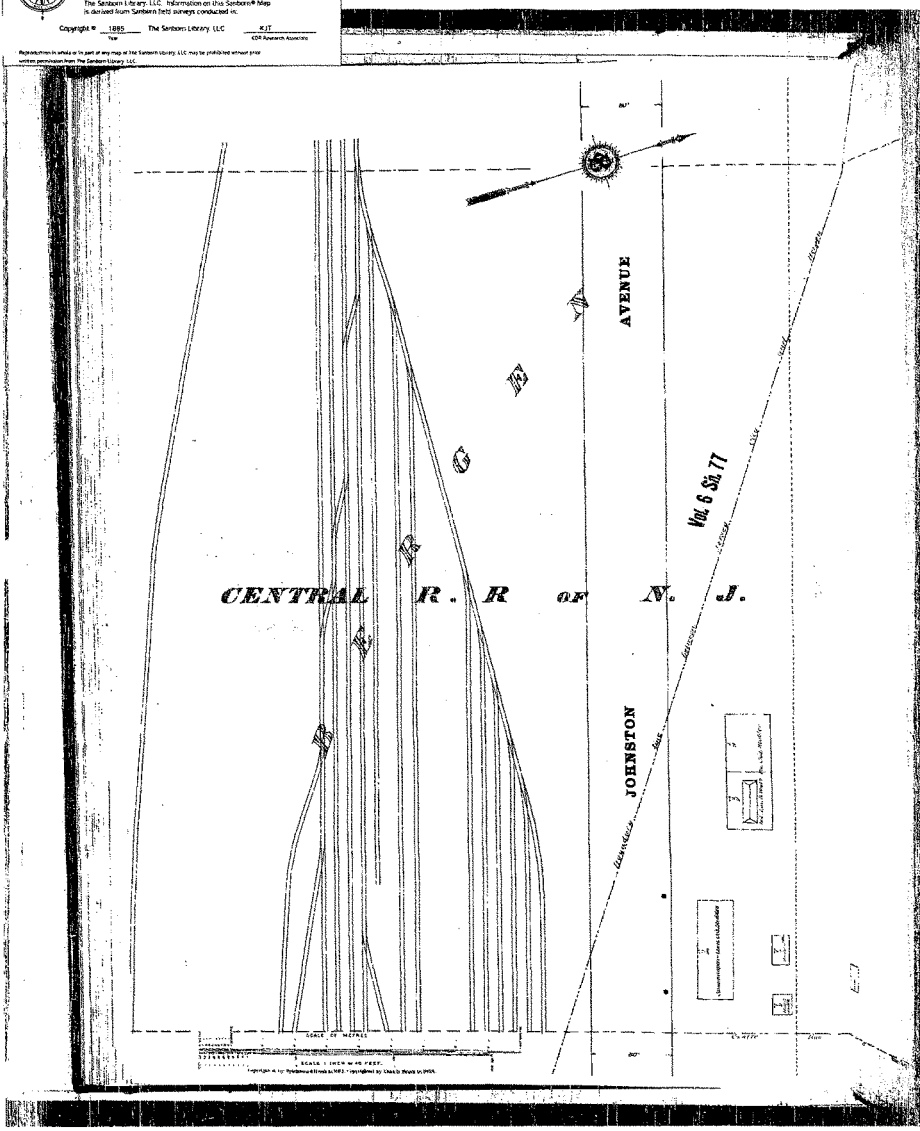
- Go to the Menu Bar.
- Click the "Graphics Select Tool"
- Draw a box around the area selected
- Go to "Menu"
- Highlight "Edit"
- Highlight "Copy"
- Go to a word processor such as Microsoft Word, paste and print.

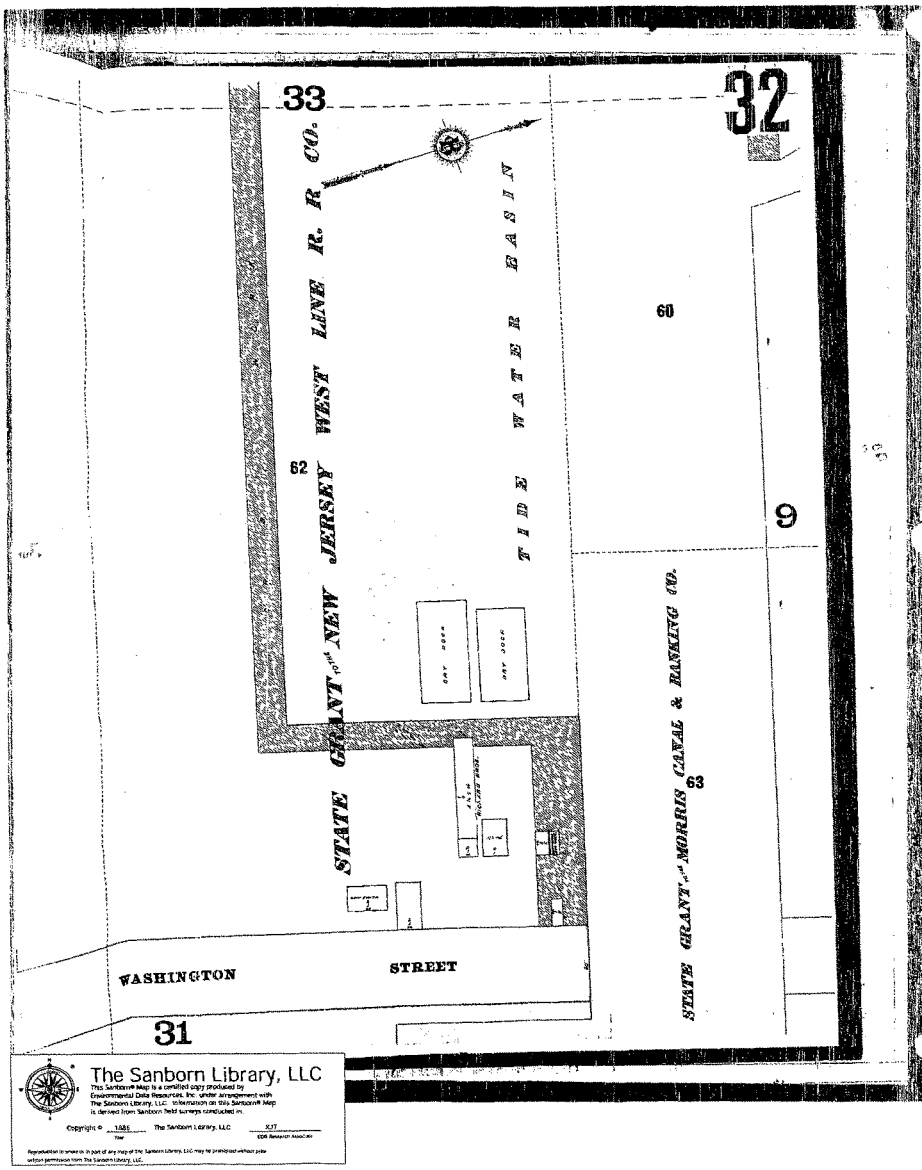
Important Information about Email Delivery of Electronic Sanborn Map Images

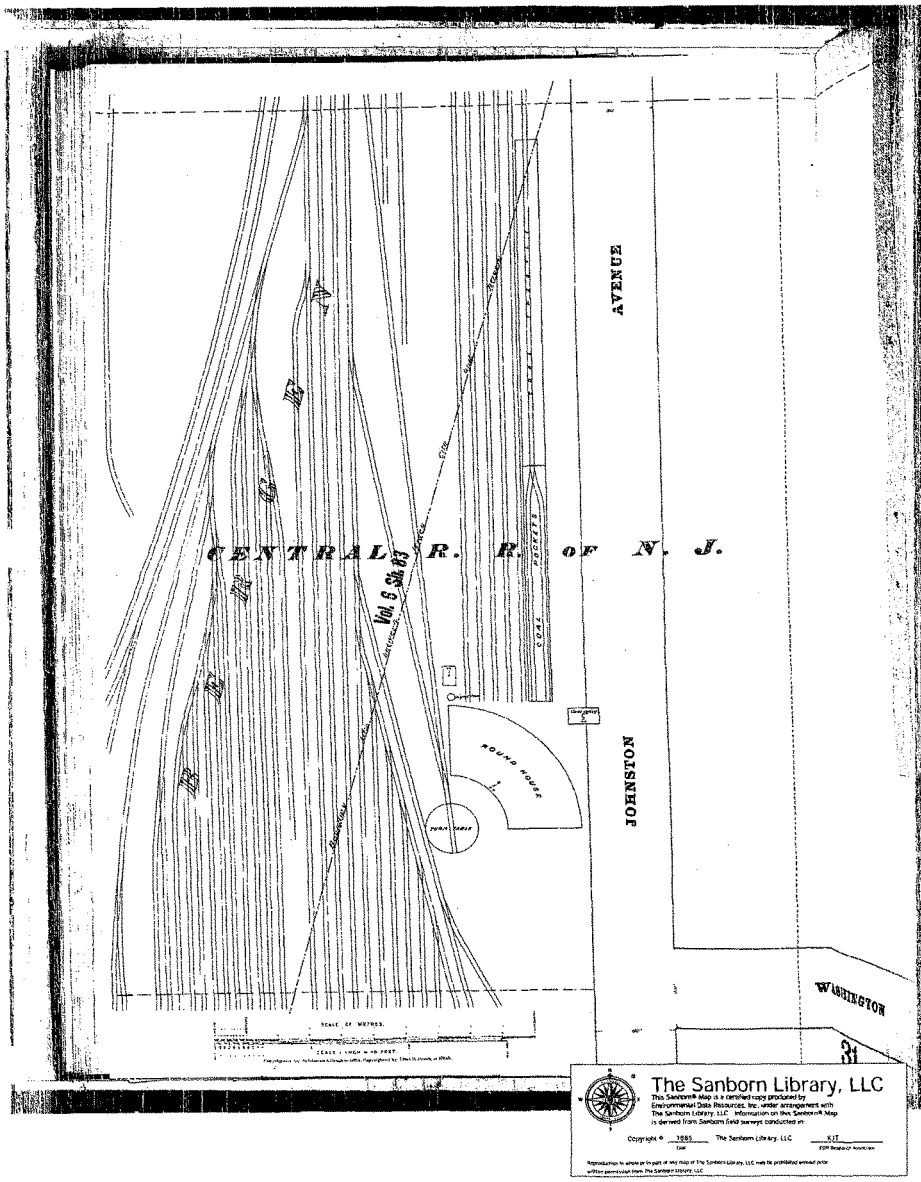
- Images are grouped into one file, up to 2MB.
- In cases where in excess of 6-7 map years are available, the file size typically exceeds 2MB. In these cases, you will receive multiple files, labeled as 1 of 3, 2 of 3, etc. including all available map years.
- Due to file size limitations, certain ISPs, including AOL, may occasionally delay or decline to deliver files. Please contact your ISP to identify their specific file size limitations.

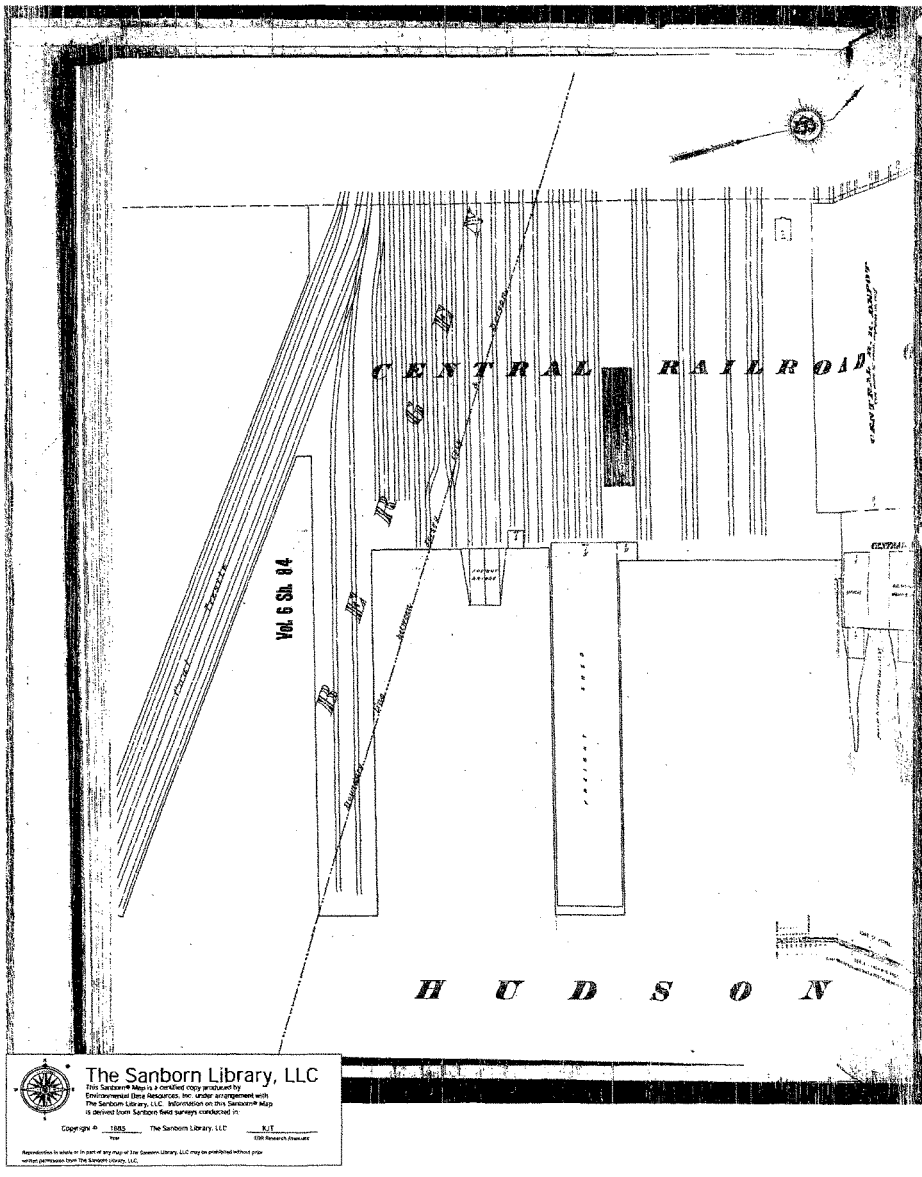

18
33
STATE GRANT TO THE
NEW JERSEY WEST LINE RAILROAD CO.
TIDE WATER BASIN
14
62
60
32
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1886 The Sanborn Library, LLC KJT
Year EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

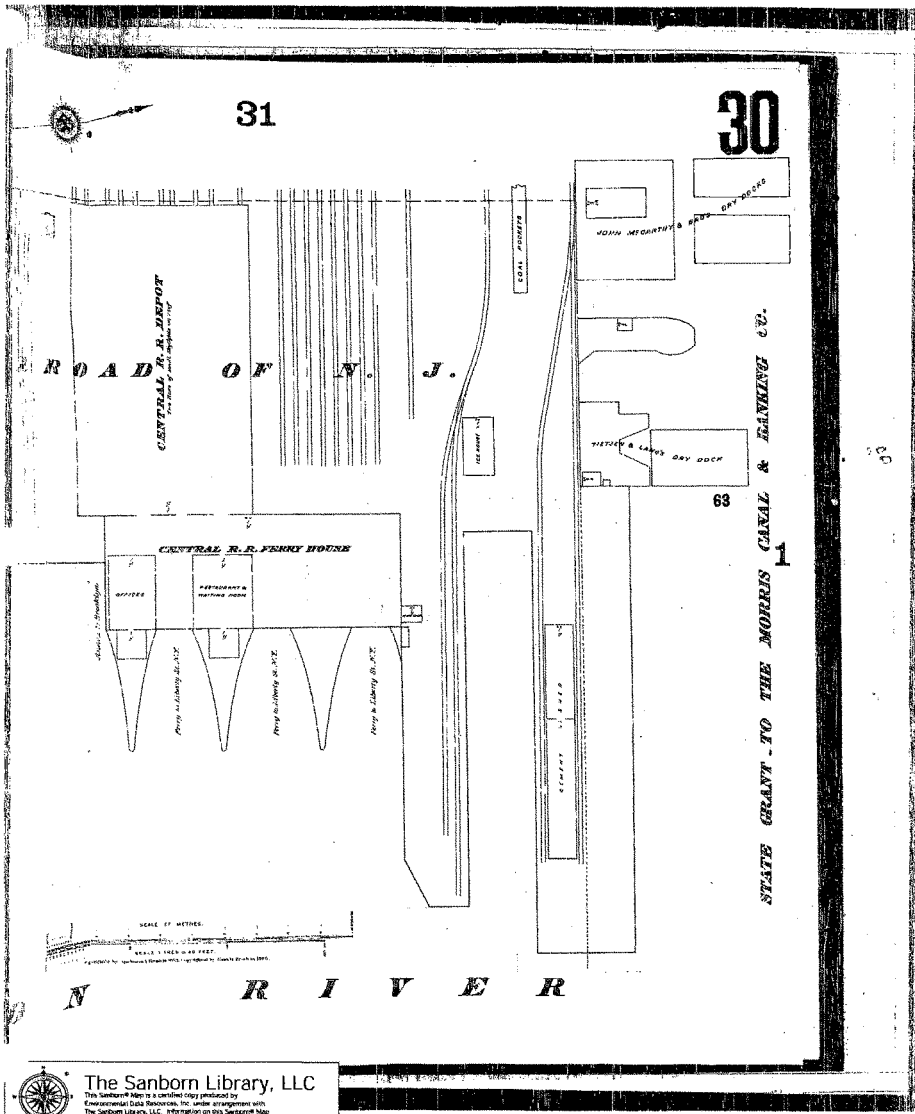
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1885 The Sanborn Library LLC KIT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library LLC may be prohibited without prior written permission from The Sanborn Library LLC



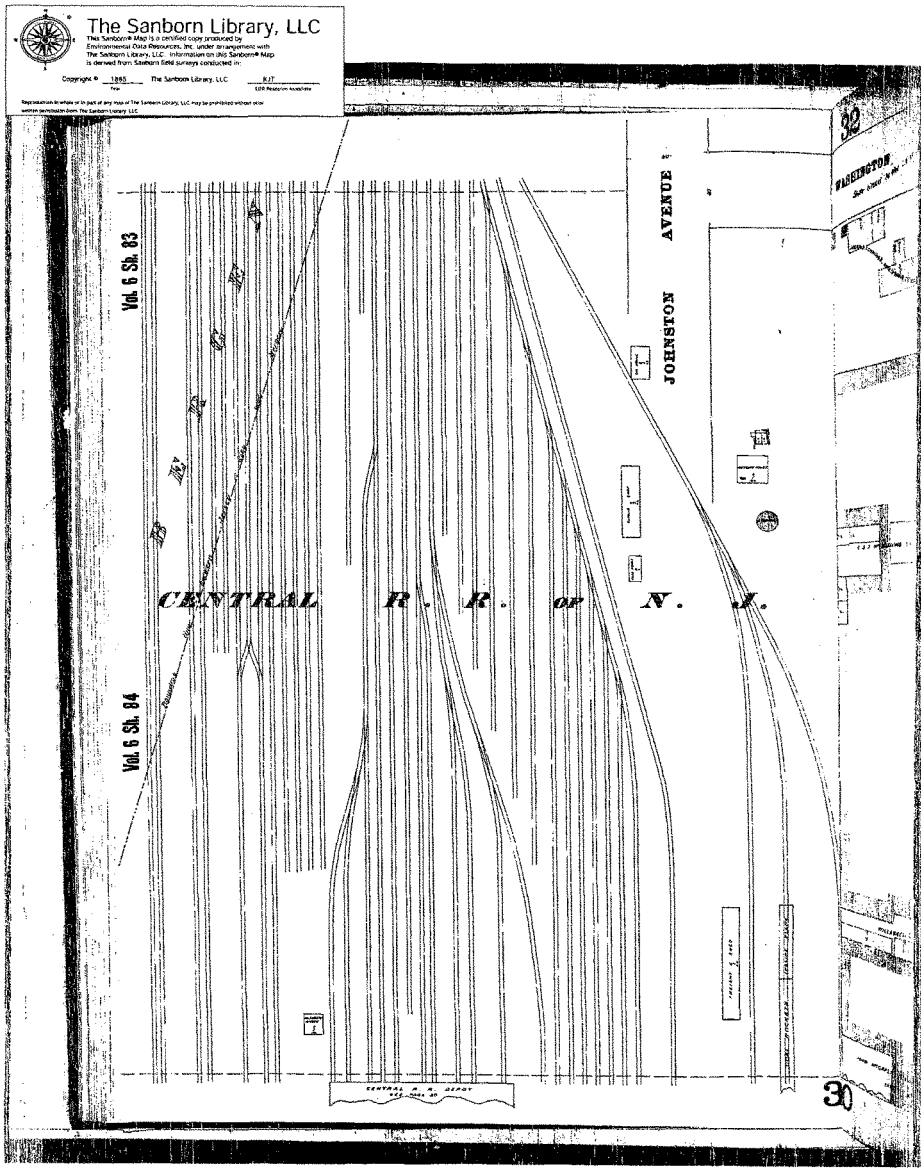

33
32
STATE GRANT TO THE NEW JERSEY WEST LINE R. R. CO.
TIDE WATER BASIN
60
62
9
STATE GRANT TO THE MORRIS CANAL & BANKING CO.
63
WASHINGTON STREET
31
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in.
Copyright © 1886 The Sanborn Library, LLC
Year
X17
EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


CENTRAL R. R. OF N. J.
JOHNSTON AVENUE
WASHINGTON
ROUND HOUSE
TURN TABLE
COAL PROCESS
Vol. 6 Sh 83
SCALE OF METRES.
SCALE 1 INCH = 40 FEET.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1985 The Sanborn Library, LLC KIT
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

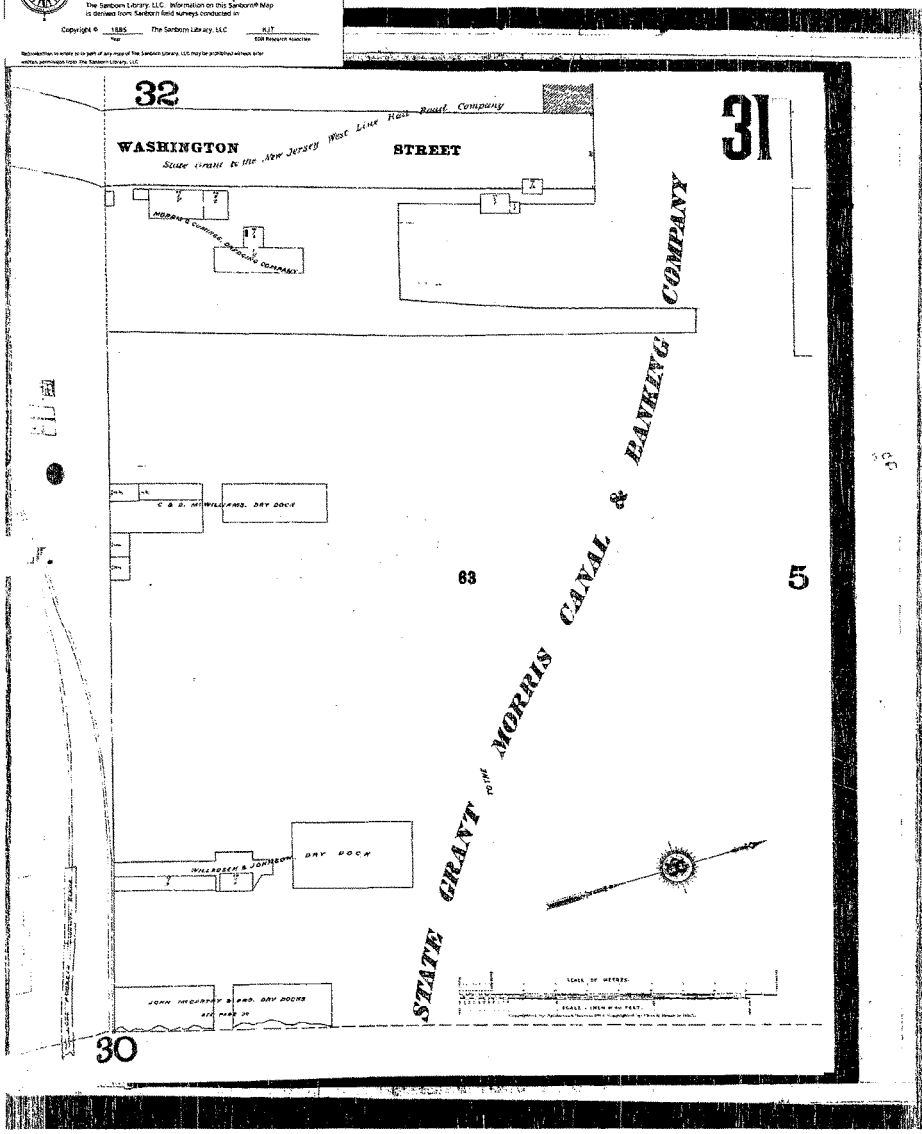

CENTRAL RAILROAD
HUDSON
Vol. 6 Sh. 84
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1885 The Sanborn Library, LLC
Year
KJT
EDR Research Analyst
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

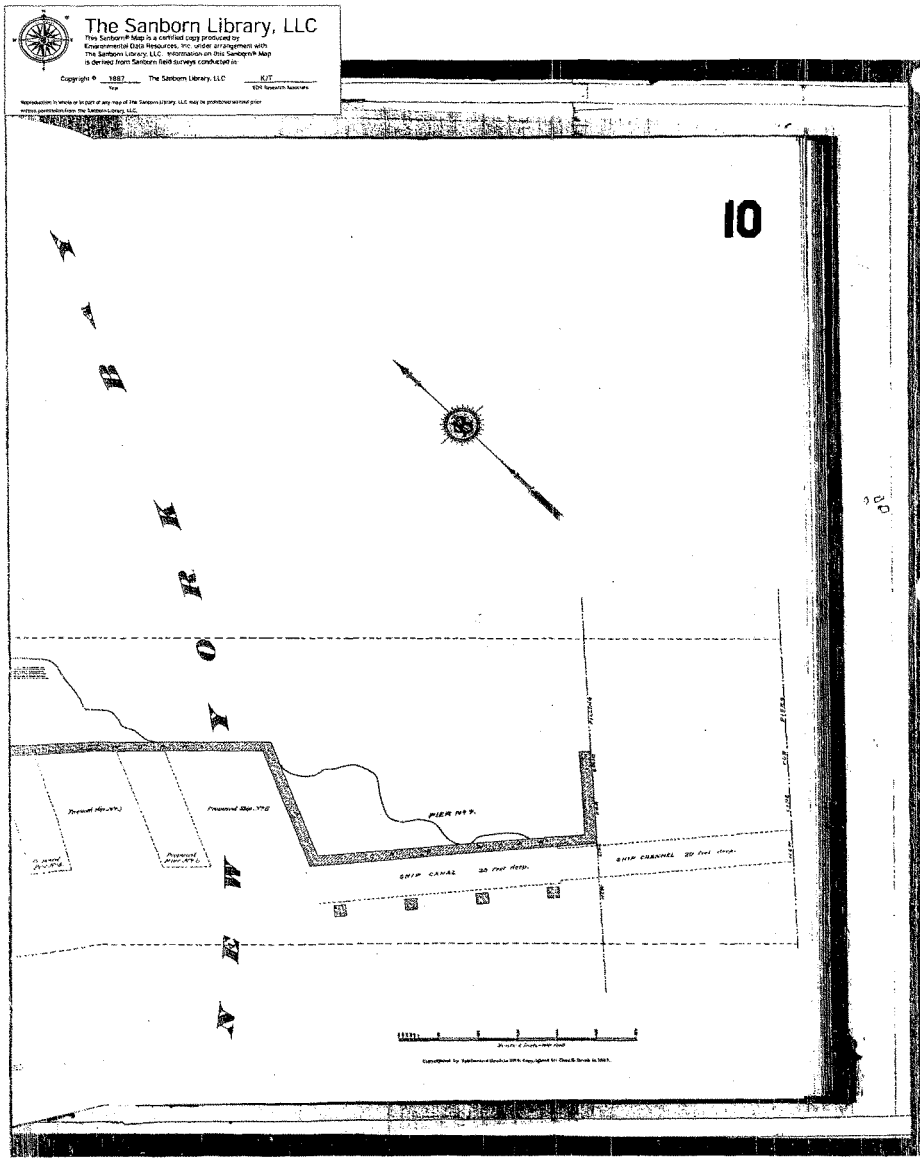


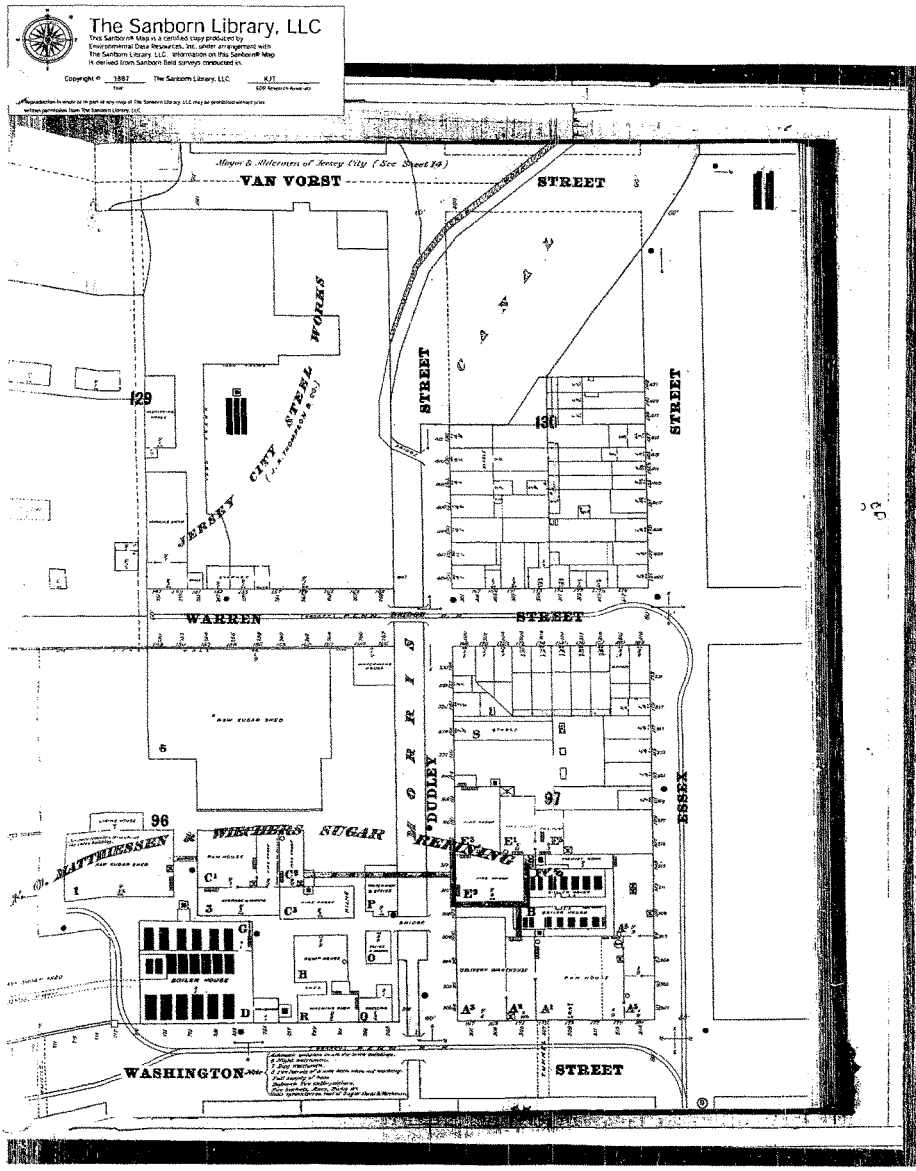
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1886 The Sanborn Library, LLC RJT
Year EDR Research Associate
Reproduction in whole or in part at any time of the Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.

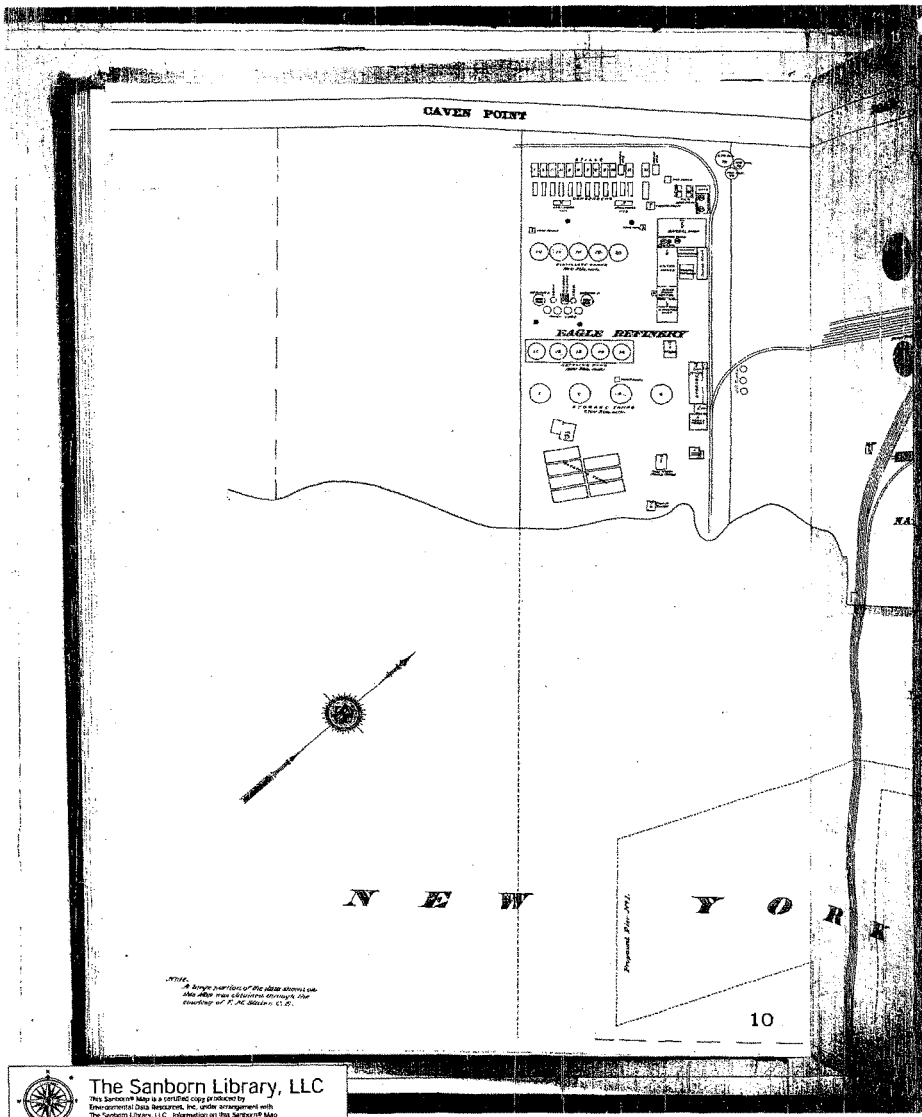

The Sanborn Library, LLC
Vol. 6 Sh. 83
Vol. 6 Sh. 84
CENTRAL R. R. OF N. J.
JOHNSTON AVENUE
WASHINGTON
32
30

The Sanborn Library, LLC
The Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in
Copyright © 1885 The Sanborn Library, LLC KJT
Year EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

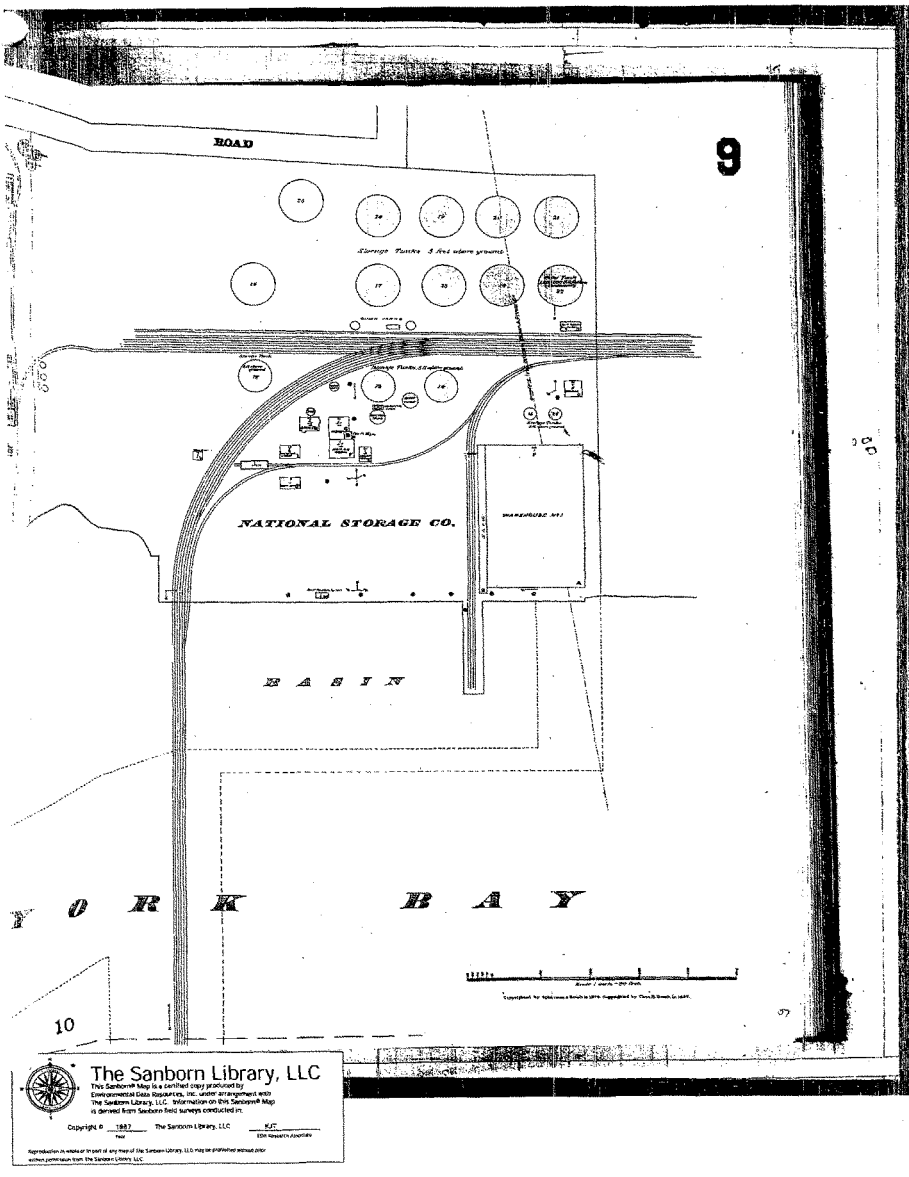



The Sanborn Library, LLC
The Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in
Copyright © 1887 The Sanborn Library, LLC
Year
KJT
1224 Seventh Avenue
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.
10
PIER No 9.
SHIP CANAL 30 feet deep.
SHIP CHANNEL 20 feet deep.

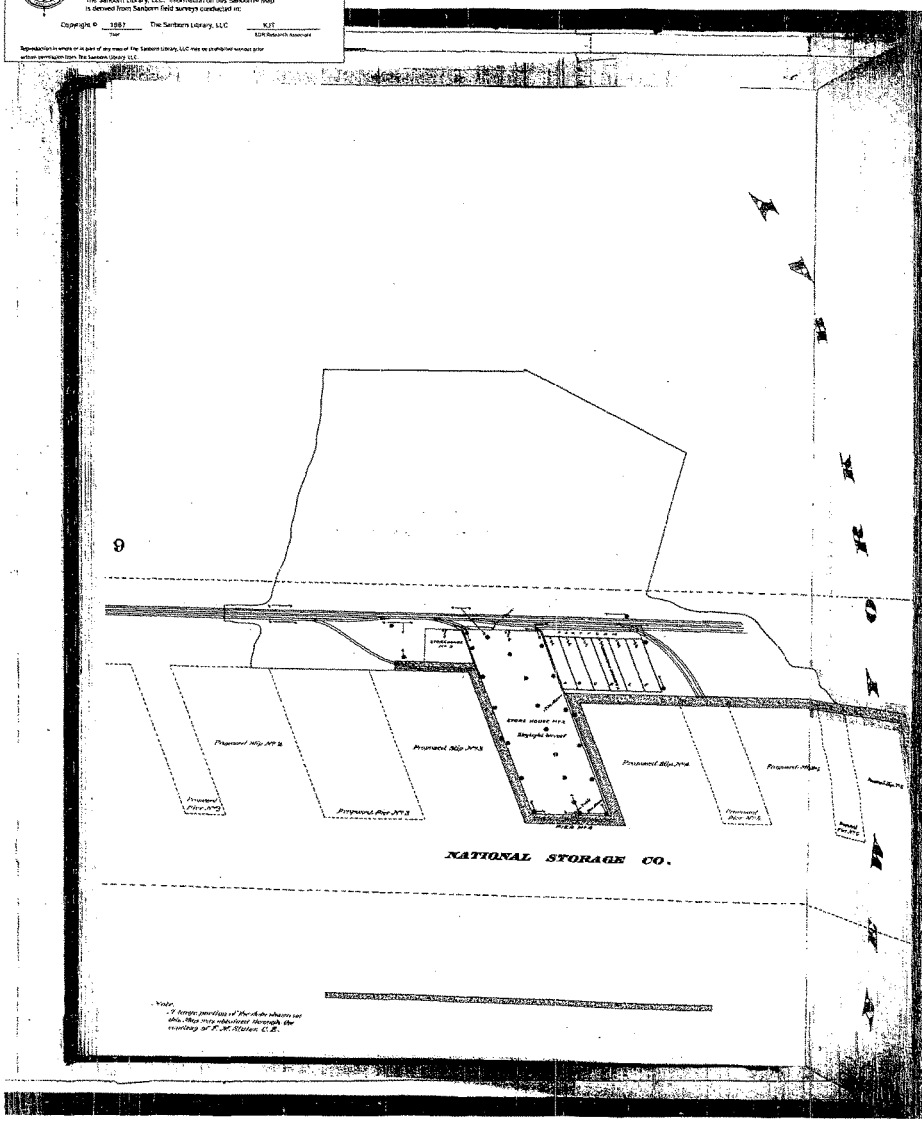

The Sanborn Library, LLC
Mayor & Aldermen of Jersey City (See Sheet 14)
VAN VORST STREET
JERSEY CITY STEEL WORKS
(J. A. Thompson & Co.)
129
130
STREET
STREET
WARREN STREET
RAW SUGAR SHED
6
96
97
MATTHIESSEN & WEICHERS SUGAR REFINERY
DUDLEY STREET
ESSEX STREET
BOILER HOUSE
WASHINGTON STREET

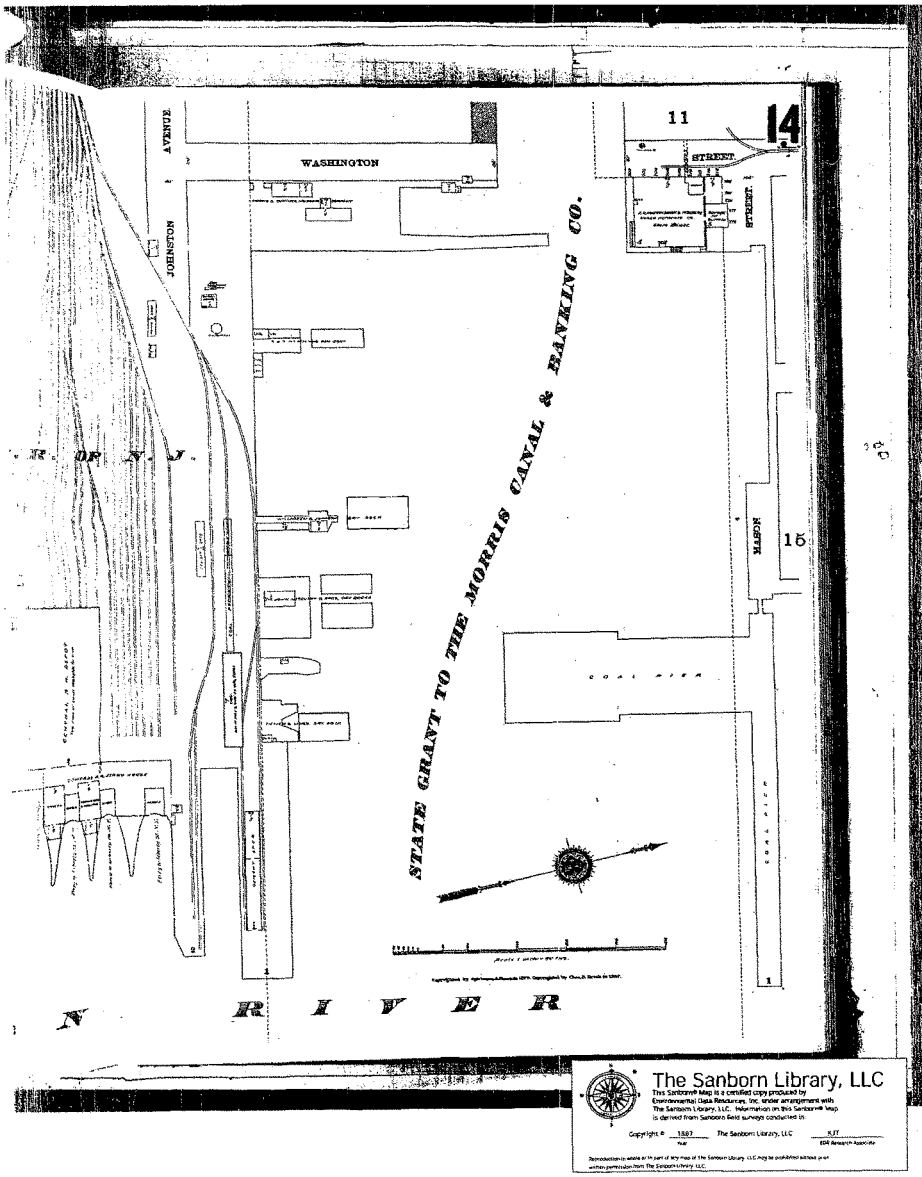


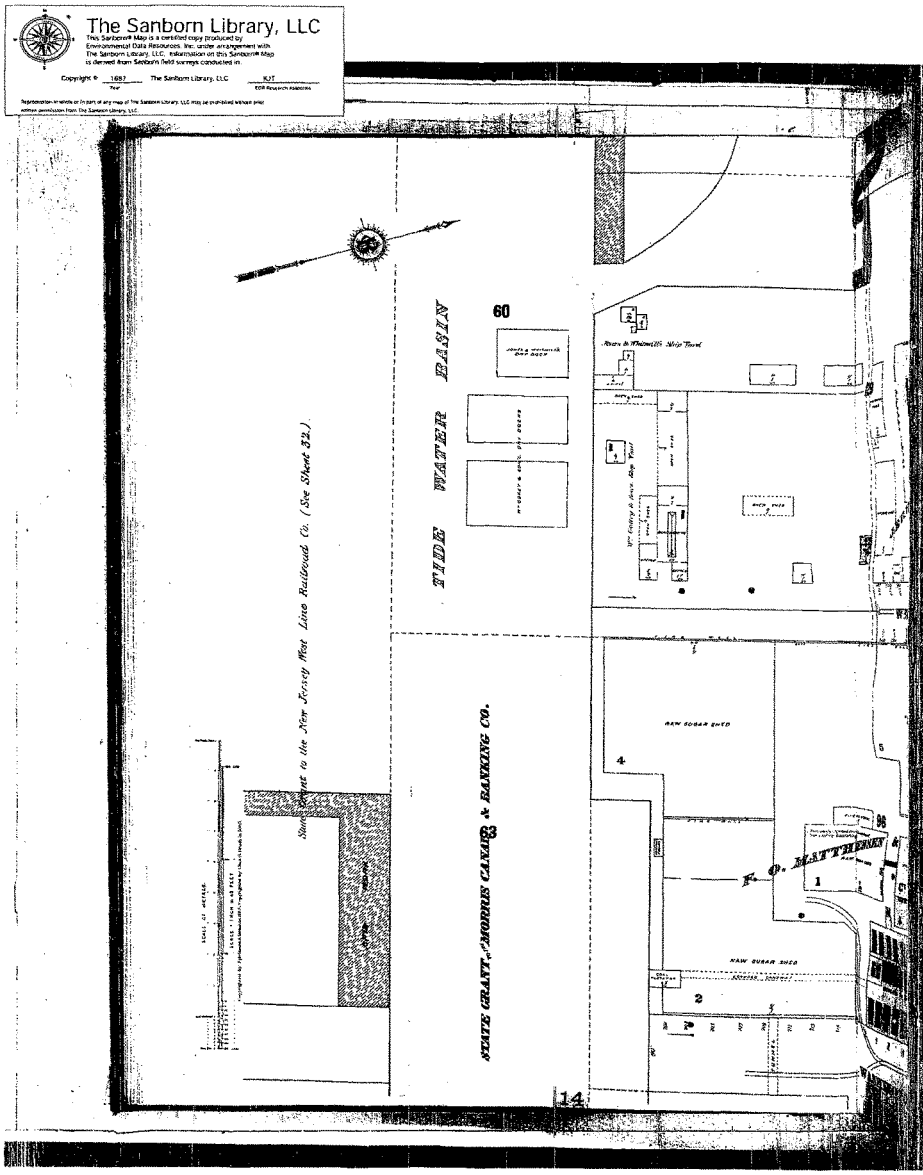
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1887 The Sanborn Library, LLC
for KJT
EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

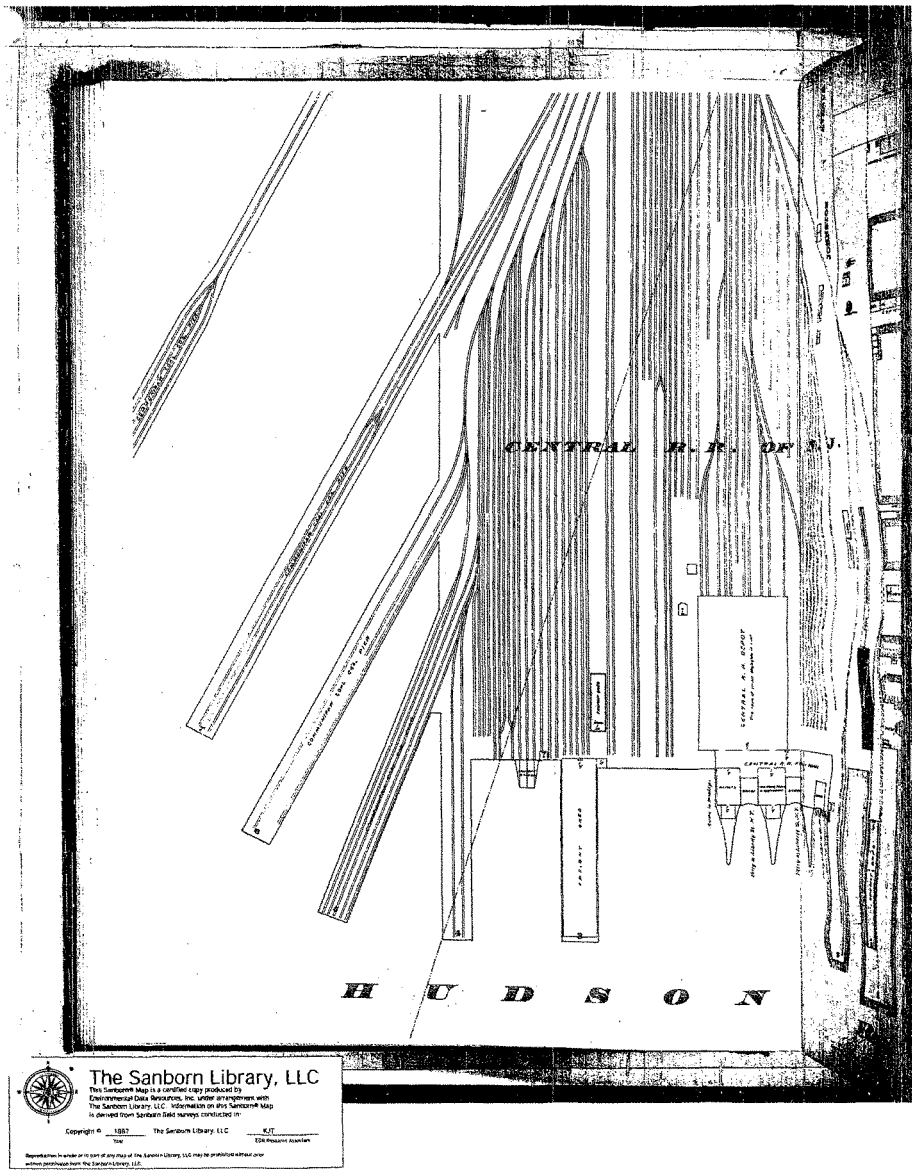

ROAD
9
NATIONAL STORAGE CO.
BASIN
YORK BAY
10
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1887 The Sanborn Library, LLC
Year
KJT
EDR Research Associate
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.

The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1987 The Sanborn Library, LLC KJT
Year EDR Research Assistant
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library LLC

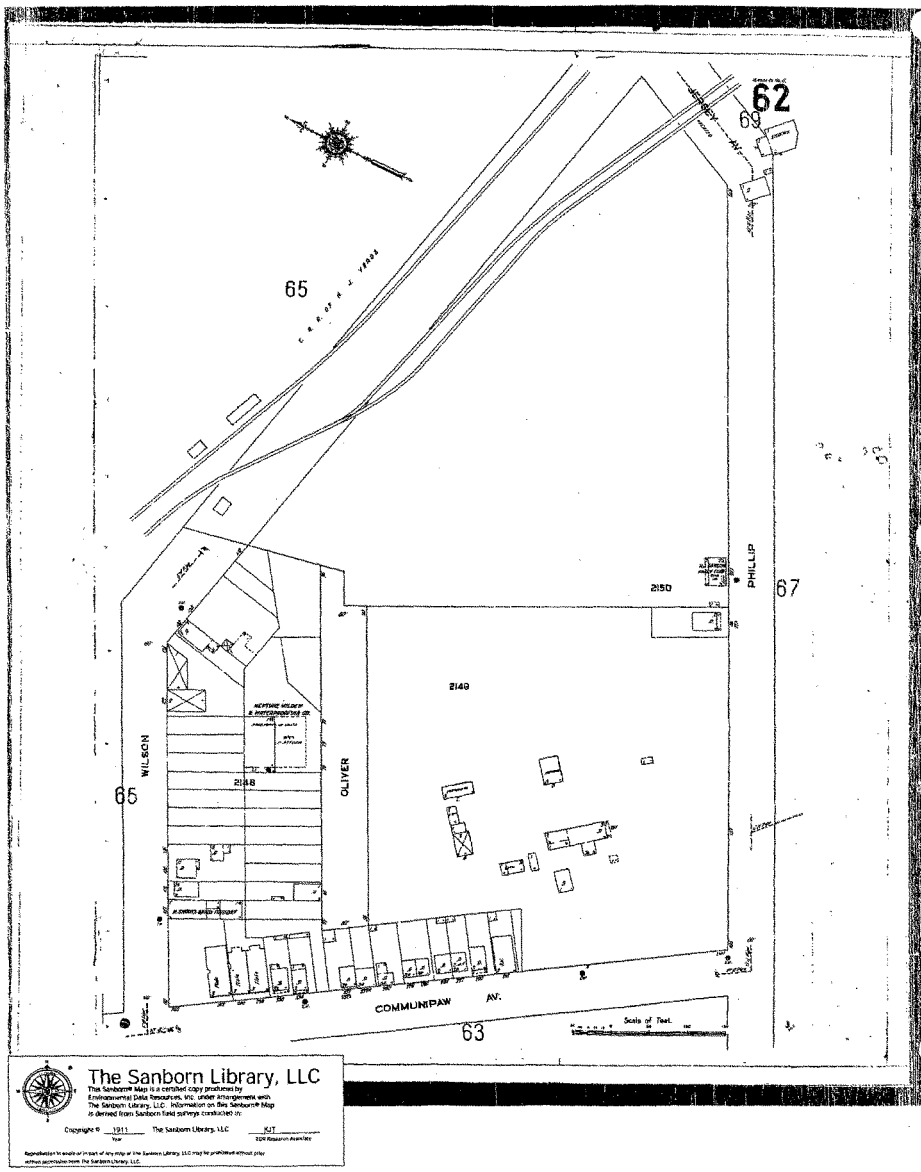


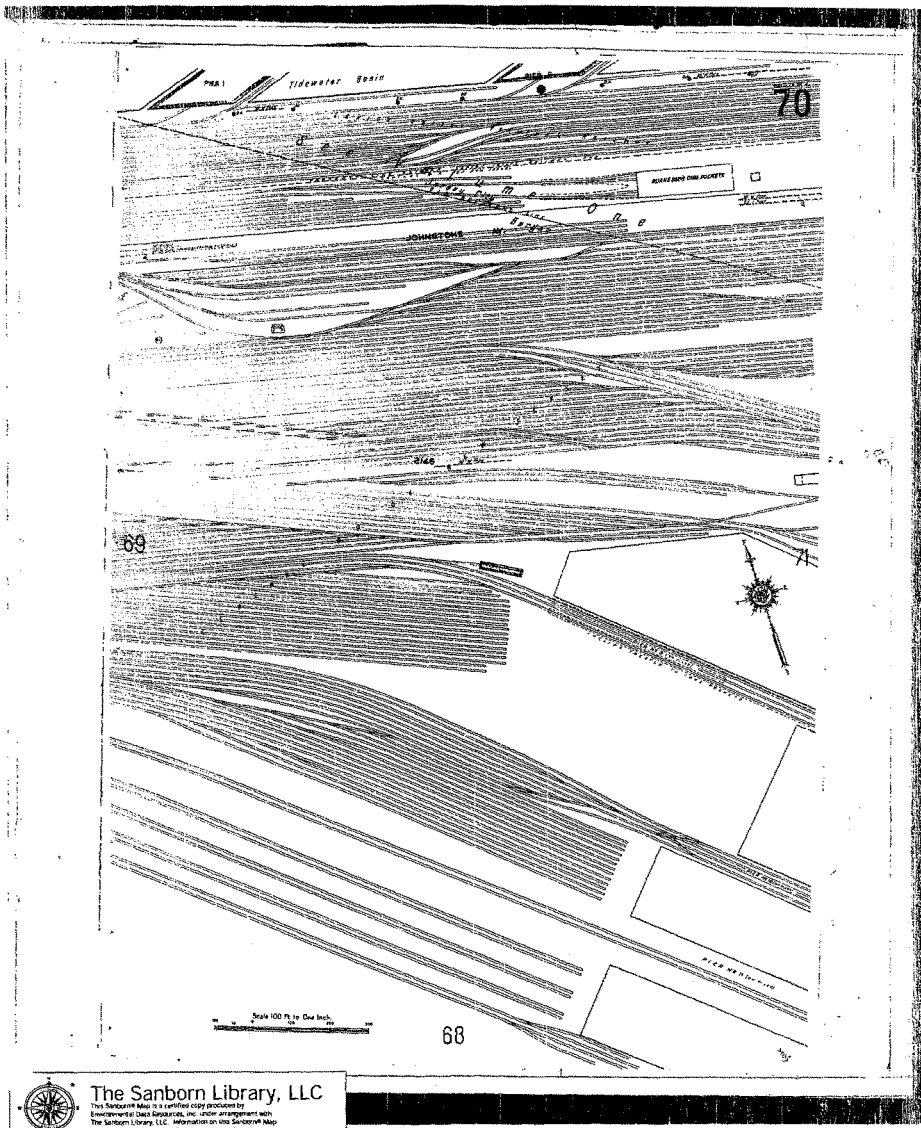

14
11
WASHINGTON
STREET
JOHNSTON
AVENUE
STATE GRANT TO THE MORRIS CANAL & BANKING CO.
NORTH
15
N R I V E R
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in
Copyright © 1887 The Sanborn Library, LLC
KJT
EDR Research Associate
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn's field surveys conducted in
Copyright © 1887 The Sanborn Library, LLC KJT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.
TIDE WATER BASIN
60
Stone Wharf to the New Jersey West Line Railroad Co. (See Sheet 32.)
STATE GRANT "MORRIS CANAL & BANKING CO."
63
RAW SUGAR SHED
RAW SUGAR SHED
F. O. MATTHIESSEN
4
1
2
5
14

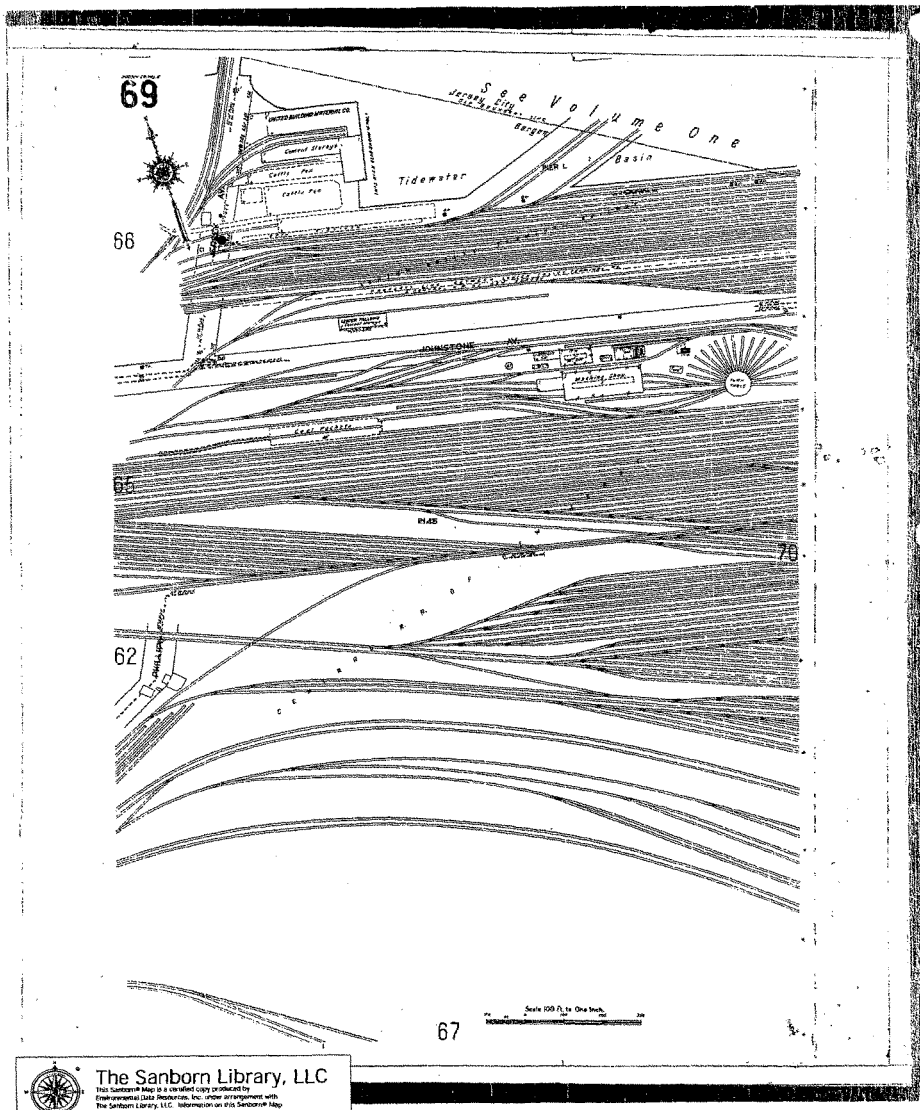


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1987 The Sanborn Library, LLC
Year
K/T
EDR Research Associates
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.

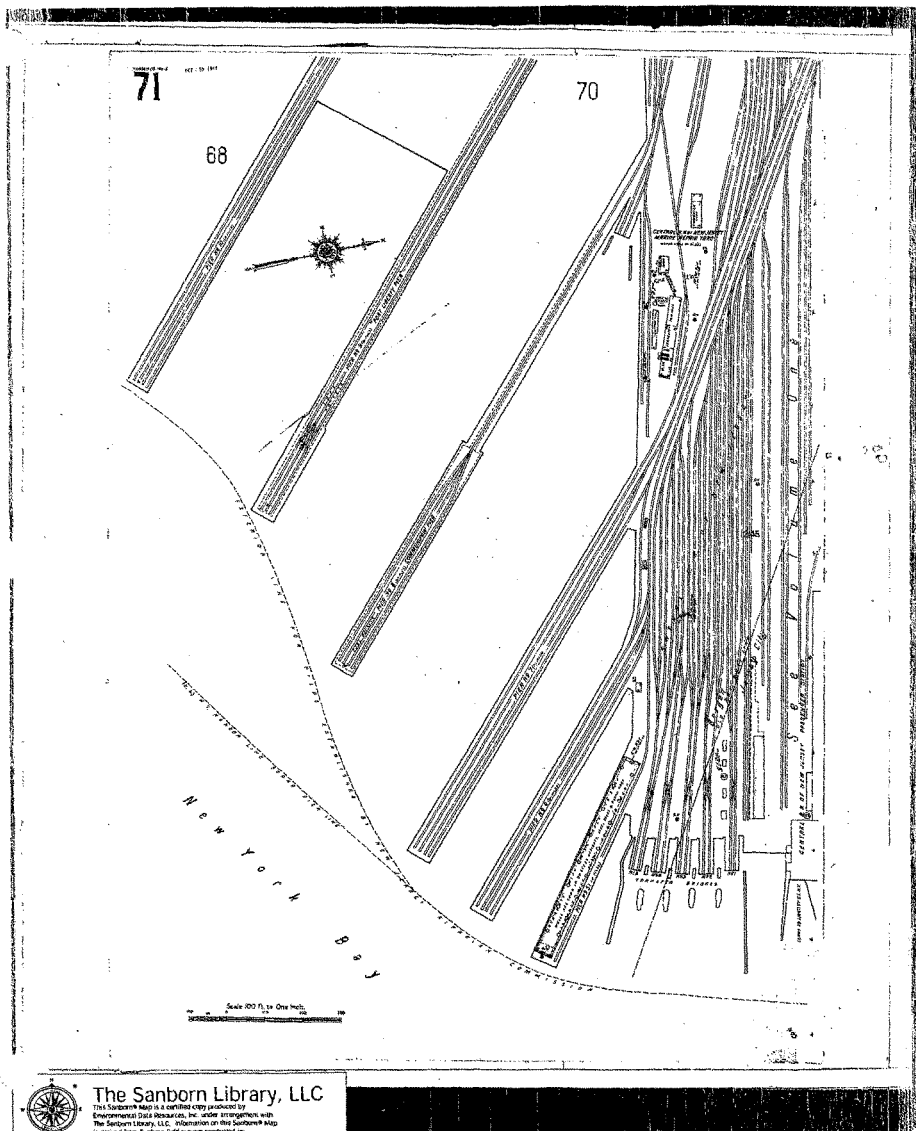

62
69
65
C. R. R. OF N. J. YARDS
PHILLIP
67
2150
2140
WILSON
65
2148
OLIVER
COMMUNIPAW AV.
63
Scale of Feet.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1911 The Sanborn Library, LLC KIT
Year 3D# Resource Area/Sec
Reproduction in whole or in part of any map or the Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.



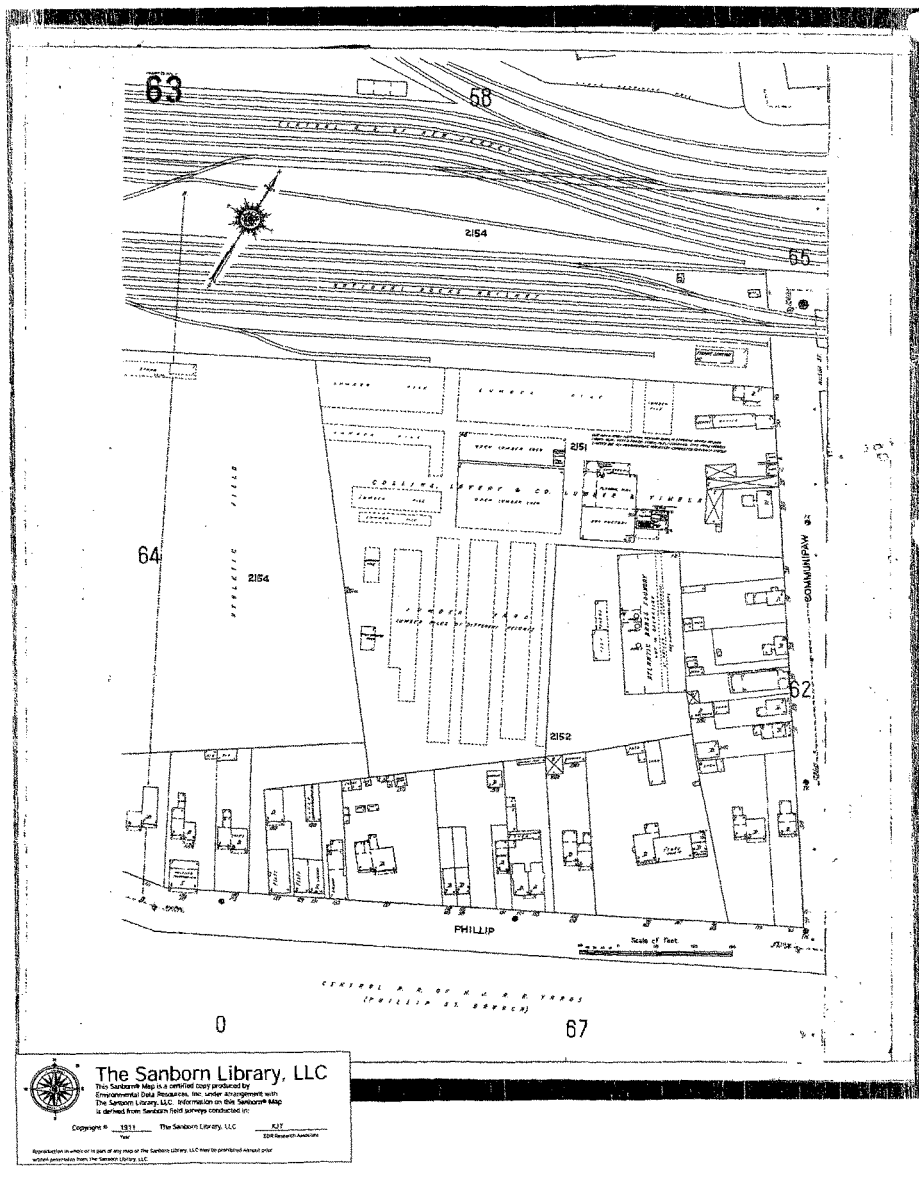
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1911 for The Sanborn Library, LLC
KJT EDR Research Specialist
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

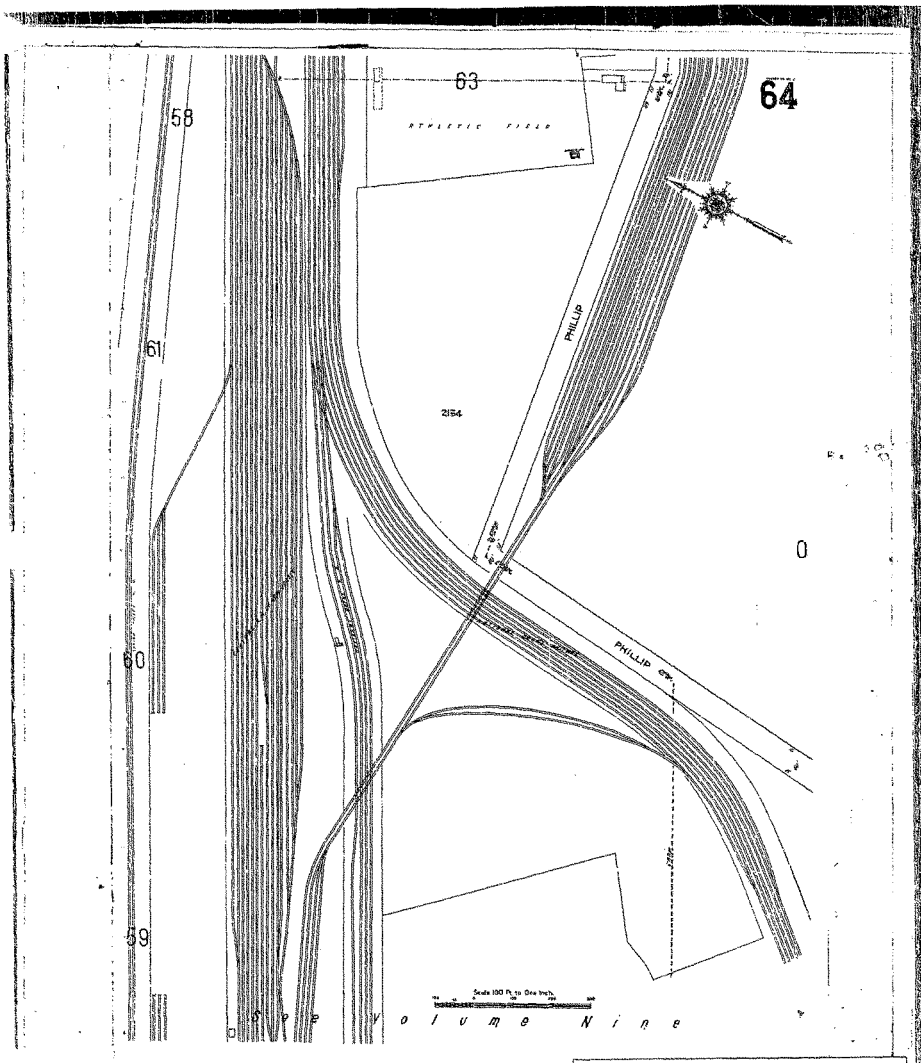


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1911 The Sanborn Library, LLC RJT
Year (EDR Reference Number)
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

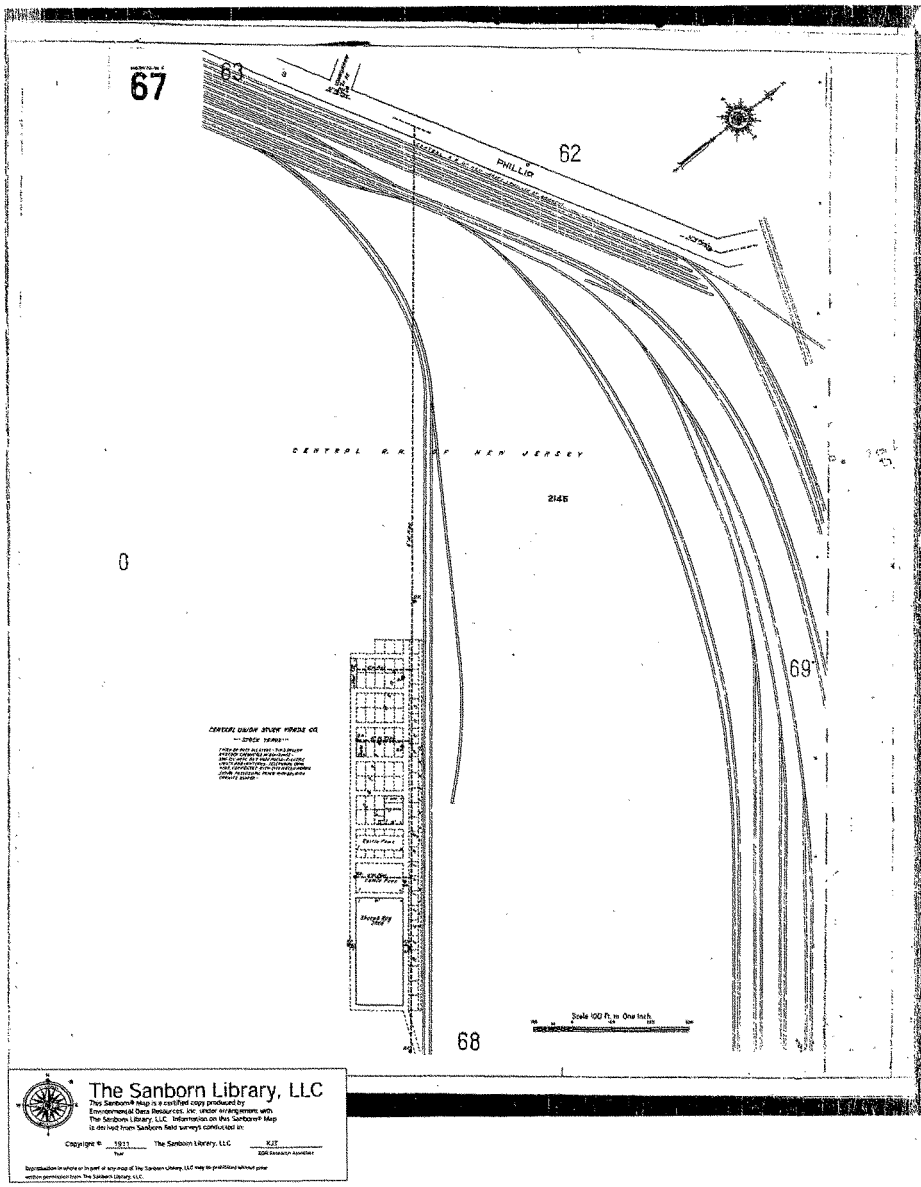


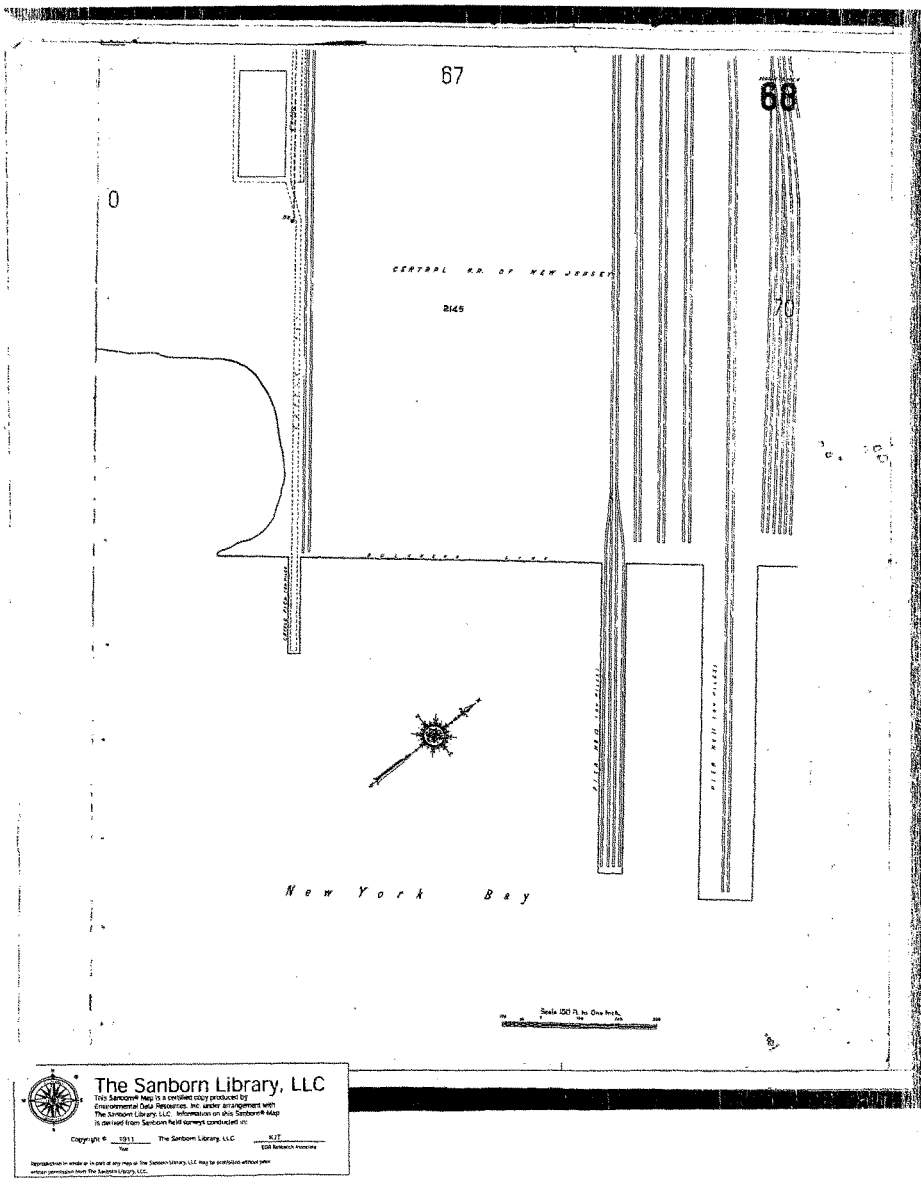
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1911 The Sanborn Library, LLC KJT
EDR Research Institute
Reproduction in whole or in part in any form of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

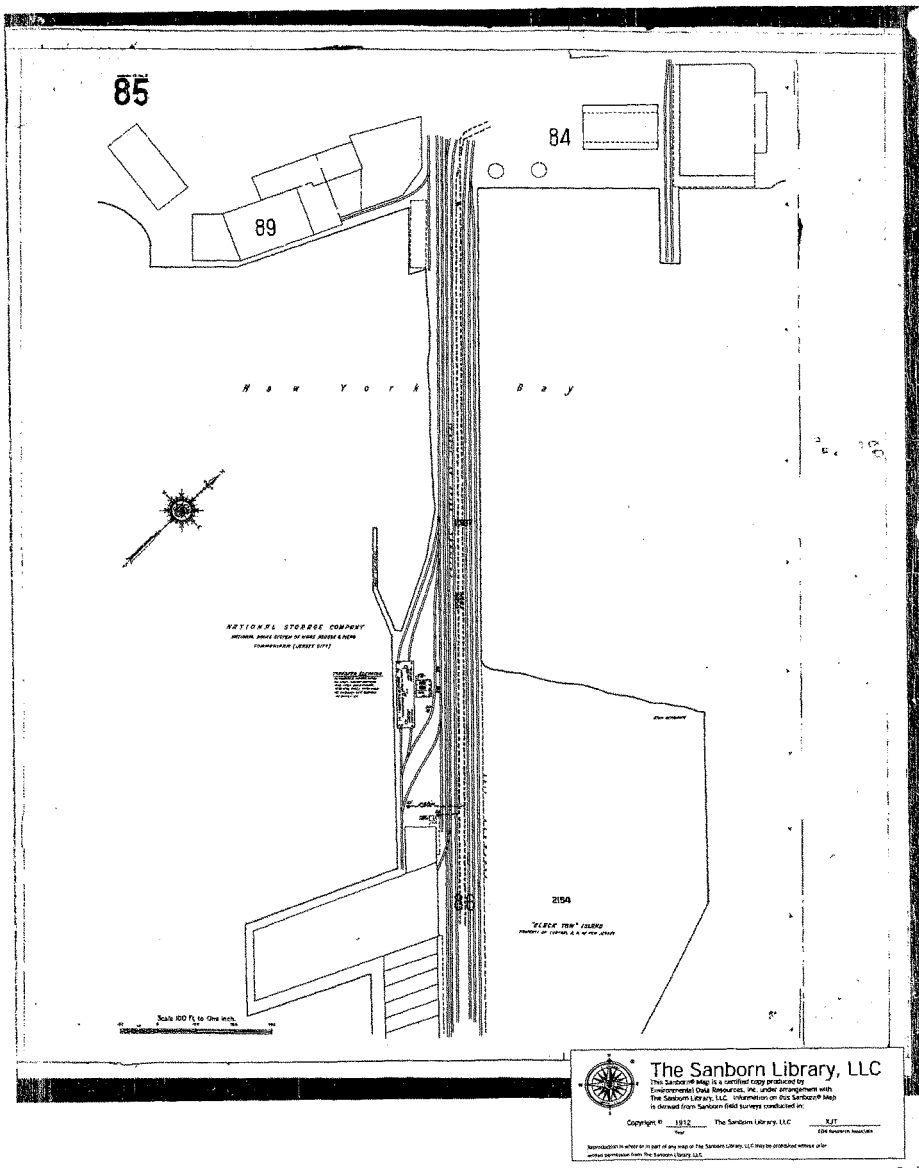

63
58
2154
65
2151
64
2154
ATHLETIC FIELD
COMMUNIPAW
62
2152
PHILLIP
Scale of Feet
0
67
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1911 The Sanborn Library, LLC

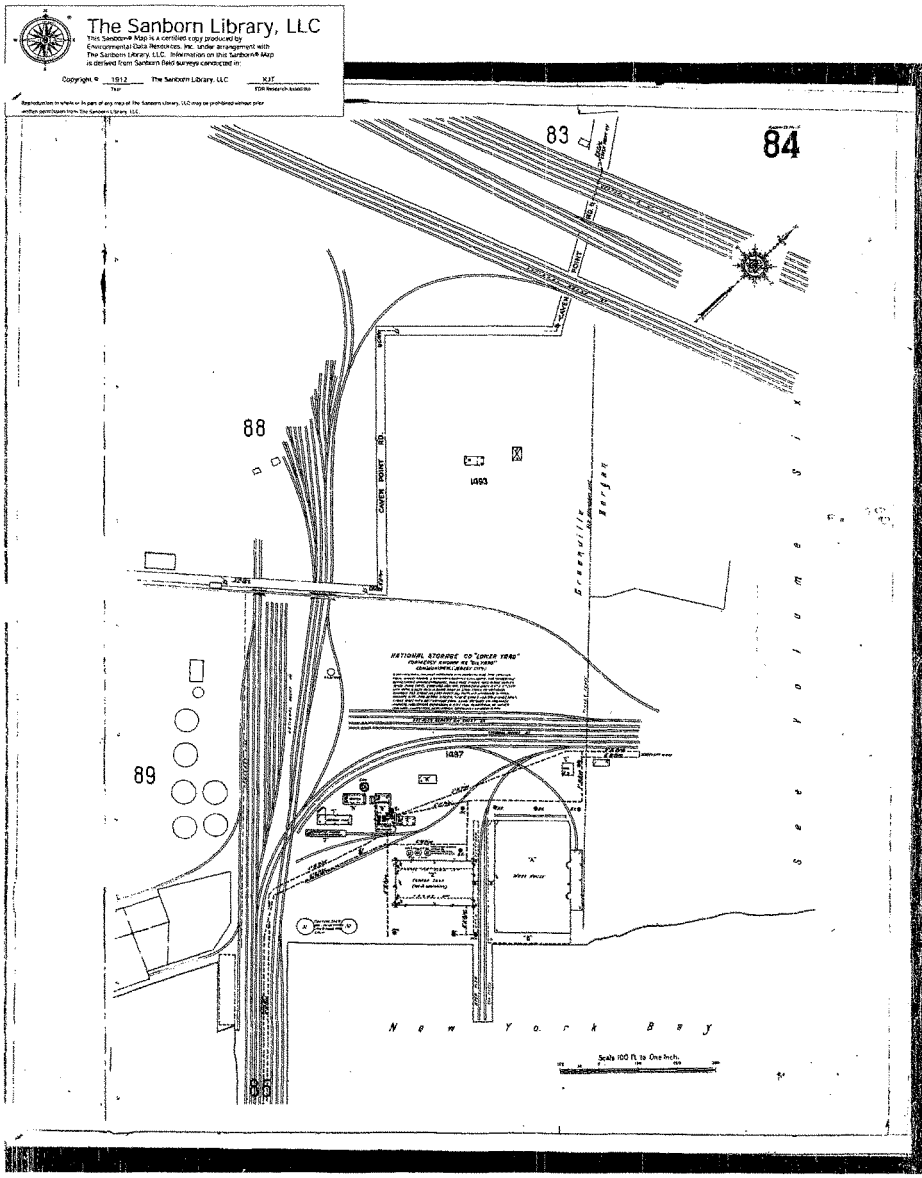


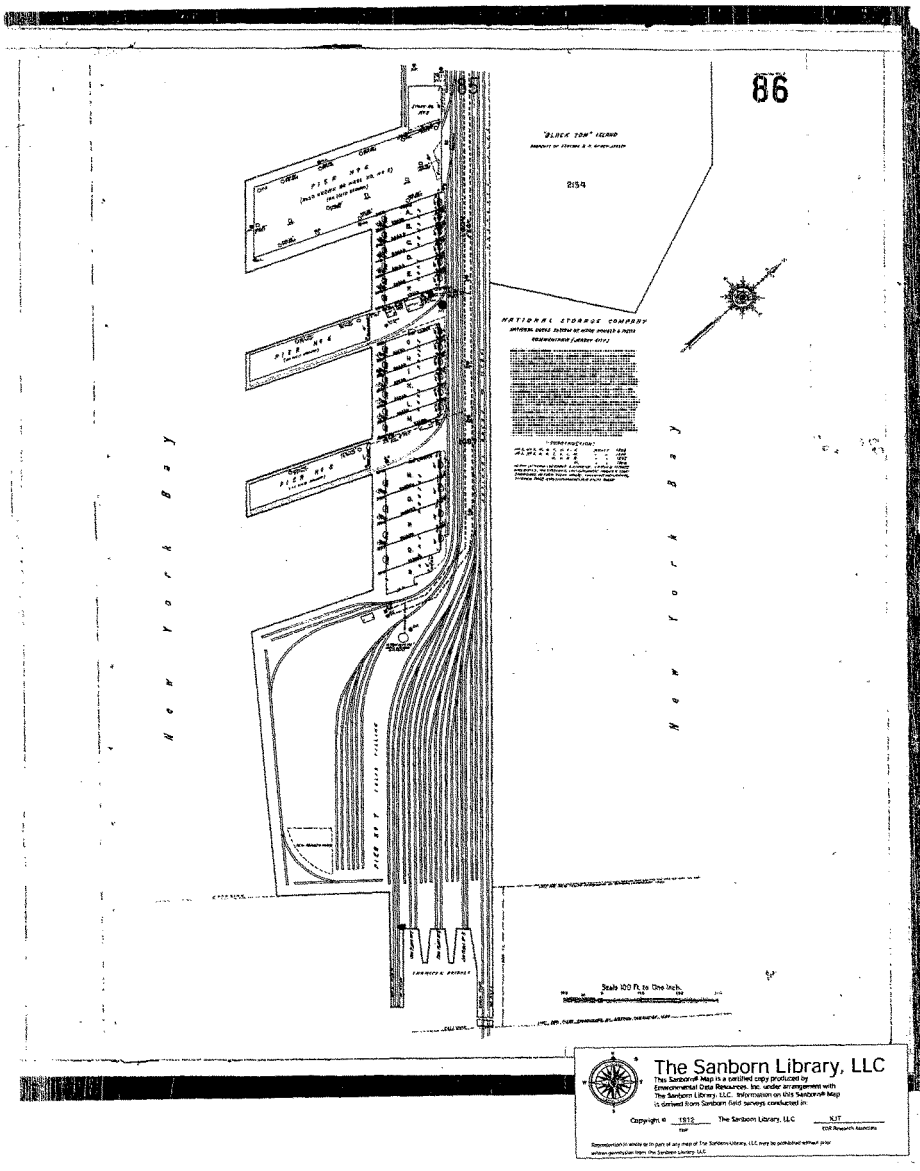
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1913 The Sanborn Library, LLC KJT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


67
63
62
PHILLIP
CENTRAL R. R. OF NEW JERSEY
2145
0
69
68
Scale 100 Ft. to One Inch
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by
Environmental Data Resources, Inc. under an agreement with
The Sanborn Library, LLC. Information on this Sanborn® Map
is derived from Sanborn field surveys conducted in:
Copyright © 1911 The Sanborn Library, LLC KJT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior
written permission from The Sanborn Library, LLC.

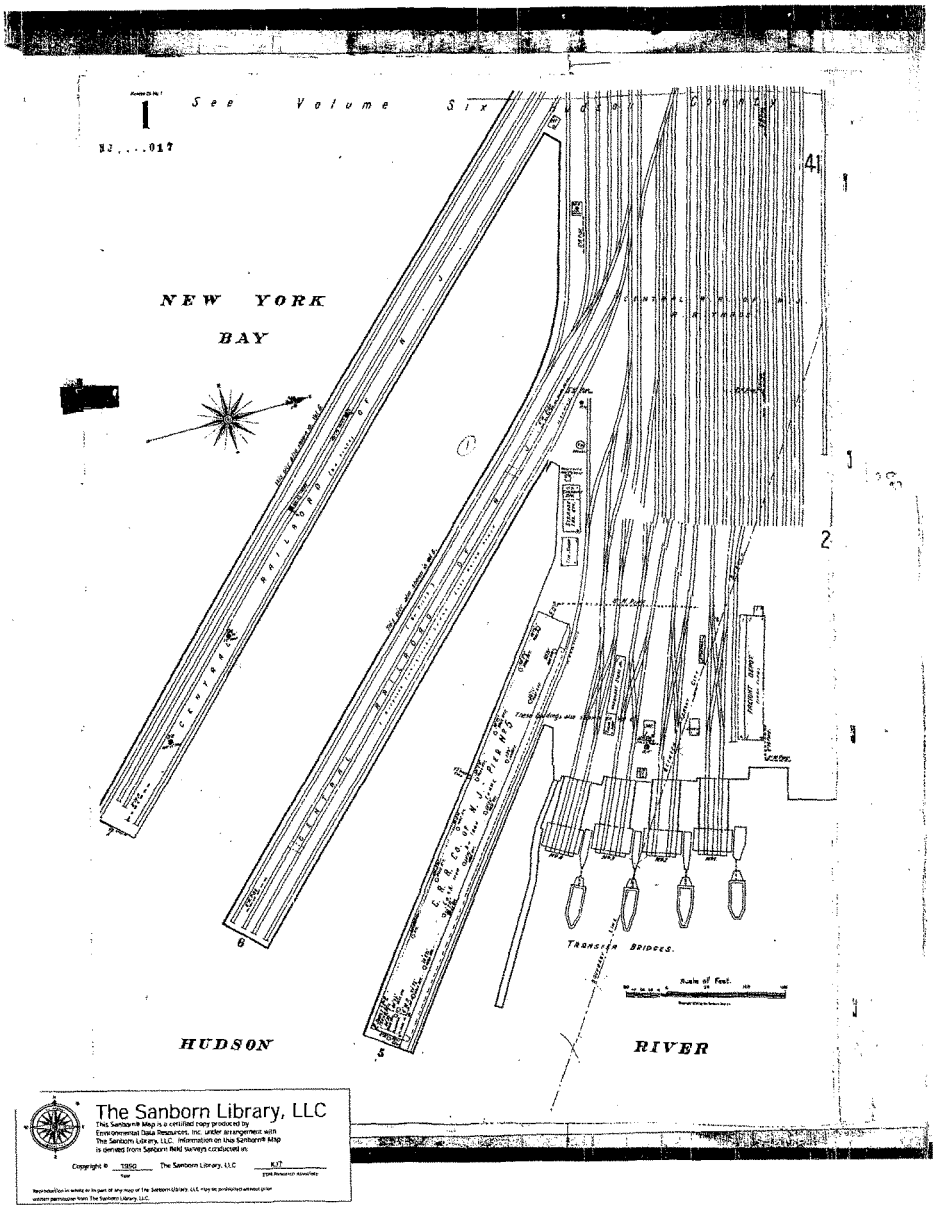

67
68
0
70
CENTRAL R.R. OF NEW JERSEY
2145
New York Bay
Scale 100 ft. to One Inch.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1911 The Sanborn Library, LLC KJT
Year EDR Research Inventory
Reproduction in whole or in part of any map or The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


85
84
89
New York Bay
NATIONAL STORAGE COMPANY
2154
Scale 100 Ft. to One Inch.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, INC. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1912 The Sanborn Library, LLC
Year
XJT
EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1912 The Sanborn Library, LLC
Year
KJT
EDR Research-based title
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.
83
84
88
89
86
CARGO POINT
1493
1497
NATIONAL STORAGE CO "CARGO YARD"
N e w Y o r k B a y
Scale 100 ft. to One Inch.

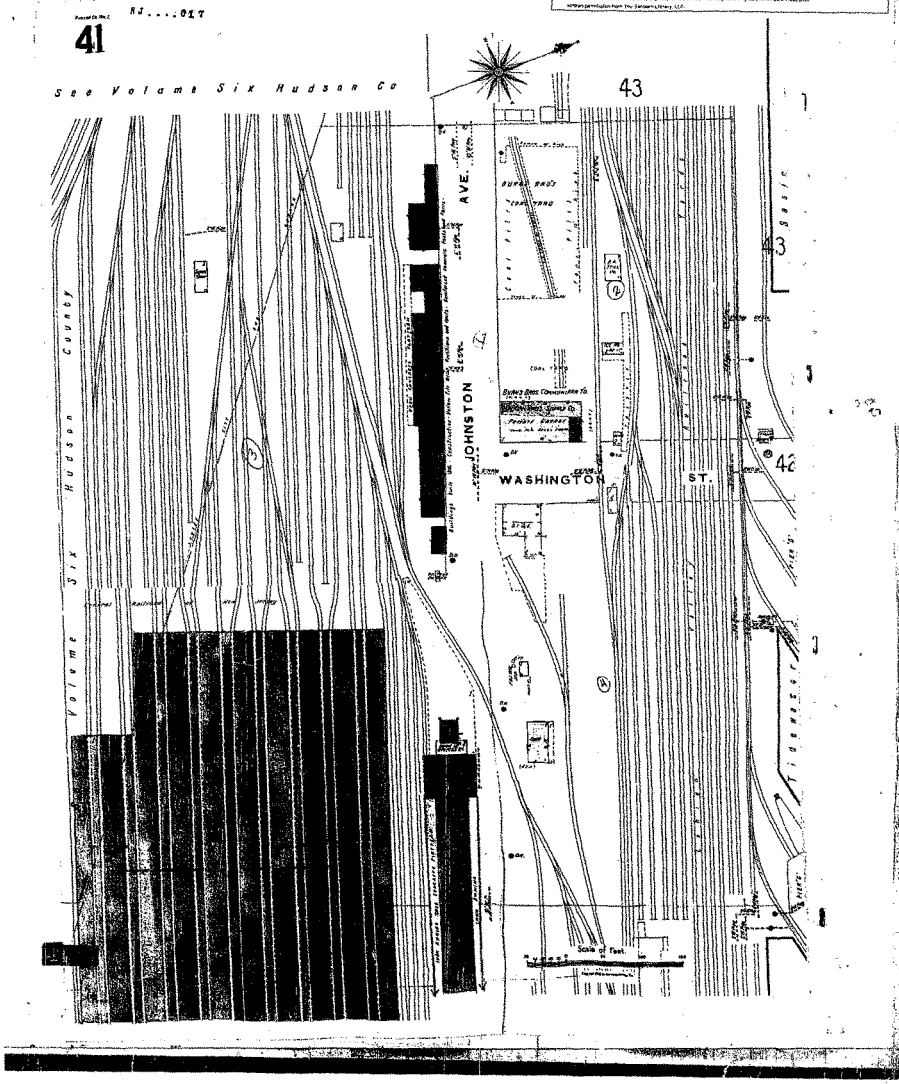


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1915 The Sanborn Library, LLC KIT
Map FOR Nonprofit Materials
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be published without prior written permission from The Sanborn Library, LLC

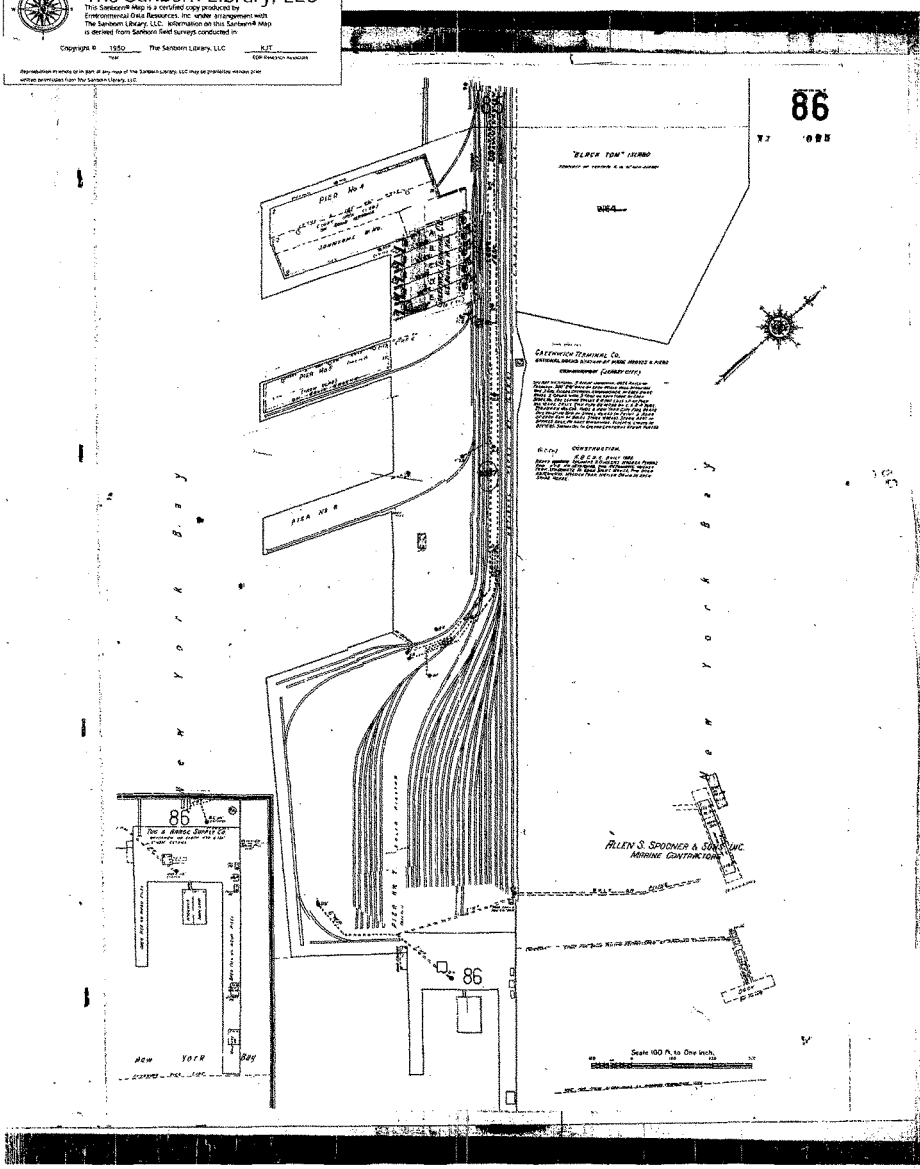


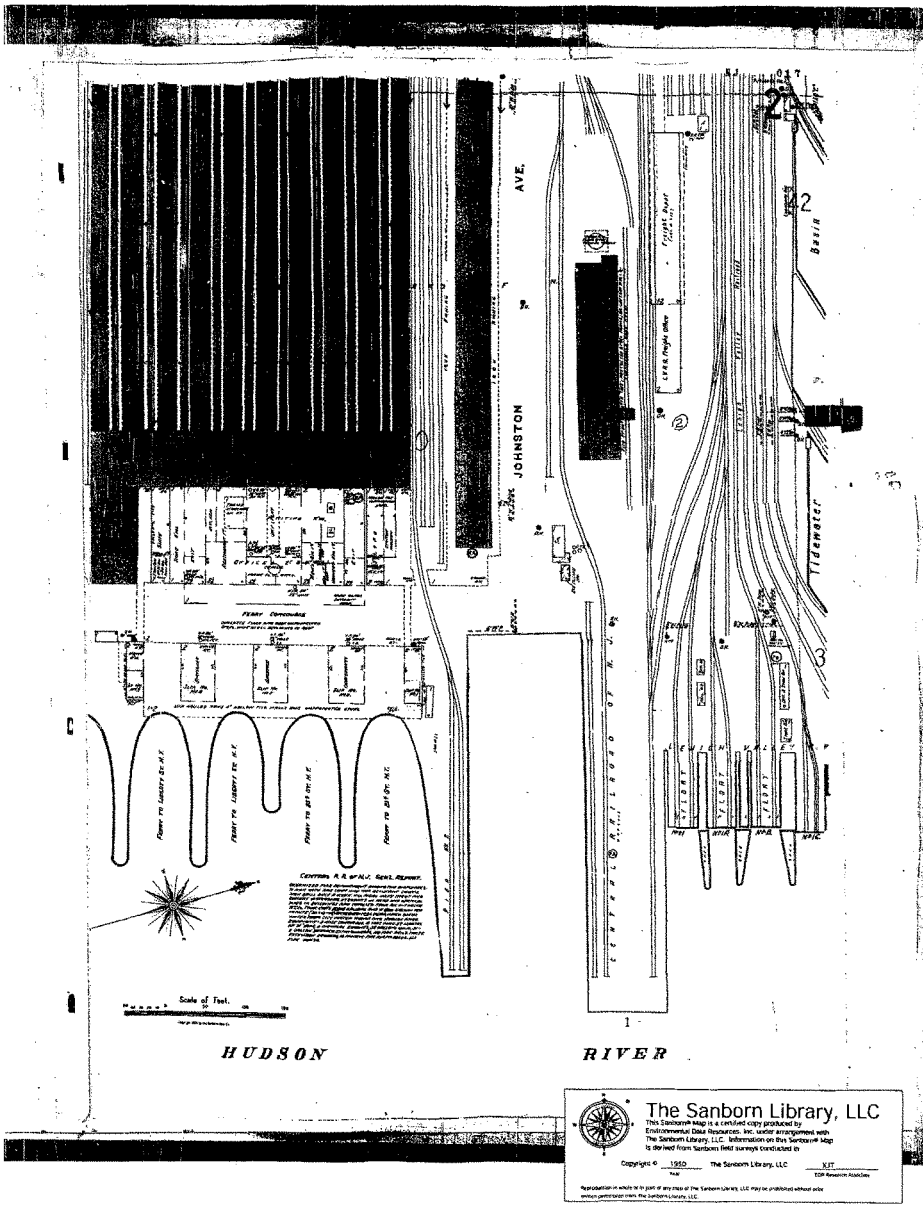
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1950 The Sanborn Library, LLC KJT
Year ESRI Research Associates
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

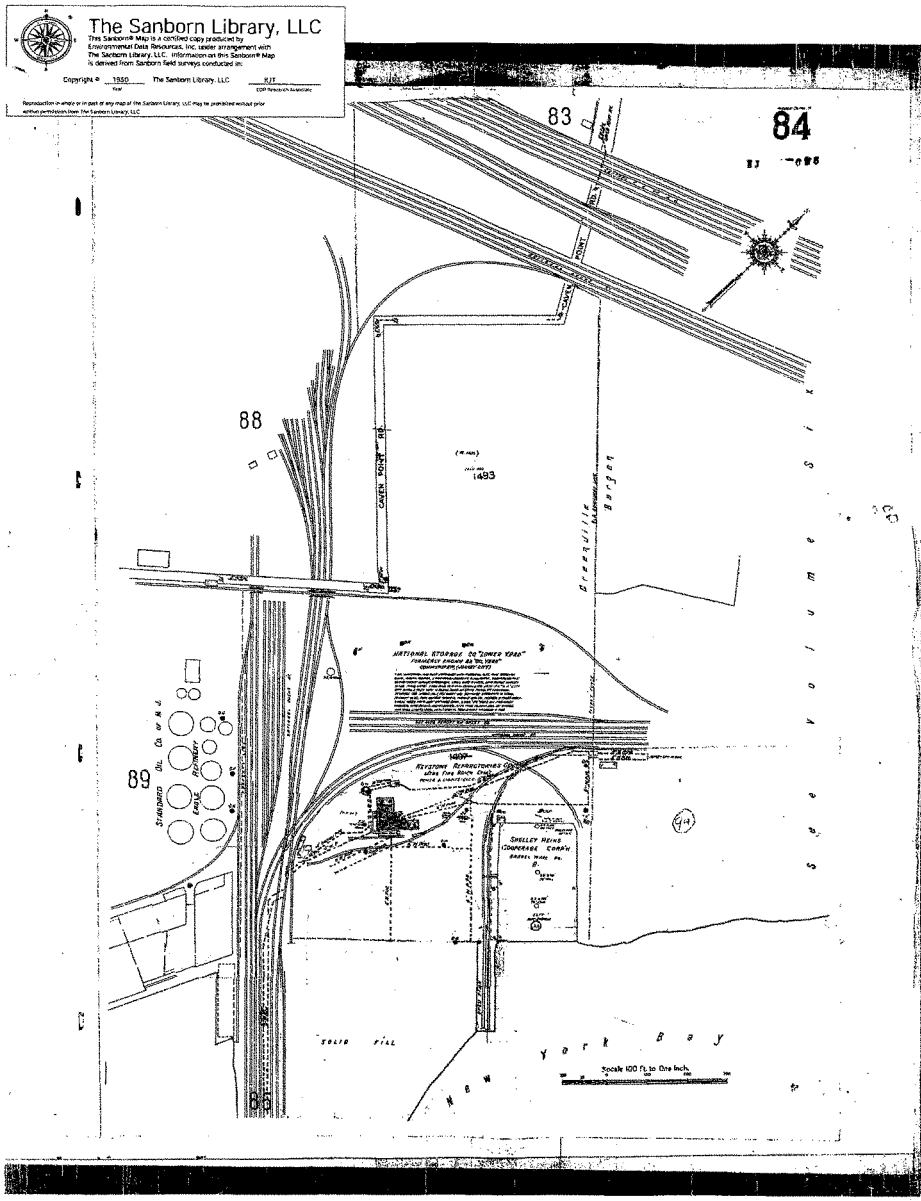
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangements with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted on:
Copyright © 1950 The Sanborn Library, LLC KJT
Year EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

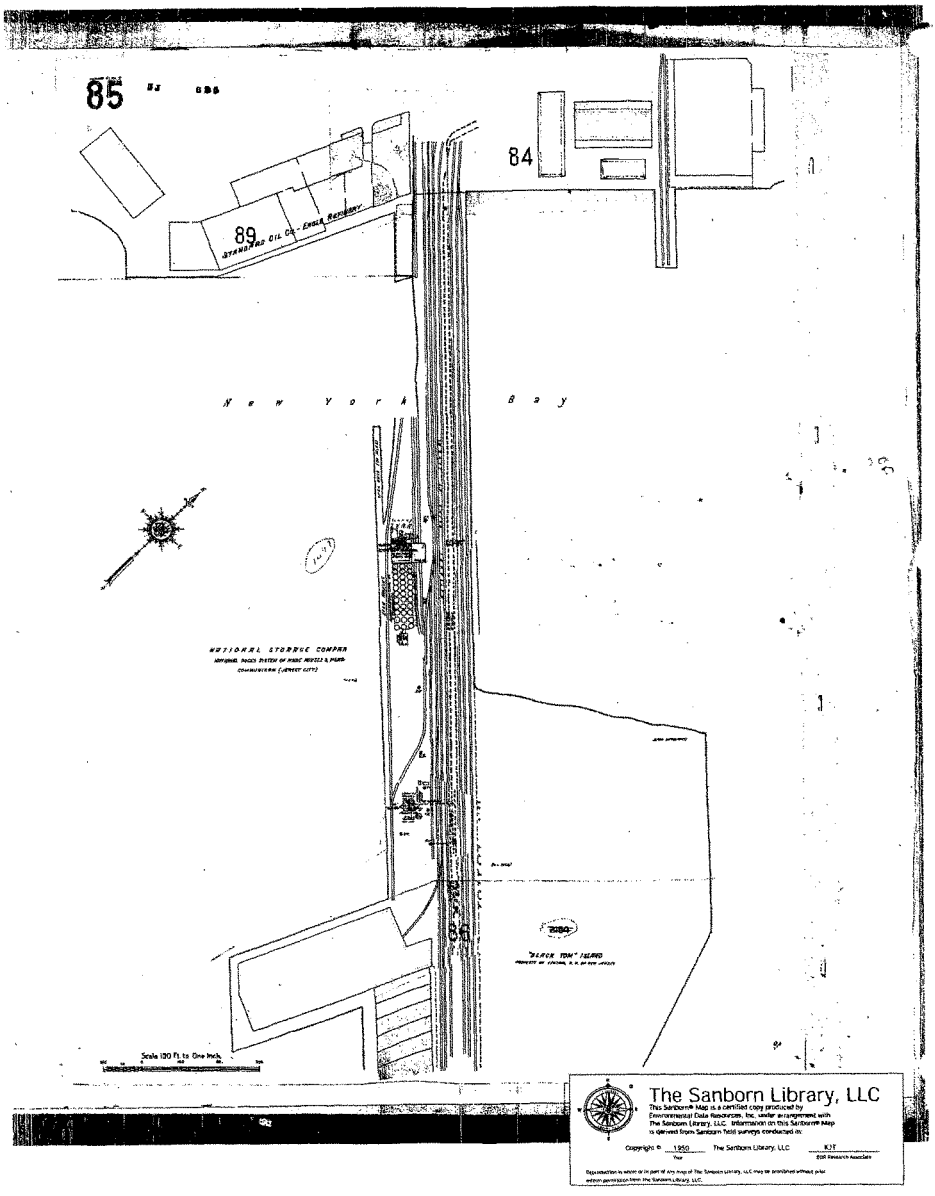


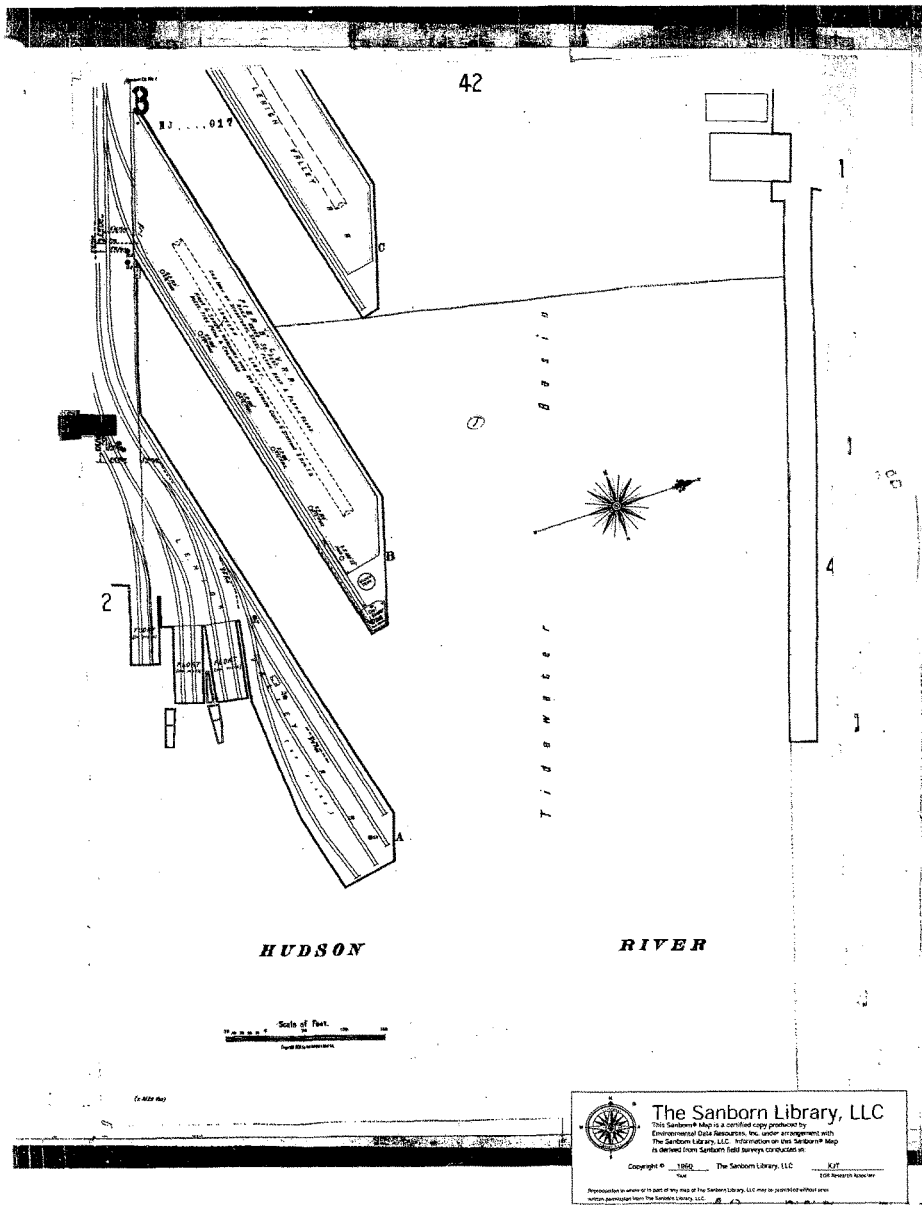
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in
Copyright © 1950 The Sanborn Library, LLC
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

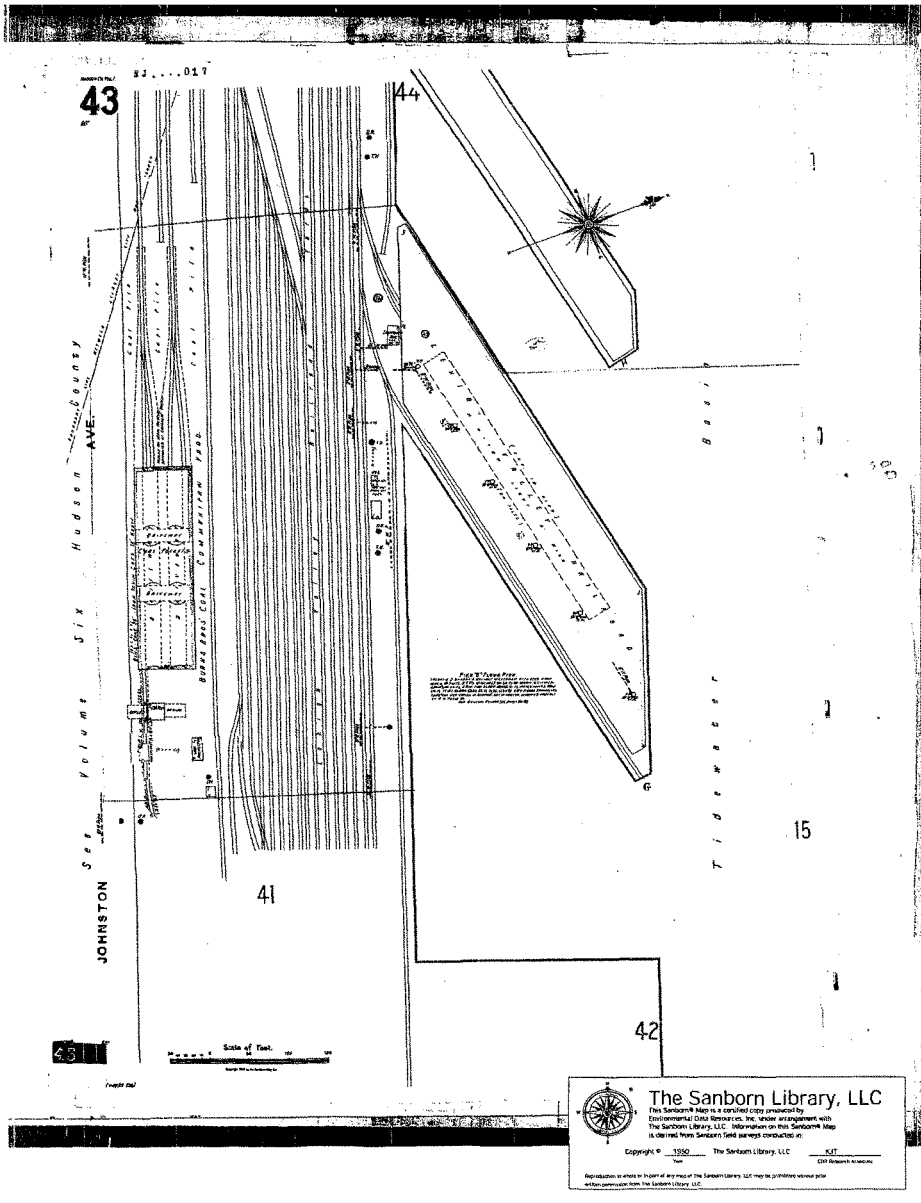


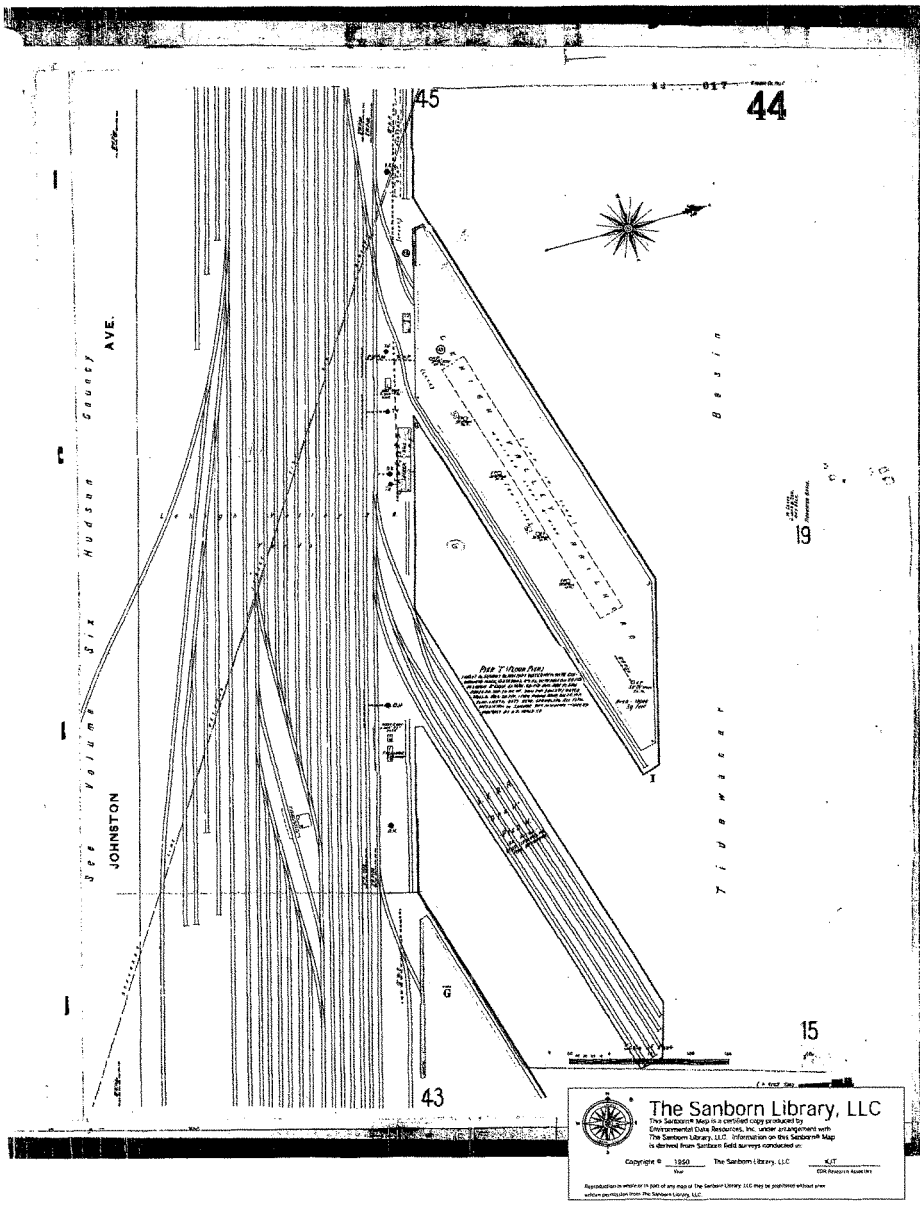

JOHNSTON AVE.
Tidewater Basin
Scale of Feet.
HUDSON RIVER
The Sanborn Library, LLC

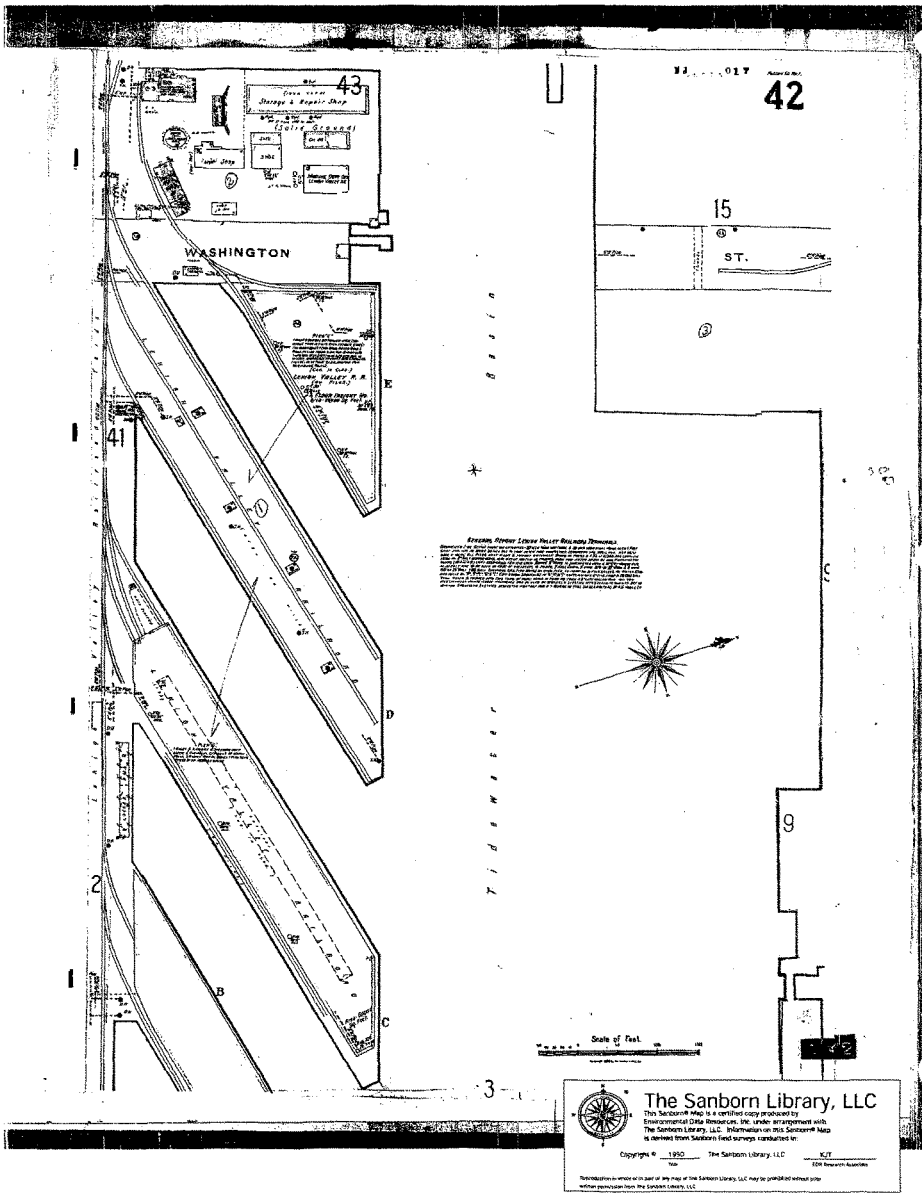

The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1950 The Sanborn Library, LLC
Year
KIT
EDR Research Associates
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC
83
84
88
89
86
1493
CAVEN POINT RD.
BRIDGE
NATIONAL STORAGE CO. "TOWER YARD"
FORMERLY KNOWN AS "BIG YARD"
KEYSTONE REPRODUCTIONS
SHELLEY HEINZ
STANDARD OIL CO. OF N.J.
EAGLE
FOUNDRY
SOLID FILL
New York Bay
Scale 100 ft. to One Inch.

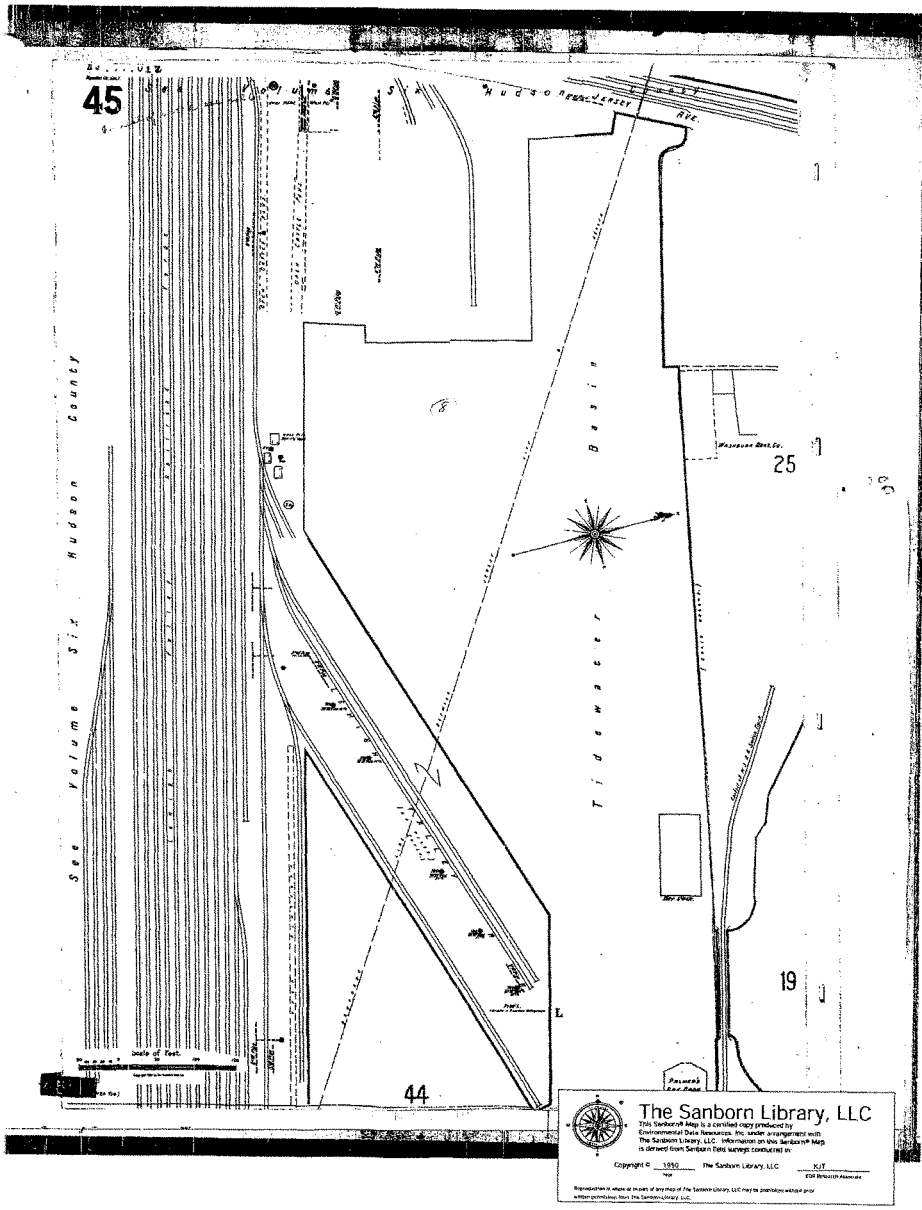

85
84
89
STANDARD OIL CO. - ENGLE REFINERY
New York Bay
NATIONAL STORAGE COMPANY
86
"BLACK TOM" ISLAND
Scale 100 Ft. to One Inch
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1950 The Sanborn Library, LLC KJT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.

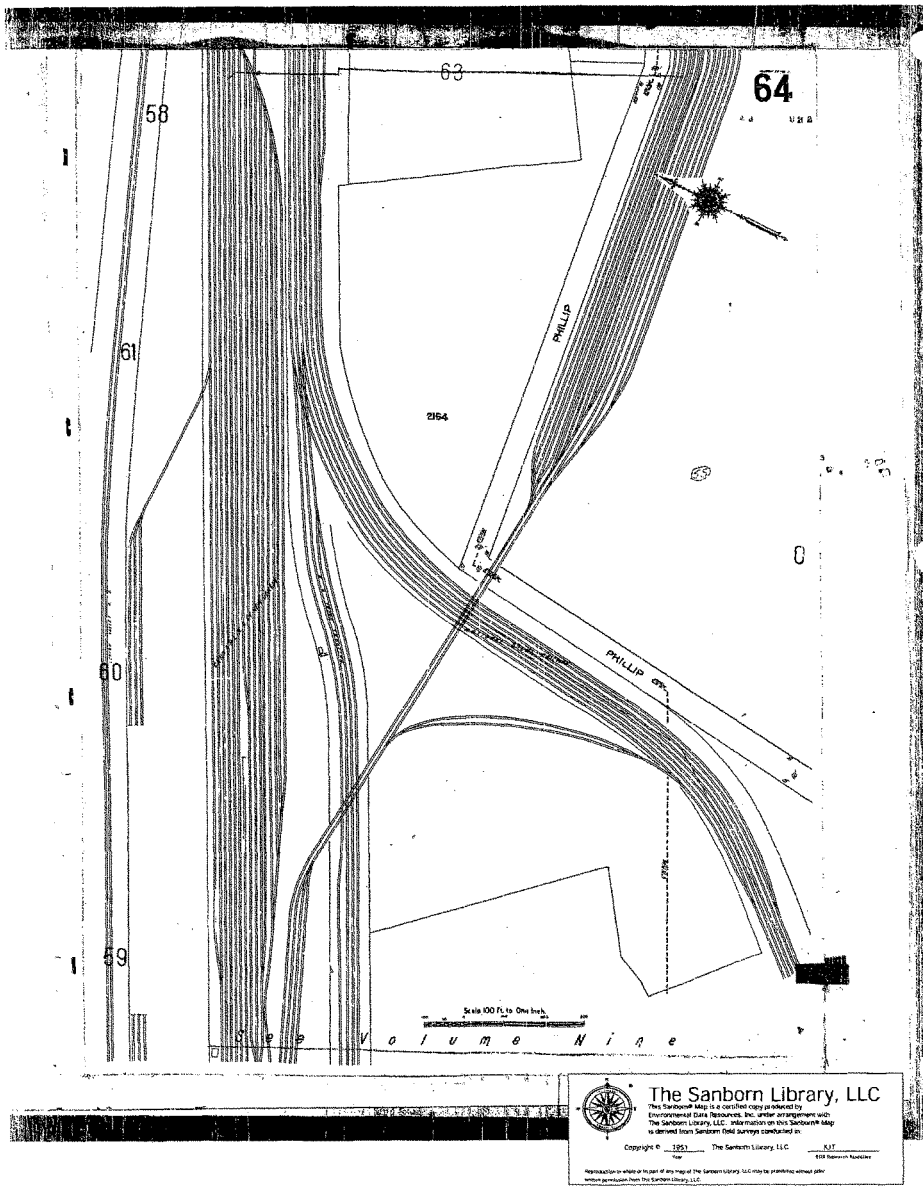

42
B
BJ....017
Tidewater Basin
HUDSON
RIVER
Scale of Feet.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1950 The Sanborn Library, LLC KJT
Year EDR Research Analyst
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

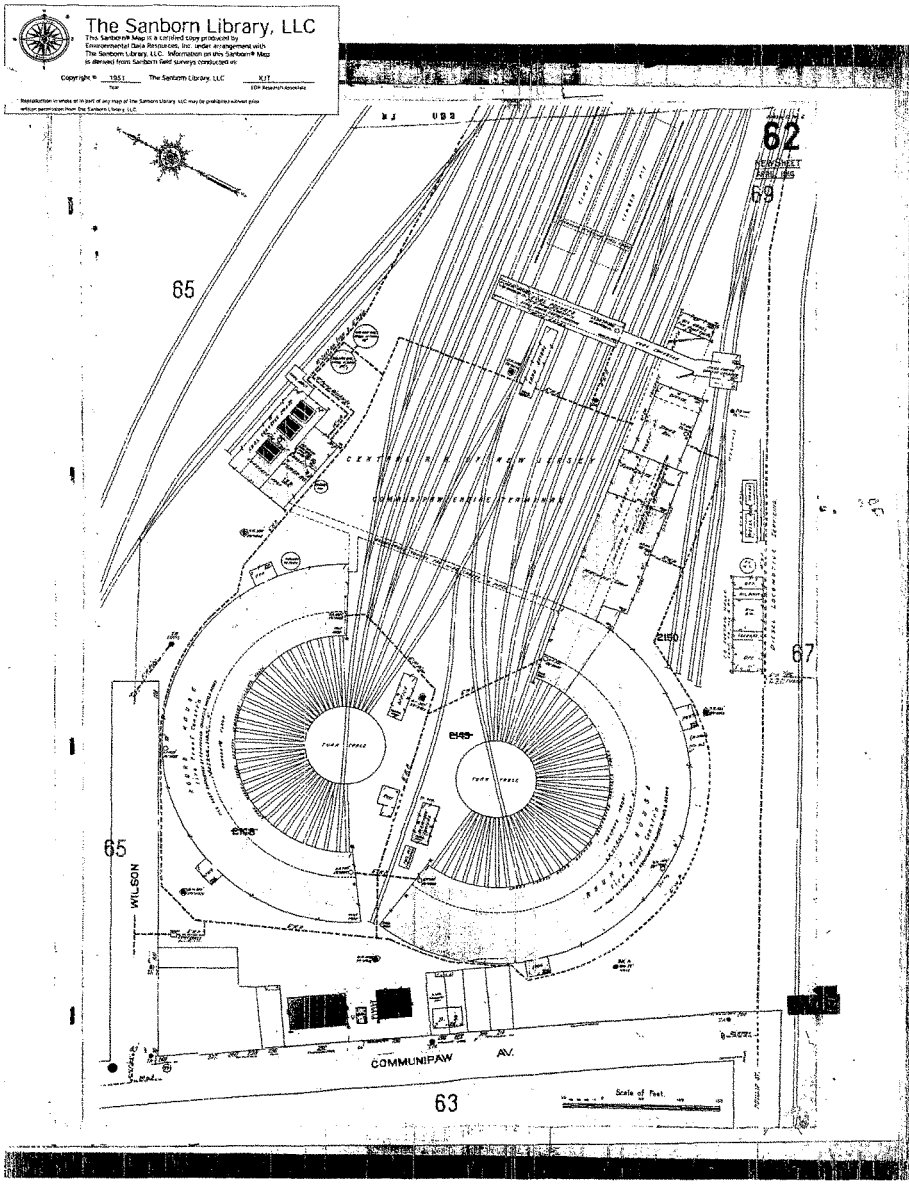

43
44
41
42
15
JOHNSTON
AVE
Hudson
Bounty
Six
Volume
Sea
Tidewater
Basin
Scale of Feet.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1950 The Sanborn Library, LLC KIT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

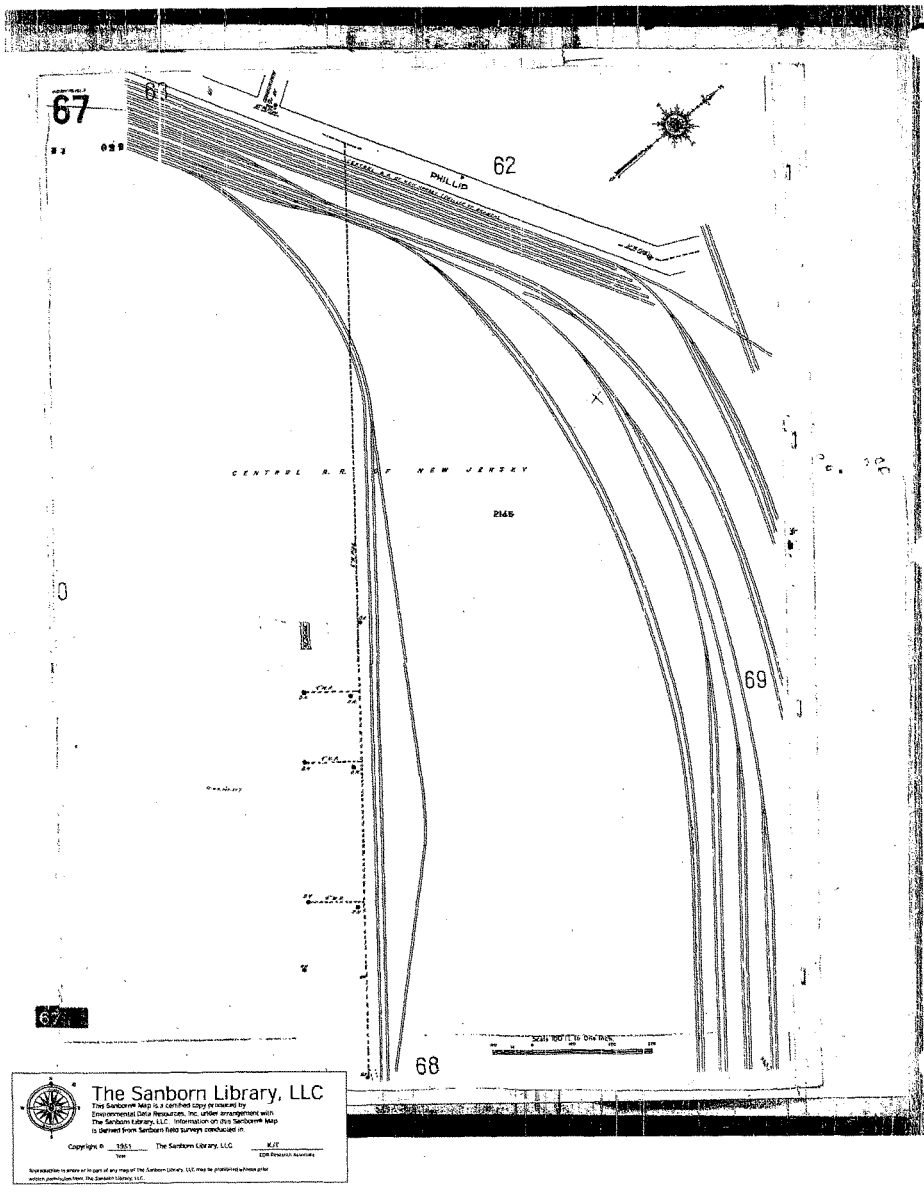

45
44
43
15
19
JOHNSTON AVE.
Hudson Street
Tidewater Basin
The Sanborn Library, LLC
Copyright © 1950 The Sanborn Library, LLC
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

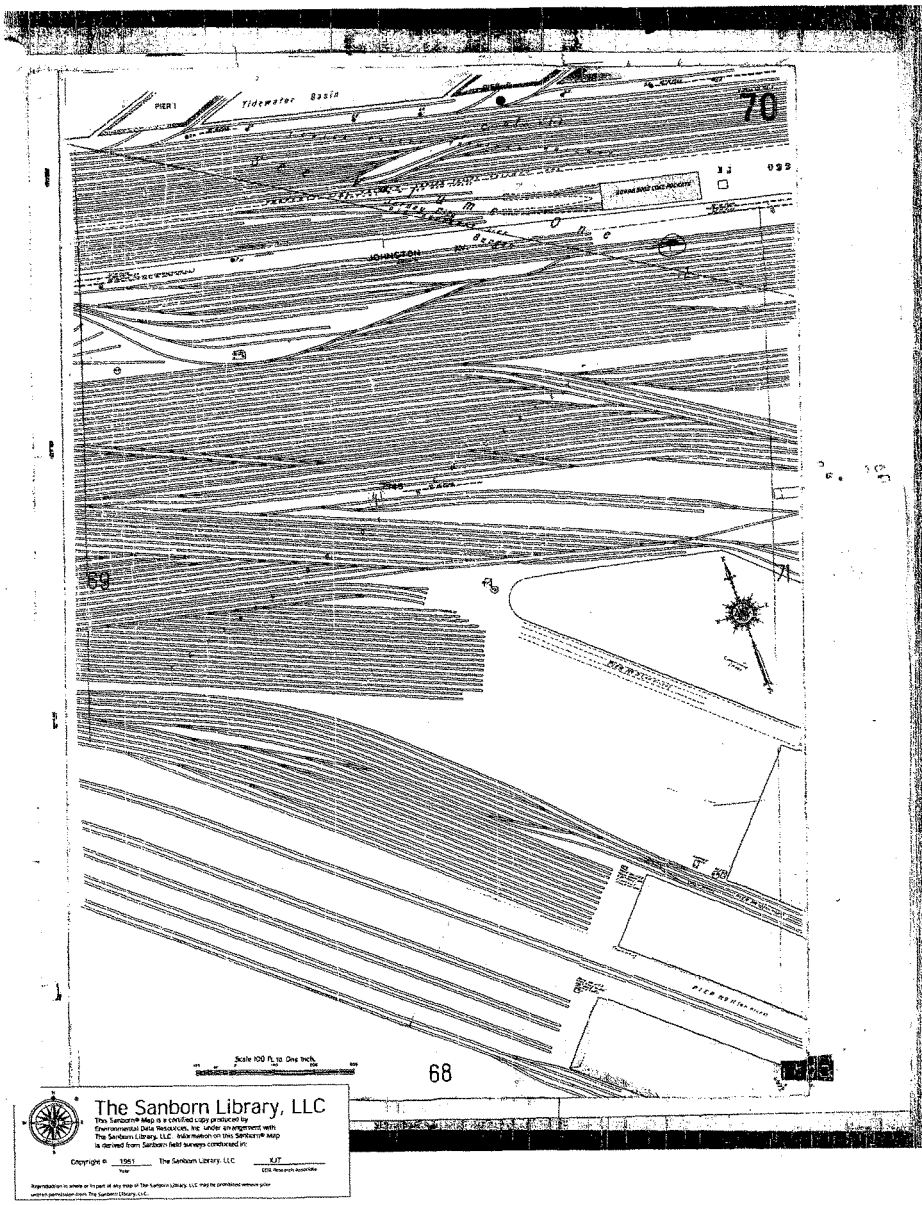

43
42
15
ST.
WASHINGTON
41
9
3
Tidewater Basin
Scale of Feet
The Sanborn Library, LLC
Copyright © 1950 The Sanborn Library, LLC

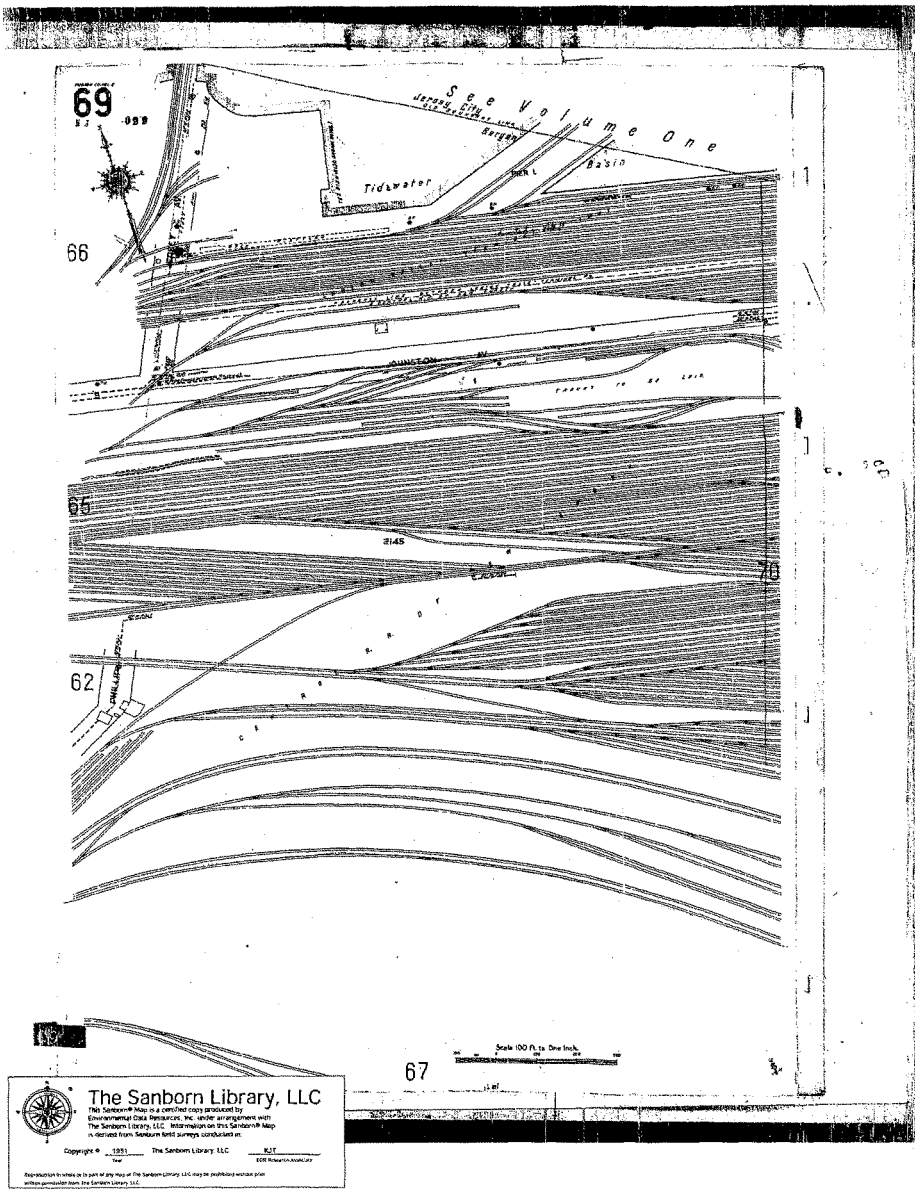

45
Hudson & Bergen Jersey Ave.
See Volume Six Hudson County
Tidewater Basin
25
19
44
L
Scale of Feet.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1950 The Sanborn Library, LLC
KJT
EDR Research Associate

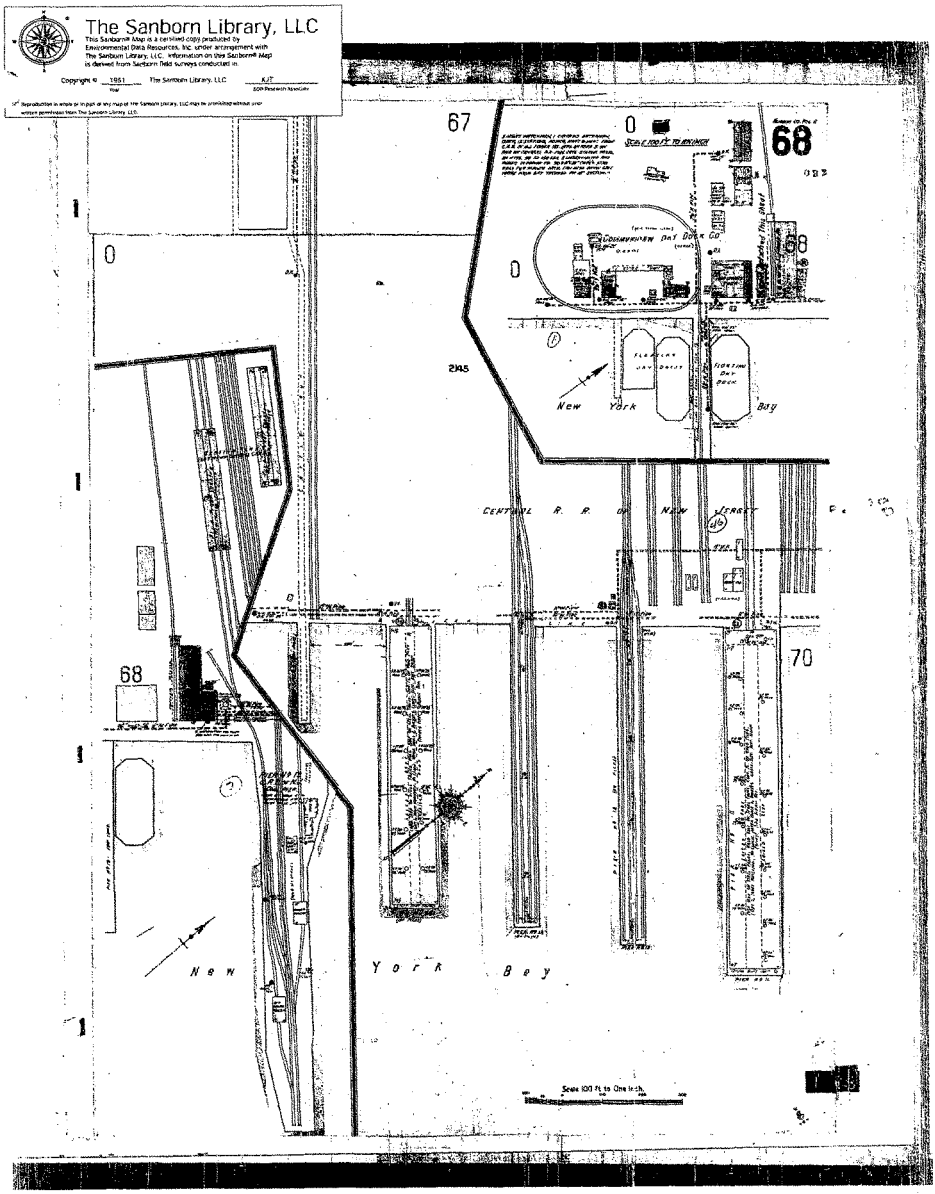

63
64
58
61
60
59
PHILLIP
PHILLIP
2164
Scale 100 Ft. to One Inch.
See Volume Nine
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in.
Copyright © 1951 The Sanborn Library, LLC
KJT
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

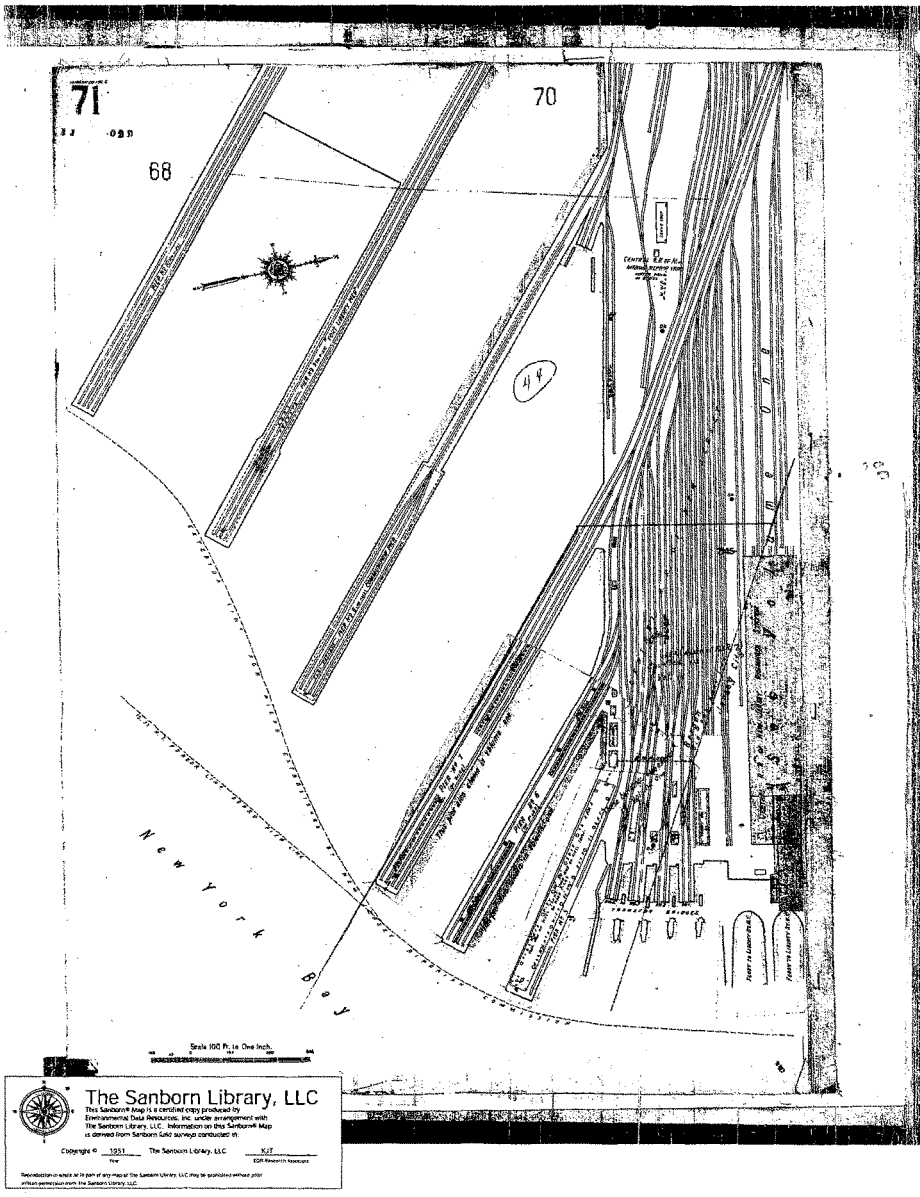

The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1951 The Sanborn Library, LLC
Year
KJT
EDR Research Associate
Reproduction in whole or in part of any map of the Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.
62
SHEET
69
65
67
63
WILSON
COMMUNIPAW
AV.
Scale of Feet

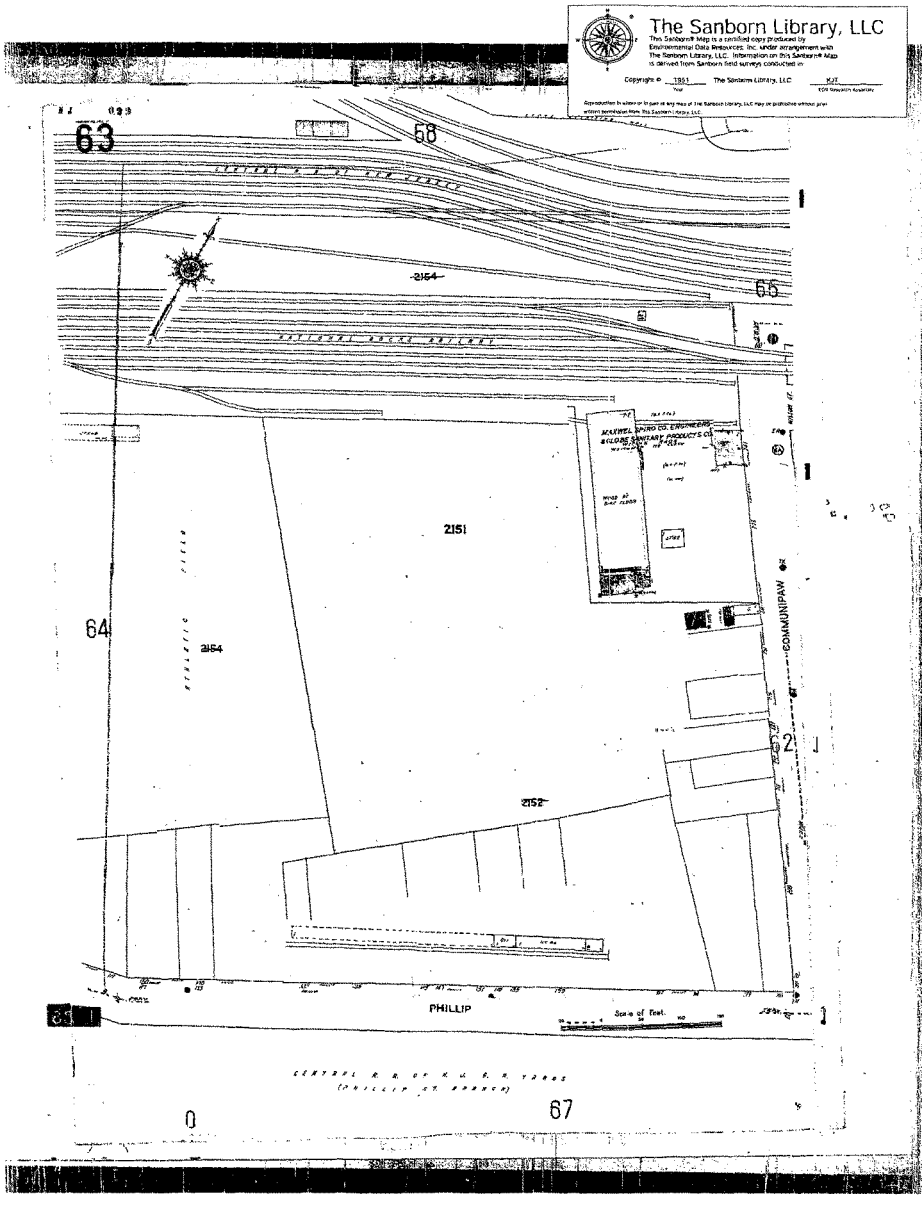

67
61
62
PHILLIP
CENTRAL R. R. OF NEW JERSEY
2145
69
68
Scale 100 ft. to One Inch
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in
Copyright © 1951 The Sanborn Library, LLC K/F
Year EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

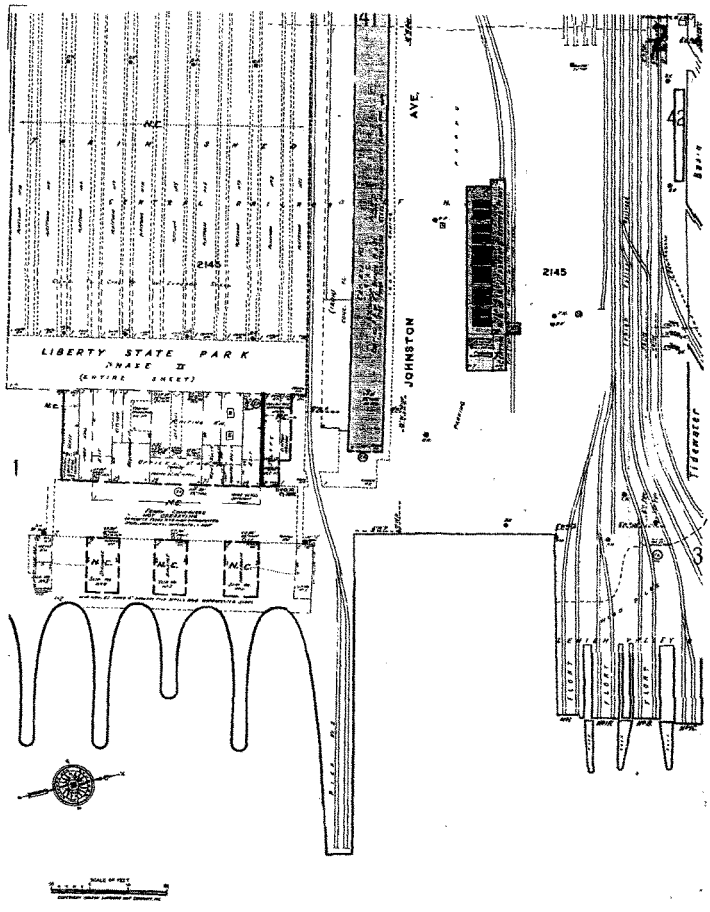

PIER 1
Tidewater Basin
70
JOHNSTON
69
71
68
Scale 100 ft. to One Inch
The Sanborn Library, LLC
The Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® map is derived from Sanborn field surveys conducted in:
Copyright © 1951 The Sanborn Library, LLC
Year
KJT
EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


69
See Volume One
Tidewater
Basin
66
65
2145
70
62
67
Scale 100 ft. to One Inch.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under an arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1951 The Sanborn Library, LLC KJT
Year EDR Research Associate
Reproduction in whole or in part of any Map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


The Sanborn Library, LLC
This Sanborn® Map is a licensed copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on the Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1951 The Sanborn Library, LLC
67
68
68
68
70
0
0
0
2145
New York Bay
CENTRAL R. R. OF NEW JERSEY
New York Bay
Scale 100 Ft. to One Inch.

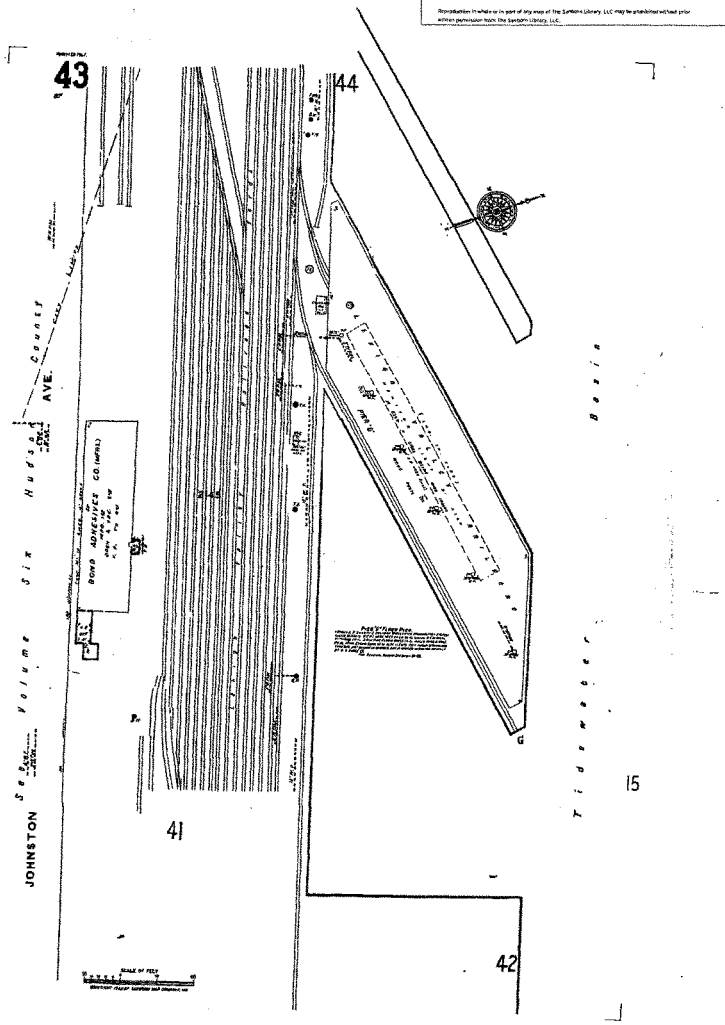

71
70
68
New York Bay
Scale 100 Ft. to One Inch.
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1951 The Sanborn Library, LLC
KJT
EDR-Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC.

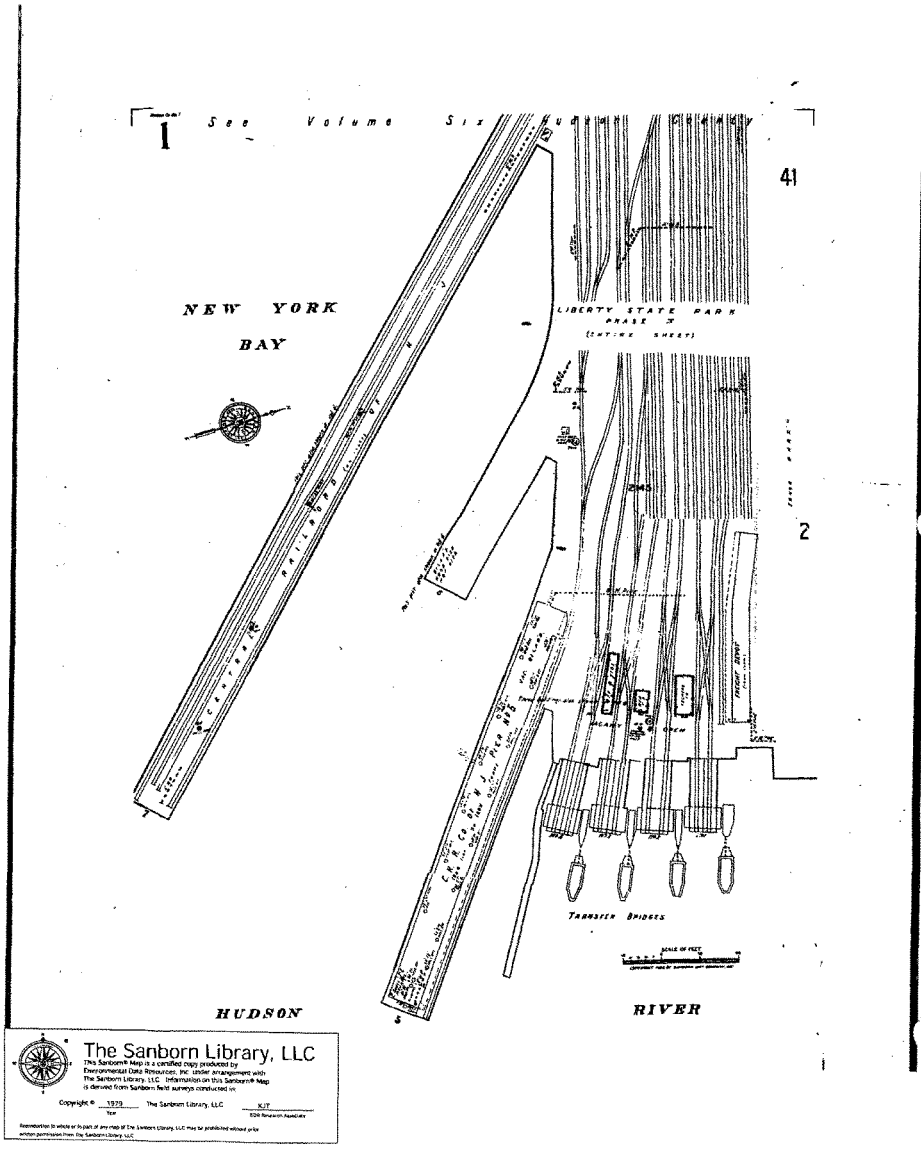

The Sanborn Library, LLC
63
68
65
2154
2151
64
2154
2152
COMMUNIPAW
PHILLIP
Scale of Feet
67
0



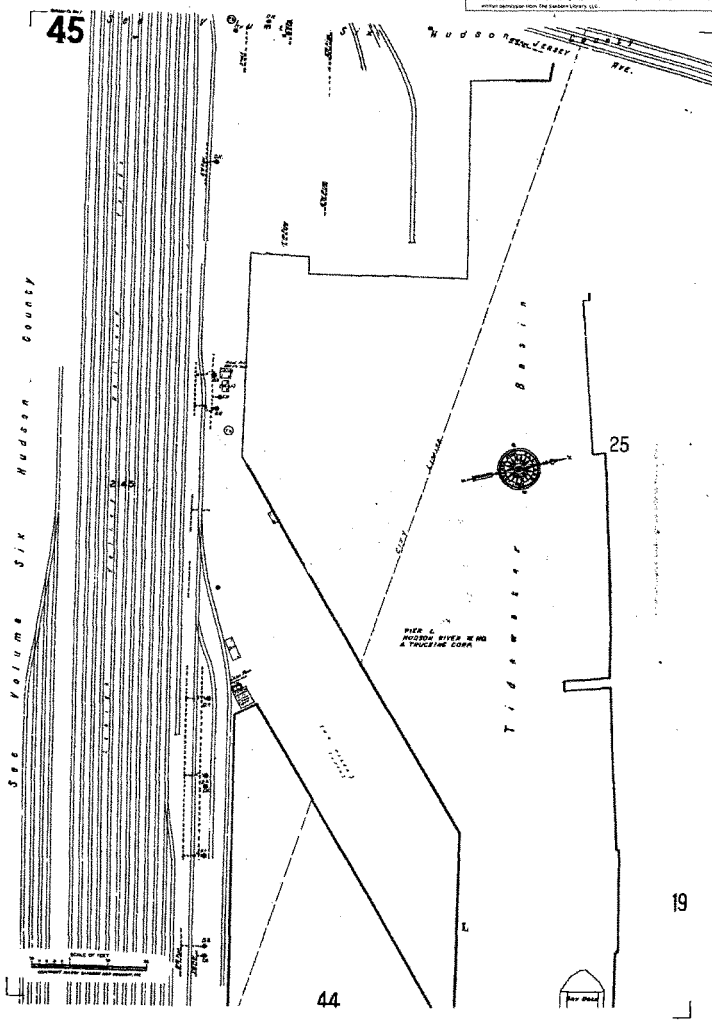
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
Year
KJT
EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

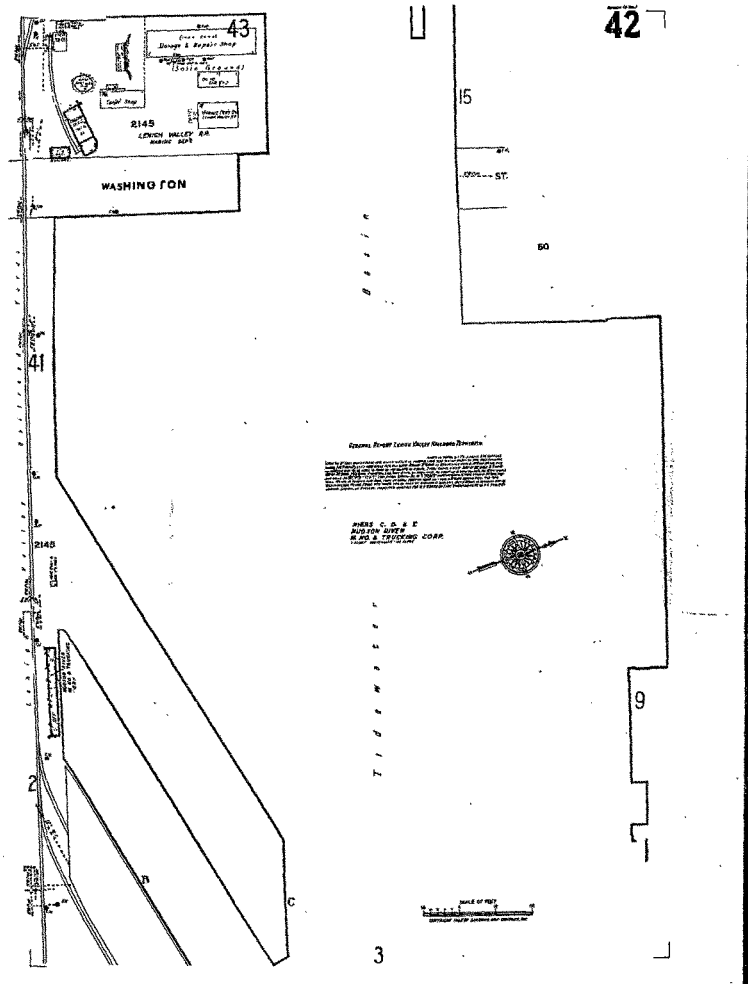
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in.
Copyright © 1979 The Sanborn Library, LLC K/T
Year EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.




See Volume Six
41
NEW YORK
BAY
LIBERTY STATE PARK
PHASE II
(LIVING SHEET)
2
TRANSFER BRIDGES
HUDSON
RIVER
The Sanborn Library, LLC
The Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
Year
KJT
EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 (Year) The Sanborn Library, LLC KJT (EDR Research Associates)
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without written permission from The Sanborn Library, LLC.

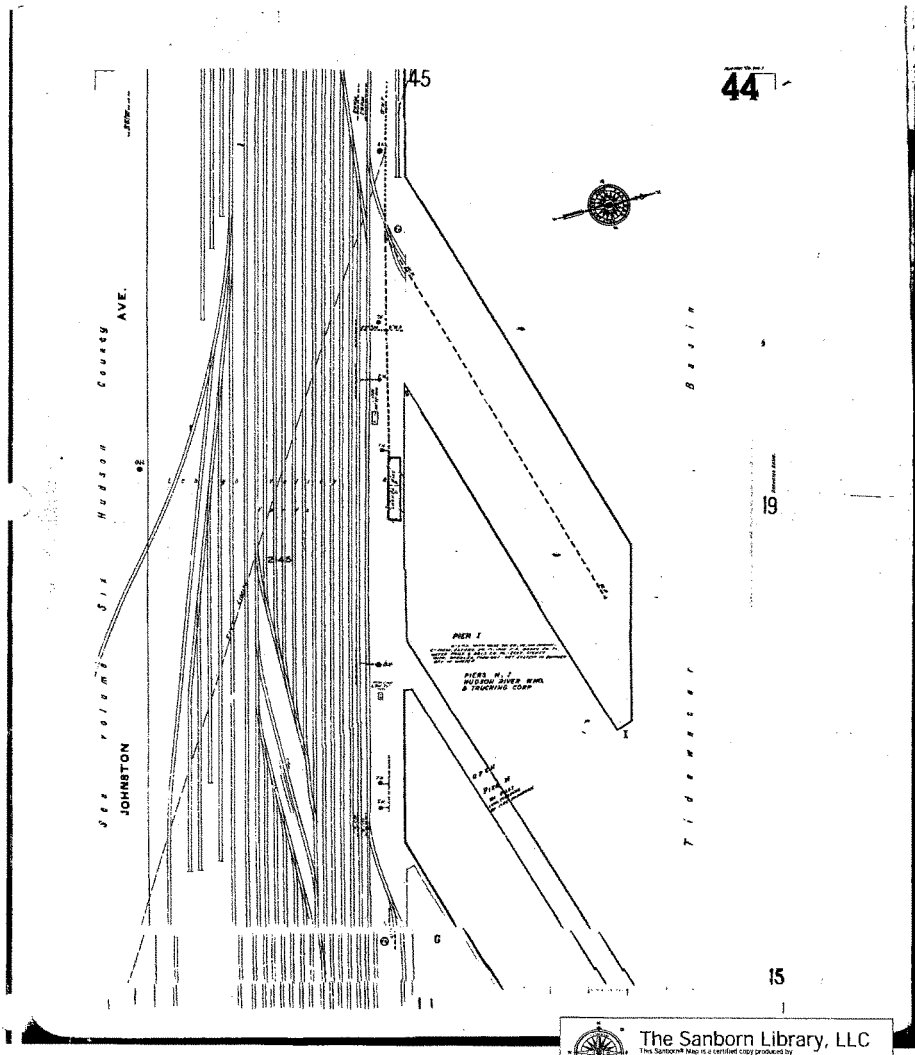




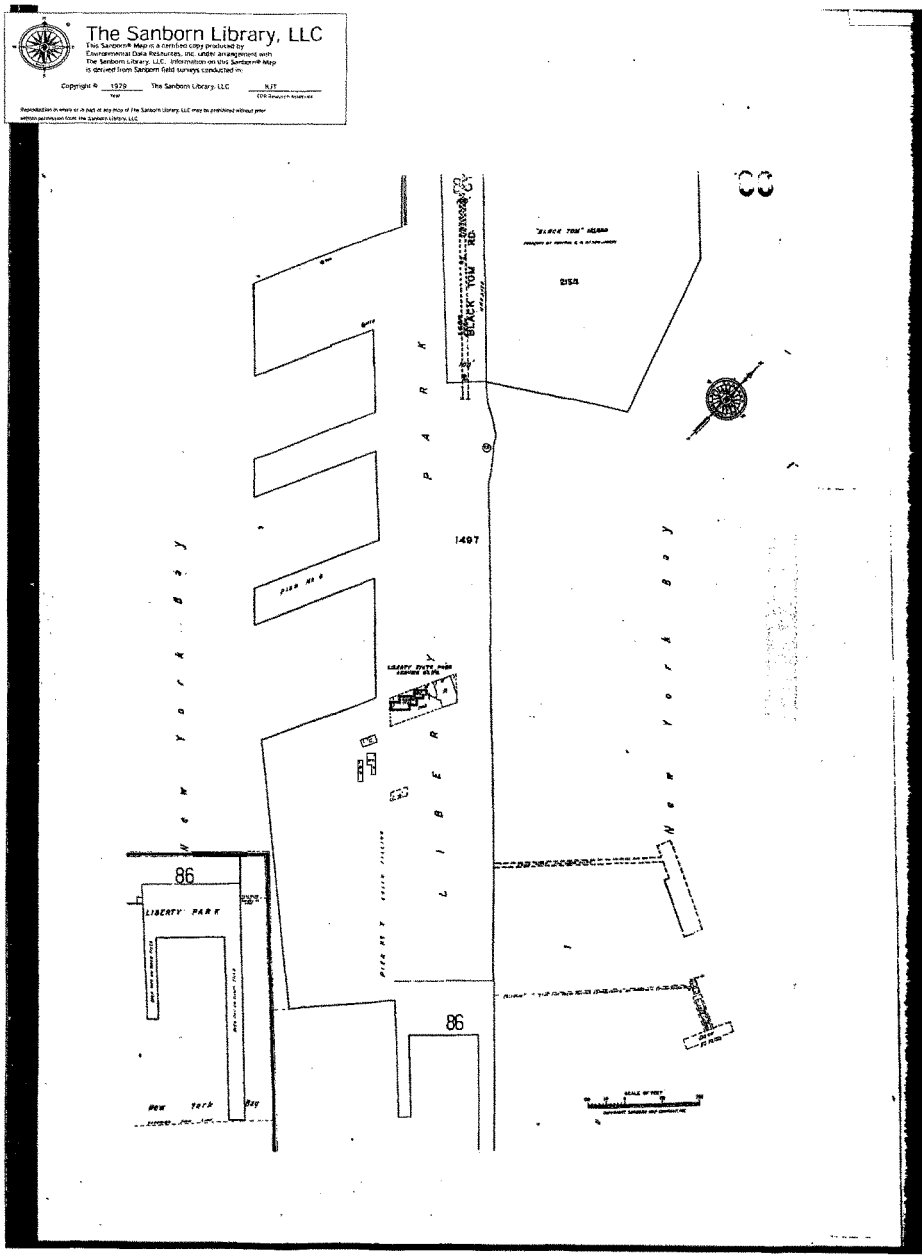
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in

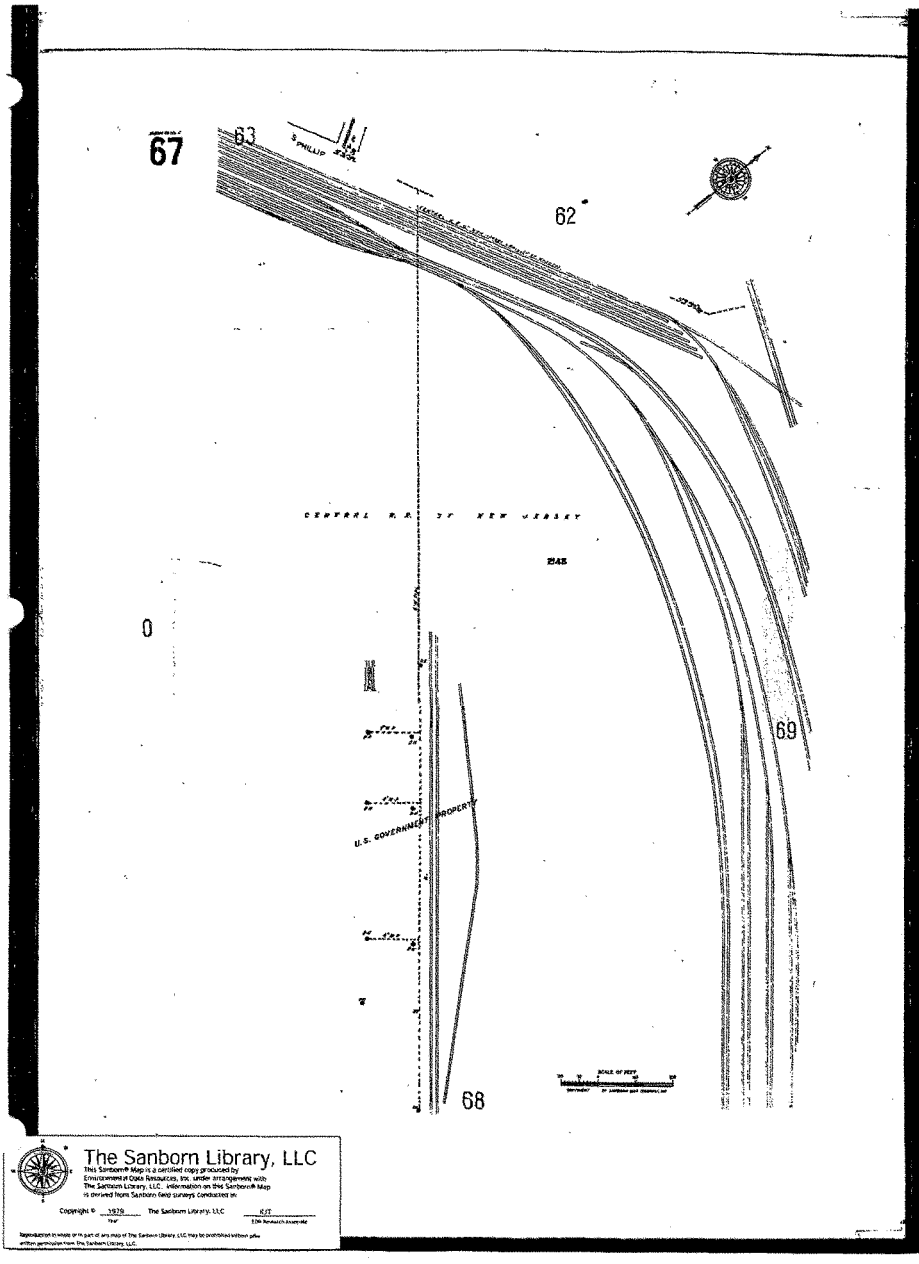
Copyright © 1979 The Sanborn Library, LLC KJT
Year EDR Research Associate

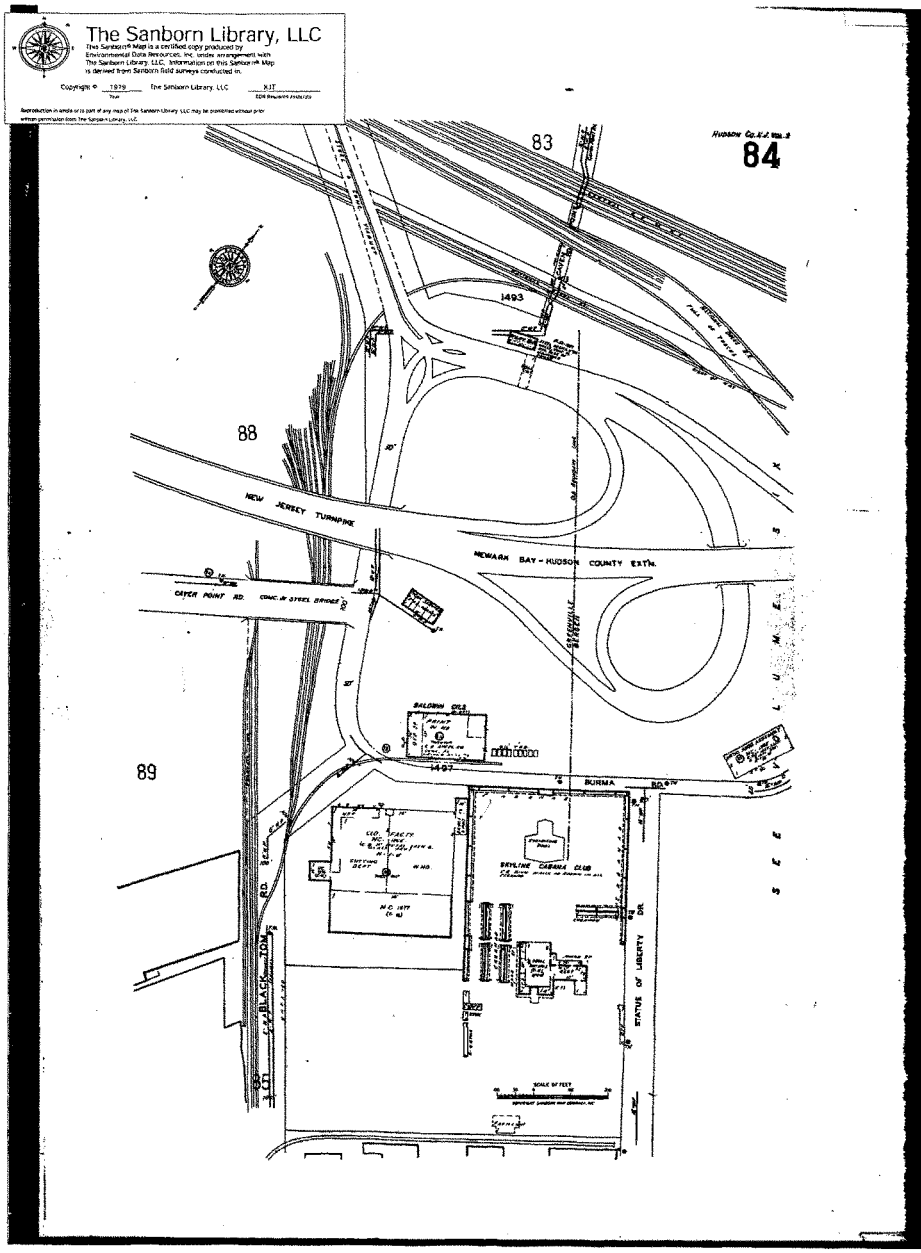
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

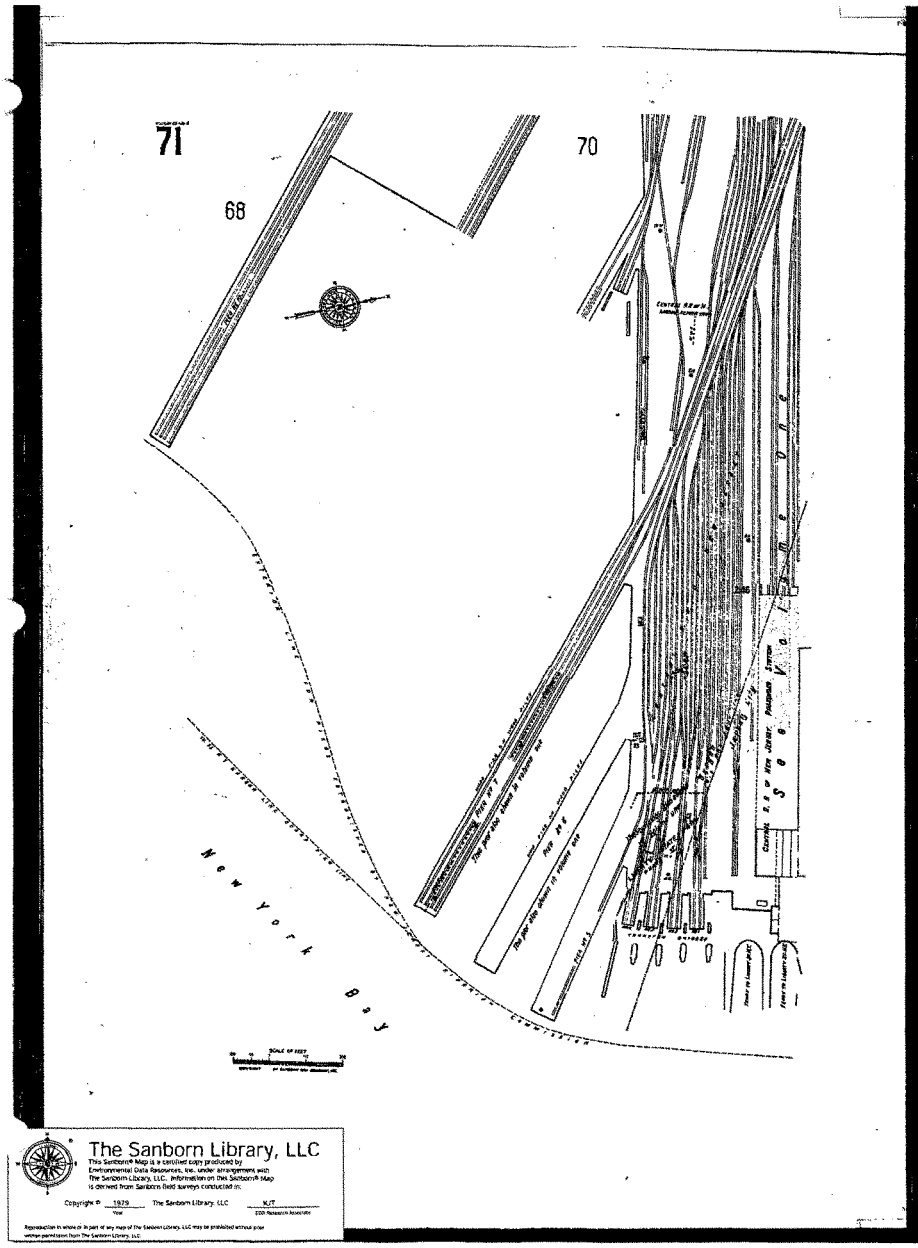


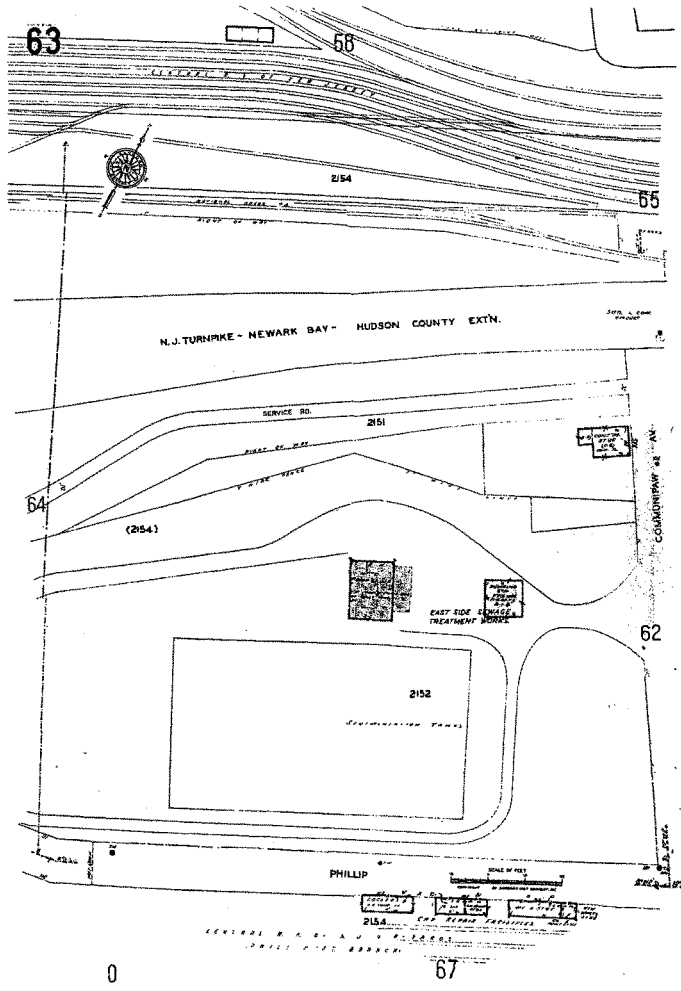
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC N/T
Year EDR Research Associates
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


The Sanborn Library, LLC
Copyright © 1929 The Sanborn Library, LLC NJT
BLACK TOM RD.
"BLACK TOM" HERMIT
2153
1497
PARK
LIBERTY
New York Bay
New York Bay
86
LIBERTY PARK
86
New York Bay

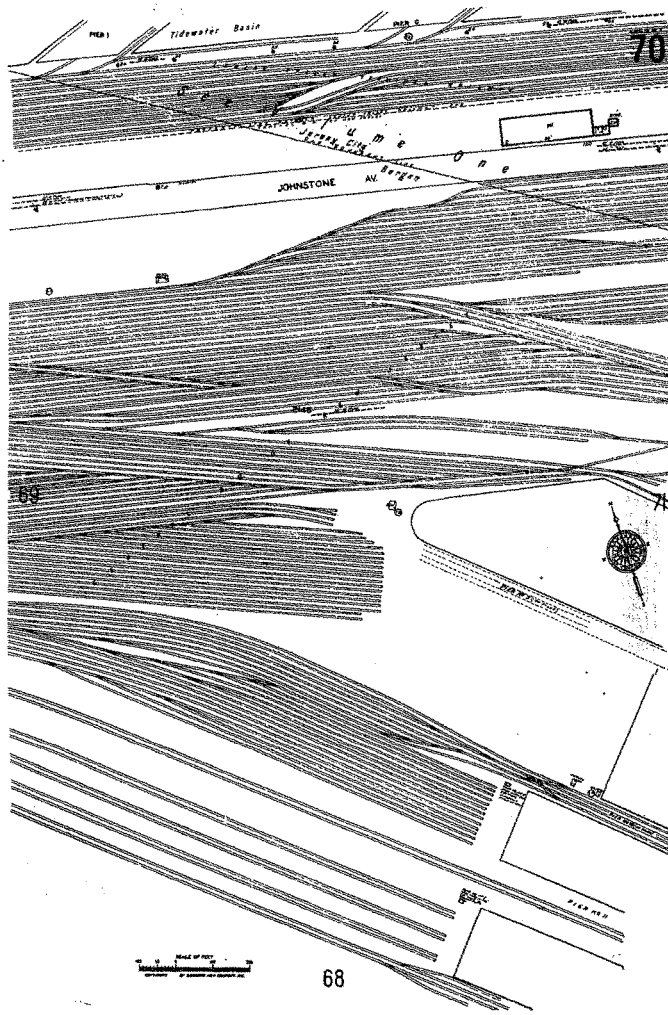

67
63
62
69
68
0
U.S. GOVERNMENT PROPERTY
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environment 1 at Oaks Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
KIT
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.


The Sanborn Library, LLC
Copyright © 1979 The Sanborn Library, LLC
Hudson Co. N.J. Vol. 3
84
83
88
89
1493
NEW JERSEY TURNPIKE
NEWARK BAY - HUDSON COUNTY EXTN.
CAYER POINT RD.
CONC. & STEEL BRIDGE
BALDWIN OIL
BURMA RD.
SKYLINE CABANA CLUB
STATUE OF LIBERTY DR.
BLACK TOM RD.
SCALE OF FEET

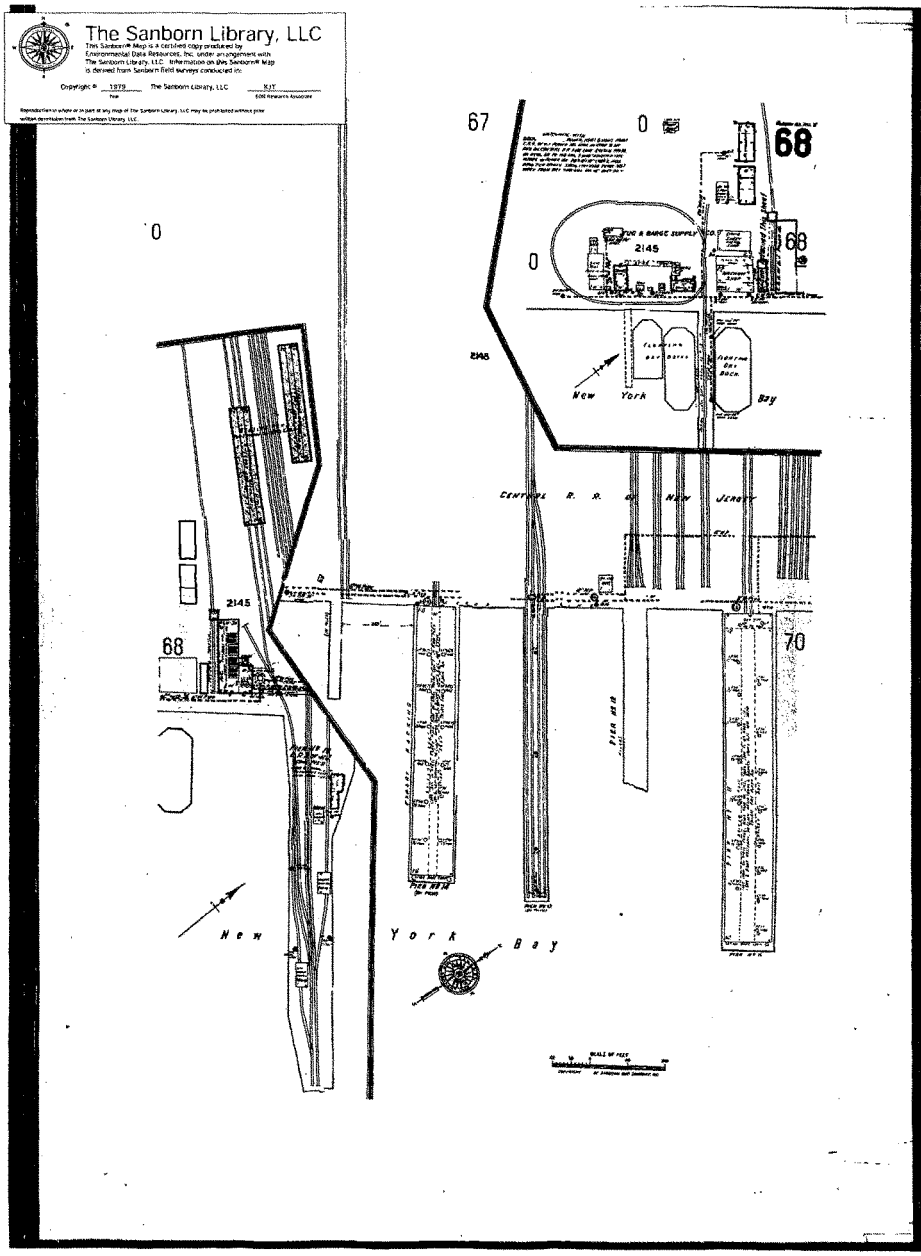

71
68
70
New York Bay
SCALE OF FEET
The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
Year
KJT
EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC

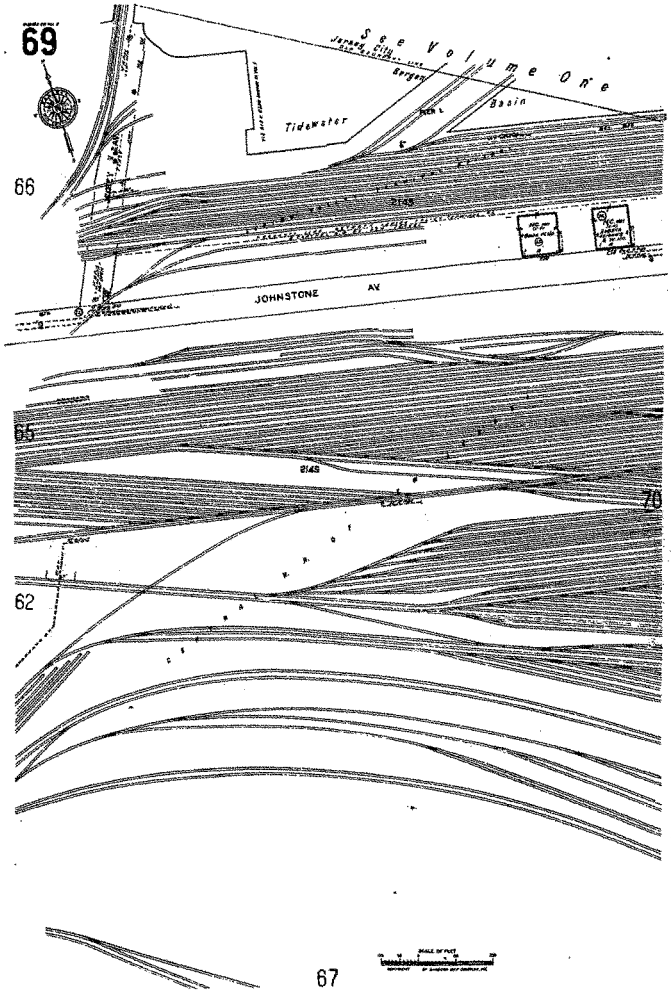


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC KIT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC

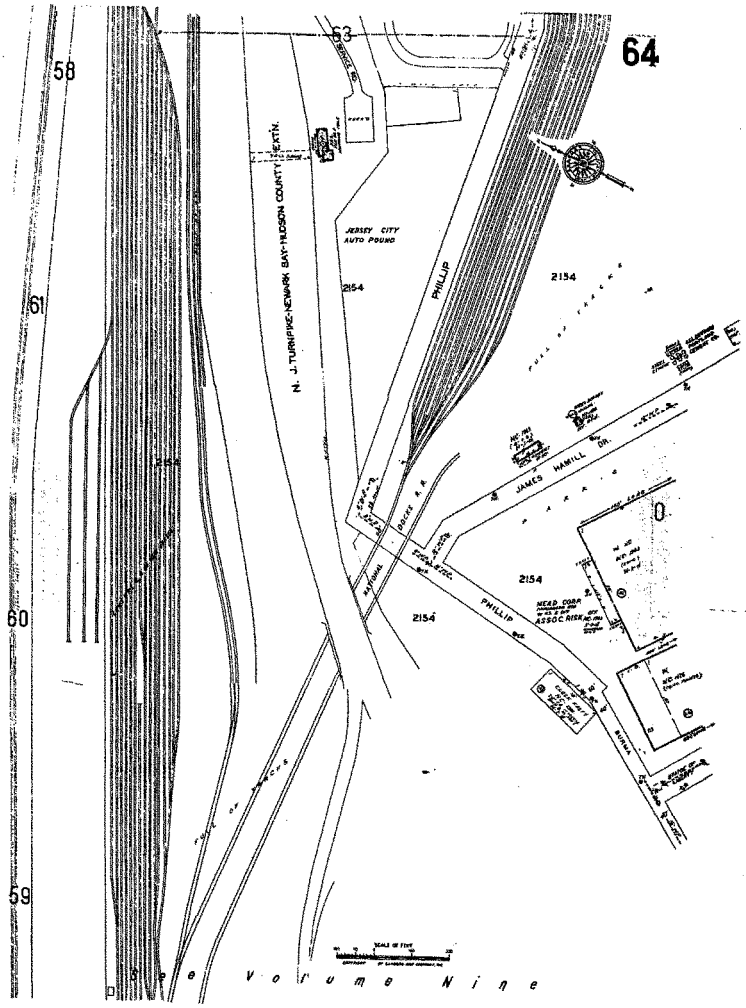


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
Year
KJT
EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from the Sanborn Library, LLC

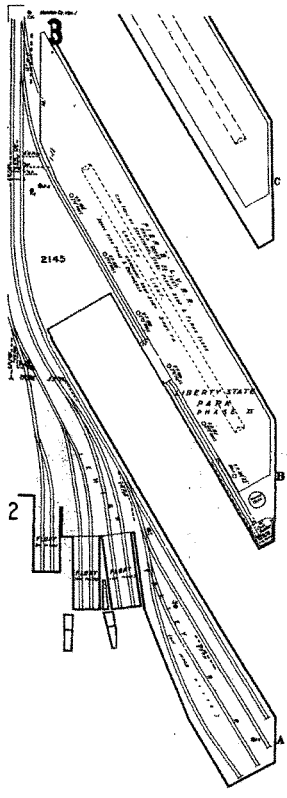

The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under an agreement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
Year
KIT
EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.
67
0
68
2145
2146
New York Bay
CENTRAL R. R. OF NEW JERSEY
70



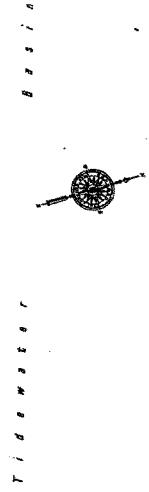
The Sanborn Library, LLC
This Sanborn® Map® is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC
Year
KJT
EDR Research Assistant
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

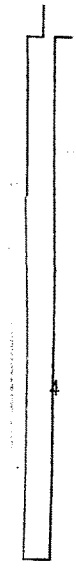


The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1979 The Sanborn Library, LLC KJT
Year EDR Research Associate
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC.

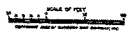


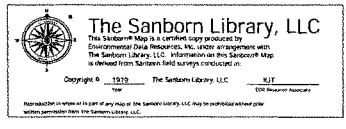
42

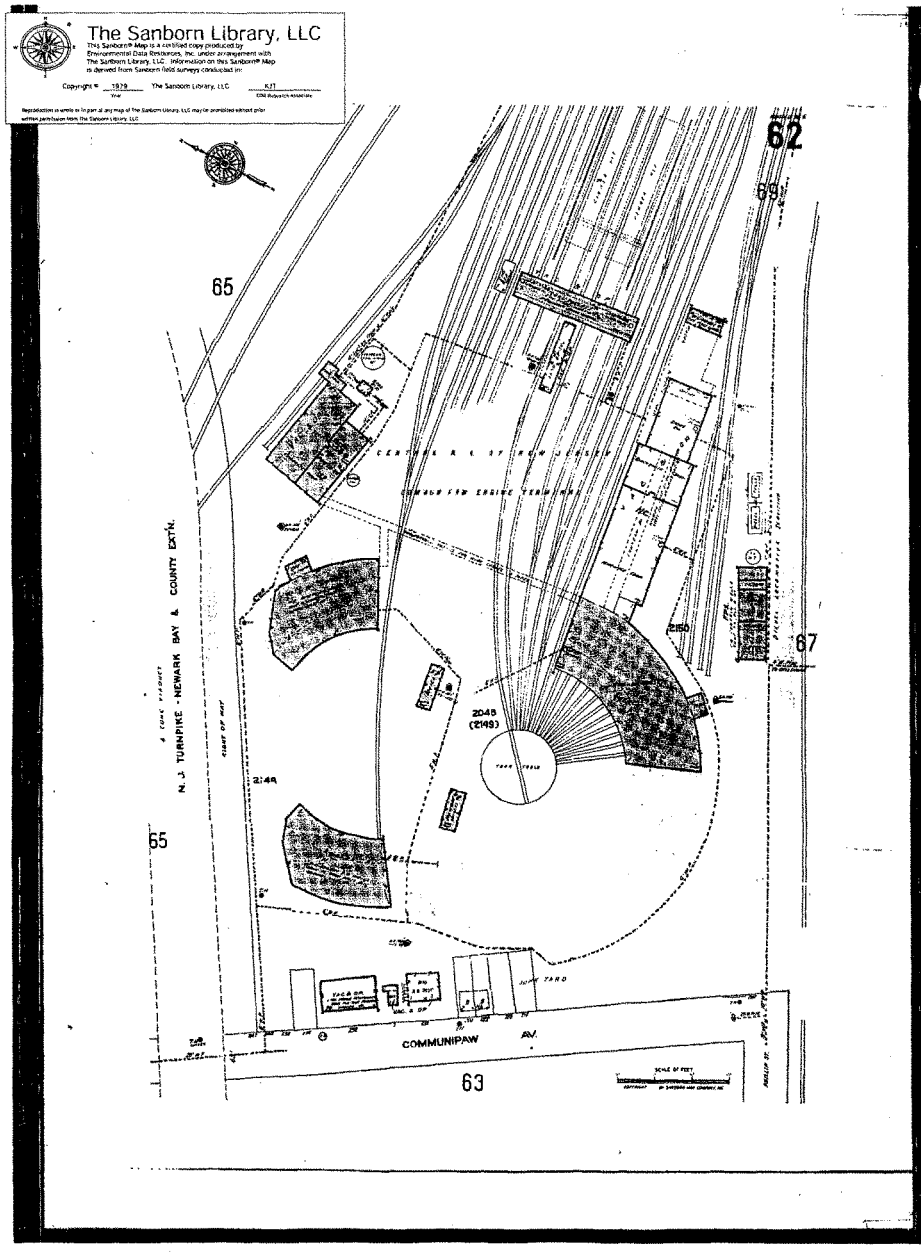


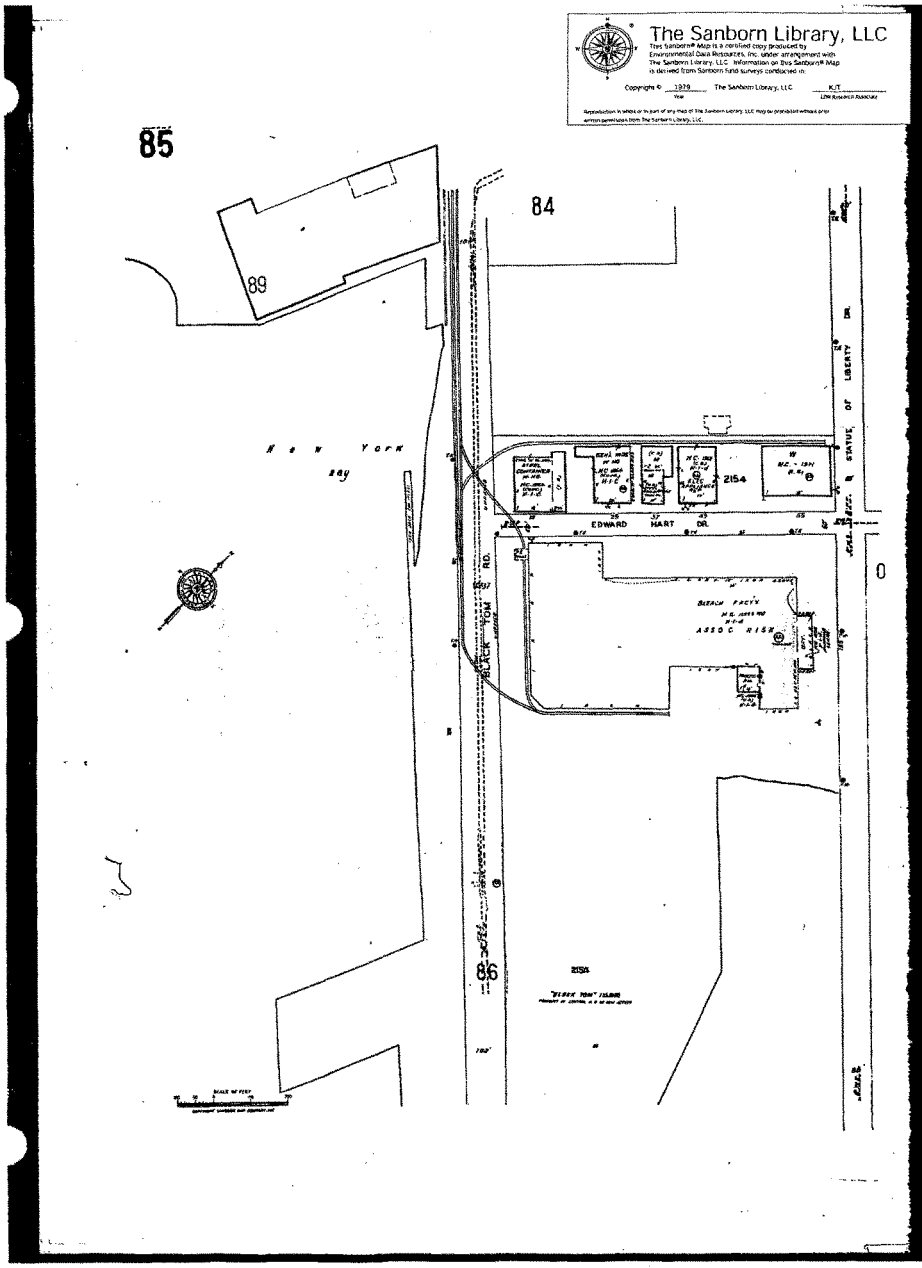


HUDSON RIVER






The Sanborn Library, LLC
This Sanborn® Map is a certified copy produced by Environmental Data Resources, Inc. under arrangement with The Sanborn Library, LLC. Information on this Sanborn® Map is derived from Sanborn field surveys conducted in:
Copyright © 1929 The Sanborn Library, LLC
Year
KIT
EDR Project Number
Reproduction in whole or in part of any map of The Sanborn Library, LLC may be prohibited without prior written permission from The Sanborn Library, LLC
62
69
65
67
63
N. J. TURNPIKE - NEWARK BAY & COUNTY DITH.
2048
(2149)
2149
COMMUNIPAW
AV.


The Sanborn Library, LLC
85
84
89
86
New York Bay
EDWARD HART DR.
BLACK TOM RD.
STATUE OF LIBERTY DR.
2154
ASSOC RISK

US Army Corps
of Engineers

BALTIMORE DISTRICT

SITE SPECIFIC HEALTH AND SAFETY PLAN

GEOTECHNICAL SUBSURFACE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NEW JERSEY

Prepared by:
Geotechnical Branch
Engineering Division
U.S. Army Engineer District, Baltimore
10 South Howard Street
Baltimore, MD 21201

July 2003

SITE SPECIFIC HEALTH AND SAFETY PLAN

GEOTECHNICAL SUBSURFACE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NEW JERSEY

TABLE OF CONTENTS

Section	Title	Page
1.0 HAZARD IDENTIFICATION		3
1.1	Task Analysis	3
1.2	Chemical Exposures	4
1.3	Chemical Hazards	5
1.4	Physical Hazards	5
1.5	Biological Hazards	5
1.6	Overall Hazard Evaluation	5
1.7	Activities Of Greatest Concern	5
2.0 TRAINING		5
2.1	Visitors	6
3.0 PERSONAL PROTECTION EQUIPMENT		6
4.0 MEDICAL SURVEILLANCE		7
5.0 EXPOSURE MONITORING/AIR SAMPLING PROGRAM		7
5.1	Chemical Contaminants	7
5.2	Noise	8
5.3	Temperature	8
5.4	Fire and Explosion	8

TABLE OF CONTENTS
(Continued)

6.0 STANDARD OPERATING SAFETY PROCEDURES, ENGINEERING CONTROLS AND WORK PRACTICES 11

6.1 Safety Meeting 11
6.2 Hazard Control 11
6.3 Standard Operating Procedures 11

7.0 SITE CONTROL AND SECURITY 13
7.1 Communication Procedures 13
7.2 Hazard Communication 14

8.0 EMERGENCY PROCEDURES 14
8.1 Emergency Procedures 14
8.2 Emergency Telephone Numbers 15
8.3 Emergency Medical Care 16
8.4 Emergency Reporting 16

9.0 STATEMENT OF UNDERSTANDING 16

SITE HEALTH AND SAFETY PLAN APPENDICES

Appendix	Title
SSHP-A	LEVELS OF PROTECTION
SSHP-B	ENVIRONMENTAL STRESS

SITE HEALTH AND SAFETY PLAN TABLES

SSHP-1	Monitoring Action Levels
SSHP-A1	Personal Protective Equipment Requirements

SITE SPECIFIC SAFETY & HEALTH PLAN

GEOTECHNICAL SUBSURFACE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NEW JERSEY

1.0 HAZARD IDENTIFICATION

1.1 Task Analysis

Site Mobilization/Demobilization: The hazards of this phase of activity are those associated with equipment movement, manual materials handling, and manual site preparation. Manual materials handling and manual site preparation may cause blisters, sore muscles, joint and skeletal injuries and may present the potential for eye hazards, contusions and lacerations. The animal and plant life of the site may present hazards of poison ivy, poison oak, ticks, fleas, mosquitoes, wasps, spiders and snakes. Slippery work surfaces can increase the likelihood of back injuries, overexertion injuries, and slips and falls.

Drill Rig Operation: Rig accidents can occur as a result of improperly placing the rig on uneven or unstable terrain, or failing to adequately secure the rig prior to the start of operations. Underground and overhead utility lines can create hazardous conditions if contacted by drilling equipment. During operation of heavy equipment associated with the installation of monitoring wells and bore holes there is the potential for personnel to be cut, struck, or pinned by equipment. Chapter 16, Section M of EM 385-1-1, provides detailed requirements for drilling equipment safety. The following standard procedures will be required during drilling operations:

- Drilling equipment will be inspected, operated, and maintained in accordance with the manufacturer's operating manual. A copy of the manufacturer's manual will be maintained on site.
- Overhead electrical hazards, ground hazards, and underground utilities will be identified prior to bringing the drill rig onsite.
- Drilling crews will be trained in the operation, inspection, maintenance, and safety features of the equipment based on the equipment's operating manual. Training will also include the locations of overhead electrical and underground utilities hazards.
- Drilling equipment will not be moved with the mast up unless the following conditions have been met:
  (1) movement is over level, smooth terrain;
  (2) the path of travel has been inspected for stability and the absence of holes, other ground hazards, and electrical hazards; and
  (3) the travel distance is limited to short, safe distances.
- Equipment will be set up on stable ground and maintained level; cribbing will be used when necessary. Outriggers will be extended in accordance with the manufacturer's specifications.
- Weather conditions will be monitored. Work will cease during electrical storms or when electrical storms are imminent.
- Loose clothing, jewelry, or equipment that can get caught in moving machinery will not be worn on site.

- Equipment operators will verbally alert employees and visually ensure employees are clear from dangerous parts of equipment before starting or engaging equipment.
- Hoists will be used only for their designed intent and will not be loaded beyond their rated capacity.
- Open boreholes will be capped and flagged; open excavations will be barricaded.

Sample Collection: The primary hazard of this task could be the potential for inhalation of contaminant organic vapors discharged during intrusive activities if hot spots are encountered. Dermal contact with contaminated water will be minimized through use of chemical resistant garments as described in Appendix A and avoidance of media that is suspected of being contaminated. Air monitoring for hazardous atmospheres will be conducted as described in section 8.0.

Decontamination Activities: Personnel involved in decontamination activities may be exposed to contaminated soil from heavily contaminated soil boring equipment, high pressure water spray, noise, and cold exposure from the water spray.

1.2 Chemical Exposure

The potential contaminants of concern (COC) at the site are Volatile Organics, Semi-Volatile Organics, Priority Pollutant – Metals, Total Chromium, Hexa-Valent Chromium, Pesticides/PCB's.

Even though the airborne exposure route for these COC is considered minimal for the site, they can still potentially cause adverse health effects to workers by the exposure routes of ingestion and direct contact.

Protective measures taken to mitigate exposure will also provide adequate and appropriate protection against known chemical contaminants detected on site. If the recommended PPE is used properly according to this plan, and Standard Operating Procedures (SOP) and decontamination procedures followed, unhealthful exposures should not occur.

1.3 Physical Hazards

Tasks required for activities associated with this project may involve exposure to slipping, falling, heat/cold stress, noise, and other physical hazards associated with intrusive activities which generate airborne particulates and/or release toxic vapors into the breathing zone of the workers. Skin absorption and ingestion may occur from contaminated soils or surface waters directly or from airborne contaminants.

1.4 Biological Hazards

Potential biological danger associated with this site are those which would be encountered working outside. Employees should exercise caution when encountering hazardous plants (poison ivy), animals and insects (snakes, spiders, bees, wasps, ticks, mosquitoes, ants, etc.) and

the surface waters at the worksite. Field personnel should wear adequate clothing to deny access to the skin and should examine themselves carefully everyday for the presence of ticks. Employees who are known to be highly sensitive to insect stings should carry a "sting kit" and notify the SSO at the worksite.

1.5 Overall Hazard Evaluation

[ ] High [ ] Medium [x] Low [ ] Unknown

1.6 Activities Of Greatest Concern (AGC)

All intrusive activities which generate airborne particulates can release toxic vapors into the breathing zone of the workers are AGC. Skin absorption may occur from contaminated soils and waters directly and from airborne contaminants.

2.0 TRAINING

All employees on this project have completed the hazardous waste worker training (40 hrs) which met the specific subjects outlined in 29 CFR 1926.65 (e) and have had the following additional training:

a. 3 days of actual field experience under the direct supervision of a trained experience supervisor.

b. 8-hours of refresher training, which is given annually.

All on-site supervisors have completed the above requirements and an additional 8-hour course for Management and Supervisor Training of hazardous waste operations. At least two members of the on-site personnel are currently certified in first aid and CPR. Documentation of training of Baltimore District employees is maintained in the Baltimore District office.

2.1 Visitors

Authorized visitors will not be permitted to enter areas where they may be exposed to hazardous substances if they do not meet the training requirements summarized above and applicable safety and health requirements. All visitors will be restricted to a passive status in which they may observe activities at the site from a distance, typically 50 feet or more.

3.0 PERSONAL PROTECTIVE EQUIPMENT

A personal protective equipment (PPE) program in accordance with 29 CFR 1926.65 (g) (5) and 29 CFR 1910.134 will be implemented. The level of protection to be implemented at the worksite was determined based on the type of chemicals suspected to be present, chemical toxicity characteristics and potential routes of worker exposure. The use of appropriate personal protective equipment, in conjunction with site entry and safety decontamination procedures will reduce the potential for worker contact with hazardous substances present at the site. It should be noted that the use of PPE can itself create hazards such as heat stress, impaired vision and mobility, and communication difficulties. Equipment and clothing selected will provide an adequate level of protection, but avoid, to the maximum extent practical, potentially adverse affects that can result from overprotection.

Levels of PPE will be used/worn as described by this plan are indicated in the following section. No downward changes to the level of protection as specified in this plan will be allowed without the approval of the Site Safety Officer. Appendix A states the specific equipment requirements of the designated Levels of Protection.

1) Description of Tasks: soil sampling, piezometer installation.

The project has planned to have the field team use a drill rig to drill boreholes at Liberty State Park and install piezometers in 20 boreholes. The SSO will collect the samples for eventual testing of volatile organic compounds, metals and other chemical groups.

[x] Intrusive [ ] Non-intrusive

Level of Protection

[ ] A [ ] B [ ] C [x] Mod-D [ ] D

2) Description of Tasks: piezometer development, decontamination, slug testing, long term monitoring

Sampling personnel will decontaminate the sampling equipment where necessary and develop the piezometers.

[] Instrusive [x] Non-intrusive

Level of Protection

[ ] A [ ] B [ ] C [x] Mod-D [ ] D

4.0 MEDICAL SURVEILLANCE

All employees working on this site have received proper medical clearance for respirator use and are enrolled in a medical surveillance program in accordance with 29 CFR 1926.65 and 29 CFR 1910.134 and are included in a medical surveillance program for hazardous waste workers.

5.0 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

5.1 Chemical Contaminants

VOC monitoring will be conducted by the Site Safety Officer continuously during the soil sampling tasks required by the project. Exposure monitoring will be conducted for the VOCs using a photoionization detector (PID) with a preferred 9.5 (or higher) eV bulb. The worker's breathing zone near the intrusive activities will be checked with the PID.

A single spike on the PID should not stop work, but a sustained reading (longer than ten seconds) or repetitive spikes (5 within 10 minutes) shall stop work. Detection of unusual odors shall not stop work.. (See emergency procedures for further instructions.) Work shall resume after adequate upgrade of PPE is accomplished. (See Appendix A for specific requirements of Levels of Protection.) Highest levels of PPE shall remain donned until additional monitoring indicates that a lower level of PPE is allowed.

Notations of momentary spikes, high readings, and actions taken will be recorded on the borings logs and in the intrusive activities logbook. All instruments will be calibrated daily according to the manufacturers instructions and recorded in the logbook.

Prior to performing field activities in dry, dusty areas where contaminated soils are likely to be encountered, workers will wet down the area of activity with water in order to decrease dust generation. If the wetting process is expected to result in potentially contaminated runoff, measures will be taken to contain the runoff. In the event that dust suppression measures are not feasible or adequate, workers in such areas will wear Level C PPE.

Monitoring Action Levels for chemical contaminants, explosion/fire, noise and temperature are shown in Table SSHP-1.

5.2 Noise

With the use of drill rig equipment as a part of this project, the potential for elevated noise levels in excess of 85 dBA is probable. A hearing protection program will be instituted if either continuous or impact noise levels exceed 85 dBA (slow response) for an 8-hour work shift, in accordance with 29 CFR 1910 and 1926. If unable to carry on conversation at an arm length, or at 3 ft. distance, hearing protection measures should be instituted. The SSO will use a Type II Noise Level Meter to monitor worker exposures. Hearing protection, such as ear plugs and

muffs, or administrative controls will be used if engineering controls are not feasible. If noise levels have sustained measurements exceeding 105 dBA, then double hearing protection (use of ear plug and muff together) will be required.

5.3 Temperatures

Heat stress monitoring of employees will be conducted when employees are wearing impermeable clothing and the ambient shaded dry bulb temperature is 70 °F or higher. Weather conditions will be monitored by the SSO. All monitoring data will be recorded in the logbook. Heat stress monitoring procedures are stated in section (1)(f) of Appendix B.

5.4 Fire and Explosion

Whenever identified materials are characterized as being flammable, the potential exist that fire and explosion could occur. Areas of intrusive activities will be monitored for combustible gas using a combustible gas/oxygen level indicator (CGI/O_2 Meter).

Table SSHP-1
Monitoring Action Levels

INSTRUMENT	LOCATION	ACTION LEVEL	ACTION
PID	Borehole	Reading above background	Move instrument to breathing zone, compare results
	Breathing zone	1.0 ppm or higher as a sustained[1] reading	Leave work area to allow levels to drop. If not dissipated in 30 minutes, continue work in Level C PPE.
		10ppm or higher as a sustained[1] reading	Cease work and consult Health and Safety Officer
		10 ppm or higher	Cease work and consult Health and Safety Officer
CGI/O_2	Borehole	< 10% of Lower Explosive Limit	No action required. Proceed with caution in areas that may contain combustible gas.
		10%-20% of LEL	Monitor work area to identify cause, perform continous CGI monitoring, remove ignition sources.
		> 20% of LEL	Evacuate work area and contact H&S Officer
Noise Meter	Entire worksite	Continuous 85 dBA or higher,	Continue work using personal hearing protection with minimum NRR of 20 dB
Environmental stress	Entire worksite	Any elevated stress condition[2]	Apply preventive measures, as required
Weather conditions	Entire worksite	Lightning within 10 statute miles	Cease work, move employees to safe area, wait for change in weather
Eye Protection	Entire worksite	Potential of projectiles/splash	Safety Glasses will be worn in the work zone, full face shield as appropriate
Slip/Trip/Fall	Entire worksite	Potential of incident	Work area will be kept clear of equipment , sediments and water. Good housekeeping practices will be followed.
Spill Containment	Entire worksite	Water/sediment	Shovels to move sediment. Absorbents applied as needed.

ACTION LEVEL - The action levels for the PID are based on measurements taken above background concentrations when the background concentration is less than 1 ppm. When background concentrations exceed 1 ppm total volatile hydrocarbons, PID action levels will be inclusive of background concentrations and so noted in the logbook.

[1] A sustained reading on the PID is a reading (longer than 10 seconds) or repetitive spikes (5 spikes within 10 minutes).

[2] As outlined in Appendix B (Environmental Stress).

6.0 STANDARD OPERATING SAFETY PROCEDURES, ENGINEERING CONTROLS AND WORK PRACTICES

6.1 Safety Meetings

The Site Safety Officer (SSO) will conduct a safety meeting at the start of each workday. Additional meetings may be conducted, as required. Meetings will include pertinent information regarding the day's work and include, but is not limited to, any of the following areas:

a. The whereabouts of any hazardous chemicals near specific work areas.

b. Methods used to detect the presence or release of hazardous chemicals at the site.

c. The physical and chemical health hazards of the hazardous chemicals at the site.

d. Protective measures such as safe work practices, emergency procedures, and personal protective equipment (PPE).

e. Details regarding the proper use of protective measures and material safety data sheets

f. The location of the evacuation point.

g. Changes to the SSHP.

6.2 Hazard Control

Work shall comply with all Federal, State, and local health and safety requirements including; OSHA 29 CFR 1904, 1910 and 1926, EPA 40 CFR 260-270, USACE EM 385-1-1, and all District safety directives and policies.

All instrusive activity sites will be inspected for health and safety hazards by the SSO prior to entering the site for the intrusive activity. The SSO will then take all corrective measures necessary to safely work at the site. This inspection and all corrective measures will be documented and communicated to all site workers at the initial safety meeting and subsequent safety meetings held.

6.3 Standard Operating Procedures

a. No eating or drinking is permitted within the contamination reduction zone (CRZ) or the exclusion zone (EZ). The CRZ and EZ are discussed in Section 10.0 and Appendix B. An exception is made for the replacement of fluids as a preventive measure for heat stress, however hands and face must be washed with potable water prior to drinking replacement fluids.

b. No tobacco use is permitted within the EZ or CRZ.

c. No beards or facial hair is allowed on site that may interfere with the seal of a negative pressure respirator.

d. No contact lenses will be worn on site in the EZ or CRZ.

e. Contamination avoidance shall be practiced to include not walking through puddles or mud unnecessarily, avoiding kneeling on ground or leaning on equipment whenever possible. Weather conditions that may escalate potential site hazards such as lightning, rain or extreme temperatures will be logged.

f. Wood planking and weighted plastic coverings will be placed over any bore holes that will remain open overnight.

g. If evidence of illegal dumping or other suspicious fill is encountered outside the project area, work at the location will stop. The area will be designated an Exclusion Zone and encircled with caution tape. The SSO will be notified immediately.

h. Noise-Hearing protection devices will be worn by all field personnel in work areas where noise levels are at or above 85 dBA.. The wearing of hearing devices is a condition of employment.

i. Employees will use extreme caution in inclined areas of the worksite. Ground surfaces may be wet, slippery and have hazardous objects protruding from the surface.

j. Dependent on the season in which the work will be performed, employees should exercise caution when encountering hazardous plants (poison ivy) and animals (snakes, spiders, bees, wasps, ticks, mosquitoes, ants, etc.) at the worksite. Employees who are known to be highly sensitive to insect stings should carry a "sting kit" and notify the SSO at the worksite. All employees are encouraged to use permethrin (0.50%) clothing repellent and DEET (30%) skin repellent for protection against ticks and mosquitoes. Skin repellent will not be used by sampling personnel.

k. Electrical - Equipment will be grounded and operating procedures will be in accordance with EM 385-1-1, Section 11.C.

l. Employees will exercise extreme caution in the vicinity of open excavations, if present. Under no circumstances will employees enter excavations or other confined spaces.

m. Thermal stress - All personnel will be assigned a "buddy" who will observe the employee for signs of thermal stress, although personnel should be alert for heat or cold related injuries. The signs and symptoms of thermal stress are included in Appendix C. In

addition, work/rest regimes, as outlined in the appendix in accordance with the ACGIH guidelines, will be established by the SSO when necessary. Water, Gatorade, or similar electrolyte liquid will be available on site.

n. Fire - No heaters or open flames will be allowed in any exclusion zone. If a heater is to be used, it will be a construction type (i.e. salamander). Flammable liquids will be stored in appropriate containers.

7.0 SITE CONTROL AND SECURITY

The worksite will be zoned to reduce the spread of hazardous substances to clean areas. An Exclusion Zone (EZ) will be established with a radius of 25 feet, when feasible, around the sampling operations and other areas of intrusive activities. No unauthorized person will be allowed within the EZ, nor will any authorized person remain unnecessarily in this zone. This zone will be delineated by yellow caution tape. Since this area has the highest potential for exposure to hazardous chemicals, the proper PPE must be worn in this area.

The Contamination Reduction Zone (CRZ) will be located just outside the EZ and delineated with yellow caution tape. Personnel in this area will be required to wear PPE which is one level less than that worn in the EZ. During intrusive field activities, the exact layout will depend on the wind direction the day of work and site conditions. The CRZ will have only one accessible point to the EZ.

The on site Support Zone (SZ) will be located upwind of the exclusion zone. The command post and staging area will be located inside this zone. No specific PPE requirements are needed in this area.

Site access will be denied to the general public by the SSO and the caution barriers. All equipment and materials will be secured during non-work hours.

Boreholes will not be left open when unattended.

7.1 Communication Procedures

a. Personnel will be informed of all known site hazards during an initial safety meeting and will be kept informed of hazards discovered during the site investigation.

b. Personnel in the Exclusion Zone will remain in constant communication or within sight of the Support Zone personnel. Failure of communication requires evacuation of the Exclusion Zone until communication is reestablished.

c. A mobile (cellular) telephone will be on-site whenever intrusive work is performed in the project area. The phone number will be determined once the SSO has been selected.

d. When the emergency signal is sounded, all personnel will depart the Exclusion Zone. Personnel will relocate to the decontamination area for personnel accountability. An emergency signal is considered an emergency signal for the Exclusion Zone and the project area.

e. The emergency signal will be one of the following:

(1) Any blast from a pressurized air horn.
(2) Verbal notification.

f. The following standard hand signals will be used:

(1) Hand gripping throat -- Out of air and cannot breathe.
(2) Grip buddy's wrist -- Leave area immediately.
(3) Both hands on buddy's waist -- Leave area immediately.
(4) Hands on top of head -- Need assistance.
(5) Thumb down -- No / negative.
(6) Thumb up -- Yes / I'm OK / I am all right.

7.2 Hazard Communication

Pursuant to OSHA, 29 CFR 1926.59, Material Safety Data Sheets (MSDS) along with a list for those materials covered by the MSDS will be available for all hazardous substances brought on site. Personnel will also be briefed by the SSO regarding hazardous chemicals present at the worksite prior to starting work that personnel could be exposed to.

8.0 EMERGENCY PROCEDURES

8.1 Emergency Procedures

a. Buddy System. A buddy system will be in effect in the Exclusion Zone (EZ) at all times.

b. Personal Injury in the EZ. If an employee is injured while in the EZ, the employee and his buddy will exit the EZ and proceed through the Primary Decontamination Area (PDA). An employee qualified in first aid/CPR will evaluate the nature of the injury and the integrity of the PPE and determine the need for first aid, evacuation and replacement of PPE. The SSO will be immediately notified of the incident. If additional aid is

required, the employee and his buddy will proceed through the Secondary Decontamination Area (SDA) as required.

c. Personal Injury in the Contaminant Reduction Zone (CRZ). If an employee is injured while in the CRZ, an employee qualified in first aid/CPR will evaluate the nature of the injury and determine the need for first aid and evacuation. The employee and his buddy will exit the CRZ, as required, proceeding through the Secondary Decontamination Area (SDA) if necessary. The SSO will be immediately notified of the incident.

d. Personal Injury in the Support Zone. If an employee is injured while in the Support Zone (SZ), an employee qualified in first aid/CPR will evaluate the nature of the injury and determine the need for first aid and evacuation. The SSO will be immediately notified of the incident.

e. Fire/Explosion. In the event of fire and/or explosion, the emergency signal will be sounded (see Section 10.1.e). All personnel will depart the EZ and move to the SDA for personnel accountability. The SSO will take appropriate action, such as controlling the spread of a small fire, summoning outside assistance or evacuating personnel to another location. For the proper operation of a fire extinguisher, the OSHA guidelines in 29 CFR 1926.150 (a) and the USACE Health and Safety Requirements from EM 385-1-1 (Section 09.E.) will be followed.

f. PPE failure. If an employee experiences a failure or alteration of PPE, the employee and his buddy shall stop work and exit the EZ. Reentry shall not be permitted until the PPE has been repaired or replaced.

g. Other Equipment Failure. If any other equipment on site fails to operate properly, the SSO and Project Team Leader shall be notified to make a determination of the effect this failure will have on operations.

h. In all situations, when an on-site emergency results in evacuation of the Exclusion Zone, personnel shall not re-enter until:

(1) The condition resulting in the emergency has been corrected;

(2) The hazards have been re-assessed;

(3) The safety plan has been revised and approval by all the initial concurring officers and

(4) Site personnel have been briefed on any changes in the SSHP.

8.2 Emergency Telephone Numbers

Names and phone numbers of all emergency response personnel (ambulance, physician, hospital, fire and police) and a map showing the route to the hospital will be conspicuously posted at the work site. All field personnel will be briefed concerning the people and equipment which will be summoned during an emergency and their responsibilities during an emergency situation requiring hospitalization. Emergency contacts and telephone numbers are provided below.

Hospitals

Name : **Christ Hospital**
Address : 176 Palisade Ave
Jersey City, NJ 07306
Telephone No.: **201-795-8200**

Name :- **Franciscan Health System**
Address :- 25 Mcwilliams Pl
Jersey City, NJ 07302
Telephone No.: **201-795-0390**

Name : **Garden State Surgical Center**
Address : 550 Newark Ave Fl 5
Jersey City, NJ 07306
Telephone No.: **201-795-0646**

Name : **Greenville Hospital**
Address : 1825 John F Kennedy Blvd
Jersey City, NJ 07305
Telephone No.: **201-547-6100**

Name : **Jersey City Medical Center** (see Figure #1 for map)
Address : **50 Baldwin Ave**
Jersey City, NJ 07304
Telephone No.: 201-915-2251

Name : **Pollack Hospital**
Address : 100 Clifton Pl
Jersey City, NJ 07304
Telephone No.: **201-432-1000**

Name : **Progressive Healthcare**
Address : 100 Clifton Pl
Jersey City, NJ 07304
Telephone No.: **201-946-2227**

Name :	**St Mary Hospital**
Address :	25 McWilliams Pl Jersey City, NJ 07302 Telephone No.: **201-418-1000**
Police	**911**
Fire Department and Ambulance (EMS)	**911**
Poison Control Center	**1-800-210-3985**
Environmental Response Teams (NY DEP)	**(718) 337-4357 or (800) 457-7362**

8.3 Emergency Medical Care

See Figure #1 for a map to the JERSEY CITY MEDICAL CENTER.

Jersey City Medical Center
50 Baldwin Ave
Jersey City, NJ 07304
201-915-2251

8.4 Emergency Reporting

The New York District Safety Office shall be notified of any incident at (212) 264-9050 and CENAN-PL-EA at (212) 264-4662. The SSO shall submit the necessary forms in accordance with EM 385-1-1.

9.0 STATEMENT OF UNDERSTANDING

SITE SAFETY AND HEALTH PLAN

Geotechnical Site Investigation
Liberty State Park, NJ
Jersey City, NJ

All site personnel have read the above plan and are familiar with its provisions. My signature below certifies that I have read, understand and will comply with the guidelines set forth.

Name	**Signature**	**Date**
Site Safety Officer (SSO):		
Other Site Personnel:		

FIGURES

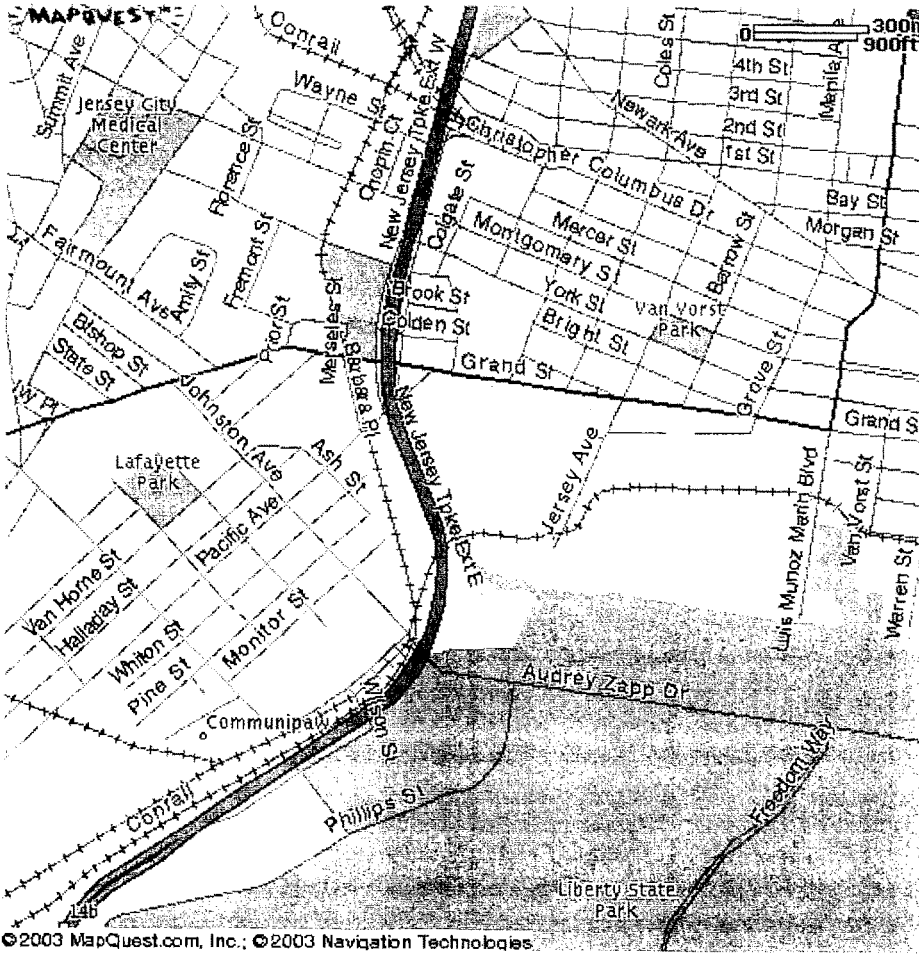


FIGURE #1 – Map to the **JERSEY CITY MEDICAL CENTER.**

Jersey City Medical Center
50 Baldwin Ave
Jersey City, NJ 07304
201-915-2251

APPENDIX A

LEVELS OF PROTECTION

Personal Protective Equipment - Levels of Protection

1. **Level B**

Positive-pressure, full-facepiece SCBA or positive-pressure, supplied-air respirator, with escape SCBA approved by NIOSH/MSHA
Inner (latex/nitrile) and outer chemical-resistant gloves (Viton)
Disposable hooded chemical-resistant coveralls (Saranex)
Chemical resistant boots with steel toe and shank
Hard hat and optional long underwear, cooler vest and inner coveralls

2. **Level C**

Hard hat, as required
Steel toe boots
Chemical-resistant outer boots, (nitrile)
Outer chemical-resistant gloves, (Viton)
Chemical-resistant inner (latex/nitrile) gloves
Hooded chemical-resistant/breathable clothing such as disposable coveralls (Kleenguard)
Hearing protection, as required
Full-face, air purifying respirator with (NIOSH approved) combination organic vapor/HEPA filtered cartridges (GMC-H)
Optional: chemical splash gear

3. **Level D Modified**

Safety glasses and same as **Level C** above, except no respiratory protection required
Optional: chemical splash gear including face shield or goggles

4. **Level D**

Hard hat, as required
Steel toe boots/shoes
coveralls
Chemical splash gear: rubber gloves, goggles, rubber boots, and rainsuit or apron (as required)

Table SSHP-A1
Personal Protective Equipment Requirements

PPE	A	B	C	Mod-D	D
Protective headgear (hardhat), as required	X	X	X	X	X
Hearing protection (minimum NRR 20 dB) (as required)	X	X	X	X	X
Safety glasses, as required				X	X
Overgarment					
Impermeable, encapsulating	X				
Impermeable, non-encapsulating (e.g. Saranex)		X	X[1]	X[1]	
Permeable, chemical resistant (e.g. Kleenguard)			X[2]	X[2]	
Permeable, non-chemical resistant (e.g. cotton)					X
Supplied air (e.g. SCBA[3] airline with EEBA[4])	X	X			
Full-face air-purifying respirator (combination organic vapor/HEPA filtered cartridges)			X		
Inner gloves (latex)	X	X	X	X	
Outer gloves (Viton or SilverShield)	X	X	X	X	
Footwear, with steel toe and shank	X	X	X	X	X
Footwear, outer, chemical resistant	X	X	X	X	
Splash-proof safety goggles				X[5]	
Face Shield (8 inch minimum length)				X[5]	

[1] For tasks involving splash or possible spills.
[2] For tasks not involving splash or possible spills.
[3] Self-contained breathing apparatus
[4] Emergency escape breathing apparatus
[5] For sediment and surface water sampling as necessary

APPENDIX B

ENVIRONMENTAL STRESS

1. **Heat Stress**

a. Heat stress injuries can easily occur when clothing (especially protective clothing) impairs the body's cooling capacity, the internal body temperature rises, and the normal thirst mechanism is not adequate to bring about fluid replacement that is lost through sweat.

b. When body temperatures taken at the beginning of a rest period indicate temperatures exceeding 99.6 °F (37.6 °C), the next work cycle should be shortened by 1/3. Another indication of rising internal temperatures is the heart rate. Heart rates can be obtained by counting the radial pulse during a 30 second period (and double it) as early as possible in a work period. If the heart rate exceeds 110 beats per minute shorten the following work cycle by 1/3.

c. The symptoms of heat stress in order of increasing severity include:

(1) Heat Cramps (inadequate fluid replacement)

(i) muscle spasms

(ii) pain in hands and feet

(2) Heat Exhaustion (inadequate blood circulation)

(i) pale, cool, moist skin

(ii) heavy sweating

(iii) dizziness

(iv) nausea

(v) fainting

(3) Heat Stroke

(i) red, hot, usually dry skin

(ii) lack of or reduced sweating

(iii) nausea

(iv) dizziness and confusion

(v) strong, rapid pulse

(vi) coma

d. Heat stress first aid includes:

(1) Heat Cramps

(i) Replace fluids

(ii) Monitor for additional symptoms

(2) Heat Exhaustion

(i) Move person to cool place

(ii) Rest with feet elevated

(iii) Give water in small amounts

(iv) Recovery is usually rapid, if not emergency medical treatment is necessary.

(3) Heat Stroke

(i) Cool body immediately with cool water or cold compresses

(ii) Call ambulance immediately

(iii) Continue cooling until ambulance arrives

e. Heat stress prevention includes:

(1) Adjusting work hours during the coolest hours;

(2) Scheduled rest periods;

(3) Maintaining body fluids at normal levels by consuming small drinks of moderate temperature every 15 to 20 minutes.

f. Since the ACGIH TLV work/rest schedule is designed for use with ordinary work clothes and not impermeable PPE, and a Wet Bulb Globe Temperature (WBGT) meter may not be available, the following modified schedule will be used to accommodate the PPE. If PPE is not being utilized, 10 °F should be added to the temperature schedule below.

(1) On a cloudy day, continuous work may be performed below 70 °F. Above this temperatures be aware of heat stress and use buddy system and guidelines below.

75% work / 25% rest each hour at air temperature 70-79 °F
50% work / 50% rest each hour at air temperature 79-85 °F
25% work / 75% rest each hour at air temperature above 85 °F

(2) At temperatures above 85 °F everyone should have their heart rate measurements taken at 30 minute intervals stop work in PPE when heart rate reaches 120 beats per minute. This schedule is conservative and if one is under a light work load the work periods can be extended. If under a heavy work load or a sunny day the rest periods can be extended.

(3) Note: Work shall cease at a shaded dry bulb temperature of 98 °F.

(4) Each employee should be aware of their own heart rate. If, between work periods, one feels their heart rate (pulse) may be greater that 120 beats per minute, STOP WORK, notify SSO, go to a shaded area, take heart rate and, if necessary, REST.

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix C

Cultural Resources

ATTN: LYNN RZKOS

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

RECEIVED
JUN 10 2003
HISTORIC PRESERVATION OFFICE

REPLY TO ATTENTION OF

June 3, 2003

HPO-F2003-230
03-1922-HF

Environmental Assessment Section
Environmental Analysis Branch

Ms. Dorothy P. Guzzo
Deputy Chief Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, New Jersey 08625

Dear Ms. Guzzo:

The New York District, U.S. Army Corps of Engineers (Corps), is proceeding with studies in connection with the Hudson-Raritan Raritan Estuary Ecosystem Restoration Project. Thirteen locations throughout the estuary have been identified as possible sites for restoration. At this time, one site, in Liberty State Park (LSP), Jersey City, Hudson County, is being studied in further detail (Enclosure 1). The draft cultural resources report for this location, entitled, "Phase IA Cultural Resources Investigation of the Hudson-Raritan Estuary Ecosystem Restoration Project, Liberty State Park, Hudson County, New Jersey," by Panamerican Consultants, Inc. is enclosed for your review (Enclosure 2).

Presently, just conceptual plans exist for the proposed restoration project. The study area is within a 251-acre parcel that extends from east-west from Freedom Way to Phillip Drive and north-south from Audrey Zapp Drive to Thomas McGovern Drive (Enclosure 3). The enclosed conceptual plan includes the creation of fresh water wetlands, salt marsh, a tidal creek, upland forest/scrub/shrub/grassland and the creation of a berm from on-site material. Much of this work would entail shallow excavation or filling. The deepest excavation is associated with the proposed salt marsh and tidal creek where excavation may go as deep as approximately two feet below mean low water. Please note that the graphics in the draft cultural resources report do not depict the proposed tidal creek that would connect the restoration area to the North Cove. The final document will include this feature.

The area proposed for wetland restoration was once open water. An analysis of soil borings, undertaken by archaeologists at the time LSP was being created, suggests that the potential for buried Late Pleistocene/Early Holocene deposits is high in certain areas within LSP as a whole (Historic Conservation and Interpretation, Inc. 1977 [HCI]). Near the project area traces of peat were found at approximately 43 feet below mean sea level (MSL). Wood, wood fiber and peat on bedrock were found between 94 and 101 feet below MSL. Work in connection with the restoration project is not anticipated to reach these depths. Shallower deposits (11 – 13 feet below MSL) were found to the south of the project area where bedrock rises rapidly. It is unlikely that any deposits would be encountered in the current project area. The sensitivity for prehistoric resources within the project area is low as the location consists entirely of man-made land and no work is anticipated to reach depths determined sensitive for paleo-environmental data. Work along the western edge of the project area, which was once the Communipaw shoreline and is therefore sensitive for prehistoric and early historic resources, will not include excavation.

Land at LSP was created over a period of six decades spanning the late 19th and early 20th centuries to hold the vast rail yards that developed along the Jersey City waterfront. HCI included a projection of shoreline changes in their 1977 report which indicates that land filling in the project area was completed by 1916 (Enclosure 4). Associated with the various fill episodes are likely to be timber cribbing and other construction methods used to retain fill. Late 19th and early 20th century cribbing has been recorded throughout the New York and New Jersey Harbor. The filling episodes were documented as they occurred and this data was included as an appendix to the HCI report (Enclosure 5). Most of the retaining structures were earthen. It should also be noted that Morris Canal boats were deliberately sunk in 1900 to form a fill retaining structure and may be present beneath the fill. Documentary evidence suggests that these boats are located to the east of the project area, on the opposite side of Freedom Way.

Railroad use within the project area was limited to rails, no longer present, and ancillary structures such as signals and livestock pens. The few remnants of these structures that remain on the property are deteriorated and are not considered eligible for the National Register of Historic Places.

The landscape on the whole was altered considerably with the construction of LSP. Within the park, little evidence remains of the once expansive rail yards. The proposed restoration project is within sight of the Statue of Liberty Ellis Island National Monument and the NRHP listed Central Railroad of New Jersey Terminal. It is not anticipated that the creation of new wetlands and habitat will have an effect on these important historic sites.

It is the Corps' opinion is that the restoration work at Liberty State Park will have no effect upon cultural resources if project plans remain as proposed. If excavation is determined necessary in the vicinity of the former Communipaw shoreline than subsurface work may be required. We will continue to coordinate with your office as the project proceeds. Please review the enclosed document and provide comments. If you or your staff require additional information or have any questions, please contact Lynn Rakos, Project Archaeologist, at (212) 264-0229.

Sincerely,

Josephine R. Cali

for Leonard Houston
Chief, Environmental Analysis Branch

Enclosures

CF (w/ enclosures)
Timpinero, LSP

Historic Conservation and Interpretation, Inc.
1977 Cultural Resource Reconnaissance Liberty State Park

CONCUR

JUN 27 2003

DEPUTY STATE HISTORIC PRESERVATION OFFICER

Contract No. DACW51-01-D-0018
Work Order No. 0009

U.S. Army Corps
of Engineers
New York District

PHASE IA CULTURAL RESOURCES INVESTIGATION OF THE HUDSON-RARITAN ESTUARY ECOSYSTEM RESTORATION PROJECT, LIBERTY STATE PARK, JERSEY CITY, HUDSON COUNTY, NEW JERSEY

FINAL REPORT

July 2003

Panamerican Consultants, Inc.
Buffalo Branch Office
2390 Clinton Street
Buffalo, New York 14227

PREPARED FOR:

Northern Ecological Associates, Inc.
451 Presumpscot Street
Portland, Maine 04103

UNDER CONTRACT TO:

Environmental Analysis Branch
Environmental Assessment Section
U.S. Department of the Army
New York District, Corps of Engineers
26 Federal Plaza
New York, NY 10278-0090

FINAL REPORT

PHASE IA CULTURAL RESOURCES INVESTIGATION OF THE HUDSON-RARITAN ESTUARY ECOSYSTEM RESTORATION PROJECT, LIBERTY STATE PARK, JERSEY CITY, HUDSON COUNTY, NEW JERSEY

Contract No. DACW 51-01-D-0018
Delivery Order No. 0009

Prepared for:
Northern Ecological Associates, Inc.
451 Presumpscot Street
Portland, Maine 04103

Under contract to:
U.S. Army Corps of Engineers
New York District
Environmental Analysis Branch
26 Federal Plaza
New York, New York 10278-0090

Prepared by:
Panamerican Consultants, Inc.
Buffalo Branch Office
2390 Clinton Street
Buffalo, New York 14227

Robert J. Hanley, M.A., RPA, Principal Investigator
Michael A. Cinquino, Ph.D., Project Director
Stacy L. Weber, M.A., Architectural Historian
Daniel M. Cadzow, B.A., Field Director
Arnold Pickman, M.A., Research Historian

July 2003

Management Summary

Project Name. Phase IA Cultural Resources Investigation for the Hudson-Raritan Estuary Ecosystem Restoration Project, Liberty State Park, Jersey City, Hudson County, New Jersey.

Project Background. Panamerican Consultants, Inc. (PCI) was contracted by Northern Ecological Associates, Inc. to conduct a reconnaissance level survey of the Liberty State Park project area for the U.S. Army Corps of Engineers, New York District (USACE). As part of the Hudson-Raritan Estuary Ecosystem Restoration Project, the USACE is examining Liberty State Park as one of thirteen areas for possible restoration from a degraded environment.

Project Location and Environmental Setting. Liberty State Park is located on the west shore of the Upper Bay of New York Harbor in Jersey City, Hudson County, New Jersey. Liberty State Park is a 1,121-acre area that includes nearly 600 acres of upland and 523 acres within a tidal zone. Adjacent attractions including the Statue of Liberty and Ellis Island draw over four million visitors to the park each year. Liberty State Park is former coastal marshland that has been filled in with refuse and construction debris in order to construct a large rail yard.

The Area of Potential Effect (APE) comprises 251 acres of overgrown terrain in the center of the park encompassed by Phillip Street, Thomas McGovern Drive, Freedom Way and Audrey Zapp Drive. Nearly the entire perimeter of the APE is surrounded by a chain link fence. Elevations do not exceed 3 m (10 ft) above mean sea level.

Purpose and Goals. The proposed ecosystem restoration includes the development and enhancement of costal upland woodlands and grasslands, the enhancement of freshwater wetlands, the restoration of tidal wetlands, and the preservation of a unique "moss mat community" (USACE 2002:2). The Phase IA cultural resource investigation was conducted to assess the potential for encountering cultural resources (i.e., archaeological sensitivity) within the APE.

Regulatory Basis. USACE, as a federal agency, has management responsibilities concerning the protection and preservation of cultural resources on land it controls or uses. Federal statutes require USACE to identify and evaluate significant cultural resources on these properties, and include: National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 *et. seq.*) through 1992 (which includes Section 106 compliance); the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800); as well as Army Regulation (AR) 200-4 "Cultural Resources Management."

Cultural Resources Survey Work Completed. Background research and field inspection were conducted for the project area as part of the Phase IA investigation. Background research included a review of historic documents, previous research reports, a site file check, and historic map analysis. Repositories visited include the New York Public Library, General Research, Local History and Genealogy, and Map Divisions; New York City Landmarks Preservation Commission; New Jersey Historic Preservation Office (HPO); and the U.S. Army Corps of Engineers New York District. Field investigations included walkover reconnaissance and photographic documentation.

Survey Results. Historic maps and literature show the entire APE to be made land for use by the Central Railroad of New Jersey (CRRNJ). The project area was formerly tidal marsh that was filled between the 1860s and 1919. Maps of the 1870s illustrate the shoreline at Phillip Street, which forms the western boundary of the APE. Therefore, the archaeological sensitivity for

prehistoric cultural resources within the APE is limited to submerged Late Pleistocene/Early Holocene deposits. These would be located beneath the landfill and also beneath underlying organic bay silts and peat that accumulated after inundation of the area by rising sea levels.

Few structures other than railroad tracks formerly existed within the project area. The most prominent structures were the Central Union stockyards formerly located near the center of the project area. The stock yards consisted of a series of structures situated on a long, narrow open platform. The structures appear to have been receiving pens including sheep and hog sheds, cattle pens, and a hay barn. CRRNJ's Marine Repair Yard, comprised of small shops for blacksmiths and carpenters, is also depicted near the northern end of the APE.

Most of the APE is overgrown with a mix of deciduous and coniferous trees, sparse and dense brush, open grassland, and low wet areas with stands of *Phragmites*. Piles of railroad ties are scattered across the north, central and west portions of the APE. Modern debris has been dumped across the APE, including building materials, garbage, a metal trailer, and push-piles of rubble. Push-pile berms are present and dirty fill was visible at some exposed locations. Approximately 24 acres in the southwest corner of the APE is covered by a landfill surrounded by a chain-link fence.

Remnants of the former rail yard are present within the Liberty State Park APE that include: two 3-by-5-ft concrete drain openings, burned remains of a wood structure, the base of a former tower, two cast concrete "telephone" booths, and partially *in situ* railroad ties/track bed.

Conclusions and Recommendations. The archaeological sensitivity for prehistoric cultural resources within the APE is very low. Documentary and field research results show the APE to be made land. Therefore, the sensitivity for prehistoric remains in the APE is limited to submerged Late Pleistocene/Early Holocene deposits located beneath the landfill and underlying natural sediment. A previous investigation (Rutsch and Leo 1979) of more sensitive locations just west of the APE did not find evidence of any shell midden or other prehistoric deposits. Further investigation will not likely yield prehistoric cultural resources.

Landfill in the northern portion of the APE could contain artifacts from mid-nineteenth-century landfill deposits, as well as landfill-retaining structures such as wooden cribbing. Landfill in the southwestern portion of the APE could contain later artifacts as well as early twentieth-century landfill-retaining cribbing. However, artifacts found in the landfill will likely not be considered cultural resources due to the lack of context and ambiguous point of origin. The cribbing used to retain the fill also has limited research importance. Canal boats, deliberately sunk as part of the landfilling process, may be present beneath the fill, although Rutsch et al. (1977:332) depict the canal boats sunk east of the APE.

Remains associated with the former rail yard do not appear to be cultural resources. A burned wooden structure appears to be the remains of a small, twentieth century railyard outbuilding. There is no structural integrity and the construction materials are modern. Further investigation of these features will not likely yield information involving the history of the rail yard or the project area in general.

In summary, the proposed ecosystem restoration project will have no impact on cultural resources as none were identified during this Phase IA cultural resource investigation. No further investigations are recommended for the APE at Liberty State Park.

Table of Contents

SECTION	PAGE
Management Summary	ii
List of Figures and Tables	v
Acknowledgments	vii
1.0 INTRODUCTION	1-1
2.0 RESEARCH DESIGN	2-1
2.1 Objectives	2-1
2.2 Properties Investigated and Recorded	2-1
2.3 Methods to Address the Research Objectives	2-2
2.3.1 Background Research	2-2
2.3.2 Field Methods	2-2
2.3.3 Problems or Biases Encountered	2-3
3.0 BACKGROUND RESEARCH	3-1
3.1 Physical Setting	3-1
3.2 Paleoenvironment	3-1
3.3 Cultural Background	3-2
3.3.1 Prehistoric Overview	3-2
3.3.2 Historic Overview	3-6
3.4 Review of Known Sites and Previous Research	3-22
4.0 INVESTIGATION RESULTS	4-1
4.1 Archaeological Sensitivity Assessment	4-1
4.2 Field Reconnaissance	4-1
5.0 CONCLUSIONS AND RECOMMENDATIONS	5-1
6.0 REFERENCES CITED	6-1

Appendix A -Interim Report
Appendix B -Scope of Work
Appendix C -Vitae of Key Personnel

List of Figures and Tables

DESCRIPTION PAGE

1.1 Location of the Liberty State Park project area within Jersey City, Hudson County, New Jersey 1-2

3.1 Coast Survey of the New York Harbor showing the approximate location of the project area in 1845 3-12

3.2 The approximate location of the project area in 1855. 3-13

3.3 The approximate location of the project area in 1873 3-15

3.4 Map of Jersey City showing the approximate location of the project area in 1879 3-16

3.5 U.S. Corps of Engineers map showing the approximate location of the project area in 1881 3-17

3.6 The approximate location of the project area in 1896 3-18

3.7a Phillip Street south of Communipaw Avenue; APE includes area south of Phillip Street.. 3-19

3.7b Phillip Street just south of Communipaw Avenue in 1896; APE includes area south of Phillip Street 3-20

3.7c Fire insurance map showing the southernmost section of Phillip Street; APE in lower right corner 3-21

3.8 The Communipaw Cove area showing the approximate location of the project area in 1908 3-23

3.9 Detail of Fire Insurance map showing the Central Union Stock Yards Co. in 1911 ... 3-24

3.10 Communipaw Cove showing the approximate location of the project area in 1919 .. 3-25

3.12 A U.S. Coast Survey of Communipaw Cove showing the approximate location of the project area in 1944 3-26

3.13 A U.S. Geological Survey showing the approximate location of the project area in 1955 3-27

4.1 Vegetation across the northern portion of the APE, facing southwest 4-4

4.2 Open fields along the western side of the APE (Liberty Science Center and Jersey City skyline in the background), facing northeast 4-5

4.3 Vegetation and asphalt road in the eastern-central portion of the APE, facing northwest... 4-6

4.4 *Phragmites* across the wet southeastern corner of the APE, facing northwest 4-7

4.5 Gravel trail and wooded area in the vicinity of the southeastern APE boundary, facing northeast 4-8

4.6 Approximately 50-acre rectangular wet area in the northeast portion of the APE, facing southwest 4-9

4.7 Illustrated plan view of the Liberty State Park APE 4-10

4.8 Pile of railroad ties in wooded northern part of APE, facing north 4-11

4.9 Push-piles in the central part of the APE, facing west 4-12

4.10 A pile of cut and drilled granite and concrete in the north-central part of the APE, facing north 4-13

4.11 Tire piles dumped in the APE, facing south 4-14

4.12 Modern garbage (e.g., sink, television, tires) dumped in the APE, facing northeast .. 4-15

4.13 Modern rubble and garbage dumped in the APE, facing south 4-16

4.14 Large berm in the south-central potion of the APE, facing north 4-17

4.15 Cinder, slag, glass, brick, mortar, and gravel fill exposed at the base of a fallen tree, facing east 4-18

4.16 Cinder and gravel fill in the south-central portion of the APE, facing southwest 4-19

4.17 Easternmost drain opening, facing east and down 4-20

4.18 Westernmost drain opening, facing west and down 4-21

4.19 Collapsed and burned structure in the north-central portion of the APE, facing east . 4-22

4.20 Close-up of tower base/footing located along the western APE boundary, facing south and down 4-23

4.21 Hexagonal concrete "phone booth", facing northwest 4-24

4.22 *In situ* railroad ties in the south central portion of the APE, facing southwest 4-25

TABLE

4.1 GPS Provenience Log 4-2

Acknowledgments

Panamerican Consultants, Inc. wishes to thank Ms. Lynn Rakos, archaeologist at the New York District Office of the U.S. Army Corps of Engineers for her assistance throughout this investigation. We would also like to thank Mr. Michael Timpanero, Liberty State Park Historian, for his assistance with this investigation and the Liberty State Park Police for granting us access to the project area. Finally, we want to thank Dr. David Turkon and Mr. Thomas Turkon for sharing their knowledge of railyard features.

1.0 Introduction

Panamerican Consultants, Inc. (PCI) was contracted by Northern Ecological Associates, Inc. to conduct a reconnaissance level survey of the Liberty State Park project area in Jersey City, Hudson County, New Jersey (Figure 1.1) for the U.S. Army Corps of Engineers, New York District (USACE). The Area of Potential Effect (APE) is a roughly 251-acre parcel of land in the center of Liberty State Park encompassed by Phillip Street, Thomas McGovern Drive, Freedom Way and Audrey Zapp Drive. As part of the Hudson-Raritan Estuary Ecosystem Restoration Project, the USACE is examining Liberty State Park as one of thirteen areas for possible restoration from a degraded environment. This location is being studied to identify and inventory water resources and sediment quality problems related to the enhancement and creation of aquatic, wetland, and adjacent upland habitats (USACE 2002:1). USACE is planning to develop and enhance coastal upland woodlands and grasslands, and freshwater wetlands; restore tidal wetlands; and preserve a unique "moss mat community" (USACE 2002:2).

The purpose of this Phase IA cultural resources investigation is to assess the potential for encountering cultural resources (i.e., archaeological sensitivity) within the APE. This investigation includes documentary and background research, historic map analysis, a site file check, and walkover reconnaissance. The field investigation was conducted during the week of December 8, 2002. Dr. Michael A. Cinquino served as Project Director. Mr. Robert J. Hanley, M.A., served as Principal Investigator and Project Archeologist. Ms. Stacy Weber, M.A., served as Historian. Mr. Daniel M. Cadzow served as Field Director. Mr. Arnold Pickman served as Research Historian. Ms. Lynn Rakos, USACE Project Archaeologist, was the technical point of contact between PCI and USACE.

This investigation was conducted in compliance with the National Historic Preservation Act as amended through 1992, the National Environmental Policy Act of 1969, Archeological Resources Protection Act of 1979 (18 CFR 1312, 32 CFR 229, 36 CFR 296, and 43 CFR 7), Archaeological and Historic Preservation Act of 1974 (Public Law 93-291; 16USC 469-469c), Native American Graves Protection and Repatriation Act of 1990 (Public Law 101-601), Curation of Federally-Owned and Administered Collections, September 12, 1990 (36 CFR 79) and the Advisory Council Procedures for the Protection of Historic and Cultural Properties (36 CFR Part 800) as well as Army Regulation (AR) 200-4 "Cultural Resources Management." The survey also complied with New Jersey Historic Preservation Office (New Jersey HPO) guidelines for preparing cultural resource reports.

Project materials (e.g., photograph negatives, field notes) will be held at PCI's Buffalo Office until completion of the project and submitted to USACE upon acceptance of the final report.

2.0 Research Design

2.1 OBJECTIVES

The Phase IA cultural resources investigation is designed to determine the presence or absence of cultural resources within the Area of Potential Effect (APE) by conducting field inspection and historic, architectural and map research. Impacts on cultural resources that could result from the proposed ecosystem restoration are also assessed as part of this investigation. Cultural remains, if present, are considered a cultural resource when they exhibit the appropriate qualities required for National Register of Historic Places (NRHP) eligibility. The Criteria of Evaluation (36 CFR 60) as outlined in the National Park Service Publication: "Guidelines for Local Surveys: A Basis for Preservation Planning" (National Register Bulletin 15) include:

Criterion A: (Event) Properties that are associated with events that have made a significant contribution to the broad patterns of our history; or

Criterion B: (Person) Properties that are associated with the lives of persons significant in our past; or

Criterion C: (Design/Construction) Properties that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

Criterion D: (Information Potential) Properties that have yielded, or may be likely to yield, information important in prehistory or history (NPS Bulletin 15, referencing 36 CFR Part 60).

For a cultural resource to be considered eligible for listing in the National Register it must be evaluated within its historic context and shown to be significant for one or more of the four criteria listed above. The cultural property (e.g., archaeological site, historic structure or landscape) must also retain the historic integrity of those features necessary to convey its significance. The information likely to be recovered from the cultural resource must confirm, refute, or supplement, in an important way, existing information. A property is not eligible if it cannot be related to a particular time period or cultural group and thereby lacks any historic context to evaluate the importance of the information to be collected (NPS Bulletin 15, pp. 3, 22).

Integrity is defined as *the ability of a property to convey its significance* (NPS Bulletin 15, p. 44). To merit eligibility, a property must be significant and must also have integrity. Seven aspects of integrity recognized by the National Register are location, design, setting, materials, workmanship, feeling, and association. (For a more detailed description of each aspect see NPS Bulletin 15, pp. 44-45.)

2.2 PROPERTIES INVESTIGATED AND RECORDED

Liberty State Park is a 1,121-acre area that includes nearly 600 acres of upland and 523 acres within a tidal zone (see Figure 1.1) (USACE 2002:2). The Area of Potential Effect (APE) comprises 251 acres of overgrown terrain in the center of the park encompassed by Phillip

3.3 CULTURAL BACKGROUND

3.3.1 Prehistoric Overview. The prehistory of northeastern North America is marked by three major periods spanning about 12,500 years. The earliest of these periods is the Paleo-Indian which lasted from 11,000 to 8000 BC. Paleo-Indians lived in seasonal camps near fresh water sources and at lithic workshops. They subsisted by hunting and gathering. The Paleo-Indian was followed by the Archaic period which lasted from 8000 to 1000 BC and was characterized by seasonally occupied campsites and later by seasonal villages. The Archaic subsistence system was hunting and gathering and possibly incipient horticulture toward the end of the period. After 1000 BC, Native Americans of the Woodland period lived in seasonally occupied villages and campsites and subsisted by hunting, gathering, and by AD 1000, horticulture. It was during this period that ceramics were first made in northeastern North America. These periods are described in more detail below.

Paleo-Indian Period. Paleo-Indian cultures were adapted to a late-Pleistocene tundra or park tundra environment. Paleo-Indians were highly mobile people whose search for food took them over long distances. The emergence of oak stands and resultant increase in resource availability allowed greater human population density toward the end of the period. Pleistocene megafauna including mammoth, mastodon, great beaver, fossil bear, and northern species like fox, seal, moose and caribou roamed the northeast. A variety of other species like fossil peccary, white tailed deer, elk, bison and horse had also adapted to the northeast.

In addition to hunting, Paleo-Indians had fish and plant foods available to them. Pollen analysis of samples from the Shawnee-Minisink site near the Delaware Water Gap has revealed the presence of many edible plants. Carbonized seeds were recovered by flotation. Some of the plants identified by these means included Goose foot (Chenopodium sp.), ground cherry, black berry, hawthorn plum, pokeweed, pigweed (Amaranthus sp.), smart weed (Polygonum sp.), wild lettuce, grape, hackberry, and meadow grass (Kraft 1986:41).

Early Paleo-Indian chipped stone artifacts include fluted points which are thin, lanceolate-shaped bifacial implements fluted down the center for hafting, unifacial end and side scrapers, utilized flakes, and waste flakes (Marshall 1982:13). Fluted points gradually decreased in size as larger game animals moved north or became extinct (Kraft 1986:47). Fluted points were eventually replaced in the late Paleo-Indian period (8000-6000 BC) with unfluted triangular points, stemmed points and Plano points. The last are lanceolate-shaped points without flutes.

Archaic Period. According to Kraft (1986), the transition from Paleo-Indian to Early Archaic is not clearly indicated in the Middle Atlantic region. The Archaic period developed out of the late Paleo-Indian period, probably as a product of changes in the environment. For the northeast, this period is divided into Early Archaic, Middle Archaic, Late Archaic, and Terminal Archaic (Kraft and Mounier 1982).

The Early Archaic began around 8000 BC and continued until 6000 BC, when the modern temperate environments began to develop. During the Early Archaic, the hills and mountains were overgrown with pine, hemlock and oak while forests in the coastal areas were chestnut and oak (Kraft and Mounier 1982:59). The retreating glacier caused a rise in sea levels forcing people to move inland. People lived in small territorial bands that hunted, fished, and gathered plant foods. With the exception of the dog, they had no domestic animals (Kraft 1986:51).

Lifeways were similar to those of the Paleo-Indian Period; but, there were modifications in technology related to gradual environmental changes (Kraft 1986:51). The people of the Early Archaic period subsisted on elk, deer, bear, beaver, turkey, migratory waterfowl, fish, shellfish, turtles, frogs (Kraft and Mounier 1982:65), as well as berries, roots, tubers, eggs, and nuts (Kraft 1986:51). They probably moved when food supplies dwindled. The small encampments close to rivers or ponds that are typical of Early Archaic sites reflect this mobility (Kraft and Mounier 1982:76). The Early Archaic tool kit consisted of stemmed and notched projectile points, bifurcate-base points, knives, scrapers, choppers, as well as wood and bone-working tools such as hammerstones and drills (Kraft and Mounier 1982:65). During this period, settlements in the vicinity of the project area were riverine/coastal encampments of small, highly mobile bands. In these areas, Archaic peoples exploited the local floral and faunal resources, including shellfish, deer, and small animals. The location of sites is directly related to resource availability.

The Middle Archaic period lasted from 6000 to 4000 BC. The environment was changing from the glacial environment to the modern temperate climate. By 5000 BC, the climate was warm and moist; as water levels continued to rise, groups moved further inland. Oak, chestnut, beech, and elm dominated the landscape causing animal populations to increase because of the abundance of mast foods in the forests. People of the Middle Archaic subsisted on chestnuts, acorns, and fish, as well as game. Heavy woodworking tools, along with net sinkers, and fish remains found on archaeological sites suggest a riverine adaptation. There are more and larger sites for this period, which signifies increased sedentism. Quarry sites are also found. Artifacts made of argillite, shale, and quartzite suggest an expansion of communication, transportation, and exchange. Territories were controlled by the bands and sites were located within these territories, and occupied seasonally (Kraft and Mounier 1982:71-83; Kraft 1986:73).

People began to develop woodworking tools during the Middle Archaic using coarse-grained stones and river cobbles as raw materials. These were commonly available in large sizes and allowed tool makers to reserve high quality lithic materials for finely flaked tools. In order to work these coarse-grained rocks, new shaping techniques had to be developed. The primary technique was pecking and grinding which shaped axes, adzes, gouges, choppers and other woodworking or rough-stone tools. These heavy woodworking tools may have been used for canoe building (Kraft and Mounier 1982:71-83; Kraft 1986:73). The Middle Archaic tool kit also included anvil stones, choppers, net sinkers, and an array of projectile points.

During the Late Archaic (4000-1000 BC) hunting, fishing, and gathering were still the principal daily activities. The temperate environment had developed by 5000 BC, and was a deciduous forest biome, with oak, chestnut, and hickory. Deer and turkey would have been available as meat resources, but, during the Late Archaic, there was a greater emphasis placed on lower links in the food chain, including small game, shellfish, nuts and wild cereal grains like Chenopodium. This shift in subsistence strategies, related to the emerging temperate environment, made higher population densities possible (Kraft and Mounier 1982:71-83; Kraft 1986:73).

As population increased, camps became larger and more numerous. Principal settlements were located near major rivers. People lived in bands, with well-defined territories (Kraft and Mounier 1982:71-83; Kraft 1986:73). By about 2500 BC, there was a center-based wandering system of subsistence and settlement, with a riverine focus. The exploitation of resources included a wide range of habitats. They moved seasonally to acquire particular resources in a new area or when resources dwindled. Groups probably congregated occasionally for exchange

and socialization. Houses of this period may have been circular and oval measuring 11 to 20 m (36 to 66 feet) in diameter with overlapping entranceways. One such house pattern was found at the Wapanucket #6 site in Massachusetts.

Heavy grinding implements like mullers, mortars and pestles provided new means of preparing food from seeds, nuts, dried berries and meat (Kraft and Mounier 1982:71-83; Kraft 1986:73). These tools were made of sedimentary and metamorphic rocks like sandstone and argillite. Other implements used were bifacial, chipped stone knives, semilunar knives which were often made of slate, the atlatl or spear thrower, bolas, and plummets. Long, narrow stemmed or narrow, weakly notched projectile points like Poplar Island, Bare Island, Lackawaxen stemmed, and Normanskill were characteristic of the Piedmont Tradition (also known as the Small Stemmed Tradition) which originated in the Southeast (Kraft 1986:73). These projectile points were seldom reworked into scrapers, drills and gravers because of their size and shape. Another innovation was steatite or soapstone pots which made cooking and food preparation easier.

The Late Archaic of northern New Jersey was formed by influences from the Piedmont Archaic in southern New Jersey, Virginia, and North and South Carolina, and the northern Archaic of New England. From the south, the main cultural traditions which affected the northern New Jersey are the Small Stemmed Point Tradition, and the Susquehanna Tradition. The Small Stemmed Point Tradition occurs from Virginia to southern New England, and is represented by small, slender, stemmed points and small triangular points, as well as, ground stone woodworking tools, such as gouges and adzes, atlatl weights, knives, scrapers, mullers, pestles, choppers, and hematite or graphite paintstones (Kraft and Mounier 1982:71-83; Kraft 1986:73).

Nut-bearing trees like oak, hickory, chestnut, and beech dominated the eastern forests during the Terminal Archaic (2000-1000 bc). Sea levels continued to rise, causing increased salinity in estuaries, including the lower Hudson river (Kraft 1986; Snow 1980). People subsisted on deer, black bears, small mammals, wild turkeys, pigeons, shellfish, fruits, roots, nuts, and fish.

The Susquehanna Tradition emerged in the Late Archaic around 2500 BC and is typified by broad stemmed and notched points, and "fish-tail" points (Kraft 1986:84). This tradition may have diffused from Georgia, northward along the Atlantic coast, into southern New Jersey, and north to Maine. It lasted until 1000 BC. Projectile points include the Brewerton, Vosburg, and Beekman Triangle types (Kraft and Mounier 1982:69).

Archaeologists have identified a Terminal Archaic subperiod for northern New Jersey, which lasted from about 1500 to 1000 BC. Marking this transitional period between the Archaic and the Woodland are changes in the forms and characteristics of the spearpoint. New points which are broader, thinner, and skillfully worked may have originated in the southern Piedmont area. At the same time, soapstone or steatite bowls were also used. People of this time inhabited the riverine areas of northern New Jersey, and cremated their dead. By the end of this subperiod, pottery was made and used in northern New Jersey. Called Marcey Creek Plain, these pots were made with fragments of steatite bowls for the temper (Kraft and Mounier 1982:69-71).

Woodland Period. The Woodland period is marked by the presence of pottery. Pottery is significant because it improves the efficiency of food preparation and storage (Curtin 1992:6). In addition to the manufacture of pottery, the Woodland period also had agriculture, more elaborate rituals, and increased sedentism. This period is normally divided into early, middle, and

late subperiods, dating between 1000 BC to AD 1650 (Williams and Thomas 1982:107). However, for New Jersey, there is little difference between the early and late subperiods, especially up to AD 1000.

In the Middle Atlantic Region, the transition from the Archaic period to the Woodland period was gradual. Artifact types and cultural traditions of the Archaic continued to be used in the Early Woodland of New Jersey (Williams and Thomas 1982:108). The change to the Middle Woodland period, in New Jersey, was likewise gradual. This period is largely defined by new ceramic types and different lithic and bone tools. Along the coast, the economic base emphasized shellfish, in addition to small-scale agriculture. Mortuary practices varied considerably, and there was greater use of exotic materials as grave goods. Sedentism appears to have increased (Williams and Thomas 1982:108-109).

There is a great deal of variety in the Early and Middle Woodland within New Jersey. This variation follows geographic and environmental patterns. Therefore, the remainder of the discussion on the prehistoric period of the survey area is restricted to the coastal area of southern New Jersey (Williams and Thomas 1982:117). Characteristics of the Early/Middle Woodland period, from 1000 BC to AD 1000, include a wandering, central-based settlement system. Base camps were large and occupied intensively. There were also seasonal and transient procurement campsites. The economic base emphasized natural resources, such as fish, shellfish, nuts, and deer. On a seasonal basis, coastal people congregated at the inland parts of estuaries, to harvest anadromous fish. Mortuary practices were elaborated upon, and included grave furnishings. Technological changes included ceramics, lithic objects made of exotic materials, and shell ornaments. The exotic materials and the complex socio-religious system signify exchange between distant groups (Williams and Thomas 1982:121). Settlement along the coast most likely occurred near the resources available in estuaries and tidal marshes such as the original state of the project area. Subsistence would emphasize shellfish, crabs, and ocean fish.

During the Late Woodland period, subsistence shifted emphasis from gathering wild foods to growing domesticated plants. "The earliest documented cultigen in the Upper Delaware Valley is Cucurbita at AD 1060 +60" (Fischler and French 1991:160). Corn horticulture developed sometime between AD 500 and 1000, made possible by the use of Northern Flint corn, which is a cold-resistant strain. Northern Flint Corn diffused broadly after its first appearance, probably in the Midwest (Fritz 1990).

Along with corn horticulture came settled village life, population growth, an enriched religious and ceremonial life, and warfare among some cultures, such as the Iroquois in New York. Unlike earlier Woodland cultures, there were no separate cemeteries and cremation was no longer practiced. People of the Late Woodland buried their dead flexed in bark-lined graves.

In northern New Jersey, the first major phase of the Late Woodland Period is the Pahaquarra/Owasco phase which dates to AD 1000-1350. Ceramics of this phase were collarless pots with cord-marked bodies and cord-impressed rims (Kraft 1986:120). Specifically, these included Sackett Corded, Overpeck Incised, Bowmans Brook Incised, and Clemson Island (Fischler and French 1991:157). Dwellings of this period were most often round-ended long houses with the doorway on one side (Kraft and Mounier 1982b:146). Deep storage pits are found at the ends. The houses ranged from 5.5 to 18.3 m (18 to 60 ft) long and up to 6.1 m (20 ft) wide. Levanna points are found in high frequencies on Late Woodland Pahaquarra sites. Other stone tools include cobble flakes that could be used for a variety of purposes, flake knives,

and hammer and anvil stones (Kraft and Mounier 1982b:148).

In addition to hunting, gathering and gardening, Pahaquarra people spent a lot of time fishing and gathering shellfish which were then smoked in hearths or dried on stone platforms (Kraft and Mounier 1982b:151). Around AD 1350-1650, ceramics having well-defined collars with incised linear geometric designs identify the Minisink phase of the Proto-Munsee people (Kraft 1986:120). Minisink longhouses were virtually the same as those of the Pahaquarra/Owasco culture. A wide variety of implements have been found on these later Woodland sites. These include tools for hunting, butchering, hide preparation, fishing, plant processing, cooking, woodworking, and domestic activities (Kraft and Mounier 1982b:154-155).

Contact Period. The Munsee and Unami were loosely linked subgroups of Algonquian Delaware or Lenni Lenape Indians who inhabited the area that would become New Jersey at the time of the arrival of Europeans. The traditional dividing line between these subcultures was the Raritan River. The native groups north of the Raritan River, including those of the New Jersey Highlands and the lower Hudson River valley spoke Munsee dialects, while those south of the Raritan River, including the Delaware River valley and Eastern Pennsylvania spoke Unami dialects. Although occupying the mountainous region of northern New Jersey-southern New York, the Minisink Delaware maintained an extensive network of trails through the mountains in order to reach the rich shellfish areas along the Atlantic Ocean (Goddard 1978:213-216, 222; Williams and Kardas 1982:186, 189-190; Kraft and Mounier 1982b:139-141; Kraft 1975:13).

3.3.2. Historic Overview. Jersey City, a historically significant port of entry and manufacturing center, is situated on a peninsula formed by the Hudson and Hackensack Rivers and Upper New York Bay. Located just across the Hudson River from the island of Manhattan, Jersey City is considered the first permanent European settlement in the state (Jersey City Online 2002). In 1623, following Henry Hudson's voyage for the Dutch East India Company, the area became part of the Dutch province of New Netherland. The trading company introduced the patroon system into the region, selling large tracts of land to wealthy "patroons," who in turn pledged to attract at least fifty permanent settlers to the colony (Stansfield 1998). In 1629, a patroon named Michael Pauw received a grant to plant a Dutch colony on the west side of the Hudson River. Pauw's grant, which eventually became the district of Pavonia, is the earliest known conveyance for what would later become Jersey City (Grundy and Caroselli 1970; Kardas and Larrabee 1978).

The patroon system, which essentially relegated settlers to the role of serfs, attracted few emigrants from the mother country and proved an ineffective colonization strategy for the Dutch (Stansfield 1998). By the mid-seventeenth century, all of New Netherland could boast only a handful of settlers whose small numbers left them vulnerable to Indian attacks as well as the land grabs and territorial counterclaims of other colonial powers. This held true for the district of Pavonia, which ran along the west bank of the Hudson River approximately between Harsimus Cove on the north and Caven Point on the south. By the late 1630s, Pavonia contained three tiny Dutch settlements within the boundaries of present-day Jersey City. These included the settlements of Harsimus, a lowland area near the present Harsimus Cove, Paulus Hook, a "noticeable promontory of high land" where Jersey City was later founded, and Communipaw, an area of relatively high land on the north side of New York Bay (Kardas and Larrabee 1978). These settlements consisted largely of scattered farms known as "bouweries" that extended along the length of the Hudson shoreline (Rutsch et al. 1977).

Despite more than a decade of relatively peaceful relations with the local Indians, unrest broke out in the early 1640s and escalated into the Dutch-Indian War of 1643-1645. Due in large measure to the poor leadership of Director-General William Kieft, the conflict quickly resulted in the destruction of most of the early Dutch farms within the colony of Pavonia (Kardas and Larrabee 1978). In the late 1640s, the Dutch made another attempt to settle the west side of the Hudson under the leadership of a new director-general, Peter Stuyvesant. After negotiating peace with local Indians, Stuyvesant established a community known as Bergen in the interior portion of the peninsula, to the west of the original settlements. Observing his predecessor's difficulty in defending the widely-scattered farmsteads of the earlier settlements, Stuyvesant ordered the village to be enclosed and fortified against attack. As an added protection, the director-general purchased most of what is now Hudson County from the Hackensacks in 1658 (Grundy and Caroselli 1970; Kardas and Larrabee1978).

The palisaded village of Bergen, which was laid out around Bergen Square on top of a high ridge, ran north from present-day Vroom Street with a central roadway following the current Bergen Avenue right-of-way. This settlement fared better than the previous colony, boasting a municipal court, legislature, school and church by the early 1660s (Jersey City Online n.d.). Around the same time, Bergen was joined on the west bank by a second new Dutch settlement known as Communipaw. The site of the new village fronted on New York Bay and consisted of a parcel of land approximately 200 feet wide by 600 feet long, running south from the present Communipaw Avenue (Kelly et al. 1960). It was separated from the bay on the east by an area of marshland known as Communipaw Cove. Together, the villages of Bergen and Communipaw were intended to replace the original European settlements destroyed in the Dutch-Indian War, although many of the shoreline bouweries were eventually reestablished (Kardas and Larrabee 1978).

All in all, Dutch colonial ambitions in the New World proved short-lived. In 1664, the Dutch lost their American colonies altogether when, drawing on land claims made by the Cabots in 1497 and 1498, Charles II of England dispatched ships and soldiers to the New World to seize possession of the colony. Realizing their inability to oppose British military might, Dutch leaders quickly conceded to the king's demands and the former province of New Netherland surrendered its allegiance to British control (Doherty 1986). New Netherland became the English proprietary colony of New Jersey, divided into the provinces of East and West Jersey under the governance of Sir George Carteret and John Lord Berkeley respectively (Pennington & Fraser 1997). In 1683, New Jersey was divided into four counties, and the Dutch villages of Bergen and Communipaw became part of a larger township called Bergen, one of three townships located in the East Jersey county of the same name (Grundy and Caroselli 1970).

Following the establishment of English rule, life on the west bank of the Hudson remained relatively unchanged for almost two centuries (Kardas and Larrabee 1978). Carteret granted a new charter to the township of Bergen, guaranteeing its inhabitants the continuation of all rights and privileges previously enjoyed under Dutch rule (Grundy and Caroselli 1970). Now removed from the "front line of European expansion," descendants of the original Dutch settlers continued to farm the fertile highlands and collect oysters from the mud flats in the quiet, rural communities of Bergen County. The only sign of coming change was the area's gradual emergence as a transportation hub and transhipment point between a growing Manhattan community and new settlements to the west (Kardas and Larrabee 1978). Several important roads were already established by the late seventeenth century, including a road running northwest from Communipaw to Bergen along the route of modern Communipaw Avenue. Another road ran from

Paulus Hook to Bergen. More importantly, the settlers began supplying ferry service to Manhattan from several points on the peninsula, including Communipaw Cove (Kardas and Larrabee 1978).

The first community to bear the name Jersey City emerged in the location of the original west shore settlement of Paulus Hook, located between Harsimus Cove on the north and Communipaw on the south. Abraham Isaacsen Planck initially purchased this waterfront acreage in 1638 for 550 guilders from the Dutch West India Company, an offshoot of the original Dutch East India Company. Planck established a small settlement on this land, using a portion of it as a tobacco plantation and the remainder for farming and dairy purposes (Rutsch et al. 1977; Marrin 2002). Following Planck's proprietorship, title to the land passed through the hands of several owners until 1804, when a group of investors led by three New York lawyers purchased the parcel and formed The Associates of the Jersey Company, which oversaw the affairs of the community for the next fifteen years. Jersey City took its initial step toward becoming an independent municipality in 1820, when the New Jersey state legislature granted the community a municipal charter and it was incorporated for the first time (Grundy and Caroselli 1970).

From the beginning, Jersey City's waterfront played a vital role in its commercial and industrial development. Oystering and shad fishing, both conducted in the mud flats of Communipaw Cove, represented one of the area's earliest and most important industries, until the arrival of the railroads and manufacturing in the nineteenth century polluted and destroyed both the cove and its adjacent waterways (Rutsch et al. 1977). The establishment of an extensive ferry service between Communipaw Cove and the island of Manhattan was another hallmark of Jersey City's early commercial growth. The first ferry service was established by William Jansen around 1661, operating from a landing at the foot of present-day Communipaw Avenue on what was the original south cove shoreline (Rutsch et al. 1977; Kardas and Larrabee1978). By 1764, Jansen's Ferry had significant competition from the newly established Paulus Hook Ferry, which operated from the foot of Grand Street as part of a stage route between New York and Philadelphia. Both enterprises provided service via rowboats and small, decked sail-boats known as periaugers. In 1812, investor and entrepreneur Robert Fulton established a drydock in Paulus Hook and soon began providing ferry service to and from Manhattan Island via steamboat. Over time the ferry industry and the hostelry business that accompanied it contributed greatly to Jersey City's role as the focal point of transportation between major industrial cities in the northeast (Rutsch et al. 1977).

The simultaneous arrival of the railroads and the Morris Canal in the 1830s solidified the city's vital role in the regional economy for the next one hundred years (Jersey City Online n.d.). The Morris Canal and Banking Company, initially authorized by the state legislature to build a waterway from Phillipsburg to Newark, broke ground for the Morris Canal in 1824. Just four years later, the company had already received permission to extend the canal to Jersey City in order to create a tidewater outlet immediately adjacent to New York City. By 1838, the completed canal provided the city's iron industry with direct access to the coal mines of eastern Pennsylvania as well as important iron markets in the northeast (Rutsch et al. 1977). Meanwhile, numerous railroad lines jockeyed for position along the Hudson's west bank, competing for access to the increasingly important New York Harbor and shipping facilities of Manhattan. By the mid-nineteenth century, the area was known for its network of rail terminals, which included the Erie, Pennsylvania, Lehigh Valley, and Jersey Central Railroads.

The city's extensive waterfront, effective transportation network, and easy access to fuel from Pennsylvania coal mines led logically to the rapid growth of the city's industrial and commercial prowess. Important early enterprises included Dummer's Glasshouse, a waterfront industry established in 1824 just south of the present-day Morris Canal Basin, and the Jersey City Pottery Works, opened on Warren Street in 1825 (Rutsch et al. 1977). The year 1845 marked the beginning of Jersey City's steel industry with the establishment of the Atlas Foundry, followed by the North Point Foundry and Machine Works in 1848 and the Adirondack Steel Works in 1849 (Rutsch et al. 1977). Other well known companies eventually made their home in Jersey City, including American Can, Emerson Radio, Colgate, and Dixon Ticonderoga (Jersey City Online n.d.).

The city's population kept pace with the growth of industrial enterprise, jumping from a mere thirteen in 1802 to 1,025 in 1829 and 2,084 in 1837. Finally, in 1838, Jersey City separated completely from the township of Bergen and formed an independent municipal government (Grundy and Caroselli 1970; Rutsch et al. 1977). Having achieved a greater measure of independence, city officials made a concerted effort to correct some of the city's problems and to undertake several public improvement projects. Streets were graded and filled, and sunken lots filled with stagnant water were eliminated (Rutsch et al. 1977). Over the next two years, Jersey City attracted another one thousand new residents to become the fastest growing municipality in the newly formed Hudson County. Within thirty years the city had outpaced the growth of neighboring communities such as Bergen and Hudson City, who voted in 1870 to consolidate with the city into one large urban area. Nearby Greenville joined the merger three years later (Grundy and Caroselli 1970).

It was the presence of the railroads, however, that determined the destiny of the Jersey City shoreline, especially the project area, throughout the nineteenth and much of the twentieth century, bringing first prosperity and ultimately decline to the waterfront community. By the mid-nineteenth century, railroads in the northeast were vying for terminal space on the Jersey City shore. The city's extensive waterfront, its proximity to the New York shipping industry, its established ferry service, and its considerable real estate values, especially when compared to the prohibitive cost of land in Manhattan, contributed to its appeal. The Jersey Railroad & Transit Company arrived first in 1853, followed quickly by the Lake Erie Railroad later that year, the Morris and Essex line in 1855, and finally the Central Railroad Company of New Jersey in 1860. By 1875, fourteen rail lines terminated in Jersey City (whereas only three in New York City. Railroads eventually owned and controlled 98% of the Jersey City waterfront (Rutsch et al. 1977). Unfortunately, this external control of the city's waterfront led to an irreversible economic interdependence between the city and the railroads. With its economic health inextricably tied to the success of the railroads, the city's prosperity lasted only as long as that of its railroad-marine terminal development (Kardas & Larrabee 1978).

Anderson (1984) and Carleton (1976) record that the Central Railroad of New Jersey (CRRNJ) terminal was constructed on a large pier, built on landfill extending outward from the shoreline south of the Morris Canal basin. Jersey City's Communipaw/South Cove area was shaped, both literally and figuratively, by the CRRNJ, which occupied this area during the second half of the nineteenth and first half of the twentieth centuries. Arriving late to the game in 1860, the CRRNJ was relegated to the mud flats of Communipaw Cove for its terminal construction, as all the desirable waterfront land had already been claimed by other lines (Rutsch et al. 1977). This portion of the shore extended from south of the Morris Canal Big Basin, newly completed in 1859, to the Black Tom Pier area. Since the shoreline at this location consisted almost entirely

of unusable marshland, CRRNJ's plans for development included the filling of almost the entire Communipaw Cove in order to create the necessary buildable area. The process began in the 1860s at the northern edge of the railroad's property, where the company placed 20,000 cubic yards of refuse from New York City to create the long pier on which their terminal was then erected. This was followed by a second placement of fill around 1880 to create a set of piers near the Black Tom area at the southern edge of the property. Over time the space between the two projecting masses on the north and south was filled in until, by 1910, the Central Railroad of New Jersey had created about 475 acres of made-land, the present-day shoreline of Liberty State Park (Rutsch et al. 1977; Kardas and Larrabee 1978) including the entire APE.

The filling of the shoreline drastically and permanently changed the character of the Communipaw Cove area of Jersey City. While development and filling had taken place on other parts of the Jersey City shore, including Paulus Hook to the north and Caven Point to the south, the cove itself had remained relatively unchanged. For more than two centuries, Communipaw had existed as a pleasant rural area and by mid-nineteenth century remained one of the few places to retain traces of the city's Dutch heritage (Rutsch et al. 1977). By the turn of the nineteenth century, however, what had been a quiet waterfront farming village became the peninsula's first inland settlement on the west side of the immense railroad yards that now lined New York Harbor's west shore (Rutsch and Leo 1979).

Toward the end of the nineteenth century, the CRRNJ had for the most part become the dominant railroad line in Jersey City. It enjoyed immense prosperity during this time, leasing trackage to and finally absorbing many of the smaller lines as it established its pre-eminence in the regional coal trade. The former Communipaw Cove became a maze of railroad lines and spurs running to the company's numerous docks and freight piers, which extended tentacle-like out into the busy New York Harbor (Rutsch et al. 1977). The company's property also held a number of rail-related structures over the course of its existence in Jersey City. During the half-century between 1860 and 1910, the CRRNJ complex increased in both size and sophistication from the two-building operation of its early days to the more elaborate physical plant of its later years. Following its extensive expansion program in 1912, the line boasted an enlarged train yard as well as numerous support buildings, including a new engine terminal, Bush-type train shed, and ferry house. The company also expanded its striking Romanesque-style depot in order to accommodate its growing passenger business, which by 1914 was estimated to carry between 30,000 and 50,000 people daily. The terminal still stands and is a popular attraction of Jersey City's Liberty State Park (Rutsch et al. 1977; Liberty State Park n.d.).

New York Harbor's decline in importance in the early decades of the twentieth century would eventually catch up with Jersey City's waterfront rail network, although it took nearly two decades for the full effects of the decline to be felt. Among the reasons for the decline, the most obvious was the "motor-revolution" of the mid-1920s, which forced railroads to compete with the cheaper, faster and more-efficient trucking industry. By 1927, the completed Holland Tunnel under the New York Harbor, allowed merchants to forego the inconvenience of railroad-marine transfer altogether. Moreover, transit on the harbor had become congested and inefficient due in large part to the massive duplication of facilities constructed over the years by numerous competing railroad lines (Rutsch et al. 1977). The waterfront enjoyed temporary spurts of renewed activity during the two world wars. During World War I, the southern area of the park served as a munitions depot and was the site of the famous Black Tom pier explosion, believed to be an act of German sabotage (Balkhage and Hahling 1964). By 1947, however, Jersey City's waterfront facilities were dilapidated and largely obsolete (Rutsch et al. 1977).

By the mid-twentieth century, only three major railroad lines remained in Jersey City - the CRRNJ, the Lehigh Valley, and the Erie-Lackawanna. Beginning in the 1940s, these lines began releasing or abandoning unused or outdated facilities. Between 1940 and 1960, as railroad traffic continued to decline, these companies released, sold, or abandoned more than 1000 acres of waterfront, most of which was assumed by the city to the distress of local officials. The CRRNJ filed for bankruptcy in 1967 (Rutsch et al. 1977).

In the 1970s, CRRNJ's former property in the Communipaw Cove area between the Morris Canal Basin and the Black Tom Pier was proposed for an extensive urban waterfront park. Using Green Acre Bond Funds and Land and Water Conservation funds, the Department of Environmental Conservation and the U.S. Army Corps of Engineers undertook an extensive harbor clean-up project in the cove area. The first segment of the park, located at the southern end of the cove, was opened to the public in 1976, in time for the nation's bicentennial celebration. Since then, more than 100 acres of parkland have been developed and include picnic areas, trails, and natural areas (Liberty State Park n.d.). The APE remains in the interior, still-undeveloped portion of the park.

Historic Map Analysis. The following maps were reviewed for the present study: an 1845 U.S. Coast Survey; William Wood's 1855 *Map of Jersey City, Hoboken and Hudson Cities*; the 1873 Hopkins *Atlas of the State of New Jersey and the City of Newark*; an 1881 Corps of Engineers *Chart of An Examination of New Jersey Flats From Docks of Central Railroad of New Jersey to Constable Point*; an 1896 U.S Coast and Geodetic Survey of the Hudson and East Rivers; an 1896 Sanborn Fire Insurance Map; a 1908 Hopkins *Atlas of Hudson County*; Hopkins' 1919 *Plat Book of Jersey City and Bayonne, Hudson County, New Jersey*; a 1944 U.S. Coast and Geodetic Survey; and a 1955 U.S. Geological Survey.

The earliest available map of the project area is an 1845 coast survey showing the part of New Jersey lying between the Hudson and Hackensack Rivers (Figure 3.1). This map confirms local historian J. Owen Grundy's assertion that the towns of Bergen and Communipaw, now part of Jersey City, retained their quiet, rural character until well into the nineteenth century (Grundy & Caroselli 1970). The region is shown to consist mainly of large, agricultural settlements, especially in the inland areas. The project area is situated in the yet-unfilled Communipaw Cove. The area is labeled with the words "Stones Mud," perhaps indicating the shallow, marshy quality of the cove in this area. The village of Paulus Hook has been laid out in a grid pattern surrounding a central square, shown on later maps to be the intersection of Washington and Grand Streets. The Morris Canal is shown running north along the shore line and then turning northeast to terminate in Paulus Hook at a rectangular basin located west of Washington Street.

William Wood's 1855 *Map of Jersey City, Hoboken and Hudson Cities* shows a considerable increase in development in the Jersey City area (Figure 3.2). As the map indicates, the north end of Communipaw Cove has been filled to create a relatively straight northern shoreline. Additional streets have been added to the south and east sides of the now squared-off Paulus Hook, including Atlantic Street, which runs north-south along the harbor, and Park and Ocean Streets, which run east-west along the northern edge of the cove. The APE remains in the undeveloped portion of the cove. Phillip Street is shown along the original shoreline, adjacent to the western boundary of the APE, and is intersected by Communipaw Avenue. The Communipaw Ferry pier extends out into the cove from the foot of Communipaw Avenue. The map shows a number of small structures, possibly residences, on the west side of Phillip Street, south of Communipaw Avenue. North of Communipaw Avenue are several larger structures.

= PROJECT AREA

0 .5 1 MILE

0 .5 1 KILOMETER

Figure 3.1. Coast Survey of the New York Harbor showing the approximate location of the project area in 1845. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(U.S. Coast Survey 1845)*

Figure 3.2. The approximate location of the project area in 1855. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Wood 1855)*.

Hopkins' 1873 *Combined Atlas of the State of New Jersey and the City of Newark* portrays the planned filling of Communipaw Cove from south of Paulus Hook to Caven's Point (Figure 3.3). Since 1855, some additional filling has already taken place on the north side of the cove. Wilson Avenue now defines the southern edge of Paulus Hook. Just north of Wilson Avenue, tracks belonging to the Central Railroad of New Jersey are shown running as far east as Washington Street. While the APE remains in an undeveloped portion of the cove, planned development in this location includes a continuation of the surrounding street grid.

Dripps' 1879 *Map of Jersey City, Hoboken and Hudson Cities* shows planned development similar to the 1873 Hopkins map (Figure 3.4). New streets, as well as the extension of existing streets, are shown to be planned for the approximate location of the APE. In addition, this map also indicates the completion of a new basin for the Morris Canal. Located between Ragun Street on the north and Walnut Avenue on the south, the waterway stretches east from present-day Jersey Avenue to open into a wider basin just north of Hudson Street. Just south of Walnut Avenue, the Central Railroad of New Jersey has continued its filling of the cove in order to create the pier on which it would eventually build its terminal. This pier is located just north of the present APE. The APE continues to be shown as undeveloped marshland.

An 1881 U.S. Army Corps of Engineers map of the shoreline shows the beginning of the nearly complete control railroad companies would eventually exercise over the Jersey City shoreline (Figure 3.5). None of the planned developments shown on the previous map have been carried out. The Central Railroad of New Jersey has extended its control of the shoreline southward, filling more of the cove to create additional small piers to the south of its terminal pier. An 1896 U.S. Coast and Geodetic Survey of the Jersey City shoreline shows continued development within the APE south of the main pier (Figure 3.6). The original CRRNJ depot and terminal, east of the APE, is indicated as a T-plan structure located at the eastern end of the main pier. Several tracks connected to the rear of the structure indicate that this wing most likely consisted of a train shed. The Communipaw Ferry to Manhattan is located on the east side of the depot. Several of the smaller piers south of the depot contain tracks extending out into the cove, most likely part of the system of transfer or float bridges that carried freight across New York Harbor to Manhattan.

The 1896 Sanborn Fire Insurance Map provides a detailed picture of Phillip Street, which hugged the original shoreline of Communipaw Cove before it was partially relocated in the early twentieth century (Figures 3.7a - 3.7c). Except for its westernmost section, this street delineates the approximate western boundary of the current APE. It is bisected by Communipaw Avenue, which originally terminated at the cove shoreline. The map shows Phillip Street to be much more developed to the west of Communipaw Avenue than to the east. To the north, an L-shaped section of made-land juts out into the bay just south of the intersection of Phillip Street and Jersey Avenue. Several small structures are shown here, including a two-story building labeled "J.C. Yacht Club." Several other small, two-story structures are shown on the north side of the street. Just east of Communipaw Avenue, six subdivided lots are shown. None of the lots contain structures. To the west of Communipaw Avenue, numerous structures line the north side of Phillip Street. These structures appear to be mostly rectangular frame structures ranging from one to three stories in height. Within the APE, a branch of the CRRNJ parallels Phillip Street on its south side. As drawn, this map implies the tracks ran on a trestle over open water, as they are shown south of the existing shoreline. The track eventually turns inland, truncating Phillip Street and intersecting the National Docks Railway.

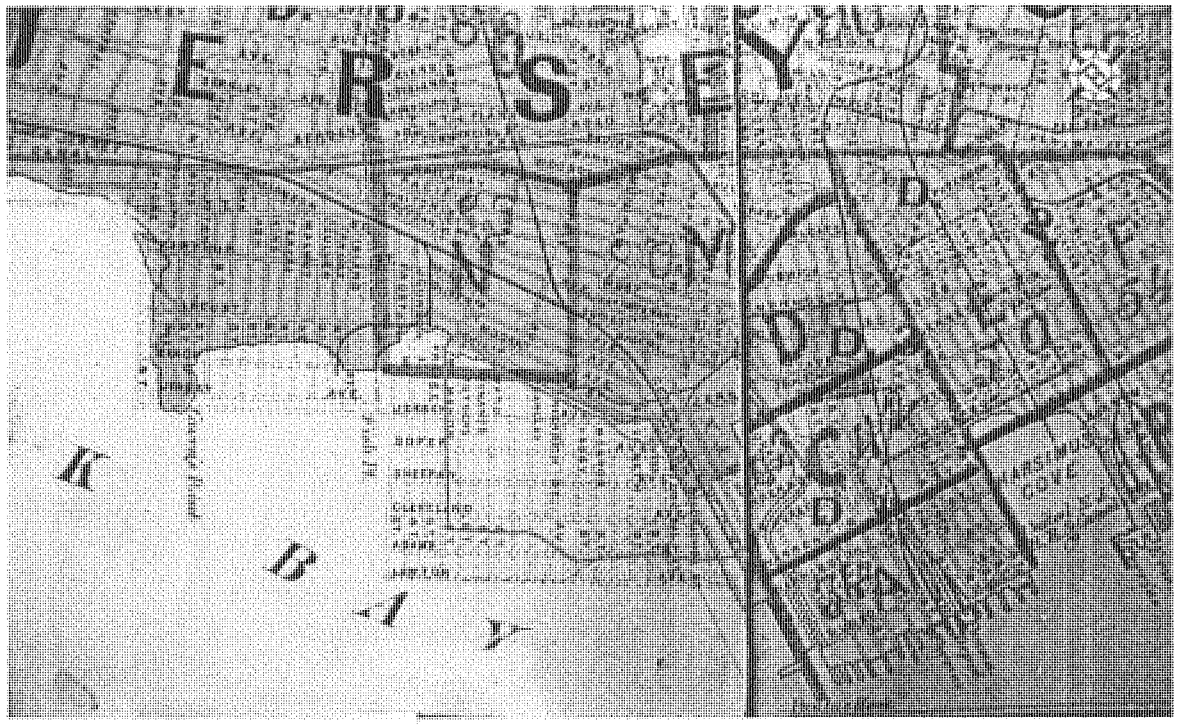


Figure 3.3. The approximate location of the project area in 1873. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Hopkins 1873).*

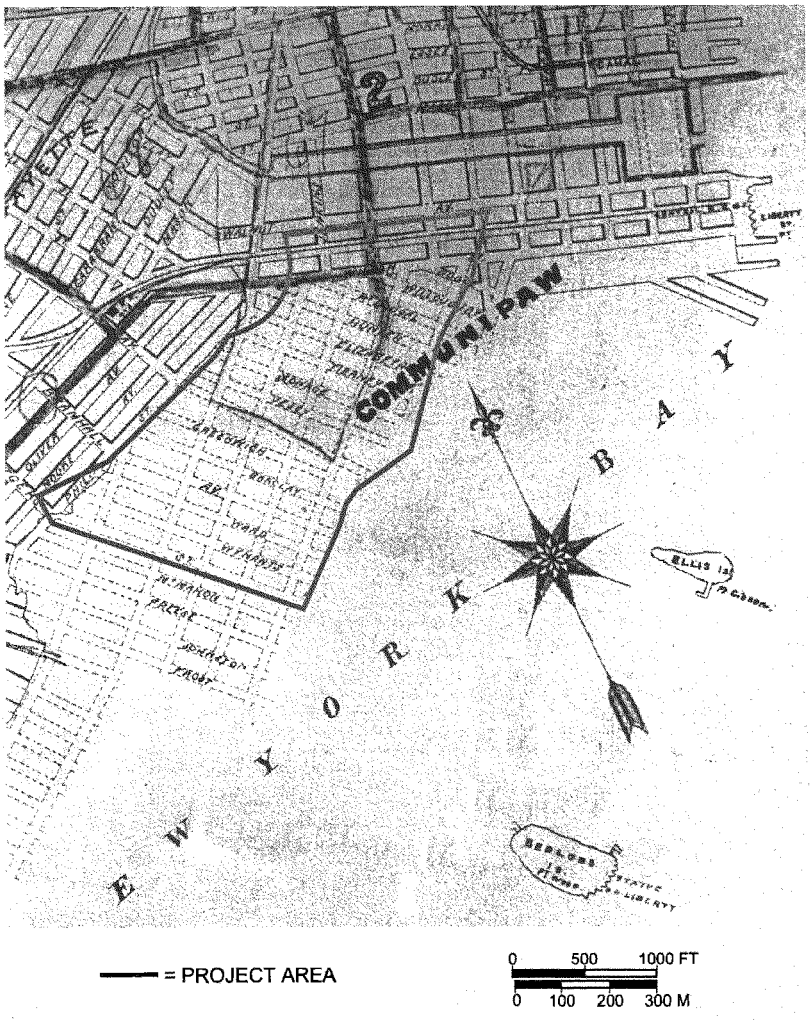


Figure 3.4. Map of Jersey City showing the approximate location of the project area in 1879. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Dripps 1879).*

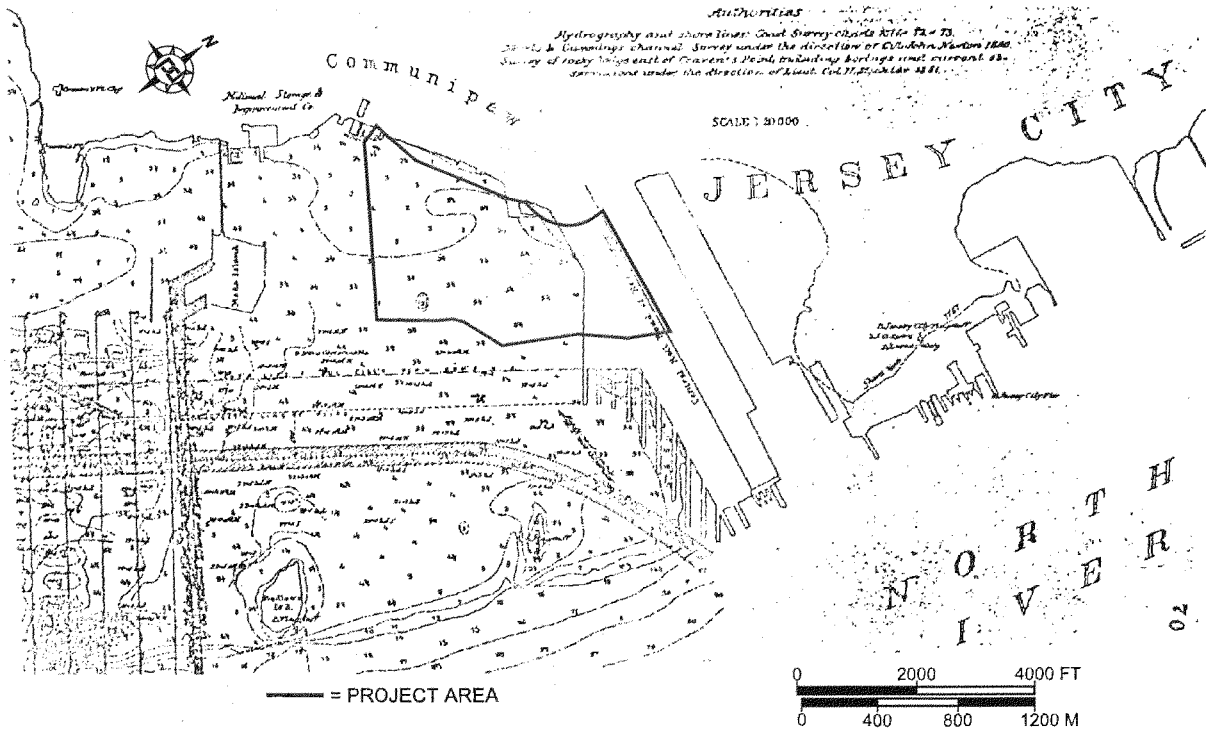


Figure 3.5. U.S. Corps of Engineers map showing the approximate location of the project area in 1881. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(USACE 1881).*

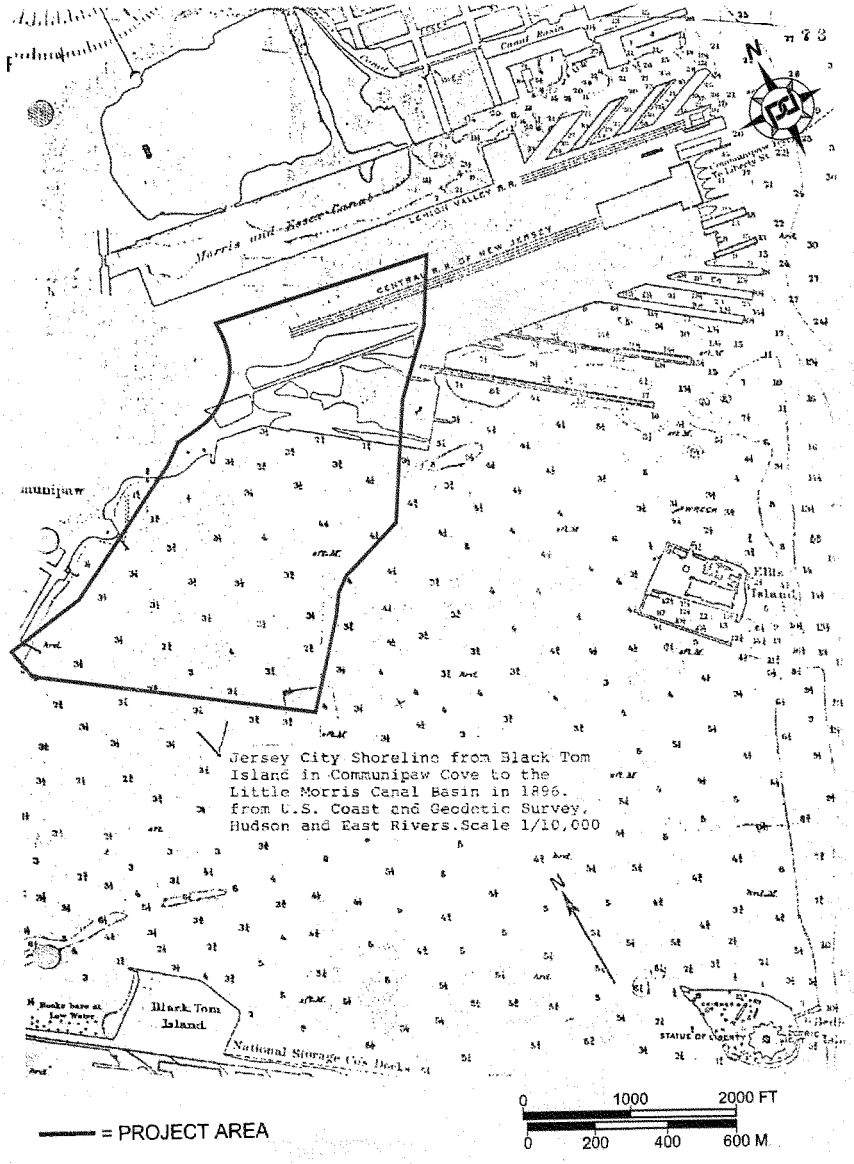


Figure 3.6. The approximate location of the project area in 1896. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(U.S. Coast and Geodetic Survey 1896).*

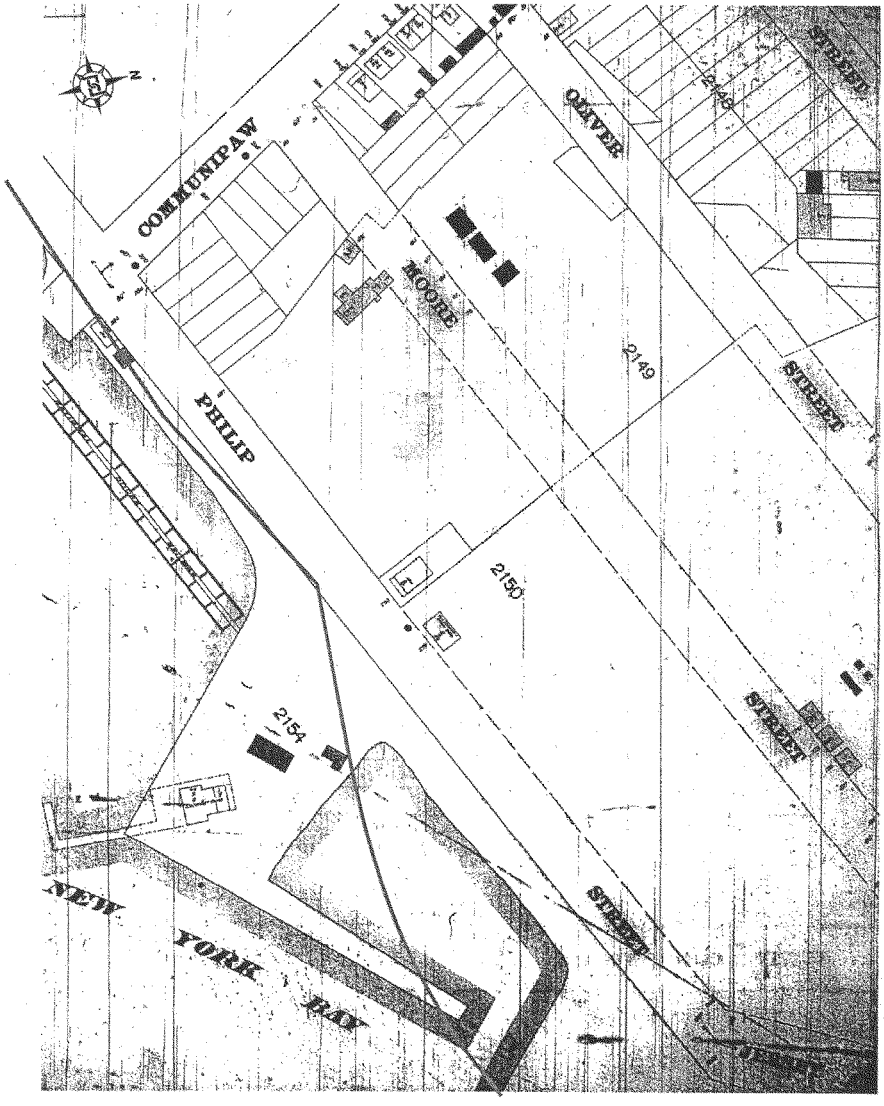
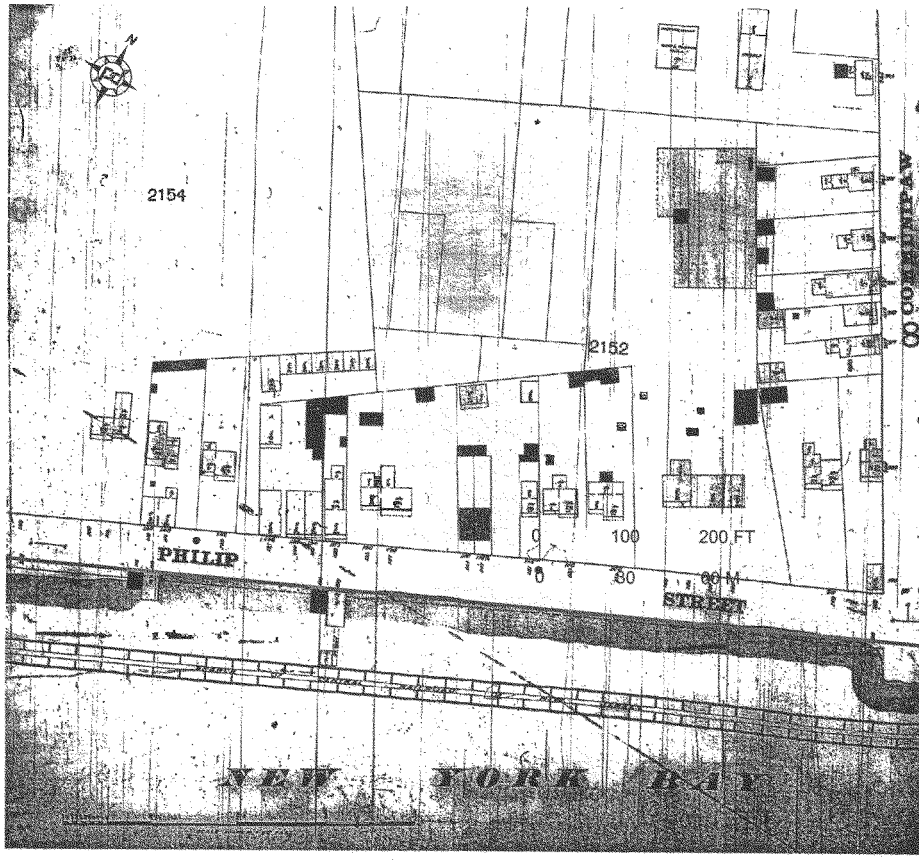


Figure 3.7a. Phillip Street south of Communipaw Avenue, APE includes area south of Phillip Street. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Sanborn Map Co.1896).*



= PROJECT AREA

Figure 3.7b. Phillip Street just south of Communipaw Avenue in 1896, APE includes area south of Phillip Street. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Sanborn Map Co. 1896)*.

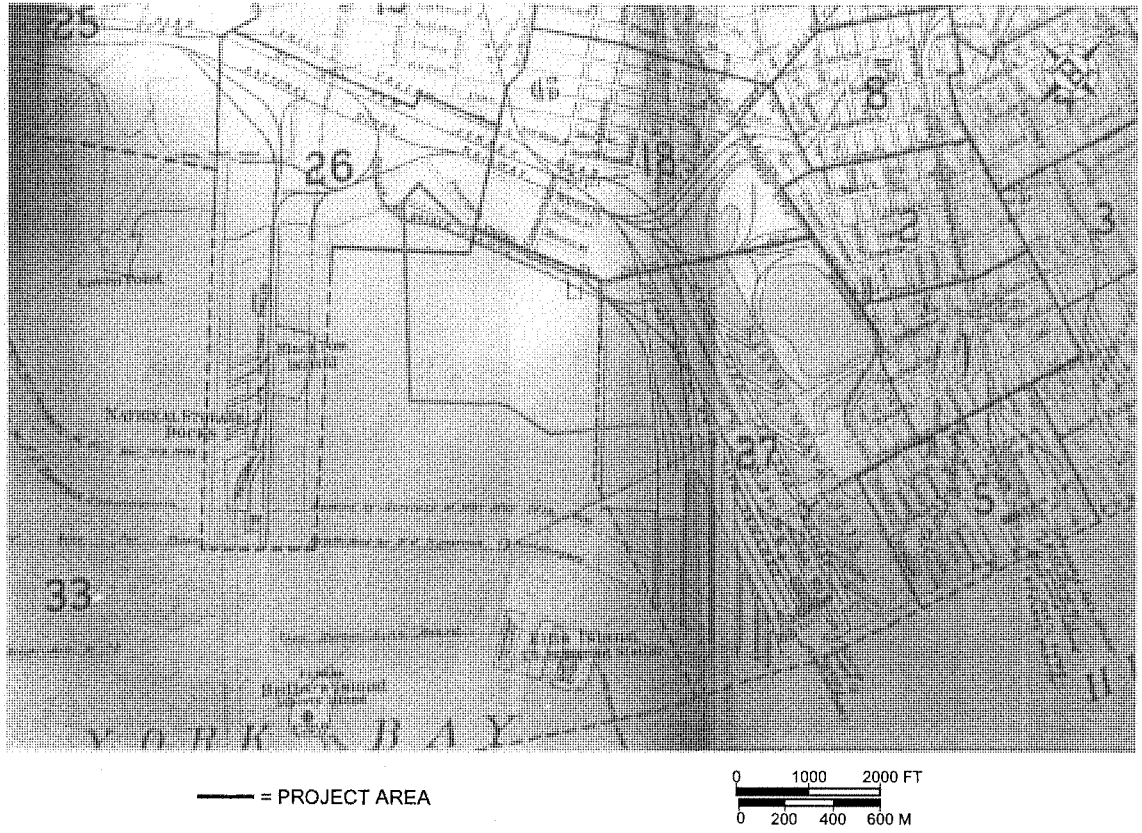


Figure 3.8. The Communipaw Cove area showing the approximate location of the project area in 1908. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Hopkins 1908).*

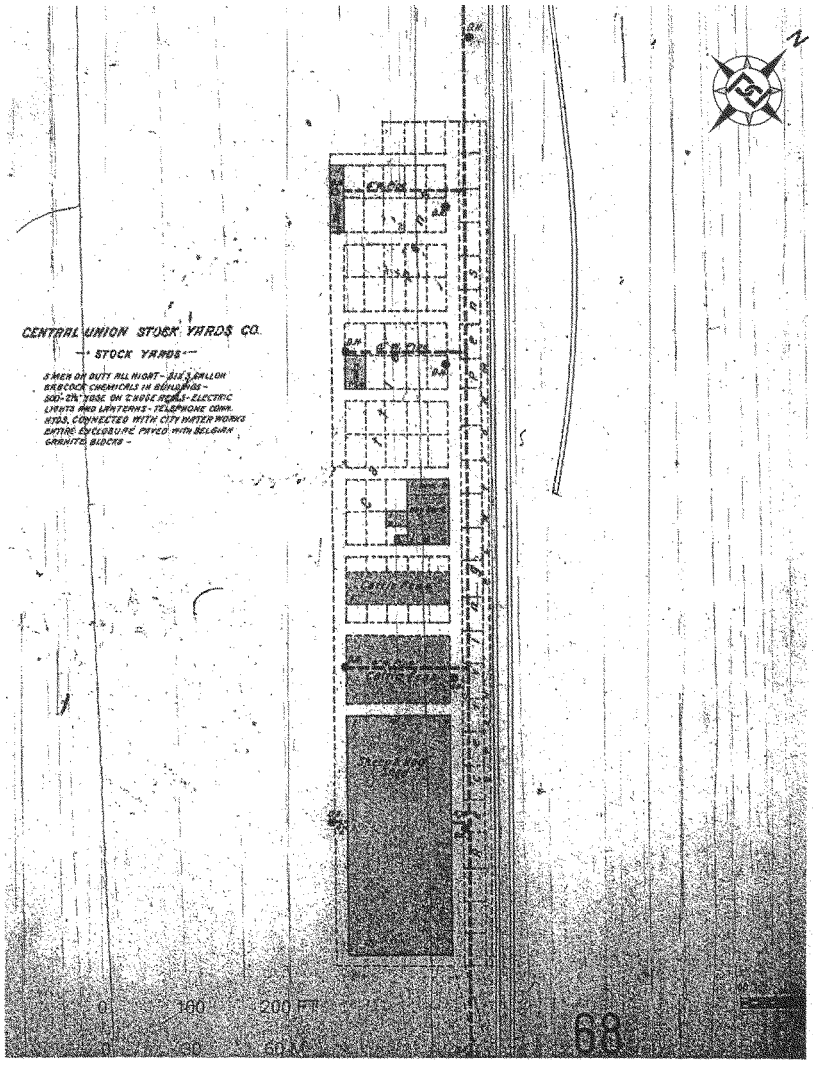


Figure 3.9. Detail of Fire Insurance map showing the Central Union Stock Yards Co. in 1911. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(Sanborn Map Co. 1911).*

Figure 3.10

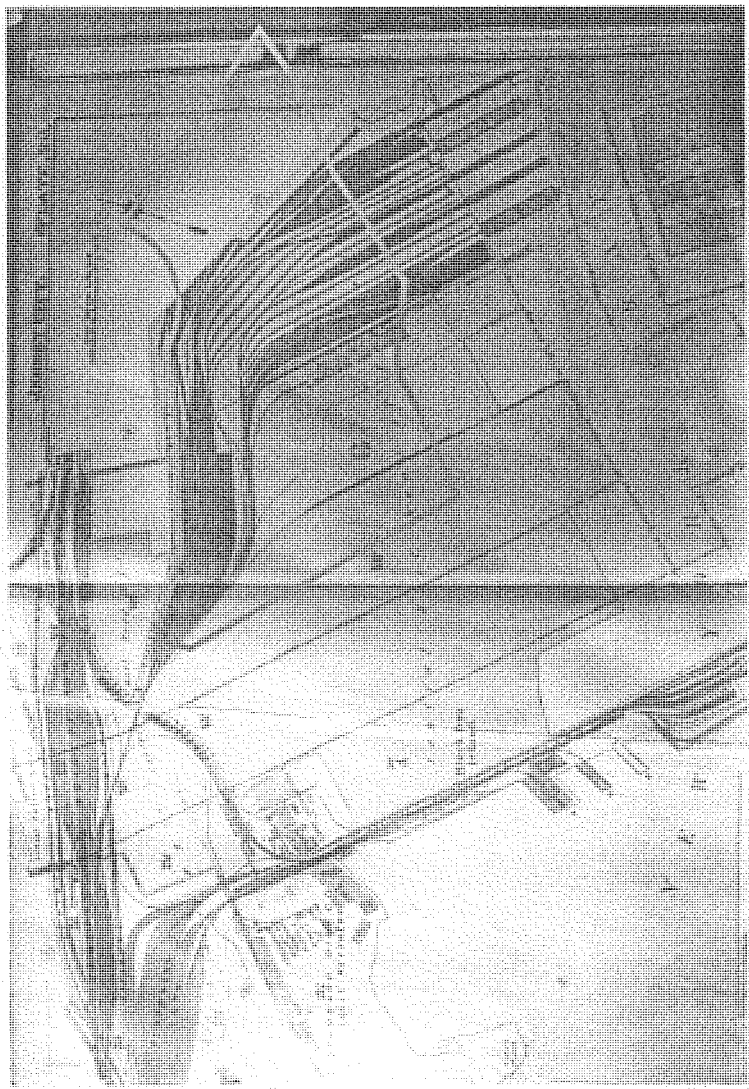


Figure 3.10. Communipaw Cove showing the approximate location of the project area in 1919. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey (*Hopkins 1919*).

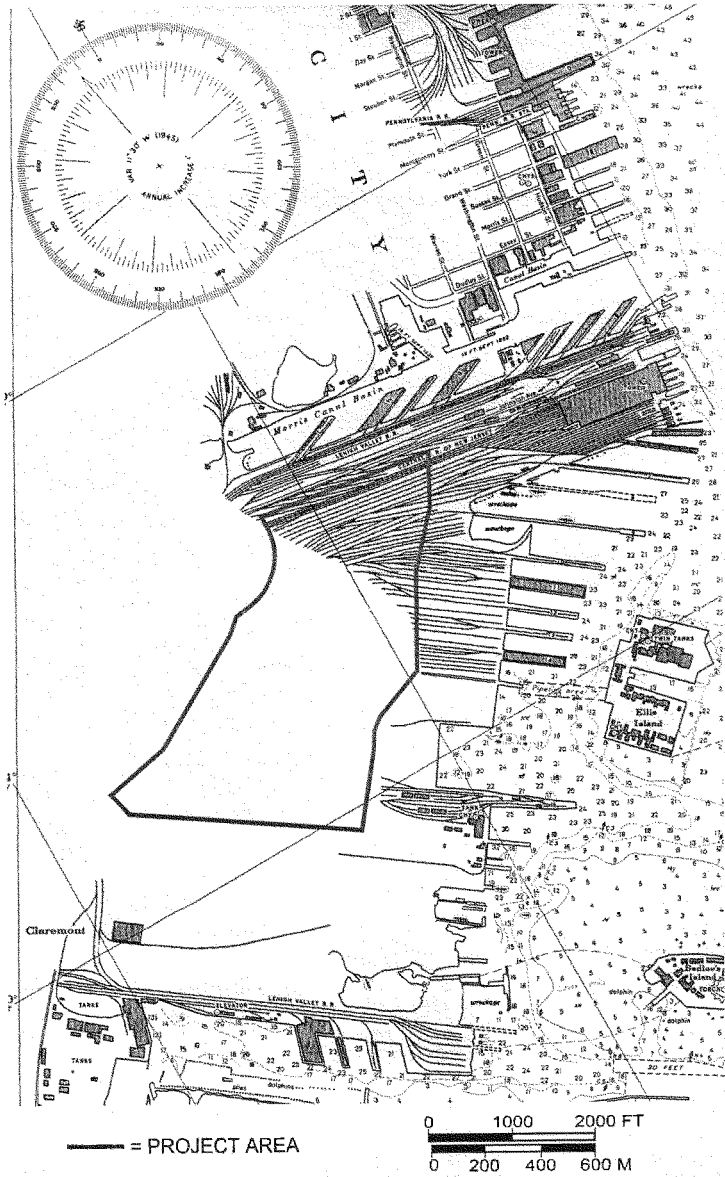
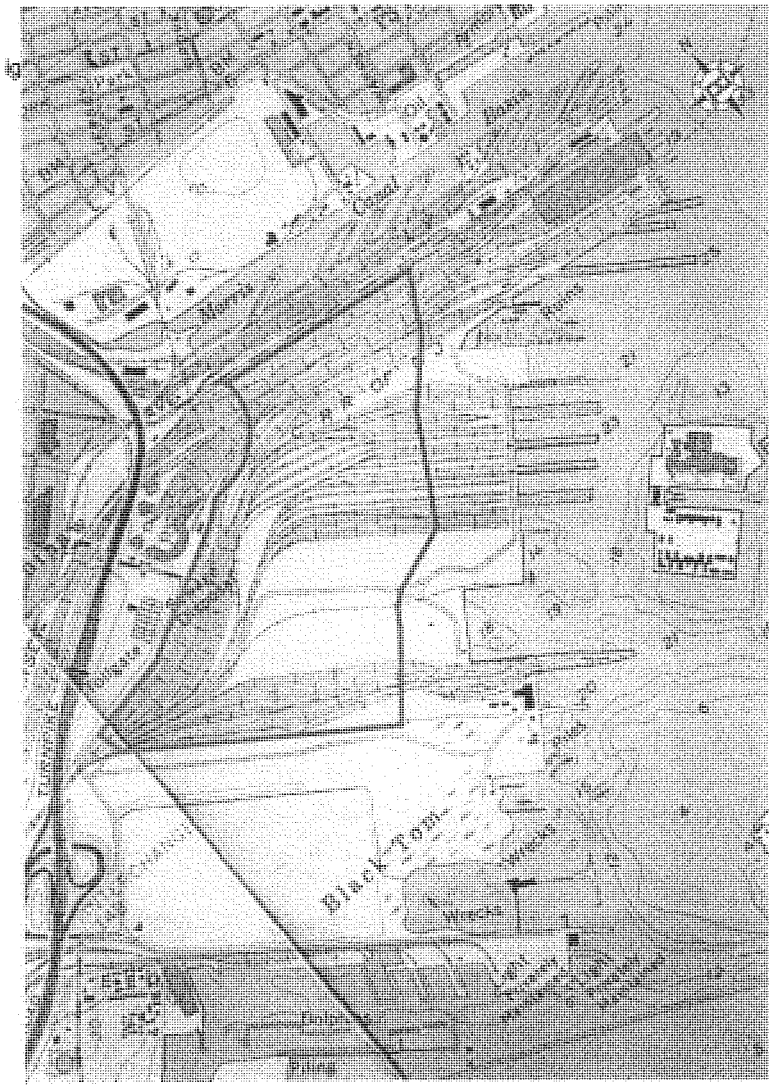


Figure 3.11. A U.S. Coast Survey of Communipaw Cove showing the approximate location of the project area in 1944. Liberty State Park Ecosystem Restoration, Hudson County, New Jersey *(U.S Coast and Geodetic Survey 1944).*


Bayonne
Jersey City
Hoboken
Weehawken
Union City
Kearny
Harrison
Newark
Bergen
Hudson
Essex
Pavonia
Hackensack
Passaic
Rahway
Elizabeth
Raritan
Bay
Kill
Van
Kull
Newark
Bay
Hackensack
River
Passaic
River
Rahway
River
Elizabeth
River
Kill
Van
Kull
Bergen
Point
Port
Newark
Port
Elizabeth
Port
Authority
Marine
Terminal
Port
Authority
Marine
Terminal
Port
Newark
Marine
Terminal
Port
Elizabeth
Marine
Terminal
Port
Jersey
Marine
Terminal
Port
Jersey
Port
Authority
Marine
Terminal
Port
Authority
Marine
Terminal
Port
Authority
Marine
Terminal

prehistoric sites depends on the location of the pre-landfilling shoreline west of the present Liberty Park boundaries. Maps dating to the 1870s (Beers 1873; Dripps 1879) make it clear that at that time the shoreline was at Phillip Street, which forms the western boundary of the USACE Liberty Park project area. Phillip Street represented a southern continuation, at an angle, of Jersey Street, which is shown north of the APE on the mid-nineteenth century maps.

These sites may have been located between Communipaw and Mill Creeks or on Jan de Lacher's Hook, east of the Morris Canal basin. Rutsch and Leo (1979:12)state that the shoreline of the Communipaw settlement was approximately at the location of Phillip Street. If the Communipaw site was at the present location of Phillip Street it is possible that occupants of the settlement may have disposed of refuse in the adjacent marshland. Such deposits could extend into the present project area. Mid-nineteenth century maps detail the street grid north of Paulus Hook prior to landfilling of the shoreline (see Figures 3.1 and 3.2) USCS 1845, Sidney 1849; Wood 1855 and NJGS 1860). According to these maps, the original shoreline may have been somewhat west of the present location of Phillip Street.

A prehistoric site (28-HD-15) was identified between Communipaw and Forrest Avenues, and between Whiton and Whitelaw, some 2,000 feet west of Phillip Street. This location may not have been the Communipaw village site however, and may represent another, more inland site. If it does represent the Communipaw site, it would also suggest that at least some landfilling occurred between the original shoreline and the location of Phillip Street. This interpretation is not consistent with reported results of backhoe tests conducted by Rutsch and Leo (1979).

Rutsch et al. (1977) also proposed archaeological sensitivity for drowned prehistoric sites. These would be located beneath the landfill and also beneath underlying organic bay silts and peat that accumulated after inundation of the area now within Liberty Park by rising sea levels. Possible site locations would be on high ground near the ancestral channels of Communipaw and Mill Creeks. Kardas and Larrabee (1978:17) mention approximately 100 USACE borings were taken from the Liberty Park area. Rutsch et al. (1977:9-10) apparently looked at some of the available boring logs as well as profiles derived from them. It is possible that the pre-inundation topography and physiography could be more completely reconstructed from these data. Such an effort is beyond the scope of the present study. Likely areas attractive to prehistoric peoples could be identified and archaeological borings examined for the presence of shell midden deposits or other indications of prehistoric activity.

Previous Surveys. The New Jersey State Historic Preservation Office lists six surveys that have been conducted in or adjacent to the Liberty State Park project area. They include:

Brouwer, Norman
1977 Survey of Cultural Resources in the Form of Derelict Ships and Boats, Priority Area 3 of Liberty State Park, New York Harbor Collection and Removal of Drift Project. Report on File U.S. Army Corps of Engineers, New York District.

Githens, Herbert and Edward S. Rutsch
1978 Emergency Investigative Survey, Various Shore Structures, Drift Removal Project Areas III-IV, Liberty State Park, Jersey City, Hudson County, N.J. Newton: Historic Conservation and Interpretation, Inc. Report on File, New Jersey Historic Preservation Office.

Kardas, S. and E. Larrabee
1978 Cultural Resource Reconnaissance, Jersey City Reach, New York harbor Collection & Removal of Drift Project. Historic Sites Research. Conducted for New York District, U.S. Army Corps of Engineers Report on file, New Jersey Historic Preservation Office.

1979 Cultural Resource Survey, Exchange Place and Pavonia Avenue Ferries, Jersey City, New Jersey. Historic Sites Research. Conducted for New York District, U.S. Army Corps of Engineers Report on file, New Jersey Historic Preservation Office.

Rutsch, Edward S., and Ralph J. Leo, Jr.
1979 Stage IB Cultural Resource Survey for the Hudson County Sewerage Authority, 201 Wastewater Facility Plan–District I, Jersey City, North Bergen, Secaucus, and Kearny, Hudson County. Newton: Historic Conservation and Interpretation, Inc. Report on File, New Jersey Historic Preservation Office.

Rutsch, Edward, Susan Kardas, Edward Larrabee, Ralph Leo, Brian Morell, James Lally, Barbara Kalata, and Herb Githens
1977 Cultural Resources Reconnaissance, Liberty State Park. Report on File U.S. Army Corps of Engineers, New York District. Prepared by Historic Conservation and Interpretation, Inc.

Rutsch et al. (1977) conducted a background and literature search of Liberty State Park for the development of the park and for the Army Corps of Engineers' New York Harbor Drift Removal Plan. The authors discuss the extensive modifications that have occurred historically at the location of Liberty State Park. Prehistoric occupations were addressed to a lesser extent.

Kardas and Larrabee (1978, 1979) conducted surveys of the areas south and north of Liberty Park, including testing of landfill and landfill retaining structures north of the project area. The other surveys include Rutsch and Leo's (1979) report summarizing their Phase IB subsurface tests within and adjacent to the project area; Brouwer's (1977) report on shipwrecks along North Cove; and Githens and Rutsch's (1978) discussion of landfilling and piers in North Cove.

4.0 Investigation Results

4.1 ARCHEOLOGICAL SENSITIVITY ASSESSMENT

Historic maps and literary sources show the entire APE to be made land for use by the Central Railroad of New Jersey (CRRNJ). Originally, the project area was tidal marsh and shallow open water, but it was filled in between the 1860s and 1919 (see Figures 3.3 and 3.4). Therefore, the archaeological sensitivity for prehistoric cultural resources within the APE is limited to submerged Late Pleistocene/Early Holocene deposits. These would be located beneath the landfill and also beneath underlying organic bay silts and peat that accumulated after inundation of the area by rising sea levels.

With the exception of the Philip Street vicinity, few structures other than railroad tracks formerly existed within the project area. The most prominent structures were perhaps the Central Union stockyards, located below Pier 15 in approximately the center of the project area (see Figure 3.9). The stockyards consisted of a series of structures situated on a long, narrow open platform. The structures appear to have been mostly one-story, rectangular-frame buildings and included sheep and hog sheds, cattle pens, and a hay barn. A row of receiving pens lined the stockyards along the south side of the platform. CRRNJ's Marine Repair Yard was near the northern end of the APE. This small complex of buildings consisted of small shops for blacksmiths and carpenters.

The CRRNJ terminal, listed on the National Register of Historic Places, is located north and east of the project APE (discussed at length by Parrot 1975 and Rutsch 1977) and will not be impacted by the proposed ecosystem restoration activities. Also, ecosystem restoration in the APE will cause no visual impact to surrounding historic properties (e.g., Statue of Liberty, Ellis Island, CRRNJ Terminal) because it will only enhance the setting already created with the inauguration of Liberty State Park.

4.1 FIELD RECONNAISSANCE

Most of the APE is enclosed by a chain-link fence and is overgrown with a mix of deciduous and coniferous trees, sparse and dense brush, open grassland, and low wet areas with stands of *Phragmites* (Figures 4.1 through 4.5). A nearly 50-acre rectangular-shaped area along the eastern side of the APE is low, wet and covered by *Phragmites* (Figures 4.6 and 4.7). Piles of railroad ties are scattered across the north, central and west portions of the APE (Figure 4.8). Modern debris has been dumped across the APE and includes building materials (e.g., chimney blocks, cement), garbage (e.g., ceramic sink, television, car tires), a metal trailer, and push-piles of rubble (e.g., concrete, asphalt) (Figures 4.9 through 4.13). Two approximately 125-meter (410-foot) long parallel berms are present in the south-central portion of the APE (Figure 4.14; see Figure 4.7). Water-filled borrow pits are adjacent to the berms. Dirty fill (e.g., slag, brick, coal, glass, mortar) was visible at some exposed locations (e.g., the base of some tree falls) (Figures 4.15 and 4.16). Approximately 24 acres in the southwest corner of the APE are covered by a landfill surrounded by a chain-link fence. A partially paved trail nearly bisects the project area in a northwest/southeast orientation (see Figure 4.3). It may be the remains of road shown on the 1955 USGS map. Table 4.1 presents UTM coordinate data for physical and cultural features.

Table 4.1 GPS Provenience Log

GPS #	UTM Coordinates (NAD 83)	FOM*	Description
01	18 T 580215 4506127	14	photograph location (Figure 4.3)
02	18 T 579779 4506412	14	push-piles near the center of the APE (Figure 4.9)
03	18 T 579838 4506423	14	location of toppled concrete "phone booth" (Figure 4.21)
04	18 T 579765 4506498	22	location of a drainage opening (Figure 4.17)
05	18 T 579781 4506528	24	fill exposed at the base of a tree fall (Figure 4.15)
06	18 T 579821 4506563	26	pile of railroad ties amid young deciduous vegetation (Figure 4.8)
07	18 T 580269 4506604	44	vegetation in the north-northeast portion of the APE**
08	18 T 580260 4506646	21	piles of cut and drilled granite and concrete (Figure 4.10)
09	18 T 580161 4506637	26	piles of dumped concrete chimney blocks
10	18 T 580212 4506695	16	burned wooden structural remains (Figure 4.19)
11	18 T 580331 4506766	16	metal trailer next to a utility pole
12	18 T 580193 4506826	15	rectangular depression
13	18 T 580035 4506717	16	tower base (Figure 4.20)
14	18 T 579730 4506541	26	location of a drainage opening (Figure 4.18)
15	18 T 579719 4506552	26	broken "phone booth"
16	18 T 579674 4506521	22	*in situ* railroad ties
17	18 T 579656 4506508	22	*in situ* railroad ties
18	18 T 579514 4506462	22	photograph location of the vegetation in the western part of the APE (Figure 4.2)
19	18 T 579458 4506400	15	fenced landfill
20	18 T 579710 4506307	21	modern garbage tire dump (Figure 4.11)
21	18 T 579775 4506305	22	modern garbage including sink, TV, tires (Figure 4.12)
22	18 T 579812 4506296	22	push-piles of rubble fill (Figure 4.13)
23	18 T 580008 4506205	20	push-piles of rubble fill including concrete
24	18 T 580577 4506817	16	photograph location of the northeast portion of the APE (Figure 4.6)

25	18 T 580864 4506891	14	NE corner of the APE
26	18 T 579914 4505767	15	SE corner of the APE
27	18 T 579771 4506086	22	push-piles in the southeast portion of the APE (Figure 4.14)
28	18 T 579663 4506150	24	n/a**
29	18 T 579607 4506133	22	*in situ* railroad ties and cinder and gravel fill in the south-central part of the APE (Figure 4.22)
30	18 T 579720 4506042	15	photograph location of vegetation in the southern portion of the APE**
31	18 T 579834 4505866	14	standing water along the southern edge of the APE (Figure 4.4)
32	18 T 578996 4506355	-	photograph location from the NJTP**

*FOM = Figure of Merit is the estimated GPS accuracy (in feet) from averaged readings.
** = Photograph not presented in this report

Cultural features were present within the Liberty State Park APE that appear to be remnants of the former rail yard:

- Two 0.9-by-1.5-m (3-by-5-ft) concrete drain openings with iron rims are located 56.4 m (185 ft) apart in the west central portion of the APE (Figures 4.17 and 4.18; see Figure 4.7). Both were partially filled with water. An arched drain conduit was partially exposed in the westernmost opening.

- The burned and collapsed remains of a wooden structure are present in the north-central part of the APE (Figure 4.19; see Figure 4.7). It appears to have been a one-story structure approximately 3.6-by-5.5-m (12-by-18 ft) in size. Wire nails, tongue-in-groove siding, tin stove pipe, tar-covered roll roofing, and metal-encased electrical conduits were found among the burnt wood debris. No subsurface foundation was visible.

- The base of a former tower was identified in the northwest part of the APE (see Figure 4.7). It consists of four concrete footings spaced 3 m (10 ft) apart. Each footing is 0.6-by-0.6 m (2-by-2 ft) and has the partial remains of steel super structure attached on top (Figure 4.20).

- Two cast concrete booths were found 175 m (574 ft) apart in the west-central part of the APE (see Figure 4.7). An *in situ* utility pole base located next to the eastern booth suggests that the booths may have been used to house communications equipment. The easternmost booth is toppled and empty. It is hexagonal in shape with one side open (Figure 4.21). The westernmost booth is broken into many pieces. These "phone booths" were probably used by brakemen and conductors for communications with the yard managers (personal communication, Dr. David Turkon and Dr. Thomas Turkon).

- *In situ* railroad ties were found at three locations in the APE (Figure 4.22; see Figure 4.7). In the west-central part of the APE, the track bed has a northeast/southwest orientation. The track bed has a northwest/southeast orientation in the south-central part of the APE.

5.0 Conclusions and Recommendations

The archaeological sensitivity for prehistoric cultural resources within the APE is very low. Documentary and field research results show the APE to be made land. Therefore, the sensitivity for prehistoric remains in the APE is limited to submerged Late Pleistocene/Early Holocene deposits located beneath the landfill and underlying natural sediment. A previous investigation (Rutsch and Leo 1979) of more sensitive locations just west of the APE did not find evidence of any shell midden or other prehistoric deposits. Further investigation will not likely yield prehistoric cultural resources.

The northern portion of the APE could contain artifacts from mid-nineteenth-century landfill deposits, as well as landfill-retaining structures such as wooden cribbing. The southwestern portion of the APE could contain later artifacts (see Rutsch and Leo 1979) as well as early twentieth-century landfill-retaining cribbing. However, artifacts found in the landfill will likely not be considered cultural resources due to the lack of context and ambiguous point of origin. The cribbing used to retain the fill also has limited research importance. A detailed account of the filling process conducted at Liberty State Park is presented in Rutsch et al. 1977: Appendix A which also includes a profile illustration of the cribbing and a plan view "progress map" of the dredging and filling process. Therefore, further investigation will not likely yield additional significant historic information. Canal boats, deliberately sunk as part of the filling process, may by present beneath the fill. Rutsch et al. (1977:332), however, depict the sunken canal boats east of Freedom Way, outside the APE.

Remains associated with the former rail yard were identified during field reconnaissance:

- A burned wooden structure in the north-central part of the APE appears to be the remains of a small rail yard outbuilding. No structures were shown at this location on historic maps, only railroad tracks. The only structures shown in the APE on historic maps were wood-frame cattle pens and sheds documented over 1,000 ft to the south of the structural ruins. Inspection of the map-documented location of the pens and sheds found no evidence of remains. The ruins have no historic integrity. Further investigation (i.e., subsurface shovel testing) at the structure ruins or the map documented structure locations will not likely yield information important in prehistory or history. The presence of cultural resources is unlikely within the dense fill of the track beds that once covered the project area.

- The two concrete drain openings and two cast concrete "phone" booths in the west-central part of the APE were most likely ancillary components of the former rail yard. These elements are not cultural resources. The drain openings are *in situ* and evidence of subsurface drain system remains. However, further investigation will not likely not yield historically significant information. The cast concrete "phone" booths have no historic integrity. One is empty, toppled and has one adjacent associated feature—a broken utility pole. The second booth is in pieces scattered across a small area with no associated features.

- The base of a former tower located in the northwest part of the APE is in all likelihood associated with the former rail yard. Only footings remain that do not qualify to be considered a cultural resource due to lack of integrity. This feature does not meet, or potentially meet NRHP criteria.

- The railroad ties found *in situ* at three locations in the APE are unremarkable remnant elements of the former rail yard. They are incomplete (i.e., have no rails, only small sections are present) and are not considered a cultural resource.

Although the project area has a rich history, no historically significant elements remain. The proposed ecosystem restoration project will have no impact on cultural resources as none were identified during this Phase IA cultural resource investigation. No further investigations are recommended within the ecosystem restoration APE at Liberty State Park.

6.0 References

Anderson, Elaine
1985 *The Central Railroad of New Jersey's First 100 Years, 1849-1949: A Historical Survey.* Center for Canal History and Technology

Balkhage, H.R. , and A.A. Hahling
1964 The Black Tom Explosion. Originally published in *The American Legion Magazine* (August). Online at http://www.jerseycityonline.com/black_tom_explosion.htm

Beers, Frederick W.
1873 *Atlas of Hudson County, New Jersey.* Beers, Comstock & Cline, New York.

Brouwer, Norman
1977 Survey of Cultural Resources in the Form of Derelict Ships and Boats, Priority Area 3 of Liberty State Park, New York Harbor Collection and Removal of Drift Project. Report on File U.S. Army Corps of Engineers, New York District.

Carleton, Paul
1976 *The Jersey Central Story.* D. Carleton Railbooks, Rivervale, New Jersey.

Curtin, Edward V.
1992 Prehistory of Eastern New York. Ms. on file, Department of Sociology, Anthropology, and Social Work, Skidmore College, Saratoga Springs, NY.

Corps of Engineers
1881 *Chart of An Examination of New Jersey Flats From Docks of Cent. R. R. Of N.J. to Constables Point.*

Doherty, Joan F.
1986 *Hudson County: The Left Bank.* Windsor Publications, Inc.

Douglas, L.F.
1941 Topographical Map of Jersey City. (Partial photostat in collection of the New York Public Library, Map Division.)

Dripps, M.
1867 Plan of New York City, from the Battery to Spuyten Duyvill. M. Dripps, New York.

1879 Map of Jersey City and Hoboken, Hudson County, N.J.

Fischler, B.R., and J.W. French
1991 The Middle Woodland to Late Woodland Transition in the Upper Delaware Valley: New Information from the Smithfield Beach Site. In *The People of Minisink: Papers from the 1989 Delaware Water Gap Symposium,* edited by D.G. Orr and D.V. Campana, pp. 145-174. National Park Service, Mid-Atlantic Region, Philadelphia.

Fritz, Gayle
1990 Multiple Pathways to Farming in Precontact Eastern North America. *Journal of World Prehistory* 4:387-435.

Funk, Robert E.
1972 Early Man in the Northeast and the Late Glacial Environment. *Man in the Northeast* 4:7-42.

1976 *Recent Contributions to Hudson Valley Prehistory.* New York State Museum Memoir 22, Albany.

1993 *Archaeological Investigations in the Upper Susquehanna Valley, New York State, Volume 1.* Persimmon Press, Buffalo.

Githens, Herbert and Edward S. Rutsch
1978 *Emergency Investigative Survey, Various Shore Structures, Drift Removal Project Areas III-IV, Liberty State Park, Jersey City, Hudson County, N.J.* Historic Conservation and Interpretation, Inc., Newton. Report on File, New Jersey Historic Preservation Office.

Goddard, Ives
1978 Delaware. In *Northeast*, edited by Bruce G. Trigger, pp. 213-239. Handbook of North American Indians, vol 15, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Grundy, J. Owen and Louis B. Caroselli.
1970 "History of Forms of Government From Early Dutch Days to the Present Time." Available on World Wide Web at http://www.jerseycityonline.com/jc_history.htm.

Hammond, C. S.
1912 Map of Jersey City & Hoboken, New Jersey. New York: C.S. Hammond, Publishers.

Hopkins, G. M.
1873 *Combined Atlas of the State of New Jersey and the City of Newark.* G.M. Hopkins & Co., Philadelphia.

1908 *Atlas of Hudson County, New Jersey, Vol I (Jersey City).* G.M. Hopkins & Co., Philadelphia.

1919 *Plat Book of Jersey City and Bayonne, Hudson County, N.J., Vol I.* G.M. Hopkins & Co., Philadelphia.

1928 *Plat Book of Jersey City, Hudson County, N.J., Vol I.* G.M. Hopkins & Co., Philadelphia.

Jersey City Online
n.d."Jersey City: America's Golden Door."
Online at http://www.jerseycityonline.com/history/jc_history.htm.

Kardas, S. and E. Larrabee
1978 *Cultural Resource Reconnaissance, Jersey City Reach, New York harbor Collection & Removal of Drift Project. Historic Sites Research.* Conducted for New York District, U.S. Army Corps of Engineers Report on file, New Jersey Historic Preservation Office.

1979 *Cultural Resource Survey, Exchange Place and Pavonia Avenue Ferries, Jersey City, New Jersey. Historic Sites Research.* Conducted for New York District, U.S. Army Corps of Engineers Report on file, New Jersey Historic Preservation Office.

Kelly, John M., Rita M. Murphy and William J. Roehrenbeck
1960 *Jersey City Tercentenary, 1660-1960: Program and Historical Souvenir.* Jersey City Tercentenary Committee, Jersey City.

Kraft, Herbert
1986 *The Lenape: Archaeology, History, and Ethnology.* The New Jersey Historical Society, Newark.

Kraft, Herbert C., and Ronald A. Mounier
1982 The Archaic Period in New Jersey (ca. 8000 BC-1000 BC). In *New Jersey's Archaeological Resources from the Paleo-Indian Period to the Present: A Review of Research Problems and Survey Priorities*, edited by Olga Chesler, pp. 52-102. Office of Cultural and Environmental Services, Department of Environmental Protection, Trenton.

Liberty State Park
n.d. "History of Liberty State Park". Online at http://libertystatepark.com/history.htm.

Lueder, Donald R., George H. Ober, William W. Homan and Franklyn C. Rogers
1952 *Engineering Soil Survey of New Jersey, Report Number 4: Hudson County.* New Jersey Joint Highway Research Project. Rutgers University, New Brunswick, New Jersey.

Marrin, Richard B.
2002 "Jersey City's Hook: Part 1." San Francisco Bay Crossings.com. Online at http://www.baycrossings.com/Archives/2002/05_June/ny_harbor_history.htm

Marshall, Sydne B.
1982 Aboriginal Settlement in New Jersey During the Paleo-Indian Cultural Period, ca..10,000 BC-6000 BC. In *New Jersey's Archaeological Resources from the Paleo-Indian Period to the Present: A Review of Research Problems and Survey Priorities*, edited by Olga Chesler, pp. 10-51. Office of Cultural and Environmental Services, Department of Environmental Protection, Trenton.

National Park Service
1985 *Guidelines for Local Surveys: A Basis for Preservation Planning.* National Register Bulletin 24. U.S. Dept. of the Interior, Washington, DC.

New Jersey Geological Survey
1869 Topographical Map of the State of New Jersey. From the State Geological Survey by G. Morgan Hopkins

New York Department of Docks and Ferries.
1911 Map of a Portion of the Borough of Manhattan and the Adjacent New Jersey Shore with Railroad Lines and Terminals. In *Annual Report 1911.*

Parrot, Charles
1975 *National Register of Historic Places, Inventory-Nomination Form, Central Railroad of Jew Jersey, Jersey City Central Railroad Terminal.* In historic site file folder, Hudson County, Central Railroad of New Jersey. New Jersey Historic Preservation Office.

Pennington, Charles R. And Marilyn R. Frasier
1997 *Stage IA Cultural Resources Survey, Combined Sewer Overflow Planning Study, Town of Harrison, Hudson County, New Jersey.* Prepared by Richard Grubb and Associates, Inc. Prepared for Killam Associates, Inc. On file at New Jersey HPO.

Pielou, E. C.
1991 *After the Ice Age: The Return of Life to Glaciated North America.* The University of Chicago Press, Chicago.

Rand-McNally
1904 Rand-McNally New Map of Jersey City, Hoboken & Bayonne.

Ritchie, William, A.
1980 *The Archaeolbgy of New York State.* Revised Edition. Harbor Hill Books: Harrison NY.

Rutsch, Edward S., and Ralph J. Leo, Jr.
1979 Stage IB Cultural Resource Survey for the Hudson County Sewerage Authority, 201 Wastewater Facility Plan -- District I, Jersey City, North Bergen, Secaucus, and Kearny, Hudson County. Newton: Historic Conservation and Interpretation, Inc. Report on File, New Jersey Historic Preservation Office.

Rutsch, Edward, Susan Kardas, Edward Larrabee, Ralph Leo, Brian Morell, James Lally, Barbara Kalata, and Herb Githens
1977 *Cultural Resources Reconnaissance, Liberty State Park.* Report on File U.S. Army Corps of Engineers, New York District. Prepared by Historic Conservation and Interpretation, Inc.

Salwen, Bert
1975 Post Glacial Environments and Cultural Change in the Hudson River Basin. *Man in the Northeast* 10:43-70.

Sanborn Map Company
1896 *Insurance Maps of Hudson County, New Jersey.* Vol. 6.

1911 *Insurance Maps of Hudson County, New Jersey.* Vol. 6.

1922 *Pier Map of New York Harbor.*

Sidney, J.C.
1849 Sidney's Map of 12 Miles Around New York.

Snow, Dean R.
1980 *The Archaeology of New England.* Academic Press, New York.

Stansfield, Charles A., Jr.
1998 *A Geography of New Jersey: The City in the Garden.* 2nd Edition. Rutgers University Press, New Brunswick, NJ.

United States Army Corps of Engineers, New York District (USACE)
2002 *Scope of Work and Request for Cost Proposal, Cultural Resources Documentary Study of Two Priority Sites for the Hudson-Raritan Estuary Ecosystem Restoration Project, Liberty State Park, Jersey City, Hudson County, New Jersey, and Sherman Creek, New York County, New York.*

United States Coast Survey
1845 New York Bay and Harbor and the Environs.

United States Coast and Geodetic Survey
1896 Hudson and East Rivers.

1944 United States - East Coast, New York and New Jersey, Hudson and East Rivers from West 67th Street to Blackwells Island. Chart #745. March 1944

United States Geological Survey
1955 [1981] *Jersey City, New Jersey Topographic Quadrangle.*

Williams, Lorraine E., and Susan Kardas
1982 Contact Between Europeans and the Delaware Indians of New Jersey. In *New Jersey's Archaeological Resources from the Paleo-Indian Period to the Present: A Review of Research Problems and Survey Priorities*, edited by Olga Chesler, pp.185-198. Office of New Jersey Heritage, New Jersey Department of Environmental Protection, Trenton.

Williams, Lorraine E., and Ronald A. Thomas
1982 The Early/Middle Woodland Period in New Jersey: ca. 1000 B.C.-A.D. 1000. In *New Jersey's Archaeological Resources from the Paleo-Indian Period to the Present: A Review of Research Problems and Survey Priorities*, edited by Olga Chesler, pp.103-138. Office of New Jersey Heritage, New Jersey Department of Environmental Protection, Trenton.

Wilson, Betty
1979 Liberty State Park: A Status Report. *Jersey Coast.* June: (11) 5-6. New Jersey Department of Environmental Protection. Copy in Hudson County, CRRNJ file, NJSHPO historic sites files.

Wood, William H.
1855 *Map of Jersey City, Hoboken and Hudson Cities.* R. B. Kashow, Jersey City.

Appendix A
INTERIM REPORT

PCI BUFFALO • TUSCALOOSA • MEMPHIS • TAMPA

Buffalo Branch Office • 2390 Clinton Street • Buffalo, NY 14227 • (716) 821-1650 • Fax (716) 821-1607

January 9, 2003

Ms. Lynn Rakos
Environmental Analysis Branch
U.S. Army Corps of Engineers, New York District
26 Federal Plaza
New York, New York 10278-0090

Subject: Phase IA Cultural Resource Surveys of Two Priority Sites for the Hudson-Raritan Estuary Ecosystem Restoration Project: Liberty State Park, Jersey City, Hudson County, New Jersey; and Sherman Creek, New York County, New York (Contract #DACW51-01-D-0018, Work Order #0009)

Dear Ms. Rakos:

Panamerican Consultants, Inc. (Panamerican) is pleased to submit this interim report for the above referenced project on behalf of Northern Ecological Associates (NEA), Portland, Maine. The New York District, U.S. Army Corps of Engineers (USACE), is conducting a study to identify and inventory water resources and sediment quality-related problems and needs in the Hudson-Raritan Estuary (USACE 2002). As part of the project, USACE is presently looking at two locations for creating and or enhancing aquatic, wetland and adjacent upland habitats. These locations include 251 acres in Liberty State Park, Jersey City, Hudson County, New Jersey; and a small embayment of the Harlem River at Sherman Creek in northern Manhattan, New York County, New York (Figures 1 and 2). Panamerican conducted Phase IA background research and field reconnaissance at both of these locations to determine the potential for encountering cultural resources. The preliminary investigation results for both locations are presented in this interim report. Separate draft and final reports will be prepared for each location to facilitate review by separate state agencies (e.g., New Jersey Historic Preservation Office and New York State Office of Parks, Recreation and Historic Preservation).

The Panamerican investigative team consisted of: Project Director Dr. Michael A. Cinquino, RPA; Principal Investigator Mr. Robert J. Hanley, M.A., RPA; Field Director Mr. Daniel M. Cadzow; and Project Historians Ms. Stacy L. Weber, M.A., and Mr. Arnold Pickman, M.A., RPA. Documentary and background research was conducted at the: New York Public Library, General Research, Local History and Genealogy, and Map Divisions; New Jersey State Historic Preservation Office, Trenton; New York City Landmarks Preservation Commission; New York State Office of Parks, Recreation and Historic Preservation, Field Service Bureau, Albany; and, the U.S. Army Corps of Engineers New York District.

The field investigation was conducted between December 9 and 13, 2002. Investigation at each location included pedestrian/walkover reconnaissance, photographic documentation, and satellite positioning (GPS). The pedestrian survey was conducted to identify cultural features and environmental conditions (e.g., surface visibility, slope, vegetation, soil disturbance, standing water) at each location. A Garmin® GPS unit was used to record the UTM (North American Datum [NAD] 83) coordinates of photograph locations and cultural features.

Results

Liberty State Park. The Area of Potential Effect (APE) in Liberty State Park included 251 acres of former rail yard in the center of the park. This area is encompassed by Phillip Street, Thomas McGovern Drive, Freedom Way and Audrey Zapp Drive. Historic maps and literary sources show the entire APE to be made land for use by the Central Railroad of New Jersey (Jersey Central). Originally, the project area was tidal marsh, but it was filled between the 1860s and 1919. Maps dating to the 1870s (Beers 1873; Dripps 1879) revealed the shoreline at Philip Street, which forms the western boundary of the APE. Therefore, the archaeological sensitivity for prehistoric cultural resources within the APE is limited to submerged Late Pleistocene/Early Holocene deposits. These would be located beneath the landfill and also beneath underlying organic bay silts and peat that accumulated after inundation of the area by rising sea levels.

With the exception of the Phillip Street vicinity, few structures other than railroad tracks formerly existed within the project area. The most prominent structures were perhaps the Central Union stockyards, located below Pier 15 in approximately the center of the project area (Sanborn 1911). The stock yards consisted of a series of structures situated on a long, narrow open platform. The structures appear to have been mostly one-story, rectangular-frame buildings and included sheep and hog sheds, cattle pens, and a hay barn. A row of receiving pens lined the stockyards along the south side of the platform. The map also showed Jersey Central's Marine Repair Yard near the northern end of the APE. This small complex of buildings consisted of a small shops for blacksmiths and carpenters.

Most of the APE is now enclosed by a chain-link fence and is overgrown with a mix of deciduous and coniferous trees, sparse and dense brush, open grassland, and low wet areas with stands of *Phragmites*. Piles of railroad ties are scattered across the north, central and west portions of the APE. Modern debris has been dumped across the APE, and included building materials (e.g., chimney blocks, cement), garbage (e.g., ceramic sink, television, car tires), a metal trailer, and push-piles of rubble (e.g., concrete, asphalt). Two approximately 410-foot (125-meter) long parallel berms are present in the south-central portion of the APE. Water-filled borrow pits are adjacent to the berms. Dirty fill (e.g., slag, brick, coal, glass, mortar) was visible at some exposed locations (e.g., the base of some tree falls). Approximately 24 acres in the southwest corner of the APE is covered by a landfill surrounded by a chain-link fence. The 1955 U.S. Geological Survey (USGS) map indicated that a sewage disposal plant was located in this general area. A partially paved trail nearly bisects the project area in a northwest/southeast orientation. It may be the remains of road shown on the 1955 USGS map.

Cultural features were present within the Liberty State Park APE that appear to be remnants of the former rail yard. These include:

- Two 3-by-5-ft concrete drain openings with iron rims are located in the west central portion of the APE. Both were partially filled with water. An arched drain conduit was partially exposed in the westernmost opening.

- The burned remains of a wood structure are present in the north-central part of the APE. It appears to have been a one-story structure approximately 12-by-18 ft in size. Wire nails, tongue-in-groove siding, tin stove pipe, tar-covered roll roofing, and metal-encased

electrical conduits were found among the burnt wood debris. No subsurface foundation was visible.

- The base of a former tower was identified in the northwest part of the APE. It consists of four concrete footings spaced 10 ft apart. Each footing is 2-by-2 ft and has the partial remains of steel super structure attached on top.

- Two cast concrete booths were found in the west-central part of the APE. An *in situ* utility pole base located next to one of the booths indicates that the booths were used to house communications equipment (i.e., telephone booths). Both booths are empty and lying on their sides.

- *In situ* railroad ties were found at two locations in the APE. In the west-central part of the APE, the track bed has a northeast/southwest orientation. The track bed has a northwest/southeast orientation in the south-central part of the APE.

Sherman Creek. The Sherman Creek project area is approximately 6½ acres bounded by 10th Avenue to the west, a former Consolidated-Edison power-plant facility the north (Academy Street), Harlem River to the east, and Marginal Street to the south. Approximately 4 acres of the APE is a tidal mud flat that includes the remains of Sherman Creek. The remaining 2½ acres are sloped fill upland located primarily along the south and west sides of the APE.

Background research results show this location to be very sensitive for cultural resources, barring soil disturbances. Several prehistoric sites were identified in northern Manhattan in nineteenth century and early twentieth century (Bolton 1924, 1934; Skinner 1961; Geismar 1984). During the Revolutionary War, the British landed troops on the south shore of Sherman Creek within the APE. They consequently established Fort George atop Laurel Hill (just south of the APE) and a rope-drawn ferry (Holland's Ferry) and camp on the hook adjacent to the north shore of Sherman Creek (north of the APE) (Bolton 1924:170, 1916:185-186). The British Headquarters map of 1782 also showed another camp (two buildings) on the south side of the creek below Fort George and immediately adjacent to the Sherman Creek marshes adjacent to the APE. Surface indications of the Holland Ferry camp were observed and a brick floor and a human skeleton were uncovered during excavations in the late nineteenth and early twentieth centuries (Bolton 1916:186-195, 1924:170).

Maps examined dating from 1815 through 1885 did not depict structures within the project area. Historic maps (Dripps 1867; Sanborn 1893; Bromley and Bromley 1897) showed a building west of the APE, on the south bank of the creek immediately west of 10th Avenue. This was also the approximate location of a structure identified as "Durando's Hotel" on the 1900 and 1913 Sanborn maps. Piers and boat houses were shown within the location of the APE on maps through the twentieth century. Boat wrecks are apparent on aerial maps as recent as 1998. However, older historic maps (e.g., USCGS 1902, 1908) did not identify wrecks in the Sherman Creek project area.

Field investigation of the Sherman Creek project area was conducted at low tide. The central portion of the APE was exposed open tidal mud flat with modern garbage and abandoned boat remains scattered across it. A small channel connects the Harlem River to a storm drain opening in a bulkhead that runs along the north edge of the APE. The bulkhead is a corrugated metal barrier parallel and adjacent to the former Academy Street and Con Ed generating plant

(currently a fenced parking area). Brick pavement, presumably remnants of Academy Street, are also present. The dilapidated remains of a docking area are present along the north shore of Sherman Creek at the Harlem River.

The western edge of the APE is a fenced lot that contains a former gas station and asphalt lot adjacent to, and level with, 10th Street. The lot is currently used by the New York City Parks Department. Marginal Street, the southern project area boundary, is essentially a driveway and parking area for Public School No. 5. The southern edge of the APE, between Marginal Street and the Sherman Creek tidal mud flat, is mostly sloped and has been created by the deposition of large amounts of fill. It is overgrown with mature deciduous trees, brush, and vines (e.g., wild grape, poison ivy). The top of the slope has some bank stabilization elements including cut stone slabs and horizontally placed steel street light polls. *Phragmites* are located on the fringe of the mud flat at the base of the slope.

Cultural features were present within the Sherman Creek APE that appear to be remnants of twentieth century marina activities. These include:

- Wooden pier or mooring piles that protrude from the mud flat along the southeast and southwest sections of the shore.
- Metal rails, presumably used as a boat launch and wood piles are located in the mud flat in the southwest corner of the APE. A dilapidated steel and wood staircase connects this location to the high ground. A partially obscured 10-by-17-ft poured concrete base is located on the high ground above the stairs.
- The remains of abandoned boats are scattered across the tidal mud flat. The City of New York recently removed debris down to the water line and abandoned vessels were cut to the mud line (USACE 2002:2-3).

Preliminary Conclusions and Recommendations

Liberty State Park. The archaeological sensitivity for prehistoric cultural resources within the APE is very low. Documentary and field research results show the APE to be made land. Therefore, the sensitivity for prehistoric remains in the APE is limited to submerged Late Pleistocene/Early Holocene deposits located beneath the landfill and underlying natural sediment. A previous investigation (Rutsch and Leo 1979) of more sensitive locations just west of the APE did not find evidence of any shell midden or other prehistoric deposits. Further investigation will not likely yield prehistoric cultural resources.

Landfill in the northern portion of the APE could contain artifacts from mid-nineteenth-century landfill deposits, as well as landfill-retaining structures such as wooden cribbing. Landfill in the southwestern portion of the APE could contain later artifacts (see Rutsch and Leo 1979) as well as early twentieth-century landfill-retaining cribbing. However, artifacts found in the landfill will likely not be considered cultural resources due to the lack of context and ambiguous point of origin. The cribbing used to retain the fill also has limited research importance. Canal boats, deliberately sunk as part of the landfilling process, may by present beneath the fill. However, Rutsch et al. (1977:332) depicts the canal boats sunk east of Freedom Way (i.e., east of the project area).

Remains associated with the former rail yard were identified during field reconnaissance. They include:

- A burned wood structure in the north-central part of the APE appears to be the remains of a small rail yard outbuilding of twentieth century (i.e., building materials) origin. No structures were shown at this location on historic maps, only railroad tracks. The only structures shown in the APE on historic maps were wood-frame cattle pens and sheds documented over 1,000 ft to the south of the structural ruins. Inspection of the map-documented location of the pens and sheds found no evidence of remains. Further investigation of the structure ruins or at the map-documented structure locations will likely not provide information required for assessing historic significance.

- The two concrete drain openings and two cast concrete "phone" booths in the west-central part of the APE were most likely ancillary components of the former rail yard. These elements are not cultural resources. Further investigation will likely not provide information involving the history of the project area.

- The base of a former tower located in the northwest part of the APE is in all likelihood associated with the former rail yard. Only footings remain and further investigation will likely not yield historic information.

- The railroad ties found *in situ* at two locations in the APE are unremarkable remnant elements of the former rail yard. They are incomplete (i.e., have no rails, only small sections are present) and are not considered a cultural resource.

The proposed ecosystem restoration project will have no impact on cultural resources as none were identified during this Phase IA cultural resource investigation. No further investigations are recommended at the Liberty State Park project area.

Sherman Creek. The archaeological sensitivity for prehistoric and historic cultural resources within the APE is very low due to substantial historic and modern landscape modifications. The majority of the APE (approximately two thirds [4-acres]) is tidal mud flat that has been historically inundated and has been dredged and utilized throughout the twentieth century. Remains found across the tidal mud flat do not appear to be cultural resources. They are badly damaged remnants of twentieth-century marina activities and include: wooden mooring piles, boat launch remains, and pieces of abandoned boats. Modern garbage also has been dumped across this area.

The rest of the APE (approximately 2½ acres) is sloped upland created by fill deposition. The south and west sides of the APE consist of large amounts of fill dumped into the Sherman Creek embayment. These portions of the APE were historically low and wet as part of a larger embayment and a more extensive creek. Therefore, the likelihood for the presence of cultural resources is low. Also, proposed ecosystem restoration between the tidal mud flat and Marginal Street will involve creation of additional upland (Bob Will, personal communication 2002). This reduces the threat of impacting deeply buried cultural resources, if at all present.

The northern edge of the APE (adjacent to former Academy Street) has been altered by construction of the former Con Ed power generating plant with an associated bulkhead and boat docking area. Two large storm sewer (presumably) outlets also drain into the Sherman Creek

embayment along the bulkhead. Proposed ecosystem restoration in this area involves the removal of the bulkhead to cut back the creek edge and create slope (Bob Will, personal communication 2002). This portion of the APE is sensitive for cultural resources associated with the Revolutionary War Holland's Ferry camp. Remains were uncovered by street grading for the construction of 201st Street and 9th Avenue in 1894, and when the power plant on the north side of Academy Street was constructed circa 1904 (Bolton 1924:170, 1916:187). However, Bolton noted that most of the camp refuse was found on the Harlem River shore and "very few objects were found on the north shore of Sherman's Bay" (1916:188).

Construction of the Con Ed facility most likely destroyed any formerly intact archaeological deposits. It is possible, but unlikely, that the construction could have also sealed deposits beneath added fill. It is uncertain how far the planned cutting back of the creek bank in this area would extend past the bulkhead. It is possible, but not likely, that this work will impact any surviving deposits. Based on preliminary investigation results, further investigation of the Sherman Creek project area is not recommended.

If you have any questions or require additional information, please do not hesitate to contact me or Dr. Michael Cinquino at your earliest convenience.

Sincerely,

Robert J. Hanley, M.A., RPA
Senior Archaeologist
Panamerican Consultants, Inc.

References Cited

Beers
1873 Atlas of Hudson County, New Jersey.

Bolton, Reginald Pelham
1916 *Relics of the Revolution.* Self-published, New York.

1924 *Washington Heights: Its Eventful Past.* Dyckman Institute, New York.

1934 *Indian Life of Long Ago in the City of New York.* Joseph Graham, New York.

Bromley, George Washington, and Walter Scott Bromley
1897 *Atlas of the City of New York, Manhattan Island.* G.W. Bromley and Co., New York.

Dripps, Matthew
1867 *Plan of New York City, from the Battery to Spuyten Duyvill.* M. Dripps, New York.

1879 *Map of Jersey City and Hoboken, Hudson County, N.J.* M. Dripps, New York.

Geismar, Joan
1984 *An Evaluation of the Archaeological Potential of the Community Hospital Site, New York , NY.* Report on File at New York City Landmarks Preservation Commission (CEQR No. 88-194-M0).

Rutsch, Edward S., and Ralph J. Leo, Jr.
1979 *Stage IB Cultural Resource Survey for the Hudson County Sewerage Authority, 201 Wastewater Facility Plan–District I, Jersey City, North Bergen, Secaucus, and Kearny, Hudson County.* Historic Conservation and Interpretation, Inc., Newton, NJ. Report on File New Jersey Historic Preservation Office, Trenton.

Rutsch, Edward S., Susan Kardas, Edward Larrabee, Ralph Leo, Brian Morrell, James Lally, Barbara Kalata, and Herb Githens
1977 *Cultural Resources Reconnaissance Liberty State Park.* Historic Conservation and Interpretation, Inc., Paterson, NJ.

Sanborn
1893 Insurance Maps of the City of New York.

1900 *Insurance Maps of the City of New York.* Vol. 12. Sanborn-Perris Map Company, New York.

1911 *Insurance Maps of Hudson County, New Jersey.* Vol. 6. Sanborn Map Company, New York.
1913 Insurance Maps of the City of New York.

Skinner, Alanson

1961 *The Indians of Manhattan Island and Vicinity.* Ira J Freidman, Inc., Port Washington, NY. [Reprint - Originally Published 1909].

United States Coast and Geodetic Survey (USCGS)
1902 *Hudson River, New York to Haverstraw.* U.S. Coast and Geodetic Survey, Washington, D.C.

1908 *Harlem River, New York.* U.S. Coast and Geodetic Survey, Washington, D.C.

United States Geological Survey
1955 *Central Park, New York Quadrangle.* 7.5 Minute series. U.S. Geological Survey, Washington, D.C.

1955 *Jersey City, New Jersey Quadrangle.* 7.5 Minute series. U.S. Geological Survey, Washington, D.C.

USACE
2002 *Scope of Work and Request for Cost Proposal Cultural Resources Documentary Study of Two Priority Sites for the Hudson-Raritan Estuary Ecosystem Restoration Project, Liberty State Park, Jersey City, Hudson County, New Jersey [and] Sherman Creek, New York County, New York.* U.S. Army Corps of Engineers, New York District, New York.

Will, Bob
2002 Personal Communication, U.S. Army Corps Engineers, New York District

Appendix B
SCOPE OF WORK

Appendix C
VITAE OF KEY PERSONNEL

ROBERT J. HANLEY III, RPA
Senior Archaeologist

EDUCATION

M.A. Archaeology, State University of New York at Albany, 1994
B.A. Anthropology, State University of New York, College at Buffalo, 1989

EXPERIENCE

Mr. Robert J. Hanley is currently a Senior Archaeologist with Panamerican Consultants, Inc. He has more than thirteen (13) years experience in prehistoric and historic period archaeology serving as principal investigator, field director, crew chief and field technician. He has participated in over 100 field investigations throughout the Northeast, including New York, New Jersey, Pennsylvania, Connecticut, Maryland, and Rhode Island, as well as in Puerto Rico, St. Croix, Iowa, Illinois, Texas and Virginia. He is experienced at conducting cultural resource investigations on large-scale projects including waterfront development, pipeline/corridor and highway projects and military installations, which often require design of field methodology including predictive site modeling strategies, all phases of archaeological field investigations, and report preparation.

He has extensive experience in lithic and human bone analysis. Mr. Hanley has directed and implemented a comprehensive array of field methodologies pertinent to cultural resource investigations, including developing and implementing research designs, directing field investigations, and preparing detailed written discussions of fieldwork. As principal investigator and field director, he has coordinated and supervised field investigations and artifact analysis. His other responsibilities include data analysis and report writing. While with PCI, he has presented *Cultural Resources Management Planning and Predictive Modeling at Picatinny Arsenal, New Jersey* at the 2000 Society for American Archaeology Meeting and for the Houghton Chapter of the New York State Archaeological Association. He has also conducted presentations for primary and secondary education classes to broaden public knowledge of archaeology and cultural resource preservation. He is a member of the Register of Professional Archaeologists (RPA) and the Society for American Archaeology (SAA).

PANAMERICAN CONSULTANTS, INC. EXPERIENCE (MAY 1997 TO PRESENT)

For Parsons Brinckerhoff Quade & Douglas, Buffalo, Mr. Hanley conducted a Phase IA archaeological and architectural reconnaissance survey as part of the Southtowns Connector/ Buffalo Outer Harbor Project, Cities of Buffalo and Lackawanna and Town of Hamburg, Erie County, New York.

For National Fuel Gas Supply Corp. under contract to Northern Ecological Associates, Inc., Mr. Hanley served as Co-Principal Investigator for a Phase I Cultural Resource Investigation of the Proposed Ellisburg Alternative Natural Gas Pipeline, Towns of Allegany and Hebron, Potter County, Pennsylvania. Served as PCI's Co-Principal Investigator for the cultural resources investigation of the proposed Northwinds natural gas pipeline installation.

Mr. Hanley was Co-Principal Investigator and Field Director for a Phase I cultural resources survey of the Selody property in the Borough of Manville, Somerset County, New Jersey. The investigation was completed for the U.S. Army Corps of Engineers (USACE), New York District under contract to Barry A. Vittor and Associates, Inc., Mobile, AL, and conducted as part of an evaluation of a potential wetland mitigation site for the Green Brook Flood Control Project.

For the New York District, USACE (under contract to NEA, Inc.), he served as PCI Field Director and Co-Principal Investigator for the Phase I cultural resources investigation of the Union Beach Flood Protection and Beach Restoration Feasibility Study, Union Beach, NJ. Field investigations included walkover reconnaissance, photographic documentation, shovel testing, and stratigraphic sampling.

For the New York District, USACE (under contract to Barry Vittor & Associates), he served as Field Director and Co-Principal Investigator for the Phase I cultural resources investigation of the South River Flood Control and Ecosystem Restoration Project in Sayreville and South River, NJ. Field investigations included walkover reconnaissance, photographic documentation, shovel testing, and stratigraphic sampling.

He was Field Director for PCI's Phase IB cultural resources investigation at Clinton Square in the City of Syracuse, Onondaga County, New York. Prepared for Edward V. Curtin & Associates (under contract to Clough, Harbour & Associates, LLP), the investigation identified the presence and assessed the condition of the historic Erie Canal at Clinton Square. Phase IB investigations at Clinton Square involved backhoe monitoring in proposed areas of construction and hand excavation at six locations determined in consultation with Dr. Robert Kuhn of the New York SHPO. Remains of canal or canal basin walls were found at five of the six locations beneath modern fill.

For National Fuel Gas Supply Corp. under contract to Northern Ecological Associates, Inc., Mr. Hanley served as Field Director for a Phase I cultural resource survey for the proposed Line S-43 replacement in the Summit Township, Erie County, Pennsylvania. Field methods consisted of intensive surface and subsurface investigations of the complete study area. The study area is a proposed 9,445-ft long gas line replacement with a 100-foot right-of-way and three existing staging areas. The purpose of the project was to determine the presence of cultural resources prior to potential construction impacts.

He has served as PCI field director for at least ten terrestrial archaeological projects sponsored by the USACE, New York District under contracts DACW51-97-D-0009 and DACW51-97-D-0010, including a cultural resource survey for the South River Flood Control and Ecosystem Restoration project, Middlesex County, NJ; a cultural resources investigation of the Selody Property, Manville, Somerset County, NJ; a Phase I investigation of the Finderne property, Bridgewater Township, NJ; a Phase II investigation for the Hemlock Street weir and wing dam, Bergen County, NJ; and a Phase I cultural resources investigation at Building 117 (the Lee House) at Fort Hamilton, Brooklyn.

For the USACE, New York District, Mr. Hanley has served as Field Director for Phase II cultural resource investigations at three prehistoric sites in Sensitivity Areas 16A and 25A at Picatinny Arsenal, Rockaway Township, Morris County, New Jersey. The investigation included field inspection of the three archaeological site areas, supplemental, close-interval shovel testing of sensitive areas, excavation of 1-x-1-meter units, and photographic documentation of the sites and field conditions.

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix D

Real Estate

U.S. Army Corps of Engineers

REAL ESTATE PLAN

Hudson-Raritan Estuary,

Liberty State Park Ecosystem Restoration Study

Prepared by:

Department of the Army
New York District
Corps of Engineers

Real Estate Division

October 2005

REAL ESTATE PLAN

Hudson-Raritan Estuary, Liberty State Park Ecosystem Restoration Project

TABLE OF CONTENTS

ITEM	PAGE
Preamble	1
1. Statement of Purpose	2
2. Project Purpose and Features	2
3. Non-Federal Sponsor Owned Lands	3
4. Estates	3
5. Existing Federal Projects	4
6. Federally-owned Lands	4
7. Navigational Servitude	4
8. Maps	4
9. Induced Flooding	4
10. Baseline Cost Estimates	4
11. Compliance with Public Law 91-646	4
12. Minerals and Timber	4
13. Assessment of Non-Federal Sponsor's Land Acquisition Experience & Ability	4
14. Zoning	4
15. Acquisition Schedules	5
16. Facility/Utility Relocations	5
17. Hazardous, Toxic or Radiological Waste (HTRW)	5
18. Project Support	5
19. Notifications to the Non-Federal Sponsor	5
20. Other Real Estate Issues	5
21. Recommendations	6

Exhibits

"A" - Estates
"B" – Baseline Cost Estimates
"C" – Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

MAPS

Figure 1 – Project Vicinity
Figure 2 – Existing Project Site
Figure 3 – Project Alignment ("Recommended Plan")

Preamble

Introduction: Liberty State Park was established in the early 1970's on land situated on the west shoreline of the Hudson River in the City of Jersey City, Hudson County, New Jersey, (opposite Liberty and Ellis Islands) that was filled in during the 19th and early 20th centuries, and subsequently abandoned in the late 1960s, by the (then-bankrupt) Central Railroad of New Jersey and/or its predecessor railroad entities. The Park consists largely of abandoned former industrial property that was acquired by the City of Jersey City and then conveyed by the City to the State of New Jersey for park purposes, as well as similar land acquired by the State specifically for park purposes. *No Federal funds were used to acquire the land.*

Authorization: – The Hudson-Raritan Estuary Ecosystem Restoration study was authorized in a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, dated 15 April 1999:

> *"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."*

Official Project Designation: *Hudson-Raritan Estuary, Liberty State Park Ecosystem Restoration Study*, Jersey City, Hudson County, New Jersey

Project Location: Liberty State Park is situated on the western shoreline of Hudson River within the City of Jersey City, due west across the River from lower Manhattan, New York City and approximately 750 feet west of Ellis Island and 1,000 feet west of Liberty Island. The Park is bounded by residential and commercial neighborhoods to the west, by the Morris Canal to the north, by the Upper New York Bay to the east, and by "Black Tom" cove to the south. The specific Project area *within* the Park is bounded on the north by Audrey Zapp Drive, on the east by Freedom Way, on the south by Morris Pesin Drive, and the west by Phillip Drive.

Non-Federal Sponsor: For the Feasibility phase of this Project, the non-Federal Sponsor is *The Port Authority of New York and New Jersey*. For the Construction phase of the Project, however, the proposed non-Federal sponsor is the *State of New Jersey*, acting by and through its *Department of Environmental Protection* (hereinafter, "NJDEP" or "the State"). The cost sharing of the Project will be **65% Federal** and **35% non-Federal**.

REAL ESTATE PLAN

1. **Statement of Purpose**: The purpose of this Real Estate Plan (the "REP" or the "Plan") is to present the overall plan describing the minimum real estate requirements for the construction, operation, maintenance, repair and rehabilitation of the proposed Project. It is Appendix "D" to the *Hudson-Raritan Estuary, Liberty State Park Integrated Feasibility Report & Environmental Impact Statement* dated October 2005.

2. **Project Purpose and Features**:

A. Liberty State Park is situated on the western side of Upper New York Bay approximately 750 to 1,000 feet west of Ellis and Liberty Islands, the latter the site of the Statue of Liberty. The Park comprises 1,121 acres, consisting of approximately 598 upland/wetland acres and 523 tidal acres.

The land currently comprising Liberty State Park was once largely cove and costal marshland. In the 1850's, the site began the process of being converted into a number of industrial/commercial sites and a large railroad yard/ railroad passenger terminal to ferry passengers and freight to and from New York City .

The railroad yard and nearby industrial/commercial properties were subsequently abandoned and were converted into an urban waterfront park in 1976 (now known as Liberty State Park). Liberty State Park is not yet completely developed as a park. Approximately 251 acres, in the center of the park, remain undeveloped. Because portions of these undeveloped lands have been contaminated with industrial by-products, they have been fenced off from public use, as required by a 2001 Consent Decree of the US District Court for the District of New Jersey – Newark Vicinage, Civ. Action Nos. 93-4774, 94-3434, 94-3793.

B. The *Plan of Improvement* calls for the re-establishment of wetlands by the restoration of lost salt marsh and tidal habitat, enhancement of existing wetlands, removal of invasive plant species, and by the planting of native species. Physically, the work will entail excavating (including the removal of debris from previous industrial activities), grading and planting of native wetland species. The Project area comprises approximately **234 acres**, consisting of approximately **225 acres** of "upland" and **9 acres** of submerged, State-owned lands.

C. *Required Lands, Easements, Rights-of-Way, and Disposal Areas* (LERRD): The prospective non-Federal sponsor, NJDEP, owns all the lands within the project boundary lines. Accordingly, no further acquisitions of real property, or interests in real property (including site access), are required for this project. Upon signing a PCA, the Corps (NY District) will provide the Sponsor with a legal description of the required project area (approx. 234 acres) and NJDEP, in turn, will submit a formal *Authorization for Entry for Construction* to the NY District.

A summary of Project LERRD requirements is as follows:

Fee: 0 acres
Permanent Easement or equivalent: 0 acres
Temporary Easement: None

D. *Appraisal information*: The proposed project area's 234 acres is currently degraded wetlands, owned in fee by the State of New Jersey and limited by New Jersey law (NJSA 13:8A-48) to "open space" uses precluded from ordinary commercial, industrial or residential development, nor can it be sold by the State except under specific, limited circumstances. The project would result in no greater restrictions on the land than are currently in place under New Jersey law.

Historically, prior to acquisition over 30 years ago by the State of New Jersey these degraded wetlands were used as a railroad yard and subject to pollution derived from that industrial use. These wetlands' highest and best use is limited by the statutory restrictions and environmental concerns and stigma from its prior industrial use that would severely hinder any potential development. The cost of cleanup and potential flooding further constrain economic value. Accordingly, the estimated economic value of the Project LERRD is nominal.

E. *Administrative Costs*: The Non-Federal Sponsor acquired the lands required for project use over 5 years ago and therefore its "administrative" acquisition costs are not credit-eligible.

Other anticipated administrative costs are as follows:

Non-Federal	$ 5,000
Federal (including Real Estate Planning)	$20,000
Sub-total:	$25,000
Twenty percent (20%) contingency	$ 5,000
TOTAL:	$30,000

3. **Non-Federal Sponsor Owned Lands**: The Sponsor owns in fee all the 598 upland/wetland acres and 523 tidal acres that comprise Liberty State Park, including the approximately 234 acres required for the construction, operation and maintenance of this Project. The Sponsor's interest is sufficient and available for construction, operation, maintenance, repair and rehabilitation of the Project.

4. **Estates**: The Non-Federal Sponsor (State of New Jersey) is the fee simple owner, and as such no other estates are required for Project acquisition. A formal *Authorization for Entry for Construction* to the NY District will be required and is hereto attached as **Exhibit "A"**.

5. **Existing Federal Projects**: There is an existing Federal Project adjacent to the proposed project, the *Liberty State Park – Levee and Seawall Project*, constructed in 1986. Neither Project will affect the other.

6. **Federally-owned Lands**: There are no Government-owned lands in the Project area.

7. **Navigational Servitude**: The Project will neither affect, nor require use of, any Navigable Waters of the United States. Although some of the Project area may at one time have been submerged, the lands required by the Project are not navigable and have not been submerged or subject to tidal influences since at least as far back in time as 1919, and are now "upland" (landward of the Mean High Water Line). Accordingly, the Government will not need to exercise its rights under the doctrine of Navigational Servitude for this Project.

8. **Maps**: *Map 1* depicts the vicinity of the Project. *Map 2* depicts the existing uses of the Project site. *Map 3* depicts the Project's "Recommended Plan."

9. **Induced Flooding**: No induced flooding is anticipated as a result of this Project.

10. **Baseline Cost Estimate**: A baseline cost estimate, in M/CASES format, is attached hereto as **Exhibit "B"**.

11. **Compliance with Public Law 91-646**: No persons, residences, farms or businesses will need to be relocated for this Project. Therefore, no relocation assistance pursuant to Public Law 91-646, as amended, will be required for the Project.

12. **Minerals and Timber**: There are no present or anticipated mineral extraction or timber harvesting activities in the Project area and/or its vicinity.

13. **Assessment of the Non-Federal Sponsor's Land Acquisition Experience and Ability**: The State of New Jersey, acting by and through its Department of Environmental Protection (NJDEP) is the proposed non-Federal sponsor for the Project's construction phase. The State of New Jersey owns in fee all Project LERRD, and no further acquisitions of real property or interests in real property are anticipated for this Project. NJDEP, however, has the legal and professional capability and experience to acquire and provide the LERRD for the construction, operation, and maintenance of the Project. They have condemnation authority and quick-take capability, although it is not anticipated that these actions will be required for this Project. An Assessment of the Non-Federal Sponsor's Land Acquisition Capability is attached as **Exhibit "C"**.

14. **Zoning**: Application or enactments of zoning ordinances are not anticipated for the Project.

15. **Acquisition Schedule**: The current Project schedule anticipates execution of a Project Cooperation Agreement on or about 31 January, 2007 (the "PCA date") and solicitation of bids for construction on or about 30 June 2007 (the "R/T/A date"). Insofar as the non-Federal Sponsor owns in fee all anticipated Project LERRD, Certification of Project LERRD by the Chief, Real Estate Division, is expected to occur approximately 30 days prior to the R/T/A date.

16. **Facility and/or Utility Relocations**: No facility or utility relocations are anticipated for this Project. An underground sanitary sewer line traverses the Project area, but it is buried deeply enough so that it will not be affected by the Project, nor will it (or any of the utilities identified in a 1975 PANYNJ Utility Plan) interfere with, or be affected by, the Project.

17. **Hazardous, Toxic, and Radiological Waste (HTRW)**: In August 2003 and February 2004, New York District, in collaboration with the Non-federal Sponsor NJDEP, conducted an extensive sub-surface soil characterization within Liberty State Park. As discussed in Section 3.12 ("HTRW") of the Study's *Integrated Feasibility Report/EIS*, there are substances listed under CERCLA/RCRA within the study area, but not at high enough levels to require CERCLA/RCRA action. It was not possible to avoid these substances during the formulation of complete and ecologically sensitive restoration measures. No excavated or disturbed soils will be removed from the Project area for off-site placement or disposal.

18. **Project Support:** Local officials and residents in the vicinity of the Project Area are very supportive of the Project. In addition, the environmental improvements anticipated by the Project are consistent with the 2001 *Consent Decree* discussed in paragraph 2A herein.

19. **Notification to Non-Federal Sponsor**: Based on its past sponsorship of other Corps water resource (Civil Works) projects and ongoing discussions during the Project's Feasibility phase, the non-Federal Sponsor is aware of the risks of acquiring LERRD required for the Project prior to the signing of the Project Cooperation Agreement ("PCA"). The Sponsor acquired its fee simple interest in the Project area before the Project was anticipated. However, formal written notification of the risks of such acquisition, in accordance with paragraph 12-31 of Chapter 5 of the Corps of Engineers Real Estate Handbook, ER 405-1-12, will be forwarded to the non-Federal Sponsor *before* the Project Cooperation Agreement (PCA) is signed.

20. **Other Issues**:

A. There are no known mitigation requirements.

B. There are no known historical or cultural artifacts within the project area. The sensitivity for prehistoric resources within the project area is low as the location consists entirely of man-made land and no work is anticipated to reach depths determined sensitive for paleo-environmental data.

The Liberty Science Center Wetlands Complex area was not under consideration for restoration at the time the cultural study was undertaken, and so has not been

surveyed. As the project proceeds, this area will be surveyed and subsequent cultural resources work will be undertaken as required. It is the Corps' opinion that the restoration work for the remaining areas at Liberty State Park will have no effect upon cultural resources if project plans remain as proposed. If excavation is determined necessary in the vicinity of the former Communipaw shoreline than subsurface work may be required. The New Jersey Historic Preservation Office has concurred with this evaluation. This work was also coordinated with the Liberty State Park Resource Interpretive Specialist.

C. Aside from the sanitary sewer line discussed in paragraph 16 hereof, there are no known existing encumbrances (i.e., easements, rights-of-way, etc) that would affect, or be affected by, the Project.

D. Insofar as the State of New Jersey is the non-Federal Sponsor, the Corps of Engineers will not be required to obtain any State (NJDEP) Tidelands Conveyance permits.

E. The non-Federal sponsor will assume responsibility to maintain the project after construction. New York District will be supplying a manual, as proscribed in the PCA, delineating actual practices for this type of project.

21. **Recommendations**: This report has been prepared in accordance with Chapter 12 of the Corps of Engineers Regulation ER 405-1-12. It is recommended that this report, and the non-Standard Estate discussed and described in Paragraph 4 herein, be approved.

NOREEN DEAN DRESSER
Chief, Real Estate Division

REAL ESTATE PLAN

Hudson-Raritan Estuary,

Liberty State Park Ecosystem Restoration Project

EXHIBIT "A" - ESTATES

Department of the Army
U.S. Army Engineer District, New York

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I, _____, _____, New Jersey Department of Environmental Protection, do hereby certify that the State of New Jersey (Department of Environmental Protection) has acquired the real property interests required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands, to support construction of the *Liberty State Park Environmental Restoration Project* at Jersey City, Hudson County, New Jersey. Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon Tract A to construct the *Liberty State Park Environmental Restoration Project* at Jersey City, New Jersey as set forth in the plans and specifications held in the U.S. Army Corps of Engineers' New York District Office, New York City, New York.

WITNESS my signature as _____, New Jersey Department of Environmental Protection, this ____ day of _____, 200___.

By: _____
(Name)

Title: _____

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, _____, Esquire, Attorney for _____, certify that the State of New Jersey (Department of Environmental Protection) has authority to grant the above Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as Attorney for _____, this ____ day of _____, 200___.

By: _____
(Name)

Title: _____

NJ Department of Environmental Protection
Land Use Regulation Program
Standard Conservation Restriction for Mitigation Sites

Prepared by:

DECLARATION OF CONSERVATION RESTRICTION/EASEMENT

This DECLARATION OF CONSERVATION RESTRICTIONS/EASEMENT made this day of .

WITNESSETH:

WHEREAS, (insert the owner's name) hereinafter called the Declarant, is the owner in fee simple of certain real property including its air space and subsurface, and all rights therein, hereinafter called the "Protected Property," which has ecological, scientific, educational and aesthetic value in its present state as a natural area which has not been subject to development or exploitation, which property known as Block ____, Lot ____ in (Municipality), (County), New Jersey is more particularly described in Exhibit A (metes and bounds description) attached hereto and incorporated by this reference; and

WHEREAS, the State of New Jersey, Department of Environmental Protection (hereinafter called the "Department") is authorized by N.J.S.A. 13:ID-9 to formulate comprehensive policies for the conservation of the natural resources of the State, the promotion of environmental protection and the prevention of pollution of the environment of the State and is authorized by N.J.S.A. 13:8B-3 to acquire and enforce conservation restrictions in conjunction with the construction of a wetland mitigation site known as the (insert name of mitigation bank/site); and

WHEREAS the Protected Property is a significant natural area and a valuable component of a freshwater wetlands ecosystem; and

WHEREAS the Declarant desires to preserve the Protected Property in its natural state so as to preserve and protect the freshwater wetlands, open waters, and resident animal and plant species on the Protected Property,

NOW, THEREFORE, the Declarant, for and in consideration of the facts above recited and of the mutual covenants, terms, conditions, and restrictions herein contained and as an absolute and unconditional gift, does hereby covenant, and agree with the Department, that the Protected Property, including its air space and subsurface and, all rights therein, is hereby subject to the following covenants, restrictions and easements in perpetuity:

1. Purpose. It is the purpose of this Conservation Restriction/Easement to assure that the Protected Property, including its air space and subsurface, will be retained forever in its natural, scenic and open condition as a valuable component of a freshwater wetlands ecosystem; to protect any rare plants, animals, or plant communities on the Protected Property, its air space and subsurface, and to prevent any use of the Protected Property that will impair or interfere with the conservation values or interests of the Protected Property, including its air space and subsurface. Declarant intends that its Conservation Restriction/Easement will confine the Protected Property, including its air space and its subsurface, to such activities as are consistent with the purpose of this Conservation Restriction/Easement and as permitted in the plans and specifications approved by the Department.

2. Prohibited Uses. Except as authorized in the plans and specifications for construction of the mitigation activity, use of the Protected Property, its air space and its subsurface, inconsistent with the purpose of this Conservation Restriction/Easement is prohibited. Without limiting the generality of the foregoing, the following activities and uses are expressly prohibited on the Protected Property, including its air space and subsurface:

2.1 There shall be no constructing or placing of any building, tennis court, landing strip, mobile home, swimming pool, fence or sign (other than those required for appropriate management), asphalt or concrete pavement, billboard or other advertising display, antenna, utility pole, tower, conduit, line or any other temporary or permanent structure or facility on, above or below the premises, other than those structures

which currently exist (which may be maintained, repaired, or replaced, but not substantially expanded, on the same site, in whole or in part by like structures used for the same or similar purposes.)

2.2 There shall be no ditching, draining, diking, filling, excavating, dredging, mining or drilling, removal of loam, peat, gravel, soil, topsoil, sand, rock, minerals or other materials on or below the Protected Property, nor any change in the topography of the Protected Property in any manner.

2.3 There shall be no removal, destruction or cutting of trees or plants, planting of trees or plants, use of fertilizers, introduction of non-native animals and plants, grazing of domestic animals, or disturbance or change in the natural habitat in any manner, except as provided in par. 3.4 below.

2.4 There shall be no storage or dumping of soil, ashes, trash, garbage, or other material, hazardous substance, or toxic waste, nor any placement of underground storage tanks in, on, above or below the Protected Property; there shall be no changing of the topography through the placing of soil or other substance or material such as land fill or dredging spoils, nor shall activities be conducted on, above or below the Protected Property or on, above or below adjacent property if owned by Declarant which could cause erosion or siltation on the Protected Property.

2.5 There shall be no pollution, alteration, depletion or extraction of surface water, natural water courses, lakes, ponds, marshes, subsurface water or any other water bodies, nor shall there be activities conducted on, above or below the Protected Property or on, above or below adjacent property if owned by Declarant, which would be detrimental to water purity, drainage, flood control, water conservation, erosion control or soil

conservation, or which could alter the natural water level and/or flow in or over the Protected Property.

2.6 The Protected Property, including its air space and its subsurface, and any portion thereof shall not be included as part of the gross area of other property not subject to this Conservation Restriction/Easement for the purposes of determining density, lot coverage, or open space requirements, under otherwise applicable laws, regulations or ordinances controlling land use and building density.

2.7 There shall be no other acts or uses detrimental to the preservation of the Protected Property, including its air space and its subsurface in their natural state as a valuable component of a freshwater wetlands ecosystem.

3. Department's Rights. To accomplish the purpose of this Conservation Restriction/Easement, the following rights are conveyed to the Department by this Conservation Restriction/Easement:

3.1 The right to preserve and protect the conservation values of the Protected Property, including its air space and subsurface.

3.2 The right of visual access to and view of the Protected Property in its natural, scenic and open condition.

3.3 Inspection and Scientific Studies. The right to enter the Protected Property at all reasonable times and, if necessary, across other lands retained by the Declarant, for the purposes of (a) inspecting the Protected Property to determine if the Declarant is complying with the covenants and purposes of this Conservation Restriction/Easement; (b) enforcing the terms of this Conservation Restriction/Easement; (c) taking any and all actions with respect to the Protected Property as may be necessary or appropriate, with or without order-of court, to remedy or abate violations

hereof; and (d) observing and studying nature and making scientific and educational observations and studies and taking samples.

3.4 Monitoring and Management. The right, but not the obligation, to monitor the condition of the rare plant and animal populations, plant communities, and natural habitats on the Protected Property, and to manage them, if necessary, for their continued survival and quality on the Protected Property. Such activities shall be in accordance with management practices of the Department, which may include, but not be limited to, mowing, fencing, trapping, prescribed burning, but not inconsistent with the maintenance or monitoring obligations under the (reference the mitigation proposal or permit condition) approving the mitigation.

3.5 Enforcement. The right to prevent any activity on or use of the Protected Property, including its air space and subsurface, that is inconsistent with the purpose of this Conservation Restriction/Easement and to require the restoration of such areas or features of the Protected Property that may be damaged by any inconsistent activity or use. Enforcement of this Conservation Restriction/Easement shall be at the discretion of the State of New Jersey and any forbearance on behalf of the -State of New Jersey to exercise its rights hereunder in the event of any breach hereof by Declarant, its successors or assigns shall not be deemed or construed to be a waiver of the State's rights granted hereunder in the event of any subsequent breach. This shall be true regardless of the number of breaches which occur or the length of time of any forbearance from enforcement.

3.6 Discretionary Consent. The Department's consent for activities otherwise prohibited under paragraph 2 above, may be given under the following conditions and circumstances. If, owing to unforeseen or changed

circumstances, any of the activities listed in paragraph 2 are deemed desirable by the Department, the Department may, in its sole discretion, give permission for such activities, subject to the limitations herein. Such requests for permission, and permission for activities requiring the Department's consent under paragraph 2 shall be in writing. The Department may give its permission only if it determines, in its sole discretion, that such activities (1) do not violate the purpose of this Conservation Restriction/Easement and (2) either enhance or do not impair any conservation interests associated with the Protected Property.

4. Air and Subsurface Rights. This Conservation Restriction/Easement expressly applies to all development and exploitation of the Protected Property, its air space and subsurface, and all development or other rights therein.

5. Access. Nothing contained in this Conservation Restriction/Easement shall give or grant to the public a right to enter upon or to use the Protected Property or any portion thereof.

6. Costs and Liabilities. Declarant retains all responsibilities and shall bear all costs and liabilities of any kind related to the ownership, operation, upkeep and maintenance of the Protected Property, including the maintenance of adequate comprehensive general liability insurance coverage. Declarant shall keep the Protected Property free of any liens arising out of any work performed from materials furnished to or obligations incurred by Declarant.

7. Taxes. The Declarant agrees to pay any real estate taxes or other assessments levied on the Protected Property. If the Declarant becomes delinquent in payment of said taxes or assessments, such that a lien against the land is created, the Department, at its option, shall, after written notice to the Declarant, have the right to purchase and acquire the Declarant's interest in said Protected Property by paying funds to discharge said lien or delinquent taxes or assessments, or to take such other actions as may be necessary to protect the Department's

interest in the Protected Property and to assure the continued enforceability of this Conservation Restrictive/Easement.

8. Parties Subject to Easement. The covenants agreed to and the terms, conditions, restrictions and purposes imposed with this grant shall not only be binding upon the Declarant, but also upon its lessees, agents, personal representatives, successors and assigns, and all other successors to Declarant in interest and shall continue as a servitude running in perpetuity with the Protected Property.

9. Subsequent Transfers. The Declarant agrees that the terms, conditions, restrictions and purposes of this Conservation Restriction/Easement will be inserted by Declarant in any subsequent deed or other legal instrument by which the Declarant divests either the fee simple title or possessory interest in the Protected Property, and Declarant further agrees to notify the Department of any pending transferal least thirty (30) days in advance.

10. Merger. The Declarant agrees that the terms of this Conservation Restriction/Easement shall survive any merger of the fee and easement interest in the Protected Property.

11. Assignment. The Department agrees that it will assign its rights under this instrument only to another governmental body or a charitable conservancy, and only in accordance with X.J..S.A. 13:8B-1 et seq..

12. Miscellaneous Provisions.

12.1 Severability. If any provision of this Conservation Restriction/Easement or the application thereof to any person or circumstances is found to be invalid, the remainder of the provisions of the Conservation Restriction/Easement and the application of such provisions to persons or circumstances other than those as to which it is found to be invalid shall not be affected thereby.

12.2 Successors and Assigns. The term Declarant shall include the Declarant and the Declarant's heirs, executors, administrators, successors and assigns and shall also mean the masculine, feminine, corporate, singular or plural form of the word as needed in the context of its use. The term Department shall include the Department, its successors and assigns.

12.3 Re-recording. The Department is authorized to record or file -any notices or instruments appropriate to assuring the perpetual enforceability of this Conservation Restriction/Easement; the Declarant agrees to execute any such instruments upon request.

12.4 Captions. The captions herein have been inserted solely for convenience of reference and are not a part of this, Conservation Restriction/Easement and shall have no effect upon construction or interpretation.

TO HAVE AND TO HOLD the said Conservation Restriction/Easement unto the said Department forever.

IN WITNESS WHEREOF, the Declarant has executed and sealed this document the day and year first above written.

ATTEST: (name of company)

_____ By:_____
Corporate Secretary (name)
Title:_____

STATE OF (fill in name)
COUNTY OF (fill in name)

On this_____day of _____before me personally appeared_____, to me personally known, who, being by me duly sworn did say that he is the (fill in title) of the corporation named in the foregoing instrument, that the seal affixed to said instrument is the corporation seal of said corporation, and acknowledged said instrument to be the free act and deed of said corporation.

NJ Department of Environmental Protection
Land Use Regulation Program
Standard Conservation Restriction for Mitigation Sites

_____
Notary Public
My Commission Expires:

vk/c:wetmit/deedrestriction

_____
Notary Public
My Commission Expires:

Exhibit B - Chart of Accounts
for
Hudson-Raritan Estuary

	Liberty State Park			
	Ecosystem Restoration Project			
	(Prepared by CENAN-RE-M)			
	TOTAL PROJECT COSTS	non-Federal	Federal	Project Cost
01	LANDS AND DAMAGES	$5,000	$20,000	25,000
	20% Contingency	$1,000	$4,000	5,000
	Grand Total: (rounded)			30,000
01A	PROJECT PLANNING	0	20,000	
01A10	REAL ESTATE SUPPLEMENT/PLAN		20,000	
01A20	PRELIMINARY RE ACQUISITION MAPS		0	
01A30	PHYSICAL TAKINGS ANALYSIS		0	
01A40	PRELIMINARY ATTORNEY'S OPINION OF COMPENSABILITY		0	
01A50	ALL OTHER RE ANALYSES/DOCUMENTS		0	
01B	ACQUISITIONS	0	0	
01B10	BY GOVERNMENT			
01B20	BY LOCAL SPONSOR (LS)	0		
01B30	BY GOVT ON BEHALF OF LS			
01B40	REVIEW OF LS		0	
01C	CONDEMNATIONS	0	0	
01C10	BY GOVERNMENT			
01C20	BY LS			
01C30	BY GOVT ON BEHALF OF LS			
01C40	REVIEW OF LS			
01D	INLEASING	0	0	
01D10	BY GOVERNMENT			
01D20	BY LS			
01D30	BY GOVT ON BEHALF OF LS			
01D40	REVIEW OF LS			
01E	APPRAISAL	0	0	
01E10	BY GOVT (IN HOUSE)			
01E20	BY GOVT (CONTRACT)			
01E30	BY LS	0		
01E40	BY GOVT ON BEHALF OF LS			
01E50	REVIEW OF LS		0	
01F	PL 91-646 ASSISTANCE	0	0	
01F10	BY GOVERNMENT			
01F20	BY LS			
01F30	BY GOVT ON BEHALF OF LS			
01F40	REVIEW OF LS			

Exhibit B - Chart of Accounts
for
Hudson-Raritan Estuary
Liberty State Park
Ecosystem Restoration Project
(Prepared by CENAN-RE-M)

01G	TEMPORARY PERMITS/LICENSES/RIGHTS-OF-ENTRY	0	0	
01G10	BY GOVERNMENT			
01G20	BY LS	0		
01G30	BY GOVT ON BEHALF OF LS			
01G40	REVIEW OF LS		0	
01G50	OTHER			
01G60	DAMAGE CLAIMS			
01H	AUDITS	0	0	
01H10	BY GOVERNMENT			
01H20	BY LS			
01H30	BY GOVT ON BEHALF OF LS			
01H40	REVIEW OF LS			
01J	ENCROACHMENTS AND TRESPASS	0	0	
01J10	BY GOVERNMENT			
01J20	BY LS			
01J30	BY GOVT ON BEHALF OF LS			
01J40	REVIEW OF LS			
01K	DISPOSALS	0	0	
01K10	BY GOVERNMENT			
01K20	BY LS			
01K30	BY GOVT ON BEHALF OF LS			
01K40	REVIEW OF LS			
01N00	FACILITY/UTILITY RELOCATIONS	0	0	
01Q00	RESERVED FOR FUTURE HQUSACE USE	0	0	
01R	REAL ESTATE PAYMENTS	0	0	
01R1	LAND PAYMENTS	0	0	
01R1A	BY GOVERNMENT			
01R1B	BY LS	0		
01R1C	BY GOVT ON BEHALF OF LS		0	
01R1D	REVIEW OF LS			
01R2	PL 91-646 ASSISTANCE PAYMENTS	0	0	
01R2A	BY GOVERNMENT			
01R2B	BY LS			
01R2C	BY GOVT ON BEHALF OF LS			
01R2D	REVIEW OF LS			

Exhibit B - Chart of Accounts
for
Hudson-Raritan Estuary
Liberty State Park
Ecosystem Restoration Project
(Prepared by CENAN-RE-M)

01R3	**DAMAGE PAYMENTS**	0	0	
01R3A	BY GOVERNMENT			
01R3B	BY LS			
01R3C	BY GOVT ON BEHALF OF LS			
01R3D	REVIEW OF LS			
01R9	**OTHER**			
01T	**LERRD CREDITING**	5,000	0	
01T10	LAND PAYMENTS			
01T20	ADMINISTRATIVE COSTS	5,000	0	
01T30	PL 91-646 ASSISTANCE			
01T40	ALL OTHER			

REAL ESTATE PLAN

Hudson-Raritan Estuary,

Liberty State Park Ecosystem Restoration Project

EXHIBIT "C"

Assessment of Non-Federal Sponsor's Real Estate
Acquisition Capability

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

PROJECT: Hudson-Raritan Estuary, Liberty State Park Ecosystem Restoration Project

NON-FEDERAL SPONSOR: New Jersey Department of Environmental Conservation

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? YES

b. Does the sponsor have the power of eminent domain for this project? YES

c. Does the sponsor have the "quick-take" authority for this project? YES

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? NO

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? NO

II. Human Resources Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? NO

b. If the answer to II.a. is yes, has a reasonable plan been developed to provide such training? N/A

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? YES

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? YES

e. Can the sponsor obtain contractor support, if required, in a timely fashion? YES

f. Will the sponsor likely request USACE assistance in acquiring real estate? NO.

Exhibit "C"

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? YES

b. Has the sponsor approved the project/real estate schedule/milestones? YES

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? YES

b. With regard to this project, the sponsor is anticipated to be: HIGHLY CAPABLE

V. Coordination:

a. Has this assessment been coordinated with the sponsor? YES

b. Does the sponsor concur with this assessment? YES

Prepared by:

Stanley Nuremburg
Realty Specialist

Reviewed and approved by:

Noreen D. Dresser
Chief, Real Estate Division

Exhibit "C"

REAL ESTATE PLAN

Hudson-Raritan Estuary,

Liberty State Park Ecosystem Restoration Project

MAPS

Map 1; Map 2; Map 3

Liberty State Park, Jersey City, New Jersey

Map 12.00
Fri Jul 22 16:46 2005
Scale 1:125,000 (at center)
2 Miles
2 KM

- Trail
- Ferry
- Secondary SR, Road, Hwy Ramp
- Major Connector
- State Route
- Primary State Route
- US Highway
- Interstate/Limited Access
- Toll Highway
- Railroad
- Point of Interest
- County Seat
- Town, Small City
- Large City
- Summit
- Geographic Feature

MAP 1

MAP 2

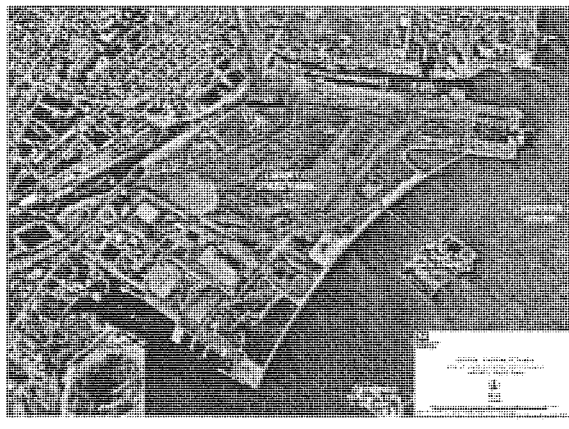
MAP 3

US ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT

HUDSON-RARITAN ESTUARY, LIBERTY STATE PARK ECOSYSTEM RESTORATION

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

Volume 3



October 2005

Liberty State Park, Hudson-Raritan Estuary

Ecosystem Restoration

Integrated Feasibility Report & Environmental Impact Statement

Volume 3: Appendices E - F

New York District
U.S. Army Corps of Engineers

October 2005

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix E - Engineering

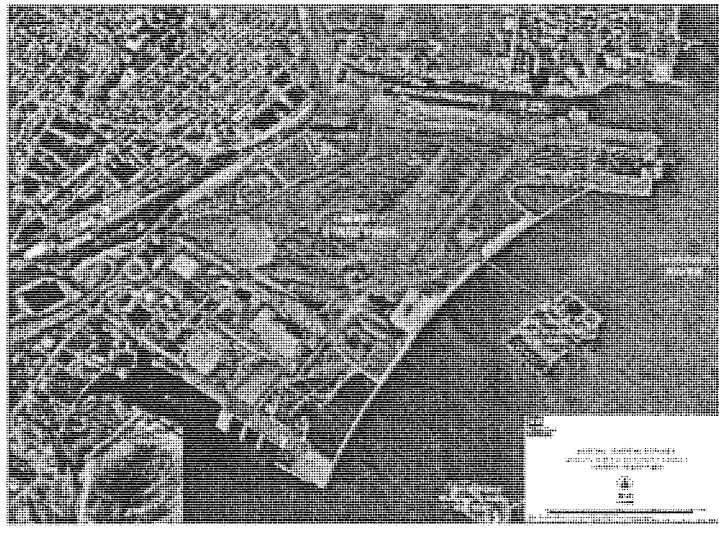
Main Report
Geotechnical Report
Freshwater Hydrology Report

US ARMY CORPS
OF ENGINEERS
NEW YORK DISTRICT

LIBERTY STATE PARK, HUDSON-RARITAN ESTUARY ECOSYSTEM RESTORATION

DRAFT INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

Engineering Appendix



July 2004

Liberty State Park, Hudson-Raritan Estuary

Ecosystem Restoration

Draft Integrated Feasibility Report & Environmental Impact Statement

Engineering Appendix

New York District
U.S. Army Corps of Engineers

July 2004

TABLE OF CONTENTS

Table of Contents ii
List of Figures iv
List of Tables vi
1. INTRODUCTION 2
1.1 General 2
1.2 Project Objectives 6
2. SITE DESCRIPTION 6
2.1 General 6
2.2 Topography/Bathymetry 6
2.3 Soils 13
2.4 HTRW Testing 13
2.5 Groundwater 17
2.6 General Watershed Description 20
2.7 Climatology and Precipitation 20
2.8 Tidal and Storm Surge Influences 20
2.9 Storm Surges 21
3.SELECTED NER PLAN 23
4. FRESH WATER WETLAND 28
4.1 Objectives 28
4.2 Hydrologic Analysis 29
4.3 Precipitaiton, Infiltration and Evapotranspiration 30
4.4 Estimated Runoff Volume 31
4.5 Environmental Design Criteria 32
4.6 Hydrologic Design Criteria 33
4.7 Fresh Water Wetland System: Components of Proposed Alternatives 35
4.8 Hydraulic Analysis and Design 42
4.8.1 Basis of Design 42
4.8.2 Hydraulic Design Criteria 43
4.8.2.1 Water Containment 43
4.8.2.2 Sediments and Debris 43
4.8.2.3 Design Event 43
4.8.2.4 Conduits 44
4.8.2.5 Materials 44
4.8.2.6 Infiltration Basin 44
4.8.3 Groundwater 44
4.8.4 SWMM Model Development 45
4.9 Analysis of Selected Alternative 45
4.10 10-year NJDOT Design Event Performance 51
4.11 Sensitivity Analysis 51
5. TIDAL WETLAND 52
5.1 Objectives 52
5.2 Tidal Analysis, Runoff and Groundwater 52
5.2.1 Tidal Analysis 52

5.2.2 Runoff 54
5.2.3 Groundwater 54
5.3 Environmental and Hydraulic Design Criteria 55
5.4 Alternatives 57
5.5 Components of Proposed Alternative 58
5.6 HEC-RAS Model Development 62
5.7 Analysis of the Selected Plan 65
5.8 Sensitivity Analysis 76
6 UPLAND MANAGEMENT AREA 76
7 DESCRIPTION OF COSTS 77
9.MONITORING 83
9.1 MONITORING PLAN 83
9.2 FIRST YEAR POST-CONSTRUCTION SITE ASSESSMENT 83
9.3 TIDAL WETLAND ONE, THREE, FIVE AND TEN YEARS POST CONSTRUCTION .. 84
9.3.1 Topographic/Bathymetric Monitoring 84
9.3.2 Sinuosity Monitoring 84
9.3.3 Hydrology/hydraulics/hydrodynamics Monitoring 84
9.3.4 Geotechnical Monitoring 85
9.4 FRESH WATER WETLAND ONE, THREE, FIVE AND TEN YEARS POST CONSTRUCTION 85
9.4.1 Topographic/Bathymetric Monitoring 85
9.4.2 Hydrology/hydraulics Monitoring 85
9.4.3 Geotechnical Monitoring 86
9.5 UPLAND MANAGEMENT AREA ONE AND FIVE YEARS POST CONSTRUCTION . 86
9.7 MONITORING COSTS 86
9.8 POTENTIAL CORRECTIVE ACTIONS 87
9.9 CONTINGENCY INSPECTIONS 88
9.10 REPORT PREPARATION 88
10. REFERENCES 89

LIST OF FIGURES

Number	Title	Page
1.1	Location Map of Hudson-Raritan Estuary (HRE)	3
1.2	Location Map of Liberty State Park (LSP)	4
1.3	Details of Liberty State Park Ecosystem Restoration Project	5
2.1	Overview of LSP topographic/bathymetric maps	8
2.2	LSP Topographic/Bathymetric Map, Sheet 1	9
2.3	LSP Topographic/Bathymetric Map, Sheet 2	10
2.4	LSP Topographic/Bathymetric Map, Sheet 3	11
2.5	LSP Topographic/Bathymetric Map, Sheet 4	12
2.6	1st Round Geotechnical and HTRW sampling locations	15
2.7	2nd Round Geotechnical and HTRW sampling locations	16
2.8	LSP Groundwater Flow Direction	17
2.9	LSP Groundwater Contours	19
2.10	Storm Surges at the Battery, NY	22
3.1	Liberty State Park Recommended Plan	25
3.2	Fresh Water Wetland Components: Close-up	27
4.1	Liberty State Park Catchment Areas	31
4.2	Sample Water Budget Used to Develop the Freshwater Wetland.	34
4.3	LSC Wetland, Plan View	37
4.4	LSC Wetland, Profile View	37
4.5	Biofilter, Plan View	38
4.6	Biofilter, Profile View	38
4.7	Deepwater Emergent Marsh, Plan View	39
4.8	Deepwater Emergent Marsh, Profile View	39
4.9	Infiltration Basin, Plan View	41
4.10	Infiltration Basin, Profile View	41
4.11	SWMM Network for Existing Conditions	47
4.12	SWMM Network for Proposed Conditions (Alternative D)	48
4.13	Biofilter Performance During a Dry Year for Chosen Alternative	49
4.14	DEM for a Wet Year	49
4.15	DEM for a Dry Year	50
4.16	Infiltration Basin for a Wet Year	51
5.1	Proposed Tidal Wetland for LSP	53
5.2	Frequency of MHHW Elevations, Reconstructed for the South Cove, LSP	54
5.3	LSP Benchmarking and Tidal Datums	56
5.4	LSP Salt Marsh Profile	56
5.5	Tidal Creek Depths and Width (top of bank)	59
5.6	Tidal Creek Bridge Design and Sections	61
5.7	HEC-RAS Cross Sections as measured from GIS layout	64
5.8	Tidal Channel Reach layout in HEC-RAS	65
5.9	Cross Section and Water Surface Elevation Plots	66
5.10	MHW-MLW Maximum Flooding of Site	71
5.11	MHW-MLW Minimum Flooding of Site	71

Number	Title	Page
5.12	Spring Maximum Flooding of Site	72
5.13	Spring Minimum Flooding of Site	72
5.14	6% Exceedence Maximum Flooding of Site	73
5.15	6% Exceedence Minimum Flooding of Site	73

LIST OF TABLES

Number	Title	Page
2.1	Tidal Datums from Water Level Recorders in the Vicinity of Liberty State Park	22
5.1	Tidal Datums for Liberty State Park* (ft NAVD88)	74
5.2	Tidal Boundary Conditions Used for HEC-RAS Analysis	53
5.3	Target Duration of Flooding Based on Biobenchmarking an Environmental Design Recommendations	74
5.4	Duration of Flooding at Three Representative Cross Sections	75
5.5	Maximum and Minimum Stages and Velocities at Selected Cross Sections	76
9.1	Estimated Cost for the Proposed Monitoring Plan: Engineering Components	

Executive Summary

New York District has completed this draft Integrated Feasibility Report/Environmental Impact Statement (FR/EIS) for the Liberty State Park Ecosystem Restoration Project in accordance with the requirements of NEPA to assess the need for modifying the existing degraded habitat, to evaluate the effects of restoration activities, and to establish a plan that maximizes environmental benefits while minimizing economic costs.

The purpose of the project is to ameliorate the adverse impacts associated with past filling activities on the project site, with the overall purpose of improving the environmental quality of the area. This previous mudflat was altered due to past fill activities and is consequently a less productive habitat. The site is dominated by invasive species, which are expected to expand and overwhelm the various vegetative habitats on site without the implementation of ecological management measures described in the plan recommended in this report.

Liberty State Park (LSP) Ecosystem Restoration Project is part of the Hudson-Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study being carried out under the U.S. Army Corps of Engineers General Investigations Program. This feasibility study was authorized in a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives, dated 15 April 1999, which reads in part, "Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army (the U.S. Army Corps of Engineers) is requested to.....(determine) the feasibility of environmental restoration and protection relating to water resources and sediment quality within the New York and New Jersey Port District (much of the lower Hudson Raritan Estuary), including but not limited to creation, enhancement and restoration of aquatic, wetland and adjacent upland habitats." The LSP project is the first implementation of the goals of the HRE Comprehensive Restoration Implementation Plan as defined in the Needs and Opportunities Report (PANYNJ, 2003).

The proposed LSP restoration project is located in Jersey City, Hudson County, New Jersey, on the western side of Upper New York Bay. It is located on the waterfront across the Upper Bay from lower Manhattan and adjacent to the Statue of Liberty and Ellis Island. The proposed project area is approximately 234 acres of mostly undeveloped semi-degraded parkland within Liberty State Park's 598 terrestrial acres. Liberty State Park has an additional 523 tidal acres, for a total of 1,121 acres. The park itself is bounded by the New Jersey Turnpike to the west, by the Morris Canal to the north, by the Upper Bay to the east and by the "Black Tom" cove to the south.

Numerous surveys, studies, and extensive literature surveys have been conducted to establish necessary baseline information to identify potential restoration options and evaluate the potential for control of invasive species and conversion to more desirable habitats currently underrepresented in the HRE. These underrepresented habitats include salt marsh, deep-water emergent palustrine marsh and significantly enhanced terrestrial habitats such as maritime grassland, scrub-shrub and hardwood forest, with a superior mix of native and wildlife-friendly species. Some of the biological tasks conducted include literature review, existing vegetative community mapping, jurisdictional wetland delineations, faunal surveys, and existing and

proposed project habitat evaluation. The results indicate strong opportunities for increasing habitat functionality at this site. Implementation of the plan recommended in this report is expected to increase and restore more desirable communities, provide more cover, nesting, and breeding habitat for wildlife, and increase species richness. Some of the engineering tasks conducted included a topographic and bathymetric survey, geotechnical and HTRW analysis, water level and water quality monitoring, hydraulic, hydrologic and hydrodynamic modeling.

Technical screening analysis was performed throughout the project development stages for each of three implementation phases of the proposed project: tidal marsh, fresh water wetlands and terrestrial habitat. For the tidal marsh, the single-inlet creek was determined to be the most efficient solution, meeting both technical and biological requirements the most successfully. Subsequently, the shape, width and length of the proposed tidal channel, and its associated intertidal flats, low marsh and high marsh habitat were refined through hydrodynamic modeling. The tidal channel is designed to maximize functional habitat value of the proposed tidal marsh area by maintaining the largest feasible tidal range, and regular tidal flooding and drainage through the maximum area available.

For the fresh water wetland phase, four separate plans were technically analyzed, each delivering different amounts of acceptable quality fresh water to the target area in the central portion of interior of the site. The selected freshwater plan provides the most amount of water for habitat creation and enhancement without expensive and high-maintenance mechanical pumping from already-stressed municipal water supplies. The recommended plan incorporates a self-maintaining gravity-based system for supplying adequate quality water. This water-delivery system gathers additional water from the NJ Transit parking area, which is then filtered in an enhanced wetland area adjacent to the Liberty Science Center (LSC). The levels of the LSC wetland are controlled by a self-adjusting weir, which directs water through a diversion pipe underneath Phillip Street to an additional *Phragmites* dominated bio-filter wetland. This biofilter wetland removes remaining suspended sediment, potential toxicants and unwanted nutrients. From the biofilter, a created swale will deliver the substantially enhanced volume and quality of water to a created permanent deep-water emergent marsh. The deep marsh will provide fish, reptile and other habitat not currently found in Liberty State Park. During high-flow periods, excess water will drain out of the deep-emergent marsh into an infiltration basin, in effect creating an additional, periodically flooded wetland. The high permeability of the infiltration basin soil will allow water to penetrate underlying groundwater, in turn feeding an existing jurisdictional freshwater wetland.

The third phase of this restoration project involves improving ecological functional value on the terrestrial portions of the site. Measures include the selective removal of invasive species and other undesirable vegetation. If monitoring indicates that further measures are necessary, the District will consider addition of topsoil and/or sand to selected areas to discourage unwanted vegetation, and promotion of native vegetation through replanting and/or seeding. A berm is planned for the southwestern portion of the site, using the material excavated from the proposed tidal marsh area. The excavated material will be completely encapsulated within the berm. The berm will act as an isolation barrier for sensitive species and add topographical relief to a relatively flat site. Most terrestrial habitats will be maintained in the same vegetative community type, while simultaneously controlling invasive species and encouraging native species. Thus, a

mosaic of high-functional value terrestrial habitat will be established including hardwood and maritime forest, scrub-shrub, maritime grassland and old field. Where possible, grassland habitat to be enhanced will be contiguous to enhance feeding areas for raptors and isolation for ground nesting birds. The functional integrity of the existing forested areas will be maintained and enhanced.

The District's National Ecosystem Restoration (NER) plan will result in a significant increase in wildlife habitat and estuarine functional value when compared to existing habitat. The NER plan will increase the availability of cover, foraging, nesting and breeding habitat for Federal and state threatened and endangered species; restore USEPA designated priority wetlands (e.g., salt marsh); improve water quality; increase the value and availability of spawning and nursery habitat for anadromous fish species; enhance wetland habitat for migratory waterfowl; assist in the enhancement of wildlife habitat corridors; and increase aesthetics and opportunities for passive recreation; and promote science education. In addition the NER plan will meet the goals and objectives for many programs, acts and policies on institutional, public and technical levels.

For further information, please contact:

Marty Goff, Technical Manager
U.S. Army Corps of Engineers, New York District
Engineering Division, Engineering Management Branch
26 Federal Plaza
New York, NY 10278-0090
ATTN: CENAN-EN-M
PHONE: 212-264-9074
FAX: 212-264-6495
marty.goff@usace.army.mil
http://www.nan.usace.army.mil

LIBERTY STATE PARK, HUDSON-RARITAN ESTUARY ECOSYSTEM RESTORATION

DRAFT INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL IMPACT STATEMENT

ENGINEERING APPENDIX

1. INTRODUCTION

1.1 General

The New York District Corps of Engineers is presently conducting a Feasibility Study of ecosystem restoration opportunities within the Hudson-Raritan Estuary, which is delineated as the surrounding greater metropolitan New York City region, within an approximate 25-mile radius of the Statue of Liberty (Figure 1.1). During the reconnaissance phase, the District conducted an extensive restoration-opportunity identification and screening process within the study area, in cooperation with Federal and state resource agencies, and environmental interest groups. The reconnaissance study identified over 80 sites that may meet Federal budgetary criteria and were recommended for inclusion in the Feasibility Study. The non-Federal sponsor for this feasibility phase, the Port Authority of New York and New Jersey (PANYNJ), in consensus with the New York/New Jersey Harbor Estuary Program (HEP) Habitat Work Group and agencies from both states, identified 13 sites as initial Building Blocks of the Feasibility Study's Comprehensive Restoration Implementation Plan (CRIP).

Liberty State Park is the first site to move through the Feasibility Study phase. The New Jersey Department of Environmental Protection (NJDEP) has expressed interest in becoming the non-federal cost sponsor for the final design and construction phases of the project. The Liberty State Park site is located in Jersey City, New Jersey approximately two (2) miles south of the Holland Tunnel Crossing and on the mainland, just west of Ellis Island. The 1,122-acre park is at the confluence of the Hudson River and the Upper New York Bay in Jersey City, New Jersey (see Figures 1.1 and 1.2). It is bounded by Morris Canal to the north and Black Tom to the south. The east side of the park faces New York Harbor, and the potential restoration site is within the boundaries of Liberty State Park on a section of property generally bounded by Audrey Zapp Drive on the north side, Phillip Drive on the west side, Thomas McGovern Drive on the south side and Freedom Way along the east side (Figure 1.3). The interior 225 acres of the park are restricted for public access due to the presence of sediment contaminants that exceed residential exposure levels. The overall study focuses on environmental restoration opportunities within the 225 acres and the existing wetland area adjacent to Liberty Science Center, which is immediately west of the park.

Figure 1.1 Location Map of Hudson-Raritan Estuary, as Defined in the Hudson-Raritan Estuary Reconnaissance Study of 2000 (next page)

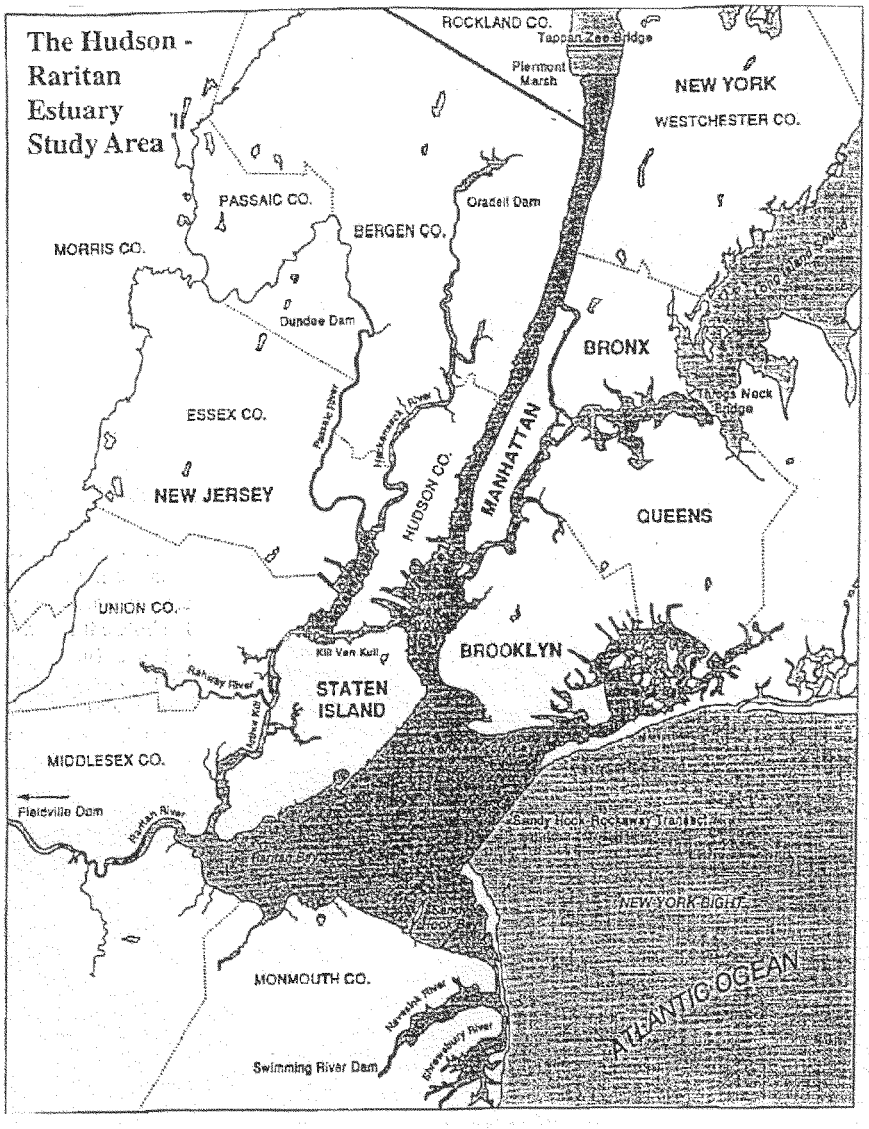


Figure 1.1 Location Map of Hudson-Raritan Estuary, as defined in the Hudson-Raritan Estuary Reconnaissance Study of 2000

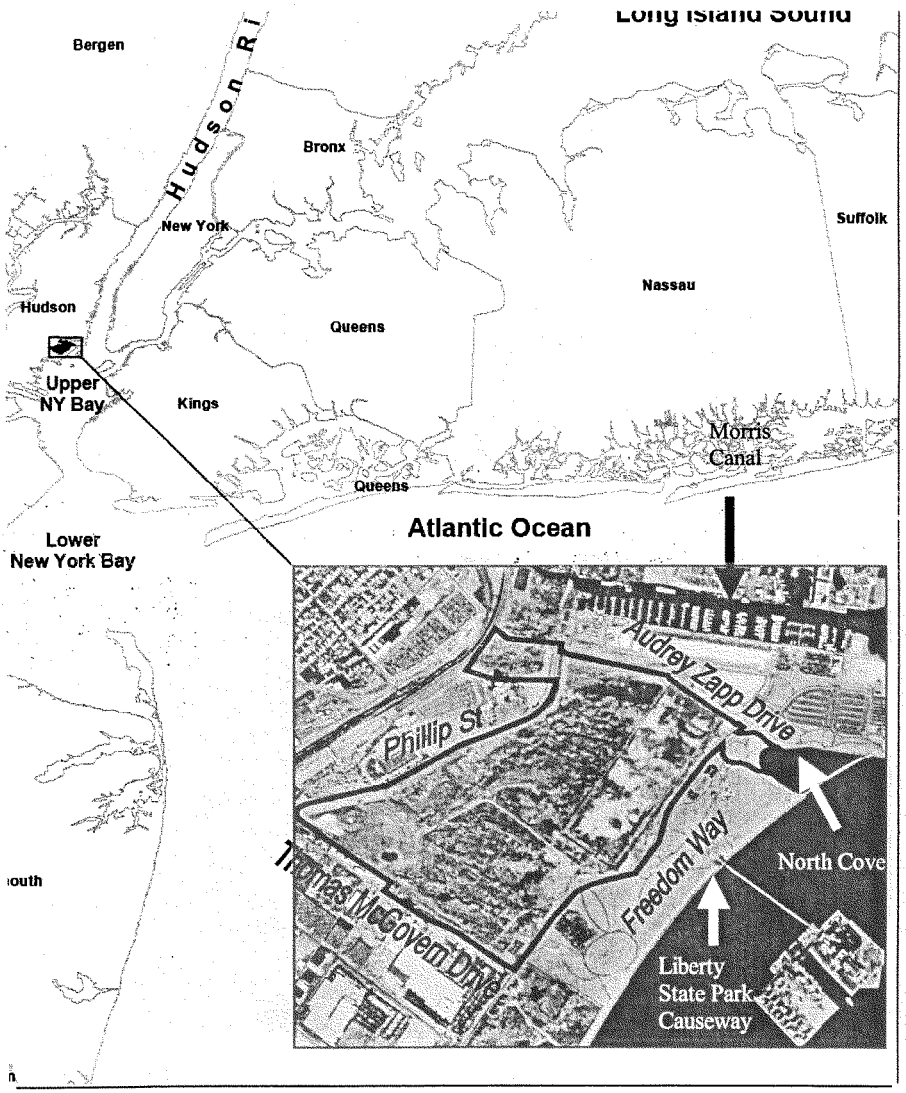


Figure 1.2 Location Map of Liberty State Park

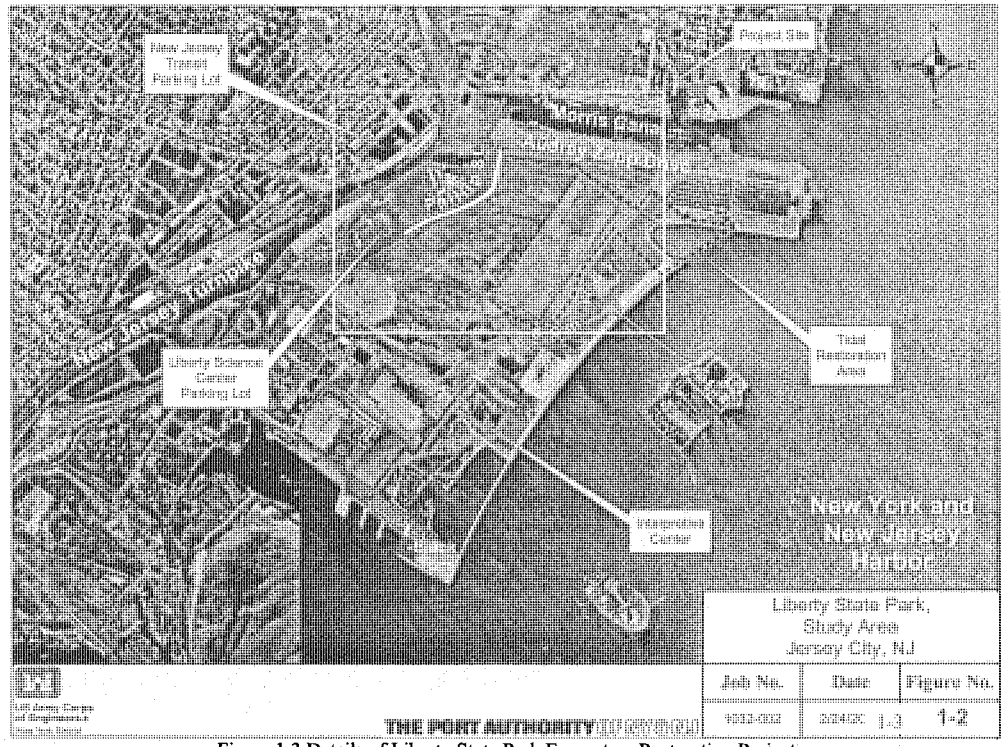


Figure 1-3 Details of Liberty State Park Ecosystem Restoration Project

888

1.2 Project Objectives

Environmental restoration opportunities being considered for Liberty State Park include the creation of a tidal marsh in the center of the park, and enhancements to the uplands and freshwater wetlands within the undeveloped area in the park. Materials will be excavated from the proposed tidal marsh area, capped and used to create a grassland berm in the southwestern section of the park. A narrow channel will connect the tidal marsh to the North Cove. Storm water will be collected from adjacent areas and will be diverted to feed freshwater wetlands on the site, creating shallow and deep emergent marshes. Nuisance plant species will be controlled, and native grasslands, shrublands and forests will be planted. The uniqueness of the three primary restoration components in analysis, function, and habitat, requires that each be evaluated separately. Therefore, the restoration feasibility analysis and evaluation has been broken into three separate components: (1) a tidal wetland, (2) a freshwater wetland system, and (3) upland areas.

2. SITE DESCRIPTION

2.1 General

Liberty State Park was an intertidal mud flat and salt marsh that was filled and used as a railroad yard during the growth of the New York City metropolitan area. A majority of the soil within the park consists of historic fill materials that were deposited to stabilize the surface between 1860 and 1919 (MacFarlane 2001). Materials from construction projects and refuse from New York City were also included in the fill material. Between 1864 and 1967, the Central Railroad of New Jersey (CRRNJ) used the site as a rail yard for both freight and passenger service. In 1967, the CRRNJ discontinued operations at the site, and over the next few years, the land was abandoned and subsequently acquired by the New Jersey Department of Environmental Protection (NJDEP) Division of Parks and Forestry (NJDPF) (LSP 2003).

The area in the center of the park has remained undeveloped and access is restricted to the public due to the presence of polynuclear aromatic hydrocarbons (PAHs), pesticides, and metals that exceed the NJDEP residential clean up criteria (MacFarlane 2001). Some of the fill in the undeveloped area is comprised of materials dredged from the Upper Bay during construction of the LSP causeway.

2.2 Topography/Bathymetry

A topographical survey was collected during the summer and fall of 2003. For the entire proposed project site, except for the North Cove, a 1 inch = 30 ft scale map was developed using GPS Real Time Kinematic techniques to establish photogrammetric mapping, with surveyed points not more than 100 ft apart. The contour intervals were in 1 ft increments. Conventional survey by angle and distance method was performed to obtain roadway and ditch cross sections, existing storm and sanitary sewer structure locations, tide gages, utilities and other features not

depicted in the base map developed by the photogrammetry. A combined topographic/bathymetric survey is displayed in Figures 2.1 – 2.5 (see enclosures for 1:100 scale maps of Figures 2.2-2.5). Information about the survey can be found in Liberty State Park: The Ground Survey Control Report (USACE 2004).

The GPS field observations were conducted and/or using as guidelines with modifications the specifications given in the "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques", Version 5.0, August 1, 1989, for First-Order, Class 1, surveys having a relative accuracy between project stations of at least 10mm + 1:100,000 at the 95% confidence level for each component of the measured vector. The accuracy standard of the orthometric heights relative to the vertical control used for this project is +/-2 cm in elevation. The horizontal datum is referenced to the New Jersey State Plane Coordinate System, North American Datum of 1983. The vertical datum is referenced to the North American Vertical Datum of 1988.

The bathymetric map is a result of sounding from bank-to-bank profiles taken every 50 ft in the North Cove in November 2003. The sounding data was collected using class 2 survey standards in accordance with EM 1110-2-1003, using a survey vessel, innerspace Model 448 Echo Sounder, Garmin GPSMAP76S and the Coastal Oceanographics "HYPACK" Software.

The park is relatively level as a result of its historical use. Small, linear berms between the old railroad tracks were created during the construction of the railroad yard. Changes in elevation exist typically only as a result of the additional deposition of dredged materials or construction of dredged material containment berms following cessation of rail operations. Additional changes in the relief within the park occurred with the commencement of development of the park, which included the creation of the shorefront promenade and the removal of the pier system that serviced the rail operations.

Inland from the flat ground of the park, the elevations increase gradually. The slope of the land draining to the exterior of the park generally ranges from only 0 to 2%. The highest point in the area which drains toward the park, with the exception of the nearby elevated NJ turnpike and Conrail rail line, is within the NJ Transit Light Rail parking lot, at 20.4 ft NAVD1988. The lowest point in the area is at the outlet to the Morris Canal, at elevation –1.56 ft NAVD1988. The slope of the drainage ditches on either side of Phillip Street is approximately 0.2 %.

The North Cove is body of water on the western shore of Upper New York Bay with a riprap on all its shores. It is completely open to the bay, with the exception of the Liberty State Park Causeway – a pedestrian walkway that has bridge piers spaced approximately every 30-40 ft. The cove is approximately 550 ft wide in the middle and 900 ft wide at its opening to the bay. Boat wakes from the passenger ferries taking commuters to lower Manhattan impact the shores of the cove, which is why its shores are armored with riprap. It is –7 ft NAVD88 in the middle (approximately –9 ft MLLW). The –3.5 ft NAVD88 contour is approximately 50 ft from the western banks of the cove in the proximity where the tidal channel is proposed. The maximum depth of the cove is -11 ft NAVD88, and it has an average slope of 1V:100H. Information about the survey can be found in the Liberty State Park: The Ground Survey Control Report (USACE 2004)

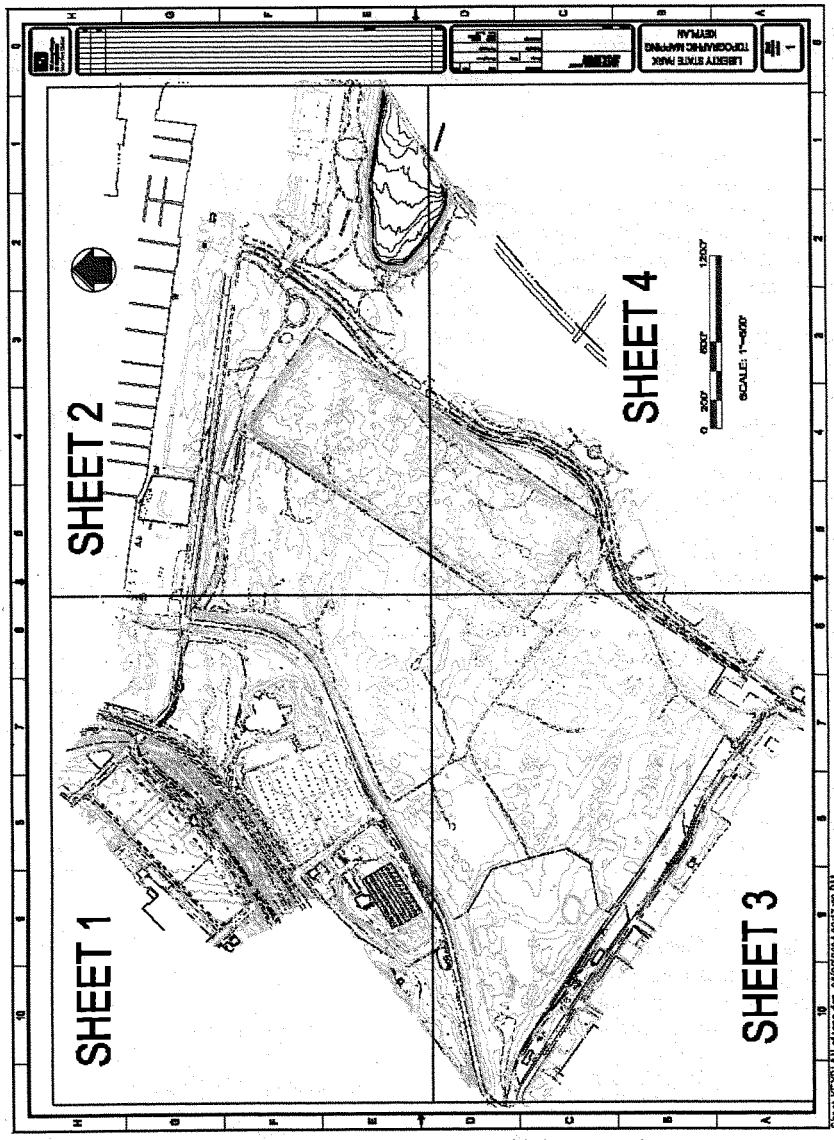


Figure 2.1 – Overview of LSP topographic/bathymetric maps

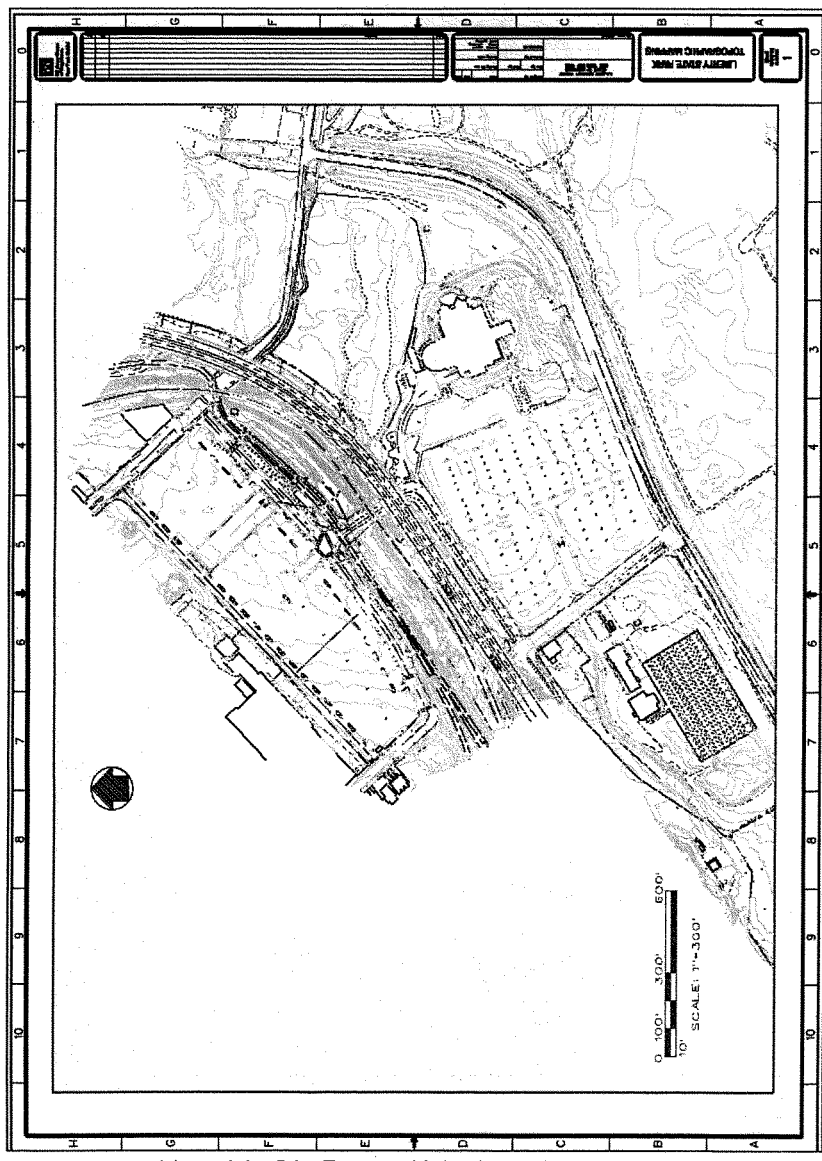


Figure 2.2 – LSP Topographic/Bathymetric Map, Sheet 1

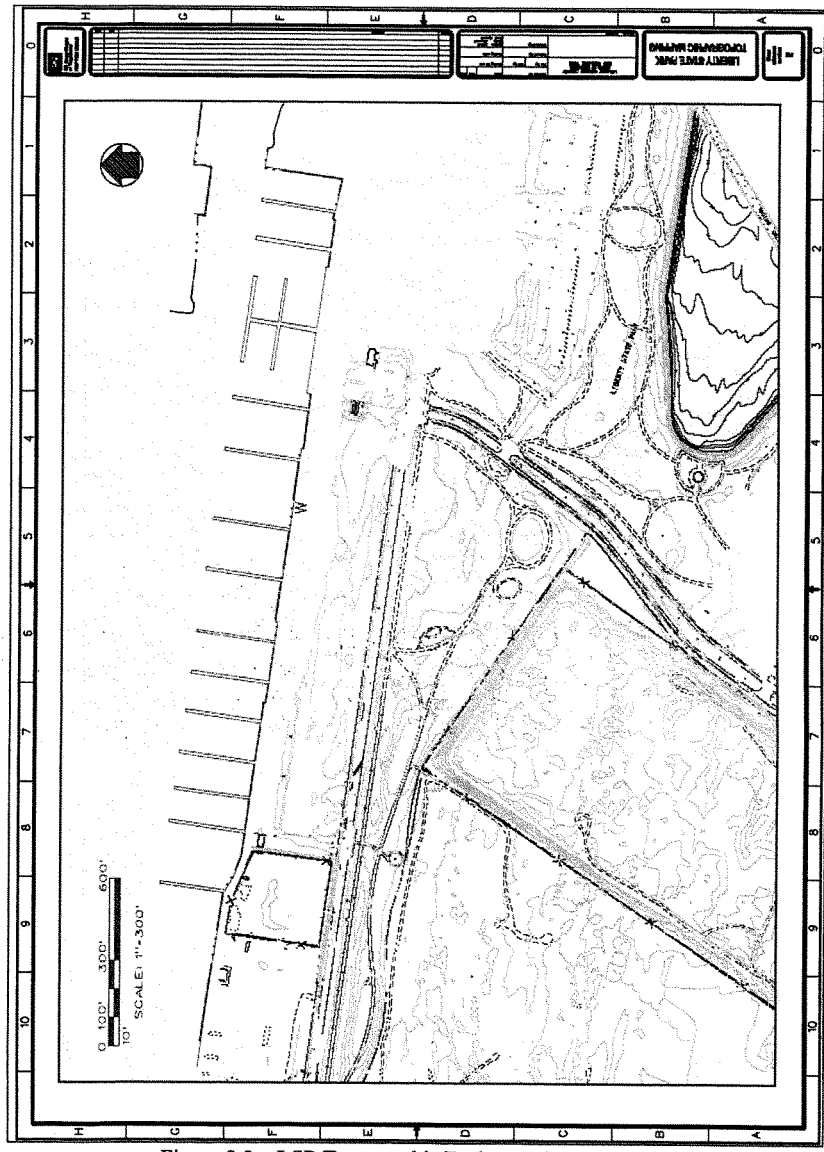


Figure 2.3 – LSP Topographic/Bathymetric Map, Sheet 2

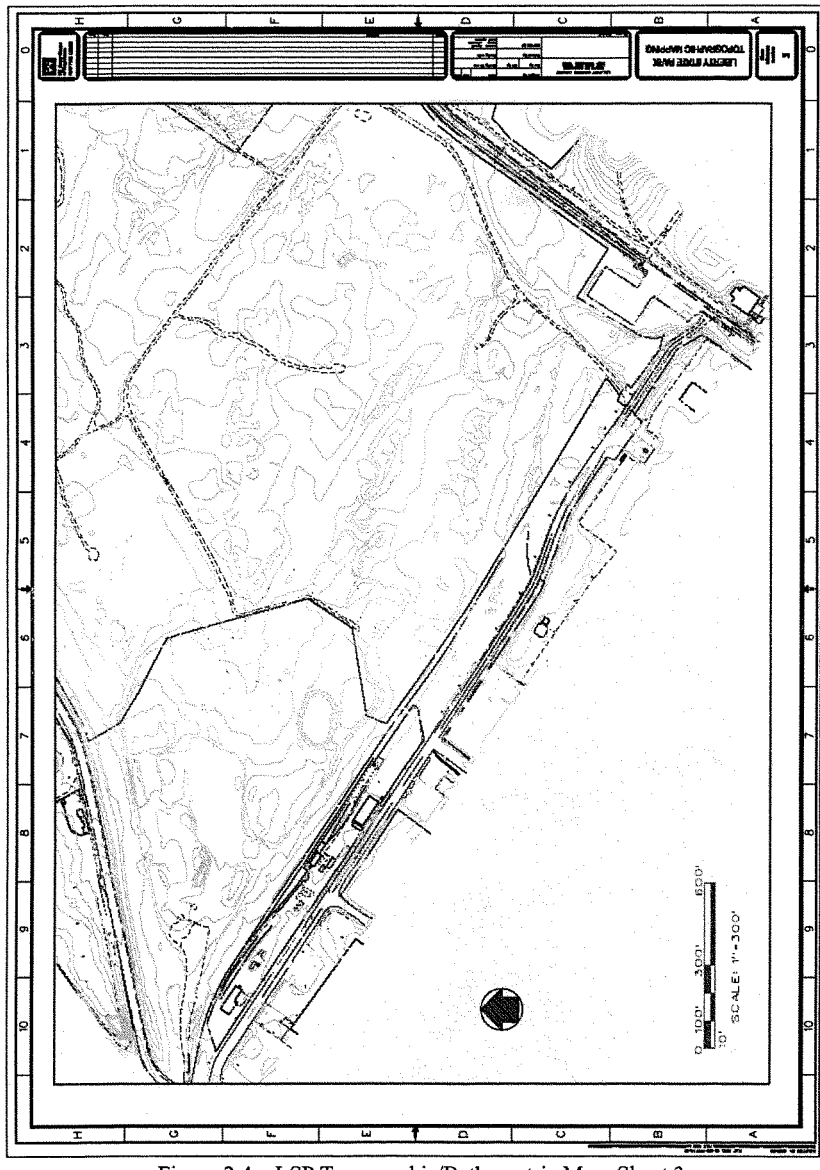


Figure 2.4 – LSP Topographic/Bathymetric Map, Sheet 3

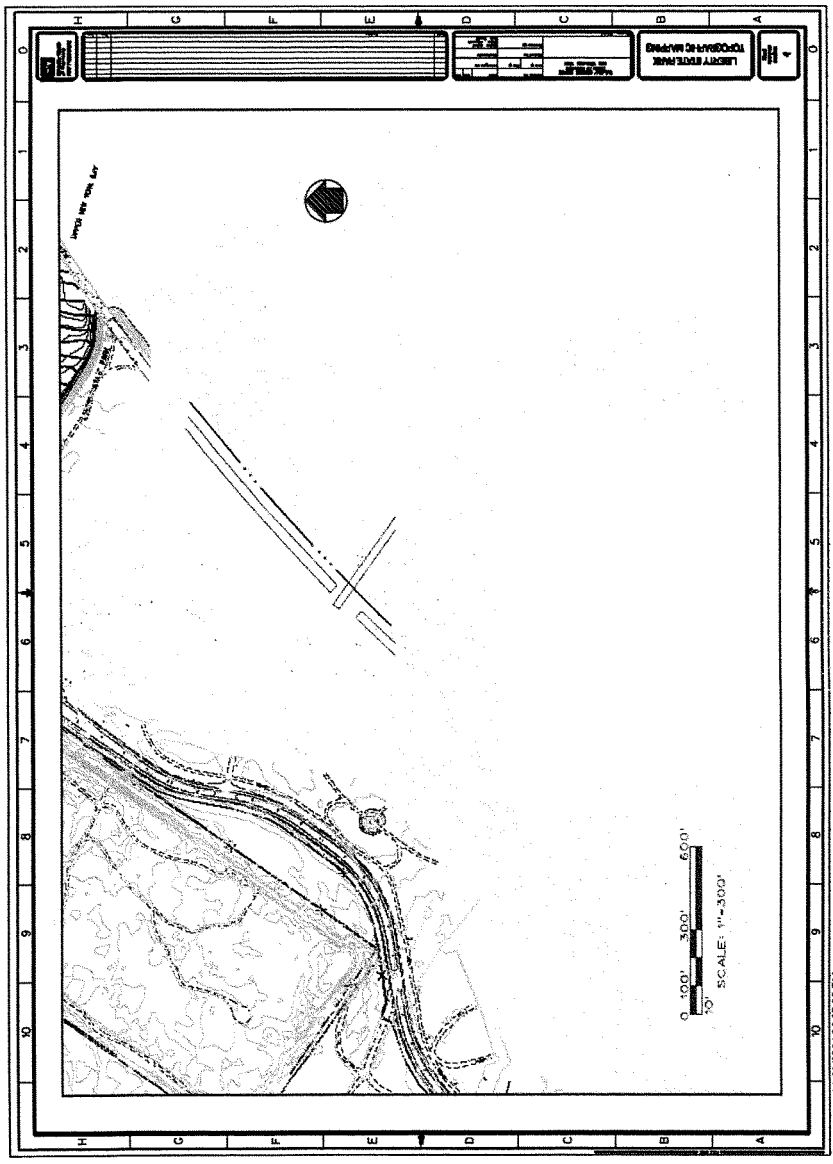


Figure 2.5 – LSP Topographic/Bathymetric Map, Sheet 4

2.3 Soils

The results of the geotechnical analysis indicate that the soils vary considerably across the site. Both fine-grained and course grained soils are present. Soils in virtually all of USCS soil classification are found on site. The project site is overlain with coarse-grained (sands, silty sands, silty gravels, etc.) soils. Average thickness of this coarse-grained layer is about 14-ft, although local variations exist with both thinner layers (3-ft) and thicker layers (30-ft plus) encountered. Underlying this coarse-grained layer is a layer of fine-grained soil (clay, clay with traces of shells, sand, and gravel, etc.). This fine-grained layer was observed in about 85% of the drill holes. On average, this fine-grained layer was encountered at a depth of about 13-ft, although local variations exist. Average thickness of this fine-grained layer is about 12-ft, although local variations exist with both thinner layers (1.5-ft) and thicker layers (27-ft plus) encountered. Subsequent lower layers of coarse-grained and then fine-grained soils were occasionally encountered. Man-made debris (refuse) materials were found in about 27 of the 49 total drill holes. Near surface excavation of this material should present no unusual excavation problems. However, deeper excavations, notably excavation of the proposed tidal inlet in the vicinity of the North Cove, may require additional earth moving and dewatering equipment to allow excavation to take place within the soft clay layer. An initial phase (Phase I) of drilling and sampling program was performed during August and September of 2003. Thirty-eight drill holes were completed and a comprehensive geotechnical testing program was performed. An additional phase (Phase II) of drilling and sampling program was performed in February 2004. The results of the geotechnical investigation can be found in the Geotechnical Site Investigation, Liberty State Park, Jersey City, NJ. Final Report. (USACE 2004).

2.4 HTRW Testing

A full explanation of the HTRW testing and analysis can be found in the main report – the Draft Integrated Feasibility Report and Environmental Impact Statement, June 2004. In summary, the NJDEP has conducted numerous environmental investigations within LSP since 1978. The results from these studies show evidence of relatively widespread soil contamination, but generally at levels below applicable hazardous-waste thresholds. Heavy metals, including arsenic, lead, zinc, and copper, and polynuclear aromatic hydrocarbons (PAHs) are nearly ubiquitous in fill materials at the site, and commonly occur at concentrations above the applicable NJDEP Soil Cleanup Criteria (SCC), the NJDEP Non Residential Soil Cleanup Criteria (NRSCC). The concentrations of PAHs and metals in common fill materials are generally within the ranges listed in the NJDEP Historic Fill Database, and appear to meet the general definition of "historic fill" under Technical Rules for Site Remediation (N.J.A.C. 7:26E App.D). Therefore, soils other than those containing chromate chemical production waste (CCPW) or petroleum free-product can be probably managed on site, such as by capping with a layer of clean soil and establishing vegetative cover. However, soils that are saturated with petroleum or which contain CCPW generally require either off-site disposal or on-site stabilization. Results from NJDEP investigations are extensive and provide detailed soil contamination data to an approximate depth of five feet below ground surface (bgs) throughout the site. However, because potential ecosystem restoration alternatives consider removal of fill in the 45-acre area to historic marsh and tidal levels, which are at least 12-15 ft bgs, New York District conducted more intensive site HTRW investigations for the feasibility study.

During the first phase in August 2003, 40 soil/sediment contaminant samples were taken throughout LSP, 38 on land, 2 in the North Cove (Figure 2.6).[1] Samples were taken from 30 feet bgs for two reasons: 1) to find the original, historic surface layer and 2) the assumption that over time, amounts of contamination, spilled fuel oil, hexavalent chromium, other heavy metals and VOA's would have migrated downward through the back fill. All samples were analyzed for: Volatile Organics Library + 15 (VOA+15), Acid Base Neutral Library +25 (ABN+25), Pesticides/PCB's (Pest/PCB), Total Petroleum Hydrocarbons (TPHC), RCRA Metals, Percent Solids (% solids). Considering the known chrome contamination additional analyses would be conducted for hexavalent chromium. The analysis for hexavalent chromium was sent to a laboratory specializing in that particular analysis. The results from this phase showed a relatively low number of borings, 16 out of 38, with measurable contamination at 30 feet bgs. No PCBs or VOAs were found in any of the samples. TPHC, dieldrin, Acid Base Neutrals, arsenic, cadmium, copper, lead, mercury, and nickel were sparsely scattered throughout the site and few exceeded NJDEP IGWSCC/NRDCSCC thresholds. It is worth noting that hexavalent chromium, the primary concern of this HTRW investigation, came in below the threshold of 10ppm for all samples in which it was detected. One sample (#20 in North Cove) had significant test results and is located at the entrance of the proposed tidal creek.

A second phase was conducted in February 2004, based on results of the August 2003 investigations (Figure 2.7). This round focused on the route of the proposed tidal creek and collected continuous samples from the surface to 15 feet bgs. No pesticides, PCBs, or Volatile Organics were detected in this round. Two areas of concern were identified in the second round, in the area of North Cove and the 45-acre containment area. Samples collected in the second round closest to sample point 20 from the first round showed the highest levels of metals, including hexavalent chromium, arsenic, lead, copper, and zinc. Other materials include petroleum hydrocarbons and semi-volatile organics, also in the North Cove and the 45-acre containment area. At the time of construction, procedures should be in place to manage excavations from this area to ensure that minimal amounts of soil/sediment are released to the general environment and that excavated materials are disposed of properly and securely in the park's on-site placement area.

[1] HTRW samples were taken concurrently with Geotechnical samples.

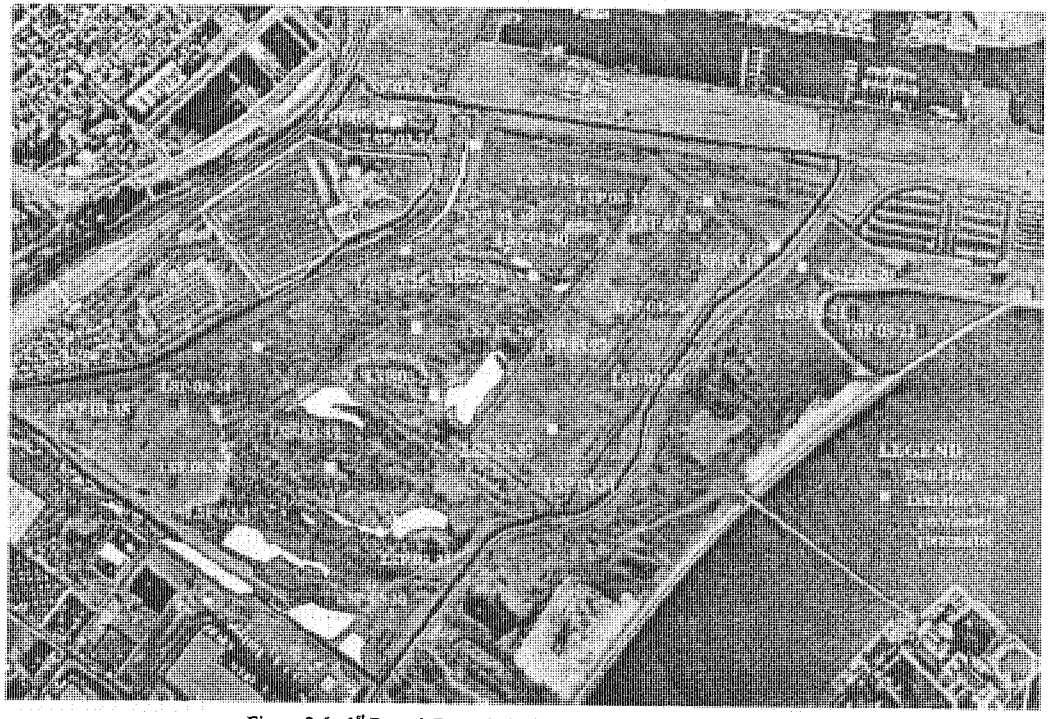


Figure 2.6. 1st Round Geotechnical and HTRW sampling locations

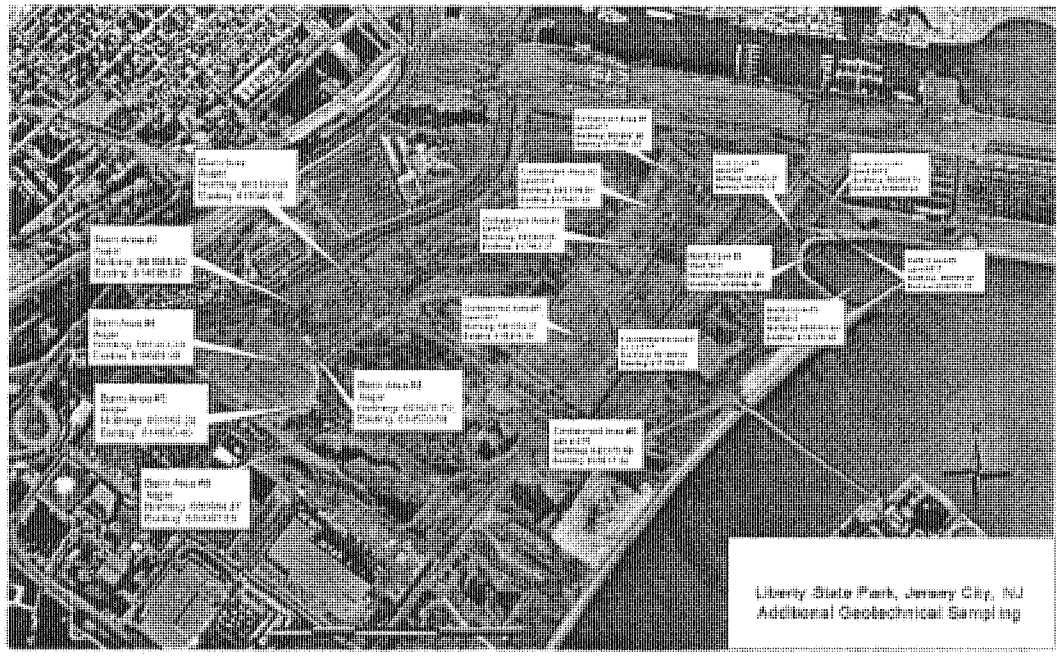


Figure 2.7. 2nd Round HTRW sampling locations

2.5 Groundwater

As part of the geotechnical analysis (USACE, 2004), twelve (12) piezometers were installed as permanent piezometers in existing drill holes for long-term groundwater level monitoring and for future use in determining permeability (hydraulic conductivity) of the soil, if required. An additional eight (8) temporary piezometers were also installed in selected existing drill holes. Groundwater depths ranged from about 1.3-ft below existing grade to about 5.5-ft below existing grade, as measured from the twenty piezometers installed throughout the site. Fluctuations in groundwater levels up to 3.1-ft were observed in the piezometers. Groundwater gradients between piezometers were typically very flat. Groundwater flow direction and average gradient calculations suggests that groundwater flow direction is about N35° and discharges towards the adjacent Morris Canal (Figure 2.8). A plan view of the groundwater contour map of the 15 November 2003 groundwater readings is shown in Figure 2.9. Due to the possibility of contamination in the ground water and/or proposed excavation elevations and soil contamination, the proposed plan includes an impervious clay layer to be placed where excavation will be necessary for the fresh water and tidal wetlands.

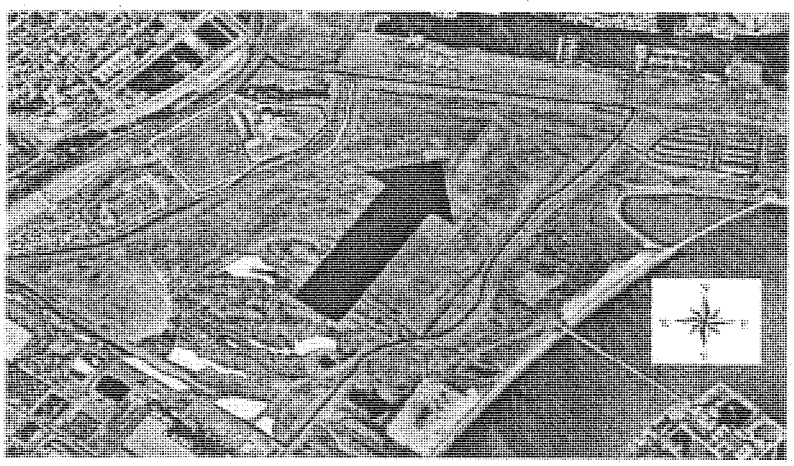


Figure 2.8 LSP Groundwater Flow Direction

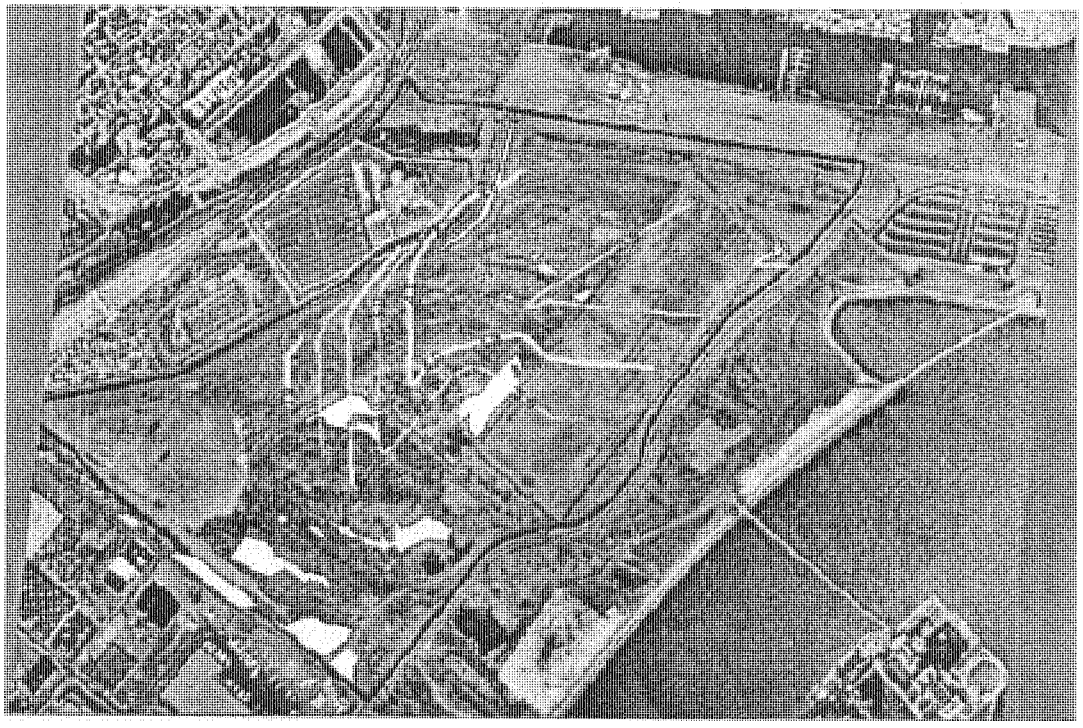


Figure 2.9 LSP Groundwater Contours (ft NAVD88)

2.6 General Watershed Description

The area surrounding Liberty State Park is essentially fully developed with little room for additional development. Commercial and industrial development is immediately adjacent to the park to the west and south. Due to the historic use of the park as a rail yard, there is little historic drainage from outside the park into the park. Recent construction, such as the Liberty Science Center and the New Jersey Transit Light Rail Terminal and parking lot, contribute stormwater runoff to the fringes of the park but not to the interior.

Currently, the project site is encompassed within the interior of Liberty State Park. The streets adjacent to the park drain into ditches that discharge either into Morris Canal or into the Harbor.

2.7 Climatology and Precipitation

The climate of Jersey City, New Jersey is characteristic of the Middle Atlantic seaboard. Marked changes in weather are frequent, particularly during the spring and fall. The winters are moderate, and the summers are hot and humid with frequent thunderstorms. Precipitation is also moderate, with about 45 inches falling annually, well distributed throughout the year. Summer totals of precipitation are slightly higher than winter totals. Average monthly temperature ranges from 38 to 78 degrees F with extremes ranging from 22 degrees below zero to 105 degrees F at Newark, NJ. The growing season averages 174 days and the mean annual relative humidity varies from 53 to 73 percent. Prevailing winds are from the northwest with an average annual velocity of approximately 10 miles per hour. The number of days with rainfall of 0.01 inch or greater averages about 122 per year.

2.8 Tidal and Storm Surge Influences

The project is located on the banks of Upper New York Harbor, at the mouth of the Hudson River, which has a drainage area of xxx square miles. While the area originally was a tidal mudflat, filling activities and hardening of the shoreline disconnected the area from the tide. For this study, water level recorders placed in the North Cove, the South Cove and in Morris Canal observed tidal signals for a period of 6-14 weeks. Unfortunately the North Cove gage malfunctioned, and the data was not recoverable. Thus, the South Cove gage was the closest gage to the proposed tidal creek inlet in the North Cove. The results of the tidal analysis at the South Cove gage revealed that the diurnal tide range, great diurnal tide range, and spring tide range at Liberty State Park for the period of record 31-July 2003 to 11-Sept. 2003 was 4.69, 4.82 and 6.39 ft, respectively.

All the tidal datums computed can be found in table 2.1. Mean High Water (MHW) and Mean Low Water (MLW) are calculated by averaging the highest water level and lowest water level for each tide cycle in the period of record. Diurnal Tide Range (RangeM) is the difference between the MHW and MLW datums. In this region of the North Atlantic Ocean, there is one slightly higher tide within each two tide cycle segments. Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW) are calculated by averaging the highest water level and lowest water level within each two tide cycle segments. Great Diurnal Tide Range (RangeGD) is the

difference between the MHHW and MLLW datums. Mean High Water Spring (MHWS) and Mean Low Water Spring (MLWS) are calculated by averaging the highest water level and lowest water level that occurs during each full and new moon (approximately twice a month). Spring Tide Range (RangeS) is the difference between the MHWS and MLWS datums.

The observations from the other gages were compared to the NOAA Tide Station 8518750 at The Battery, NY, 2000 ft accross the bay, and the signals were extrapolated to the 1983-2001 Tidal Epoch using the NOAA ,modified range ratio method. The results of the extrapolation revealed that the 1983-2001 Tidal Epoch for the South Cove diurnal tide range, great diurnal tide range, and spring tide range at Liberty State Park is 4.51, 4.84 and 5.60 ft, respectively. All the datums observed and calculated can be found in Table 2.1

The purpose of installing temporary water level recorders is to observe how the tide signal differs from published water level observations from nearby long-term stations. Having a few redundant water level recorder instruments installed is important to review the quality of the data, and to account for malfunctions in equipment that often occur in the marine environment. Morris Canal gage recorded water levels for over 3 months. Unfortunately the South Cove gage malfunctioned in the last 6 weeks of the data collection time period, and a North Cove gage malfunctioned for the entire data collection period. Table 2.1 shows that the Morris Canal behaves very similar (-/+ 0.1 ft) to the Battery gage, both in the first 6 week and the entire 17-week periods of record. However, the mean tide level for the South Cove was 0.4 and 0.45 feet lower than the battery and Morris Canal, respectively. Yet, the South Cove MTL was only 0.2 ft lower than the Tidal Epoch MTL at the Battery. The South Cove gage was considerably closer to the proposed project, and to the reference area used to design the tidal wetland portion of the project. Thus, the South Cove reconstructed tidal datums were used to evaluate the tidal wetland design. One higher water level event was analyzed (see section 5), to evaluate the flooding/drying and velocity patterns in the proposed marsh when those events occur.

2.9 Storm Surges

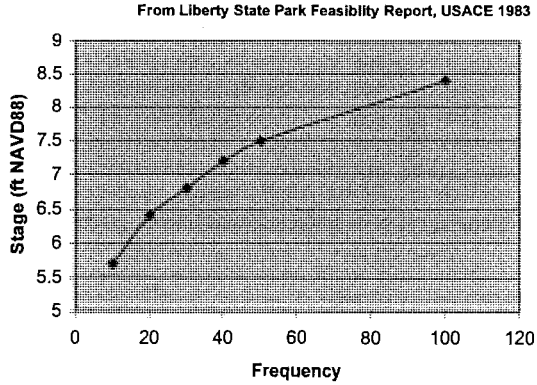
Hurricanes and Northeaster storm events frequently influence the tide stage in Upper New York Harbor. The Liberty State Park Causeway Project (USACE, 1983) determined the frequency of these high water events (Figure 2.10). Morris Canal and the North Cove will experience similar stages for the same storm surge events. Audrey Zapp Drive on the north side, Phillip Street on the west side, Thomas McGovern Drive on the south side and Freedom Way along the east side all lie at elevations between +8 to +10 ft NAVD88. These surrounding roadways act as levees for more frequent storm surge events. The proposed tidal wetland will be connected to the bay via the proposed tidal creek inlet in the North Cove, thus creating a break in the levee system created by the surrounding roads. Fortunately, the existing elevations of the upland adjacent areas surrounding the proposed tidal wetland currently are about +10ft NAVD88, and the proposed plan places an additional 3 ft of fill on top of these areas. Thus, for lower frequency events, the proposed tidal wetland will flood, but the floodwaters would be contained within the wetland. It is anticipated that the wetland will be resilient enough to withstand these flood events, just as natural tidal wetlands currently do in the vicinity of Liberty State Park. In the proposed Fresh Water Wetland area, the scenario is the same as the fresh water wetland, except it does not break the levee system created by the surrounding roads.

Location	Morris Canal	South Cove	NOAA-NOS Battery, NY	Morris Canal	NOAA-NOS Battery, NY	NOAA-NOS Battery, NY	Reconstructed* South Cove
start	31-Jul	31-Jul	31-Jul	31-Jul	31-Jul	1983 to	1983 to
finish	11-Sep	11-Sep	11-Sep	21-Nov	21-Nov	2001	2001
MHWS	3.01	2.72	3.14	3.17	3.28	2.44	2.29
MHHW	2.36	1.96	2.58	2.24	2.43	2.28	1.91
MHW	2.25	1.84	2.24	2.19	2.12	1.95	1.75
MTL	-0.06	-0.51	-0.11	-0.08	-0.08	-0.31	-0.51
MLW	-2.37	-2.85	-2.46	-2.34	-2.27	-2.57	-2.77
MLLW	-2.39	-2.86	-2.46	-2.36	-2.47	-2.78	-2.93
MLWS	-3.20	-3.67	-3.14	-3.26	-3.24	-3.06	-3.31
RangeM	4.62	4.69	4.70	4.53	4.39	4.52	4.51
RangeGD	4.75	4.82	5.04	4.60	4.90	5.06	4.84
RangeS	6.21	6.39	6.28	6.43	6.52	5.50	5.60

*Reconstructed South Cove Tidal Datums were used for the design of the tidal wetland. They were obtained by comparing the South Cove and Battery datums from 31-Jul-2003 to 11-Sep-2003, and reconstructing them to the 1983-2001 tidal epoch, using the Battery as the primary record.
**All elevations are in ft NAVD88

Table 2.1 Tidal Datums from Water Level Recorders in the Vicinity of Liberty State Park

Figure 2.10 Storm Surges at the Battery, NY
From Liberty State Park Feasiblity Report, USACE 1983



3.SELECTED NER PLAN

The Federal objectives in making investments in water resource/ecosystem restoration projects are to contribute to National Ecosystem Restoration (NER) and National Economic Development (NED). USACE planning objectives must be consistent with Federal, State, and local laws and policies, and technical, economic, environmental, regional, social, and institutional considerations. Recommended restoration plans should maximize benefits to the environment and meet local preferences to the fullest extent possible. The Draft Integrated Feasibility Report and Environmental Impact Statement discusses at length the process and analysis that took place to arrive at the Selected NER Plan. Figure 3.1 is the Selected NER Plan.

The Selected NER Plan can be broken down into 3 components: 1) Fresh Water Wetland, 2) Tidal Wetland, and 3) Upland Management Area. The proposed Fresh Water Wetland is located in the Northwest section of the park. The proposed construction activities are to create the following palustrine communities noted in Figure 3.1: Deep Emergent Marsh, Shallow Emergent Marsh, and Shrub Swamp. Maritime Grass, a terrestrial community, is also a component of the Fresh Water Marsh. Figure 3.2 is a close-up of the proposed Fresh Water Wetland plan.

The proposed Tidal Wetland is located in the northeast section of the park. The proposed construction activities are to create the following estuarine communities noted in Figure 3.1: Estuarine Subtidal, Tidal Creek, Intertidal Mudflat, Low Marsh and High Marsh. The fill material that is removed to create the estuarine communities will be placed in the southwest corner of the site, as noted in Figure 3.1. Maritime grassland is proposed on top of disposal area.

The remaining area show in figure 3.2 not included in the fresh water wetland, tidal wetland, and disposal area, with the exception of the mowed lawn parcels, incorporates the upland management areas. The proposed construction activities in the upland management area are currently limited to clearing and grubbing of invasive species. The clearing and grubbing will enhance the terrestrial and palustrine communities that currently exist on the site.

Many restoration alternatives were evauluated, which are discussed in the main report. The firstconceptual layouts for the project were first based on biological/ecological considerations, in accordance with the *General Design Memorandum for the Parks Interior Sections*.(NJDEP 2001) Next, the fetidal wetlandasibility of these conceptual plans were evaluated, based on hydraulic, hydrologic, hydrodynamic, geotechnical, topographical/bathymetrical and construction costs considerations. For the fresh water wetland, the engineering analysis of the alternatives evaluated the topography, soils and the potential fresh water sources needed for a Deepwater Emergent Marsh (DEM). Other restoration features were added to enhance either the DEM or to independly improve habitat (see Liberty State Park Hydrology and Hydraulics for Fresh Water Wetlands, USACE 2004). For the tidal wetland, the local sponsor reserved a 45 acre dredge disposal area in the center of the park for this activity (see rectangle in Figure 1.3). The alternatives that created a tidal wetland in the 45-acre rectangle ranged from having 2 inlets discharing into NY Harbor to having an upland island surrounded by tidal creeks with one inlet. The two inlet option was screened out because the second inlet discharged witin 500 ft from the

Jersey City combined sewage/storm outfall, and the additional concern that maintaining 2 inlet openings would be more difficult and costly. The upland island plan was also eliminated because of the concern that phraagmities may invade the island and tidal marsh from this area. Also, additional upland habitat was planned in other sections of the park. Having more low and high marsh would add more diversity.

Once the general layout of the tidal marsh was agreed upon by the project delivery team, channel widths between 15-150 ft wide were evaluated in the vicinity of where the tidal marsh connects to New York Harbor.

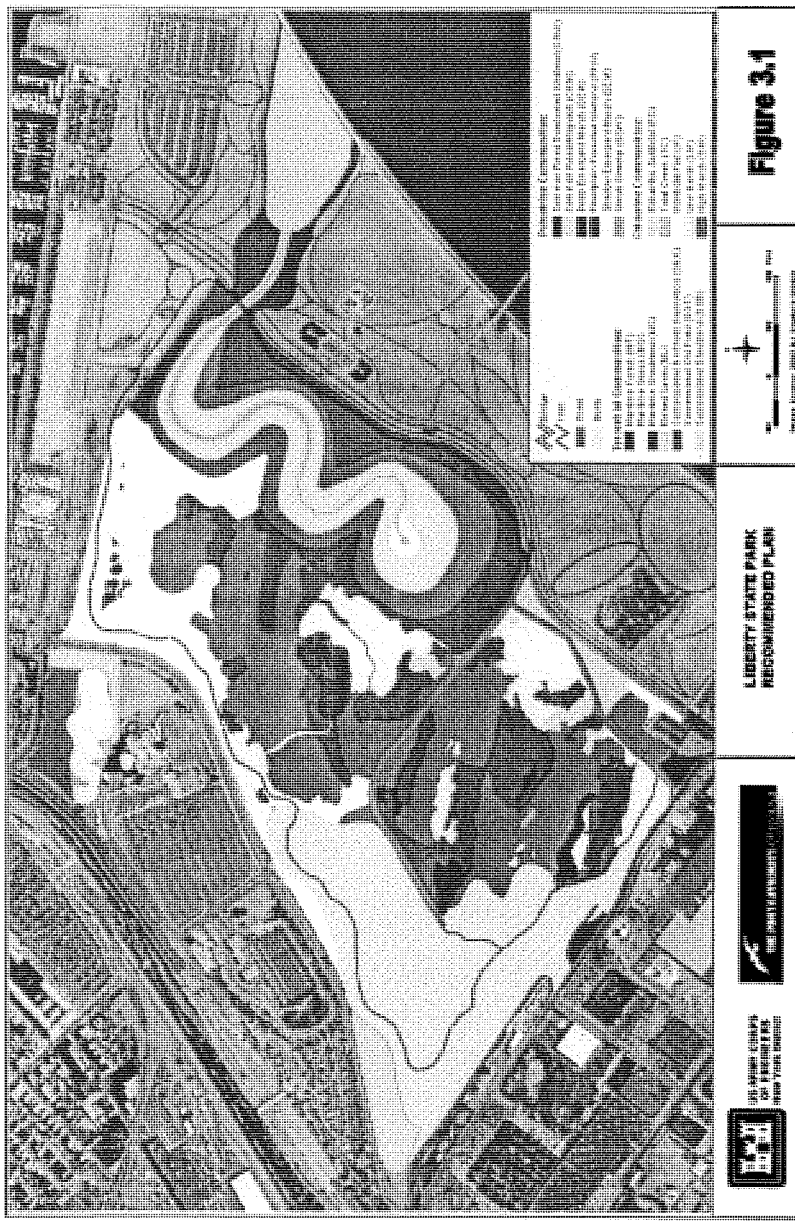


Figure 3.1

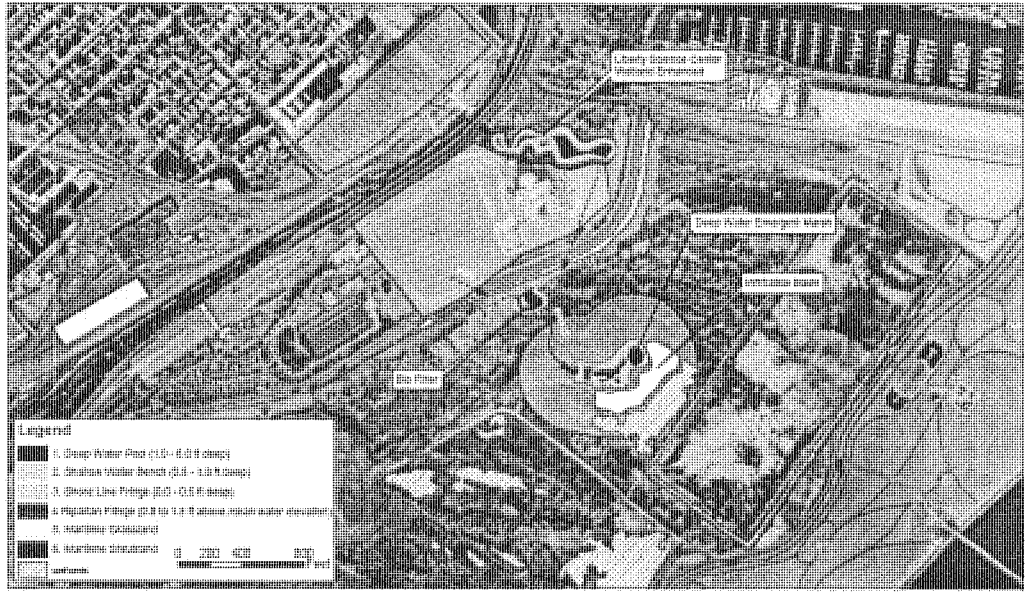


Figure 3.2 Fresh Water Wetland Components: Close-up

4. FRESH WATER WETLAND

4.1 Objectives

One goal of the ecosystem restoration project was to enhance/restore/create fresh water wetlands at the site. The southeast section of the 225-acre restricted area contains a significant number of small wetlands. The number of existing wetlands in this area and its distance from additional stormwater runoff sources precluded this area from consideration for wetlands enhancement. In the center of the park, a natural freshwater wetland area (shallow emergent marsh) exists immediately west of the 45-acre dredge spoil area being evaluated for saltwater wetland restoration (see Figure 1-3.) The enhancement and expansion of existing freshwater wetlands near this wetland has been proposed by the State of New Jersey as part of the overall Liberty State Park environmental restoration plan. The enhancement is expected to require additional water sources; thus, the Liberty State Park Science Center and the nearby New Jersey Transit (NJ Transit) Light Rail Terminal parking lot are being considered as potential sources of stormwater runoff.

An evaluation of the existing and potential sources of freshwater was necessary to determine the feasibility of the wetlands expansion. A hydrologic budget was developed to analyze the viability of various wetland restoration alternatives with regard to wetland sustainability. The objectives of the hydraulic design process for the fresh water wetlands were to establish conduit dimensions for transporting stormwater runoff, evaluate the hydraulic impacts (e.g., flooding or draining) to existing areas, and analyze the expected hydraulic performance of the wetland system. The hydraulic performance of the system helped determine the target vegetative structure and wetland functions.

Within Liberty State Park, the natural reclamation process is resulting in a gradual improvement of the environment. Outside the park is an urban environment, which has developed independent of the park ecological system. The intent of this project is to accelerate the natural reclamation processes in combination with restoring some of the historical ecological functions to the park through the redirection of some of the stormwater drainage from the adjacent, urban areas. However, the stormwater drainage in the urban environment has been designed to meet regulatory drainage requirements. Therefore, the effort to redirect the stormwater drainage requires marrying the hydrologic needs of the enhanced wetlands with the regulatory drainage requirements in the urban areas.

The stormwater drainage for the Liberty Science Center and parking lot, and the NJ Transit Light Rail Terminal and parking lot was not necessarily designed for wetland sustainability, but rather, it was designed for maximum drainage to prevent flooding. Any constrictions or diversion of flow from these urban sources will require that no induced flooding occur up to the original design criteria.

Wetland hydraulic design is an iterative process, consisting of: (1) developing a proposed hydraulic design, (2) conducting a site drainage analysis and surface flow hydrodynamic analysis with the proposed features in place, (3) evaluation of the proposed design against the design criteria, and (4) modification of the proposed design. The development of the proposed wetland

alternatives was based on typical wetland environmental, hydrologic, and hydraulic design criteria.

4.2 Hydrologic Analysis

The basic hydrologic data analyzed for the fresh water wetlands includes precipitation, surface runoff, the development of annual and monthly runoff volumes, and runoff routing in the derivation of existing and improved conditions. Inflows include direct rainfall and snowmelt; rainfall and snowmelt runoff from tributary areas; and groundwater inflow. Outflows are evaporation, groundwater infiltration, and surface runoff. These computations were accomplished using two techniques, the Simple Method and a Stormwater & Wastewater Management Model (SWMM).

The Simple Method and SWMM were selected for this analysis in order to attempt to accurately predict and model runoff *volumes* available for input to the proposed wetlands. Other models, such as HEC-1, HEC-HMS, and TR-55 are typically event-driven models, more appropriate for drainage capacity design for predicted events. The Simple Method and SWMM model were used to model annual and monthly runoff volumes and detention within the proposed wetlands system.

The watersheds that are a part of the proposed project consist of four catchment areas: (1) the interior of Liberty State Park, (2) the Liberty Science Center (LSC) and parking lot, (3) the existing wetland area immediately adjacent to the Science Center, and (4) the NJ Transit parking lot and adjacent drainage area (Figure 4.1). In the interior of Liberty State Park, there are several small drainage areas within the park itself due to the lack of significant relief within the park and the presence of old berms, dredged material mounds, and other debris mounds. There are numerous small drainage areas and several existing freshwater wetlands areas that will be retained in the proposed plan. North and west of this wetland is upland area. This upland area presented itself as a likely place for restoration due to the lack of existing freshwater wetlands and its relatively close proximity to potential sources of additional freshwater runoff. The drainage area for the existing, two-acre shallow emergent marsh is approximately 20 acres. This area is 100% pervious as it is entirely within the 215-acre restricted area. No additional impervious areas provide runoff to this area. No significant source of runoff is currently routed to the proposed tidal wetland.

The drainage area within the LSC complex can be divided into two main subcatchment areas: the LSC parking lot and the LSC itself, which consists of roof drains, walkways, and nearby mowed areas. The LSC parking lot is approximately 10.4 acres, 89% of which is impervious. Along Phillip Drive is a drainage ditch referred to as the East Ditch. This ditch primarily provides the conduit for runoff from the LSC parking lot to the Morris Canal. The drainage area of the LSC itself is approximately 8.48 acres, with 50% impervious. Runoff from the LSC has two destinations: either to the West Ditch along Phillip Drive or to the adjacent wetland.

An existing wetland is currently located immediately north of the LSC. The wetland area is approximately 2.3 acres in size, with an immediate drainage area consisting of the New Jersey Transit parking lot and a small adjacent area totaling approximately 11.13 acres.

Across the NJ Turnpike from the Liberty Science Center is the NJ Transit Light Rail Liberty State Park Station, which provides service to Bayonne, Jersey City and Hoboken. The terminal consists of an outdoor station and an approximately 800-car parking lot. The NJ Transit terminal area is divided into the three-subcatchment areas: the parking lot and interior detention basin, the southern terminal area and detention basin, and the northern terminal area and drainage swale.

4.3 Precipitaiton, Infiltration and Evapotranspiration

Monthly and hourly precipitation data was obtained from the National Climatic Data Center for the period 1948-2003 for Newark International Airport (cooperative station ID 286026), approximately 7 miles to the west of the study area. The average annual precipitation for the study area is approximately 45.65 inches. The observed extreme annual values were 65.50 inches in 1983 and 31.44 inches in 2001. The monthly extremes ranged from 0.36 to 11.53 inches.

Development of the hydrologic budget involved in quantifying sources of inflow or outflow to the deep emergent marsh. Runoff from the catchment (including snowmelt), direct precipitation on the wetlands, evapotranspiration, and groundwater inflow were defined by a combination of National Weather Service data, in-situ measurements, and model results. The period 1971 – 2002, for which all meteorological parameters (precipitation, snowfall, temperature, and pan evaporation) needed to develop the hydrologic budget were available, was used as the period of record to select dry and wet years.

Newark Airport (7 miles south of site) was selected as the data station for this study since the record was more complete than other stations of closer proximity. Inflows in the hydrologic budget include precipitation falling directly on the wetland, surface water runoff, groundwater, and pumped flow. Both direct precipitation and surface water runoff may be composed of rainfall and snowmelt.

Subcatchment infiltration is the water that infiltrates into the ground and does not become runoff (directly) during a precipitation event. Due to the heterogeneous nature of the fill material within the park as a result of years of fill, an effort was made to measure infiltration rates within the limited-access area. A series of 11 double ring infiltrometer tests were conducted within the park. The results and discussion of the infiltrometer tests can be found in the Liberty State Park Hydrology and Hydraulics of Fresh Water Wetland Report, (USACE 2004.)

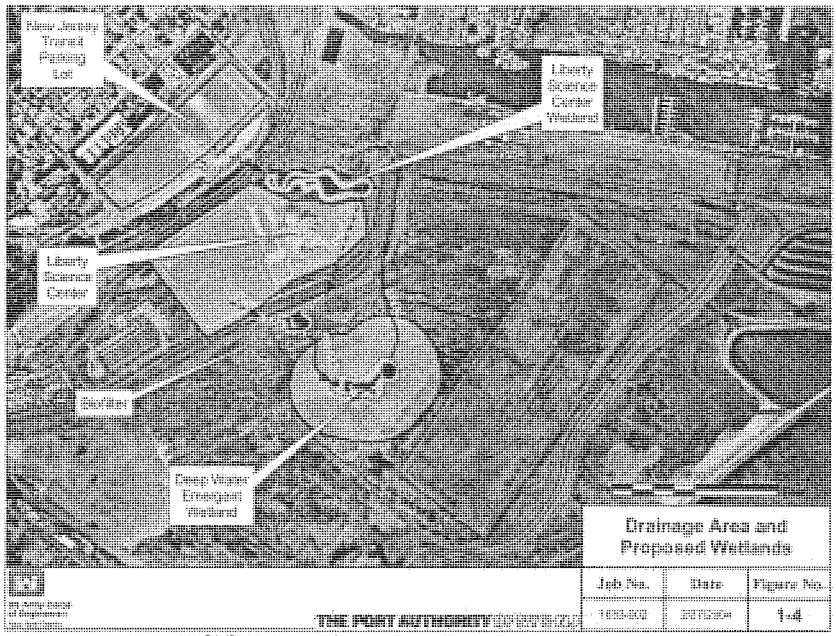


FIGURE 4.1 Liberty State Park Catchment Areas.

4-1

For the SWMM modeling, the maximum and minimum infiltration rates of 4.5 and 0.02 inches per hour, respectively, were used within the wetland areas of park. These rates are typical of a relatively impervious clay or other geo-lining, as planned for the wetlands. The typical maximum and minimum values of 3.0 and 0.02 inches per hour, respectively were used for the pervious, mowed surfaces outside the park. These values are consistent for landscaped turf. The decay coefficient was set at 4 hr^{-1} which is equivalent to a decline in infiltration of 98 percent towards the limiting value after the first hour.

From the results of the analysis, it is assumed that due to the high infiltration rates and relatively shallow grades that there will be minimal runoff from the drainage areas within the park. Outflows may include surface water, groundwater, and evapotranspiration. A model developed at the Northeast Regional Climate Center was used to provide estimates of monthly pan evaporation (DeGaetano 1994). Evapotranspiration was then calculated as 75% of pan evaporation estimates based on research results by others (Hammer 1992, Hubbard et al. 1988).

4.4 Estimated Runoff Volume

Runoff volumes for the subcatchments in the study area were initially estimated using the Stormwater Manager's Resource Center's Simple Method. The Simple Method provides an easy

way to evaluate potential runoff from the watershed using annual and monthly precipitation values.

The Simple Method (SMRC 2003) is generally used to estimate stormwater runoff pollutant loads for urban areas. For the hydrologic budget, the method was used to calculate runoff only; for sediment transport calculations described Liberty State Park: Hydrology and Hydraulics of Fresh Water Wetlands Report (USACE 2004) the Simple Method was also used to simulate total suspended solids. The technique requires a modest amount of information, including the subwatershed drainage area and impervious cover, and annual precipitation. It provides reasonable estimates of stormwater runoff volumes. Unlike other hydrologic methods, preliminary volumes can be estimated based on average rainfall rather than specific storm events.

Computed volumes were checked by comparison to XP-SWMM model results for one scenario. Although significant disparities between SWMM and Simple Method results are sometimes seen for individual months, the total yearly volumes for the simple method are only 12% higher than SWMM for 1976 and 15% lower than SWMM for 1983. In light of the inherent differences between the two modeling approaches, these differences are relatively small. Therefore, the Simple Method results are validated by the SWMM computations.

4.5 Environmental Design Criteria

As indicated in the General Management Plans, NJDEP, 2001, water depth and draw down must be controlled to the degree that will maintain a viable and attractive wetland and pond community and to provide wildlife habitat value to the park.

The deepwater emergent pond/wetland has been designed to provide a permanent source of water with a depth of approximately 4-6 feet. This, along with very shallow (5%) side slopes will provide a controlled proportion of deeper and shallower habitats throughout the growing season.

The Threatened and Endangered listed bird species do not have habitat requirements that include a specific hydroperiod. They can be expected to use wetland or upland habitats if the vegetative structure of these habitats meets their needs. For example, the northern harriers prefer grassland habitat with few trees and shrubs. Harriers will nest in either uplands or wetlands, but the pair nesting at Liberty State Park seems to prefer uplands for nesting. For winter roosts, harriers prefer upland sites. Many sources indicate harriers prefer to nest and roost in fields that are 50 acres or more in size; however, the species has also been documented to nest in habitat blocks as small as 20 acres.

Aside from the northern harrier, none of the other Threatened and Endangered bird species of special concern that were observed during inventory surveys have been documented as breeding in the park. As mentioned previously, their use of habitat relies more on habitat with the correct vegetative structure and adequate food resources rather than hydroperiod.

One listed plant species, Torrey's rush, was found on the site. This species has hydrologic requirements and is adapted to specific types of soils. It is a facultative wetland (FACW) species, which means it has the probability of being found in a wetland 67-99% of the time. The

Natural Resource Conservation Service's (NRCS) Plant Database indicates this species is adapted to medium to coarse-textured soils and has a low-tolerance for drought conditions. The NRCS lists the minimum and maximum amount of precipitation needed as 14 and 50 inches per year, respectively. The minimum root depth is 10 inches and the species is intolerant of both shade and salinity. This species was identified in a freshwater wetland on-site. That wetland area should be protected during construction while also considering the habitat requirements for the species when enhancing other freshwater wetland habitats on-site.

4.6 Hydrologic Design Criteria

The minimum water requirements for wetland sustainability are determined by a combination of factors that need to be balanced. In order to maintain a wetland with a permanent pool of water and sufficient flow to maintain good water quality, sufficient drainage area is required. Without supplementing the water supply through pumping, a minimum watershed of about ten acres is required for maintaining a year round permanent pool of approximately one acre. A second rule of thumb is that four acres of contributing watershed are needed for each acre-foot of storage (Md SCS, 1976; Schueler, 1987). For this plan, from five to nine acres of contributing urban watershed are available for each acre-ft of planned wetland storage. This range of ratios suggests that the watershed is sufficiently large to support the planned wetlands. Relying on a smaller watershed than this would make maintaining a permanent pool difficult and would produce large fluctuations in the water level due to evaporation and infiltration losses. Examination of the water balance diagrams (Appendix A in Liberty State Park: Hydrology and Hydraulics of Fresh Water Wetlands Report (USACE 2004) indicates that the base flow entering the wetland would run out during the summer months, and input cannot compensate for gradual drawdown. The result may be poor water quality, the production of algal matting and odor problems. During extremely dry periods such as 1976, it is possible that the existing wetland may completely dry up i.e., have almost no standing water yet still have saturated substrate, as do most of the existing wetlands on the site.

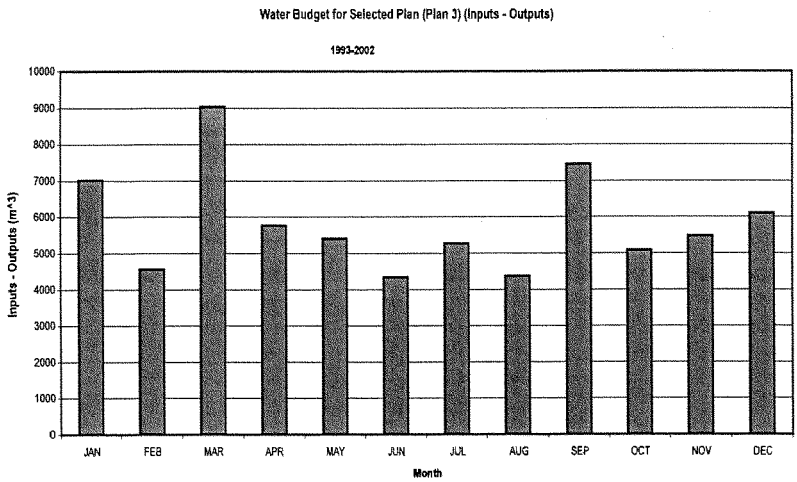


Figure 4.2 Sample Water Budget Used to Develop the Freshwater Wetland.

There are many hydrologic and hydraulic considerations important to wetland restoration and construction. The primary list of design criteria includes the following basic interrelated elements.

- Hydrologic setting,
- Flood duration and timing,
- Flooding depth,
- Flow velocities and hydraulic retention time,
- Storage capacity and surface area.

Hydrologic Setting: The hydrologic setting of the wetland describes the location of the wetland in relation to other water bodies. The hydrologic setting is important to all wetland functions, but is of particular importance to groundwater recharge/discharge, sediment retention, flood-flow alteration, and production export. The existing and proposed freshwater wetlands within Liberty State Park are generally independent of any other water body (e.g., stream, river, lake, etc.). They occur in typically heterogeneous material that has a relatively shallow water table. Thus, they are presumably influenced by a fluctuating water table. The proposed wetlands would be constructed in the same general area (park interior) as the existing wetland in similar substrate types.

Flooding Duration and Timing: The existing wetlands within Liberty State Park are typically seasonally wet (i.e., during the spring and fall), with the exception of the Liberty Science Center wetland, which is frequently flooded from runoff from the NJ Transit terminal and parking lot.

Similarly, the drainage ditches along Phillip Street are frequently flooded with runoff from the Liberty Science Center. Based on the hydrologic budget analysis, diversion of stormwater runoff from the parking lots adjacent to the park into the proposed wetlands will result in the proposed wetlands maintaining measurable pool depths most of the year.

Water Depth: Water depth is an important factor in determining the types and extent of vegetation supported by the wetland. The existing wetlands are shallow, seasonal wetlands, most likely augmented by a rising water table during the wet seasons of the year. The proposed wetland system would have both shallow and deepwater areas to support a greater abundance of plants and wildlife than the existing wetlands.

Flow Velocity and Hydraulic Retention Time (HRT): Maintaining a low velocity related level of flowing water shear stress is important to several wetland functions. As a result of the shallow gradient of the park and the detention-design of the wetlands, velocities will be minimal. The HRT is defined as the average amount of time that a parcel of water stays within the wetland before exiting. The HRT is the key design criteria for water quality enhancement functions such as sediment/toxicant removal and nutrient removal/transformation. For this feasibility analysis, the focus was on flood frequency and duration, and depth. It is expected that the wetland system will cause a measurable increase in HRT, which will further result in improved water quality entering the Harbor. Obviously, excessive HRT in the wetland could result in wetland water quality problems such as low dissolved oxygen and the production of sulfide and methane gases. However, frequent runoff is expected to provide frequent flushing of the wetland system.

Storage Capacity and Surface Area: The storage capacity is most important in the flood-flow alteration function because the amount of available storage in the wetland determines how much of the runoff can be routed into and through the wetlands. The storage capacity may also affect aquatic abundance and diversity, in that larger wetlands will have more potential for groundwater recharge, greater volume and surface area, and may support more aquatic organisms. Storage capacity was used in this analysis to reach design water surface elevations based on seasonal inflows. The wetland bottom area is important for groundwater recharge and discharge. Ground water recharge was not a primary concern of the proposed designs; it is anticipated that the wetlands will be lined with a low permeability liner. Runoff inflows were expected to be sufficient to overcome evapotranspiration, even during the drier months of the year.

4.7 Fresh Water Wetland System: Components of Proposed Alternatives

In order to maximize habitat function and value, the freshwater wetland system may have four primary components: (1) an enhanced Liberty State Park wetland, (2) a Biofilter (BF) wetland, (3) a Deep Emergent Marsh (DEM), and (4) natural connecting swales. The proposed freshwater wetland system should be located in the center of the park, in close proximity to the proposed tidal wetland. Ideally, the DEM should be at least 400 or 500 feet away from the nearest road or heavily used area so there is a buffer between fast moving vehicles and the inhabitiants of the wetland.

The proposed freshwater wetlands will contain a number of hydrologic/habitat zones, as follows:

- Zone 1. Deep Water Pool (1-6 feet deep), to support submerged aquatic plants such as wild celery, sago pondweed, and redhead grass.

- Zone 2. Shallow Water Bench (6-12 inches between groundwater level and the discharge invert), to support emergent aquatic plants. Proposed plants are obligates and are relatively intolerant to drawdowns. Typical plants in this zone include: Pickerelweed (*Pontederia cordata*), Duck potato, (*Sagittaria latifolia*), Three square (*Scirpus pungens* (*S. americanus*)), and Soft stem bulrush (*Scirpus validus*).

- Zone 3. Shoreline Fringe. This is the regularly inundated area, which supports wet meadow scrub-shrub wetland, including plants such as sedges, switchgrass, and buttonbush. This zone is typically between the discharge invert and an overflow elevation.

- Zone 4. Riparian Fringe. This is the periodically inundated area, which supports wet soils or scrub-shrub transition, including plants such as red osier dogwood, red maple, and swamp oak. This zone is typically above the overflow elevation.

Enhanced LSC Wetland (Wetland 1): The wetland will be enhanced through the removal of the common reed, regrading, and replanting. The enhanced wetland will contain Zones 1 through 4 as described above. Figures 4.3 and 4.4 shows the enhanced LSC wetland. The area of the wetland will be 2.27 acres.

Biofilter Wetland. (Wetland 2): The second wetland will be designed for water quality pre-treatment and contain wetland Zones 1 through 3 as described above. The wetland will provide pre-treatment by removing coarser sediments, trash, and debris. This pre-treatment should also provide for the significant removal of particulate pollutants. The deeper areas of the wetland will function as either a permanent pool or shallow marsh areas. The deep area will enhance the removal of soluble phosphorus and nitrogen. Figures 4.5 and 4.6 shows the Biofilter wetland. The area of the wetland will be 0.79 acres.

Deepwater Emergent Marsh (Wetland 3): The mean water elevation of the DEM will be approximately 5.0 ft NAVD with bottom elevation around 0.0 ft NAVD. The wetland area is about 1.8 acres and average volume is approximately 32,700 cubic feet. These dimensions include all of the four-wetland zones (Figures 4.7 and 4.8). The DEM will include all four wetland zones discussed above. The deep water areas of the wetland should be permanently flooded. The zone between the typical low level and the overflow outlet may be seasonally flooded. Above the overflow elevation will be a transition zone to upland areas.

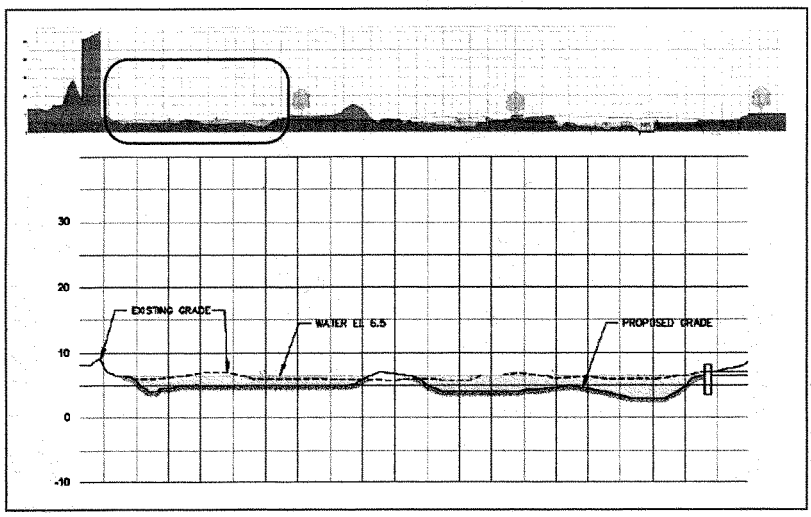


Figure 4.3 LSC Wetland, Plan View

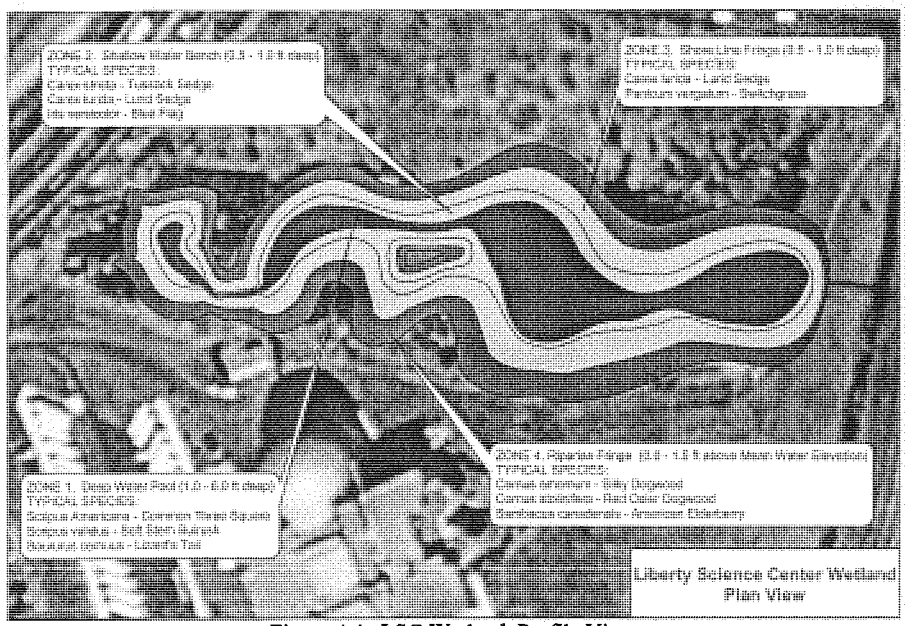


Figure 4.4. LSC Wetland, Profile View

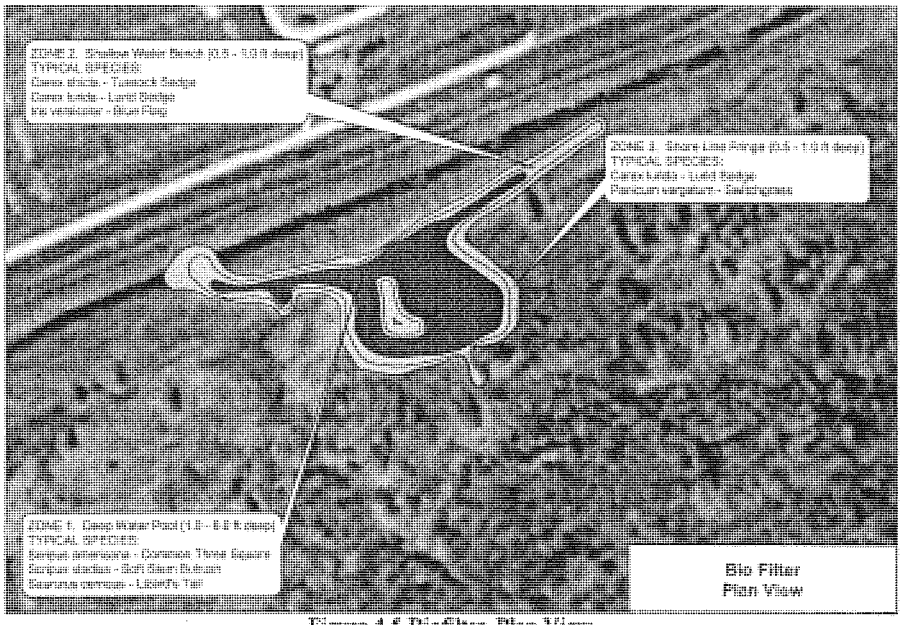


Figure 4.5 Biofilter, Plan View

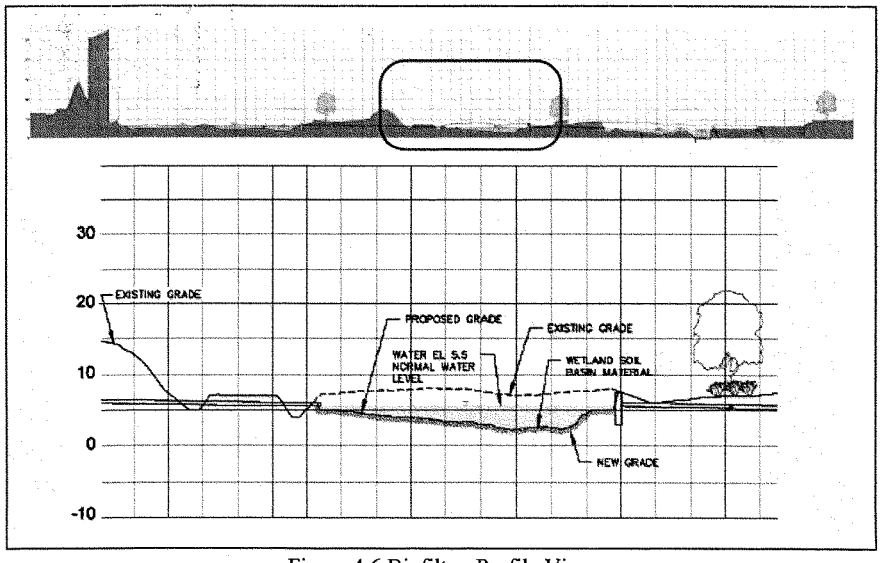


Figure 4.6 Biofilter, Profile View

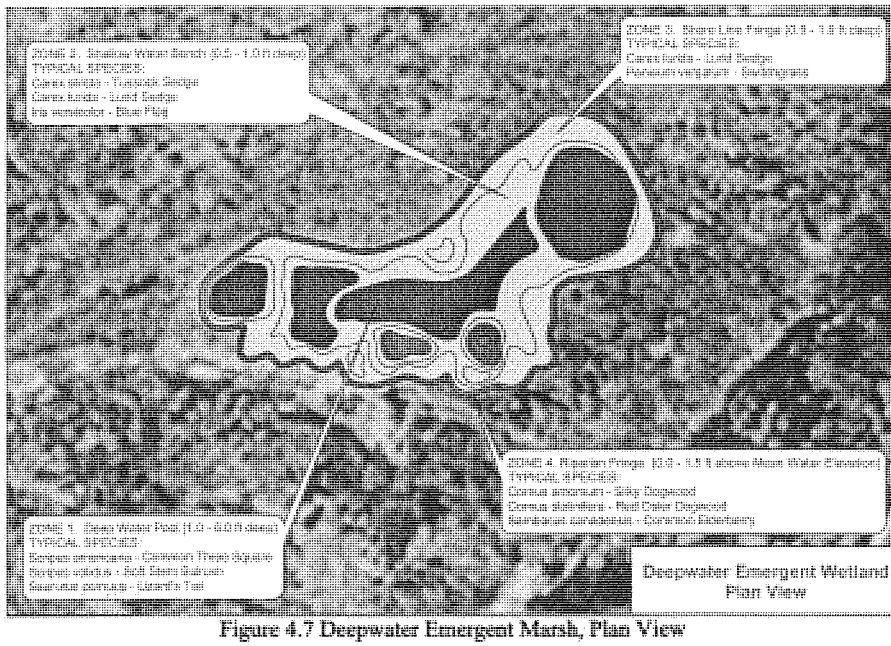


Figure 4.7 Deepwater Emergent Marsh, Plan View

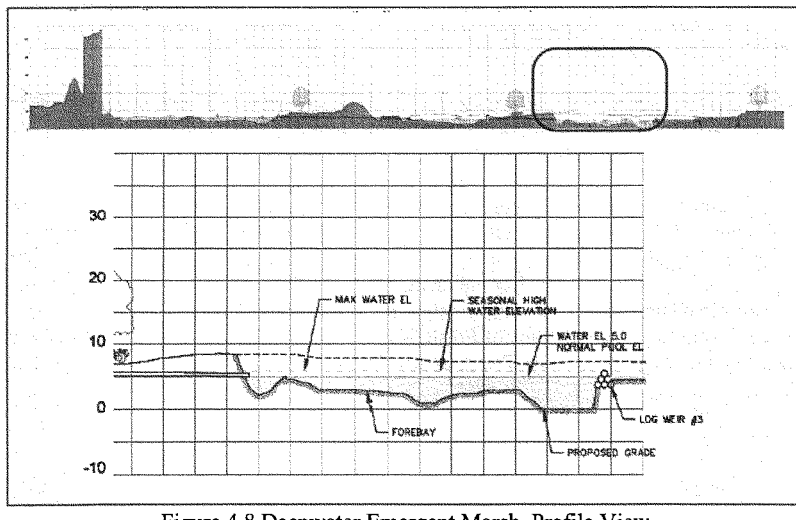


Figure 4.8 Deepwater Emergent Marsh, Profile View

Connecting Swales: Natural swales will connect the wetland system within the park to limit the need for structural components in the freshwater system, provide additional functional value, and maintain the ecological nature of the site. Swale slopes should be graded as close to zero (1:500) as drainage will permit. The side slopes would be 1V:3H. Between the biofilter (5.5 ft NAVD) and the deep emergent marsh (5.0 ft NAVD) there is a half foot elevation drop in about 400 feet or a slope of about 0.125%. Side slopes of the swale will be about 3:1 (h:v) or less. The swales will be planted with a dense cover of water tolerant, erosion resistant grass. This grass will not be mowed close to the ground to avoid impeding the filtering and hydraulic functions of the swale. Since the system will use parking lot runoff, sensitive grass species with a low salt tolerance such as bluegrass, should be avoided. Reed canary grass is ideal but is also considered an invasive species.

Infiltration Basin: One method of returning excess stormwater to the interior of the site would be to direct this excess to an infiltration basin. This would ensure that the water is being discharged to an area with high permeability and allow quick groundwater recharge. Infiltration basins are also effective in removing both soluble and fine particulate pollutants that may still be in the stormwater discharged. The basin would be receiving this water during wet months and/or during larger storms. While this water will have been treated by the other constructed wetlands, the discharge may still contain some pollutants during large storms. In this case, the basin would serve as a final polishing system along with providing control of peak discharges for large design storms. The high permeability soils are well suited for use as an infiltration basin with little soil augmentation required. The infiltration basin, shown in Figures 4.9 and 4.10, would provide an impoundment by excavating the soil to an elevation of approximately elevation of 4.5 NAVD. The impoundment will store a defined quantity of about 3 acre feet of runoff, allowing it to slowly infiltrate through the permeable soils of the basin floor. The floor would be graded as flat as possible and a dense native grass cover would be established to promote infiltration, add habitat value and bind up deposited sediments.

The vegetative zones and elevations associated with each of the proposed wetlands are presented in Liberty State Park Hydrology and Hydraulics of Fresh Water Wetlands: Appendix C (USACE 2004).

Existing conditions and four different scenarios were evaluated and modeled during the feasibility study. The alternatives considered for the fresh water wetland component of this feasibility study are modifications of one primary freshwater wetland system consisting some or all of the five previously described components. The alternatives primarily differ in their source or sources of stormwater. For information regarding Alternatives A, B and C, see Liberty State Park Hydrology and Hydraulics of Fresh Water Wetlands: (USACE 2004). Alternative D was chosen by the Project Delivery Team, as it offered the most habitat units for the cost (see main report).

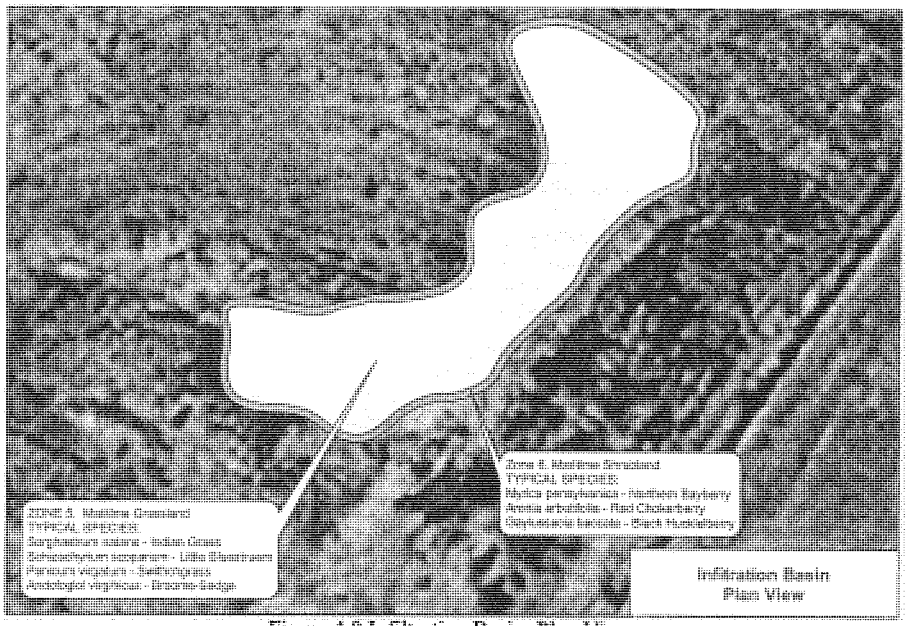


Figure 4.9 Infiltration Basin, Plan View

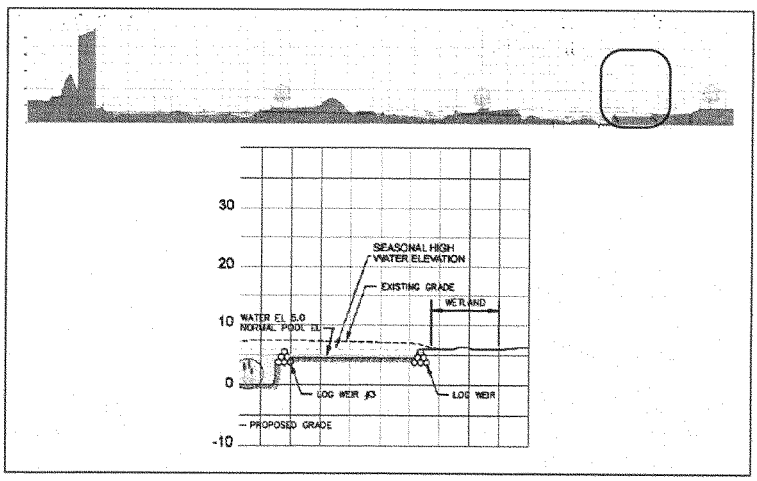


Figure 4.10 Infiltration Basin, Profile View

Selected Alternative (Alternative D)

All features discussed above are included in the selected alternative. LSC Wetland (Wetland 1) will be enhanced by increasing the hydraulic retention time of water reaching the wetland by building stop log weirs, removing invasive species, and planting of plants that offer more habitat value. Stormwater from the NJ Transit parking lot currently drains to the LSC wetland, which maintains a surface water elevation from 5.6 to 7.5 feet NAVD. The runoff from the LSC wetland will then be routed via an 800 ft long culvert, with an upstream invert of 6.5 ft NAVD, under Philips St to the biofilter. The LSC Wetland will have a bottom invert elevation at approximately 3.0 feet NAVD. The LSC wetland area will be about 2.3 acres and the storage volume and perimeter will be approximately 110,000 cubic feet and 2,000 feet, respectively.

In addition to LSC Wetland runoff, the biofilter also will accept runoff from the LSC Building and Parking, also via a 150 ft long culvert traversing under Phillips St. The mean water elevation of the Biofilter will be approximately 5.5 feet NAVD with bottom elevation of approximately 3.0 feet NAVD. The wetland area is about 0.8 acres and the storage volume is approximately 59,800 cubic feet. The perimeter is approximately 1,400 feet. The Biofilter and DEM are connected via a natural swale 430 ft long.

The excess water that is not detained in the DEM by the log and stone weir will be discharged to an infiltration basin adjacent to the DEM. The new bottom elevation of the basin will be approximately 4.5 feet NAVD with an overflow invert elevation at approximately 6.0 feet NAVD. The basin area is about 2.2 acres and the storage volume is approximately 134881 cubic feet. The perimeter is approximately 1,703 feet. If water does go over the spillway, it will be directed to the adjacent existing freshwater wetland.

4.8 Hydraulic Analysis and Design

For this analysis, the hydraulic evaluation of the proposed freshwater wetland alternatives was conducted using XP Software's Stormwater & Wastewater Management Model (XP-SWMM or SWMM). The SWMM results were used in conjunction with the hydrologic budget analysis to evaluate the potential performance of the proposed wetland alternatives.

4.8.1 Basis of Design

The analysis presented herein is based on the concepts and guidelines contained in U.S. Army Corps of Engineers' Engineer Research and Development Centers' *Wetlands Engineering Handbook* (USACE 2001).

Initial stormwater runoff volumes used in the hydrologic budget were estimated using the Simple Method. The Simple Method values were checked for reasonableness using the SWMM output, as discussed previously. The performance of the existing and proposed conduits, such as pipes,

drainage ditches, and swales integral to the freshwater wetland system were analyzed using SWMM. Typically, conduits proposed as additions to the existing drainage network were sized to convey the modeled volumes and maintain the wetland system target water surface elevations. The objective of the conduit sizing was not to provide drainage to meet any regulatory requirements (e.g., providing sufficient drainage for a specific frequency event); rather, the conduits were sized to adequately convey the typical runoff volumes without inducing flooding. The only design limitation was to ensure that changes in the drainage as a result of the rerouting of runoff did not result in induced flooding in the drainage area during the 10-year NJDOT design event (NJDOT 2003; 5.25 in./24 hr).

4.8.2 Hydraulic Design Criteria

Man-made wetlands require means to control the quantity and depth of water at a given location. Consequently, hydraulic structures are a basic part of creating, restoring, and enhancing wetlands. The following sections describe the hydraulic design criteria and assumptions for the Liberty State Park freshwater wetlands system.

4.8.2.1 Water Containment

Due to the relatively flat topography of the site, the inverts of the existing drainage structures, and the distances between drainage areas and the wetlands, it is expected that the proposed wetlands would be constructed primarily by excavation. Levees or berms to retain water were not considered in the design with the exception of berms adjacent to outlet structures where it was necessary to direct and control outflow.

4.8.2.2 Sediments and Debris

Reduced flow velocities found in wetlands allow sediments transported into the wetland with the inflow to settle to the bottom. Trapped sediments eventually occupy part of the wetland volume, thereby reducing its effectiveness at removing future sediments from the inflow. Therefore, the inclusion of a forebay in the Biofilter wetland is necessary to trap incoming sediments and prevent them from settling in the main section of the wetland and potentially moving downstream to the deepwater wetland.

Wetlands immediately adjacent to impervious surfaces such as roadways and parking lots are also subject to the inclusion of debris and trash in stormwater runoff. The construction of a forebay will also help capture debris which would otherwise enter the wetland system and potentially degrade habitat and threaten wildlife.

4.8.2.3 Design Event

Hydraulic drainage structures are typically designed to routinely pass flow up to some design event. For the proposed freshwater wetlands at Liberty State Park, the construction of the wetlands within the environmental area of the park reduces the need to design the wetlands for a specific event because any potential overflow of the wetlands would occur within the existing ecological area. The only area of concern is in the vicinity of Phillip Street, which may be

impacted if the outflow structures cannot convey flow quickly enough during extreme precipitation events, and flooding occurs. To reduce the potential for induced flooding during extreme events, the existing drainage ditches along Phillip Street will remain in place, separated from the wetland system by overflow berms or weirs. This will allow any overflow from the wetlands to drain through the drainage ditches before flooding the roadways.

Current New Jersey Department of Transportation guidance (NJDOT 2003) requires that longitudinal systems and cross drain pipes for land service highways be of sufficient capacity to pass the runoff from a storm with a 10-year recurrence interval. Therefore, the performance of the freshwater wetland system was analyzed to ensure that no induced roadway flooding occurs during the design event (5.25in/24hr).

4.8.2.4 Conduits

Ideally, the conduits between the wetlands and the outlets should be environmentally beneficial, that is, natural. Therefore, the wetland system was designed using natural, trapezoidal channels to convey flow within the park. These channels are expected to contain vegetative growth and were modeled using a roughness coefficient (Manning's n-value) to reflect vegetation similar to the vegetation presently in the existing drainage ditches within the park. Vegetated swales were designed with a 5-foot bottom width and 1:4 side slope. The channels will initially be lined with grass; however, additional vegetation growth is expected over time. Flow under the roadways will be conveyed through pipes.

4.8.2.5 Materials

Pipes are needed to convey the flows beneath the roadways. For this analysis, it is assumed that the outlet pipes are reinforced concrete pipes (RCP). The outlet weirs within the wetlands will be constructed of natural materials, such as logs or stones.

4.8.2.6 Infiltration Basin

An infiltration basin is a facility constructed within highly permeable soils that provides temporary storage of runoff during rain events. The basin does not normally have a structural outlet to discharge runoff except during very high flow events. Instead, outflow from an infiltration basin is through the surrounding soil. Preliminary infiltration rates measured at the site indicate relatively high surface permeability; however, the permeability of the soils at and below the basin invert must be measured to ensure adequate basin performance. Typical tests such as a percolation test, pit-bailing test, or piezometer test, as outlined in N.J.A.C. 7:9A *Standards for Individual Subsurface Sewage Disposal Systems*, are necessary to ensure adequate soil permeability. For this analysis, a conservative infiltration rate of 1 in/hr was used based on preliminary infiltration measurements.

4.8.3 Groundwater

Preliminary data indicates that the groundwater table within Liberty State Park is relatively shallow. It is likely that the groundwater table may even rise above the lowest land surfaces within the park during the wettest periods of the year. However, there is not yet sufficient data to

confirm this fact. Furthermore, there is no groundwater quality data available to date. Therefore, for this analysis it is assumed that the wetlands are constructed with a clay or other impervious liner to limit groundwater flow to the wetlands. Potential hydrostatic or buoyant forces on the liner as a result of groundwater are expected to be offset by the presence of water within the wetlands. It is also assumed that groundwater will not impact the infiltration basin.

4.8.4 SWMM Model Development

The model used for the hydraulic analysis of the proposed wetlands alternatives is a version of the EPA-SWMM: XP-SWMM2000, version 8.52. This version of SWMM has both graphical input and output routines making it easier to make changes in the model and to visualize results. SWMM is a comprehensive model that can perform both hydrologic and hydraulic calculations.

The Liberty State Park SWMM used the RUNOFF and HYDRAULICS (known as EXTRAN in other versions) blocks. The HYDRAULICS block solves the complete St. Venant (Dynamic Flow) equations throughout the drainage network and includes modeling of backwater effects, flow reversal, surcharging, looped connections, pressure flow and tidal outfalls and interconnected ponds. The existing conditions SWMM network is shown in Figure 4.11

4.9 Analysis of Selected Alternative

The four freshwater wetland system alternatives were each modeled with hydrologic input for a wet year and a dry year to evaluate performance. The success of an alternative was predicated on: (1) maintaining the water surface elevation within the Biofilter wetland throughout a majority of the year, (2) maintaining a measurable depth of water within the Deep Emergent Marsh (DEM) throughout the entire year, and (3) achieving some periodic outflow through the DEM overflow in order to achieve circulation or flushing of the DEM. The Liberty State Park: Hydrology and Hydraulics of Fresh Water Wetlands Report (USACE 2004) shows how each alternative performed in meeting the success criteria. The alternative analysis concluded that alternative D best met the design criteria. The environmental benefits and construction cost comparison of the 4 alternatives found in the main body of this report also demonstrates that Alternative D is the best alternative. The SWMM network for Alternative D is shown in Figure 4.12.

In Alternative D, the biofilter maintains a design WSEL of 5.5 feet NAVD throughout much of a dry rain year, as shown in Figures 4.13 Using both the Liberty Science Center and the NJ Transit Parking Lot as sources of stormwater to the freshwater wetland system, it increases the time the DEM maintains the design WSEL and increases outflow from the DEM, improving circulation and flushing. As shown in Figures 4.14 and 4.15, the DEM maintains the design WSEL of 5.0 feet NAVD during most of the wet year of precipitation and during the dry year the DEM WSEL is at the design elevation for 10 of 12 months.

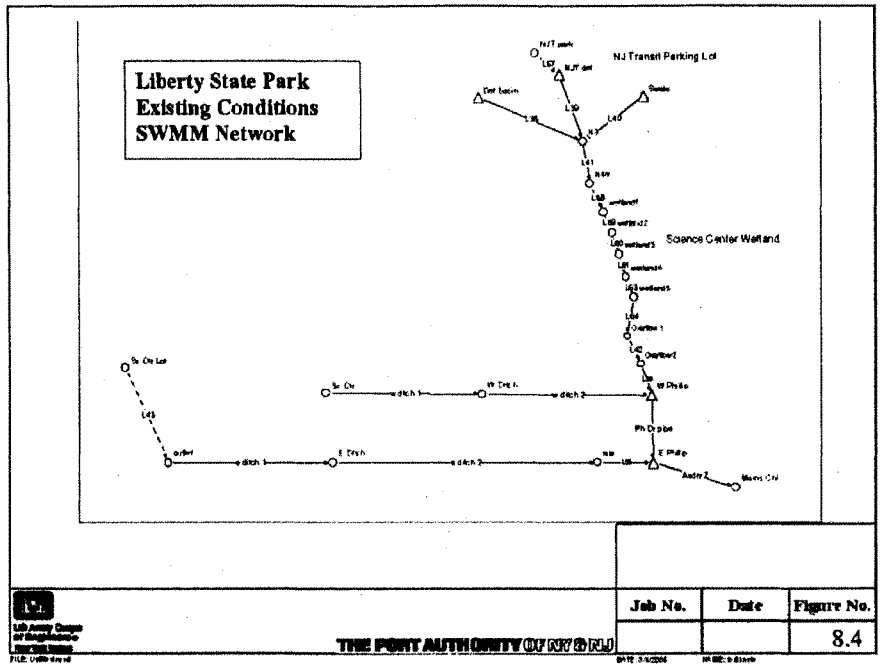


Figure 4.11 SWMM Network for Existing Conditions

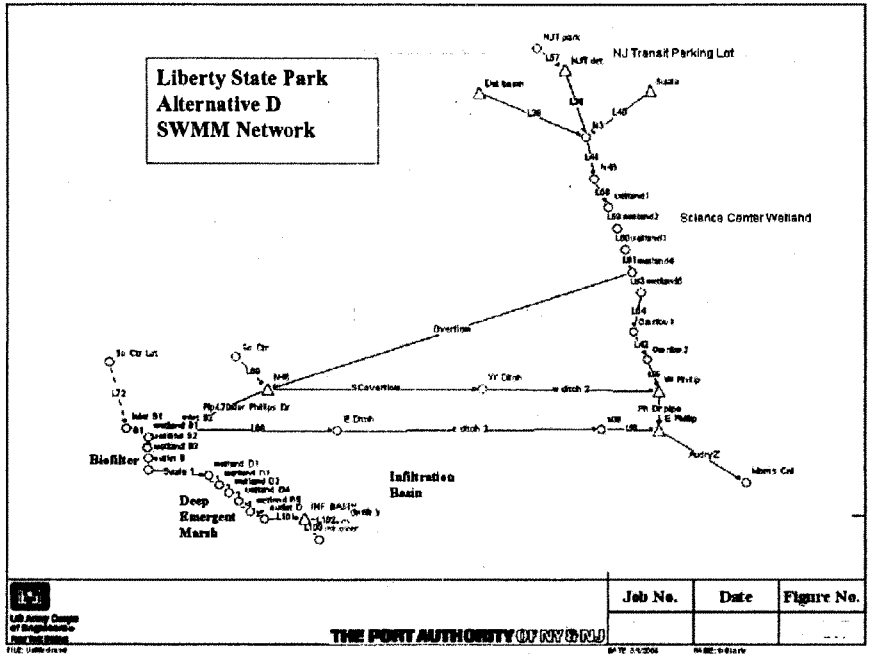


Figure 4.12 SWMM Network for Proposed Conditions (Alternative D)

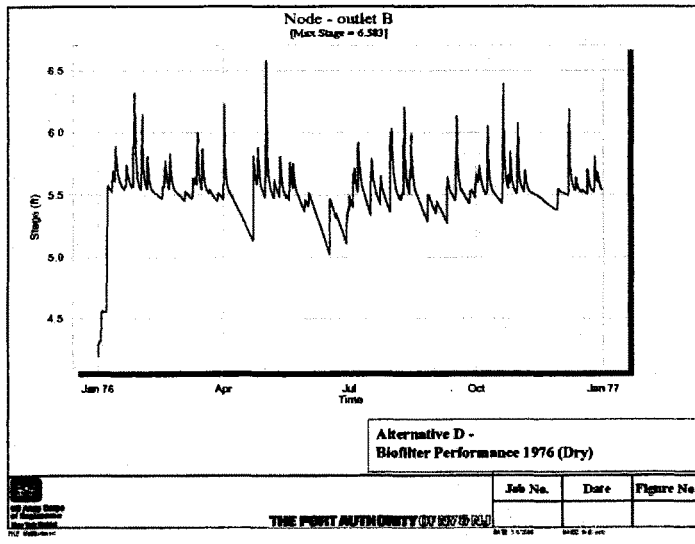


Figure 4.13 Biofilter Performance During a Dry Year for Chosen Alternative

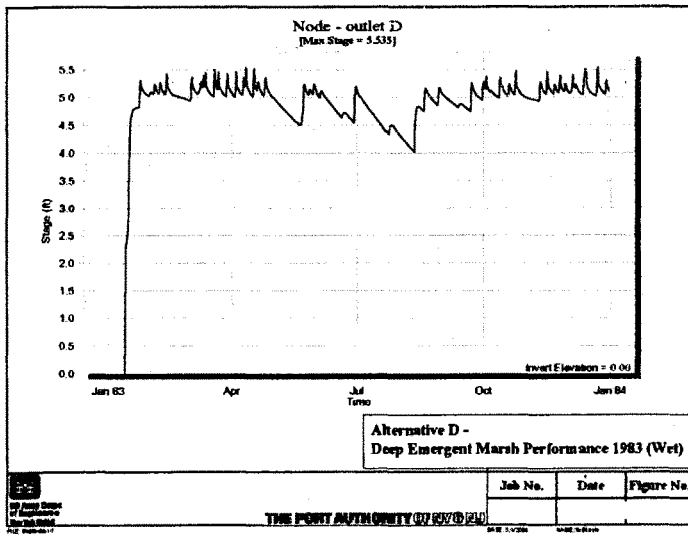


Figure 4.14 DEM for a Wet Year

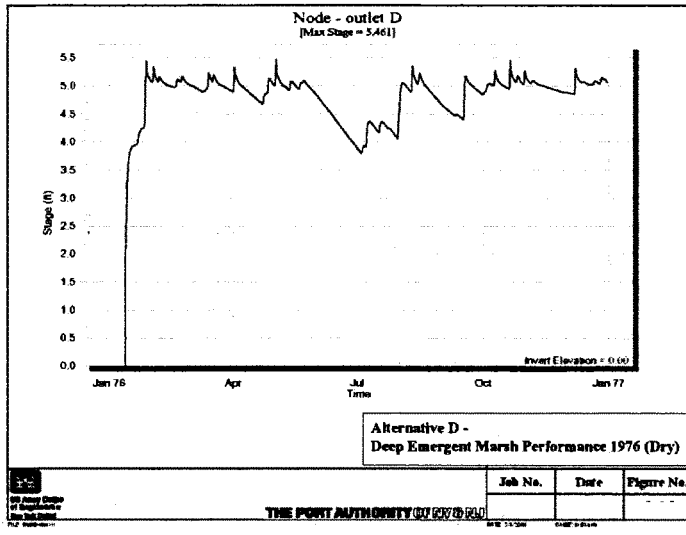


Figure 4.15 DEM for a Dry Year

Overflow from the DEM enters the infiltration basin and is lost from the system through infiltration. As shown in Figure 4.16, periods of higher rainfall surcharge the infiltration basin above the design WSEL of the DEM for brief periods of time.

For the dry model year, input to the infiltration basin is less frequent . Subsequently, there is less infiltration. See Liberty State Park Hydrology and Hydraulics of Fresh Water Wetlands Report (USACE 2004) for the stage/time plots for all the SWMM nodes for wet, dry and normal rain years.

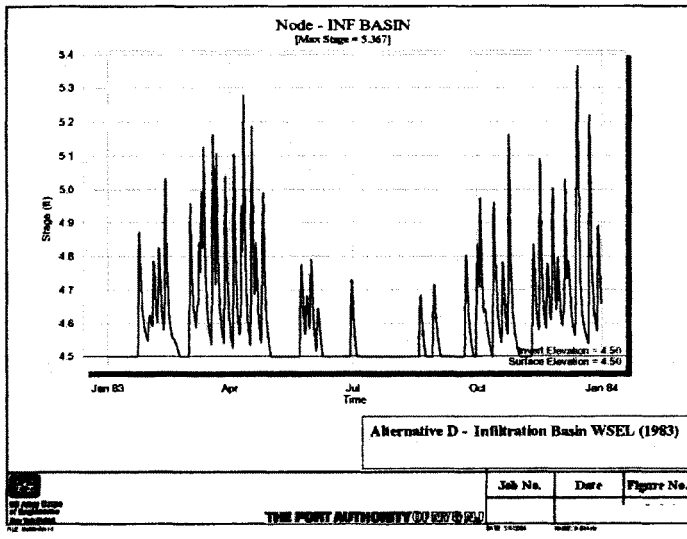


Figure 4.16 Infiltration Basin for a Wet Year

4.10 10-year NJDOT Design Event Performance

The performance of the freshwater wetland system was evaluated to ensure that no induced roadway flooding occurs during the NJDOT roadway design event. The NJDOT design event is a 10-year/24-hour rainfall event of approximately 5.25 total inches of rainfall. Unlike the annual models, the design event was modeled using SWMM's "hot-start" feature, which enabled modeling of the events with antecedent conditions in the wetlands. Starting the model with existing water in the wetland more realistically represents the behavior of the WSELs in the system.

The primary areas of concern in the wetland system are: 1) the Biofilter and, 2) the detention/ponding area west of Phillip Drive (the upstream end of the Phillip Drive pipe). Excessive backwater flooding in these areas could overtop Phillip Drive as a result of the proposed wetland system. The WSELs of both the Biofilter and upstream detention area just reach the minimum curb height of 7.0 feet NAVD along Phillip Drive as a result of the 10-year/24-hour storm runoff in each alternative. From these results, it is assumed that flooding is not likely to occur at Phillip Drive following a 10-year/24-hour storm event as a result of the freshwater wetland system construction.

4.11 Sensitivity Analysis

Uncertainty has been incorporated into the hydrology through the use of precipitation from extreme wet and dry years of record. Evaporation uncertainty is incorporated through the use of monthly averages. However, at this point in the analysis there is some degree of uncertainty associated with the potential infiltration of the proposed infiltration basin. Small changes in the infiltration rate are not expected to be critical to the wetland system performance; however, a sensitivity analysis is appropriate to demonstrate the impact of potential changes in filtration.

As defined, a sensitivity analysis is a technique of varying assumptions to examine the effects of alternative assumptions on the determined outcome. In this case, a sensitivity analysis was used to show how the wetland system will perform if the infiltration of the proposed infiltration basin is changed. To evaluate the system sensitivity to a change in the infiltration rate, the proposed infiltration rate was modeled during the wet year (1983) with an outlet sized for a maximum outflow of approximately 1 cfs at 1.5 feet of head, which is equivalent to maximum infiltration rate of 0.5 in/hr over the 2 acre infiltration basin, or half of the assumed infiltration rate of 1 in/hr.

Infiltration is half the rate originally modeled for this sensitivity run; however, the WSEL elevation increase in the infiltration basin is only approximately 0.4 feet during the largest storm. The greatest impact is a backwater impact into the DEM; however, this is minimal and quickly dissipates as the infiltration basin WSEL drops. It can be assumed that an increase in the infiltration rate will have the opposite effect on the WSEL of the infiltration basin and DEM during a given year. Regardless, minor changes in the infiltration rate should not detrimentally impact the freshwater system.

5. TIDAL WETLAND

5.1 Objectives

The study team determined that creation of a Tidal Creek/Salt Marsh would increase biodiversity, improve water quality in the immediate vicinity by augmenting tidal circulation and restore underrepresented habitat in Liberty State Park, three of the major goals for the area and for the Hudson-Raritan Estuary Ecosystem Restoration Project. The proposed location for this feature is the northeast corner of the site starting in the North Cove. It extends into the southern half of the existing 45-acre dredged material containment area. The creation of low marsh, high marsh, mudflat and tidal creek habitat, and the enhancement of sub-tidal habitat are proposed in the selected NER plan (Figure 5.1)

5.2 Tidal Analysis, Runoff and Groundwater

5.2.1 Tidal Analysis

Section 2.8 discusses the analysis of tidal influences in the Upper New York Harbor, adjacent to the proposed tidal wetland. DH-21 Water Level Recorders were used to collect the data. The output files can be found in appendix A. The reconstruction of the tidal epoch was done using the "datum reduction method" (National Ocean Service, NOAA). The use of the datum

reduction method results in local tidal datums that provide estimates of what would have been observed over the 1983-2001-epoch period. It was found that the effect of heavy precipitation events on the observed tide data was negligible. Table 5.1 restates the computed tidal datums used for the tidal wetland analysis and design.

Figure 5.1 Proposed Tidal Wetland for Liberty State Park

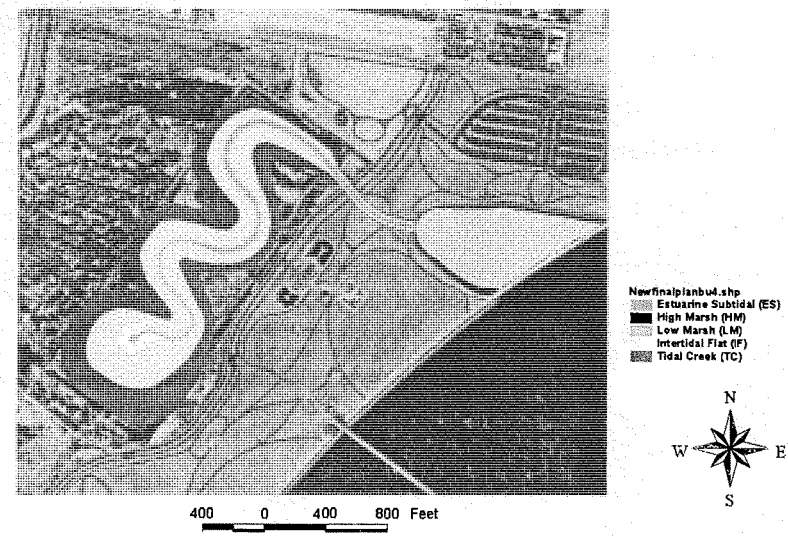


Table 5.1 Tidal Datums for Liberty State Park* (ft NAVD88)

Mean High Water Spring	2.29
Mean Higher High Water	1.91
Mean High Water	1.75
Mean Tide Level	-0.51
Mean Low Water	-2.77
Mean Lower Low Water	-2.93
Mean Low Water Spring	-3.31
Diurnal Tide Range	4.51
Great Diurnal Tide Range	4.84
Spring Tide Range	5.60

* Reconstructed South Cove Tidal Datums were used for the design of the tidal wetland. They were obtained by comparing the South Cove and Battery datums from 31-Jul-2003 to 11-Sep-2003, and reconstructing them to the 1983-2001 tidal epoch, using the Battery as the primary record.

The project site's proximity to the long-term NOS Battery gage allowed for more tidal analyses than what has been done in past feasibility studies. The dependence of high marsh on episodic events less frequent that spring tide events has been observed by scientists (Tiner, 1985), and will be discussed in the next sub-section. Figure 5.2 looks at 1 year of data from the Battery gage, adjusted to represent the south cove by subtracting 0.2 ft from the elevations (the derived from the datum reduction routine). The highest water level observed in the South Cove from July 31 to September 11 was 3.16 ft. That translates to the 6% exceedence value on Figure 5.2. The corresponding low water for this event was 3.16 ft. Where the biobenchmarks fall within figure 5.2 and within the computed tidal datums is discussed in the next sub-section.

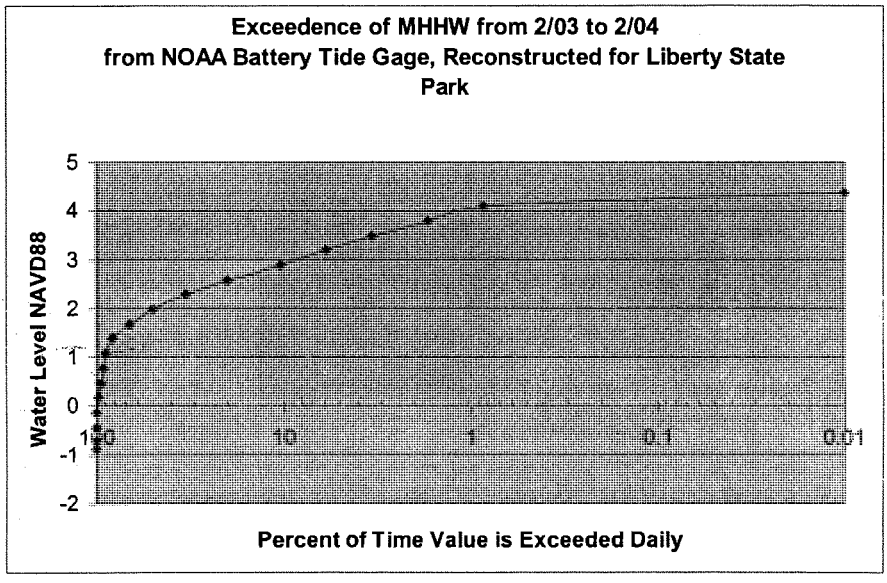


Figure 5.2 Frequency of MHHW Elevations, Reconstructed for the South Cove, LSP

5.2.2 Runoff

As discussed previously, there is very little topographical relief within Liberty State Park. The presence of Philip Street on the western perimeter of the project site (and its adjacent drainage ditches that discharge into Morris Canal) prevents significant runoff from entering the interior of the park and the proposed tidal marsh area. When compared to a tidal range of over 4.5 ft, the effect of rainfall on the proposed tidal wetland design is negligible. The slight topographical relief in the park in the immediate vicinity of the proposed tidal wetland will be accounted for by specifying the routing of the runoff via the regrading plans to be developed in the next phase of the study.

5.2.3 Groundwater

Groundwater monitoring wells observed water level and water quality parameters. The wells were installed in April, 2004, and they will still be recording when this document is released.

The preliminary results show that groundwater is 5 ft below ground surface in the vicinity of the proposed tidal wetland site (approximately +5 ft NAVD88). In most locations, more than 5 ft will be excavated, so groundwater will be encountered. Because of the potential of contaminants found in the groundwater, the tidal marsh will be hydraulically disconnected from the groundwater. A 1-ft thick impervious clay liner will be placed in the footprint of the tidal wetland. In addition, a 1-ft thick cap of sand will be placed on the impervious clay layer, on the footprint of the tidal wetland to provide a substrate for the wetland plants to take root without disturbing the integrity of the impervious clay liner.

5.3 Environmental and Hydraulic Design Criteria

Salt marsh vegetation communities are tightly coupled with the tidal regime. Water levels fluctuate over the daily and monthly tidal cycle, flooding the shoreline for different periods of time. The period of inundation is dictated by elevation contours, and zonation among plant species occurs along these contours. The location of plant species along the gradient is determined by the species' tolerance to salinity and water (frequency, duration, and/or depth of inundation). Species that are tolerant to water and salinity occur at lower elevations in the intertidal zone, between the Mean High Water (MHW) level and the Mean Low Water (MLW) level. Less tolerant species occur at higher elevations, which are inundated only during spring-tide high water levels.

The success of a salt marsh restoration effort greatly depends upon the location of the planted vegetation along the shoreline gradient. Since local conditions vary (salinity, tidal amplitude, etc), biological benchmarks, measured from surrounding local marsh vegetation and local tidal information, should be used as a guide for determining the elevations for vegetation replanting. Elevation ranges of plant communities in reference wetlands can be duplicated in the restored salt marsh.

Thriving wetland communities throughout the Hudson-Raritan Estuary were surveyed to collectively establish the general environmental design criteria and flow prescription for the four proposed tidal wetland communities. To account for varying local conditions, two sites were chosen as reference sites for the tidal salt marsh: One was in the South Cove of Liberty State Park and the second was just south west of the site in Port Liberté. Their characteristics were documented on 17 and 25th September 2003 and 14 October 2003. The results of this biobenchmarking effort is documented in Appendix G of the Liberty State Park Environmental Resource Inventory Report, USACE 2004, and is summarized in Figure 5.3 and Figure 5.4

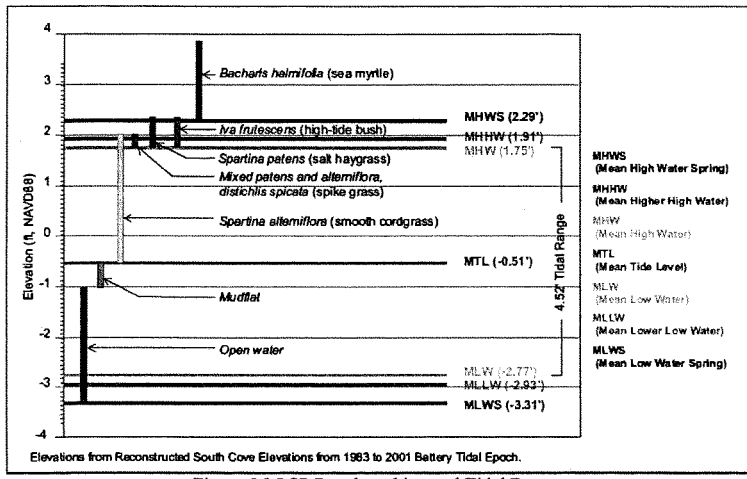


Figure 5.3 LSP Benchmarking and Tidal Datums

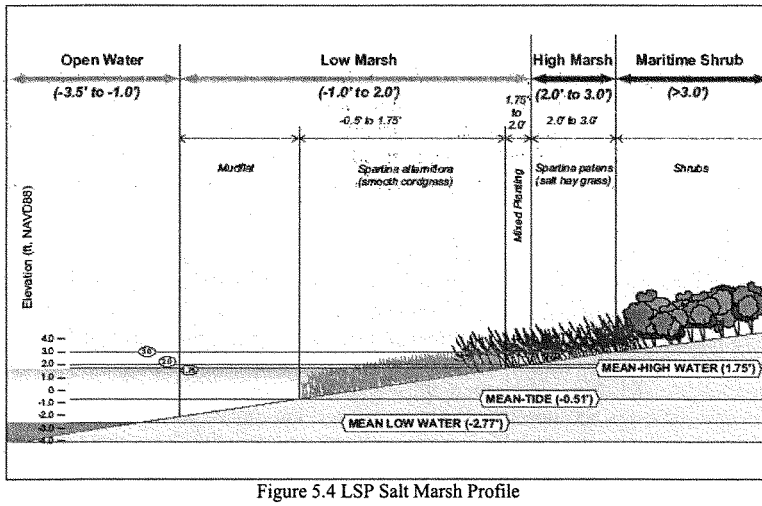


Figure 5.4 LSP Salt Marsh Profile

The following describe the design criteria for each proposed tidal salt marsh community.

1. Tidal Creeks. Tidal Creeks are permanently flooded for the mean tide range (MHW to MLW). The creeks offer a place for fish to congregate at low water. The substrate of the tidal creeks should be able to retain sufficient Dissolved Oxygen and other water quality parameters to support benthic populations, and to have the proper conditions for sub-aquatic vegetation to eventually take root. The velocities in the creek should not be so great as to trigger unrecoverable deposition and erosion in the

channel so that parts of the wetland become hydraulically disconnected from the tide. However, circulation within the marsh is encouraged to facilitate better water quality and to avoid stagnant water. Sinuosity of the creek layout is an important feature as it maximizes fringe habitat, it slows down the high velocities in the creek, and also encourages greater water circulation.

2. Mudflats. Mudflats connect the tidal creeks and low marsh. They will dry out at low tide, although they usually are flooded for more than half of the tide cycle. The mudflats also should be able to retain sufficient Dissolved Oxygen and other water quality parameters to support benthic populations.
3. Low Salt Marsh. In the Hudson-Raritan Estuary and in other estuaries in the Northeast United States, the dominant low salt marsh species is *Spartina alterniflora*. *Spartina alterniflora* needs both wet and dry conditions every day, and it is usually found growing between MTL and MHW. The extent of the tall and short form of *Spartina alterniflora* biobenchmarking data was used to determine the regrading and planting plan for low marsh (see Figure 5.3 and Figure 5.4).
4. High Salt Marsh. In the Hudson-Raritan Estuary and in other estuaries in the Northeast United States, the dominant high salt marsh species is *Spartina patens*. However this zone is usually much less homogeneous than the low marsh, and is often a mosaic of a number of species including salt hay grass (*Spartina patens*), spike grass (*Distichlis spicata*), a short form of smooth cordgrass, black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), high tide bush (*Iva frutescens*) and common reed (*Phragmites australis*) (Tiner, 1985). *Spartina patens* grows at a minimum to mean high water spring (elevation +2.29ft NAVD88) but often occurs up to the extreme high tide. This upper boundary may be inundated infrequently, in some locations as little as once or twice annually. Such inundation usually occurs during the spring tide cycle (highest annual tides or MHWS) and during the severe storm events. This is confirmed for New Jersey salt marshes by Tiner (1985), who states that the upper margins of the high marsh may be flooded only during storm tides which are more frequent in winter. Extreme high tide is not specifically recorded in the regional tide data. While the highest observed water level was actually over 4 feet above MHWS, about one foot above MHWS or an elevation of 3.3 ft is a reasonable estimate of the extreme high tide, and a possible upper limit for the high marsh. The 6% MHHW Exceedence tide, or the highest tidal cycle observed in the monitoring period will be analyzed in the hydrodynamic model to determine if the upper reaches of Spartina *patens* will be inundated in the selected plan. The Spartina *patens* biobenchmark results are also found in Figure 5.3 and Figure 5.4. The regrading and planting plan for high marsh also was developed by merging the tidal datum and biobenchmarking information, and by incorporating the observations of scientists in the region studying salt marshes.

5.4 Alternatives

The alternatives analyzed by the study team for the tidal wetland design ranged in plan view from a wetland that had two inlets open to Upper New York Harbo,r to a creation of an upland habitat island in the center of the tidal creek system. In the two-inlet system, the southern inlet would need to be cut through a seawall adjacent to the Harbor, risking the stability of the

seawall. There is a combined sewage outfall in the vicinity of the southern inlet which should be avoided if possible. Thus, that alternative was eliminated. The island system was eliminated because of the potential for 1 side of the creek to be favored, resulting in the siltation and drying out of the creek on the other side of the island and its surrounding marsh. A one-inlet meandering creek layout offered the least potential risks of failure.

The tidal creek cross sections were evaluated next. A 75ft wide tidal creek promised to function properly within the 50-year project life from a duration-of-flooding perspective, but there were concerns about its biological benefits. Based on visual observations and the experience of the PDT members, a 75ft wide creek for a 42-acre marsh is wider than the naturally occurring tidal creeks in the area. There were concerns that so much open water would detract from the amount of desirable salt marsh habitat. Thus, the 75 ft wide tidal creek was eliminated in the preliminary screening. A preliminary HEC-RAS analysis showed that a 25 ft wide creek would significantly dampen the tidal signal, risking the success of the low and high marsh in the upstream reaches of the wetland. A 50' tidal creek, though slightly wider than naturally occurring tidal creeks in the region, was determined to provide both adequate water for proper tidal flushing and ensure that natural sedimentation would not impair its functionality. A hydrodynamic model, discussed later, validates this design.

Lastly, disposal options for the material removed to create the tidal wetland were evaluated. Because of the contaminated nature of the material, the placement of dredged material is limited by the stipulations of a Consent Decree. [2] The Consent Decree defines how the contaminated material must be treated in the case that there is any disruption of the site. The contamination of the soil makes off-site disposal prohibitively expensive. As a result, the study team had to formulate alternatives that would allow for the placement of dredged material from the tidal creek in an environmentally sensitive manner. In addition, the area from which the tidal creek would be excavated is currently capped with physically unstable material. This area will need to be re-capped within the next five years if this project does not go forward. The southwest corner of the park was chosen as the disposal area for this material. The material will be placed in a manner so it will replicate a natural berm. Maritime grassland is the proposed habitat for the berm. The southwest corner currently does not hold significant ecological value. The berm creates an opportunity to re-place this material in an environmentally sensitive manner for the long term.

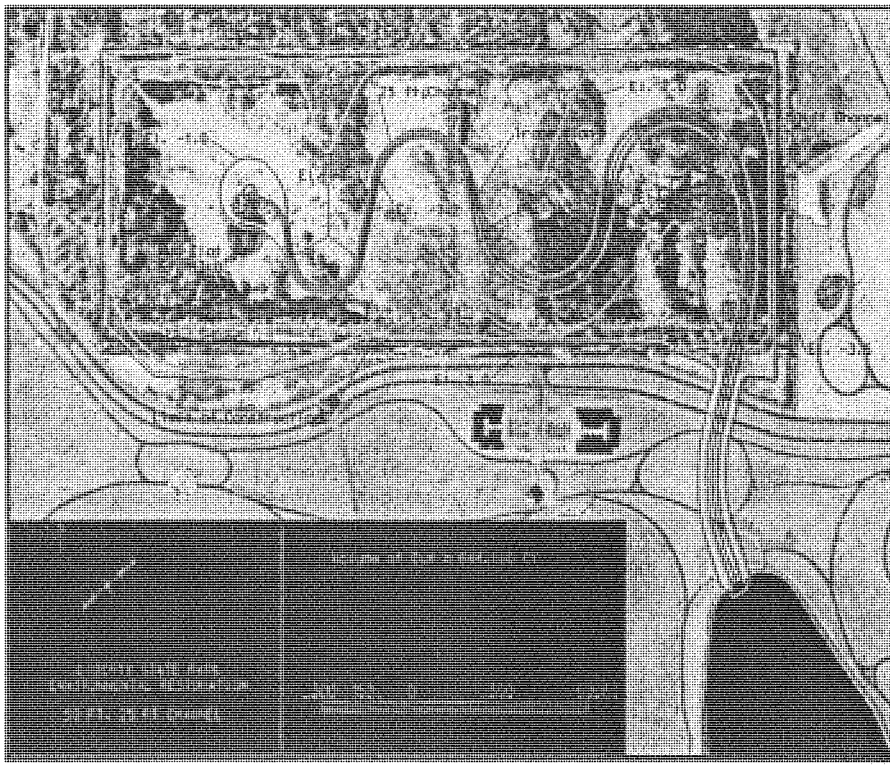
5.5 Components of Proposed Alternative

A channel width of 50 ft at the North Cove confluence, tapering to 25 ft at the upstream end of the marsh was found to convey sufficient flooding to the proposed low and high marsh throughout the site (Figure 5.5). A 48 ft wide bridge will be constructed to facilitate the creation of the tidal creek under Freedom Way. The bridge is necessary to allow the tidal waters from the North Cove to reach the proposed tidal marsh within the rectangle. The proposed bridge will span 50 ft to allow one lane of vehicular traffic in both directions. The channel will have a natural bottom consistent with the sandy bottom proposed for the entire length of the tidal

[2] Liberty State Park Consent Decree 33-35

channel. The roadway will be supported over the channel by means of a reinforced concrete arch bridge (Figure 5.6).

Figure 5.5 Tidal Creek Depths and Width (top of bank)



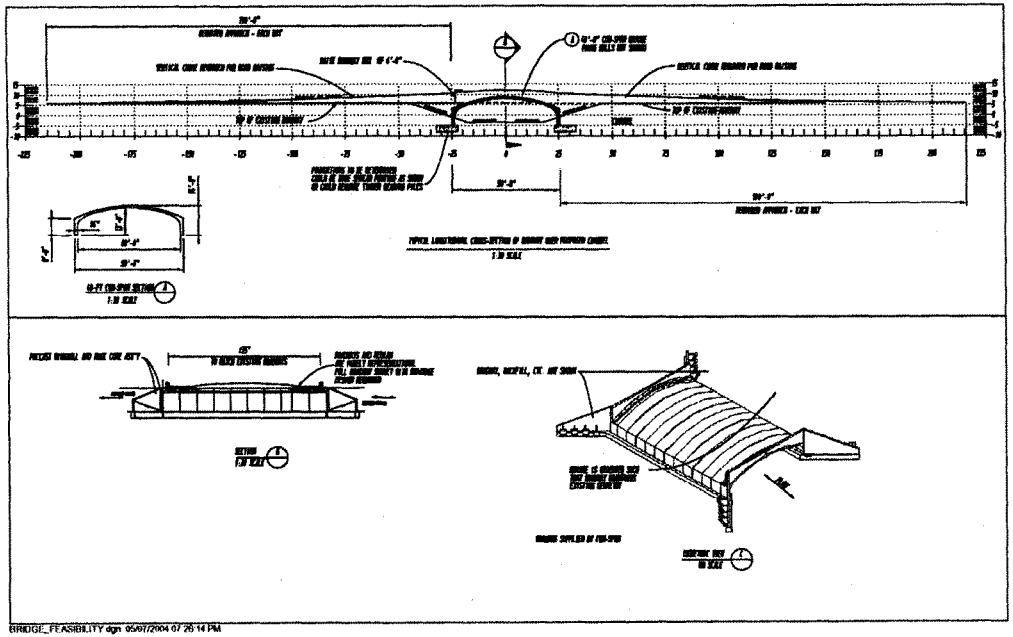


Figure 5.6 Tidal Creek Bridge Design and Sections

Natural tidal marsh channels in the region have very mild slopes in the longitudal direction. The proposed LSP tidal channel slope is 0.0001 ft/ft. The proposed sinuosity, or the ratio between the tidal channel length and the tidal valley length is 1.7, also similar to natural tidal channels in the region.

The maximum channel side slope used in the design of the mudflats was 1V:3H. The geotechnical investigation revealed that unconsolidated, silty material lies in the location of the proposed tidal creek outlet. A 1V:3H slope was suggested by contractors as the steepest slope at which their earth moving equipment can operate comfortably. The marsh will undergo an adjustment period after a few tidal cycles whereby equilibrium slopes will form, and it is anticipated that minimal adjustments will be made to the planting plan to adjust to the equilibrium process. Natural tidal mudflats in the region vary considerably in slope. However, well established *Spartina alterniflora* dominated tidal marshes have the root structure in the soil to support much steeper slopes. These slopes cannot be constructed without the use of hard structures. Monitoring the slope of the mudflats will be a part of the monitoring plan, and efforts will be made to guide the mudflat slopes to mimic natural systems. A mudflat feature was created at the upstream extent of the tidal channel. This feature adds more essential fish habitat and more diversity to the tidal marsh plan.

The low and high marsh regrading plan was discussed in the previous section. To stabilize the slopes and to out-compete phragmitites, *Spartina alterniflora* and *Spartina patens* will be densely planted, at a spacing of 18 inches on-center for each plug. To account for contingencies in the regrading equilibrium process, in the elevation zones between low marsh and high marsh, both *Spartina alterniflora* and *Spartina patens* will be planted. Similarly, in the elevation zones between high marsh and maritime scrub/shrub, *Spartina patens*, spike grass (*Distichlis spicata*), a short form of smooth cordgrass, black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), high tide bush (*Iva frutescens*), sea myrtle (*Baccharis halimifolia*), rose mallow (*Hibiscus moscheutos*), and seaside goldenrod (*Solidago sempervirens*) will be planted.

Low levels of contamination have been found during previous HTRW investigations at Liberty State Park. For added security, to minimize exposing the proposed tidal marsh to contaminants, a one-foot layer of compacted cohesive material will line the footprint of the tidal marsh. A one-ft layer of clean sand will be placed on top of the cohesive material to provide a more common substrate for tidal marsh plants to take root.

The HTRW testing conducted for this feasibility report indicated that low levels of contamination might be present in the North Cove. To prevent this material from entering the proposed tidal marsh, and to provide a more suitable substrate for benthic habitats, the entire North Cove below MLLW, out to the Liberty State Park Causeway will also be capped with 1 ft of clean sand.

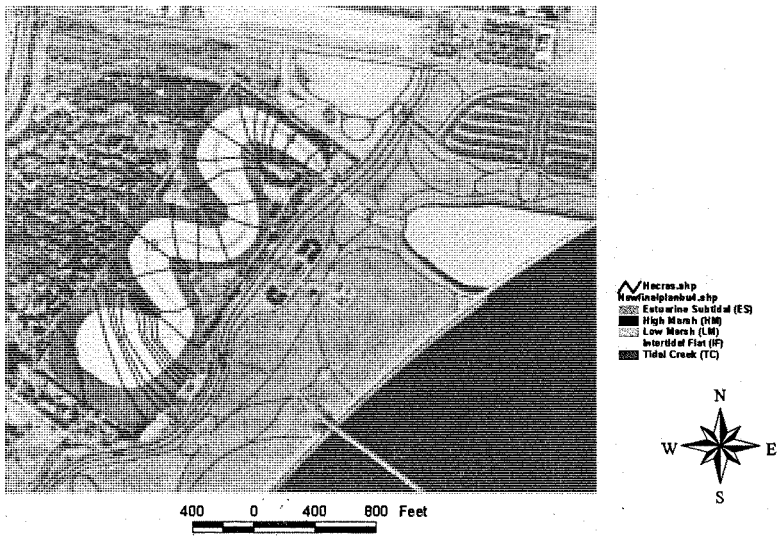
5.6 HEC-RAS Model Development

The USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) software was used to size the channel and bridge so water will be conveyed from NY Harbor to the tidal wetland. The software performs one-dimensional steady and unsteady flow hydraulic computations to simulate stage and flow through a network of channels The numerical algorithms solve the one-dimensional energy equation. Friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head) contribute to the energy losses. When the water surface profile varies rapidly, the momentum equation is utilized. Rapidly varying profiles occur at bridges, culverts, weirs, river confluences, or at sudden changes in slope or bottom friction.

An unsteady flow simulation tool was used to evaluate the tidal cycle on the proposed channel system. The unsteady flow equation solver was adapted from Dr. Robert L. Barkau's Unet model (Barkau, 1992, HEC 1997). These equations are based on the conservation of mass (continuity), and the conservation of momentum. The unsteady flow simulation tool was developed for subcritical flows.

The plan view for the tidal marsh was developed by the study team (see Figures 5.1 and 5.5). The proposed habitats (low marsh, high marsh, mudflat and tidal creeks) were laid out to mimic natural systems. By obtaining the horizontal coordinates of the habitat boundaries via the GIS file (Figure 5.7), and assigning the boundaries the elevations from the biobenchmarking analysis (Figures 5.3 and 5.4), the creek cross sections were coded into HEC-RAS. The reinforced concrete arched bridge cross sections for the 48 ft wide span was available from the CON-SPAN manufacturer. The ineffective flow areas were assigned in the channel sections upstream and downstream from the bridge. The layout of the channel in HEC-RAS and the channel station numbers is shown in Figure 5.8. The Manning's friction coefficient used for the creek bottom (a 1-ft sand cap is proposed over the entire site) is 0.2, and the low and high marsh areas in the cross sections have an assigned Manning's friction coefficient of 0.5, typical of highly vegetative banks. (Chow, 1959). Since the bridge will have a natural bottom, 0.2 was also used for the bridge cross sections. The Manning's coefficients are the least know variable in the analysis. A sensitivity test is done on this variable later in this report.

Figure 5.7 HEC-RAS Cross Sections as measured from GIS layout



Five cross sections have been selected to represent the output of the model. Cross section 25 was the most upstream cross section. The model validated whether the tide adequately flooded the low and high marsh in that area of the marsh. Cross section 19 was at a meander in the creek, where the wetland was fairly wide. Again, the model validated whether the tide adequately flooded the low and high marsh in that section. Cross section 6 showed how the tidal signal was affected by the bridge restriction, upstream from the structure, far enough away from the localized phenomenon associated with a channel restriction. Cross section 3 was the closest cross section to the bridge. The results from that cross section shows what was happening at the bridge restriction. Cross section 2 displayed the tide in the narrow channel, downstream from the bridge.

Three flow regimes were run in this study. MHW-MLW was the flow regime that dictates the low marsh, as low marsh usually begins growing at mean tide, and stops at MHW. Spring tide (MHWS-MLWS) usually dictates the limit of high marsh, with the MHWS datum being the upland limit of high marsh. However, the biobenchmarking data showed high marsh growing at elevations higher than MHWS. Based on the observations found in Tiner (1985), the 6% Exceedence of MHHW tide regime was also run in this study. This value was the highest observed water level during the 6-week monitoring period from 31 July to 11 Sept, 2003. The summary of the flow regimes is found in table 5.2. The tidal stage was the downstream boundary condition, applied at cross section 1. For all runs an initial upstream flow boundary condition of 2 cfs was applied at cross section 25, which tapered to 0.1 cfs in 1hour. Thus, after the first hour, this boundary replicates upland drainage that is a result of the topography sloping towards the creek.

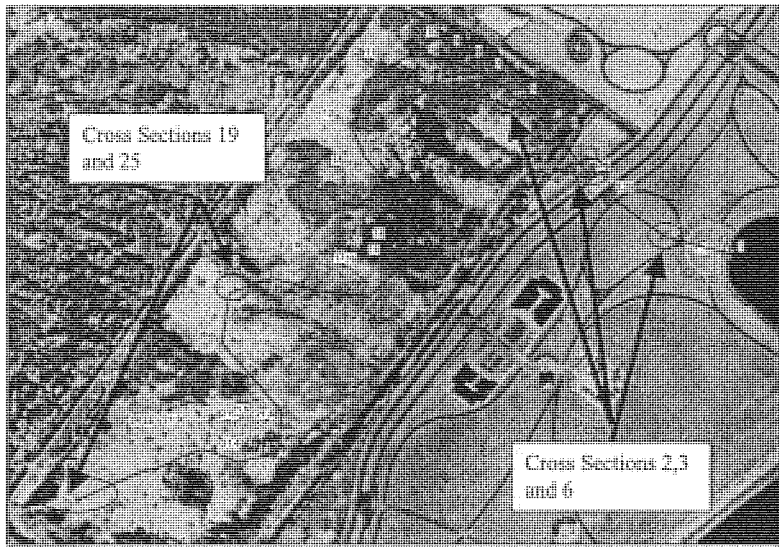


Figure 5.8 Tidal Channel Reach Layout in HEC-RAS

Table 5.2 Tidal Boundary Conditions Used for HEC-RAS Analysis

	Maximum Stage	Mean Tide	Minimum Stage	Range
MHW-MLW	1.75	-0.5	-2.75	4.5
Spring Tide	2.29	-0.5	-3.31	5.6
6% Exceedence	3.17	0	-3.17	6.34

* All Elevations in NAVD88
** The actual tidal period is 12.24 hours. 12 hours was used because it allowed for equal time increments of 0.25 hours. By using 12 hours the velocities could be slightly higher thus making the model tidal period a conservative assumption.

5.7 Analysis of the Selected Plan

Figure 5.9 shows the cross sections indicated in Figures 5.7 and 5.8, and the maximum water surface reached for the three flow regimes tested by the HEC-RAS Model. Initially the model was used to size the bridge opening. The 48 ft wide opening was selected because smaller

openings would dampen the tidal signal, thus limiting the amount of low and high marsh that can survive upstream of the bridge. By comparing cross section 2 and 6, upstream and downstream from the bridge, the maximum water surface for the MHW-MLW, Spring Tide, and 6% Exceedence level dropped by 0.08, 0.12 and 0.02 ft, respectively, after going under the bridge. With a 4.5 ft tide range, that amount of head loss is acceptable.

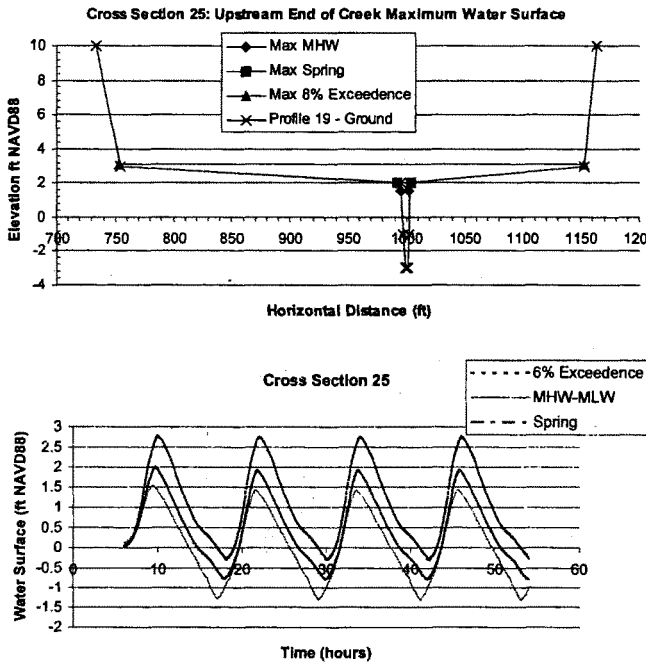
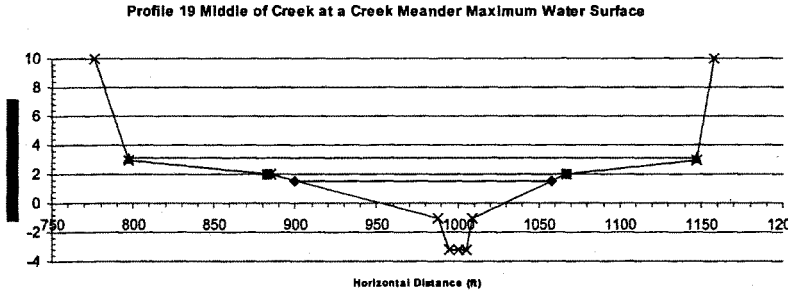


Figure 5.9 Cross Section 25 Water Surface Elevation Plots.



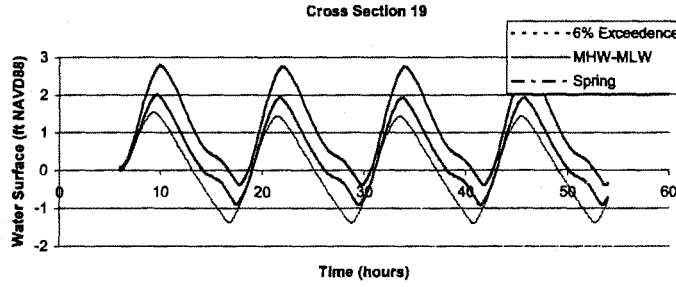
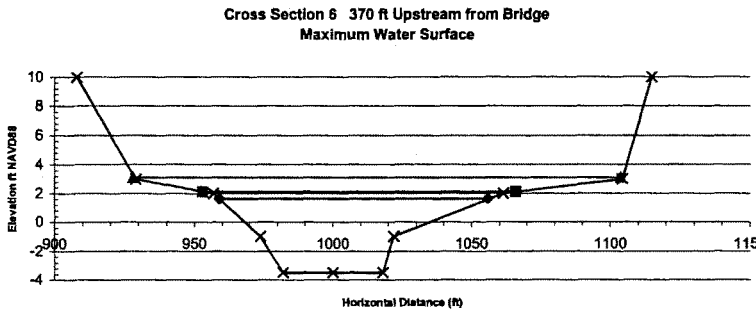


Figure 5.9 (continued) Cross Section 19 Water Surface Elevation Plots.



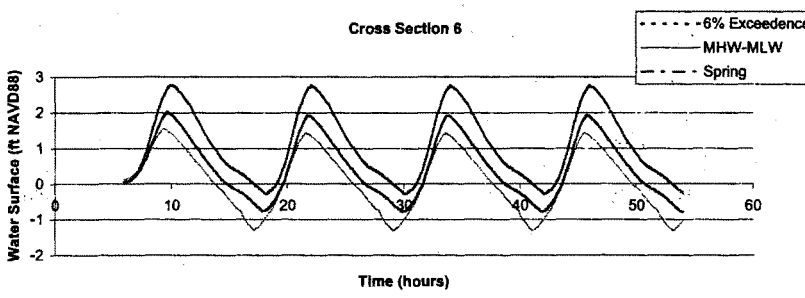
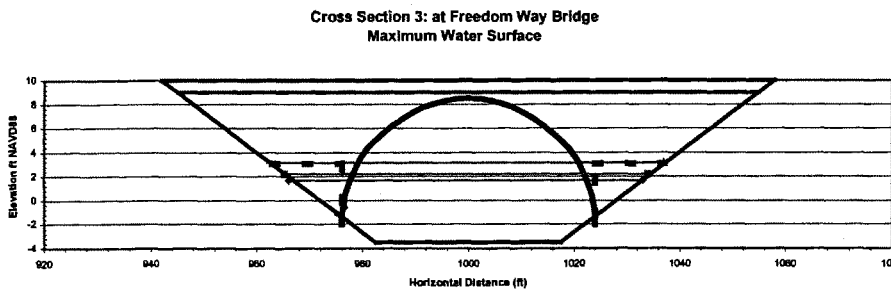


Figure 5.9 (continued) Cross Section 6 Water Surface Elevation Plots



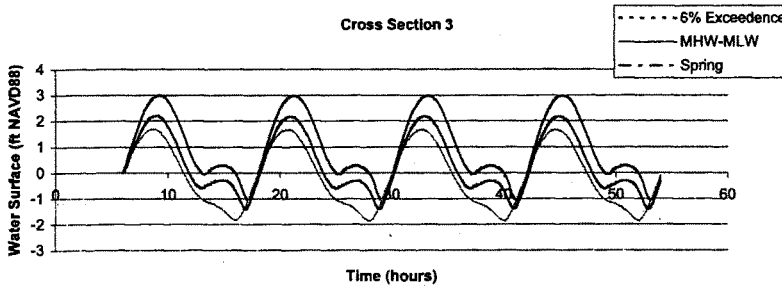
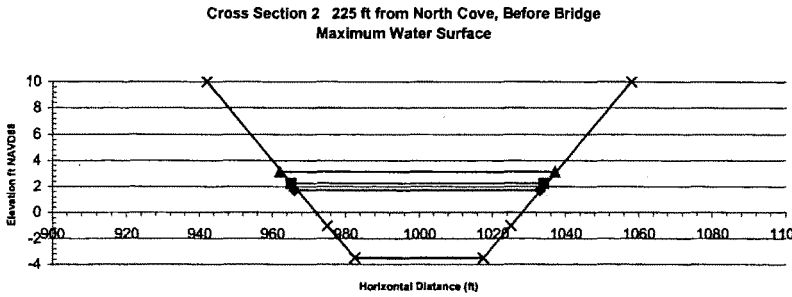


Figure 5.9 (continued) Cross Section 3 Water Surface Elevation Plots



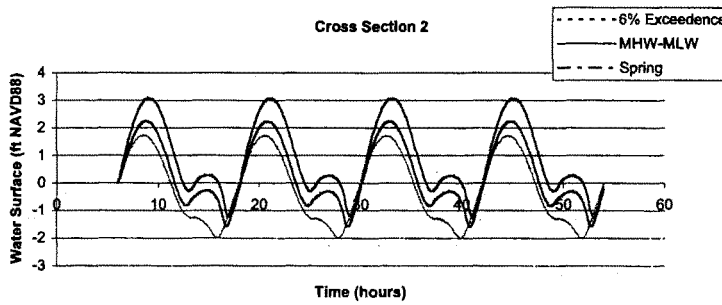


Figure 5.9 (continued) Cross Section 2 Water Surface Elevation Plots.

Figures 5.10 through 5.15 show the extent of flooding throughout the marsh for the highest and lowest stage experienced for the three flow regimes. These perspective plots demonstrate that the marsh adequately drains and floods through the 3 flooding regimes tested. To be certain that the correct duation of flooding will be achieved for the desired vegetative zone, the percent of time a contour is inundated (Table 5.3) is compared to the bipbenchmarking results (Table 5.4). With the exception of the 6% exceedence flood inundating the back portions of the marsh at higher durations than the reference marsh, since the 6% exceedence is an infrequent occurance, it is anticipated that the back marsh will be resilient enough to withstand a high duration of flooding for that low frequency event. Cross Sections 2 and 3 were not evaluated for this analysis because the proposed plan only specifies a small fringe low and high marsh for these cross sections.

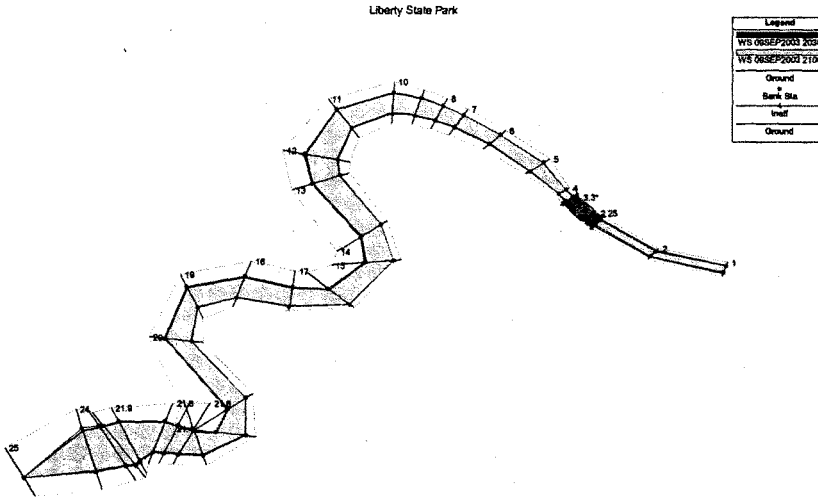


Figure 5.10 MHW-MLW Maximum Flooding of Site

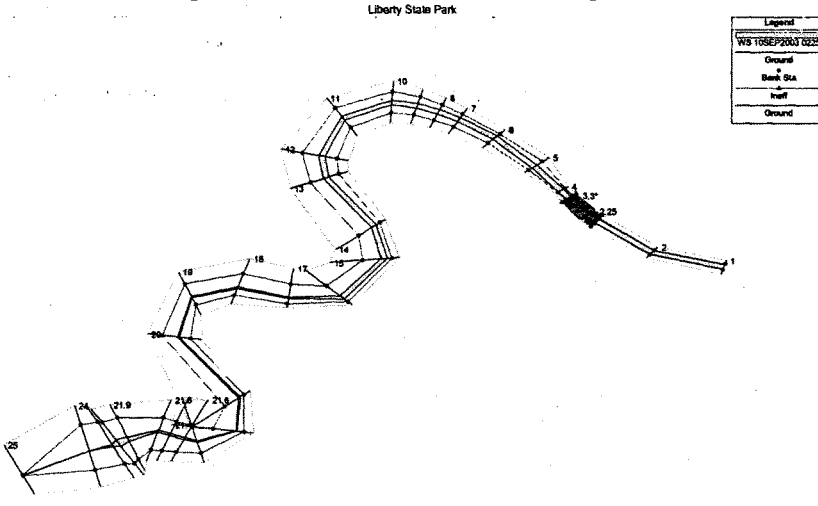
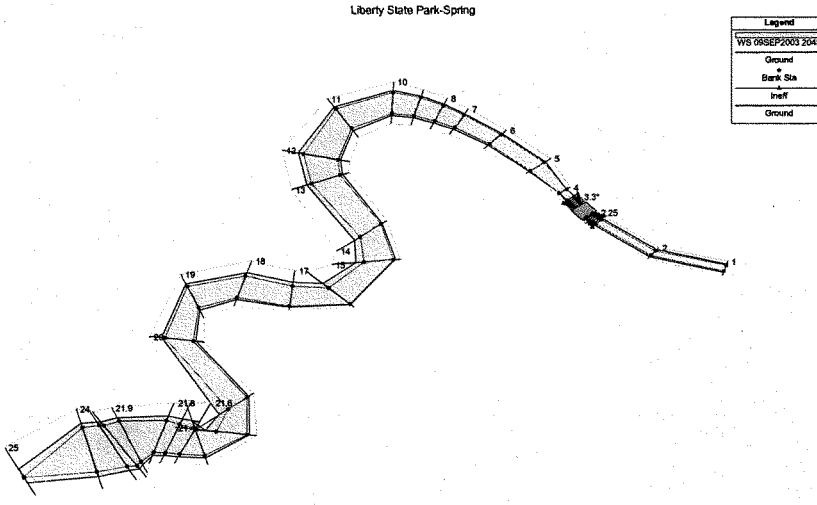


Figure 5.11 MHW-MLW Minimum Flooding of Site



Spring

Figure 5.12 Tide Maximum Flooding of Site

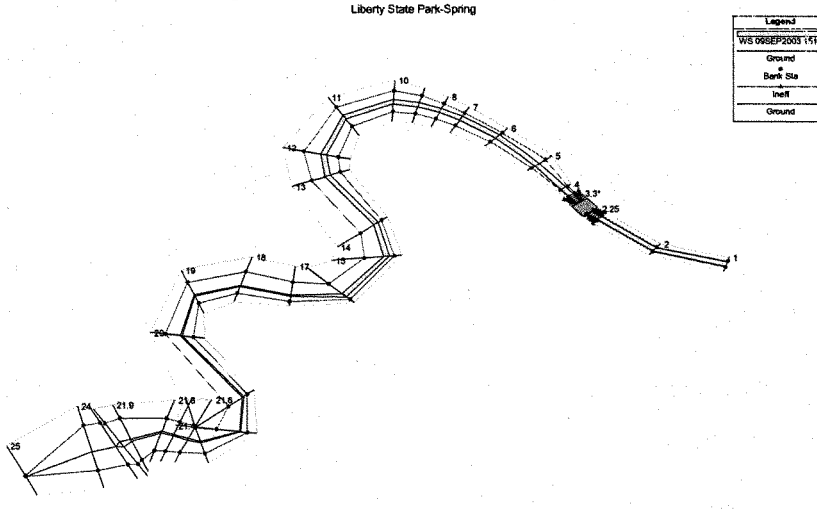


Figure 5.13 Spring Tide Minimum Flooding of Site

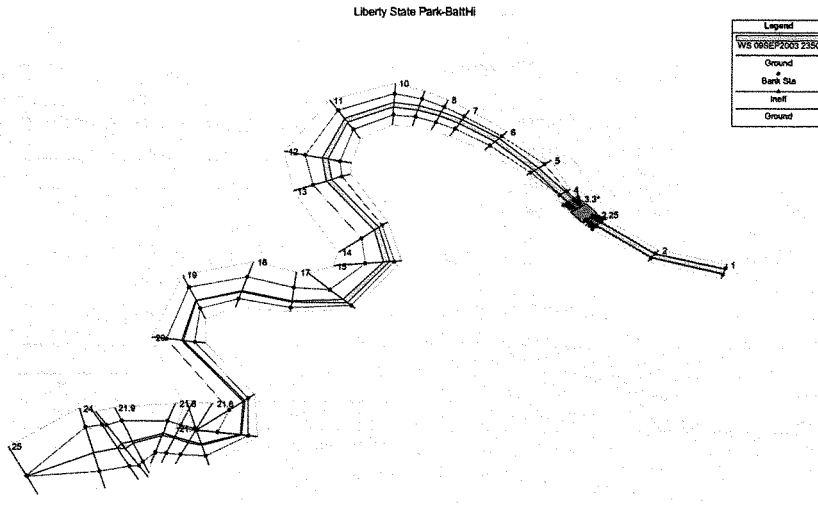


Figure 5.14 6% Exceedence Minimum Flooding of Site

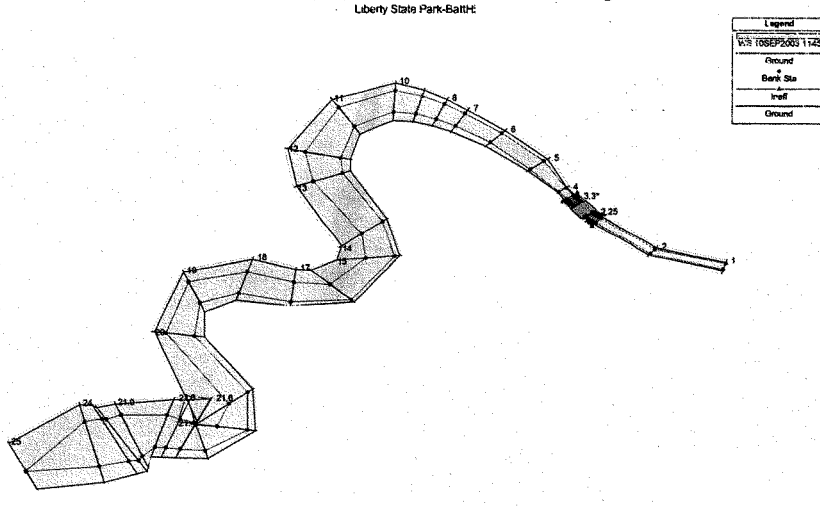


Figure 5.15 6% Exceedence Maximum Flooding of Site

Duration of Flooding - Directly from Biobenchmarking Results

	elevation (ft NAVD88)		duration of flooding of the tide cycle					
			Mean Tide Range		Spring Tide Range		6% Exceedence of MHHW	
	lowest	highest	max	min	max	min	max	min
Spartina alternaflora	-1.5	3.6	65%	0%	61%	0%	66%	2%
Spartina patens	1.9	4.6	0%	0%	18%	0%	45%	0%

Duration of Flooding - Environmental Resources Inventory Suggested Ranges:

	elevation (ft NAVD88)		duration of flooding of the tide cycle					
			Mean Tide Range		Spring Tide Range		6% Exceedence of MHHW	
	lowest	highest	max	min	max	min	max	min
low marsh	0	2.4	21%	0%	48%	0%	28%	22%
mid marsh	1.9	2.4	0%	0%	18%	0%	30%	22%
high marsh	1.9	3	0%	0%	18%	0%	22%	9%

Table 5.3 Target Duration of Flooding Based on Biobenchmarking an Environmental Design Recommendations

Table 5.4 Duration of Flooding at Three Representative Cross Sections

	elevation (ft NAVD88)		duration of flooding of the tide cycle: Mean Tide Range		Spring Tide Range		6% Exceedence of MHHW		
Cross Section 25	lowest	highest	max	min	max	min	max	min	Conclusion
low marsh	0	2.4	50%	0%	59%	2%	92%	27%	Floods too much on 6% Exceedence Tide
mid marsh	1.9	2.4	0%	0%	2%	0%	27%	22%	Gets wet at Spring and 6% Exceedence Tide
high marsh	1.9	3	0%	0%	2%	0%	27%	0%	Gets wet at Spring and 6% Exceedence Tide
Cross Section 19	lowest	highest	max	min	max	min	max	min	
low marsh	0	2.4	51%	0%	59%	0%	83%	16%	Floods too much on 6% Exceedence Tide
mid marsh	1.9	2.4	0%	0%	3%	0%	28%	16%	Gets wet at Spring and 6% Exceedence Tide
high marsh	1.9	3	0%	0%	3%	0%	28%	0%	Gets wet at Spring and 6% Exceedence Tide
Cross Section 6	lowest	highest	max	min	max	min	max	min	
low marsh	0	2.4	46%	0%	49%	0%	83%	2%	Floods too much on 6% Exceedence Tide
mid marsh	1.9	2.4	0%	0%	13%	0%	30%	2%	Gets wet at Spring and 6% Exceedence Tide
high marsh	1.9	3	0%	0%	13%	0%	30%	0%	Gets wet at Spring and 6% Exceedence Tide

The marsh also should be able to drain to give the spartina alternaflora roots periods in the tide cycle whereby their roots can be exposed to air. Adequate drainage of the marsh also stimulates water circulation, which improves water quality for flora and fauna. Table 5.5 shows that for all tides analyzed, a signifcant amount of the mudflat is exposed, which starts at elevation 1.0 ft NAVD88. For the MHW-MLW tide cycle, a significant amount of the the marsh drains so that there is 1.7 ft of water in the back of the marsh at cross section 25, and 1.81 ft and 1.5 ft for cross sections 19 (mid creek) and 2 (near creek mouth), respectively. For the other 2 flow regimes, drainage occurs less than the mean tide cycle, but both runs expose the mudflat at all cross sections.

Lastly, the velocities for all the flow regimes, for all the cross sections were calculated by the HEC-RAS model for all of the cross sections. There is a concern that excessive velocities can mobilize sediment and then deposit the sediment in locations that can impede the proper flooding low and high marsh areas. Since a 1-ft thick cap is being placed on the entire channel and marsh surface, the sediment size can be specified so that minimal channel scouring will occur. For

sediment sizes between 0.1-1.0 mm (silty sand to sandy gravel), the velocity needed for incipient motion of particles is between using the Sheilds equation .The channel velocities of the selected cross sections for various degrees in water temperaturein

Maximum and Minimum Water Surface (ft NaVD88)

Flow Regime	MHW-MLW		Spring Tide		6% Exceedence	
Profile	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
25*	1.54	-1.3	2.01	-0.79	2.77	-0.29
19	1.55	-1.39	2.01	-0.91	2.78	-0.39
6	1.64	-1.74	2.12	-1.28	2.89	-0.88
3	1.68	-1.85	2.19	-1.41	2.99	-1.04
2	1.72	-2	2.24	-1.57	3.08	-1.24

Maximum and Minimum Velocities(fps)

Flow Regime	MHW-MLW		Spring Tide		6% Exceedence	
Profile	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
25*	0.15	n/a	0.16	n/a	0.16	n/a
19	0.23	-0.23	0.2	-0.25	0.18	-0.27
6	0.33	-0.29	0.33	-0.34	0.44	-0.41
3	0.4	-0.36	0.48	-0.44	0.61	-0.58
2	0.46	-0.36	0.54	-0.43	0.68	-0.55

Table 5.5 Maximum and Minimum Water Surfaces and Velocities as Selected Cross Sections

5.8 Sensitivity Analysis

A sensitivity analysis was done for the Manning's friction coefficient. This study used a value of 0.2 for the channels and 0.5 for the vegetative marsh surface. When the HEC-RAS model was run using 0.1 and 0.2 for the channels and vegetative marsh surfaces, respectively, there was less dampening of the tidal signal, thus more flooding of the site. Due to the invasive nature of phragmities, the plant the project will be eradicating in the project area, a conservative design errors on the wetter design. Thus, the higher n value design is the conservative design. Yet, the lower n value results did produce slightly higher velocities, approaching 1 fps, with the maximum velocity occurring at cross section 19. Since this occurred at one of the meanders of the creek, it may be possible to change the geometry of the creek slightly in that area to minimize the velocities. Or, gravel can line the channel at its critical locations.. These issues will be addressed in the next phase of the study.

6 UPLAND MANAGEMENT AREA

In order to create a more contiguous ecosystem within Liberty State Park, the remaining 131 acres within the undeveloped section of the park should mimic natural upland systems found in maritime systems in the Northeast United States. Currently within the 131 acres, invasive species such as phragmities and mugwort are thriving. The presence of these very aggressive

invasive species, so close to the proposed tidal and fresh water wetlands, imposes a great risk to the sustainability of these communities. Therefore, the selected LSP plan proposes to clear out these and other species that do not offer high habitat values. This area, along with the tidal and fresh water systems, will be managed in the years following construction to minimize the reintroduction of invasive species. If monitoring of the cleared upland areas show that additional measures are required, a mixture of clean fill and topsoil could be brought in where needed, and maritime scrub/shrub plants could be planted in the places where vegetation of low habitat value currently exists.

As mentioned in previous sections, Liberty State Park is losing biodiversity and habitat value to invasive species. Existing maritime grassland communities are located adjacent to monocultures of the invasive species common reed and mugwort. Without human intervention, invasive species is likely to encroach upon the grasslands and eventually out compete them for resources, and the maritime grasslands will likely be rare or non-existent in Liberty State Park as little as ten years. The no-action alternative would produce a negative habitat value, so all Upland Management options presented include clearing and grubbing to remove invasive species. Without this step, any other upland option is bound to fail.

Beyond removal of invasive species, there are three alternatives for the upland area of the site. These measures could be used together for increased habitat value. These are landscaping and planting of native species, topsoil/sand treatment to cap some habitats in order to prevent the recurrence of some of the more stubborn invasive species, and erosion control. No matter the Upland Management alternative chosen, monitoring will have to be a significant element in order to ensure the success of the program.

7 DESCRIPTION OF COSTS

Implementation costs for each restoration scenario were calculated based on estimates of location, mobilization/demoblization, site access, site preparation and excavation, disposal, planting, erosion and sediment control and monitoring costs. These project construction costs were estimated as part of the planning phase for the purpose of determining project feasibility, and to provide a means of comparing proposed restoration options. The chosen alternative will be designed further, and the quantities and costs will be refined in the cost appendix. However, for the alternative analysis, all alternatives have the same quantity and cost assumptions. A contingency cost of 20% was included to account for uncertainties in the final design and/or implementation of the selected NER Plan. Preliminary Engineering and Design (PED) and Management during construction were assumed as 8% and 7% respectively, of the total construction costs. An escalation factor of 3% was included to project the present day construction costs to the estimated midpoint of construction. All labor, material, equipment, overhead, bond and profit costs were considered in the costs. The costs were based on the cost estimate on experience at other projects and published estimating tools such as RS Means©.

The following describes the assumptions considered in the calculation of costs.

Costs Associated with All Proposed Restoration Areas and Activities:

Real Estate and Location

- The local sponsor owned the site prior to the start of the project, so no real estate costs were considered. However, all costs include an area cost factor of 3.6% to account for the higher cost of living in the project area (RS Means©).

Mobilization/Demobilization

- Mobilization and demobilization costs were the lump sum costs associated with the initiation and cessation of activities at the site, including obtaining and transporting equipment, and the removal of temporary site features and equipment upon completion of the Project.

Staging/Storage/Refueling Area

- A 4 in layer of gravel in an estimated 2500 sf area within Liberty State Park would be placed over a flat area before heavy machinery arrived at the site.
- Temporary chain link fencing would be erected around the site.

Temporary Erosion and Sediment Control

- During the earth movement phase of the project, the erosion of sediment will be minimized by controlling the runoff and turbidity that leaves the site. Erosion and sediment control is assumed to be required along the perimeters of the work zones. They will include staked straw bales, reinforced silt fencing, sediment traps with filters and maintenance of control measures

Site Access

- New access roads and maintenance costs were projected for the project area. The use of timber mats was included to allow heavy construction equipment to traverse the unconsolidated marsh surface.

Clearing and Grubbing

- Site preparation included the costs associated with the removal of *Phragmities Australis* and other existing vegetation in the proposed regrading locations. The assumption was made that this task, to be done for the entire proposed site, will entail herbicide treatments, clearing of existing vegetation by mowing above grade, stockpiling, shredding, loading and hauling to a designated area in the park. Herbicide and mechanical removal techniques will be used. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material.
- The additional cost of excavation of thatch material, including the rhizomes when indicated and other root material, is included in the locations that do not have cut/fill activities. Herbicide and mechanical removal techniques will be used. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material.

Monitoring Project Site

- Monitoring costs were assumed to be 1% of construction costs.

Tidal Wetland Costs

Earthwork

- Earthwork costs assumed that in the proposed low and high marsh areas, 60% of the material being excavated would be dry, and 40% would be wet, which is based on when groundwater was encountered in the geotechnical borings taken in the Fall 2003. The material would be hauled 0.5 miles round trip or less. The excavation locations will be finely graded/shaped and surveyed. The deposition area will be roughly graded.

Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material. The volume of material to be excavated was calculated from the 2003 site survey. For the low and high marsh, the proposed excavation depths were based on excavating the site to the range in which *Spartina alternaflora* and *Spartina patens* will most likely thrive. These elevations are based on bio-benchmarking and tidal datum data, plus an additional foot to allow room for a cap of clean clay fill 1 ft deep to be placed in all excavated areas, and another foot to allow room for a cap of clean sand fill 1 ft deep. A survey crew will be on site to confirm cut and fill placement elevations.

Clean Clay and Sand Fill Placement

- 1 ft of clean clay fill will be placed in the channel, mudflat, low and high marsh areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications. The placed clay will be compacted to create an impervious subsurface.
- 1 ft of clean sand fill will be placed in the channel, mudflat, low and high marsh areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.
- 3 ft of clean sand fill will be placed in the upland scrub/shrub areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.

Dewatering

- Dewatering will be necessary due to the high water table.. It is assumed that 4 dewatering systems will operate for 12 months in the proposed tidal wetland area.

Temporary Cofferdam at Tidal Inlet

- Temporary sheeting will be installed at the mouth of the main inlet to prevent tidal inundation into the site while the earthwork is being completed.

Rip-Rap and Filter Fabric

- Rip-Rap and geotextile filter fabric will be placed at the tidal creek opening to stabilize the side slopes of the inlet to the North Cove. The costs include labor, equipment and materials for loading, hauling and placement.

Planting

- The costs for plants within the low and high marsh zones were based on plugs to be planted 18 in o.c. The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control, weeding, watering and a restoration specialist. The high marsh will also have planted 100 shrubs/acre.
- The costs for plants within the maritime scrub/shrub zone were based on shrubs to be planted 8 ft o.c. The cost includes the purchase of the shrubs, fertilizer, seeding, vector, pest control, weeding, watering and a restoration specialist.

Bird Control – Plant Protection

- The costs for protecting the young plugs from Waterfowl were based on methods used by the New York City Department of Parks and Recreation Department. Temporary goose exclusion fences will be placed at 25ft spacing intervals.

Hydraulic Placement of Fill

- The costs to place a 1ft thick clean sand cap in the North Cove assumes the material will be placed hydraulically using off-shore based equipment.

Bridge Construction

- The bridge will be fabricated from precast concrete sections and wingwalls assembled on-site. Foundations (spread footings or timber pile-supported footings, depending on the results of design analyses) would be cast-in-place. These precast sections are pre-engineered and are readily available from nearby suppliers. The pre-engineered bridge can accommodate a wide range of highway loadings (HS20-44, etc.). A 48-foot span provides an adequate hydraulic section for the channel. The 75-foot wide bridge's construction duration is estimated as less than a week.

Upland Management Area and Disposal Area Costs

Top Soil/Sand Treatment

- It is assumed that either 2 ft of topsoil, or 3 ft of clean sand fill will be placed in the upland management areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.

Planting

- The costs for plants within the maritime forest zone were based the following planting scheme;
    - Canopy trees 1.5-2 inches diameter, spaced 10 ft o.c., for 10% of the upland management area
    - Canopy trees, 1-4 ft diameter, spaced 10 ft o.c., for 30% of the upland management area
    - Canopy trees, 5-6 ft diameter, spaced 10 ft o.c., for 30% of the upland management area
    - Understory trees, spaced 10 ft o.c., for 20% of the upland management area
    - Ferns/Forbs, spaced 3 ft o.c., for 5% of the upland management area
    - Shrubs, spaced 8 ft o.c., for 5% of the upland management area
    - The cost for all of the upland management plants listed above include the purchase of the stock, fertilizer, seeding, vector, pest control, weeding, watering and a restoration specialist.

Disposal Area Costs

Top Soil

- It is assumed that 1 ft of topsoil will be placed in the upland management areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.

Planting

- Grass seed and fertilizer will be placed on the disposal berm. It will be watered, and a jute mesh will be placed on it to minimize erosion.

Fresh Water Wetland Area

Earthwork

- Earthwork costs assumed that in the proposed fresh water areas, 80 % of the material being excavated would be dry, and 20% would be wet, which is based on when

groundwater was encountered in the geotechnical borings taken in the Fall 2003. This ratio will vary with the season and depend on when the actual construction is carried out. The material would be hauled 0.5 miles round trip or less. The excavation locations will be finely graded/shaped and surveyed. The deposition area will be roughly graded. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material. The volume of material to be excavated was calculated from the 2003 site survey. The proposed regrading elevations are based on the existing drainage patterns within the site and the necessary hydrology to maintain the proposed ecosystems, plus an additional foot to allow room for a cap of clean clay fill 1 ft deep to be placed in all excavated areas, (and another foot to allow room for a cap of clean sand fill 1 ft deep on the average depending on specific soil conditions) A survey crew will be on site to confirm cut and fill placement elevations.

- Specialized equipment is needed to grade the wetland areas to 0.1 ft accuracy

Clean Clay and Sand Fill Placement

- 1 ft of clean clay fill will be placed in the drainage swales and area below Mean High Water.. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications. The placed clay will be compacted to create an impervious subsurface. Above this will be 6 inches of sandy loam or topsoil.

Dewatering

- Dewatering will be necessary due to the high water table. It is assumed that 4 dewatering systems will operate for 3 months.
- Planting
- The costs for plants within the biofilter are based on plugs to be planted 18 o.c . (The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control)
- The costs for plants within the deep emergent marsh are based on plugs to be planted 18 o.c (The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control)
- The costs for plants within the swales are based on seeding and net anchoring. (The cost includes seedbed prep, mulch, anchoring, fertilizer, one post germination watering)
- The costs for plants within the liberty science center wetland are based on plugs to be planted 18 o.c (The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control)

Bird Control – Plant Protection

- The costs for protecting the young plugs from Waterfowl were based on methods used by the New York City Department of Parks and Recreation Department. Temporary goose exclusion fences will be placed at 25ft spacing intervals.

Culverts

- The costs for the culverts assume they are 30 in diameter culverts, and it includes purchase, mob/demob, and installation.

Access Road:

Costs assume unbound base course of 1-1/2" stone base compacted 8" deep. ($9.00 per square yard [RS Means]. Assuming 9 foot wide access road or $9.00 per linear foot.

Biofilter:

Costs include:

- Excavation volume assume 3,541 CY based on over excavation by 1 foot. (under excavation costs)
- Clearing and grubbing area .95 acres or 20% larger area then the area within mean high water level.(under clearing and grubbing)
- Existing topsoil to be stockpiled and used to dress Riparian zone.
- Assume an additional 6 inch topsoil layer

Infiltration Costs:

- For LSP a full infiltration basin design can be used since infiltration tests indicate extremely permeable soils.
- The only outlet is and emergency spillway which passes larger storm (greater then 2 year design storm) events .
- A rip-rap apron is needed near the inlet to reduce incoming runoff velocities to promote more uniform infiltration. There is no need for other features for routing stormflow or baseflow through the structure.

Components include:

- Flat basin floor roto-tilled to ensure high permeability
- Based on infiltration test minimum sand is required (assume 4" of sand added)
- Dense grass turf to be seeded throughout the basin bottom.
- Inlet structure from adjacent deep emergent marsh
- Rip –rap area around the inlet
- Erosion control mat along embankment
- Emergency spillway
- Excavation volume assume 4,995 CY. Overexcavation is not needed (under excavation costs)
- Clearing and grubbing area 2.64 acres. Assume 20% greater than

Infiltration Costs:

Infiltration costs were estimated based on the dry pond cost equation (Schueller, 1987); particularly for basing with greater the 10,000 cubic feet in volume. The following equation has been used:

C = 10.7 Vs**0.69

C=Cost in dollars

Vs = storage volume up to the crest of the of the emergency spillway in the basin (including any dead storage reserved for exfiltration purposes)

C = 10.7 (4,995)**0.69

Log Weirs:

25 Low weir is made up of three layers of logs; length varies; 30 feet long

- Bottom layer; 3 logs 12 feet' long - 12-14" dia.
- 2nd layer 4 logs 6 ft long -10-14" dia.
- 3rd layer 2 logs 6 feet long - 8-12" dia.
- 4th layer 2 logs - 4 long; 4-6" dia

Assumes installation will be implemented by a crew with a backhoe

Stone Weirs

Boulders set in place
6" gravel base

Assumes installation will be implemented by a crew with a backhoe

9.MONITORING

9.1 MONITORING PLAN

Ecological Monitoring and Adaptive Management is included in the project plan. The ecological success of the restored habitats will be evaluated based on the following performance critera:

- Successful establishment of each habitat type(tidal marsh: low marsh, high marsh, mudflat, tidal creek, estuarine subtital,; fresh water marsh: deep water pool, shallow water bench, shoreline fringe and riparian fringe; upland: maritime forest, maritime grass, martime srub/shrub) relative to similar habitat types in the region
- Vegetation growth in the proper zones (e.g., hydric species in wet sites)
- Air quality parameters within permit constraints
- Water quality, general landscape, sinuosity and water depth similar to natural tidal creeks in the region.

The following monitoring plan discusses how the hydrology/hydraulics/hydrodynamics, topography/bathymetry, and geotechnical parameters of the site will be observed to understand their relationship to the project's performance as stated above. It is assumed that the compliance with submitted work plans (i.e., elevation checks) has been performed prior to and after planting. The monitoring plan presented below involves a first year post-construction site assessment and identification of performance criteria, methods, costs, and potential corrective actions for each of the created cover types.

9.2 FIRST YEAR POST-CONSTRUCTION SITE ASSESSMENT

The restoration site will need to be closely monitored during the first year after construction to ensure proper establishment of tidal and fresh water marsh vegetation, as well as upland habitiats. Inspections would involve site checks by the project biologist and hydraulic engineer to allow the opportunity for identification and resolution of any gross problems (i.e., excessive erosion, invasive plants, tidal restrictions). Weekly post-construction inspection tours are recommended during the 2-month period following construction. Monthly inspections should follow for an additional 10-month period. The estimated costs for the first year post-construction site assessment program is $20,000 (Table 12).

9.3 TIDAL WETLAND ONE, THREE, FIVE AND TEN YEARS POST CONSTRUCTION

There are several environmental factors that control the establishment, viability, and success of salt marsh habitat: salinity, hydrology, geomorphology, and soil texture and nutrients. These factors have been considered during the planning process, and will be revisited during the Plans and Specifications phase of the Project, to maximize the potential for salt marsh establishment. The South Cove has been used as a reference marsh for this feasilbility study. Either the south cove or an existing productive tidal marsh closer in size to the planned tidal marsh will be used as a reference site during the monitoring phase.

9.3.1 Topographic/Bathymetric Monitoring

A topographic/bathymetric survey is planned one year post construction. Six (6) cross sections will be surveyed in the project area in similar locations as the 5 selected cross sections discussed in section 5 of this report. One cross section will be in the North Cove. The cross sections will be perpendicular to the tidal creek and the direction flow, and they will extend to the upland limit of high marsh on both sides of the creek. Eight (8) spot elevations will be surveyed in each cross section to be used as biobenchmarks. Six (6) cross sections will be surveyed in the reference marsh, along with 8 biobenchmark spot elevations in each of the cross sections. This information will compare the project's design criteria and the project's performance criteria. Topographic/bathymetric monitoring is planned one, five and ten years after construction.

9.3.2 Sinuosity Monitoring

Sinuosity is a measure of the degree to which a channel deviates from a straight path and is calculated as the ratio of a channel's sinuous length to its straight length. Sinuosity sampling would occur at each reach of created channels at the restoration area and an equal number of reaches at the reference area. Sampling would occur during the year prior to construction and at post-construction years 1, 3, and 5. Sinuosity will be measured during low tide using a hand-held GPS instrument (accuracy +/- 3 ft). Sinuosity monitoring is planned one, three, five and ten years after construction.

9.3.3 Hydrology/hydraulics/hydrodynamics Monitoring

The hydrology/hydraulics/hydrodynamics of the tidal marsh is an integral part of the success of the tidal marsh habitat survival. Five (5) water level recorders will be placed in the project site

for a 3 month period, and three (3) water level recorders will be placed in the reference site during the same time interval. The duration of flooding throughout the project and reference site will be evaluated and compared with the established plant communities. Hydrology/hydraulics/hydrodynamics monitoring is planned one, five and ten years after construction.

9.3.4 Geotechnical Monitoring

Three (3) geotechnical samples will be taken at the project site, and 3 (3) geotechnical samples will be taken at the reference site. Particle size distribution of the substrate would be measured by collecting a 30-cm soil core, dividing it into a 0 to 10 cm portion and a 10 to 30 cm portion, drying, sieving, and weighing the sample for bulk density. Particle size distribution would be estimated. The ground surface at the location of the sample will be surveyed to determine if rebound/subsidence occurred as a result of removing large quantities of fill. Geotechnical monitoring is planned one, and five years after construction.

9.4 FRESH WATER WETLAND ONE, THREE, FIVE AND TEN YEARS POST CONSTRUCTION

There are similar environmental factors that control the establishment, viability, and success of fresh water wetland habitats as well. These factors have been considered during the planning process, and will be revisited during the Plans and Specifications phase of the Project, to maximize the potential for freshwater wetland establishment. An existing productive fresh water marsh closer in size to the planned tidal marsh will be chosen and used as a reference site during the monitoring phase.

9.4.1 Topographic/Bathymetric Monitoring

A topographic/bathymetric survey is planned one year post construction. Four (4) cross sections will be surveyed in the project area in similar locations in each of the freshwater wetland features (LSP Wetland, Biofilter, DEM, and Infiltration Basin). . The cross sections will be perpendicular to the tidal creek and the direction flow, and they will extend to the upland limit of high marsh on both sides of the creek. Eight (8) spot elevations will be surveyed in each cross section to be used as biobenchmarks. Six (6) cross sections will be surveyed in the reference marsh, along with 8 biobenchmark spot elevations in each of the cross sections. This information will compare the project's design criteria and the project's performance criteria. Topographic/bathymetric monitoring is planned one, five and ten years after construction.

9.4.2 Hydrology/hydraulics Monitoring

The hydrology/hydraulics of the fresh water marsh is an integral part of the success of the tidal marsh habitat survival. Four (4) water level recorders will be placed in the project site for a 12 month period, and three (3) water level recorders will be placed in the reference site during the

same time interval. The duration of flooding throughout the project and reference site will be evaluated and compared with the established plant communities. Topographic/bathymetric monitoring is planned one, five and ten years after construction.

9.4.3 Geotechnical Monitoring

Three (3) geotechnical samples will be taken at the project site, and 3 (3) geotechnical samples will be taken at the reference site. Particle size distribution of the substrate would be measured by collecting a 30-cm soil core, dividing it into a 0 to 10 cm portion and a 10 to 30 cm portion, drying, sieving, and weighing the sample for bulk density. Particle size distribution would be estimated. The ground surface at the location of the sample will be surveyed to determine if rebound/subsidence occurred as a result of removing large quantities of fill. Geotechnical monitoring is planned one, and five years after construction.

9.5 UPLAND MANAGEMENT AREA ONE AND FIVE YEARS POST CONSTRUCTION

The success of the habitats planned for the upland management area are not as dependent on engineering considerations as the tidal and freshwater wetlands. Soil properties are variables that can have a considerable affect on the success of upland habitats. A reference upland area will be established. Three (3) soil sample 12 (30-cm) inches deep will be taken, and three (3) soil samples 12 (30-cm) inches deep will be taken in the 3 different habitat communities planned: maritime forest, maritime grass, martime srub/shrub. Geotechnical monitoring is planned one, and five years after construction.

9.7 MONITORING COSTS

Table 9.1 summerizes the estimated monitoring costs. The costs for the biological monitoring are not included in the summary.

Table 9.1 Estimated Cost for the Proposed Monitoring Plan: Engineering Components

	1year Post Constr'n	3 years Post Constr'n	5 years Post Constr'n	10 years Post Constr'n	Total
First Year Post-Construction Site Assessment	$20,000	$0	$0	$0	$20,000
Low/High Marsh, Mudflat, Tidal Creek, Estuarine Subtidal					
Topographic Survey	$ 12,000	N/A	$ 12,000	$ 12,000	$36,000
Sinuosity Assessment	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$20,000
Geotechnical Assessment	$ 10,000	N/A	$ 10,000	N/A	$20,000
Hydrology Assessment	$ 12,000	N/A	$ 12,000	$ 12,000	$36,000
Subtotal	$ 39,000	$ 5,000	$ 39,000	$ 29,000	$112,000
Deep Water Pool, Shallow Water Bench, Shoreline Fringe and Riparian Fringe					
Topographic Survey	$7,000	N/A	$7,000	7000	$21,000
Geotechnical Assessment	$3,000	N/A	$3,000	N/A	$6,000
Hydrology Assessment	$10,000	N/A	$10,000	$10,000	$30,000
Subtotal	$20,000	$0	$20,000	$17,000	$57,000
Upland Management Area					
Geotechnical Assessment	$3,000	N/A	$3,000	N/A	$6,000
[redacted]					

9.8 POTENTIAL CORRECTIVE ACTIONS

The District would review post-construction survey data and determine the need for corrective actions such as restocking previously planted areas, enhancing survival of planted vegetation, preventing *Phragmites* encroachment, and/or improvement of tidal flushing. Poor survival of planted stock (i.e., less than 50%) may require application of Osmocote® at 100 pounds (lbs.) of nitrogen/acre and 40 lbs. of phosphorus/acre as recommended by Broome et al. (1983), additional actions to improve tidal flushing, or additional protection from herbivores.

Encroachment of *Phragmites* into intertidal marsh would be monitored, and ameliorative actions would be taken as necessary. If *Phragmites* encroached upon more than 10% of a restoration site, the District would apply Rodeo® or a comparable herbicide recommended by the Middlesex County NRCS Office to the site. Prior to the application of any herbicides, the District would obtain approval of the landowner and appropriate state agencies.

In some areas, grazing by waterfowl and mammals can affect the success of marsh vegetation. Canada geese (*Branta canadensis*) and snow geese (*Chen hyperborean*) graze on emergent

vegetation and can damage new plantings. Installations of fencing along the water's edge and shrub borders along the upland edge have been used to exclude geese and have been included under the initial Project costs. However, additional waterfowl and mammal control may be necessary.

Extreme cases of erosion or inadequate flushing may require mechanical recontouring of channel shape and sinuosity, or changing the wier heights in the fresh water wetland. Lack of colonization by desired plant species adjacent to restored channels may warrant additional planting efforts and possibly even soil organic matter amendments to enhance structure for benthic macroinvertebrates. A combination of bank stabilization measures such as coconut fiber mats or rolls with soil amendments or plantings would serve to enhance ecosystem structure adjacent to the wetland channels.

If there is a significant difference in the vegetation variables the restoration area and the reference area at any monitoring year, and these difference are determined to be undesirable by the participating regulatory agencies, corrective action would be taken, and monitoring would continue on an annual basis until the criteria are met.

9.9 CONTINGENCY INSPECTIONS

The restoration area and the reference area would be inspected for damage in the event of severe storms or other destructive events. These visits should be conducted subsequent to such events to ensure that damage is documented and plans for repair and debris removal are made at the earliest possible opportunity.

9.10 REPORT PREPARATION

Data collected from the sampling events described above will be essential in determining whether the proposed project is meeting the restoration goals. A detailed report organizing and summarizing the field data would be prepared upon completion of each field inspection/survey. These reports would include copies of all completed field data forms, color photographs, and any other reports/data required by the state and federal permitting agencies. These reports would include a comparison between restored and reference area sites. In addition, to this analysis and where practical, the data will be presented graphically so restoration development can be easily compared and tracked over time.

The results of these reports can be presented at interagency meetings where recommendations for corrective actions can be discussed or to determine if the original performance criteria or Project goals should be reevaluated. The results can also be used to determine if additional monitoring may be required beyond the scope of the original plans or if other parameters should be monitored (e.g., salinity) to better evaluate the causes of failure if they occur.

10. REFERENCES

Chow, Ven, Te. *Open Channel Hydraulics,* McGraw-Hill, New York, 1959

Chow, Maidment, and Mays. 1988. *Applied Hydrology*. pp 108-117.

DeGaetano, A.T., K.L. Eggleston, and W.W. Knapp. 1994. *Daily Evapotranspiration and Soil Moisture Estimates for the Northeastern United States*. Northeast Regional Climate Center Research Series Publication No. RR 94-1.

Fields, James, M. 1990. "Policy-Related Goals For Community Response Studies". *Environment International*, Volume 16, pp. 501-514.

Groundwater Flow Direction and Gradient Calculator [online], LMNO Engineering, Research, and Software, Ltd., http://www.lmnoeng.com/Groundwater/gradient.htm. March 2004

Haltiner, J., and Williams, P.B. 1987. Hydraulic Design in Salt Marsh Restoration. In Proceedings of the National Wetland Symposium: Wetland Hydrology, September 16-18, 1987.

Hammer, D.A. 1992. *Creating Freshwater Wetlands*. Lewis Publishers, Ann arbor, Michigan. 298 p.

Hood, W.G. 2000. Landscape Allometry of Oligohaline Tidal Channels of the Lower Chehalis River, Washington. Doctoral dissertation, University of Washington.

Hubbard, D.E., J.L. Richardson, and D.D. Malo. 1988. *Glaciated Prairie Wetlands: Soils, Hydrology, and Land Use* Issues. P. 137-143 In: Kusler and Brooks 1988, Proceedings of the National Wetlands Symposium: Mitigation of Impacts and Losses, Association of State Wetland Managers, Berne, New York, Technical Report 3.

Huber W.C. and R.E. Dickinson. 1988. *Storm Water Management Model, Version 4*: Users Manual, US Environmental Protection Agency

Hume, T.M. 1991. Empirical Stability Relationships for Estuarine Waterways and Equations or Stable Channel Design. Journal of Coastal Research. Fall 1991, p. 1097-1111.

Liberty State Park (LSP) 2003. History of Liberty State Park. http://www.libertystatepark.com/1/lsp_history/history.htm

MacFarlane, D.W. 2001. The Ecology of Liberty State Park: A Historical Perspective

Maryland Soil Conservation Service (Md SCS). 1983. Maryland Specifications for Soil Erosion and Sediment Control. Maryland Water Resources, Administration. Annapolis Maryland.

NCDC. 2000. Hourly Precipitation Data (1948-1999).

National Marine Fisheries Services (NMFS). 1998. The 1996 Amendments to the Magnuson-Stevens Fishery Conservation and Management Act.

NCDC. 2000. Hourly Precipitation Data (1948-1999).

New Jersey Department of Environmental Protection (NJDEP). 1989. *Executive Summary: The History of Environmental Investigations at the Liberty State Park.* NJDEP Hazardous Waste Program, Division of Hazardous Site Mitigation, Bureau of Environmental Measurements and Quality Assurance, Division of Hazardous Waste Management, Bureau of Planning and Assessment.

New Jersey Department of Environmental Protection (NJDEP). 1994. Memorandum dated from 03 October, 1994 from Catherine Drake, Assistant to the Director, Division of Parks and Forestry to Edward Putnam, Assistant Director, Hazardous Site Mitigation.

New Jersey Department of Environmental Protection (NJDEP). 1995. Liberty State Park Soil Sampling Report, August 1995. NJDEP Site Remediation Program.

New Jersey Department of Environmental Protection (NJDEP). 1999. *1998 Air Quality Monitoring Report.* NJDEP, Bureau of Air Monitoring.

New Jersey Department of Environmental Protection (NJDEP). 2000. *Liberty State Park – Dredge Material Storage Area. Remedial Planning and Design Element.* NJDEP Site Remediation Program, Division of Publicly Funded Site Remediation.

New Jersey Department of Environmental Protection (NJDEP). 2001. *General Design Memorandum for the Parks Interior Sections.* Division of Parks and Forestry.

New Jersey Department of Environmental Protection (NJDEP). 2003. New Jersey Stormwater Best Management Practice Manual, Draft February 2003

New Jersey Department of Transportation (NJDOT),. 2003. New Jersey Department of Transportation Design Manual – Roadway.

New Jersey Geological Survey [online],http://www.state.nj.us/dep/njgs/March 2004

Pierce, G. 1993. *Planning Hydrology for Constructed Wetlands.* Prepared by the Wetland Training Institute.

Port Authority of New York and New Jersey. 1975. State of New Jersey Liberty Park – Engineering Report on Proposed Landfill in New York Bay. Liberty State Park Existing Utility Plan – Sketch No. SK-LSP-2.

Regional Plan Association. 2003. *Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary.* (Based on recommendations of the Harbor Estuary Program Habitat Working Group and Estuary Stakeholders.

Schueler, T.R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Prepared for Washington Metropolitan Water Resources Planning Board.

SMRC. 2003. Stormwater Manager's Resource Center website, www.stormwatercenter.net. Turf-Tec International. 2003. Coral Springs FL.

United States Army Corp of Engineers (USACE). 1976. Effects of Construction of the Liberty Sate Park on Hydraulic Characteristics of New York Harbor.

United States Army Corp of Engineers (USACE). 1977. Cultural Resource Reconnaissance Liberty State Park

United States Army Corp of Engineers (USACE). 1978. Protective Noise Levels. A Supplement to the USEPA Report: Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA/ONAC 550/9-74-004, March, 1974, Office of Noise Abatement and Control, Washington, D.C.

United States Army Corp of Engineers (USACE). 1980. Plan of Study, Liberty State Park.

United States Army Corp of Engineers (USACE). 1981. Liberty State Park, New Jersey, Levee and Seawall Design Memorandum and Project Design.

United States Army Corp of Engineers (USACE). 1994. Priority Wetlands for the State of New Jersey. USEPA, Region 2, Marine and Wetlands Protection Branch.

United States Army Corp of Engineers (USACE). 1998. National Air Quality and Emissions Trends Report, 1997, EPA 454/R-98-016, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

USACE. 1999. Groundwater Hydrology (EM 1110-2-1421).

United States Army Corp of Engineers (USACE). 1999. *Hudson-Raritan Estuary Ecosystem Restoration Reconnaissance Report.* USACE, New York District. (CENAN-PL-F). Prepared by Northern Ecological Associates, Inc. for U.S. Army Corps of Engineers, New York District.

USACE. 2001. Wetlands Engineering Handbook (ERDC/EL TR-WRO-RE-21). Engineer Research and Development Center.

USACE. 2002. South River, Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Draft Integrated Feasibility Report and Environmental Impact Statement – Hydrology, Hydraulics & Design Appendix.

United States Army Corp of Engineers (USACE). 2003. New York Harbor Deepening Limited Reevaluation Report. (CENAN-PL-F), U.S. Army Corps of Engineers, New York District.

United States Army Corp of Engineers (USACE). 2004. *Liberty State Park Environmental Resource Inventory.* USACE, New York District (CENAN-PL-EA). Prepared by LMS. for U.S. Army Corps of Engineers, New York District, April 2004.

United States Army Corp of Engineers (USACE). 2004. *Site Investigation Liberty State Park Jersey City, NJ.* USACE, New York District (CENAN-EN-HH). Prepared by U.S Army Corps of Engineers, Baltimore District for U.S. Army Corps of Engineers, New York District, April 2004.

United States Army Corp of Engineers (USACE). 2001. Restoration Opportunities in the Hudson-Raritan Estuary. U.S. Army Corps of Engineers, New York District (CENAN-PL-ES).

United States Army Corp of Engineers (USACE). 2003. Phase IA Cultural Resources Investigation of the Hudson-Raritan Estuary Ecosystem Restoration Project, Liberty State Park, Hudson County, New Jersey"

United States Army Corps of Engineers (USACE). 2003. Final Phase 1 Environmental Site Assessment of Priority Sites. Part 1: Liberty State Park, Jersey City, Hudson County, New Jersey. Prepared by AMEC Earth & Environmental, Inc and Northern Ecological Associates, Inc.

United States Army Corp of Engineers (USACE). 2004. Liberty State Park Environmental Resource Inventory Report.

United States Army Corp of Engineers (USACE). 2004. Liberty State Park: Geotechnical Site Investigation, Final Report

United States Army Corp of Engineers (USACE). 2004. Liberty State Park: The Ground Survey Control Report.

United States Army Corp of Engineers (USACE). 2004. Liberty State Park Hydrology and Hydraulics of Fresh Water Wetlands, Final Report.

USEPA. 1999. Infiltration Through Disturbed Urban Soils and Compost – Amended Soil Affects

U.S. Fish and Wildlife Service (USFWS). 1999a. Written communication on January 20, 1999 from Lisa Arroyo, USFWS, to Frank Santomauro, USACE, New York District

U.S. Fish and Wildlife Service (USFWS). 2000a. Federally-Listed Rare, Threatened, or Endangered Species. [Online]. Available: http://endangered.fws.gov/wildlife.htm.

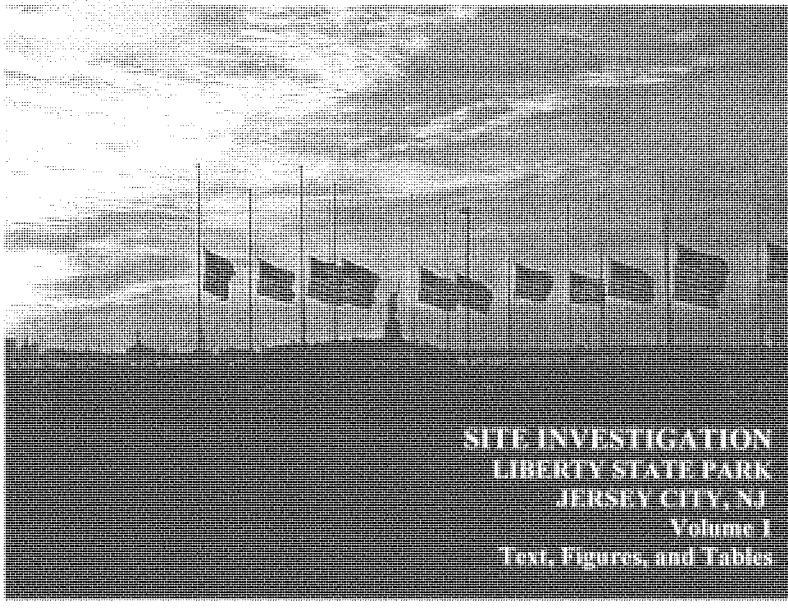
Viessman, W., J.W. Knapp, G.L.Lewis, and T.E. Harbaugh. 1977. Introduction to Hydrology. Harper & Row Publishers. New York.

Williams, P.B. 1995. Design Guidelines for Tidal Channels in Coastal Wetlands. Prepared for U.S. Army Waterways Experiment Station by Philip Williams and Associates, Ltd.

XP Software. 1999. XP-SWMM2000 Version 8.0, Stormwater & Wastewater Management Model, Getting Started Manual.

This document was created with Win2PDF available at http://www.daneprairie.com.
The unregistered version of Win2PDF is for evaluation or non-commercial use only.

US Army Corps
of Engineers
BALTIMORE DISTRICT



SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ
Volume I
Text, Figures, and Tables

Prepared by:
U.S. Army Corps of Engineers
Baltimore District
10 South Howard Street
Baltimore, MD 21201

Project Partner:
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278

April 2004

SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ

FINAL REPORT
Volume 1

TABLE OF CONTENTS

Section	Title	Page
1.0	INTRODUCTION	1
2.0	BACKGROUND	2
3.0	OBJECTIVES	2
4.0	CONTAMINANTS AND PREVIOUS INVESTIGATIONS	3
5.0	SITE LOCATION AND DESCRIPTION	3
6.0	GEOLOGY	4
	6.1 Regional	
	6.2 Glaciation	
	6.3 Local	
7.0	SITE INVESTIGATION PROGRAM	5
	7.1 Drilling And Sampling	
	7.2 Positioning	
8.0	PIEZOMETERS	6
	8.1 Permanent Piezometers	
	8.2 Temporary Piezometers	
9.0	GEOTECHNICAL TESTING	7
	9.1 Geotechnical Testing Methodology	
	9.2 Soil Characterization	

TABLE OF CONTENTS - Continued

Section	Title	Page
10.0	SUBSURFACE CONDITIONS	9
	10.1 Fill	
	10.2 Soils	
	10.3 Buried Mud Flat	
	10.4 Hydrologic Soils Groups	
	10.5 Hydraulic Conductivity	
11.0	GROUNDWATER	14
	11.1 Levels	
	11.2 Flow	
12.0	GEOTECHNICAL CHARACTERIZATION	15
	12.1 Strength	
	12.2 Excavation	
	12.3 Drainage and Dewatering	
	12.4 Slopes	
13.0	CONCLUSIONS	17
	13.1 Soils	
	13.2 Groundwater	
	13.3 Subsurface Conditions	
14.0	RECOMMENDATIONS	19
15.0	REFERENCES	20
	15.1 Required Publications	
	15.2 Online Publications	
	15.3 Referenced Publications	

TABLE OF CONTENTS - Continued

TABLES

Number	Title
1	Summary of Drilling and Sampling Program
2	Drill Hole Locations and Elevations for On-Land Drill Holes
3	Drill Hole Locations and Water Depths for Off-Shore Drill Holes
4	Summary of the Geotechnical Laboratory Testing Program
5	Summary of USCS Soil Types Encountered in All Drill Holes From 0.0-ft to Bottom of Drill Hole
6	Summary of USCS Soil Types Encountered in all Drill Holes From 0.0-ft to 10.5-ft Depth
7	Summary of USCS Soil Types Encountered in all Drill Holes From 0.0-ft to 4.5-ft Depth
8	Summary of USCS Soil Types Encountered in the Off-Shore Drill Holes From 0.0-ft to Bottom of Drill Hole
9	General Summary of the Geotechnical Laboratory Testing Results
10	Grain Size Distribution Summary for Coarse-Grained Soils
11	Sediment Size Distribution For Selected Coarse-Grained Soils Using The Folk & Ward Method
12	Coefficient of Uniformity (C_u) and Coefficient of Curvature (C_k) for Selected Soils Samples
13	Grain Size Distribution Summary for Fine-Grained Soils
14	Hydrologic Soil Properties Classified By USDA Soil Textures For Coarse-Grained Soils
15	Hydrologic Soil Properties Classified By USDA Soil Textures For Fine-Grained Soils
16	Hydraulic Conductivity (K) Calculation Per Hazen Approximation For Coarse-Grained Soils
17	Summary of Groundwater Depths During Drilling
18	Initial Groundwater Reading in Piezometers
19	Piezometer Groundwater Readings From 15 November 2003
20	Piezometer Groundwater Readings From 8 February 2003
21	Piezometer Groundwater Readings From 9 February 2003
22	Piezometer Groundwater Readings From 10 February 2003
23	Changes in Piezometer Groundwater Readings
24	Summary of Groundwater Gradients Between Piezometers on 15 November 2003
25	Summary of Groundwater Gradients Between Piezometers on 8 February 2003
26	Summary of Groundwater Gradients Between Piezometers on 9 February 2003
27	Summary of Groundwater Gradients Between Piezometers on 10 February 2003
28	Groundwater Flow Direction And Gradient Calculations For Groundwater Readings Taken on 15 November 2003
29	Groundwater Flow Direction And Gradient Calculations For Groundwater Readings Taken on 8 February 2004

TABLE OF CONTENTS - Continued

TABLES - Continued

Number	Title
30	Groundwater Flow Direction And Gradient Calculations For Groundwater Readings Taken on 9 February 2004
31	Groundwater Flow Direction And Gradient Calculations For Groundwater Readings Taken On 10 February 2004

FIGURES

Number	Title
1	Regional Location Map Showing Hudson County, NJ
2	Liberty State Park Vicinity Map
3	Liberty State Park Site Map
4	Physiographic Provinces of New Jersey
5	Liberty State Park Phase I Drill Hole Locations
6	Liberty State Park Permanent Piezometer Location Plan
7	Liberty State Park Phase II Drill Hole Locations
8	Liberty State Park Oblique View of Drill Holes
9	Liberty State Park Generalized Conceptual Geologic Model
10	Liberty State Park Groundwater Contour Map – 15 Nov 2003
11	Liberty State Park Groundwater Contour Map – 8 Feb 2004
12	Liberty State Park Groundwater Contour Map – 9 Feb 2004
13	Liberty State Park Groundwater Contour Map – 10 Feb 2004
14	Liberty State Park General Groundwater Flow Direction using LMNO Software

LIST OF ABBREVIATIONS AND ACRONYMS

SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ

FINAL REPORT
Volume 2

TABLE OF CONTENTS

APPENDICES

Section	Title
A	Field Drill Logs
B	Final Drill Logs

SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ

FINAL REPORT
Volume 3

TABLE OF CONTENTS

APPENDICES

Section	Title
C	Visual-Manual Soil Classifications
D	Geotechnical Testing Results
E	Permanent Piezometer As-Built Records
F	Permanent Piezometer Construction Schematics
G	Temporary Piezometer As-Built Records
H	Temporary Piezometer Construction Schematics
I	Changes in Groundwater Elevations in Permanent Piezometers

EXECUTIVE SUMMARY

This site investigation report documents the results of a geotechnical subsurface site investigation program performed at Liberty State Park, Jersey City, Hudson County, NJ. An initial phase (Phase I) of drilling and sampling program was performed during August and September of 2003. Thirty-eight drill holes were completed and a comprehensive geotechnical testing program was performed. An additional phase (Phase II) of drilling and sampling program was performed in February 2004. Eleven drill holes and six auger boring were completed along with geotechnical testing. This report contains the results of the geotechnical site investigation program and discussions of regional geology, soils, hydrogeology, and the geotechnical conditions observed at the site. Characterization of subsurface geotechnical conditions is consistent with a feasibility level site investigation program.

The geotechnical site investigation program revealed that project site is overlain with coarse-grained (sands, silty sands, silty gravels, etc.) soils. Average thickness of this coarse-grained layer is about 14-ft, although local variations exist with both thinner layers (3-ft) and thicker layers (30-ft plus) encountered. Underlying this coarse-grained layer is a layer of fine-grained soil (clay, clay with traces of shells, sand, and gravel, etc.). This fine-grained layer was observed in about 85% of the drill holes. On average, this fine-grained layer was encountered at a depth of about 13-ft, although local variations exist. Average thickness of this fine-grained layer is about 12-ft, although local variations exist with both thinner layers (1.5-ft) and thicker layers (27-ft plus) encountered. Subsequent lower layers of coarse-grained and then fine-grained soils were occasionally encountered. Man-made debris (refuse) materials were found in about 27 drill holes.

The coarse-grained surficial soils consist primarily of sand size particles, although minor amounts of gravel and silt or clay size particles were also included. The coarse-grained soils are typically very poorly sorted and the distributions are often skewed to the finer sized portion. The immediately underlying fine-grained soils consist primarily of silt or clay size particles, although some minor amounts of fine and medium sand are also typically included. The fine-grained soils are often highly plastic. Hydrologic soil properties for both the coarse-grained and fine-grained soils were also estimated.

Groundwater depths range from about 1.3-ft below existing grade to about 5.5-ft below existing grade, as measured from the twenty piezometers installed throughout the site. Maximum fluctuations in groundwater levels up to 3.1-ft were observed in the piezometers. Groundwater flow direction and average gradient calculations using LMNO Groundwater Flow Direction and Gradient Calculator software suggests that groundwater flow direction is about N35° and discharges towards the adjacent Morris Canal.

Near surface excavation of this material should present no unusual excavation problems. However, deeper excavations, notably excavation of the Ecochannel in the vicinity of the North Cove, may present excavation problems. The presence of 'Active' clays may become result in stability and foundation problems in slopes and beneath structures. The presence of soft, fine-grained soils may cause excavation problems due to its very soft consistency, which may result in slumping of cuts and corresponding problems with maintaining channel grade control, its ability to stick to excavating equipment and tools, and its ability to deform and maintain excess pore pressure. Earthmoving type construction equipment may have difficulty operating directly on this material. Since the site is bounded by surface water on two separate sides, the impact of groundwater on any excavations may be significant and dewatering may be required. Additional subsurface investigations, engineering testing and further geotechnical analyses may alter or modify the current conceptual geotechnical characterizations.

SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ

1.0 INTRODUCTION

This document presents and summaries the geotechnical data obtained from the subsurface site investigation program performed at Liberty State Park (LSP), Jersey City, Hudson County, NJ. The Baltimore District, U.S. Army Corps of Engineers (BCOE) completed the subsurface site characterization program.

The Phase I site investigation obtained continuous sampling from thirty-eight (38) separate boreholes to a depth of approximately 30-ft below grade. Two additional drill holes located within the North Cove were drilled in the Phase II program. Twelve (12) piezometers were installed as permanent piezometers in existing drill holes for long-term groundwater level monitoring purposes and for future use in determining permeability (hydraulic conductivity) of the soil, if required. An additional eight (8) temporary piezometers were also installed in selected existing drill holes. These temporary piezometers shall be removed at the completion of the groundwater monitoring program. The Phase II site investigation obtained continuous sampling from eleven (11) separate boreholes, depths ranged from 30-ft below grade in the Contaminant Area to 20-ft below grade in the North Cove Area. Six auger borings were also drilled in the Berm Area. Geotechnical laboratory testing was completed on representative geotechnical samples to determine Unified Soil Classification System (USCS) soil classifications and engineering properties. Chemical analysis of select soil samples was performed by an off-site analytical testing laboratory at the Fort Monmouth Environmental Testing Lab, Fort Monmouth, NJ. The data collected was used to provide a descriptive summary of the horizontal and vertical extent of any chemical or constituent found at the site. Results of the chemical analyses are not included in this summary report, but are available in a separate technical summary report.

This work was completed under the North Atlantic Division's Regional Business Center (RBC) concept. The Baltimore District and the New York District partnered to plan, conduct, and complete this comprehensive site investigation. New York District personnel provided critical, and often invaluable, technical, administrative, and logistical support during prosecution of this work, as well as, providing all Project Management functions. Personnel from the Geotechnical Branch (Engineering Division) of the Baltimore District implemented the site investigation project and prepared this Site Investigation Report. This collaborative effort made optimal use of the technical capabilities and resources within the Division, with the partnering District organizations acting as a single business entity.

2.0 BACKGROUND

From the time of its opening on June 14, 1976, Liberty State Park has attracted sustained, significant public support from citizen groups interested in promoting and protecting New Jersey's first, and to date, only urban state park. Liberty State Park's 1,212 acres include magnificent views of New York Harbor, the Statue of Liberty, the historic Central New Jersey Rail Terminal, the Liberty Science Center and the Liberty Landing Marina. LSP also provides a historic gateway to Ellis Island and the Statue of Liberty. LSP serves nearly 4.5 million visitors annually, including visitors from Jersey City and Hudson County to travelers from across the region and the Nation.

Liberty State Park is managed and protected by the New Jersey Department of Environmental Protection (NJDEP) Division of Parks and Forestry, working closely with park constituencies ranging from Jersey City residents to local parks and environmental groups. Since 1986, the Liberty State Park Development Corporation (LSPDC), established by Governor Kean to promote public-private partnerships, also has had a significant role in park development. In recent years, numerous LSPDC proposals have generated significant controversy among citizens concerned about the park. With the recent completion of the General Management Plan, which determined the future of the remaining 251 acres of undeveloped space, there is little work remaining that falls under the LSPDC's original mandate. Accordingly, the McGreevey Administration has revisited the role of the LSPDC, in light of the vision for the future of Liberty State Park.

3.0 OBJECTIVES

In consultation with the public advisory committee established by NJDEP Policy Directive 2003-03, dated April 24, 2003, NJDEP's Division of Natural and Historic Resources was tasked to focus on the following priorities for Liberty State Park:

Acceleration of the Interior Restoration. In coordination with the United States Army Corps of Engineers, NJDEP shall accelerate the restoration of the Park's natural and vegetated areas, including the 251 acres identified for restoration in the center of the Park.

Active Recreation. Recognizing the needs of the surrounding Jersey City communities and the absence of significant facilities for active recreation, NJDEP shall expand and improve opportunities for active recreation at the Park to better serve Jersey City and other local residents.

Entrance and Transportation Improvements. NJDEP shall work to improve the Park entrance and develop road and transit improvements to increase access and convenience, reduce impacts of parking and transit, and improve the appearance of the Park.

Non-commercial entertainment. NJDEP shall develop a memorandum of understanding (MOU) with the New Jersey Symphony Orchestra (NJSO) to explore the possible siting of a limited-seating venue for NJSO performances and similar cultural events at the Park. Any proposal shall be fully reviewed by the Park advisory committee and subject to notice and comment prior to any final decision.

4.0 CONTAMINANTS AND PREVIOUS INVESTIGATIONS

The New York District of the US Army Corps of Engineers is partnering with the New Jersey Department of Environmental Protection (NJDEP) to characterize the sub-surface soils in the central part of Liberty State Park. This effort is part of the overall effort to construct a coastal wetland within that central area. This wetland would replicate what existed prior to settlement and industrialization. That area of LSP slated for this is entirely composed of fill material. The material is a mix of soil, construction debris, sunken wooden barges, and industrial waste. Land filling activities lasted approximately 75 years, finally completing in the late 1950's. The main activity on this filled in area was railroads. Railroad operations involved fueling, repair, maintenance, freight and passenger movements. By the mid 1960's railroad activities were winding done and by the early1970's ceased all together.

The NJDEP purchased the land in the late 1970's to create what is today Liberty State Park and embarked on a clean up and site restoration project that continues to this day. Restoration of previously existing wetlands is part of the NJDEP's overall plan. From the time of the NJDEP's purchase of the land to present there have been numerous sub-surface characterization projects. The focus of these projects was to determine the lateral and vertical extent of the pollutants. In this case the pollutants of concern are metals (the most concern is on hexa-valent, tri-valent chromium) and hydro-carbons (oil, either as free product or as absorbed into the soil). As a result of these characterizations an area of 50 acres has been fenced off and posted to prevent the public from entering this area. The soil in this restricted area is dredged sediment from the New York Harbor.

5.0 SITE LOCATION AND DESCRIPTION

The Liberty State Park Site is located in Jersey City, New Jersey, along the Hudson River, approximately two (2) miles south of the Holland Tunnel Crossing and on the mainland, just west of Ellis Island. Located in Hudson County, NJ, the potential restoration site is within the boundaries of Liberty State Park on a section of property generally bounded by Audrey Zapp Drive on the north side, Phillip Drive on the west side, Thomas McGovern Drive on the south side and Freedom Way, a flood control levee, along the east side.

Previous investigations of the fill material at Liberty State Park by NJDEP (NJDEP 1995) indicate that the material consists primarily of cinder and ash fill, mixed rubble and debris, and dredge spoil, likely underlain by organic clay, glacial meltwater

deposit, alluvial deposits, and glacial till. Bedrock in nearby New Jersey Geological Survey (NJGS) borings is 40 feet deep or deeper. Hazardous, toxic, and radioactive waster (HTRW) contaminants reported by NJDEP in their 1995 investigation include chromium, lead, arsenic, and other heavy metals, petroleum hydrocarbons, pesticides, PCBs, and semi-volatile organics (NJDEP 1995). Heaving sands have also been reported by NJDEP at depths greater than 20 feet. A freshwater wetland that exists at the West Side of the site must be supported and maintained. Because of known HTRW contamination at the site area, it is a project requirement that no soils be removed from the site.

A regional location map showing Hudson County, NJ is shown in Figure #1. A Liberty State Park Vicinity Map is shown in Figure #2 and a Liberty State Park Site Map is shown in Figure #3.

6.0 GEOLOGY

6.1 Regional: New Jersey has a very diverse geology containing rocks ranging from the Precambrian Era through the Paleozoic Era, Mesozoic Era, Cenozoic era, and Holocene (recent) Era. Overall, the rock of these different Eras are distributed across the state from north to south according to age, although the order is reversed in the New Jersey Highlands due to thrusting of deeper and older Precambrian rocks over younger Paleozoic rocks. Four major geologic provinces occur in New Jersey, namely: (i) Appalachian Valley and Ridge, (ii) New England (Reading Prong), (iii) Piedmont, and (iv) Coastal Plain. A map showing the four geologic provinces is shown in Figure #4. The Liberty State Park project site is located within the Piedmont physiographic province. Rocks of the Piedmont providence included interbedded sandstone, shale, conglomerate, basalt, and diabase and underlie a broad lowland interpreted by long, generally northeast-southwest trending ridges and uplands. The rocks of the Piedmont Province are of Late Triassic and Early Jurassic age (230 to 190 million years old). They rest on a large, elongated, crustal block that dropped downward in initial stages of the opening of the Atlantic Ocean – one of a series of such blocks in the eastern part of North America. These dropped down block form valleys known as rift basins. Sediment eroded from adjacent uplands, was deposited along rivers and in lakes within the basins. These sediments became compacted and cemented to form conglomerate, sandstone, siltstone, and shale, which commonly have a distinctive reddish-brown color.

6.2 Glaciation: New Jersey has undergone three major glaciations. The last glacier (the late Wisconsin advance) began to melt back from its maximum extent approximately 20,000 years ago. North of the limit of the last Glaciation the surface is covered with glacial deposits. Upland areas in this region are thinly draped with till, and unsorted mixture of sand, clay, and boulders deposited directly from the glacier. Valleys and lowlands are filled with up to 350 feet of sand and gravel deposited from glacial meltwater and silt and clay that settled in glacial lakes. Much of the surficial deposits include artificial fill, alluvial, estuarine, and eolian sediments of postglacial age, and glacial meltwater deposits that are of late Wisconsin age.

6.3 Local: During each Glaciation, sea level dropped as water from the ocean was transferred to ice sheets. Rivers extended and deepened their valley to conform to the lower sea levels. When the ice sheets melted, sea level rose, flooding the deepened valleys and establishing new shorelines. The present configuration of the shoreline is the result of rapid post-glacial rise in sea level. Many of the estuaries along the shore are drowned lower reached of former river valleys. Mud and sand transported by rivers is gradually filled the former river valleys, creating extensive wetlands.

7.0 SITE INVESTIGATION PROGRAM

7.1 Drilling and Sampling:

Soil samples were obtained in accordance with ASTM D1586 (Standard Penetration Test (SPT) method). The SPT method is a procedure for driving a split-barrel (split-spoon) sampler to obtain a representative soil sample and to measure the resistance of the soil to penetration. The SPT method provides a disturbed sample for defining sediment stratification as well as blow count data, which gives an indication of soil consistency and relative density. The SPT method involves driving a 1-3/8 inch ID by two foot long split-spoon sampler using a 140 pound hammer free falling thirty inches onto an anvil attached to drill rods (viz., rods used to transmit downward force to the sampling spoon while drilling a borehole). The number of blows required to advance the sample spoon over each 6-inch drive increment was recorded. Often, the weight of the sampling spoon and drilling rods alone were sufficient to drive the sampling spoon into the soil (sediments). This condition was described as Weight of Rods (WR) or Weight of Hammer (WH), since no hammer blows were required to advance the sampling spoon. Split spoon sampling was performed using a CME-750 drill rig. Hollow Stem Augers (2-1/4-inch ID) were used to advance the boring and to stabilize the drill hole. The SPT test method is discussed in ASTM D 1586 Test Methods for Penetration Test and Split-Barrel Sampling of Soils.

A Phase I drilling and sampling program was completed during August and September of 2003. Thirty-eight drill holes were completed throughout the project site during this phase. Drill holes were designated as LSP-03-01 through LSP-03-40, respectively. Although drill hole Nos. LSP-03-21 and LSP-03-22 were not drilled in 2003. But they were drilled in 2004 and were renamed NC-04-01 and NC-04-02. The planned investigation sampling depth was typically -30.0 feet below existing grade. All borings were typically sampled continuously in one and one-half foot increments from the top of the drill hole to a typical depth of -30.0 feet. Recovered samples for each split-spoon were placed in clean, air tight, one-quart glass jars for preservation and then shipped to the geotechnical-testing laboratory. Approximately 1,123 linear feet of soil was drilled in the 38 subsurface borings with 753 separate sample spoons collected. Twelve drill holes were converted into permanent groundwater piezometers (LSP-03-01 through LSP-03-12) and eight drill holes were converted into temporary piezometers (LSP-03-17, LSP-03-19, LSP-03-24, LSP-028, LSP-03-31, LSP-03-32, LSP-03-35, and

LSP-03-38). A Phase I drill hole location plan is shown in Figure #5 and a Phase I drill hole location plan showing the location of drill holes where permanent piezometers were installed is shown in Figure #6.

An additional phase (Phase II) of drilling and sampling was conducted during February 2004. Six SPT drill holes were completed in the Containment Area, designated as CA-04-01 thorough CA-04-06. Five SPT drill holes were completed in the North Cove area, designated as NC-04-01 through NC-04-05. Two North Cove drill holes (NC-04-01 and NC-04-02) were completed from a barge located in the water within the North Cove. Six auger borings were completed in the Berm Area, designated as BA-04-01 through BA-04-06. A Phase II drill hole location plan is shown in Figure #7. Approximately 280 liner feet of SPT drilling was completed in this additional phase, with 187 separate sample spoons collected. Recovered samples for each split-spoon were placed in clean, air tight, one-quart glass jars for preservation and then shipped to the geotechnical-testing laboratory.

A general summary of the drilling program is shown in Table #1. Drill hole coordinates and top of drill hole elevations for all on-land drill holes are shown in Table #2. Drill hole locations and water depths for the offshore drill holes are sown in Table #3. Field (preliminary) drill logs are located in Appendix A. Final drill logs are located in Appendix B.

7.2 **Positioning**: Locations for each boring were established utilizing an Ashtek® ProMark2 Differential Global Positioning System (GPS). The ProMark2 has a reported static horizontal accuracy of 0.016-ft and a reported static vertical accuracy of 0.032-ft, subject to a number of operational conditions.

8.0 PIEZOMETERS

8.1 Permanent Piezometers: Twelve permanent piezometers were installed in drill hole Nos. LSP-03-01, LSP-03-02, LSP-03-03, LSP-03-04, LSP-03-05, LSP-03-06, LSP-03-07, LSP-03-08, LSP-03-09, LSP-03-10, LSP-03-11, and LSP-03-12. These piezometers are classified as standpipe type piezometers and are used to monitor piezometric groundwater levels across the site. Standpipe piezometers contain a porous element that is connected via rigid tubing to ground level. Piezometric pressure at the tip is indicated by the head of water that develops inside the standpipe tubing. A permanent leak-resistant cover was installed at the surface to protect the piezometer. As-built records for the twelve permanent piezometers are shown in Appendix E. Construction Schematics for the twelve permanent piezometers are shown in Appendix F.

8.2 Temporary Piezometers: Eight temporary permanent piezometers were installed in drill hole Nos. LSP-03-17, LSP-03-19, LSP-03-24, LSP-03-28, LSP-03-31, LSP-03-32, LSP-03-35, and LSP-03-38. These piezometers are also classified as standpipe type piezometers and are used to monitor piezometric water levels across the site. No permanent leak-resistant cover was installed at the surface to protect the

piezometer. These eight piezometers shall be removed at the completion on the site investigation program. As-built records for the eight temporary piezometers are shown in Appendix G. Construction Schematics for the eight temporary piezometers are shown in Appendix H.

9.0 GEOTECHNICAL TESTING

9.1 Geotechnical Testing Methodology: All geotechnical soil tests were performed by the Baltimore Districts Materials and Instrumentation (Soils Laboratory) Unit, located at 2603 Leahy Street, Ft McHenry Yard, Baltimore, MD 21230. Telephone (410) 962-4045, Fax (410) 962-7627. Upon receipt of the sample jars collected during the field investigation, a visual-manual USCS (Unified Soil Classification System) soil classification was completed on the soil in each (disturbed) jar sample collected. Visual-Manual Soil Classifications are shown in Appendix C. The Geotechnical Laboratory testing results are shown in Appendix D. A tabulated summary of the geotechnical laboratory-testing program performed on the soil is shown in Table #4. All soil testing was performed in accordance with EM 1110-2-1906 and appropriate ASTM Standard Testing Methods. Due to the potential contamination levels of the soils, the testing was completed using contaminated material testing protocols and performed under an approved "Management Plan for the Handling and Disposal of Laboratory Soil Samples." All soils were disposed at a designated facility that is permitted for hazardous waste treatment, storage, and disposal. All geotechnical testing was performed under an approved geotechnical laboratory "Quality Assurance Plan."

9.2 Soil Characterization:

9.2.1 General: Soils behave quite differently depending upon their geotechnical characteristics. In coarse-grained soils, where more than 50% of the soil is retained on the No. 200 (0.075 mm) sieve, the engineering behavior is influenced mainly by the relative proportions of the different sizes of grains present (gradation), the shapes of the soil grains, and the density of packing. In the USCS, coarse-grained soils have their major descriptors as either G (Gravel) or S (Sand). Minor descriptors include W (Well-Graded), P (Poorly Graded), M (Silty), and C (Clayey). In fine-grained soils, where more than 50% of the soil passes on the No. 200 (0.075 mm) sieve, the mineralogy of the soil grains, water content, inter-particle physico-chemical forces, etc., have a greater influence on the engineering behavior of the soil than the grain sizes. In the USCS, fine-grained soils have their major descriptors as M (Silt), C (Clay), or O (Organic). Minor descriptors include L (Low Plasticity), and H (High Plasticity).

9.2.2 Fine Grained Soil: Fine-grained soils are characterized by Plasticity parameters. Plasticity parameters, which are expressed in terms of moisture content of the soil (Atterberg limits) have been defined and standard methods for measurements have been established. Plastic Limit, PL, is defined as the water content on a dry weight basis corresponding to the arbitrary limit between plastic and brittle states of consistency of a soil. Liquid Limit, LL, is defined as the water content on a dry

weight basis corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil. Plasticity Index, PI, is the difference between the liquid and plastic limits and represents the range of moisture within which the soil is plastic. Silts and sands have slight or no plasticity indices, whereas clays have higher indices. The Plasticity Index, in combination with the Liquid Limit, indicates how sensitive the soil is to changes in moisture. Liquidity Index, LI, is defined as the ratio of the difference between the natural soil water content and plastic limit to the soil plastic index (PI) of the same soil. If a soil Liquidity Index (LI) is less than 1.0, the soil water content is less than liquid limit. If a soil Liquidity Index (LI) is very low or close to 0.0, the soil water content is near to plastic limit and the soil will have a high cohesion. If the Liquidity Index (LI) is greater than 1.0, the soil behaves as a viscous liquid when sheared; if the LI is less than 0.0, the soils exhibits a brittle type fracture when sheared; and when the $0.0<LI<1.0$, the soil behaves as a plastic solid when sheared. Activity Index, A, defines the activity of a clay as the ratio of the PI to the percent clay fraction (clay fraction <0.002 mm) by weight. Activity is a good indictor of the potential swell-shrink associated with specific clays. The higher the Activity Index, the higher the swell-shrink potential. Clays with $A<0.75$ are classified as "inactive clays;" clays where $0.75<A<1.25$ are "normal clays;" and clays where $A>1.25$ are "active clays." High activity indexes suggests large volume changes when wetted; large shrinkage when dried; and very reactive (chemically) clays.

9.2.3 Coarse Grained Soils: Coarse-grained soils are divided into two major divisions: gravels and sands. If more than half of the coarse fraction by weight is retained on a No. 4 (4.75 mm) sieve, the soil is classified as a gravel. It is classified as a sand, if more than half of the coarse fraction is smaller than a No. 4 (4.75 mm) sieve. In general practice there is no clear-cut boundary between gravelly and sandy soils, and as far as behavior is concerned, the exact point of division is relatively unimportant. Where a mixture occurs, the primary name is the predominant fraction and the minor fraction is used as an adjective. For example, a sandy gravel is a mixture containing more gravel than sand by weight.

9.2.4 Borderline Soils: Coarse-grained soils that contain between 5 and 12 percent of material passing the No. 200 sieve (0.075 mm) are classified as border line and are given a dual symbol, such as GW-GM. Similarly, coarse-grained soils that contain more than 12 percent of material passing the No. 200 sieve, and for which the limits plot in the shaded portion of the plasticity chart, are classified as border line and require dual symbols, such as SM-SC. It is possible, in rare instances, for a soil to fall into more than one borderline zone. In this case, if appropriate symbols were used for each possible classification, the result would be a multiple designation consisting of three or more symbols.

9.2.5 Relative Density and Consistency: Coarse-grained cohesionless soils (sands, gravels, & non-plastic silts) are sufficiently pervious that excess pore pressures do not develop when stress conditions are changed. Their shear strengths are primarily characterized by the angle of internal friction. The value of the internal angle of friction depends upon the particle shapes, the gradation, and the relative density. The

approximate relationship between the relative density of coarse-grained cohesionless soils and the standard penetration test (SPT) resistance is as follows:

RELATIVE DENSITY (SPT)

Coarse-Grained Soils	Blows/Foot
Very Loose	0 – 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	32 – 50
Very Dense	Over 50

In fine-grained cohesive soils (clays & plastic silts), the shear strength is considerably more complex than coarse-grained soils because of their significantly lower permeability, higher void ratios, and the interaction between the pore pressure and the soils particles. The approximate relationship between the relative consistency of fine-grained cohesive soils and the standard penetration test (SPT) resistance is as shown below.

CONSISTENCY (SPT)

Fine-Grained Soils	Blows/Foot
Very Soft	0 – 2
Soft	2 – 4
Medium Stiff	4 – 8
Stiff	8 – 16
Very Stiff	16 – 32
Hard	Over 32

10. SUBSURFACE CONDITIONS

10.1 Fill: Numerous drill holes recovered man-made debris (refuse) materials consisting of cinders, wood, coal, brick, glass, leather, concrete, etc, including drill hole Nos.: LSP-03-05, LSP-03-06, LSP-03-11, LSP-03-12, LSP-03-13, LSP-03-14, LSP-03-16, LSP-03-17, LSP-03-20, LSP-03-23, LSP-03-24, LSP-03-25, LSP-03-26, LSP-03-28, LSP-03-29, LSP-03-34, LSP-03-35, LSP-03-38, LSP-03-39, CA-04-01, CA-04-02, CA-04-03, CA-04-04, CA-04-05, CA-04-06, NC-04-03, and NC-04-05. Traces of wood were found at the very top of two offshore borings (NC-04-01 and NC-04-02). Petroleum odor was evident in the drill hole Nos. NC-04-01, NC-04-02, NC-04-03, and NC-04-5.

10.2 Soils: The on-site soils vary considerably across the site. Both fine-grained and course grained soils are present. Soils in virtually all of non-organic USCS soil classifications are found on site. Table #1 shows the USCS soil classifications found in each drill hole. Visual-manual soil classifications are shown in Appendix C and geotechnical-testing results are shown in Appendix D. The DOD GMS software was used to develop the conceptual geologic model. An oblique view of the drill holes is shown in Figure #8 and a generalized conceptual geologic model of the subsurface is shown in Figure #9.

10.2.1 Distribution: Based upon the material recovered from the entire drilling and sampling program, approximately 61% of the top 30-ft of on-site soils are coarse-grained materials and approximately 39% of the soils are fine-grained materials, see Table #5. However, from depths of 0.0-ft to 10.5-ft below existing grade, approximately 87% of the on-site soils are coarse-grained materials and approximately 13% of the soils are fine-grained materials, as shown in Table #6. From depths of 0.0-ft to 4.5-ft below existing grade, approximately 91% of the on-site soils are coarse-grained materials and approximately 9% of the on-site soils are fine-grained materials, as shown in Table #7. Whereas in the two water borings (NC-04-01 and NC-04-02), approximately 8% of the soils are coarse-grained materials and 92% of the soils are fine-grained materials, as shown in Table #8. A general summary of the geotechnical laboratory testing results is shown in Table #9.

10.2.2 Coarse Grained Soil Properties: On average, fine grained Sand (<No. 70 sieve and >No. 200 sieve) comprise about 33% of the coarse-grained materials,; medium grained Sand (<No. 20 sieve and >No. 70 sieve) comprise about 20% of the coarse-grained materials; coarse grained Sand (No. 10 sieve) comprise about 8% of the coarse-grained materials; fine Gravel (<1/2-inch and > No. 4 sieve) comprise about 13% of the coarse-grained materials; and coarse Gravel (<3-inch and > 3/4-inch) comprise about 3% of the coarse grained materials. Silts and clays (< No. 200 sieve) comprise about 17% of the coarse grained materials. Although local variations exist, soils with considerably more coarse Gravels (41.7%) may be encountered in the on-site coarse-grained soils and soil with considerably more Silt and Clay (49.9%) size particles may also be encountered in the on-site coarse-grained soils. A summary of the grain size distributions for the coarse-grained soils is shown in Table #10.

10.2.2.1 Grain Size Analyses: One of the most important characteristics of soil is the size and distribution of the soil particles. Grain sizes analyses were conducted in selected coarse–grained soil samples in accordance with methods derived by Folk and Ward (1957). The Folk and Ward method estimates the Geometric mean, the skewness, and the kurtosis of the distribution. Results of the sediment size distribution for selected coarse-grained soils using the Folk and Ward analysis are presented in Table #11

Geometric Mean is considered the best measure for central tendency for a soil distribution. Standard deviation is the measure to which the sample spreads out around its mean and is a mathematical expression of sorting. A soil is described as well sorted if all soil particles have sizes that are close to the mean size (small standard deviation). If the soil particle sizes are distributed evenly over a wide range of sizes, the sample is considered well graded. A well-graded sample is poorly sorted; a well-sorted sample is poorly graded.

Skewness is a measure of symmetry of a distribution. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. Most natural systems do not produce normally distributed grain sizes, there are almost always more fine material than coarse material, or vice versa. A distribution has a longer tail less

than the maximum, the function has negative skewness (viz., skewed to coarse-size materials). Otherwise, it has positive skewness (viz., skewed to fine-size materials).

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. That is, data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. A uniform distribution would be the extreme case. Kurtosis assesses the percent frequency distribution of particle sizes in terms of a different sort of departure from the normal distribution. If the distribution is excessively peaked it is called "Leptokurtic;" if it is squashed or flattened, it is called "Platykurtic." "Mesokurtic" distributions have zero Kurtosis. Relative relationships for a range of standard deviation, skewness, and kurtosis are shown below.

phi Size Range	Verbal Description of Sorting	Kurtosis Value	Verbal Description of Kurtosis	Skewness	Verbal Description of Skewness
under .35 phi	very well sorted	under 0.67	very platykurtic	from +1.00 to +0.30	strongly fine skewed
0.35 - 0.50 phi	well sorted	0.67 - 0.90	platykurtic	from +0.30 to +0.10	fine skewed
0.50 - 0.71 phi	moderately well sorted	0.90 - 1.11	mesokurtic	from +0.10 to -0.10	near symmetrical
0.71 - 1.0 phi	moderately sorted	1.11 - 1.50	leptokurtic	from -0.10 to -0.30	coarse skewed
1.0 - 2.0 phi	poorly sorted	1.50 - 3.00	very leptokurtic	from -0.30 to -1.00	strongly coarse skewed
2.0 - 4.0 phi	very poorly sorted	over 3.00	extremely leptokurtic		
over 4.0 phi	extremely poorly sorted				

10.2.2.2 Distribution Curves: An important characteristic of the distribution of soil particles is the shape of the distribution curve. Grain size distributions curves are also described by gradation characteristics, such as, shape (Coefficient of Uniformity: $Cu = D_{60}/D_{10}$) and curvature (Coefficient of Gradation: $Ck = (D_{30})^2/(D_{10})(D_{60})$). Where:

Cu < 5 very uniform
Cu = 5 medium uniform
Cu > 5 non uniform
1.0 < Ck < 3.0 indicates a well-graded soil
Ck < 0.1 indicates a possible gap-graded soil

Results of Uniformity and Curvature analyses on selected coarse-grained soil samples are shown in Table #12.

10.2.3 Fine-Grained Soil Properties: On average, Silts and Clays (< No. 200 sieve) comprise about 82% of the fine grained materials; fine grained Sand (<No. 70 sieve and >No. 200 sieve) comprise about 5% of the coarse-grained materials; medium grained Sand (<No. 20 sieve and >No. 70 sieve) comprise about 2% of the coarse-grained materials; coarse grained Sand (No. 10 sieve), fine Gravel (<1/2-inch and > No. 4 sieve), and coarse Gravel (<3-inch and > 3/4-inch) comprise <1% of the fine-grained materials. Although local variations exist, soils with considerably more fine and medium Sand may be encountered in the on-site fine-grained soils and rarely fine Gravel may rarely be encountered in the on-site fine-grained soils. A summary of the grain size distributions for the fine-grained soils is shown in Table #13. Most of the fine-grained materials contain highly plastic clays. Average Liquid Limits (LL) were about 67 and Plactic Limits (PL) were 32. An average Plasticity Index (PL)of 35 and Liquidity Index (LI) of 0.88 were observed. Thirty samples contained clay factions at or close to the 2μ size, which results in an average Activity Index (AI) of 1.66. Considerable ranges of LL, PL, and Water Contents were observed in the tested samples. A summary of the geotechnical laboratory testing results is shown in Table #9.

10.3 Buried Mud Flat: Remnants of a possible mud flat was encountered in several drill holes. Soils thought to be typically associated with a mud flat include very moist, soft, dark gray, highly plastic (fat) clay materials containing traces of sand, gravel and shells, occasionally containing traces of organic material. Soil materials thought to be typically associated with mud flat have been recovered in drill holes Nos. LSP-03-04, LSP-03-05 LSP-03-07, LSP-03-08, LSP-03-10, LSP-03-11, LSP-03-12, LSP-03-17, LSP-03-18, LSP-03-19, LSP-03-20, LSP-03-23, LSP-03-24, LSP-03-25, LSP-03-26, LSP-03-27, LSP-03-31, LSP-03-32, LSP-03-33, LSP-03-34, LSP-03-36, LSP-03-37, LSP-03-38, CA-04-01, CA-04-01, CA-04-02, CA-04-03, CA-04-04, CA-04-05, CA-04-06, NC-04-01, and NC-04-02.

10.4 Hydrologic Soils Groups: Soils are classified into Hydrologic Soil Groups (HSG) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. HSG's are based upon USDA soil textural classes. Hydrologic Soil Groups are at classified as A, B, C, and D. Two hydrologic soil properties are associated with the soil textural group: (i) the Effective Water Capacity (C_w) and (ii) the minimum Infiltration Rate (*f*). The effective water capacity of a soil is the fraction of the void space available for water storage, measures in inches per inch. The minimum infiltration rate is the final rate that water passes through the soil profile during saturated conditions, measured in

inches per hour.

Saturated infiltration rate is a measure of how quickly water can move through the soil when it is saturated. Soil infiltration rate, in conjunction with water storage capacity, is fundamental to controlling the soil-water regime that determines land suitability for a range of purposes.

Soils with a slow infiltration rate at or near the soil surface (e.g. less than 1.18/hr) cannot transmit water from heavy showers of rain and this can lead to excessive run-off and potentially to erosion. Run-off also represents a loss of water that could have otherwise been available to plants. Subsoil layers are nearly always less permeable than surface layers because of the lower rates of biological activity. Soils with a strong texture contrast between topsoil and subsoil may have a sharp reduction in infiltration rate with depth. In this case, drainage of water is impeded and water logging can be a problem

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have *very* low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

Approximate numerical ranges for Infiltration Rate (*f*) and Effective Water Capacity (C_w) and the associated hydrologic soil groups for coarse-grained soils are shown in Table #14. Approximate numerical ranges for Infiltration Rate (*f*) and Effective Water Capacity (C_w) and the associated hydrologic soil groups for fine-grained soils are shown in Table #15.

10.5 Hydraulic Conductivity: Several empirical relationships exist between hydraulic conductivity (permeability) and the grin size distribution for a soil. Two notable methods include the Hazen Approximation Method and the Krumbein and Monk Method. The Hazen Approximation method is calculated as follows:

$$K = C(D_{10})^2$$

Where K is the hydraulic conductivity (cm/sec) and D10 is the Hazen's effective grain size (mm). The Hazen approximation of hydraulic conductivity is applicable when the effective size (D10) is between 0.1 mm and 3.0 mm. Several coarse-grained soils met the effective size criteria. Hazen derived hydraulic conductivity's for selected soil samples are shown in Table #16.

The Krumbein and Monk Method is also used to empirically estimate the permeability's of soil, and is calculated as follows:

$$k = 760\ (GM_e)^{2e-1.31\sigma\phi}$$

Where k is the intrinsic permeability (in darcies), GMe is the geometric mean grain diameter in mm, and σ_{ϕ} is the standard deviation in phi (ϕ) units. The Krumbein and Monk equation requires mean grain size ranging from -0.75ϕ (1.682 mm) to 1.25ϕ (0.420 mm) and standard deviations ranging between 0.04ϕ (0.973 mm) to 0.80ϕ (0.574 mm). No sample obtained in this site investigation meet that requirement, which precluded the application of the Krumbein and Monk method.

11.0 GROUNDWATER:

11.1 Levels: Piezometric groundwater levels varies across the site. Groundwater levels as encountered during drilling, at the completion of drilling, and after 24-hours are shone in Table #17. All drill holes remained open for at least 24-hours to obtain a groundwater level reading. Initial groundwater readings taken in all piezometers are shown in Table #18. Synoptic groundwater readings taken on 15 November 2003 are shown in Table #19. Synoptic groundwater readings taken on 8 February 2004 are shown in Table #20. Synoptic groundwater readings taken on 9 February 2004 are shown in Table #21. Synoptic groundwater readings taken on 10 February 2004 are shown in Table #22. Changes in groundwater readings are shown in Table #23. Changes in groundwater elevations observed in the permanent piezometers are plotted in Appendix I. Groundwater levels detected in temporary piezometer No. LSP-03-35 appears to be abnormally low and should be used only with caution until a determination as to the reliability of the readings is made. Groundwater levels in permanent piezometer No. LSP-03-05 appears to be abnormally high. Due to its proximity to the North Cove, this piezometer may be better hydraulically connected to water in the North Cove than any other piezometer. Groundwater-surface water interactions and tidal effects may effect groundwater levels, but were not considered in this report. Groundwater contour maps for groundwater readings taken in the permanent piezometers are shown in Figure Nos. 10, 11, 12, and 13 for groundwater levels obtained on15 Nov 03, 8 Feb 04, 9 Feb 04, and 10 Feb 04, respectively. Groundwater contours were created in GMS Version 4.0 using the simple triangulation TIN generation method.

11.2 Flow: Groundwater gradients were analyzed for each synoptic reading set. Groundwater gradients between all piezometers were analyzed to determine both the relatively steepest and flattest gradients and to determine the piezometers which have the relatively higher groundwater levels (flow toward) and the piezometers which have relatively lower groundwater levels (flowing away) from each permanent piezometer. The summary of groundwater gradients between piezometers based upon the 15 November 2003 synoptic reading set is shown in Table #24. The summary of groundwater gradients between piezometers based upon the 8 February 2004 synoptic reading set is shown in Table #25. The summary of groundwater gradients between piezometers based upon the 9 February 2004 synoptic reading set is shown in Table #26. The summary of groundwater gradients between piezometers based upon the 10 February 2004 synoptic reading set is shown in Table #27. Groundwater flow direction and average gradient calculations were also analyzed using LMNO Groundwater Flow Direction and Gradient Calculator software available from LMNO Engineering, Research, and Software, Ltd. Groundwater flow direction and average gradient calculations for the 15 November 2003 synoptic reading set is shown in Table #28. Groundwater flow direction and average gradient calculations for the 8 February 2004 synoptic reading set is shown in Table #29. Groundwater flow direction and average gradient calculations for the 9 February 2004 synoptic reading set is shown in Table #30. Groundwater flow direction and average gradient calculations for the 10 February 2004 synoptic reading set is shown in Table #31. A general groundwater flow direction map using averaged results from the LMNO Groundwater Flow Direction and Gradient Calculator software is shown in Figure #14.

12.0 GEOTECHNICAL CHARACTERIZATION

12.1 Strength: The strength of the surficial materials depends on their grain size, compaction, and water content. Estuarine, tidal, and alluvial deposits are typically of low strength because they have not been subject to water or sediment loads greater than those at present, and have been continuously saturated or moist, and so are not compact. They also may contain significant amounts of organic matter, which is weaker than mineral soil. Any significant structures which may be proposed for this site, other than those which are lightly loaded, may require addition foundation analyses to be performed once the structure has been sited.

12.1 Excavation: As discussed in Paragraph 10.2, silty Sand is predominate throughout the project site, especially within the top five feet. A review of SPT blow counts for the silty/clayey Sand (viz., sand without gravel or man-made fill materials) encountered with the top five feet, suggests an approximate average blow count of 8-9 blows per foot. This suggests that the soil be classified as 'loose,' although some 'very loose' and 'dense' soils were also encountered. Near surface excavation of this material should present no unusual excavation problems. However, deeper excavations, notably excavation of the Ecochannel in the vicinity of the North Cove, may present excavation problems. Much of the soft clays encountered in the vicinity of the North Cove (viz., drill hole Nos. LSP-03-03, LSP-03-04, LSP-03-05, LSP-03-20, NC-04-01, and NC-04-

02, etc.) is zero or very low blow count material. This suggests that the soil is 'very soft.' Based upon blow count data, the estimated unconfined compressive strength of the clay is less than 0.25 tons/sq. ft. This soil may exhibit excavation problems due to its very soft consistency, which may result in slumping of cuts and corresponding problems with maintaining channel grade control, its ability to stick to excavating equipment and tools, and its ability to deform and maintain excess pore pressure. Earthmoving type construction equipment may not be able to operate directly on this material. Special considerations may be needed during construction to minimize excavation problems if cuts into the soft Clay are needed to construct the proposed Eco-Channel near the North Cove.

12.3 Drainage and Dewatering: The site is bounded by surface water on two separate sides. Subsequently, the impact of groundwater on any excavations may be significant. As such, dewatering of excavations may be required to allow construction. Drainage of the coarse-grained, granular soils may be efficiently drained by gravity. Considerable quantities of water may be removed from the coarse-grained, granular soils. Water stored in soil pores is released slowly. In silty sands, drainage may take days or weeks. Sumps, drains, and open pumping may be effective in those areas with coarse-grained, granular soils. Drainage of clays is more problematic. The quantity of water to be removed in clays is typically small, often tens of gpm or less. Gravity drainage is usually not effective. A well-point type collection system may be required in those areas with extensive fine-grained, cohesive soils present. Since the water moves though the soil with difficulty, the spacing of collection (well) points must be very close and prolonged pumping time would be beneficial. Especially in those areas in the immediate proximity of surface water or where deep excavations are required.

12.4 Slopes: Stability of the excavated slopes for the Ecochannel depends upon the characteristics of foundation and slope materials and the geometry of the slope. Excavated slopes must be designed to ensure stability, as well as, practical considerations. The stability of slopes consisting of cohesionless materials depends upon the angle of internal frictions (Φ), the slope angle, the unit weight of soil, and internal pore pressures. Generally in granular materials, a slope of 1 vertical on 1-1/2 horizontal is adequate. However, slopes of 1 vertical to 3 horizontal are recommend to ensure safety of maintenance personal that may be required to work on the slope (viz., grass moving) or where the general public has unrestricted access to the slope. Even flatter slopes (viz., 1 V to 10H) should be considered if vehicle access is required into the channel. Stone protection and appropriate bedding should be provided on the slope face. Surface drainage features should also be provided to prevent erosion from surface runoff. Topsoil from stripping operations should be stockpiled ands spread over the excavated slope after excavation has been completed. This will provide a good base for vegetative growth.

13.0 CONCLUSIONS

13.1 Soils:

In general, the on-site soils consist primarily of coarse-grained materials overlying fine-grained soils, although about 15% of the drill holes did not encounter any fine-grained materials to the bottom of the drill hole. About 85% of the drill holes encountered at least one layer of fine-grained materials underlying the surficial coarse-grained layer. In theses drill holes, the overlying coarse-grained materials ranged from about 3-ft thick to about 27-ft thick, averaging about 14-ft thick. The average depth of the fine-grained layer immediately underlying the surficial coarse-grained layer was about 13-ft, although it was encountered at a depth of 3-ft to a depth of 28.5-ft in the drill hole. This fine-grained layer ranged from about 1.5-ft to about 27-ft thick, averaging about 12-ft thick. A second, lower coarse-grained layer was encountered in about 45% of the drill holes. The average depth of this lower, second coarse-grained layer was about 19-ft, although it was encountered at a depth of 6-ft to a depth of 28.5-ft in the drill hole. A second, lower fine-grained layer and a third, lower coarse-grained layer was detected in about 9% and 4% of the drill holes, respectively. Where detected, the thickness of the second, lower fine-grained layer was about 12-ft and the thickness of the third, lower coarse-grained layer was about 7-ft.

The coarse-grained soils consisted primarily of sand size particles, although minor amounts of gravel and silt or clay size particles were also typically found within the coarse-grained soils. The coarse-grained soils are typically very poorly sorted and the distributions are often skewed to the finer sized portion. The soil distributions were often leptokurtic (excessively peaked). Although some platykurtic (flatten) type distributions were also observed. Coefficient of Uniformity and Coefficient of Curvature analyses also suggest that the coarse-grained soils are non-uniform and well-graded, respectively. Based upon blows counts from the drilling and sampling program, the relative density of the coarse-grained soils suggests that the soil be classified as 'loose,' although some 'very loose' and 'dense' soils were also encountered.

The fine-grained soils consisted primarily of silt or clay size particles, although some minor amounts of fine and medium sand as also typically sound in the fine-grained soils. The fine-grained soils are often highly plastic (PI>15) and may have a tendency to swell. The typically high Activity Index of the fine-grained soils classifies it as an 'active' clay. Active clays are typically highly expansive and are the most troublesome in slopes and beneath structural foundations. Several samples of fine-grained soils has LI >1.0, which suggests that portions of these soils are already at its liquid limit water content and is extremely soft. High Liquid Limits (LL) and high clay (2μ size) content suggests that these soils are very cohesive and sticky. Based upon blows counts from the drilling and sampling program, much of the fine-grained soils are weight-of-rod or low blow count materials. This suggests that the in-situ consistency of the fine-grained soils soil is 'very soft' to 'occasionally 'soft.'

Based upon USDA soil textures classifications, the coarse–grained soils are typically in the Group A Hydrologic Soil Group. Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr). Based upon USDA soil textures classifications, the fine–grained soils are typically in the Group B and C Hydrologic Soil Groups. Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Base upon empirical relationships (viz., Hazen Approximation Method), the coarse-grained soils have an estimated Hydraulic Conductivity (K) of about 1.87 cm/sec.

13.2 Groundwater:

Groundwater depth range from about 1.3-ft below existing grade to about 12.1-ft below existing grade, as measured from the eighteen piezometers installed through out the site. Maximum fluctuations in groundwater levels up to 3.12-ft were observed in the piezometers.

The highest groundwater elevation was typically observed in piezometer No. LSP-03-09 and the lowest groundwater elevation was typically observed in piezometer No. LSP-03-04. This suggest that groundwater flows across the site away from LSP-03-09 and towards LSP-03-04.

Groundwater gradients are typically very flat. As such, relatively minor differences in groundwater readings between adjacent piezometers may impact the groundwater contour maps.

Groundwater flow direction and average gradient calculations using LMNO Groundwater Flow Direction and Gradient Calculator software suggests that groundwater flow direction is about N35°. Based upon this analysis, groundwater flows across the site and discharges toward the adjacent Morris Canal.

13.3 Subsurface Conditions:

Near surface excavation of this material should present no unusual excavation problems. However, deeper excavations, notably excavation of the Ecochannel in the vicinity of the North Cove, may present excavation problems. The presence of 'Active' clays may become result in stability and foundation problems in slopes and beneath structures.

The presence of soft, fine-grained soils may cause excavation problems due to its very soft consistency, which may result in slumping of cuts and corresponding problems with maintaining channel grade control, its ability to stick to excavating equipment and tools, and its ability to deform and maintain excess pore pressure. Earthmoving type construction equipment may not be able to operate directly on this material.

Since the site is bounded by surface water on two separate sides, the impact of groundwater on any excavations may be significant. As such, dewatering of excavations may be required to allow construction.

Slopes of 1 vertical to 3 horizontal are recommend to ensure safety of maintenance personal that may be required to work on the slope (viz., grass moving) or where the general public has unrestricted access to the slope. Even flatter slopes (viz., 1 V to 10H) should be considered if vehicle access is required into the channel.

Stone protection and appropriate bedding should be provided on the slope face. Surface drainage features should also be provided to prevent erosion from surface runoff. Topsoil from stripping operations should be stockpiled ands spread over the excavated slope after excavation has been completed to provide a good base for vegetative growth.

14.0 RECOMMENDATIONS

14.1 Long Term Groundwater Monitoring fluctuations in groundwater levels should be studied in depth. Short-term, tidal, seasonal, and long-term fluctuations in groundwater may have a significant impact on wetlands. Fluctuations in groundwater can drastically impact the development and ecological integrity of wetlands. It is recommended that additional investigations be made into documenting and understanding the short-term, tidal, seasonal, and long-term fluctuations of groundwater at the Liberty State Park site.

14.2 Any future groundwater studies should also attempt to determine the 3D groundwater flow system including the local, intermediate, regional system, as well as the presence of stagnation points in the flow regime. 3D groundwater flow patterns can be quite complex at both small and large scales. The groundwater-surface water interaction may be the key to understanding the groundwater flow regime at Liberty State Park. Given the transit nature of groundwater flow patterns, as well as the complexities of groundwater flow patterns at both large and small scales, a good conceptualization of groundwater flow patterns is required for design.

14.3 Since the project site is bounded on two by water, dewatering during construction will probably be required. In order to better predict dewatering requirements, it is recommended that additional field investigations be undertaken to confirm the empirical hydraulic conductivity's presented in this report. Hydraulic conductivity testing may be conducted using 'slug' tests performed within the existing

piezometers and analyzed using a suitable analytical method, such as Horslev or Bouwer and Rice.

15.0 REFERENCES

15.1 Required Publications

ASTM D 420
Standard Guide for Investigating and Sampling Soil and Rock

ASTM D 653
Standard Terminology Relating to Soil, Rock, and Contained Fluids

ASTM D 854
Standard Test Method for Specific Gravity of Soils

ASTM D 1542
Standard Practice for Soil Investigation and Sampling by Auger Borings

ASTM D 1586
Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils

ASTM D 1587
Standard Practice for Thin-Walled Tube Sampling of Soils

ASTM D 2487
Standard Test Method for Classification of Soils for Engineering Purposes (USCS)

ASTM D 2488
Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

ASTM D 4220
Standard Practices for Preserving and Transporting Soil Samples

ASTM D 4220
Standard Practices for Handling, Storing, and Preparing Soft Undisturbed Marine Soil

ASTM D 5088
Standard Practices Decontamination of Field Equipment Used at Nonradioactive Waste Sites

EM 200-1-3
Requirements for the Preparation of Sampling and Analysis Plans

EM 1110-1-1802
Soil Sampling

EM 1110-1-1804
Geotechnical Investigations

EM 1100-2-1906
Laboratory Soils Testing

EM 1110-2-2504
Design of Sheet Pile Walls

ER 1105-2-100
Planing Guidance Notebook

TM 5-818-7
Foundations in Expansive Soils

Soil Mechanics - Design Manual 7.1
Naval Facilities Engineering Command, Department Of The Navy, Alexandria, VA, 1974.

"Quality Assurance Plan," US Army Corps of Engineers, Baltimore District, Engineering Division, Geotechnical Branch, Materials and Instrumentation (Soils Lab) Unit. July 2003.

15.2 Online Publications

Australian Soil Resources Information System [online],
http://audit.ea.gov.au/ANRA/agriculture/docs/national/Agriculture_ASRIS_shc.html
March 2004

Groundwater Flow Direction and Gradient Calculator [online],
LMNO Engineering, Research, and Software, Ltd.,
http://www.lmnoeng.com/Groundwater/gradient.htm
March 2004

Soil Classification and Properties [online],
http://www.dot.ca.gov/hq/esc/construction/Manuals/TrenchingandShoring/ch3_soil.pdf
March 2004

USDA NRCS Soils web site [online],
http://soils.usda.gov/
March 2004

Grain Size Distribution and Hydraulic Properties, Pfannkuch, HO & Paulson, R. [online], http://www.cs.pdx.edu/~ian/geology2.5.html
March 2004

Soil Classification [online], http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/5-410/Ch5.htm
March 2004

Sediment Analysis - Graphical presentation and statistics [online], http://www.lifesciences.napier.ac.uk/teaching/MB/phidiag01.html
March 2004

Policy Directive 2003-03 [online], April 24, 2003, http://www.nj.gov/dep/commissioner/policy/pdir2003-03.htm
March 2004

New Jersey Geological Survey [online], http://www.state.nj.us/dep/njgs/
March 2004

Soil Classification [online], http://fbe.uwe.ac.uk/public/geocal/SoilMech/classification/class_menu.htm
March 2004

Geological Map of New Jersey [online], http://www.meadowlands.state.nj.us/ec/professional/ci-geo-map.gif
March 2004

Groundwater Flow Patterns Near Surface Water Bodies, Meigs, L. C., [online], http://www.wef.org/pdffiles/TMDL/Meigs.pdf
March 2004

15.3 Referenced Publications

Fetter, C. W., *Applied Hydrogeology*, 4th ed., Prentice Hall, NJ, (2001).

Fetter, C. W., *Contaminant Hydrogeology*, Prentice Hall, NJ, (1993).

Folk, R. L., and Ward, W. C, Brazos River Bar: A Study of the Significance of Grain-Size Parameters; *J. Sediment. Petrology*, 27:3-26, (1957).

Freeze, R. A. and J. A. Cherry, Groundwater, Prentice Hall, (1979).

Hazen, A., Some Physical Properties of Sands and Gravel, *Massachusetts State Board of Health, Annual Report*, (1892).

Hunt, R. E., Geotechnical Engineering Investigation Manual, McGraw-Hill, NY, (1983).

Krumbein, W. C. and Monk, G. D., "Permeability as a Function of Size o Parameters of Unconsolidated Sand," *Transactions of the American Institute of Mining, Metallurgical and Petroleum Engineers*, v. 151, p. 153-163, (1943).

Peck, R. A., Foundation Engineering, John Wiley & Sons, Inc., New York, (1953).

Rawls, W. J., Brakenseik, D.L., and K. E. Saxton, K.E., Estimation of soil water properties. *Trans. ASAE* 25:1316-1320, (1982).

Sanders, L. L., A Manual of Field Hydrogeology, Prentice Hall, (1998).

Skempton, A. W., "The Colloidal Activity of Clays," *Proc. 3d. Intl. Conf. Soil Mechs. and Found. Engrg.*, Switzerland, Vol. I, pp. 57-61, (1953).

Sowers, G. F., Introductory Soil Mechanics and Foundations: Geotechnical Engineering, MacMillan Publishing Co, NY, (1979).

EM 1110-2-1100, Coastal Engineering Manual Part III, (April 2002).

US Army Military Soil Engineering, Field Manual 5-410, (1997).

TABLES

TABLE 1

LIBERTY STATE PARK
SUMMARY OF DRILLING AND SAMPLING PROGRAM

DRILL HOLE NO.	TOTAL DEPTH OF DH (FT)	NO. OF DISTURBED SAMPLES	USCS SOIL CLASSIFICATIONS TYPES FOUND IN DRILL HOLE
LSP-03-01	26.4	18	SM, GP-GM, SP-SM, GM, SP
LSP-03-02	30.0	20	CL, SM, SP-SM
LSP-03-03	30.0	20	CL, SM, SP-SM, SM
LSP-03-04	30.0	20	SM, GM, CH
LSP-03-05	30.0	20	SM, SP-SM, GP-GM, SM, CH
LSP-03-06	30.0	20	SM, SC, SP-SM
LSP-03-07	30.0	20	SP-SM, GM, SM, CH, SC
LSP-03-08	30.0	20	SP-SM, CH, SM
LSP-03-09	30.0	20	SM, SP-SM, CH, SC, ML, GM
LSP-03-10	30.0	20	SM, SP-SM, CL, CH
LSP-03-11	30.0	20	SM, SP-SM, CH, SC
LSP-03-12	30.0	20	CL, SM, SC, CH, SC
LSP-03-13	21.3	15	SM, SC/SM, SC/GC
LSP-03-14	27.9	19	SM, SC, SM/SC, SP-SM
LSP-03-15	30.0	20	SM, GP-GM, SM, CL/ML
LSP-03-16	30.0	20	SP-SM, SM, CH, SC
LSP-03-17	30.0	20	SM, SM/SC, SC, CH
LSP-03-18	30.0	20	CL, SM, CH
LSP-03-19	30.0	20	SM, GM, CL/CH, CH
LSP-03-20	30.0	20	SM, CL/CH, CH
LSP-03-23	30.0	23	SM, GM, CH, SC, SP-SM
LSP-03-24	30.0	20	SM, CL, CH
LSP-03-25	30.0	20	SM, SC, CH, SP-SM
LSP-03-26	27.0	18	SM, SP-SM, CH
LSP-03-27	30.0	20	SM, SP-SM, ML, CH. CL
LSP-03-28	30.0	20	SM, SP-SM, CL/CH, CH
LSP-03-29	30.0	20	SP-SM, SC, CH, SM
LSP-03-30	30.0	20	SM, SP-SM, CL/ML, CH
LSP-03-31	30.0	20	SM, SP-SM, CH
LSP-03-32	30.0	20	SM, CL, CL/CH, CH, SC
LSP-03-33	30.0	20	SP-SM, SM, CH, SC
LSP-03-34	30.0	20	SM, CH, SC, SC/SM
LSP-03-35	30.0	20	SM, SP-SM, CL
LSP-03-36	30.0	20	SC/SM, SM, CH, SC, CL/SC, OL
LSP-03-37	30.0	20	SM, SP-SM, CH
LSP-03-38	30.0	20	SM, ML, CL, CH, SC
LSP-03-39	30.0	20	SM, GM, CH, SP-SM
LSP-03-40	30.0	20	SP-SM, SM, CL, SP

TABLE 1 - Continued

LIBERTY STATE PARK
SUMMARY OF DRILLING AND SAMPLING PROGRAM

DRILL HOLE NO.	TOTAL DEPTH OF DH (FT)	NO. OF DISTURBED SAMPLES	USCS SOIL CLASSIFICATIONS TYPES FOUND IN DRILL HOLE
NC-04-01	21.0	13	SM, CL, CH
NC-04-02	21.0	12	SM, CL, CH
NC-04-03	21.0	14	SM, SP-SM, ML
NC-04-04	21.0	14	SM, SP-SM
NC-04-05	21.0	14	SM SP-SM
CA-04-01	30.0	20	CL, SM, SP-SM, CL, CH
CA-04-02	30.0	20	ML/CL, CL, SM, SC, CH
CA-04-03	30.0	20	SM, ML, CL, SP, SP-SM, CH
CA-04-04	30.0	20	CL, SC, SM, SP-SM, CH
CA-04-05	30.0	20	CL, SM, ML, CL, CH
CA-04-06	30.0	20	SM, SP-SM, CL, CH
BA-04-01	20.0	0	--
BA-04-02	20.0	0	--
BA-04-03	20.0	0	--
BA-04-04	20.0	0	--
BA-04-05	20.0	0	--
BA-04-06	20.0	0	--

TABLE 2

LIBERTY STATE PARK
DRILL HOLE LOCATIONS AND ELEVATIONS
FOR ON-LAND DRILL HOLES

DH No.	NORTH	EAST	ELEVATION
LSP-03-01	683,832.04799	616,002.71436	6.90
LSP-03-02	683,517.39349	616,362.32508	7.37
LSP-03-03	683,192.86435	617,998.45475	7.05
LSP-03-04	682,884.30817	618,440.32038	5.04
LSP-03-05	682,589.50605	618,535.55579	9.78
LSP-03-06	682,834.70794	615,902.61584	7.56
LSP-03-07	682,579.04042	616,800.74738	6.53
LSP-03-08	682,280.46765	615,978.02068	6.73
LSP-03-09	682,011.33382	614,834.20085	11.59
LSP-03-10	681,879.57853	616,168.43446	9.05
LSP-03-11	681,149.50173	615,521.93873	7.91
LSP-03-12	681,514.54832	616,749.81368	8.70
LSP-03-13	683,740.03234	615,450.41968	9.86
LSP-03-14	683,756.67291	615,727.44005	7.96
LSP-03-15	683,548.61749	616,161.41928	7.13
LSP-03-16	683,160.30583	616,573.93342	6.64
LSP-03-17	682,979.20081	616,986.62282	6.80
LSP-03-18	682,828.57477	617,431.15663	9.09
LSP-03-19	682,477.62098	617,933.68717	7.38
LSP-03-20	682,601.90390	618,859.81917	9.85
LSP-03-23	682,551.80450	616,198.14123	6.35
LSP-03-24	682,189.16123	617,249.39812	10.31
LSP-03-25	682,458.36113	615,633.10481	6.42
LSP-03-26	682,185.59132	616,344.21849	6.67
LSP-03-27	682,017.45506	616,742.15925	7.61
LSP-03-28	681,500.67515	617,241.07892	7.45
LSP-03-29	681,837.12062	615,662.27604	7.65
LSP-03-30	681,511.76718	616,267.23026	7.58
LSP-03-31	681,126.57585	616,796.39857	7.16
LSP-03-32	680,562.33551	614,827.67803	8.15
LSP-03-33	680,802.27112	615,968.93213	6.69
LSP-03-34	680,785.98830	614,318.55425	13.16
LSP-03-35	681,672.48762	613,786.85158	12.46
LSP-03-36	681,220.83780	614,399.82904	11.85
LSP-03-37	680,938.00510	614,681.62305	10.89
LSP-03-38	680,654.67995	615,601.34192	9.44
LSP-03-39	683,052.44778	616,234.58076	7.55
LSP-03-40	682,836.04028	616,405.06099	6.24

TABLE 2 - Continued

LIBERTY STATE PARK
DRILL HOLE LOCATIONS AND ELEVATIONS
FOR ON-LAND DRILL HOLES

DH No.	NORTH	EAST	ELEVATION
NC-04-03	682,544.63	618,700.83	6.41
NC-04-04	682,668.42	618,819.14	6.43
NC-04-05	682,601.71	619,002.72	7.41
CA-04-01	682,986.23	617,851.94	9.16
CA-04-02	682,731.06	617,641.69	8.80
CA-04-03	682,461.27	617,438.02	10.02
CA-04-04	681,938.08	617,114.38	9.24
CA-04-05	681,689.74	616,900.75	9.30
CA-04-06	681,256.92	616,603.32	6.57
BA-04-01	682,153.40	615,159.08	7.11
BA-04-02	681,882.18	614,686.79	7.41
BA-04-03	681,669.09	614,566.37	9.35
BA-04-04	681,444.47	614,574.94	8.22
BA-04-05	681,162.64	614,663.81	11.34
BA-04-06	680,961.88	614,884.18	9.11

NOTES:
1. Final DH coordinates were obtained using an Ashtech ProMark2 GPS survey system.
2. Conversions obtained using Corpscon for Windows 5.11.08.
3. Horizontal Datum: State Plane, NAD83, Geographic NAD83.
4. Horizontal Zone: New Jersey – 2900 Horizontal Units: U.S. Survey Feet.

TABLE 3

LIBERTY STATE PARK
DRILL HOLE LOCATIONS AND WATER DEPTHS
FOR OFF-SHORE DRILL HOLES

DH No.	NORTH	EAST	WATER DEPTH
NC-04-01	682,441.45	618,911.02	7.90
NC-04-02	682,302.23	619,381.51	5.40

TABLE 4

LIBERTY STATE PARK
SUMMARY OF THE GEOTECHNICAL LABORATORY TESTING PROGRAM

NOMENCLATURE	NO. OF TESTS COMPLETED
Visual–Manual Classifications	958
Water Contents	68
Atterberg Limits	30
Mechanical Analysis (with hydrometer)	68

TABLE 5

LIBERTY STATE PARK
SUMMARY OF USCS SOIL TYPES ENCOUNTERED IN ALL DRILL HOLES FROM 0.0-FT TO BOTTOM OF DRILL HOLE

USCS SOIL CLASSIFICATION	PERCENTAGE OF USCS SOIL TYPE ENCOUNTERED DURING DRILLING
GM (silty GRAVEL)	1%
GP-GM (GRAVEL w/silt)	1%
SP (poorly graded SAND)	1%
SP-SM (SAND w/silt)	14%
SM or SC (silty/clayey SAND)	44%
CL/ML (lean CLAY)	7%
CH/MH (fat CLAY)	32%

* Note: Excludes the Two Off-Shore Drill Holes (NC-04-01 & NC-04-02).

TABLE 6

LIBERTY STATE PARK
SUMMARY OF USCS SOIL TYPES ENCOUNTERED IN ALL DRILL HOLES FROM 0.0-FT TO 10.5-FT DEPTH

USCS SOIL CLASSIFICATION	PERCENTAGE OF USCS SOIL TYPE ENCOUNTERED DURING DRILLING
GM (silty GRAVEL)	2%
GP-GM (GRAVEL w/silt)	1%
SP (poorly graded SAND)	0%
SP-SM (SAND w/silt)	18%
SM or SC (silty/clayey SAND)	66%
CL/ML (lean CLAY)	8%
CH/MH (fat CLAY)	5%

* Note: Excludes the Two Off-Shore Drill Holes (NC-04-01 & NC-04-02).

TABLE 7

LIBERTY STATE PARK
SUMMARY OF USCS SOIL TYPES ENCOUNTERED IN ALL DRILL HOLES FROM 0.0-FT TO 4.5-FT DEPTH

USCS SOIL CLASSIFICATION	PERCENTAGE OF USCS SOIL TYPE ENCOUNTERED DURING DRILLING
GM (silty GRAVEL)	2%
GP-GM (GRAVEL w/silt)	1%
SP (poorly graded SAND)	0%
SP-SM (SAND w/silt)	21%
SM or SC (silty/clayey SAND)	67%
CL/ML (lean CLAY)	9%
CH/MH (fat CLAY)	0%

* Note: Excludes the Two Off-Shore Drill Holes (NC-04-01 & NC-04-02).

TABLE 8

LIBERTY STATE PARK
SUMMARY OF USCS SOIL TYPES ENCOUNTERED IN THE OFF-SHORE DRILL HOLES* FROM 0.0-FT TO BOTTOM OF DRILL HOLE

USCS SOIL CLASSIFICATION	PERCENTAGE OF USCS SOIL TYPE ENCOUNTERED DURING DRILLING
GM (silty GRAVEL)	0%
GP-GM (GRAVEL w/silt)	0%
SP (poorly graded SAND)	0%
SP-SM (SAND w/silt)	0%
SM or SC (silty/clayey SAND)	8%
CL (lean CLAY)	8%
CH (fat CLAY)	84%

* Note: Drill Hole Nos. NC-04-01 and NC-04-02.

TABLE 9

LIBERTY STATE PARK
GENERAL SUMMARY OF THE GEOTECHNICAL LABORATORY TESTING RESULTS

DH No.	Sample Depth (ft)	USCS	NatW%	%Gravel	%Sand	%Fines	%Clay	LL	PL	PI	LI	AI
LSP-03-01	3.0-4.5	SM	37.5	26.0	51.7	22.3	0	--	--	--	--	--
LSP-03-02	4.5-6.0	SM	32.7	11.5	50.1	38.4	0	--	--	--	--	--
LSP-03-03	4.5-6.0	GM	15.8	53.6	32.5	13.9	0	--	--	--	--	--
	24.0-25.5	CH	54.2	0.0	4.8	95.2	15	68	30	38	0.64	2.53
LSP-03-04	4.5-6.0	SM	29.6	24.8	56.9	18.3	0	--	--	--	--	--
	10.5-12.0	CH	57.1	7.0	9.4	83.6	25	68	31	37	0.71	1.48
LSP-03-05	4.5-6.0	GP-GM	9.6	50.5	42.8	6.7	0	--	--	--	--	--
	9.0-10.5	MH	60.5	2.6	35.2	62.2	14	74	39	35	0.61	2.50
LSP-03-06	3.0-4.5	GM	11.4	42.0	36.7	21.3	0	--	--	--	--	--
LSP-03-07	4.5-6.0	SM	30.9	32.8	53.1	14.1	0	--	--	--	--	--
	10.5-12.0	MH	55.6	1.2	6.3	92.5	23	64	32	32	0.74	1.39
LSP-03-08	7.5-9.0	CH	47.9	0.0	12.7	87.3	27	62	28	34	0.59	2.62
LSP-03-09	4.5-6.0	CH	66.1	0.0	8.5	91.5	27	72	32	40	0.85	1.48
LSP-03-10	15.0-16.5	CH	64.0	6.1	9.8	84.1	25	75	32	43	0.74	1.72
LSP-03-11	3.0-4.5	SP-SM	20.5	1.9	91.1	7.0	0	--	--	--	--	--
LSP-03-12	18.0-19.5	CH	58.2	0.2	21.3	78.5	22	64	30	34	0.83	1.55
LSP-03-13	6.0-7.5	ML	22.2	0.0	32.4	67.6	0	--	--	--	--	--
LSP-03-14	15.0-16.5	ML	21.1	0.0	44.0	56.0	0	--	--	--	--	--
LSP-03-15	1.5-3.0	GW-GM	6.0	65.2	26.0	8.8	0	--	--	--	--	--
	7.5-9.0	SM	39.8	26.0	49.9	24.1	0	--	--	--	--	--
LSP-03-16	1.5-3.0	SM	29.4	19.5	62.4	18.1	0	--	--	--	--	--
	18.0-19.5	CH	52.7	0.0	10.0	90.0	30	74	31	43	0.50	1.43
LSP-03-17	3.0-4.5	SW-SM	26.5	24.4	65.1	10.5	0	--	--	--	--	--
	22.5-24.0	MH	65.3	0.9	7.3	91.8	30	75	35	40	0.76	1.33

TABLE 9 - Continued

LIBERTY STATE PARK
GENERAL SUMMARY OF GEOTECHNICAL LABORATORY TESTING RESULTS

DH No.	Sample Depth (ft)	USCS	NatW%	%Gravel	%Sand	%Fines	%Clay	LL	PL	PI	LI	AI
LSP-03-18	4.5-6.0	SM	23.9	22.7	63.2	14.1	0	--	--	--	--	--
	12.0-13.5	CH	51.0	0.0	6.8	93.2	26	65	31	34	0.59	1.31
LSP-03-19	4.5-6.0	SM	38.0	16.3	66.3	17.4	0	--	--	--	--	--
	21.0-22.5	ML	55.3	0.0	3.4	96.6	29	69	32	37	0.63	1.28
LSP-03-20	1.5-3.0	SP-SM	3.6	1.6	88.6	9.8	0	--	--	--	--	--
	21.0-22.5	CH	75.7	0.0	11.8	88.2	24	92	38	54	0.70	2.25
LSP-03-23	10.5-12.0	MH	61.6	0.0	5.1	94.9	31	81	38	43	0.55	1.39
LSP-03-24	6.0-7.5	SM	32.7	27.6	57.5	14.9	0	--	--	--	--	--
	13.5-15.0	CL	52.8	0.0	13.2	86.8	24	49	27	22	1.17	0.92
LSP-03-25	13.5-15.0	CH	68.7	0.4	4.8	94.8	34	83	36	47	0.70	1.38
LSP-03-26	10.5-12.0	CH	69.8	0.0	1.3	98.7	26	80	35	45	0.77	1.73
LSP-03-27	4.5-6.0	SM	20.9	0.3	87.4	12.3	0	--	--	--	--	--
	12.0-13.5	CH	59.4	0.0	4.2	95.8	31	69	33	36	0.73	1.16
LSP-03-28	4.5-6.0	SM	17.6	3.3	76.2	20.5	0	--	--	--	--	--
LSP-03-29	3.0-4.5	SP-SM	22.9	2.4	91.0	6.6	0	--	--	--	--	--
LSP-03-30	1.5-3.0	SP-SM	12.6	0.0	90.8	9.2	0	--	--	--	--	--
LSP-03-31	3.0-4.5	SM	16.2	1.5	86.2	12.3	0	--	--	--	--	--
	13.5-15.0	SC-H	38.0	9.5	40.6	49.9	12	55	28	27	0.37	2.25
LSP-03-32	3.0-4.5	SM	21.0	20.6	55.8	23.6	0	--	--	--	--	--
LSP-03-33	10.5-12.0	ML	49.9	0.0	4.7	95.3	4	46	33	13	1.30	3.25
LSP-03-34	3.0-4.5	SM	9.2	14.8	62.1	23.1	0	--	--	--	--	--
LSP-03-35	4.5-6.0	SM	14.3	14.9	66.1	19.0	0	--	--	--	--	--
LSP-03-36	16.5-18.0	CH	45.2	0.0	17.4	82.6	20	56	28	28	0.61	1.40

TABLE 9 - Continued

LIBERTY STATE PARK
GENERAL SUMMARY OF GEOTECHNICAL LABORATORY TESTING RESULTS

DH No.	Sample Depth (ft)	USCS	NatW%	%Gravel	%Sand	%Fines	%Clay	LL	PL	PI	LI	AI
LSP-03-37	3.0-4.5	SM	22.6	0.3	77.3	22.4	0	--	--	--	--	--
LSP-03-38	19.5-21.0	CH	63.4	0.0	6.0	94.0	19	74	32	42	0.75	2.21
LSP-03-39	9.0-10.5	SM	52.1	2.5	71.3	26.2	0	--	--	--	--	--
LSP-03-40	4.5-6.0	SM	38.1	28.9	52.8	18.3	0	--	--	--	--	--
NC-04-01	4.5-6.0	CH	125.0	0.0	6.0	94.0	26	84	37	47	1.87	1.81
NC-04-02	3.0-4.5	MH	103.5	1.3	6.7	92.0	18	82	39	43	1.50	2.39
NC-04-03	1.5-3.0	SM	9.6	20.4	57.9	21.7	0	--	--	--	--	--
NC-04-04	1.5-3.0	SM	8.7	7.2	67.3	25.5	0	--	--	--	--	--
NC-04-05	4.5-6.0	SP-SM	8.9	43.5	46.9	9.6	0	--	--	--	--	--
CA-04-01	7.5-9.0	SW-SM	18.2	24.6	67.1	8.3	0	--	--	--	--	--
	18.0-19.5	CH	59.7	0.5	8.7	90.8	19	54	29	25	1.23	1.32
CA-04-02	4.5-6.0	SM	37.8	16.8	68.3	14.9	0	--	--	--	--	--
	15.0-16.5	MH	70.0	0.0	7.7	92.3	17	60	35	25	1.40	1.47
CA-04-03	4.5-6.0	SW-SM	31.1	24.9	64.8	10.3	0	--	--	--	--	--
	19.5-21.0	CH	53.8	0.5	16.6	82.9	16	56	29	27	0.92	1.69
CA-04-04	9.0-10.5	SW-SM	25.4	19.3	70.0	10.7	0	--	--	--	--	--
	15.0-16.5	MH	60.9	4.8	12.2	83.0	14	54	31	23	1.30	1.64
CA-04-05	7.5-9.0	SM	26.5	10.0	55.3	34.7	0	--	--	--	--	--
	15.0-16.5	MH	54.9	1.0	5.9	93.1	16	51	29	22	1.18	1.38
CA-04-06	3.0-4.5	SP-SM	23.6	0.5	91.0	8.5	0	--	--	--	--	--
	13.5-15.0	CH	59.4	0.0	6.0	94.0	24	52	27	25	1.30	1.04
							Average	*67*	*32*	*35*	*0.88*	*1.66*
							Maximum	*92*	*39*	*54*	*1.87*	*3.25*
							Minimum	*46*	*27*	*13*	*0.37*	*0.92*

TABLE 10

LIBERTY STATE PARK
GRAIN SIZE DISTRIBUTION SUMMARY FOR COARSE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	%Coarse Gravel	%Fine Gravel	%Coarse Sand	%Medium Sand	%Fine Sand	%Silt or Clay
LSP-03-01	3.0-4.5	SM	0.0	26.0	8.9	22.4	20.4	22.3
LSP-03-02	4.5-6.0	SM	0.0	11.58	3.1	17.5	29.5	38.4
LSP-03-03	4.5-6.0	GM	30.6	23.0	6.5	10.4	15.6	13.9
LSP-03-04	4.5-6.0	SM	0.0	24.8	10.2	18.7	28	18.3
LSP-03-05	4.5-6.0	GP-GM	7.2	43.3	11.1	17.9	13.8	6.7
LSP-03-06	3.0-4.5	GM	26.5	15.5	4.7	13.8	18.2	21.3
LSP-03-07	4.5-6.0	SM	15.3	17.5	8.1	21.3	23.7	14.1
LSP-03-11	3.0-4.5	SP-SM	0.0	1.9	1.8	26.7	62.6	7.0
LSP-03-15	1.5-3.0	GW-GM	41.7	23.5	5.1	10.1	10.8	8.8
LSP-03-15	7.5-9.0	SM	3.8	22.2	4.8	18.5	26.6	24.1
LSP-03-16	1.5-3.0	SM	0.0	22.7	17.1	26.1	20.0	14.1
LSP-03-17	3.0-4.5	SW-SM	11.5	12.9	12.2	33.3	19.6	10.5
LSP-03-18	4.5-6.0	SM	0.0	22.7	17.1	26.1	20.0	14.1
LSP-03-19	4.5-6.0	SM	0.0	16.3	16.1	30.7	19.5	17.4
LSP-03-20	1.5-3.0	SP-SM	0.0	1.6	3.6	35.9	49.1	9.8
LSP-03-24	6.0-7.5	SM	4.5	23.1	11.3	25.7	20.5	14.9
LSP-03-27	4.5-6.0	SM	0.0	0.3	1.7	24.0	91.7	12.3
LSP-03-28	4.5-6.0	SM	0.0	3.3	9.0	45.5	21.7	20.5
LSP-03-29	3.0-4.5	SP-SM	0.0	2.4	0.2	22.8	68.0	6.6
LSP-03-30	1.5-3.0	SP-SM	0.0	0.0	0.0	24.9	65.9	9.2
LSP-03-31	3.0-4.5	SM	0.0	1.5	1.3	23.8	61.1	12.3
	13.5-15.0	SC-H	0.0	9.5	9.3	21.6	9.7	49.9

TABLE 10 - Continued

LIBERTY STATE PARK
GRAIN SIZE DISTRIBUTION SUMMARY FOR COARSE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	%Coarse Gravel	%Fine Gravel	%Coarse Sand	%Medium Sand	%Fine Sand	%Silt or Clay
LSP-03-32	3.0-4.5	SM	5.1	15.5	5.4	21.5	28.9	23.6
LSP-03-34	3.0-4.5	SM	0.0	14.8	7.0	22.1	33.0	23.1
LSP-03-35	4.5-6.0	SM	0.0	14.9	11.5	24.7	29.9	19.0
LSP-03-37	3.0-4.5	SM	0.0	0.3	0.3	3.5	73.5	22.4
LSP-03-39	9.0-10.5	SM	0.0	2.5	6.0	30.1	35.2	26.2
LSP-03-40	4.5-6.0	SM	9.1	19.8	8.3	20.4	24.1	18.3
NC-04-03	1.5-3.0	SM	0.0	20.4	7.3	16.4	34.2	21.7
NC-04-04	1.5-3.0	SM	0.0	7.2	6.5	15.4	45.4	25.5
NC-04-05	4.5-6.0	SP-SM	22.2	21.3	8.6	19.1	19.2	9.6
CA-04-01	7.5-9.0	SW-SM	0.0	24.6	16.4	31.9	18.8	8.3
CA-04-02	4.5-6.0	SM	0.0	16.8	20.8	28.7	18.8	14.9
CA-04-03	4.5-6.0	SW-SM	0.0	24.9	22.0	25.0	17.8	10.3
CA-04-04	9.0-10.5	SW-SM	6.2	13.1	7.0	18.1	44.9	10.7
CA-04-05	7.5-9.0	SM	0.0	10.0	4.5	16.4	34.4	34.7
CA-04-06	3.0-4.5	SP-SM	0.0	0.5	0.9	16.2	73.9	8.5
		Average	*2.66*	*12.91*	*8.28*	*19.34*	*33.25*	*17.30*
		Maximum	*41.70*	*43.30*	*22.00*	*45.50*	*91.70*	*49.90*
		Minimum	*0.00*	*0.00*	*0.00*	*3.50*	*9.70*	*6.60*

TABLE 11

LIBERTY STATE PARK
SEDIMENT SIZE DISTRIBUTION FOR SELECTED COARSE-GRAINED SOILS
USING THE FOLK & WARD METHOD

DRILL HOLE No.	SAMPLE DEPTH (ft)	GM_e GEOMETRIC MEAN SIZE D_{50} (mm)	STANDARD DEVIATION	DESCRIPTION	COEFF. of SKEWNESS (*Sk*)	DESCRIPTION	COEFF. of KURTOSIS (*K*)	DESCRIPTION
NC-04-03	1.5-3.0	0.45	3.92	Very poorly sorted	-0.05	Near-symmetrical	1.03	Mesokurtic
NC-04-04	1.5-3.0	0.21	3.16	Very poorly sorted	0.01	Near-symmetrical	1.43	Leptokurtic
NC-04-05	4.5-6.0	2.11	3.30	Very poorly sorted	0.21	Fine-skewed	0.70	Platykurtic
CA-04-01	7.5-9.0	1.27	2.63	Very poorly sorted	0.15	Fine-skewed	0.89	Platykurtic
CA-04-02	4.5-6.0	1.12	3.26	Very poorly sorted	0.36	Fine-skewed	1.13	Leptokurtic
CA-04-03	4.5-6.0	1.21	2.44	Very poorly sorted	0.24	Fine-skewed	0.70	Platykurtic
CA-04-04	9.0-10.5	0.68	3.25	Very poorly sorted	-0.25	Coarse-skewed	1.27	Leptokurtic
CA-04-05	7.5-9.0	0.18	2.49	Very poorly sorted	-0.07	Near-symmetrical	1.24	Leptokurtic
CA-04-06	3.0-4.5	0.25	1.15	Poorly sorted	0.18	Fine-skewed	1.56	Very Leptokurtic

*Reference: EM 1110-2-1100 Part III, 30 Apr 02.

TABLE 12

LIBERTY STATE PARK
COEFFICIENT OF UNIFORMITY (C_u) AND COEFFICIENT OF CURVATURE (C_k) FOR SELECTED SOIL SAMPLES

DH No.	Sample Depth (ft)	USCS	D_{10} SIZE (mm)	D_{60} SIZE (mm)	C_u	D_{30} SIZE (mm)	C_k
CA-04-01	7.5-9.0	SW-SM	0.097	2.108	21.73	0.504	1.24
CA-04-02	4.5-6.0	SP-SM	0.016	1.788	111.75	0.323	3.64
CA-04-03	4.5-6.0	SW-SM	0.050	2.623	52.46	0.493	1.85
CA-04-04	9.0-10.5	SW-SM	0.060	0.575	9.58	0.232	1.56
CA-04-05	7.5-9.0	SM	0.008	0.271	33.88	0.058	1.55
CA-04-06	3.0-4.5	SP-SM	0.084	0.314	3.74	0.206	1.61
NC-04-03	1.5-3.0	SM	0.013	0.601	46.23	0.125	1.99
NC-04-04	1.5-3.0	SM	0.010	0.286	28.60	0.092	2.96
NC-04-05	1.5-3.0	SP-SM	0.080	7.025	87.81	0.466	0.39
				Average	*39.58*		*1.68*

*Reference: EM 1110-2-1100 Part III, 30 Apr 02.

TABLE 13

LIBERTY STATE PARK
GRAIN SIZE DISTRIBUTION SUMMARY FOR FINE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	%Coarse Gravel	%Fine Gravel	%Coarse Sand	%Medium Sand	%Fine Sand	%Silt or Clay
LSP-03-03	24.0-25.5	CH	0.0	0.0	0.1	2.4	2.3	95.2
LSP-03-04	10.5-12.0	CH	0.0	7.0	1.7	4.1	3.6	83.6
LSP-03-05	9.0-10.5	MH	0.0	2.6	3.7	11.8	19.7	62.2
LSP-03-07	10.5-12.0	MH	0.0	1.2	0.3	2.3	3.7	92.5
LSP-03-08	7.5-9.0	CH	0.0	0.0	0.4	4.4	7.9	87.3
LSP-03-09	4.5-6.0	CH	0.0	0.0	0.1	2.7	5.7	91.5
LSP-03-10	15.0-16.5	CH	0.0	6.1	1.0	3.4	5.4	84.1
LSP-03-12	18.0-19.5	CH	0.0	0.2	0.3	4.1	16.9	78.5
LSP-03-13	6.0-7.5	ML	0.0	0.0	0.0	0.4	32.0	67.6
LSP-03-14	15.0-16.5	ML	0.0	0.0	0.4	9.6	34.0	56.0
LSP-03-16	18.0-19.5	CH	0.0	0.0	1.1	2.7	3.0	93.2
LSP-03-17	22.5-24.0	MH	0.0	0.9	0.8	3.1	3.4	91.8
LSP-03-18	12.0-13.5	CH	0.0	0.0	1.1	2.7	3.0	93.2
LSP-03-19	21.0-22.5	ML	0.0	0.0	0.4	1.2	1.8	96.6
LSP-03-20	21.0-22.5	CH	0.0	0.0	0.1	1.4	10.3	88.2
LSP-03-23	10.5-12.0	MH	0.0	0.0	0.9	1.6	2.6	94.9
LSP-03-24	13.5-15.0	CL	0.0	0.0	0.1	1.3	11.8	86.8
LSP-03-25	13.5-15.0	CH	0.0	0.4	0.5	1.6	2.7	94.8
LSP-03-26	10.5-12.0	CH	0.0	0.0	0.0	0.4	0.9	98.7
LSP-03-27	12.0-13.5	CH	0.0	0.0	0.8	1.6	1.8	95.8
LSP-03-33	10.5-12.0	ML	0.0	0.0	0.0	0.6	4.1	95.3
LSP-03-36	16.5-18.0	CH	0.0	0.0	0.4	3.8	13.2	82.6

TABLE 13 - Continued

LIBERTY STATE PARK
GRAIN SIZE DISTRIBUTION SUMMARY FOR FINE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	%Coarse Gravel	%Fine Gravel	%Coarse Sand	%Medium Sand	%Fine Sand	%Silt or Clay
LSP-03-38	19.5-21.0	CH	0.0	0.0	0.2	1.8	4.0	94.0
NC-04-01	4.5-6.0	CH	0.0	0.0	1.2	1.4	3.4	94.0
NC-04-02	3.0-4.5	MH	0.0	1.3	0.4	1.4	4.9	92.0
CA-04-01	18.0-19.5	CH	0.0	0.5	0.3	2.4	6.0	90.8
CA-04-02	15.0-16.5	MH	0.0	0.0	0.6	2.3	4.8	92.3
CA-04-03	19.5-21.0	CH	0.0	0.5	1.1	5.3	10.2	82.9
CA-04-04	15.0-16.5	MH	0.0	4.8	1.2	3.3	7.7	83.0
CA-04-05	15.0-16.5	MH	0.0	1.0	1.0	1.3	3.6	93.1
CA-04-06	13.5-15.0	CH	0.0	0.0	0.2	1.2	4.6	94.0
		Average	*0.00*	*0.81*	*0.62*	*2.04*	*4.92*	*81.61*
		Maximum	*0.00*	*7.00*	*3.70*	*11.80*	*34.00*	*98.70*
		Minimum	*0.00*	*0.00*	*0.00*	*0.40*	*0.90*	*56.00*

TABLE 14

LIBERTY STATE PARK
HYDROLOGIC SOIL PROPERTIES CLASSIFIED BY USDA SOIL TEXTURES*
FOR COARSE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	EQUIV. USDA %SAND	EQUIV. USDA %SILT	EQUIV. USDA %CLAY	USDA SOIL TEXTURAL CLASSIFICATION	EFFECTIVE WATER CAPACITY (inch/inch)	MINIMUM INFILTRATION RATE (inch/hour)	HYD SOIL GROUP
LSP-03-01	3.0-4.5	SM	66	28	6	SANDY LOAM	0.25	1.02	A
LSP-03-02	4.5-6.0	SM	63	30	7	SANDY LOAM	0.25	1.02	A
LSP-03-03	4.5-6.0	GM	70	30	0	LOAMY SAND	0.31	2.41	A
LSP-03-04	4.5-6.0	SM	78	20	2	LOAMY SAND	0.31	2.41	A
LSP-03-05	4.5-6.0	GP-GM	84	16	0	LOAMY SAND	0.31	2.41	A
LSP-03-06	3.0-4.5	GM	68	32	0	SANDY LOAM	0.25	1.02	A
LSP-03-07	4.5-6.0	SM	81	19	0	LOAMY SAND	0.31	2.41	A
LSP-03-11	3.0-4.5	SP-SM	97	3	0	SAND	0.35	8.27	A
LSP-03-15	1.5-3.0	GW-GM	80	20	0	LOAMY SAND	0.31	2.41	A
LSP-03-15	7.5-9.0	SM	70	30	0	LOAMY SAND	0.31	2.41	A
LSP-03-16	1.5-3.0	SM	79	21	0	LOAMY SAND	0.31	2.41	A
LSP-03-17	3.0-4.5	SW-SM	84	16	0	LOAMY SAND	0.31	2.41	A
LSP-03-18	4.5-6.0	SM	78	22	0	LOAMY SAND	0.31	2.41	A
LSP-03-19	4.5-6.0	SM	76	24	0	LOAMY SAND	0.31	2.41	A
LSP-03-20	1.5-3.0	SP-SM	93	7	0	SAND	0.35	8.27	A
LSP-03-24	6.0-7.5	SM	79	21	0	LOAMY SAND	0.31	2.41	A
LSP-03-27	4.5-6.0	SM	90	10	0	SAND	0.35	8.27	A
LSP-03-28	4.5-6.0	SM	80	20	0	LOAMY SAND	0.31	2.41	A
LSP-03-29	3.0-4.5	SP-SM	95	5	0	SAND	0.35	8.27	A
LSP-03-30	1.5-3.0	SP-SM	93	7	0	SAND	0.35	8.27	A
LSP-03-31	3.0-4.5	SM	90	8	2	SAND	0.35	8.27	A
LSP-03-31	13.5-15.0	SC-H	43	42	15	LOAM	0.19	0.52	B

TABLE 14 - Continued

LIBERTY STATE PARK
HYDROLOGIC SOIL PROPERTIES CLASSIFIED BY USDA SOIL TEXTURES*
FOR COARSE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	EQUIV. USDA %SAND	EQUIV. USDA %SILT	EQUIV. USDA %CLAY	USDA SOIL TEXTURAL CLASSIFICATION	EFFECTIVE WATER CAPACITY (inch/inch)	MINIMUM INFILTRATION RATE (inch/hour)	HYD SOIL GROUP
LSP-03-32	3.0-4.5	SM	74	26	0	LOAMY SAND	0.31	2.41	A
LSP-03-35	4.5-6.0	SM	76	23	1	LOAMY SAND	0.31	2.41	A
LSP-03-37	3.0-4.5	SM	94	6	0	SAND	0.35	8.27	A
LSP-03-39	9.0-10.5	SM	76	21	3	LOAMY SAND	0.31	2.41	A
LSP-03-40	4.5-6.0	SM	75	25	0	LOAMY SAND	0.31	2.41	A
NC-04-03	1.5-3.0	SM	68	32	0	LOAMY SAND	0.31	2.41	A
NC-04-04	1.5-3.0	SM	77	23	0	LOAMY SAND	0.31	2.41	A
NC-04-05	4.5-6.0	SP-SM	100	0	0	SAND	0.35	8.27	A
CA-04-01	7.5-9.0	SW-SM	90	10	0	SAND	0.35	8.27	A
CA-04-02	4.5-6.0	SM	76	24	0	LOAMY SAND	0.31	2.41	A
CA-04-03	4.5-6.0	SW-SM	81	19	0	LOAMY SAND	0.31	2.41	A
CA-04-04	9.0-10.5	SW-SM	86	14	0	SAND	0.35	8.27	A
CA-04-05	7.5-9.0	SM	73	27	0	LOAMY SAND	0.31	2.41	A
CA-04-06	3.0-4.5	SP-SM	100	0	0	SAND	0.35	8.27	A
		Average	*76*	*17*	*0*	*LOAMY SAND*	*0.30*	*4.20*	

* Reference: Rawls, Brakensiek, and Saxton, 1982.

TABLE 15

LIBERTY STATE PARK
HYDROLOGIC SOIL PROPERTIES CLASSIFIED BY USDA SOIL TEXTURES*
FOR FINE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	EQUIV. USDA %SAND	EQUIV. USDA %SILT	EQUIV. USDA %CLAY	USDA SOIL TEXTURAL CLASSIFICATION	EFFECTIVE WATER CAPACITY (inch/inch)	MINIMUM INFILTRATION RATE (inch/hour)	HYD SOIL GROUP
LSP-03-03	24.0-25.5	CH	7	78	15	SILT LOAM	0.17	0.27	B
LSP-03-04	10.5-12.0	CH	13	59	27	SILTY CLAY LOAM	0.11	0.17	C
LSP-03-05	9.0-10.5	MH	37	48	15	LOAM	0.19	0.52	B
LSP-03-07	10.5-12.0	MH	12	65	23	SILT LOAM	0.17	0.27	B
LSP-03-08	7.5-9.0	CH	15	58	27	SILTY CLAY LOAM	0.14	0.17	C
LSP-03-09	4.5-6.0	CH	13	59	28	SILTY CLAY LOAM	0.14	0.17	C
LSP-03-10	15.0-16.5	CH	15	58	27	SILTY CLAY LOAM	0.14	0.17	C
LSP-03-12	18.0-19.5	CH	28	49	22	SILT LOAM	0.17	0.27	B
LSP-03-13	6.0-7.5	ML	63	35	2	SANDY LOAM	0.25	1.02	A
LSP-03-14	15.0-16.5	ML	62	34	4	SANDY LOAM	0.25	1.02	A
LSP-03-16	18.0-19.5	CH	14	56	30	SILTY CLAY LOAM	0.14	0.17	C
LSP-03-17	22.5-24.0	MH	6	63	31	SILTY CLAY LOAM	0.14	0.17	C
LSP-03-18	12.0-13.5	CH	15	59	26	SILT LOAM	0.17	0.27	B
LSP-03-19	21.0-22.5	ML	7	64	29	SILTY CLAY LOAM	0.11	0.17	C
LSP-03-20	21.0-22.5	CH	16	60	24	SILT LOAM	0.17	0.27	B
LSP-03-23	10.5-12.0	MH	6	62	32	SILTY CLAY LOAM	0.11	0.17	C
LSP-03-24	13.5-15.0	CL	18	58	24	SILT LOAM	0.17	0.27	B
LSP-03-25	13.5-15.0	CH	5	61	34	SILTY CLAY LOAM	0.11	0.17	C
LSP-03-26	10.5-12.0	CH	6	67	27	SILTY CLAY LOAM	0.11	0.17	C
LSP-03-27	12.0-13.5	CH	6	63	31	SILTY CLAY LOAM	0.11	0.17	C

TABLE 15 - Continued

LIBERTY STATE PARK
HYDROLOGIC SOIL PROPERTIES CLASSIFIED BY USDA SOIL TEXTURES*
FOR FINE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	EQUIV. USDA %SAND	EQUIV. USDA %SILT	EQUIV. USDA %CLAY	USDA SOIL TEXTURAL CLASSIFICATION	EFFECTIVE WATER CAPACITY (inch/inch)	MINIMUM INFILTRATION RATE (inch/hour)	HYD SOIL GROUP
LSP-03-33	10.5-12.0	ML	16	80	4	SILT LOAM	0.17	0.27	B
LSP-03-36	16.5-18.0	CH	23	56	21	SILT LOAM	0.17	0.27	B
LSP-03-38	19.5-21.0	CH	10	71	19	SILT LOAM	0.17	0.27	B
NC-04-01	4.5-6.0	CH	7	67	26	SILT LOAM	0.17	0.27	B
NC-04-02	3.0-4.5	MH	8	74	17	SILT LOAM	0.17	0.27	B
CA-04-01	18.0-19.5	CH	6	75	19	SILT LOAM	0.17	0.27	B
CA-04-02	15.0-16.5	MH	11	73	16	SILT LOAM	0.17	0.27	B
CA-04-03	19.5-21.0	CH	20	63	16	SILT LOAM	0.17	0.27	B
CA-04-04	15.0-16.5	MH	15	70	15	SILT LOAM	0.17	0.27	B
CA-04-05	15.0-16.5	MH	6	77	17	SILT LOAM	0.17	0.27	B
CA-04-06	13.5-15.0	CH	9	77	24	SILT LOAM	0.17	0.27	B
		Average	*11*	*65*	*16*	*SILT LOAM*	*0.16*	*0.25*	*B*

*Reference: Rawls, Brakensiek, and Saxton, 1982.

TABLE 16

LIBERTY STATE PARK
HYDRAULIC CONDUCTIVITY (K) CALCULATION PER HAZEN APPROXIMATION*
FOR COARSE-GRAINED SOILS

DH No.	Sample Depth (ft)	USCS	D_{10} SIZE (mm)	C	K (cm/sec)
LSP-03-05	4.5-6.0	GP-GM	0.15	150	3.38
LSP-03-11	3.0-4.5	SP-SM	0.11	150	1.82
LSP-03-15	1.5-3.0	GW-GM	0.10	150	1.50
LSP-03-20	1.5-3.0	SP-SM	0.10	150	1.50
LSP-03-29	3.0-4.5	SP-SM	0.15	150	3.38
LSP-03-30	1.5-3.0	SP-SM	0.10	150	1.50
				Average	*1.87*

*Reference: Fetter, C.W. *Applied Hydrogeology*, 1994.

TABLE 17

LIBERTY STATE PARK
SUMMARY OF GROUNDWATER DEPTHS DURING DRILLING

DRILL HOLE NO.	GROUNDWATER DEPTH (ft) - AS ENCOUNTERED	GROUNDWATER DEPTH (ft) - AT COMPLETION	GROUNDWATER DEPTH (ft) - AT 24-HOURS
LSP-03-01	3.0	3.0	2.8
LSP-03-02	4.0	10.6	3.7
LSP-03-03	5.3	24.7	20.5
LSP-03-04	3.0	3.2	3.2
LSP-03-05	3.5	30.0	3.4
LSP-03-06	4.3	10.8	10.5
LSP-03-07	3.0	4.6	2.6
LSP-03-08	4.0	5.7	3.7
LSP-03-09	2.1	11.5	4.7
LSP-03-10	4.0	5.7	4.0
LSP-03-11	3.0	13.8	3.2
LSP-03-12	6.8	10.2	3.4
LSP-03-13	9.0	6.6	4.4
LSP-03-14	3.0	2.8	1.2
LSP-03-15	5.3	17.7	3.2
LSP-03-16	2.4	16.4	13.2
LSP-03-17	3.0	3.6	3.0
LSP-03-18	5.9	20.6	5.4
LSP-03-19	4.0	27.3	4.3
LSP-03-20	7.5	5.8	5.6
LSP-03-23	3.0	2.8	2.8
LSP-03-24	6.0	9.3	4.8
LSP-03-25	4.0	3.3	3.0
LSP-03-26	2.6	4.5	1.8
LSP-03-27	7.1	10.4	4.2
LSP-03-28	6.0	20.8	5.4
LSP-03-29	4.5	12.5	12.6
LSP-03-30	5.8	6.3	3.9
LSP-03-31	4.2	18.1	3.1
LSP-03-32	3.8	11.1	5.6
LSP-03-33	5.0	23.3	3.1
LSP-03-34	7.5	22.0	7.6
LSP-03-35	9.7	12.6	10.1
LSP-03-36	9.0	21.7	9.6
LSP-03-37	6.0	9.6	6.6
LSP-03-38	5.4	30.0	9.6
LSP-03-39	4.5	11.1	4.5
LSP-03-40	4.2	11.8	2.6

TABLE 17 - Continued

LIBERTY STATE PARK
SUMMARY OF GROUNDWATER DEPTHS DURING DRILLING

DRILL HOLE NO.	GROUNDWATER DEPTH (ft) - AS ENCOUNTERED	GROUNDWATER DEPTH (ft) - AT COMPLETION	GROUNDWATER DEPTH (ft) - AT 24-HOURS
NC-04-03	5.9	5.6	5.9
NC-04-04	6.0	6.7	6.3
NC-04-05	7.5	7.8	8.0
CA-04-01	5.5	11.4	4.8
CA-04-02	4.0	10.2	4.7
CA-04-03	6.2	27.2	5.2
CA-04-04	7.1	28.3	7.6
CA-04-05	8.0	28.1	6.2
CA-04-06	1.0	2.4	2.0

TABLE 18

LIBERTY STATE PARK
INITIAL GROUNDWATER READINGS IN PIEZOMETERS

PIEZOMETER NUMBER.	DATE WELL DEVELOPMENT COMPLETED	GROUNDWATER DEPTH at 24-HOURS (ft)	GROUNDWATER ELEVATIONS at 24-HOURS (ft MSL)
LSP-03-01	9 Sep 03	2.80	4.10
LSP-03-02	9 Sep 03	3.70	3.67
LSP-03-03	5 Sep 03	4.50	2.55
LSP-03-04	8 Sep 03	3.20	1.84
LSP-03-05	8 Sep 03	3.45	6.33
LSP-03-06	6 Sep 03	4.02	3.54
LSP-03-07	10 Sep 03	2.60	3.93
LSP-03-08	10 Sep 03	3.70	3.03
LSP-03-09	5 Sep 03	4.70	6.89
LSP-03-10	9 Sep 03	4.00	5.05
LSP-03-11	5 Sep 03	3.20	4.71
LSP-03-12	9 Sep 03	3.40	5.30
LSP-03-17	7 Sep 03	3.00	3.80
LSP-03-19	5 Sep 03	4.30	3.08
LSP-03-24	12 Sep 03	4.80	5.51
LSP-03-28	15 Sep 03	5.40	2.05
LSP-03-31	8 Sep 03	3.10	4.06
LSP-03-32	9 Sep 03	5.60	2.55
LSP-03-35	12 Sep 03	10.10	2.36
LSP-03-38	12 Sep 03	9.60	-0.16

TABLE 19

LIBERTY STATE PARK
PIEZOMETER GROUNDWATER READINGS FROM 15 NOVEMBER 2003

PIEZOMETER NUMBER	GROUNDWATER DEPTH (feet below grade)	GROUNDWATER ELEVATION (feet MSL)	TIME OF GROUNDWATER READING
LSP-03-01	1.61	5.29	09:55
LSP-03-02	3.67	3.70	08:48
LSP-03-03	4.88	2.17	10:06
LSP-03-04	3.16	1.88	10:12
LSP-03-05	4.32	5.46	10:20
LSP-03-06	4.82	2.74	08:52
LSP-03-07	1.74	4.79	08:30
LSP-03-08	3.72	3.01	08:17
LSP-03-09	3.43	8.16	08:57
LSP-03-10	4.74	4.31	07:58
LSP-03-11	2.99	4.92	08:08
LSP-03-12	4.02	4.68	07:42
LSP-03-17	3.15	3.65	08:40
LSP-03-19	4.14	3.24	07:28
LSP-03-24	5.48	4.83	07:23
LSP-03-28	4.64	2.81	07:33
[1]LSP-03-31	3.42	3.74	07:15
LSP-03-32	3.65	4.50	09:02
LSP-03-35	12.12	0.34	09:43
LSP-03-38	5.35	4.09	09:20
[2]LSP-03-31	3.42	3.74	10:18

Notes:
1. First Reading of day.
2. Last Reading of day.
3. Start Time:07:06 - Tide Reading: -0.2 Rising at the Battery.
4. Finish Time:10:18- Tide Reading: +2.8 Rising at the Battery.

TABLE 20

LIBERTY STATE PARK
PIEZOMETER GROUNDWATER READINGS FROM 8 FEBRUARY 2004

PIEZOMETER NUMBER	GROUNDWATER DEPTH (feet below grade)	GROUNDWATER ELEVATION (feet MSL)	TIME OF GROUNDWATER READING
LSP-03-01	NR	NR	NR
LSP-03-02	3.17	4.20	10:41
LSP-03-03	4.32	2.73	10:47
LSP-03-04	3.25	1.79	10:59
LSP-03-05	4.13	5.65	11:06
LSP-03-06	3.82	3.74	10:23
LSP-03-07	3.62	2.91	10:27
LSP-03-08	3.42	3.31	10:09
LSP-03-09	2.78	8.81	10:17
LSP-03-10	3.31	5.74	09:37
LSP-03-11	2.27	5.64	08:52
LSP-03-12	3.15	5.55	08;24
LSP-03-17	2.94	3.86	10:48
LSP-03-19	2.99	4.39	08:14
LSP-03-24	4.55	5.76	07:48
LSP-03-28	3.81	3.64	08:35
LSP-03-31	2.44	4.72	08:41
LSP-03-32	2.48	5.67	09:07
LSP-03-35	9.47	2.99	07:30
LSP-03-38	4.82	4:62	08:46

Notes:
1. Start Time: 07:30 - Tide Reading: +4.1 Rising at Bayonne.
2. Finish Time: 11:06 - Tide Reading: +3.1 Falling at Bayonne.
3. NR = Not Recorded due to ice covering piezometer.

TABLE 21

LIBERTY STATE PARK
PIEZOMETER GROUNDWATER READINGS FROM 9 FEBRUARY 2004

PIEZOMETER NUMBER	GROUNDWATER DEPTH (feet below grade)	GROUNDWATER ELEVATION (feet MSL)	TIME OF GROUNDWATER READING
LSP-03-01	NR	NR	NR
LSP-03-02	3.05	4.32	09:24
LSP-03-03	4.25	2.80	11:10
LSP-03-04	3.07	1.97	11:04
LSP-03-05	4.15	5.63	10:50
LSP-03-06	3.05	4.51	09:11
LSP-03-07	3.17	3.36	09:15
LSP-03-08	2.57	4.16	08:58
LSP-03-09	3.62	7.97	08:31
LSP-03-10	3.70	5.35	08:23
LSP-03-11	2.38	5.53	08:44
LSP-03-12	3.00	5.70	09:52
LSP-03-17	2.18	4.62	09:36
LSP-03-19	3.18	4.20	10:02
LSP-03-24	4.72	5.59	10:10
LSP-03-28	3.95	3.50	09:59
LSP-03-31	2.72	4.44	08:00
LSP-03-32	2.54	5.61	08:36
LSP-03-35	9.64	2.82	11:15
LSP-03-38	4.75	4.69	07:51

Notes:
1. Start Time: 07:51 - Tide Reading: -1.1 Rising at Kings Point.
2. Finish Time: 11:15 - Tide Reading: +4.3 Rising at Kings Point.
3. NR = Not Recorded due to ice covering piezometer.

TABLE 22

LIBERTY STATE PARK
PIEZOMETER GROUNDWATER READINGS FROM 10 FEBRUARY 2004

PIEZOMETER NUMBER	GROUNDWATER DEPTH (feet below grade)	GROUNDWATER ELEVATION (feet MSL)	TIME OF GROUNDWATER READING
LSP-03-01	NR	NR	NR
LSP-03-02	3.22	4.15	01:48
LSP-03-03	4.40	2.65	01:55
LSP-03-04	3.17	1.87	02:00
LSP-03-05	4.00	5.78	01:53
LSP-03-06	3.00	4.56	01:31
LSP-03-07	0.90	5.63	01:36
LSP-03-08	2.45	4.28	01:10
LSP-03-09	2.93	8.66	01:48
LSP-03-10	3.11	5.94	01:00
LSP-03-11	2.18	5.73	12:48
LSP-03-12	3.00	5.70	12:55
LSP-03-17	3.00	3.80	12:52
LSP-03-19	3.35	4.03	01:39
LSP-03-24	4.65	5.66	01:23
LSP-03-28	3.95	3.50	01:31
LSP-03-31	2.77	4.39	01:15
LSP-03-32	2.64	5.51	01:44
LSP-03-35	9.53	2.93	01:00
LSP-03-38	4.64	4.80	01:38

Notes:
1. Start Time: 12:48 - Tide Reading: +4.2 Falling at Bayonne.
2. Finish Time: 01:55 - Tide Reading: +2.1 Falling at Bayonne.
3. NR = Not Recorded due to ice covering piezometer.

TABLE 23

LIBERTY STATE PARK
CHANGES IN PIEZOMETER GROUNDWATER READINGS

PIEZOMETER NUMBER	GROUNDWATER ELEV. at 24-HOURS (ft)	ELEV. on 15 Nov 03 (ft)	ELEV. on 8 Feb 04 (ft)	ELEV. on 9 Feb 04 (ft)	ELEV. on 10 Feb 04 (ft)	Min Elev. (ft)	Max Elev. (ft)	Range (ft)
LSP-03-01	4.10	5.29	--*	--*	--*	4.10	5.29	1.19
LSP-03-02	3.67	3.70	4.20	4.32	4.15	3.67	4.32	0.65
LSP-03-03	2.55	2.17	2.73	2.80	2.65	2.17	2.80	0.63
LSP-03-04	1.84	1.88	1.79	1.97	1.87	1.79	1.97	0.18
LSP-03-05	6.33	5.46	5.65	5.63	5.78	5.46	6.33	0.87
LSP-03-06	3.54	2.74	3.74	4.51	4.56	2.74	4.56	1.82
LSP-03-07	3.93	4.79	2.91	3.36	5.63	2.91	5.63	2.72
LSP-03-08	3.03	3.01	3.31	4.16	4.28	3.01	4.28	1.27
LSP-03-09	6.89	8.16	8.81	7.97	8.66	6.89	8.81	1.92
LSP-03-10	5.05	4.31	5.74	5.35	5.94	4.31	5.94	1.63
LSP-03-11	4.71	4.92	5.64	5.53	5.73	4.71	5.73	1.02
LSP-03-12	5.30	4.68	5.55	5.70	5.70	4.68	5.70	1.02
LSP-03-17	3.80	3.65	3.86	4.62	3.80	3.65	4.62	0.97
LSP-03-19	3.08	3.24	4.39	4.20	4.03	3.08	4.39	1.31
LSP-03-24	5.51	4.83	5.76	5.59	5.66	4.83	5.76	0.93
LSP-03-28	2.05	2.81	3.64	3.50	3.50	2.05	3.64	1.59
LSP-03-31	4.06	3.74	4.72	4.44	4.39	3.74	4.72	0.98
LSP-03-32	2.55	4.50	5.67	5.61	5.51	2.55	5.67	3.12
LSP-03-35	2.36	0.34	2.99	2.82	2.93	0.34	2.99	2.65
LSP-03-38	--**	4.09	4.62	4.69	4.80	4.09	4.80	0.71

Notes: *Readings were not available due to ice cover on piezometer.
**Reading was considered erroneous and was eliminated from consideration.

TABLE 24

SUMMARY OF GROUNDWATER GRADIENTS BETWEEN PIEZOMETERS ON 15 NOVEMBER 2003

PIEZOMETER (PZ) No.	GROUND WATER DEPTHS (ft)	GROUND WATER ELEV. (ft MSL)	STEEPEST gradient (ft/ft) FLOWING TOWARDS	FLATTEST gradient (ft/ft) FLOWING TOWARDS	No. of PZs FLOWING TOWARDS	STEEPEST gradient (ft/ft) FLOWING AWAY FROM	FLATTEST gradient (ft/ft) FLOWING AWAY FROM	No. of PZs FLOWING AWAY FROM
LSP-03-01	1.61	5.29	0.0013	0.0001	2	-0.0033	-0.0001	9
LSP-03-02	3.67	3.70	0.0033	0.0004	7	-0.0012	-0.0005	4
LSP-03-03	4.88	2.17	0.0041	0.0003	10	-0.0005	-0.0005	1
LSP-03-04	3.16	1.88	0.0116	0.0003	11	0.0000	0.0000	0
LSP-03-05	4.32	5.46	0.0007	0.0007	1	-0.0116	-0.0001	10
LSP-03-06	4.82	2.74	0.0040	0.0005	9	-0.0003	-0.0003	2
LSP-03-07	1.74	4.79	0.0016	0.0001	4	-0.0022	-0.0001	7
LSP-03-08	3.72	3.01	0.0044	0.0005	8	-0.0005	-0.0004	3
LSP-03-09	3.43	8.16	0.0000	0.0000	0	-0.0044	-0.0007	11
LSP-03-10	4.74	4.31	0.0029	0.0005	6	-0.0029	-0.0004	5
LSP-03-11	2.99	4.92	0.0029	0.0001	3	-0.0016	-0.0001	8
LSP-03-12	4.02	4.68	0.0018	0.0001	5	-0.0015	-0.0005	6

TABLE 25

SUMMARY OF GROUNDWATER GRADIENTS BETWEEN PIEZOMETERS ON 8 FEBRUARY 2004

PIEZOMETER (PZ) No.	GROUND WATER DEPTHS (ft)	GROUND WATER ELEV. (ft MSL)	STEEPEST gradient (ft/ft) FLOWING TOWARDS	FLATTEST gradient (ft/ft) FLOWING TOWARDS	No. of PZs FLOWING TOWARDS	STEEPEST gradient (ft/ft) FLOWING AWAY FROM	FLATTEST gradient (ft/ft) FLOWING AWAY FROM	No. of PZs FLOWING AWAY FROM
LSP-03-01	--*	--	--	--	--	--	--	--
LSP-03-02	3.17	4.20	0.0021	0.0006	5	-0.0012	-0.0006	5
LSP-03-03	4.32	2.73	0.0036	0.0001	9	-0.0017	-0.0017	1
LSP-03-04	3.25	1.79	0.0125	0.0006	10	0.0000	0.0000	0
LSP-03-05	4.13	5.65	0.0008	0.0000	2	-0.0125	0.0000	8
LSP-03-06	3.82	3.74	0.0038	0.0006	6	-0.0009	-0.0005	4
LSP-03-07	3.62	2.91	0.0030	0.0005	8	-0.0007	-0.0001	2
LSP-03-08	3.42	3.31	0.0055	0.0007	7	-0.0006	-0.0003	3
LSP-03-09	2.78	8.81	0.0000	0.0000	0	-0.0047	-0.0008	10
LSP-03-10	3.31	5.74	0.0023	0.0023	1	-0.0055	0.0000	9
LSP-03-11	2.27	5.64	0.0029	0.0000	3	-0.0019	-0.0001	7
LSP-03-12	3.15	5.55	0.0016	0.0000	4	-0.0025	-0.0007	6

* Note: LSP-03-01 was ice covered during reading cycle.

TABLE 26

SUMMARY OF GROUNDWATER GRADIENTS BETWEEN PIEZOMETERS ON 9 FEBRUARY 2004

PIEZOMETER (PZ) No.	GROUND WATER DEPTHS (ft)	GROUND WATER ELEV. (ft MSL)	STEEPEST gradient (ft/ft) FLOWING TOWARDS	FLATTEST gradient (ft/ft) FLOWING TOWARDS	No. of PZs FLOWING TOWARDS	STEEPEST gradient (ft/ft) FLOWING AWAY FROM	FLATTEST gradient (ft/ft) FLOWING AWAY FROM	No. of PZs FLOWING AWAY FROM
LSP-03-01	--*	--	--	--	--	--	--	--
LSP-03-02	3.05	4.32	0.0017	0.0002	6	-0.0011	-0.0001	4
LSP-03-03	4.25	2.80	0.0035	0.0004	9	-0.0015	-0.0015	1
LSP-03-04	3.07	1.97	0.0118	0.0008	10	0.0000	0.0000	0
LSP-03-05	4.15	5.63	0.0006	0.0000	2	-0.0118	0.0000	8
LSP-03-06	3.05	4.51	0.0026	0.0004	5	-0.0012	-0.0002	5
LSP-03-07	3.17	3.36	0.0023	0.0009	8	-0.0008	-0.0004	2
LSP-03-08	2.57	4.16	0.0032	0.0001	7	-0.0009	-0.0006	3
LSP-03-09	3.62	7.97	0.0000	0.0000	0	-0.0032	-0.0006	10
LSP-03-10	3.70	5.35	0.0020	0.0001	4	-0.0027	-0.0006	6
LSP-03-11	2.38	5.53	0.0022	0.0000	3	-0.0011	-0.0002	7
LSP-03-12	3.00	5.70	0.0011	0.0011	1	-0.0022	0.0000	9

* Note: LSP-03-01 was ice covered during reading cycle.

TABLE 27

SUMMARY OF GROUNDWATER GRADIENTS BETWEEN PIEZOMETERS ON 10 FEBRUARY 2004

PIEZOMETER (PZ) No.	GROUND WATER DEPTHS (ft)	GROUND WATER ELEV. (ft MSL)	STEEPEST gradient (ft/ft) FLOWING TOWARDS	FLATTEST gradient (ft/ft) FLOWING TOWARDS	No. of PZs FLOWING TOWARDS	STEEPEST gradient (ft/ft) FLOWING AWAY FROM	FLATTEST gradient (ft/ft) FLOWING AWAY FROM	No. of PZs FLOWING AWAY FROM
LSP-03-01	--*	--	--	--	--	--	--	--
LSP-03-02	3.22	4.15	0.0021	0.0001	8	-0.0010	-0.0009	2
LSP-03-03	4.40	2.65	0.0039	0.0007	9	-0.0014	-0.0014	1
LSP-03-04	3.17	1.87	0.0126	0.0010	10	0.0000	0.0000	0
LSP-03-05	4.00	5.78	0.0008	0.0001	2	-0.0126	0.0000	8
LSP-03-06	3.00	4.56	0.0030	0.0005	6	-0.0011	-0.0005	4
LSP-03-07	0.90	5.63	0.0015	0.0001	5	-0.0023	-0.0011	5
LSP-03-08	2.45	4.28	0.0037	0.0005	7	-0.0010	-0.0001	3
LSP-03-09	2.93	8.66	0.0000	0.0000	0	-0.0037	-0.0008	10
LSP-03-10	3.11	5.94	0.0020	0.0020	1	-0.0037	-0.0001	9
LSP-03-11	2.18	5.73	0.0027	0.0000	3	-0.0012	0.0000	7
LSP-03-12	3.00	5.70	0.0015	0.0000	4	-0.0018	-0.0001	6

*Note: LSP-03-01 was ice covered during reading cycle.

TABLE 28

LIBERTY STATE PARK
GROUNDWATER FLOW DIRECTION AND GRADIENT CALCULATIONS
FOR GROUNDWATER READINGS TAKEN ON 15 NOVEMBER 2003

Groundwater Flow Direction and Gradient Calculator	User enters heads at x, y locations. Groundwater flow direction, gradient, and rate computed. Confined or unconfined aquifer.

LMNO Engineering, Research, and Software, Ltd.
7860 Angel Ridge Rd. Athens, OH 45701 (USA) (740) 592-1890
LMNO@LMNOeng.com http://www.LMNOeng.com

This calculation has been purchased for use as a stand-alone program. User does not need to be connected to the internet. It is illegal to load this program on a publicly-accessible internet server.

Unconfined Aquifer	Stand-alone version	Click to Calculate
10 head measurements	Flow Direction, s (degrees):	35.56373310566864
Sandy Soil (sets K)	Composite Grad, h dh/ds (ft):	-0.003836060291999838
Heads in feet	Saturated Thickness, H (m):	Not used
Distances in feet	Flow per unit width, Q (gpd/ft):	0.0913422093455151
Flow per unit width in gpd/ft	Hydraulic Cond, K (cm/s):	0.0010
Hydraulic Conductivity in cm/s	http://www.LMNOeng.com	© 2000 LMNO Engineering, Research, and Software, Ltd.

Enter x (ft)	Enter y (ft)	Enter head, h (ft)
616362.32	683517.39	3.7
617999.45	683192.66	2.17
618535.56	682589.51	5.46
615902.62	682834.71	2.74
616860.75	682578.04	4.79
615978.02	682280.47	3.01
614834.2	682011.33	8.16
616168.43	681979.58	4.31
615921.94	681149.5	4.92
616749.81	681514.55	4.68

It is illegal for this calculation to run on any publicly-accessible website except www.LMNOeng.com

TABLE 29

LIBERTY STATE PARK
GROUNDWATER FLOW DIRECTION AND GRADIENT CALCULATIONS
FOR GROUNDWATER READINGS TAKEN ON 8 FEBRUARY 2004

Groundwater Flow Direction and Gradient Calculator	User enters heads at x, y locations. Groundwater flow direction, gradient, and rate computed. Confined or unconfined aquifer.

LMNO Engineering, Research, and Software, Ltd.
7860 Angel Ridge Rd. Athens, OH 45701 (USA) (740) 592-1890
LMNO@LMNOeng.com http://www.LMNOeng.com

This calculation has been purchased for use as a stand-alone program. User does not need to be connected to the internet. It is illegal to load this program on a publicly-accessible internet server.

Unconfined Aquifer	Stand-alone version	Click to Calculate
10 head measurements	Flow Direction, a (degrees):	34.16428916507535
Sandy Soil (sets K)	Composite Grad, h dh/ds (ft):	-0.005572663992161719
Heads in feet	Saturated Thickness, H (m).	Not used
Distances in feet	Flow per unit width, Q (gpd/ft):	0.1161662343193602
Flow per unit width in gpd/ft	Hydraulic Cond, K (cm/s):	0.0019
Hydraulic Conductivity in cm/s	http://www.LMNOeng.com	© 2009 LMNO Engineering, Research, and Software, Ltd.

Enter x (ft)	Enter y (ft)	Enter head, h (ft)
616362.32	683517.39	4.2
617596.45	683192.86	2.73
618535.56	682599.51	5.65
615802.62	682834.71	3.74
616800.75	682579.04	2.91
615978.02	682260.47	3.31
614834.2	682011.33	8.81
616168.43	681879.58	5.74
615521.94	681149.5	5.64
616743.91	681514.55	5.55

It is illegal for this calculation to run on any publicly-accessible website except www.LMNOeng.com

TABLE 30

LIBERTY STATE PARK
GROUNDWATER FLOW DIRECTION AND GRADIENT CALCULATIONS
FOR GROUNDWATER READINGS TAKEN ON 9 FEBRUARY 2004

Groundwater Flow Direction and Gradient Calculator	User enters heads at x, y locations. Groundwater flow direction, gradient, and rate computed. Confined or unconfined aquifer.

LMNO Engineering, Research, and Software, Ltd.
7860 Angel Ridge Rd. Athens, OH 45701 (USA) (740) 592-1890
LMNO@LMNOeng.com http://www.LMNOeng.com

This calculation has been purchased for use as a stand-alone program. User does not need to be connected to the internet. It is illegal to load this program on a publicly-accessible internet server.

Unconfined Aquifer	Stand-alone version	Click to Calculate
10 head measurements	Flow Direction, z (degrees):	31.993855052587778
Sandy Soil [sets K]	Composite Grad, h db/ds (B):	0.004565750231604206
Heads in feet	Saturated Thickness, H (m):	Not used
Distances in feet	Flow per unit width, Q (gpd/ft):	0.096815006849317775
Flow per unit width in gpd/ft	Hydraulic Cond, K (cm/s):	0.0010
Hydraulic Conductivity in cm/s	http://www.LMNOeng.com	© 2000 LMNO Engineering, Research, and Software, Ltd.

Enter x (ft)	Enter y (ft)	Enter head, h (ft)
616362.32	683517.39	4.32
617999.45	683192.86	2.80
618535.56	682588.51	5.63
615902.62	682834.71	4.51
616806.75	682579.04	3.36
615978.02	682280.47	4.16
614834.2	682011.33	7.97
616168.43	681879.58	5.35
615521.34	681149.5	5.53
616749.91	501514.55	5.70

It is illegal for this calculation to run on any publicly-accessible website except www.LMNOeng.com

TABLE 31

LIBERTY STATE PARK
GROUNDWATER FLOW DIRECTION AND GRADIENT CALCULATIONS
FOR GROUNDWATER READINGS TAKEN ON 10 FEBRUARY 2004

Groundwater Flow Direction and Gradient Calculator	User enters heads at x, y locations. Groundwater flow direction, gradient, and rate computed. Confined or unconfined aquifer.

LMNO Engineering, Research, and Software, Ltd.
7860 Angel Ridge Rd. Athens, OH 45701 (USA) (740) 592-1890
LMNO@LMNOeng.com http://www.LMNOeng.com

This calculation has been purchased for use as a stand-alone program. User does not need to be connected to the internet. It is illegal to load this program on a publicly-accessible internet server.

Unconfined Aquifer	Stand-alone version	Click to Calculate
10 head measurements	Flow Direction, s (degrees):	35.443761099861692
Sandy Soil (sets K)	Composite Grad, h dh/ds (ft):	0.005183477810710254
Heads in feet	Saturated Thickness, H (m):	Not used
Distances in feet	Flow per unit width, Q (gpd/ft):	0.109913698939644937
Flow per unit width in gpd/ft	Hydraulic Cond, K (cm/s):	0.0010
Hydraulic Conductivity in cm/s	http://www.LMNOeng.com	© 2000 LMNO Engineering, Research, and Software, Ltd.

Enter x (ft)	Enter y (ft)	Enter head, h (ft)
616362.32	683517.39	4.15
617398.45	683132.86	2.65
618535.56	682589.51	5.78
615902.62	682834.71	4.56
616800.75	682579.04	5.63
615978.02	682280.47	4.28
614834.2	682011.33	6.66
616168.43	681679.58	5.94
616521.94	681149.5	5.73
616749.81	681514.55	5.70

It is illegal for this calculation to run on any publicly accessible website except www.LMNOeng.com

FIGURES

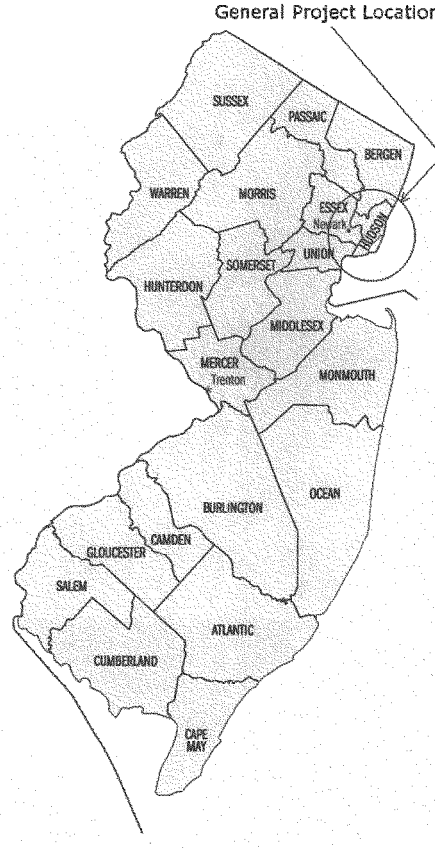


FIGURE #1 – Regional Location Map Showing Hudson County, NJ

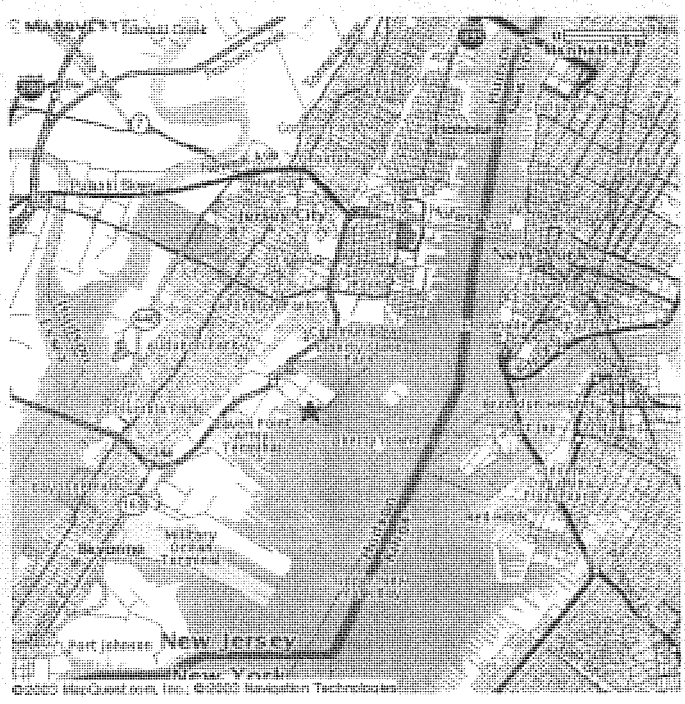


FIGURE #2 – Liberty State Park Vicinity Map.

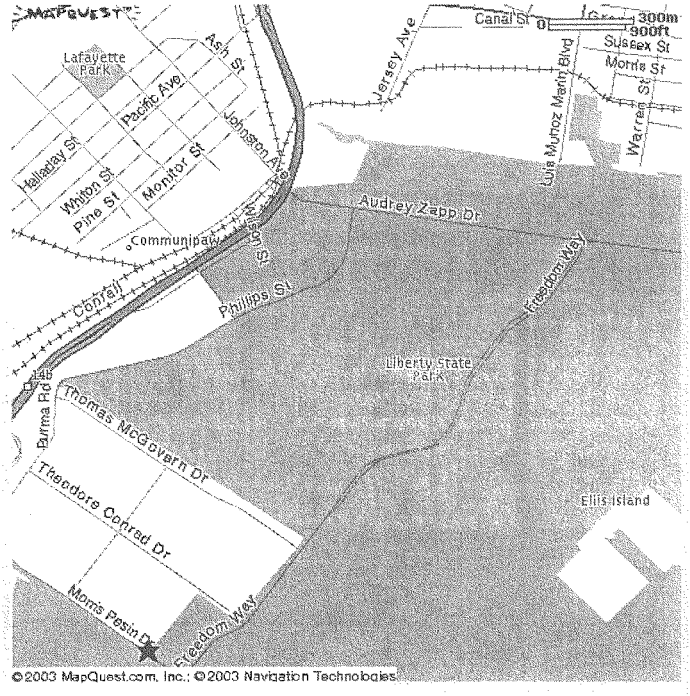


FIGURE #3 – Liberty State Park Site Map.

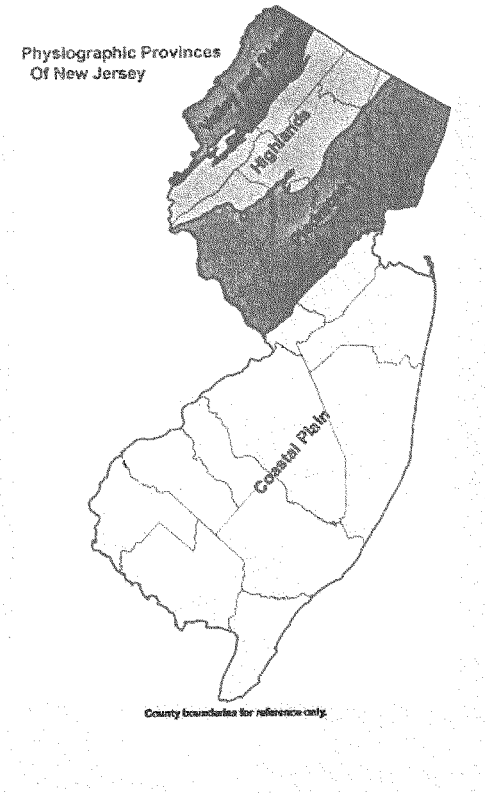


FIGURE #4 – Physiographic Provinces of New Jersey.

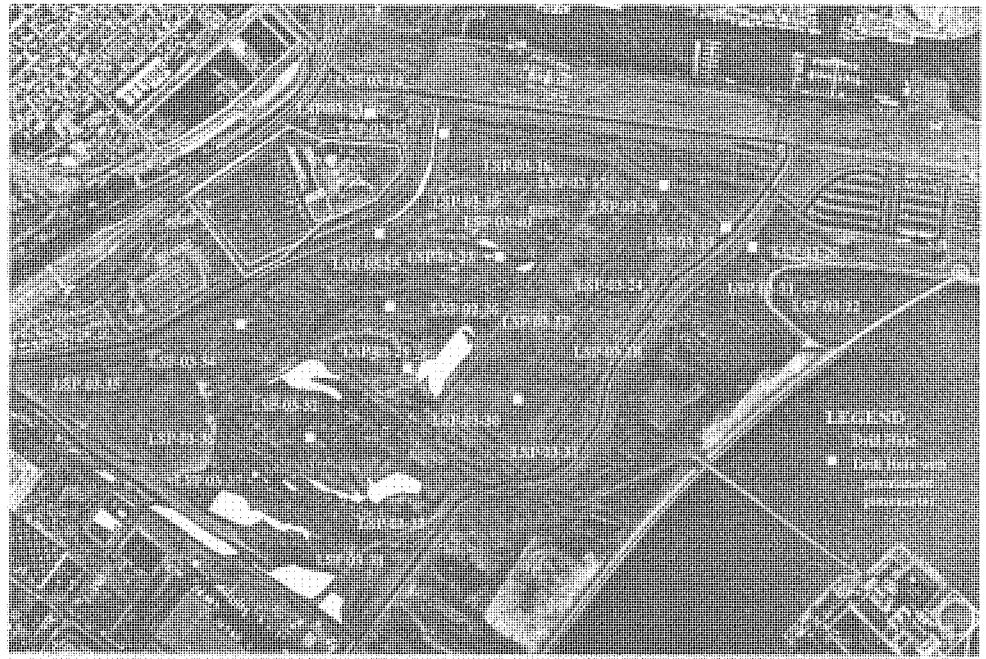


FIGURE #5 - Liberty State Park Phase I Drill Hole Locations.

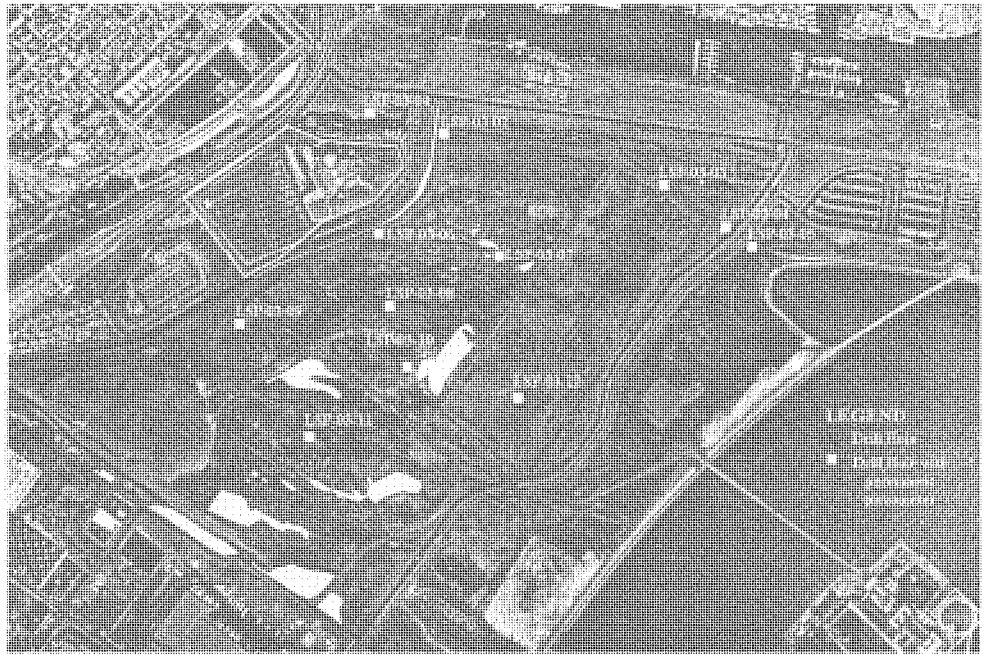


FIGURE #6- Liberty State Park Permanent Piezometer Location Plan.

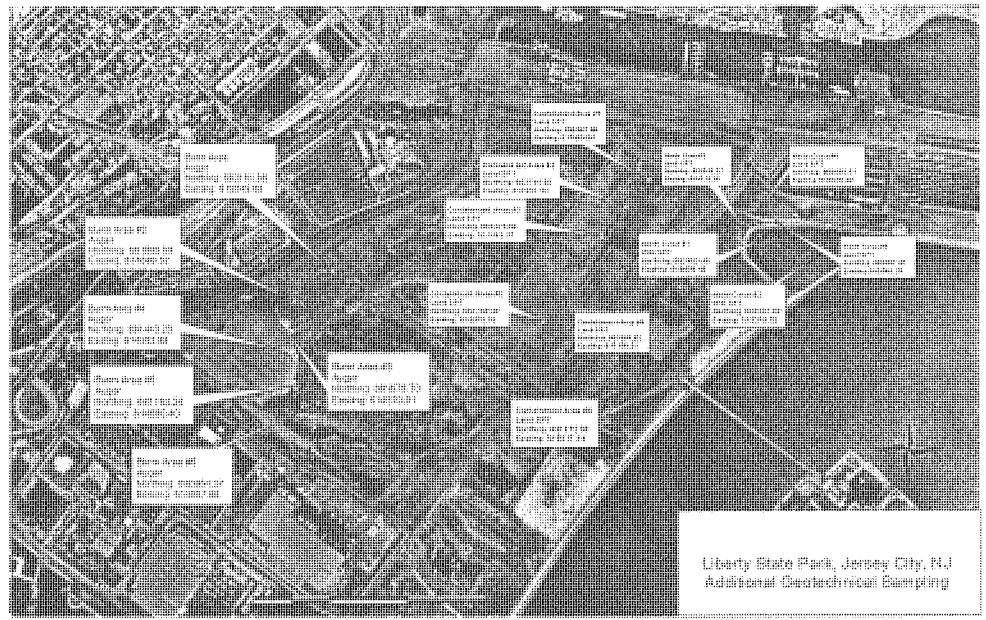


FIGURE #7 - Liberty State Park Phase II Drill Hole Locations.

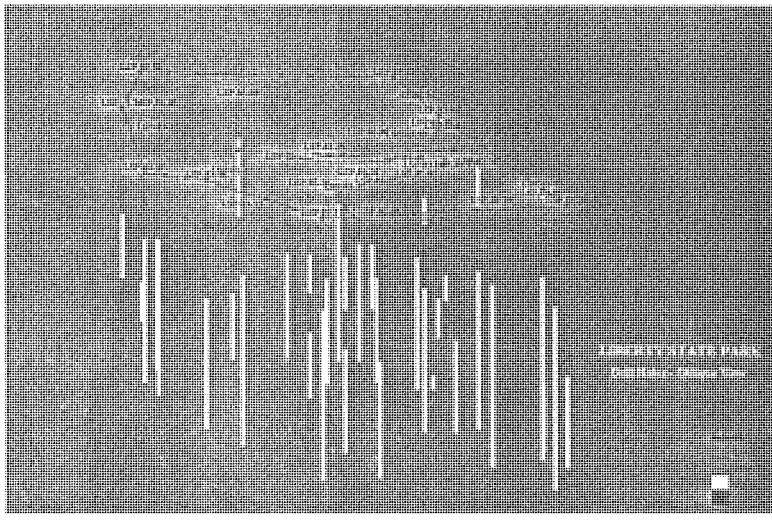


FIGURE #8- Liberty State Park Oblique View of Drill Holes.

Note: Drill Holes have been magnified 100x in the vertical scale.

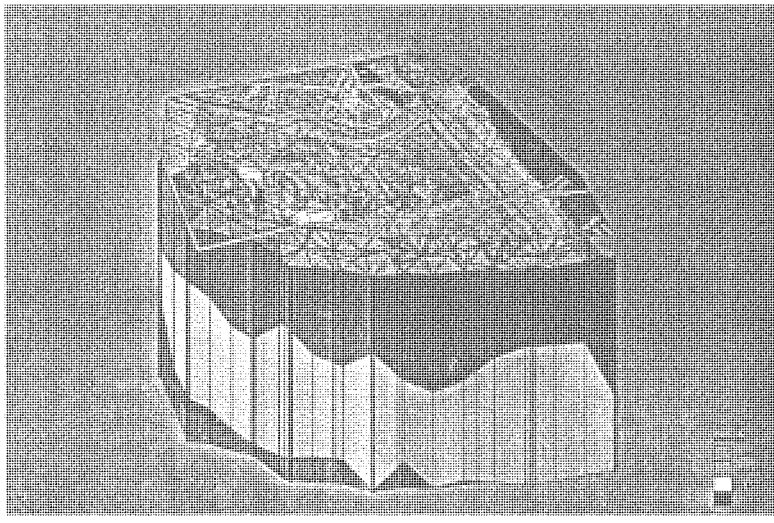


FIGURE #9 – Liberty State Park Generalized Conceptual Geologic Model.

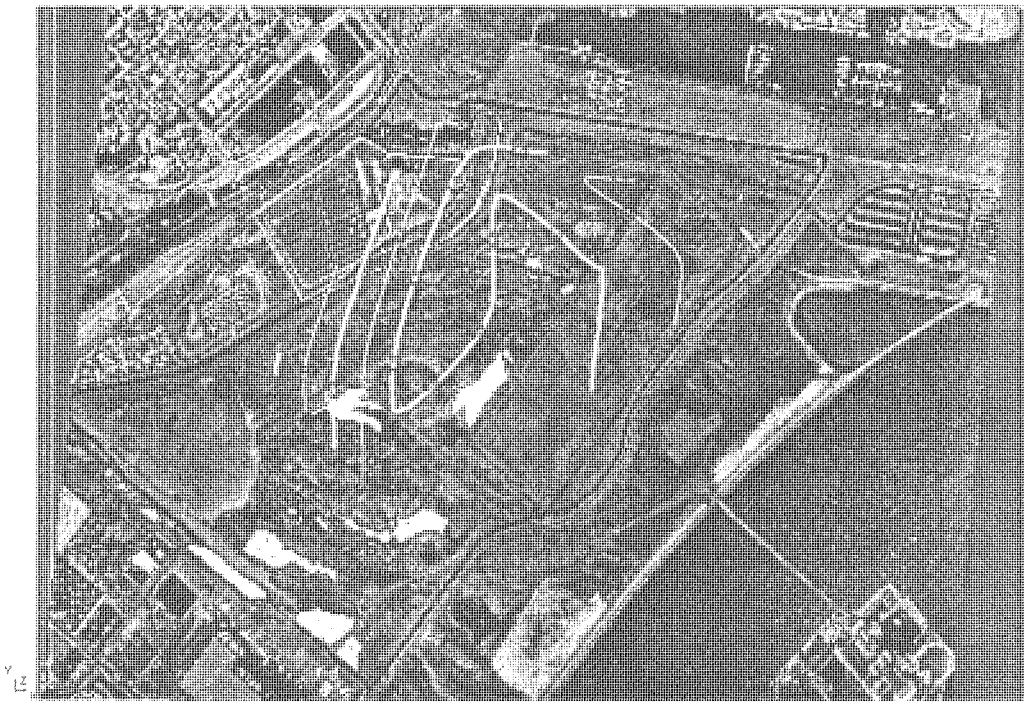


FIGURE #10 – Liberty State Park Groundwater Contour Map - 15 Nov 2003.

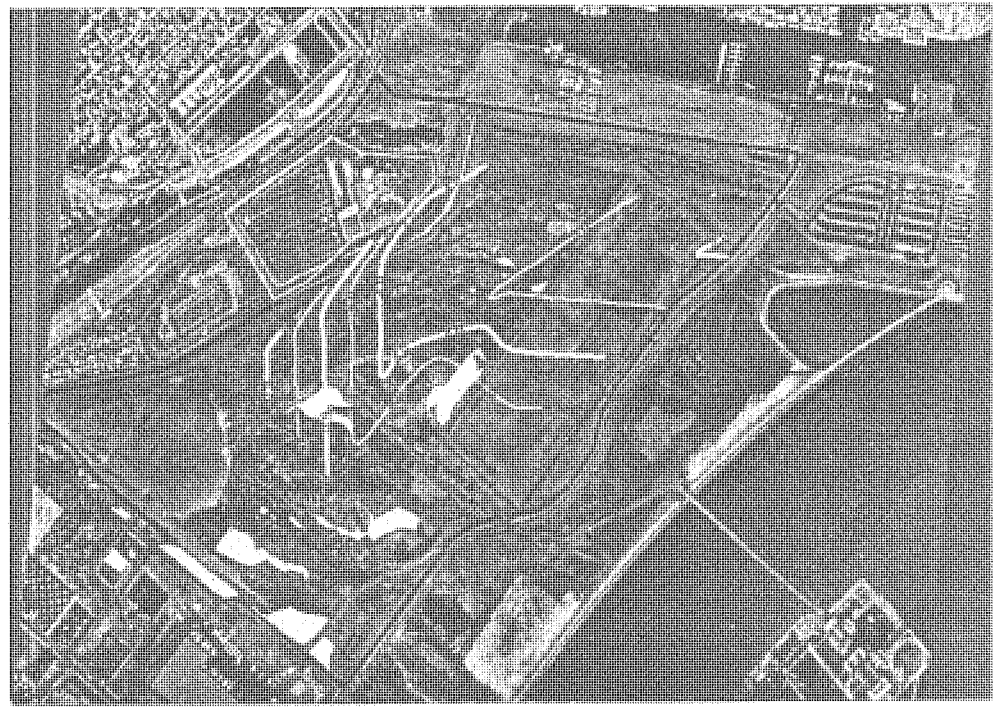


FIGURE #11 – Liberty State Park Groundwater Contour Map - 8 Feb 2004.

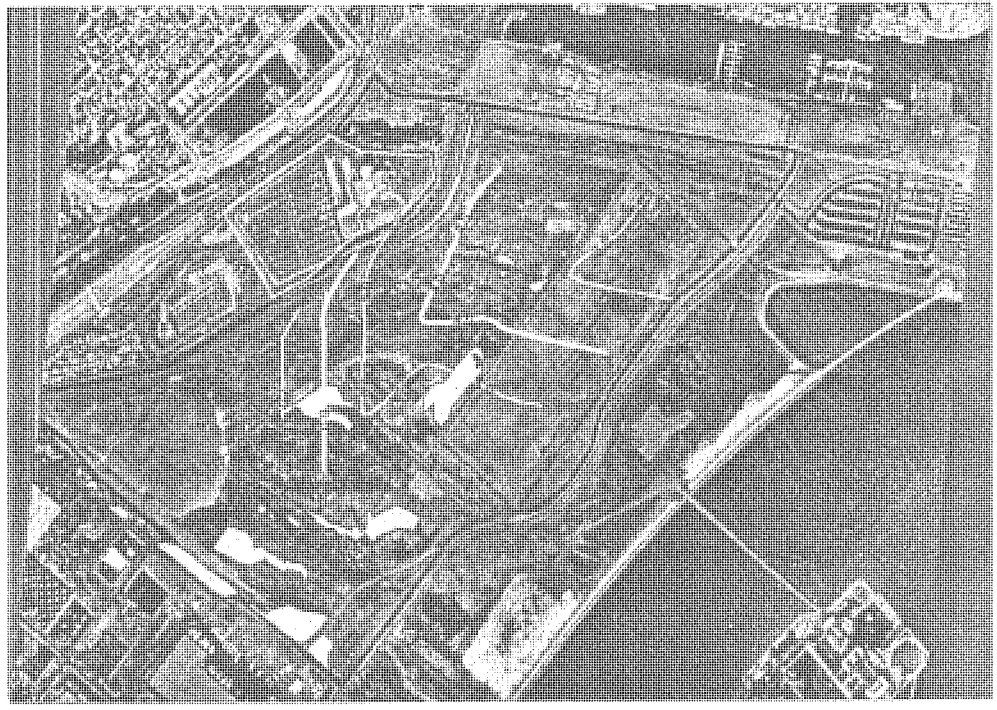


FIGURE #12 – Liberty State Park Groundwater Contour Map - 9 Feb 2004.

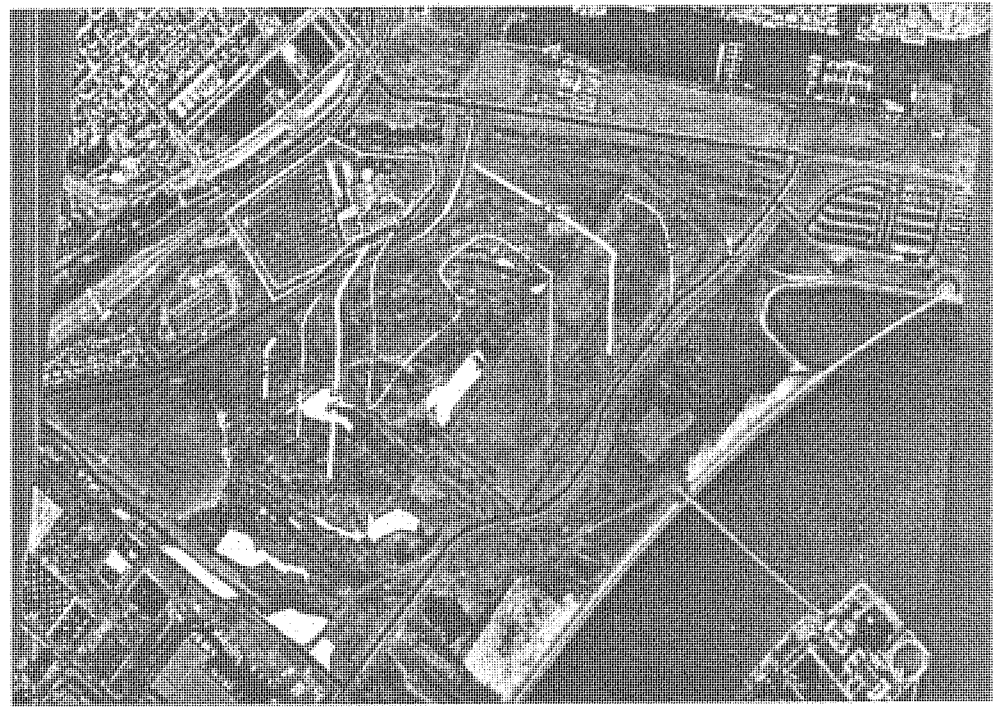


FIGURE #13 – Liberty State Park Groundwater Contour Map - 10 Feb 04.

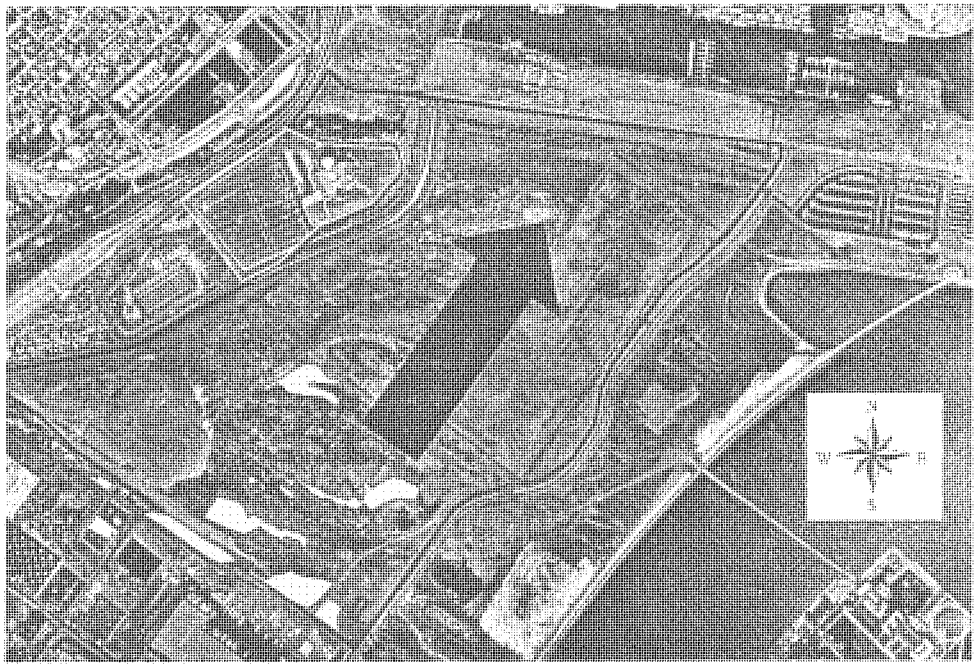


FIGURE #14– Liberty State Park General Groundwater Flow Direction using LMNO Software.

LIST OF ABBREVIATIONS AND ACRONYMS

LIST OF ABBREVIATIONS AND ACRONYMS

D_{10} Size = Particle diameter (mm) such that 10% of the particles are finer

D_{16} Size = Particle diameter (mm) such that 16% of the particles are finer

D_{25} Size = Particle diameter (mm) such that 25% of the particles are finer

D_{50} Size = Particle diameter (mm) such that 50% of the particles are finer

D_{60} Size = Particle diameter (mm) such that 60% of the particles are finer

D_{75} Size = Particle diameter (mm) such that 75% of the particles are finer

D_{84} Size = Particle diameter (mm) such that 84% of the particles are finer

D_{95} Size = Particle diameter (mm) such that 95% of the particles are finer

D_{10} = Effective Size (Hazen)

ϕ = Particle size in phi (ϕ) units:

$$\phi = -\log_2 d = -(\log_{10} d / \log_{10} 2)$$

where: d = diameter of particle (mm)

GM_e = Geometric (graphic) mean:

$$GM_e = [(\phi_{16} + \phi_{50} + \phi_{84})/3]$$

σ_ϕ = Inclusive (graphic) standard deviation:

$$\sigma_\phi = [(\phi_{84} - \phi_{16})/4] + [(\phi_{95} - \phi_5)6.6]$$

S_k = Coefficient of Skewness

K = Coefficient of Kurtosis

Cu = Coefficient of Uniformity:

$$Cu = D_{60}/D_{10}$$

Ck = Coefficient of Gradation:

$$Ck = (D_{30})^2/((D_{10})(D_{60}))$$

K = Permeability

C = Coefficient that factors in the sorting characteristics of the soil

Φ = Internal angle of friction

LIST OF ABBREVIATIONS AND ACRONYMS - Continued

ASTM = American Society for Testing and Materials

BCOE = Baltimore District, U.S. Army Corps of Engineers

DH = Drill Hole

GPM = Gallons Per Minute

HSG = Hydrologic Soil Group

HTRW = Hazardous, Toxic, and Radioactive Waste

LSP = Liberty State Park

LSPDC = Liberty State Park Development Committee

NJGS = New Jersey Geological Survey

NJDEP = New Jersey Department of Environmental Protection

SPT = Standard Penetration Test

USCS = Unified Soil Classification System

USDA = US Department of Agriculture Soil Classification System

WH = Weight of (drill) Hammer

WR = Weight of (drill) Rod

NatW% = Natural Water Content

%Gravel = % retained on No. 4 sieve by weight

%Coarse Gravel = % passing 3-inch sieve & retained on the ¾-inch sieve by weight

%Fine Gravel = % passing ¾-inch sieve & retained on the No. 4 sieve by weight

%Sand = % retained on No. 200 sieve by weight

%Coarse Sand = % passing No. 4 sieve & retained on the No. 10 sieve by weight

%Medium Sand = % passing No. 10 sieve & retained on the No. 40 sieve by weight

%Fine Sand = % passing No. 40 sieve & retained on the No. 200 sieve by weight

LIST OF ABBREVIATIONS AND ACRONYMS - Continued

%Silt or Clay = % passing No. 200 sieve by weight

%Fines = % passing No. 200 sieve by weight

%Clay = % Passing Clay Fraction <0.002 mm

LL = Liquid Limit

PL = Plastic Limit

PI = Plasticity Index

LI = Liquidity Index

AI = Activity Index

GW = Well-Graded Gravel, Fine To Coarse Gravel

GP = Poorly-Graded Gravel

GM = Silty Gravel

GC = Clayey Gravel

SW = Well-Graded Sand, Fine To Coarse Sand

SP = Poorly-Graded Sand

SM = Silty Sand

SC = Clayey Sand

ML = Silt

CL = Clay

OL = Organic Silt, Organic Clay

MH = Silt Of High Plasticity, Elastic Silt

CH = Clay Of High Plasticity, Fat Clay

OH = Organic Clay, Organic Silt

PT = Peat

US Army Corps
of Engineers
BALTIMORE DISTRICT

Prepared by:
U.S. Army Corps of Engineers
Baltimore District
10 South Howard Street
Baltimore, MD 21201

Project Partner:
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278

April 2004

SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ

FINAL REPORT
Volume 2

TABLE OF CONTENTS

APPENDICES

Section	Title
A	Field Drill Logs
B	Final Drill Logs

APPENDIX A
FIELD DRILL LOGS

Hole No. LSP-03- 1

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 1		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN: DISTURBED 18	UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE: STARTED 8-23-03	COMPLETED 8-23-03
7. THICKNESS OF OVERBURDEN 26.4		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 26.4		19. SIGNATURE OF INSPECTOR W E Saylor	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT. TR SILT, DAMP, SOFT. PEAT, COARSE DARK BROWN.	27%	J-1
	2.0'		PEAT, COARSE, WET, SOFT. TR SILT, TR SAND, COARSE. DARK BROWN. GWE 3.0'	54%	J-2
	4.0'		SAND, COARSE, WET, SOFT, TR SILT, BLACK.	47%	J-3
			SAME AS JAR-3	20%	J-4
	6.0'		SAND, COARSE, WET, SOFT, TR SILT, TR DEBRIS COARSE, BLACK.	20%	J-5
	8.0'		SAME AS JAR-5	47%	J-6 HTAW 1430
	10.0'		SAND, FINE, WET, SOFT, MEDIUM BROWN TO GRAY.	100%	J-7
			SAME AS JAR-7	100%	J-8
	12.0'		GRAVELLY SAND, WET SOFT TO HARD, DULL BRIGHTISH GRAY.	80%	J-9
	14.0'		SAME AS JAR-9	80%	J-10
			SAME AS JAR-9	80%	J-11
	16.0'		SAME AS JAR-9	67%	J-12
	18.0'		SAME AS JAR-9	73%	J-13
			SAME AS JAR-9	47%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	3,3,4	NA
J-2	1.5-3.0	3,2,2	NA
J-3	3.0-4.5	3,2,1	NA
J-4	4.5-6.0	3,2,4	NA
J-5	6.0-7.5	3,2,2	NA
J-6	7.5-9.0	2,1,4	NA
J-7	9.0-10.5	8,4,4	NA
J-8	10.5-12.0	8,9,7	NA
J-9	12.0-13.5	23,29,21	NA
J-10	13.5-15.0	9,26,27	NA
J-11	15.0-16.5	17,13,21	NA
J-12	16.5-18.0	3,4,16	NA
J-13	18.0-19.5	9,21,22	NA
J-14	19.5-21.0	9,30,15	NA
J-15	21.0-22.5	6,11,6	NA
J-16	22.5-24.0	12,35,25	NA
J-17	24.0-25.5	5,13,28	NA
J-18	25.5-26.4	33,50/.4	NA

Ground Water Readings

Encountered: 3.0'
Completion: 3.0'
24 hours: 2.9'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 1

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** LSP-03-1

PROJECT LIBERTY STATE PARK JERSEY CITY, NJ | INSTALLATION BALTIMORE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0			47%	J-14	
			SAND WET, SOFT, MEDIUM MEDIUM BROWN.	100%	J-15	
	22.0					
			SAND, WET, SOFT, MEDIUM TO COARSE, TR GRAVEL MEDIUM BROWN	100%	J-16	
	24.0					
			SAME AS SAM-16	100%	J-17 HTAW 1615	
			SAME AS SAM-16 (REFUSAL)	57%	J-18	
	26.0					
			EOH - 26.4'			
	28.0					

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A (ER 1110-1-1801) GPO 1980 OF-528-503 | PROJECT LIBERTY STATE PARK JERSEY CITY, NJ | HOLE NO. LSP-03-1

Hole No. LSP-03-02

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-02		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-13-03	COMPLETED 8-13-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Stump	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SANDY CLAY MEDIUM, WITH SOME HUMUS, SOFT, DAMP. .8 SAND, DAY, SOFT, COARSE WITH TR GRAVEL. BLACK	100%	J-1
	2.0'		CLAYEY GRAVEL, SOFT DAMP, BROWN.	13%	J-2
	4.0'		SANDY CLAY, MEDIUM, WITH SOME GRAVEL, WET, SOFT GRE 4.0	67%	J-3
			SILTY GRAVEL, WET, SOFT BLACK	67%	J-4
	6.0'		SAME AS JAR-4	47%	J-5
	8.0'		SAME AS JAR-4	87%	J-6
	10.0'		SAME AS JAR-4	33%	J-7
			SAME AS JAR-4	54%	J-8
	12.0'		SAME AS JAR-4	27%	J-9
	14.0'		SAME AS JAR-4 14.4- CLAY, WET, SOFT TR SILT, GRAY	54%	J-10
			CLAY, WET, SOFT, TR SILT GRAY	13%	J-11
	16.0'		SAME AS JAR-11	100%	J-12 MTW 1015
	18.0'		SAME AS JAR-11	100%	J-13
	20.0		SAME AS JAR-11 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	1,9,9	NA
J-2	1.5-3.0	12,10,7	NA
J-3	3.0-4.5	2,2,2	NA
J-4	4.5-6.0	1,1	NA
J-5	6.0-7.5	1,1	NA
J-6	7.5-9.0	WH,WH,1	NA
J-7	9.0-10.5	1,1,1	NA
J-8	10.5-12.0	WH,1,1	NA
J-9	12.0-13.5	1,1,2	NA
J-10	13.5-15.0	1,1,WH	<2.5,<2.5,<2.5
J-11	15.0-16.5	WH,WH,WH	<2.5,<2.5,<2.5
J-12	16.5-18.0	WH,WH,WH	<2.5,<2.5,<2.5
J-13	18.0-19.5	WH,1,2	<2.5,<2.5,<2.5
J-14	19.5-21.0	1,2,2	NA
J-15	21.0-22.5	1,2,2	NA
J-16	22.5-24.0	2,2,2	NA
J-17	24.0-25.5	4,6,6	NA
J-18	25.5-27.0	6,9,9	NA,3.0,4.0
J-19	27.0-28.5	6,8,9	NA,2.0,3.5
J-20	28.5-30.0	7,9,11	NA

Ground Water Readings

Encountered: 8.0
Completion: 10.6'
24 hours: 3.7'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-02

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-02
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-11	100%	J-14 (LWM)	
	22.0'		SAND, WET, SOFT, MEDIUM, MEDIUM GRAY 22.0 - SANDY SILT, WET, SOFT, FINE, TR CLAY, DULL GREENISH GRAY	100%	J-15	
			SAME AS JAR-15	100%	J-16	
	24.0'		SAND, FINE, SOFT, WET. TR SILT. DULL GREENISH GRAY.	100%	J-17	
	26.0'		SAND, WET, SOFT, MEDIUM, TO CLAYEY SILT, NEARLY MOTLED DULL GREENISH GRAY TO BROWNISH GRAY	100%	J-18	
	28.0'		SAND, WET, SOFT, FINE, WITH SOME SILT, TR CLAY BROWN.	100%	J-19	
			SAME AS JAR-19	100%	J-20 HPW 1325 hrs	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-03
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-4	80%	J-14 (CUT)	
			SAME AS JAR-5	87%	J-15	
	22.0'		22.0' CLAY, SOFT, WET, TR SILT, TR SHELL FRAGMENTS COARSE DULL GREENISH GRAY.			
			CLAY, SOFT, WET, TR SILT, TR SHELL FRAGMENTS COARSE, WITH A LITTLE SAND, MEDIUM DULL GREENISH GRAY.	67%	J-16	
	24.0'		CLAY, WET, SOFT, TR SILT, TR SHELL FRAGMENTS COARSE. DULL GREENISH GRAY.	100%	J-17	
	26.0'		SAME AS JAR-17	100%	J-18	
	28.0'		SAME AS JAR-17	100%	J-19	
			SAME AS JAR-17	100%	J-20 HTAW 16.5' HAD	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-4

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-4		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8-28-03 / COMPLETED 8-28-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Stamp	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT. SAND, FINE, SOFT, DRY, WITH SOME SILT DARK BROWN	80%	J-1
			1.4 SAND, DAMP, SOFT, MEDIUM BROWN TR GRAVEL WITH A LITTLE SILT.		
	2.0'		SAND, DAMP, SOFT, MEDIUM BROWN TR GRAVEL WITH A LITTLE SILT. 1.9 SAND, SOFT, DAMP, COARSE. BLACK, TR CHARRED MATERIAL	73%	J-2
			SAND, SOFT, WET, COARSE BLACK TR CHARRED MATERIAL	67%	J-3
	4.0'		SAME AS JAR-3 5.0 - SAND, WET, SOFT, MEDIUM, TR SILT, GRAY.	67%	J-4
	6.0'		GRAVELLY SAND, WET, SOFT, FINE, TR SILT BLACK.	80%	J-5
	8.0'		SAME AS JAR-5	47%	J-6
			SILTY CLAY, DAMP, SOFT, TR SAND DARK GRAY	100%	J-7 HTAW 1010 1423
	10.0'		CLAY, WET, SOFT, TR SILT DARK GRAY.	67%	J-8
	12.0'		SAME AS JAR-8	100%	J-9
	14.0'		SAME AS JAR-8	100%	J-10
	16.0'		SAME AS JAR-8	100%	J-11
			SAME AS JAR-8	100%	J-12
	18.0'		SAME AS JAR-8	100%	J-13
	20.0		SAME AS JAR-8	100%	J-14
			CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	7,11,10	NA
J-2	1.5-3.0	5,12,14	NA
J-3	3.0-4.5	3,6,7	NA
J-4	4.5-6.0	7,4,4	NA
J-5	6.0-7.5	6,3,2	NA
J-6	7.5-9.0	5,4,4	NA
J-7	9.0-10.5	2,1,2	<.5,<.5,<.5
J-8	10.5-12.0	3,1,1	<.5,<.5,<.5
J-9	12.0-13.5	WOH,WOH,WOH	<.5,<.5,<.5
J-10	13.5-15.0	WOH,WOH,WOH	<.5,<.5,<.5
J-11	15.0-16.5	WOR,WOR,WOR	<.5,<.5,<.5
J-12	16.5-18.0	WOR,WOR,WOR	<.5,<.5,<.5
J-13	18.0-19.5	WOR,1,1	<.5,<.5,<.5
J-14	19.5-21.0	3,1,1	<.5,<.5,<.5
J-15	21.0-22.5	WOR,WOR,WOR	<.5,<.5,<.5
J-16	22.5-24.0	WOR,WOR,WOR	<.5,<.5,<.5
J-17	24.0-25.5	WOR,WOR,WOR	<.5,<.5,<.5
J-18	25.5-27.0	WOR,WOR,WOR	<.5,<.5,<.5
J-19	27.0-28.5	WOR,WOR,WOR	<.5,<.5,<.5
J-20	28.5-30.0	WOR,WOR,WOR	<.5,<.5,<.5

Ground Water Readings

Encountered: 3.0'
Completion: 3.2'
24 hours: 3.2'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-4

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-4
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-8	100%	J-14 (EWT)	
	22.0'		SAME AS JAR-8	100%	J-15	
	24.0'		SAME AS JAR-8	100%	J-16	
	26.0'		SAME AS JAR-8	100%	J-17	
	28.0'		SAME AS JAR-8	100%	J-18	
			SAME AS JAR-8	100%	J-19	
	30.0'		BOH - 30.0'		J-20 RTTW 1140 hrs	
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-5

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-5		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-11-03	COMPLETED 8-11-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W. E. Epm	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL GRASS AND ROOT MAT. SILTY CLAY, MEDIUM BROWN WITH SOME PARTIALLY DECOMPOSED ROCK, SANDSTONE	80%	J-1
	2.0'		SAND, WET, SOFT, MEDIUM, BROWN 2.3 SAND, DAMP, SOFT, COARSE, TR SILT, TR DECOMPOSED ROCK BLOCK.	80%	J-2
	4.0'		SAND, WET, SOFT, COARSE TR SILT. BLOCK.	67%	J-3
			SANDY GRAVEL, WET SOFT DARK BROWN	80%	J-4
	6.0'		SAME AS JAR-4	33%	J-5
	8.0'		SAME AS JAR-4	27%	J-6
	10.0'		CLAY, SOFT, WET, IN SOME SILT, TR SHELL FRAGMENTS COARSE TR SAND, FINE, BLACK	60%	J-7 1470W 0820 HRS
			SAME AS JAR-7	87%	J-8
	12.0'		CLAY, SOFT, WET. DARK GRAY TR SHELL FRAGMENTS COARSE	100%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
	16.0'		SAME AS JAR-9	100%	J-11
			SAME AS JAR-9	100%	J-12
	18.0'		SAME AS JAR-9	100%	J-13
	20.0		CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0–1.5	2,42,24	NA
J-2	1.5-3.0	8,12,9	NA
J-3	3.0-4.5	7,17,21	NA
J-4	4.5-6.0	3,5,5	NA
J-5	6.0-7.5	3,1,1	NA
J-6	7.5-9.0	WOH,WOH,1	NA
J-7	9.0-10.5	1,1,WOH	<.5,<.5,<.5
J-8	10.5-12.0	WOH,WOH,WOH	<.5,<.5,<.5
J-9	12.0-13.5	WOH,WOH,WOH	<.5,<.5,<.5
J-10	13.5-15.0	WOH,WOH,WOH	<.5,<.5,<.5
J-11	15.0-16.5	WOH,WOH,1	<.5,<.5,<.5
J-12	16.5-18.0	WOH,WOH,WOH	<.5,<.5,<.5
J-13	18.0-19.5	WOH,WOH,WOH	<.5,<.5,<.5
J-14	19.5-21.0	WOH,WOH,WOH	<.5,<.5,<.5
J-15	21.0-22.5	WOH,WOH,WOH	<.5,<.5,<.5
J-16	22.5-24.0	WOH,WOH,WOH	<.5,<.5,<.5
J-17	24.0-25.5	WOH,WOH,WOH	<.5,<.5,<.5
J-18	25.5-27.0	WOH,WOH,WOH	<.5,<.5,<.5
J-19	27.0-28.5	WOH,WOH,WOH	<.5,<.5,<.5
J-20	28.5-30.0	WOH,WOH,WOH	<.5,<.5,<.5

Ground Water Readings

Encountered: 3.5'
Completion: 30.0'
24 hours: 3.45'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-5

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-5
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		CLAY, SOFT, WET, TR SHELL FRAGMENTS COARSE, TR GRAVEL, DARK GRAY	100%	J-14 (CUM)	
	22.0'		SAME AS JAR-9	100%	J-15	
	24.0'		SAME AS JAR-9	100%	J-16	
	26.0'		SAME AS JAR-9	100%	J-17	
	28.0'		SAME AS JAR-9	100%	J-18	
	30.0'		SAME AS JAR-9	100%	J-19	
	32.0'		BOH - 30.0'		J-20 HTAW 0945 HRS	
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-5

Hole No. LSP-03- 06

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 06		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-23-03	COMPLETED 8-23-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Stat	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL AND FILL MAT, SILTY SAND, FINE, DRY, SOFT, MEDIUM BROWN. .5' SAND, COARSE, DRY, SOFT, BLACK, MIXED CHARRED DEBRIS.	100%	J-1
	2.0'		SAND, DRY, SOFT, COARSE WITH A LITTLE GRAVEL BLACK WITH CHARRED DEBRIS	100%	J-2
	4.0'		SAME AS JAR-2 GWE 4.3'	54%	J-3
			SAND, WET, SOFT, COARSE WITH TR GRAVEL BLACK. 5.4' SILTY CLAY, WET, SOFT, DARK REDDISH BROWN.	67%	J-4
	6.0'		SAND, WET, SOFT, MEDIUM, TR GRAVEL LIGHT GRAY	73%	J-5
			SAME AS JAR-5		
	8.0'		8.5' - SILTY CLAY WET, SOFT, TR SHELL FRAGMENTS COARSE. MEDIUM GRAY.	87%	J-6
			SILTY SAND, WET, SOFT FINE, TR CLAY, MEDIUM GRAY	100%	J-7 HTAW 1435
	10.0'		SILTY CLAY, WET SOFT, DARK GRAY	100%	J-8
	12.0'		SAND, WET, SOFT, MEDIUM, TR SILT, TR CLAY, TR GRAVEL. BLACK.	87%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
	16.0'		SAND, WET, SOFT, MEDIUM. DARK GRAY, WOOD FRAGMENT COARSE BLOCKING 1HOG	27%	J-11
			SAND, WET, SOFT, MEDIUM TR SILT, DULL GRAYISH BROWN.	100%	J-12
	18.0'		SAME AS JAR-12	100%	J-13
	20.0		SAME AS JAR-12	100%	J-14
			CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	7,11,6	NA
J-2	1.5-3.0	5,4,7	NA
J-3	3.0-4.5	4,6,4	NA
J-4	4.5-6.0	3,1,6	NA,<.5,NA
J-5	6.0-7.5	2,5,5	NA
J-6	7.5-9.0	1,1,1	NA,NA,<.5
J-7	9.0-10.5	WOH,WOH,WOH	NA
J-8	10.5-12.0	WOH,WOH,2	<.5,<.5,<.5
J-9	12.0-13.5	WOH,1,2	NA
J-10	13.5-15.0	2,1,1	NA
J-11	15.0-16.5	WOH,WOH,WOH	NA
J-12	16.5-18.0	WOH,WOH,WOH	NA
J-13	18.0-19.5	WOH,WOH,1	NA
J-14	19.5-21.0	2,2,3	NA
J-15	21.0-22.5	WOH,2,28	NA
J-16	22.5-24.0	7,23,15	NA
J-17	24.0-25.5	3,4,4	NA
J-18	25.5-27.0	7,11,9	NA
J-19	27.0-28.5	4,6,6	NA
J-20	28.5-30.0	5,9,7	NA

Ground Water Readings

Encountered: 4.3'
Completion: 10.8'
24 hours: 10.5'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 06

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-06
1. PROJECT Liberty State Park, Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-12	100%	J-14 (GWM)	
	22.0'		SAND, WET, SORT MEDIUM, TR SILT, TR GRAVEL DULL GRAYISH BROWN.	100%	J-15	
	24.0'		SAME AS JAR-15	100%	J-16	
			SAME AS JAR-15	100%	J-17	
	26.0'		SAND, WET, SORT, MEDIUM TR SILT DULL BROWNISH GRAY.	100%	J-18	
	28.0'		SAME AS JAR-18	100%	J-19	
			SAME AS JAR-18	100%	J-20 HTAW 1545	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-06

Hole No. LSP-03-7

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-7		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN DISTURBED 20	UNDISTURBED 0
5. NAME OF DRILLER Paul Van Dorn		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9-3-03	COMPLETED 9-3-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Stamp	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SAND, COARSE, DAMP, SOFT, DARK BROWN VARIABLE	67%	J-1
	2.0'		NO RECOVERY SAME AS JAR-1 FROM AUGERS GWE 3.0'	0%	J-2
	4.0'		GRAVEL, WET, SOFT, TR SAND, TR SILT, MEDIUM BROWN	70%	J-3
			SAME AS JAR-3	33%	J-4
	6.0'		SAME AS JAR-3	33%	J-5
	8.0'		SAME AS JAR-3	100%	J-6 HRW 0840
			SAME AS JAR-3 9.5- CLAY, SOFT, WET, TR SILT DARK GRAY.	100%	J-7
	10.0'		CLAY, SOFT, WET, TR SILT DARK GRAY.	100%	J-8
	12.0'		CLAY SOFT, WET, TR SILT, TR SHELL FRAGMENTS COARSE DARK GRAY.	100%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
			SAME AS JAR-9	100%	J-11
	16.0'		SAME AS JAR-9	100%	J-12
	18.0'		SAME AS JAR-9	100%	J-13
			SAME AS JAR-9	100%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	2,4,4	NA
J-2	1.5-3.0	3,3,3	NA
J-3	3.0-4.5	3,2,2	NA
J-4	4.5-6.0	3,2,1	NA
J-5	6.0-7.5	2,2,3	NA
J-6	7.5-9.0	2,1,1	NA
J-7	9.0-10.5	1,1,1	NA, <.5, <.5
J-8	10.5-12.0	WOH, WOH, WOH	<.5, <.5, <.5
J-9	12.0-13.5	WOH, 1, 1	<.5, <.5, <.5
J-10	13.5-15.0	WOH, WOH, WOH	<.5, <.5, <.5
J-11	15.0-16.5	WOH, WOH, WOH	<.5, <.5, <.5
J-12	16.5-18.0	WOH, WOH, WOH	<.5, <.5, <.5
J-13	18.0-19.5	WOR, WOR, WOR	<.5, <.5, <.5
J-14	19.5-21.0	WOR, WOR, WOR	<.5, <.5, <.5
J-15	21.0-22.5	WOR, WOR, WOR	<.5, <.5, <.5
J-16	22.5-24.0	WOR, WOR, WOR	<.5, <.5, <.5
J-17	24.0-25.5	WOR, WOR, WOR	<.5, WAYNE
J-18	25.5-27.0	WOH, WOH, WOH	NA
J-19	27.0-28.5	3,3,4	NA
J-20	28.5-30.0	3,3,3	NA

Ground Water Readings

Encountered: 3.0'
Completion: 4.6'
24 hours: 2.6'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. LSP-03-7

1. PROJECT Liberty State Park, Jersey City, NJ | 2. INSTALLATION Baltimore District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAN-9	100%	J-14 (RAW)	
	22.0'		SAME AS JAN-9	100%	J-15	
			SAME AS JAN-9	100%	J-16	
	24.0'		SAME AS JAN-9			
			24.5 SAND, WET, SOFT, FINE, TR CLAY, TR SILT BROWNISH GRAY.	100%	J-17	
	26.0'		SAND, WET, SOFT, FINE, TR CLAY, TR SILT, BROWNISH GRAY.	100%	J-18	
	28.0'		SAME AS JAN-18	100%	J-19	
			SAME AS JAN-18	100%	J-20 HTAW 0930	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) | PROJECT Liberty St Pk Jersey City, NJ | HOLE NO. LSP-03-7

Hole No. LSP-03-8

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-8		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20. / UNDISTURBED 0
5. NAME OF DRILLER Paul Van Dorn		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 9-3-03 / COMPLETED 9-3-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Stamp	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		SAND, DAMP, SOFT, TR SILT. COARSE, BLACK WITH DARK BROWN.	73%	J-1	Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAME AS JAR-1 2.2 SAND, FINE, SOFT, DAMP. GOLDEN BROWN. GWE 4.0'	80%	J-2	
	4.0'		SAND, FINE, SOFT, DAMP TO WET, GOLDEN BROWN.	100%	J-3	
			SAME AS JAR-3 5.1 CLAY, WET, SOFT, TR SILT. DARK GRAY	100%	J-4	
	6.0'		CLAY, WET, SOFT, TR SILT DARK GRAY.	100%	J-5 HTRW 152011	
	8.0'		SAME AS JAR-5	100%	J-6	
			SAME AS JAR-5	100%	J-7	
	10.0'		SAME AS JAR-5	100%	J-8	
	12.0'		CLAY, WET, SOFT, TR SILT TR SAND FINE: DARK GRAY.	46%	J-9	
	14.0'		CLAY, WET, SOFT, TR SILT TR SAND FINE, TR WOOD FRAGMENTS, COARSE DARK GRAY	67%	J-10	
			SAME AS JAR-10	67%	J-11	
	16.0'		CLAY, WET, SOFT, TR SILT DARK GRAY.	100%	J-12	
	18.0'		SAME AS JAR-10	80%	J-12	
			CLAY, WET, SOFT, TR SILT DARK GRAY.	73%	J-14	
	20.0		CONTINUED.			

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	4,3,4	NA
J-2	1.5-3.0	4,7,1	NA
J-3	3.0-4.5	4,5,4	NA
J-4	4.5-6.0	1,1,1	NA, <.5, <.5
J-5	6.0-7.5	1,1,1	<.5, <.5, <.5
J-6	7.5-9.0	WOH, WOH, 1	<.5, <.5, <.5
J-7	9.0-10.5	2,1,1	<.5, <.5, <.5
J-8	10.5-12.0	1,1,1	<.5, <.5, <.5
J-9	12.0-13.5	2,4,4	<.5, <.5, <.5
J-10	13.5-15.0	3,1,1	<.5, <.5, <.5
J-11	15.0-16.5	3,5,1	<.5, <.5, <.5
J-12	16.5-18.0	3,2,2	<.5, <.5, <.5
J-13	18.0-19.5	4,1,1	<.5, <.5, <.5
J-14	19.5-21.0	4,5,7	<.5, <.5, <.5
J-15	21.0-22.5	3,3,3	<.5, <.5, NA
J-16	22.5-24.0	6,3,1	NA
J-17	24.0-25.5	WOH, WOH, WOH	NA
J-18	25.5-27.0	7,3,1	NA
J-19	27.0-28.5	11,14,9	NA
J-20	28.5-30.0	10,6,5	NA

Ground Water Readings

Encountered: 4.0'
Completion: 5.7'
24 hours: 3.7'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-8

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03- 8
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'			73%	J-14 (6000)	
			SAME AS JAR-14 21.8 - PEAT, WITH SOME CLAY, LOOSE, WET, SOFT. 22.0 SAND, WET, SOFT, MEDIUM, TR SILT, GRAY	100%	J-15	
	22.0'					
			SAND, WET, SOFT, MEDIUM TR SILT, GRAY,	100%	J-16	
	24.0'					
			SAME AS JAR-16	100%	J-17	
	26.0'		SAME AS JAR-16	100%	J-18	
	28.0'		SAME AS JAR-16	100%	J-19	
			SAME AS JAR-16	100%	J-20 HTAW 1630	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03- 8

Hole No. LSP-03-09

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-09		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-21-03	COMPLETED 8-21-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Bailey	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT, SILTY SAND, FINE, DAMP, SOFT, DARK BROWN. 1.3 SAND, DAMP, SOFT, FINE, TR GRAVEL, TAN	100%	J-1
	2.0'		SAND, DAMP TO WET, SOFT, FINE TO COARSE, LIGHT BROWN. GWE 2.1'	80%	J-2
	4.0'		SAND, SOFT, WET, MEDIUM TO COARSE PALE BROWNISH LIGHT GRAY.	80%	J-3
			SILT, WET, SOFT, WITH A LITTLE CLAY, TR SAND FINE, MEDIUM GRAY	100%	J-4
	6.0'		SAME AS JAR-4	100%	J-5
	9.0'		SAME AS JAR-4	100%	J-6 HTRW 1045
	10.0'		SAME AS JAR-4	100%	J-7
			SAME AS JAR-4	100%	J-8
	12.0'		CLAYEY SAND, WET SOFT, MEDIUM DARK GRAY	100%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
	16.0'		SAND, WET, SOFT, COARSE BROWN.	100%	J-11
			SAME AS JAR-11	54%	J-12
	18.0'		SAND, WET, SOFT, FINE WITH A LITTLE SILT MEDIUM BROWN.	80%	J-13
	20.0		SAME AS JAR-13	100%	J-14
			CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	7,10,12	NA
J-2	1.5-3.0	4,6,7	NA
J-3	3.0-4.5	10,11,14	NA
J-4	4.5-6.0	1,WH,1	<.5,<.5,<.5
J-5	6.0-7.5	WH,WH,WH	<.5,<.5,<.5
J-6	7.5-9.0	2,1,2	<.5,<.5,<.5
J-7	9.0-10.5	2,1,1	<.5,<.5,<.5
J-8	10.5-12.0	WH,1,1	<.5,<.5,<.5
J-9	12.0-13.5	1,3,1	NA
J-10	13.5-15.0	2,2,12	NA
J-11	15.0-16.5	19,16,16	NA
J-12	16.5-18.0	16,32,20	NA
J-13	18.0-19.5	2,1,2	NA
J-14	19.5-21.0	27,32,8	NA
J-15	21.0-22.5	23,9,7	NA
J-16	22.5-24.0	8,15,16	NA
J-17	24.0-25.5	8,15,23	30,1.8,1.5
J-18	25.5-27.0	8,12,21	NA
J-19	27.0-28.5	18,15,21	NA
J-20	28.5-30.0	15,32,32	NA

Ground Water Readings

Encountered: 2.1'
Completion: 11.5'
24 hours: 4.7'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-09

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-09
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS TAR-13	100%	J-14 (LWD)	
	22.0'		SAME AS TAR-13	80%	J-15	
			SAME AS TAR-13	87%	J-16	
	24.0'		SAND, WET, SOFT, FINE, TR SILT, TR GRAVEL. MEDIUM BROWN.	73%	J-17	
	26.0'		SAME AS TAR-17	73%	J-18	
	28.0'		SANDY GRAVEL, WET, SOFT, MEDIUM BROWN.	67%	J-19	
			SAME AS TAR-19	47%	J-20 HTRW 1420	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-10

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-10		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9-7-03	COMPLETED 9-7-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E [illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		TOPSOIL, GRASS AND ROOT MAT, SAND FINE, WITH SOME SILT, MEDIUM BROWN. .7 SAND COARSE TO COBBLE, DRY 1.4 SAND, GRAY TO LIGHT BROWN	80%	J-1	Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, DAMP TO DRY, MEDIUM WITH SOME GRAVEL, TR SILT. BROWN TO BLACK	100%	J-2	**Samples** JAR# DEPTH BLOW COUNT PENETROMETER J-1 0.0–1.5 3,8,21 NA J-2 1.5-3.0 12,12,13 NA
	4.0'		SAND, DAMP, SOFT, MEDIUM, TR GRAVEL, BROWN TO BLACK WET AT 4.0' GWE 4.0'	100%	J-3	J-3 3.0-4.5 18,6,3 NA J-4 4.5-6.0 2,1,1 NA, NA, <.5
			SAND, WET, SOFT MEDIUM. TR GRAVEL BROWN TO BLACK 5.5 CLAY, WET, SOFT, TR SILT, MEDIUM GRAY.	80%	J-4	J-5 6.0-7.5 1,[illegible] <.5, NA, <.5 J-6 7.5-9.0 2,3,3 NA
	6.0'		CLAY WET, SOFT, TR SILT MEDIUM GRAY, MIXED WITH SAND, WET, MEDIUM, SOFT, MEDIUM GRAY.	80%	J-5	J-7 9.0-10.5 3,1,3 NA J-8 10.5-12.0 6,4,3 NA
	8.0'		SAND, WET, SOFT, MEDIUM, TR SILT, DARK GRAY.	100%	J-6 HRAW 1400 HSA	J-9 12.0-13.5 [illegible] NA J-10 13.5-15.0 1,1,[illegible] NA, <.5, <.5
			SAME AS JAR-6	100%	J-7	J-11 15.0-16.5 [illegible] <.5, <.5, <.5 J-12 16.5-18.0 [illegible] <.5, <.5, <.5
	10.0'		SAME AS JAR-6	100%	J-8	J-13 18.0-19.5 [illegible] <.5, <.5, <.5 J-14 19.5-21.0 [illegible] <.5, <.5, <.5
						J-15 21.0-22.5 [illegible] <.5, <.5, <.5
	12.0'		SAME AS JAR-6	100%	J-9	J-16 22.5-24.0 [illegible] <.5, <.5, <.5 J-17 24.0-25.5 [illegible] <.5, <.5, NA
			SAME AS JAR-6 14.0 - CLAY, WITH SOME SILT, TR SAND, FINE DARK GRAY TO DARK BROWN.	80%	J-10	J-18 25.5-27.0 [illegible] NA J-19 27.0-28.5 1,2,4 NA
	14.0'					J-20 28.5-30.0 2,2,4 NA
			SAME AS BOTTOM OF JAR-10 15.5 CLAY, WET, SOFT, TR SILT, TR SHELL FRAGMENTS COARSE GRAY.	100%	J-11	Ground Water Readings Encountered: 4.0' Completion: 5.7' 24 hours: 4.0'
	16.0'					
			SAME AS BOTTOM OF JAR-11	100%	J-12	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	18.0'		SAME AS BOTTOM OF JAR-11	100%	J-13	
			SAME AS BOTTOM OF JAR-11	100%	J-14	
	20.0		CONTINUED			

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-10

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE — Hole No. LSP-03-10

PROJECT LIBERTY STATE PARK JERSEY CITY, NJ — INSTALLATION BALTIMORE DISTRICT — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0		SAME AS BOTTOM OF JAR-11	100%	J-14	
	22.0		SAME AS BOTTOM OF JAR-11	100%	J-15	
			SAME AS BOTTOM OF JAR-11	100%	J-16	
	24.0		SAND, WET, SORT, MEDIUM TO SILT MEDIUM GRAY	100%	J-17	
	26.0		SAME AS JAR-17	100%	J-18	
	28.0		SAME AS JAR-17	100%	J-19	
	30.0		SAME AS JAR-17	100%	J-20 HRZN 1525	
			EOH-30.0'			

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A (ER 1110-1-1801) GPO 1980 OF-628-603 — PROJECT LIBERTY STATE PARK JERSEY CITY, NJ — HOLE NO. LSP-03-10

Hole No. LSP-03-11

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-11		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8-24-03 / COMPLETED 8-25-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Ryan	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SILTY SAND, DAY, SOFT, MEDIUM. TR ORGANICS. DARK BROWN TO BLACK.	33%	J-1
	2.0'		SAND, SAND TOWET, SOFT, MEDIUM. MEDIUM BROWN GWT 3.0'	33%	J-2
	4.0'		SAND, WET, SOFT, MEDIUM. MEDIUM BROWN.	100%	J-3
			SAME AS JAR-3 S.B SILTY SAND, WET, SOFT, MEDIUM TR CLAY, GRAY.	100%	J-4
	6.0'		SAND, WET, SOFT, MEDIUM MEDIUM BROWN.	100%	J-5
	8.0'		SAME AS JAR-5	100%	J-6 HRZN 1550
			SILT, WET, SOFT, TR SAND. FINE, TR CLAY, MEDIUM GRAY.	100%	J-7
	10.0'		SILTY SAND, WET, SOFT, MEDIUM TR GRAVEL TR SHELL FRAGMENTS COARSE, MEDIUM GRAY.	100%	J-8
	12.0'		SAME AS JAR-6	100%	J-9
	14.0'		SANDY SILT, WET, SOFT, FINE. TR CLAY, TR SHELL FRAGMENTS COARSE, MEDIUM GRAY	100%	J-10
	16.0'		CLAY, WET, SOFT, TR SILT. TR SHELL FRAGMENTS COARSE DARK GRAY	100%	J-11
	18.0'		SAME AS JAR-11	100%	J-12
			SAME AS JAR-11	42%	J-13
	20.0		SAME AS JAR-11 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0–1.5	1,2,2	NA
J-2	1.5-3.0	2,3,3	NA
J-3	3.0-4.5	1,2,1	NA
J-4	4.5-6.0	WOH,1,WOH	NA
J-5	6.0-7.5	WOH,WOH,WOH	NA
J-6	7.5-9.0	WOH,WOH,WOH	NA
J-7	9.0-10.5	WOH,WOH,WOH	<.5,<.5,<.5
J-8	10.5-12.0	WOH,WOH,1	NA
J-9	12.0-13.5	1,1,1	NA
J-10	13.5-15.0	WOH,WOH,WOH	<.5,<.5,<.5
J-11	15.0-16.5	WOH,WOH,WOH	<.5,1.0,.5
J-12	16.5-18.0	WOH,WOH,WOH	<.5,1.0,.5
J-13	18.0-19.5	WOH,WOH,WOH	<.5,<.5,<.5
J-14	19.5-21.0	WOH,WOH,WOH	<.5,<.5,<.5
J-15	21.0-22.5	WOH,WOH,WOH	<.5,<.5,<.5
J-16	22.5-24.0	WOH,WOH,WOH	<.5,<.5,<.5
J-17	24.0-25.5	WOH,WOH,1	<.5,<.5,<.5
J-18	25.5-27.0	1,2,2	NA
J-19	27.0-28.5	1,3,4	NA
J-20	28.5-30.0	2,3,4	NA

Ground Water Readings

Encountered: 3.0'
Completion: 13.8'
24 hours: 3.2'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 74 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-11

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-11
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-11	100%	J-14 (GWT)	
	22.0'		SAME AS JAR-11	100%	J-15	
			CLAYEY SAND, WET, SOFT, MEDIUM TR SHELL FRAGMENTS COARSE, MEDIUM GRAY	100%	J-16	
	24.0'		SAME AS JAR-16	100%	J-17	
	26.0'		SAND, WET, SOFT, MEDIUM, TR CLAY, TR SILT, DULL BROWNISH GRAY	100%	J-18	
	28.0'		SAME AS JAR-18	100%	J-19	
			SAME AS JAR-18	100%	J-20 HTAW 0840	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-11

Hole No. LSP-03-12

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-12		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		18. DATE HOLE	STARTED 8-22-03 / COMPLETED 8-23-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Gray	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL GRASS AND ROOT MAT, DRY, LOOSE, SILTY SAND, TR GRAVEL TR COBBLE, BROWN TO DARK GRAY.	14%	J-1
	2.0'		CLAY, SOFT, DAMP, WITH SOME SILT. MOTTLED, DULL ORANGISH BROWN TO GRAY.	73%	J-2
	4.0'		SAND, SOFT, DAMP, WITH TR CLAY, TR SILT. ORANGISH BROWN TO DARK GRAY.	27%	J-3
			SILTY SAND, DAMP, SOFT, MEDIUM GRAY TO BROWN	73%	J-4
	6.0'		SILTY SAND, DAMP TO WET, SOFT MEDIUM, GRAY TO BROWN. GWE 6.8'	73%	J-5
	8.0'		SILTY CLAY WET, SOFT DARK GRAY	100%	J-6 HTAW 1430
			CLAY, WET, SOFT TO FIRM, DARK GRAY	100%	J-7
	10.0'		SILTY CLAY WET, SOFT, TR GRAVEL, BLACK.	100%	J-8
	12.0'		SILTY CLAY, WET, SOFT, TR GRAVEL, TR SAND, MEDIUM, BLACK.	100%	J-9
	14.0'		SAND, WET, SOFT, MEDIUM, TR SILT, BLACK	73%	J-10
	16.0'		SAND, WET, SOFT, FINE TO MEDIUM, WITH A LITTLE GRAVEL TR SILT, BLACK TO BROWN	67%	J-11
			SAND, WET, SOFT, FINE TO MEDIUM, TR SILT, BLACK TO BROWN 17.4 CLAY, SOFT, WET, BLACK.	73%	J-12
	18.0'		SAND, WET SOFT, FINE TO MEDIUM, TR SILT, A LITTLE CLAY BLACK.	80%	J-13
			CLAY, SOFT, WET, TR SILT TRSHELL FRAGMENTS COARSE.	100%	J-14
	20.0		DARK GRAY CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	4,2,3	NA
J-2	1.5-3.0	1,2,5	<.5,<.5,<.5
J-3	3.0-4.5	2,6,10	NA
J-4	4.5-6.0	5,7,6	NA
J-5	6.0-7.5	5,7,4	NA
J-6	7.5-9.0	WOH,1,1	<.5,<.5,<.5
J-7	9.0-10.5	1,1,1	<.5,10,.6
J-8	10.5-12.0	1,1,1	<.5,<.5,<.5
J-9	12.0-13.5	7,5,4	<.5,<.5,<.5
J-10	13.5-15.0	4,4,3	NA
J-11	15.0-16.5	3,4,2	NA
J-12	16.5-18.0	1,1,WOH	NA,NA,<.5
J-13	18.0-19.5	WOH,1,WOH	NA,<.5,.8
J-14	19.5-21.0	1,1,1	<.5,<.5,<.5
J-15	21.0-22.5	WOH,WOH,1	<.5,<.5,<.5
J-16	22.5-24.0	WOH,1,WOH	<.5,<.5,<.5
J-17	24.0-25.5	WOH,WOH,1	<.5,<.5,<.5
J-18	25.5-27.0	WOH,WOH,1	<.5,<.5,<.5
J-19	27.0-28.5	WOH,WOH,1	<.5,<.5,<.5
J-20	28.5-30.0	WOH,WOH,WOH	<.5,<.5,<.5

Ground Water Readings

Encountered: 6.8'
Completion: 10.2'
24 hours: 3.4'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-12

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-12
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'			100%	J-14 (cont)	
	22.0'		SAME AS SAR-14	80%	J-15	
	24.0'		SAME AS SAR-14	100%	J-16	
			SAME AS SAR-14	100%	J-17	
	26.0'		SAME AS SAR-14	100%	J-18	
	28.0'		SAME AS SAR-14	100%	J-19	
			SAME AS SAR-14	100%	J-20 NTRW 0905	NRS.
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** LSP-03-13

PROJECT LIBERTY STATE PARK | INSTALLATION BALTIMORE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0		SAME AS JAN-12	80%	J-14	
			SAME AS JAN-12	62%	J-15	
			EOH - 21.3'			
	22.0		AUGER REFUSAL			

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A (ER 1110-1-1801) GPO 1980 OF-620-603 | PROJECT LIBERTY STATE PARK JERSEY CITY, NJ. | HOLE NO. LSP-03-13

Hole No. LSP-03-14

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-14		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED ~~20~~ 19 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8 - 11 - 03 / COMPLETED 8 - 11 - 03
7. THICKNESS OF OVERBURDEN ~~28.0'~~ 27.9'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE ~~28.0'~~ 27.9'		19. SIGNATURE OF INSPECTOR W E Sightp	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		.3 TOPSOIL, PEAT, DARK BROWN SAND, WET SOFT, COARSE, WITH MIXED DEBRIS COARSE. TR CLAY TR SILT, BROWN	73%	J-1
	2.0'		SAND, WET, SOFT, MEDIUM TO COARSE TR SILT, TR CLAY BLACK. GWE 3.0'	100%	J-2
	4.0'		GRAVELLY SAND, COARSE, WET, SOFT, TR SILT, TR CLAY, BLACK.	100%	J-3
			SAME AS JAR-3	100%	J-4
	6.0'		SAME AS JAR-3	80%	J-5 HRAW 1500
	8.0'		SAME AS JAR-3	87%	J-6
	10.0'		SILTY SAND, FINE, WET, SOFT, TR CLAY DARK GRAY	20%	J-7
			SAME AS JAR-7	80%	J-8
	12.0'		SILTY SAND, FINE, WET, SOFT, TR CLAY TR GRAVEL. TR COBBLE, DARK GRAY.	100%	J-9
	14.0'		SILTY SAND, FINE, WET, SOFT DULL GREENISH BROWN	40%	J-10
			SAME AS JAR-10 160- SAND, WET, SOFT, MEDIUM DULL GREENISH BROWN.	100%	J-11
	16.0'		SAND, WET, SOFT, MEDIUM TO COARSE DULL ORANGISH BROWN	100%	J-12
	18.0'		SAME AS JAR-12	100%	J-13
			SAND, WET, SOFT, MEDIUM TO COARSE, TR GRAVEL DULL ORANGISH BROWN TO BROWN.	100%	J-14
	20.0		CONTINUED		

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0–1.5	2,3,3	NA
J-2	1.5-3.0	8,11,9	NA
J-3	3.0-4.5	7,4,4	NA
J-4	4.5-6.0	4,3,3	NA
J-5	6.0-7.5	5,2,1	NA
J-6	7.5-9.0	1,1,4	NA
J-7	9.0-10.5	6,6,7	NA
J-8	10.5-12.0	4,5,5	NA
J-9	12.0-13.5	4,4,6	NA
J-10	13.5-15.0	2,2,2	NA
J-11	15.0-16.5	2,4,6	NA
J-12	16.5-18.0	6,9,11	NA
J-13	18.0-19.5	3,6,13	NA
J-14	19.5-21.0	4,13,16	NA
J-15	21.0-22.5	3,7,11	NA
J-16	22.5-24.0	4,10,9	NA
J-17	24.0-25.5	7,13,26	NA
J-18	25.5-27.0	11,14,24	NA
J-19	27.0-~~28.5~~ 27.9	6,100/.4	NA
~~J-20 28.5-30.0~~			

Ground Water Readings

Encountered: 3.0'
Completion: 2.8
24 hours: 1.2'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-14

Hole No. LSP-03-15

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-15		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-20-03	COMPLETED 8-20-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Gram	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SILTY SAND, FINE, GRASS + ROOT MAT, DAMP, SOFT, MEDIUM BROWN	100%	J-1
			1.3, SAND, COARSE SOFT, DAMP WITH SOME CHARRED MATERIAL BLACK.		
	2.0'		SAND, COARSE, DAMP, SOFT, TR COBBLE, TR GRAVEL, TR CLAY BLACK.	40%	J-2
			SAME AS JAR-2		
	4.0'		3.3 - SAND, DAMP, SOFT, MEDIUM, TR SILT TR CLAY, REDDISH BROWN.	100%	J-3
			SAND, DAMP TO WET, SOFT, MEDIUM TO COARSE, TR SILT TR CLAY TR GRAVEL, BLACK GWE 5.3'	50%	J-4
	6.0'		SILTY SAND, WET, SOFT, MEDIUM TO FINE, TR CLAY, TR GRAVEL MEDIUM GRAY	100%	J-5 MTRW 1005 HAS
	8.0'		SAME AS JAR-5	73%	J-6
			SAME AS JAR-5	80%	J-7
	10.0'		SAND, WET, SOFT, COARSE TO MEDIUM TR SILT BLACK.	47%	J-8
	12.0'		SAME AS JAR-6		
			13.0 - SILTY SAND, WET, SOFT, FINE, DARK GRAY.	67%	J-9
	14.0'		SILTY SAND, WET, SOFT FINE DARK GRAY.	100%	J-10
			SAME AS JAR-10	100%	J-11
	16.0'		SAND, WET, SOFT, FINE, TR SILT, GRAY.	100%	J-12
	18.0'		SAME AS JAR-12	TR	J-13
	20.0		SAME AS JAR-12 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	3,5,6	NA
J-2	1.5-3.0	15,11,16	NA
J-3	3.0-4.5	6,4,3	NA
J-4	4.5-6.0	3,2,1	NA
J-5	6.0-7.5	3,1,2	NA
J-6	7.5-9.0	1,1,1	NA
J-7	9.0-10.5	1,2,1	NA
J-8	10.5-12.0	WH,1,1	NA
J-9	12.0-13.5	WH,1,1	NA,NA,<.5
J-10	13.5-15.0	WH,1,1	<.5,<.5,<.5
J-11	15.0-16.5	2,2,2	NA
J-12	16.5-18.0	WH,1,3	NA
J-13	18.0-19.5	2,1,2	NA
J-14	19.5-21.0	1,1,3	NA
J-15	21.0-22.5	2,1,1	NA
J-16	22.5-24.0	3,4,5	NA
J-17	24.0-25.5	3,5,5	NA
J-18	25.5-27.0	5,6,6	NA,2.7,2.2
J-19	27.0-28.5	4,5	1.8,1.7,1.7
J-20	28.5-30.0	4,7,9	1.7,2.7,3.4

Ground Water Readings

Encountered: 5.3'
Completion: 12.7'
24 hours: 3.2'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-15

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-15
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAL-12	100%	J-14 (LOW)	
	22.0'		SILTY SAND WET, SOFT, FINE DULL GREENISH GRAY	100%	J-15	
	24.0'		SAME AS JAL-15 23.0 - SAND, WET, SOFT, MEDIUM TR GRAVEL, LIGHT BROWN.	100%	J-16	
	26.0'		SAND, WET, SOFT MEDIUM TR GRAVEL LIGHT BROWN. SAME AS JAL-17 26.0 - SILT, WET, FIRM TR CLAY, TR SAND, FINE BROWN.	100%	J-17	
	28.0'		SAME AS JAL-18	100%	J-18	
			SAME AS JAL-18	100%	J-19	
	30.0'		BOH - 30.0'		J-20 HTAW 1130 HR.	
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03- 16

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 16		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-12-03	COMPLETED 8-12-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		SAND, HUMUS, DAMP, BLACK	100%	J-1	Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, BLACK WET. GWE 2.4'	100%	J-2	
	4.0'		SAND COARSE, BLACK WET.	47%	J-3	
			SAME AS JAR-3	27%	J-4	
	6.0'		SAME AS JAR-3	20%	J-5	
	8.0'		SAME AS JAR-3	13%	J-6	
			CLAYEY SAND, WITH 5% OF GRAVEL BLACK.	13%	J-7	
	10.0'		SAME AS JAR-7	54%	J-8	
	12.0'		SAME AS JAR-7	13%	J-9	
	14.0'		SAME AS JAR-7	TR	J-10	
	16.0'		SAME AS JAR-2	7%	J-11	
			CLAY: WET, SOFT. DARK GRAY	40%	J-12	
	18.0'		SAME AS JAR-12	100%	J-13 HSAW 17.0	
	20.0'		SANDY CLAY WET, SOFT DARK GRAY. CONTINUED	100%	J-14	

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	3,4,3	NA
J-2	1.5-3.0	3,3,1	NA
J-3	3.0-4.5	6,1,1	NA
J-4	4.5-6.0	1,WH,WH	NA
J-5	6.0-7.5	WH,WH,WH	NA
J-6	7.5-9.0	WH,WH,1	NA
J-7	9.0-10.5	WH,1	NA
J-8	10.5-12.0	WH,WH	NA
J-9	12.0-13.5	WH,WH,WH	NA
J-10	13.5-15.0	WH,WH,WH	NA
J-11	15.0-16.5	WH,WH,WH	<.5
J-12	16.5-18.0	WH,WH,WH	<.5
J-13	18.0-19.5	WH,WH,WH	<.5
J-14	19.5-21.0	WH,WH,WH	<.5
J-15	21.0-22.5	WH,1,1	NA
J-16	22.5-24.0	2,4,6	NA
J-17	24.0-25.5	1,1,2	NA
J-18	25.5-27.0	3,4,6	NA
J-19	27.0-28.5	5,7,8	NA
J-20	28.5-30.0	4,8,11	NA.

Ground Water Readings

Encountered: 2.4'
Completion: 16.4'
24 hours: 13.2'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 16

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE **Hole No.** LSP-03-16

PROJECT LIBERTY STATE PARK JERSEY CITY, NJ | INSTALLATION BALTIMORE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0			100%	J-14	
	22.0		SAME AS JAR-14	60%	J-15	
	24.0		SANDY CLAY, WET, SOFT, TR GRAVEL, DARK GRAY.	67%	J-16	
			SAME AS JAR-16	27%	J-17	
	26.0		SAME AS JAR-16	40%	J-18	
	28.0		SAME AS JAR-16	100%	J-19	
	30.0		SAME AS JAR-16	87%	J-20 HTRW 0815	

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-801) GPO 980 OF-628-503 | PROJECT LIBERTY STATE PARK JERSEY CITY, NJ | HOLE NO. LSP-03-16

Hole No. LSP-03-17

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-17		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8-28-03 / COMPLETED 8-28-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Stark	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL GROSS MOSTLY MAT SAND, SOME BRK, SOFT TR SILT DARK BROWN .4 SAND COARSE, DRY, SOFT, BLACK, CARBONIZED MATERIAL	67%	J-1
	2.0'		SAND, COARSE, DRY, SOFT BLACK, CARBONIZED MATERIAL GWE 3.0'	80%	J-2
	4.0'		SAND, WET, SOFT TO HARD, COARSE, BLACK TR SILT.	87%	J-3
			SAME AS JAR-3		
			5.7 - SAND, WET, SOFT, MEDIUM TO COARSE, BROWN TO MEDIUM GRAY.	87%	J-4
	6.0'		SAME AS JAR-4	67%	J-5
	8.0'		SAME AS JAR-4	80%	J-6 ATTEW 1420 HRS
			SAND, WET, SOFT, MEDIUM, TR GRAVEL, TR SILT. BLACK.	73%	J-7
	10.0'		SAME AS JAR-7	77%	J-8
	12.0'		SAME AS JAR-7	67%	J-9
	14.0'		SAME AS JAR-7	100%	J-10
	16.0'		SAME AS JAR-7	47%	J-11
			SAND WET, MEDIUM WITH A LITTLE GRAVEL, TR SILT BLACK.	27%	J-12
	18.0'		SAME AS JAR-12	100%	J-13
			SAME AS JAR-12	60%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g			
Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".			
Samples			
JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	7,5,5	NA
J-2	1.5-3.0	3,2,10	NA
J-3	3.0-4.5	9,11,12	NA
J-4	4.5-6.0	9,6,13	NA
J-5	6.0-7.5	5,11,10	NA
J-6	7.5-9.0	5,4,2	NA
J-7	9.0-10.5	2,1,2	NA
J-8	10.5-12.0	2,1,1	NA
J-9	12.0-13.5	2,1,1	NA
J-10	13.5-15.0	2,1,2	NA
J-11	15.0-15.5	2,1,2	NA
J-12	16.5-16.0	4,4,3	NA
J-13	18.0-19.5	3,3,2	NA
J-14	19.5-21.0	4,11	NA NA <.5
J-15	21.0-22.5	1,1,2	<.5,<.5,<.5
J-16	22.5-24.0	wor,wor,wor,wor	<.5,<.5,<.5
J-17	24.0-25.5	wor,3,1	<.5,<.5,<.5
J-18	25.5-27.0	wor,wor,wor,wor	<.5,<.5,<.5
J-19	27.0-28.5	wor,wor,wor,wor	<.5,<.5,<.5
J-20	28.5-30.0	wor,wor,wor,wor	<.5,<.5,<.5

Ground Water Readings

Encountered: 3.0'
Completion: 3.6'
24 hours: 3.0'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-17

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-17
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		20.7 CLAY WET, SOFT TRACE DARK GRAY.	60%	J-14 (GW17)	
	22.0'		CLAY, WET, SOFT, TR SILT DARK GRAY.	73%	J-15	
	24.0'		SAME AS JAR-15	100%	J-16	
	26.0'		SAME AS JAR-15	100%	J-17	
	28.0'		SAME AS JAR-15	100%	J-18	
	30.0'		SAME AS JAR-15	100%	J-19	
	32.0'		SAME AS JAR-15	100%	J-20 WTAW 1615	
	34.0'		BOH - 30.0'			
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-18

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-18		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-25-03	COMPLETED 8-25-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Sp[illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT. SAND, FINE, DRY FIRM. BROWN. .2 SAND, LOOSE, SOFT, DRY, COARSE BLACK	20%	J-1
	2.0'		SILT, DRY, SOFT, BROWNS. MOTTLED, TR ROOT.	80%	J-2
	4.0'		SILT, WITH SOME CLAY AND A LITTLE SAND, TR GRAVEL, DARK BROWN.	20%	J-3
			SAND, DAMP, SOFT, COARSE, TR SILT, TR GRAVEL. BLACK. GWE 5.9'	67%	J-4
	6.0'		SAND, WET, SOFT COARSE, TR SILT, TR GRAVEL BLACK.	80%	J-5
	8.0'		SAME AS JAR-5	100%	J-6
	10.0'		SAME AS JAR-5	100%	J-7
			SAME AS JAR-5	87%	J-8
	12.0'		CLAY, WET, SOFT. TR SILT DARK GRAY.	87%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
	16.0'		SAME AS JAR-9	100%	J-11
			SAME AS JAR-9	100%	J-12
	18.0'		SAME AS JAR-9	100%	J-13
	20.0		SAME AS JAR-9 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0–1.5	4,4,4	NA
J-2	1.5-3.0	2,2,2	NT
J-3	3.0-4.5	3,3,7	<.5,<.5, NA
J-4	4.5-6.0	5,10,11	NA
J-5	6.0-7.5	9,15,24	NA
J-6	7.5-9.0	4,10,10	NA
J-7	9.0-10.5	4,10,8	NA
J-8	10.5-12.0	3,16,24	NA
J-9	12.0-13.5	1,1,1	<.5,<.5, .8
J-10	13.5-15.0	1,1,1	<.5, .8, <.5
J-11	15.0-16.5	1,2,1	<.5,<.5,<.5
J-12	16.5-18.0	1,2,2	<.5,<.5,<.5
J-13	18.0-19.5	1,1,1	<.5,<.5,<.5
J-14	19.5-21.0	WH,1,2	<.5,<.5,<.5
J-15	21.0-22.5	WH,WH,2	<.5,<.5,<.5
J-16	22.5-24.0	WH,WH,2	<.5,<.5,<.5
J-17	24.0-25.5	WH,WH,WH	<.5,<.5,<.5
J-18	25.5-27.0	WH,WH,WH	<.5,<.5,<.5
J-19	27.0-28.5	WH,WH,WH	<.5,<.5,<.5
J-20	28.5-30.0	WH,WH,WH	<.5,<.5,<.5

Ground Water Readings

Encountered: 5.9'
Completion: 20.6'
24 hours: 5.4'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-18

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-18
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-9	100%	J-14 (Cont)	
	22.0'		SAME AS JAR-9	100%	J-15	
	24.0'		SAME AS JAR-9	100%	J-16	
	26.0'		SAME AS JAR-9	100%	J-17	
	28.0'		SAME AS JAR-9	100%	J-18	
			SAME AS JAR-9	100%	J-19	
	30.0'		SAME AS JAR-9	100%	J-20	
	32.0'		BOH - 30.0'			
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-18

Hole No. LSP-03- 19

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 19		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-26-03	COMPLETED 8-26-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W. S. Stephens	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT SILTY SAND, FINE, DRY SOFT, TR SAND, DRY, SOFT, FINE, TR SILT, TR ORGANICS, WITH A LITTLE GRAVEL MEDIUM BROWN TO BLACK	67%	J-1
	2.0'		SAND, DRY, SOFT, FINE, TR SILT TR ORGANICS WITH A LITTLE GRAVEL, MEDIUM BROWN TO BLACK	67%	J-2
	4.0'		SAND AND TOWET, SOFT, MEDIUM TO COARSE, TR GRAVEL BLACK.	73%	J-3
			SAME AS JAR-3	50%	J-4
	6.0'		SAME AS JAR-3	33%	J-5
	8.0'		SAME AS JAR-3	47%	J-6
	10.0'		SAME AS JAR-3 9.4 CLAY, SOFT, WET, TR SILT. TR SHELL FRAGMENTS COARSE. DARK GRAY	100%	J-7 HTAW 10.25'
			SAME AS JAR-2	87%	J-8
	12.0'		SAME AS JAR-7	100%	J-9
	14.0'		SAME AS JAR-7	100%	J-10
	16.0'		SAME AS JAR-7	100%	J-11
			SAME AS JAR-7	100%	J-12
	18.0'		SAME AS JAR-7	100%	J-13
			SAME AS JAR-7	100%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	4,3,3	NA
J-2	1.5-3.0	9,4,4	NA
J-3	3.0-4.5	8,11,14	NA
J-4	4.5-6.0	13,14,15	NA
J-5	6.0-7.5	6,5,5	NA
J-6	7.5-9.0	2,2,2	NA
J-7	9.0-10.5	1,1,1	NA, .5, .5
J-8	10.5-12.0	2,1,1	<.5,<.5,<.5
J-9	12.0-13.5	WOH,WOH,WOH	<.5,<.5,<.5
J-10	13.5-15.0	WOH,WOH,WOH	<.5,<.5,<.5
J-11	15.0-16.5	WOR,WOR,3	<.5,<.5,<.5
J-12	16.5-18.0	WOR,WOR,WOR	<.5,<.5,<.5
J-13	18.0-19.5	WOH,2,2	<.5,<.5,<.5
J-14	19.5-21.0	WOH,2,2	<.5,<.5,<.5
J-15	21.0-22.5	WOH,2,2	<.5,<.5,<.5
J-16	22.5-24.0	2,2,2	<.5,<.5,<.5
J-17	24.0-25.5	WOH,WOH,2	<.5,<.5,<.5
J-18	25.5-27.0	WOH,WOH,WOH	<.5,<.5,<.5
J-19	27.0-28.5	2,2,2	<.5,<.5,<.5
J-20	28.5-30.0	WOH,WOH,WOH	<.5,<.5,<.5

Ground Water Readings

Encountered: 4.0'
Completion: 23.3'
24 hours: 4.3'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 19

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03- 19
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-7	100%	J-14 (Cont)	
	22.0'		SAME AS JAR-7	100%	J-15	
	24.0'		SAME AS JAR-7	100%	J-16	
	26.0'		SAME AS JAR-7	100%	J-17	
	28.0'		SAME AS JAR-7	100%	J-18	
			SAME AS JAR-7	100%	J-19	
	30.0'		BOH - 30.0'		J-20 HTRW 1150	
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03- 19

Hole No. LSP-03-20

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-20		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8-28-03 / COMPLETED 8-28-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S [illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT. SANDY, SOFT, TR SILT, TR CLAY TR GRAVEL MEDIUM BROWN	87%	J-1
	2.0'		SAND, MEDIUM, DAMP, SOFT LIGHT BROWN.	80%	J-2
	4.0'		SAME AS JAR-2	83%	J-3
			SAME AS JAR-2 4.7 SAND, DAMP, SOFT, MEDIUM TO COARSE, TR SILT, TR GRAVEL BLACK.	100%	J-4
	6.0'		SAME AS JAR-4 6.WE.	80%	J-5
	8.0'		SAND, WET, SOFT, MEDIUM TO COARSE, TR SILT, TR CLAY BLACK	67%	J-6 4TRW 6815
			SAME AS JAR-6	54%	J-7
	10.0'		SAND, COARSE, WET, SOFT, TR CLAY, TR SILT, TR GRAVEL, DULL BROWNISH DARK GRAY.	87%	J-8
	12.0'		SAME AS JAR-8	80%	J-9
	14.0'		SAME AS JAR-8 14.5 - WOOD FRAGMENT, .5'	73%	J-10
			SAND, WET, SOFT, MEDIUM, TR COARSE, BLACK.	73%	J-11
	16.0'		SAME AS JAR-11	73%	J-12
	18.0'		SAND WET, SOFT, MEDIUM. TR SILT, TR CLAY BLACK	100%	J-13
			CLAY, WET, SOFT, TR SILT BLACK.	100%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	14,12,10	NA
J-2	1.5-3.0	5,6,8	NA
J-3	3.0-4.5	3,6,11	NA
J-4	4.5-6.0	19,13,5	NA
J-5	6.0-7.5	12,12,10	NA
J-6	7.5-9.0	1,2,24	NA
J-7	9.0-10.5	5,8,5	NA
J-8	10.5-12.0	9,7,16	NA
J-9	12.0-13.5	5,8,9	NA
J-10	13.5-15.0	7,10,6	NA
J-11	15.0-16.5	5,8,8	NA
J-12	16.5-18.0	4,3,4	NA
J-13	18.0-19.5	4,6,8	NA
J-14	19.5-21.0	2,2,1	<.5, 1.0, .8
J-15	21.0-22.5	1,1,1	<.5, <.5, <.5
J-16	22.5-24.0	wor, wor, 2	<.5, <.5, <.5
J-17	24.0-25.5	wor, wor, wor	<.5, <.5, <.5
J-18	25.5-27.0	2,2,2	<.5, <.5, <.5
J-19	27.0-28.5	wor, wor, wor	<.5, <.5, 2.5
J-20	28.5-30.0	wor, wor, wor	<.5, <.5, <.5

Ground Water Readings

Encountered: 7.5'
Completion: 5.8'
24 hours: 5.6'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-20

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-20
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'			100%	J-14 (RUN)	
			SAME AS JAL-14	100%	J-15	
	22.0'					
			SAME AS JAL-14	100%	J-16	
	24.0'					
			SAME AS JAL-14	100%	J-17	
	26.0'		SAME AS JAL-14	100%	J-18	
			SAME AS JAL-14	100%	J-19	
	28.0'					
			SAME AS JAL-14	100%	J-20 HRW 0925	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-23

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-23		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 23 / UNDISTURBED 0
5. NAME OF DRILLER Paul Van Dorn		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9-2-03	COMPLETED 9-2-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E [illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		SAND, DAMP, SOFT, FINE, COARSE TR SILT, TR CLAY TR GRAVEL DEBRIS, TR PEAT, COARSE. TR ROOTS, DARK BROWN	67%	J-1	Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, DAMP, SOFT, COARSE, TR GRAVEL, TR SILT, BLACK. GWE. 3.0'	73%	J-2	**Samples** JAR# DEPTH BLOW COUNT PENETROMETER J-1 0.0-1.5 3,3,4 NA J-2 1.5-3.0 3,4,4 NA
	4.0'		SAND, WET, SOFT, COARSE. TR SILT, TR GRAVEL DARK GRAY	40%	J-3	J-3 3.0-4.5 2,2,2 NA J-4 4.5-6.0 6,2,3 NA
			SAME AS JAR-3	54%	J-4	J-5 6.0-7.5 4,3,6 NA J-6 7.5-9.0 1,4,4 NA
	6.0'		SAND, WET, FINE TO COARSE. TR GRAVEL, TR SILT, TR DEBRIS COARSE, BLACK	40%	J-5	J-7 9.0-10.5 2,1,1 NA, <.5,<.5 J-8 10.5-12.0 1,1,1 <.5,<.5,<.5
	8.0'		SAME AS JAR-5	47%	J-6 HTRW MW NA4	J-9 12.0-13.5 1,weight <.5,<.5,<.5 J-10 13.5-15.0 weight,weight,weight <.5,<.5,<.5
			SAME AS JAR-5 95 CLAY, WET, SOFT, TR SILT, MEDIUM GRAY	67%	J-7	J-11 15.0-16.5 2,1,1 <.5,<.5,<.5 J-12 16.5-18.0 1,2,3 NA
	10.0'		CLAY, WET, SOFT, TR SILT MEDIUM GRAY.	100%	J-8	J-13 18.0-19.5 weight,weight,weight NA,<.5,<.5 J-14 19.5-21.0 weight,weight,weight NA
			SAME AS JAR-8	100%	J-9	J-15 21.0-22.5 weight,weight,weight NA J-16 22.5-24.0 8,6,5 NA
	12.0'					J-17 24.0-25.5 5,5,5 NA J-18 25.5-27.0 10,8,11 NA
	14.0'		SAME AS JAR-8	100%	J-10	J-19 27.0-28.5 9,7,11 NA J-20 28.5-30.0 8,10,12 NA
			SAME AS JAR-8	100%	J-11	**Ground Water Readings** Encountered: 3.0' Completion: 2.8' 24 hours: 2.8'
	16.0'		SAND, FINE, WET, SOFT, TR CLAY, GRAYISH BROWN.	100%	J-12	**PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL**
	18.0'		SAME AS JAR-12	100%	J-13	
			SAND, WET, SOFT, FINE LIGHT BROWNISH GRAY.	100%	J-14	
	20.0		CONTINUED			

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-23

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-23
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'			100%	J-14 (cont)	
	22.0'		SAME AS JAL-14	100%	J-15	
			SAME AS JAL-14	100%	J-16	
	24.0'		SAND, WET, SOFT, FINE WITH A LITTLE GRAVEL LIGHT BROWNISH GRAY.	100%	J-17	
	26.0'		SAME AS JAL-17	100%	J-18	
	28.0'		SAND, WET, SOFT, FINE, WITH A LITTLE GRAVEL. TRACE CLAY, LIGHT BROWNISH GRAY	100%	J-19	
			SAME AS JAL-19.	100%	J-20 MTAN 1600	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801)

PROJECT Liberty St Pk Jersey City, NJ

HOLE NO. LSP-03-23

Hole No. LSP-03-24

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-24		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-26-03	COMPLETED 8-26-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Spring	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT. SAND, FINE, DAMP, SOFT, TRACE DARK BROWN.	40%	J-1
	2.0'		SILTY SAND, FINE, DAMP, SOFT, TR CLAY, MOTTLED, ORANGISH BROWNS.	67%	J-2
	4.0'		SAND, DAMP, SOFT, MEDIUM. WITH A LITTLE SILT BLACK.	93%	J-3
			SAME AS JAR-3		
			S.O. SILTY CLAY, DAMP, SOFT, DARK GRAY GWE ~ 6.0'	100%	J-4
	6.0'		SILTY CLAY, WET, SOFT, DARK GRAY	67%	J-5
	8.0'		SAME AS JAR-5	67%	J-6
			SAND, WET, SOFT, COARSE, BLACK TO BROWN	47%	J-7 HTRW 0745
	10.0'				
			SAME AS JAR-7	33%	J-8
	12.0'		SAME AS JAR-7		
			12.7. CLAY, WET, SOFT, WITH TR SILT, TR SHELL FRAGMENTS COARSE DARK GRAY	47%	J-9
	14.0'		CLAY, WET, SOFT, WITH TR SILT TR SHELL FRAGMENTS, COARSE DARK GRAY	67%	J-10
	16.0'		SAME AS JAR-10	67%	J-11
			SAME AS JAR-10	100%	J-12
	18.0'		SAME AS JAR-10	100%	J-13
			SAME AS JAR-10	100%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	4,6,5	NA
J-2	1.5-3.0	2,2,2	NA
J-3	3.0-4.5	2,2,2	NA
J-4	4.5-6.0	1,2,2	<.5, <.5, <.5
J-5	6.0-7.5	5,4,3	NA
J-6	7.5-9.0	5,4,2	NA
J-7	9.0-10.5	2,2,2	NA
J-8	10.5-12.0	2,2,4	NA
J-9	12.0-13.5	10,7,5	NA, NA, <.5
J-10	13.5-15.0	1,2,1	<.5, <.5, <.5
J-11	15.0-16.5	2,1,1	<.5, <.5, <.5
J-12	16.5-18.0	2,1,1	<.5, <.5, <.5
J-13	18.0-19.5	wh, wh, wh	<.5, <.5, <.5
J-14	19.5-21.0	1,2,2	<.5, <.5, <.5
J-15	21.0-22.5	wh, 2, 2	<.5, <.5, <.5
J-16	22.5-24.0	wh, 2, 1	<.5, <.5, <.5
J-17	24.0-25.5	wh, 2, 2	<.5, <.5, <.5
J-18	25.5-27.0	wh, wh, wh	<.5, <.5, <.5
J-19	27.0-28.5	wh, wh, wh	<.5, <.5, <.5
J-20	28.5-30.0	wh, 1, 1	<.5, <.5, <.5

Ground Water Readings

Encountered: ~6.0'
Completion: 9.3'
24 hours: 4.8'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-24

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-24
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-10	100%	J-14 (Cont)	
	22.0'		SAME AS JAR-10	100%	J-15	
			SAME AS JAR-10	100%	J-16	
	24.0'		SAME AS JAR-10	100%	J-17	
	26.0'		SAME AS JAR-10	100%	J-18	
	28.0'		SAME AS JAR-10	100%	J-19	
			SAME AS JAR-10	100%	J-20 HTAW 0850	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-24

Hole No. LSP-03-25

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-25		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Paul Van Dorn		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9-3-03	COMPLETED 9-3-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Ryan	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		TOPSOIL, GRASS AND ROOT MAT, SILT, SOFT BROWN			Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
			.4 SAND, COARSE, DAMP, SOFT TR SILT, TR GRAVEL, BLACK.	73%	J-1	
	2.0'		SAND, COARSE, DAMP, SOFT, TR SILT, TR GRAVEL, BLACK	80%	J-2	
			SAME AS JAR-2			
	4.0'		3.7 SAND, FINE, DAMP, SOFT, TR SILT, ORANGISH BROWN GWE 4.0'	100%	J-3	
			SAND, FINE, DAMP, SOFT, TR SILT, ORANGISH BROWN COBBLE BLOCKED, SHOE.	TR	J-4	
	6.0'		SAND, WET, SOFT, A LITTLE CLAY. TR GRAVEL, TR SILT, TR COARSE WOOD FRAGMENTS DARK BROWNISH GRAY.	73%	J-5 HTAW 1200 HAS	
	8.0'		SANDY GRAVEL WET, SOFT, TR SILT BLOCK	100%	J-6	
			CLAY, WET, SOFT, TR SAND, FINE, DARK GRAY.	80%	J-7	
	10.0'		CLAY WET, SOFT, TR SILT, TR SHELL FRAGMENTS COARSE, DARK GRAY.	100%	J-8	
	12.0'		SAME AS JAR-8	73%	J-9	
	14.0'		SAME AS JAR-8	100%	J-10	
			SAME AS JAR-8	80%	J-11	
	16.0'		SAME AS JAR-8 17.0 CLAY WET, SOFT, TR SILT SHELL FRAGMENTS GRAVEL SIZED 17.2 CLAYEY PEAT, WET, SOFT. DARK BROWN TO GRAY	100%	J-12	
	18.0'		SAND, FINE, WET, SOFT TR SILT, MEDIUM GRAY.	100%	J-13	
			SAME AS JAR-13	100%	J-14	
	20.0		CONTINUED.			

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	3,3,7	NA
J-2	1.5-3.0	5,4,8	NA
J-3	3.0-4.5	6,4,5	NA
J-4	4.5-6.0	6,8,6	NA
J-5	6.0-7.5	4,4,23	NA
J-6	7.5-9.0	4,6,3	NA
J-7	9.0-10.5	1,1,1	<.5,<.5,<.5
J-8	10.5-12.0	WOH,1,1	<.5,<.5,<.5
J-9	12.0-13.5	WOR,WOR,WOR	<.5,<.5,<.5
J-10	13.5-15.0	WOR,WOR,WOR	<.5,<.5,<.5
J-11	15.0-16.5	WOR,WOR,WOR	<.5,<.5,<.5
J-12	16.5-18.0	1,1,1	<.5,<.5,<.5
J-13	18.0-19.5	WOH,1,1	NA
J-14	19.5-21.0	1,1,1	NA
J-15	21.0-22.5	4,6	NA
J-16	22.5-24.0	9,14,14	NA
J-17	24.0-25.5	5,15,17	NA
J-18	25.5-27.0	12,14,11	NA
J-19	27.0-28.5	4,7,6	NA
J-20	28.5-30.0	30,4,7	NA

Ground Water Readings

Encountered: 4.0'
Completion: 3.3'
24 hours: 3.0'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-25

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-25
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-13	100%	J-14 (1000)	
	22.0'		SAME AS JAR-13	100%	J-15	
			SAND, FINE, WET SOFT TR SILT, TR GRAVEL SIZE SHELL FRAGMENTS. MEDIUM GRAY.	100%	J-16	
	24.0'		SAME AS JAR-13	100%	J-17	
	26.0'		SAND, FINE, WET, SOFT, TR SILT, TR GRAVEL TR GRAVEL SIZED SHELL FRAGMENTS, MEDIUM GRAY	100%	J-18	
	28.0'		SAME AS JAR-18	100%	J-19	
			SAME AS JAR-18	100%	J-20 HTAW 1400	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801)

PROJECT Liberty St Pk Jersey City, NJ

HOLE NO. LSP-03-25

Hole No. LSP-03- 26

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 26		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 18 / UNDISTURBED 0
5. NAME OF DRILLER Paul Van Dorn		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9 - 4 - 03	COMPLETED 9 - 4 - 03
7. THICKNESS OF OVERBURDEN 27.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 27.0'		19. SIGNATURE OF INSPECTOR W. T. Sylvester	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		SAND, COARSE, DAMP, SOFT, LOOSE TR GRAVEL, TR SILT BLACK.	80%	J-1	Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, COARSE, DAMP TO WET LOOSE, TR GRAVEL, TR SILT BLACK. GW @ 2.6'	73%	J-2	**Samples** JAR# DEPTH BLOW COUNT PENETRO-METER J-1 0.0-1.5 4,7,11 NA J-2 1.5-3.0 9,7,6 NA
	4.0'		SAND, COARSE, WET, LOOSE, TR GRAVEL, TR SILT, BLACK	80%	J-3	J-3 3.0-4.5 4,4,3 NA
			SAME AS JAR-3 5.1. CLAY, WET, SOFT, TR SILT DARK GRAY 5.4 GRAVEL, WET, HARD, TR SILT, TR CLAY, TR SAND MEDIUM DARK GRAY.	13%	J-4	J-4 4.5-6.0 3,2,2,2 NA, <5, NA J-5 6.0-7.5 10,5,1 NA
	6.0'		SAND, WET, SOFT, FINE TR GRAVEL. SOME SILT BLACK.	60%	J-5	J-6 7.5-9.0 WOH,WOH,WOH <5,<5,<5 J-7 9.0-10.5 WOH,WOH,WOH <5,<5,<5
	8.0'		CLAY, WET, SOFT, TR SILT DARK GRAY	100%	J-6 MTW 08/30 NA	J-8 10.5-12.0 WOH,WOH,WOH <5,<5,<5 J-9 12.0-13.5 WOH,WOH,1 <5,<5,<5 J-10 13.5-15.0 WOH,WOH,WOH <5,<5,<5
	10.0'		SAME AS JAR-6	100%	J-7	J-11 15.0-16.5 WOR,WOR,WOR <5,<5,<5 J-12 16.5-18.0 WOR,WOR,WOR <5,<5,<5
			SAME AS JAR-6	100%	J-8	J-13 18.0-19.5 WOR,WOR,WOR <5,<5,<5 J-14 19.5-21.0 WOR,WOR,WOR <5,<5,<5 J-15 21.0-22.5 1,2,2 NA
	12.0'		SAME AS JAR-6	80%	J-9	J-16 22.5-24.0 WOH,WOH,WOH NA J-17 24.0-25.5 5,6,7 NA J-18 25.5-27.0 5,11,13 NA
	14.0'		CLAY, WET, SOFT, TR SILT TR GRAVEL DARK GRAY	100%	J-10	
	16.0'		CLAY, WET, SOFT, TR SILT, TR SHELL FRAGMENTS, COARSE. DULL GREENISH GRAY.	100%	J-11	Ground Water Readings Encountered: 2.6' Completion: 4.5' 24 hours: 1.8'
			CLAY, WET, SOFT, TR SILT, TR SHELL FRAGMENTS COARSE. DARK GRAY.	100%	J-12	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	18.0'		SAME AS JAR-12	87%	J-13	
	20.0'			100%	J-14	

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 26

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE **Hole No.** LSP-03-26

PROJECT LIBERTY STATE PARK JERSEY CITY, NJ | INSTALLATION BALTIMORE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	210		CLAY, WET, SOFT, TR SILT DARK GRAY MIXED WITH PEAT, WET, SOFT, COARSE, DARK BROWN	100%	J-14	
	220		SAND, WET, SOFT, FINE TO MEDIUM, TR CLAY, TR SILT GRAY	100%	J-15	
			SAME AS J-12-15	100%	J-16	
	240		SAND, WET, SOFT, MEDIUM TR COBBLE AND GRAVEL MEDIUM GRAY	100%	J-17	
	260		SAME AS J-12-17	100%	J-18 HTRW 0930	
			EOA 27.0'			
	280					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A (ER 1110-1-1801) GPO 1980 OF-620-603 PROJECT LIBERTY STATE PARK HOLE NO. LSP-03-26

Hole No. LSP-03-27

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-27		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-22-03	COMPLETED 8-25-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Gaffney	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SAND, FINE DRY, LOOSE, TAN, TOPSOIL AND ROOT MAT.	73%	J-1
	2.0'		SAND, COARSE, DAMP, SOFT BLACK.	87%	J-2
	4.0'		SAME AS JAR-2 3.5' SAND, VERY DAMP, SOFT, FINE TO MEDIUM, MOTTLED YELLOWISH BROWN TO ORANGISH BROWN	80%	J-3
			SAND, VERY DAMP, SOFT, FINE TO MEDIUM, MOTTLED YELLOWISH BROWN TO ORANGISH BROWN	33%	J-4
	6.0'		SAND, WET, SOFT, TR SILT PALE ORANGISH BROWN TO MEDIUM GRAY. GWE 7.1'	47%	J-5
	8.0'		GRAVELLY SICT, LGT, SOFT, WITH SOME SAND, MEDIUM, DARK GRAY.	100%	J-6 HTAW 1140 lbs
			SAME AS JAR-6	100%	J-7
	10.0'		SAME AS JAR-6 12.3 SILTY CLAY, LGT, SOFT, TR SAND, MEDIUM, MEDIUM GRAY.	100%	J-8
	12.0'		SILTY CLAY, WET, SOFT, TR SAND, MEDIUM, MEDIUM GRAY.	100%	J-9
	14.0'		SAME AS JAR-9	67%	J-10
	16.0'		SAME AS JAR-9	100%	J-11
			SAME AS JAR-9.	100%	J-12
	18.0'		SAME AS JAR-9	100%	J-13
	20.0		SAME AS JAR-9 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	6,6,5	NA
J-2	1.5-3.0	11,11,13	NA
J-3	3.0-4.5	9,9,5	NA
J-4	4.5-6.0	3,5,10	NA
J-5	6.0-7.5	1,4,3	NA
J-6	7.5-9.0	6,6,3	NA
J-7	9.0-10.5	5,4,3	NA
J-8	10.5-12.0	3,3,3	NA
J-9	12.0-13.5	1,1,2	<.5,<.5,<.5
J-10	13.5-15.0	2,1,3,3	<.5,NA,<.5
J-11	15.0-16.5	3,3,2	1.0,.8,.8
J-12	16.5-18.0	[illegible]	<.5,<.5,<.5
J-13	18.0-19.5	2,2,1	<.5,<.5,<.5
J-14	19.5-21.0	3,2,2	<.5,<.5,<.5
J-15	21.0-22.5	6,7,8	<.5,NA,NA
J-16	22.5-24.0	3,2,3	NA
J-17	24.0-25.5	5,3,9	NA
J-18	25.5-27.0	2,3,7	NA
J-19	27.0-28.5	2,4,6	NA
J-20	28.5-30.0	3,4,4	NA

Ground Water Readings

Encountered: 7.1'
Completion: 10.4'
24 hours: 4.2'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-27

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-27
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-9	100%	J-14 (WM)	
	22.0'		SAND, WET, SOFT, MEDIUM, TR SILT, MEDIUM BROWN.	100%	J-15	
	24.0'		SAME AS JAR-15	100%	J-16	
			SAME AS JAR-15	100%	J-17	
	26.0'		SAME AS JAR-15	100%	J-18	
	28.0'		SAME AS JAR-15	100%	J-19	
			SAME AS JAR-15	100%	J-20 HTRW 1320 HRS	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-27

Hole No. LSP-03-28

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-28		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-26-03	COMPLETED 8-26-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Symp	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		TOPSOIL, GRASS AND ROOT MAT SILT, DRY, SOFT MEDIUM BROWN. .3 SAND, DAMP, SOFT, COARSE, WITH MINOR DEBRIS, BLACK.	87%	J-1	Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, DAMP, COARSE, SOFT, WITH MINOR DEBRIS, BLACK	40%	J-2	**Samples** JAR# DEPTH BLOW COUNT PENETRO-METER
	4.0'		SAME AS JAR-2	60%	J-3	J-1 0.0-1.5 4,8,6 / J-2 1.5-3.0 4,2,2 / J-3 3.0-4.5 4,15,20
			SAND, DAMP, COARSE, SOFT, WITH MINOR DEBRIS, BLACK AND DULL ORANGISH BROWN. GWE 6.0	73%	J-4	J-4 4.5-6.0 11,15,12 / J-5 6.0-7.5 5,10,12
	6.0'		SAND, WET, SOFT, COARSE, WITH MINOR DEBRIS BLACK AND DULL ORANGISH BROWN	87%	J-5	J-6 7.5-9.0 6,10,11 / J-7 9.0-10.5 4,4,3
	8.0'		SAME AS JAR-5	87%	J-6 HTRW 1435	J-8 10.5-12.0 5,6,6 / J-9 12.0-13.5 3,6,3 / J-10 13.5-15.0 4,4,3
			SAND, SOFT, WET, MEDIUM MEDIUM BROWN. 10.0 - SILT, WET, SOFT, TR SAND, FINE, GRAY.	100%	J-7	J-11 15.0-16.5 3,4,1 / J-12 16.5-18.0 WH,WH,3
	10.0'		SAND, WET, SOFT, MEDIUM. TR SILT, DULL BRAWNISH GRAY	100%	J-8	J-13 18.0-19.5 1,2,1 / J-14 19.5-21.0 WH,WH,3 / J-15 21.0-22.5 WOR,WOH,2
	12.0'		SAME AS JAR-8	100%	J-9	J-16 22.5-24.0 WOR,WOR,WOR / J-17 24.0-25.5 2,2,2
	14.0'		SAND, WET, SOFT, COARSE, TR SILT, BLACK.	100%	J-10	J-18 25.5-27.0 WH,3,2 / J-19 27.0-28.5 WOR,WOH,WOH / J-20 28.5-30.0 WOR,WOR,WOR
			SAME AS JAR-10 16.0 - CLAY, SOFT, WET TR SILT, TR SHELL FRAGMENTS COARSE, BLACK	100%	J-11	Ground Water Readings Encountered: 6.0' Completion: 20.8' 24 hours: 5.4'
	16.0'		CLAY, SOFT, WET, TR SILT TR SHELL FRAGMENTS COARSE, BLACK.	100%	J-12	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	18.0'		SAME AS JAR-12	100%	J-13	
			SAME AS JAR-12	100%	J-14	
	20.0		CONTINUED			

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-28

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-28
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-12	100%	J-14 (KWM)	
	22.0'		SAME AS JAR-12	100%	J-15	
	24.0'		SAME AS JAR-12	100%	J-16	
	26.0'		SAME AS JAR-12	100%	J-17	
	28.0'		SAME AS JAR-12	100%	J-18	
			SAME AS JAR-12	100% HTRW 1530	J-19	
	30.0'				J-20	
	32.0'		BOH - 30.0'			
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-29

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 3 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE (Earth Matters, Inc.)		12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-61	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-29		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Frank Klecka		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-21-03	COMPLETED 8-22-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Ryan	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SAND, FINE, LOOSE, DRY, TR SILT TR SHELL FRAGMENTS COARSE LIGHT BROWN	100%	J-1
	2.0'		SAND, DAMP, LOOSE, SOFT, MEDIUM TR SHELL FRAGMENTS, COARSE. TR GRAVEL. LIGHT BROWN.	100%	J-2
	4.0'		SAME AS JAR-2	87%	J-3
			SAND, WET, LOOSE, SOFT, MEDIUM TR SHELL FRAGMENTS COARSE TR GRAVEL, LIGHT BROWN	80%	J-4
	6.0'		SILT, WET, SOFT, TR CLAY, TR SHELL FRAGMENTS COARSE TR SAND, FINE, MEDIUM GRAY	100%	J-5 HTAW 1615
	8.0'		SAME AS JAR-5	100%	J-6
			SAND, WET, SOFT, MEDIUM TO FINE, TR SILT, MEDIUM GRAY.	100%	J-7
	10.0'		SAME AS JAR-7 11.0 CLAY, SOFT, WET, MEDIUM GRAY 11.5 SAME AS JAR-7	100%	J-8
	12.0'		SAND, WET, SOFT, MEDIUM WITH SOME CLAY, MEDIUM GRAY	100%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
			COBBLE BLOCKING SHOE ORANGISH RED SANDSTONE TR CLAY, GRAY.	TR	J-11
	16.0'		SANDY SILT, WET, SOFT, TR CLAY, MEDIUM, MEDIUM GRAY.	100%	J-12
	18.0'		SAME AS JAR-12	67%	J-13
			SILTY CLAY, WET, SOFT, MEDIUM GRAY	100%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)

Boring was drilled using 3¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	5,4,5	NA
J-2	1.5-3.0	5,5,4	NA
J-3	3.0-4.5	4,4,4	NA
J-4	4.5-6.0	2,3,2	NA
J-5	6.0-7.5	2,3,1	<.5,<.5,<.5
J-6	7.5-9.0	2,1,1	<.5,<.5,<.5
J-7	9.0-10.5	3,3,5	NA
J-8	10.5-12.0	4,4,2	NA,<.5,NA
J-9	12.0-13.5	2,1,1	NA
J-10	13.5-15.0	3,7,7	NA
J-11	15.0-16.5	2,3,3	<.5, NA, NA
J-12	16.5-18.0	4,2,2	<.5,<.5,<.5
J-13	18.0-19.5	2,2,2	<.5,<.5,<.5
J-14	19.5-21.0	2,1,2	<.5,<.5,<.5
J-15	21.0-22.5	1,2,2	<.5,<.5,<.5
J-16	22.5-24.0	5,5,4	<.5,<.5,<.5
J-17	24.0-25.5	4,6,1	NA
J-18	25.5-27.0	6,5,5	NA
J-19	27.0-28.5	5,5,6	NA
J-20	28.5-30.0	3,3,1	NA

Ground Water Readings

Encountered: 4.5'
Completion: 12.5'
24 hours: 12.6'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-29

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-29
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'			100%	J-14 (CWM)	
	22.0'		SAME AS JAR-14 22.0 - PEAT, COARSE, DAMP, FIRM, DARK BROWN.	67%	J-15	
			SILTY CLAY, WET, SOFT, MEDIUM GRAY MIXED WITH SOME PEAT COARSE, FIRM, DAMP, DARK BROWN.	100%	J-16	
	24.0'		SAND, WET, SOFT, WITH SOME SILT AND CLAY, MEDIUM GRAY.	100%	J-17	
	26.0'		SAME AS JAR-17	100%	J-18	
	28.0'		SAME AS JAR-17	80%	J-19	
			SAND, WET, SOFT, MEDIUM, TR SILT, MEDIUM GRAY.	100%	J-20 HRW 0915 4/26	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-30

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-30		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-18-03	COMPLETED 8-19-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Stahl	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		TOPSOIL, GRASS AND ROOT MAT, SILT. SAND, SOFT, DARK BROWN. 1.0-1.2 - SAND, BLACK. CHARRED LAYER. 1.2-1.5 - SAND, LOOSE, DAMP, MEDIUM PALE YELLOWISH BROWN TO LIGHT BROWNISH GRAY MOTTLED	100%	J-1	Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, LOOSE, DAMP, MEDIUM, MOTTLED WHITE, YELLOWISH BROWN TO BRONZISH BROWN.	100%	J-2	**Samples**
	4.0'		SAME AS JAR-2	100%	J-3	JAR# DEPTH BLOW COUNT PENETRO-METER J-1 0.0-1.5 4,1,4 NA J-2 1.5-3.0 7,7,7 NA J-3 3.0-4.5 3,4,4 NA
			SAME AS JAR-2	100%	J-4	J-4 4.5-6.0 3,2,2 NA J-5 6.0-7.5 1,2,2 NA
	6.0'		GWE 5.8' SAND, LOOSE, WET, MEDIUM, TR CLAY, DULL ORANGISH BROWN TO GRAYISH BROWN.	100%	J-5 HTRW 1630	J-6 7.5-9.0 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5 J-7 9.0-10.5 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5
	8.0'		SILTY CLAY, WET SOFT, TR SAND FINE, MEDIUM GRAY.	100%	J-6	J-8 10.5-12.0 MOTTLED, 2, 2 <.5, NA, <.5 J-9 12.0-13.5 1,1,2 NA
			SAME AS JAR-6	100%	J-7	J-10 13.5-15.0 MOTTLED, MOTTLED, MOTTLED NA J-11 15.0-16.5 MOTTLED, MOTTLED, MOTTLED NA
	10.0'		SILTY CLAY, WET, SOFT, GRAY. MIXED WITH SAND, MEDIUM, WET, LOOSE, WITH TR SILT, TR CLAY, TR GRAVEL, GRAY.	100%	J-8	J-12 16.5-18.0 MOTTLED, MOTTLED, MOTTLED NA <.5, <.5, NA J-13 18.0-19.5 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5 J-14 19.5-21.0 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5
	12.0'		SAND, WET, LOOSE, MEDIUM TO FINE, MEDIUM GRAY	100%	J-9	J-15 21.0-22.5 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5 J-16 22.5-24.0 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5
			SAME AS JAR-9	100%	J-10	J-17 24.0-25.5 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5 J-18 25.5-27.0 MOTTLED, MOTTLED, MOTTLED <.5, <.5, <.5 J-19 27.0-28.5 1,3,3 <.5, <.5, <.5
	14.0'		SAME AS JAR-9	100%	J-11	J-20 28.5-30.0 5,3,4 <.5, <.5, <.5 **Ground Water Readings** Encountered: 5.8' Completion: 6.3' 24 hours: 3.9'
	16.0'		SAME AS JAR-9	100%	J-12	**PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL**
	18.0'		SILTY CLAY WET, SOFT. VERY DARK GRAY TRSHELL FRAGMENTS COARSE.	100%	J-13	
	20.0		SAME AS JAR-13 CONTINUED	100%	J-14	

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-30

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-30
1. PROJECT Liberty State Park, Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-13	100%	J-14 (CUM)	
	22.0'		SAME AS JAR-13	100%	J-15	
	24.0'		SAME AS JAR-13 2.5 PEAT, DAMP, SOFT, COARSE MIXED WITH SILTY CLAY AS ABOVE:	100%	J-16	
			CLAYEY SAND, WET, SOFT, FINE, MEDIUM DARK GRAY	100%	J-17	
	26.0'		SAME AS JAR-12	100%	J-18	
	28.0'		CLAYEY SAND WET, SOFT, FINE, WITH TRACE OF MODERATELY BROWN SAND, MEDIUM. DARK GRAY.	100%	J-19	
			SAME AS JAR-19	100%	J-20 HTRW 08/10 HRS	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-32
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		20.7 CLAY, SOFT, WET, TR SILT TR METAL FRAGMENTS COARSE DARK GRAY MIXED WITH SOME PEAT WET FIRM, COARSE, DARK BROWN.	100%	J-14 (LOW)	
	22.0'		SAME AS BOTTOM OF JAR-14	100%	J-15	
			SAME AS BOTTOM OF JAR 14 23.3 - SAND WET, SOFT, MEDIUM, WITH SOME CLAY, TR SILT MEDIUM GRAY.	100%	J-16	
	24.0'		SAME AS BOTTOM OF JAR-16			
			24.8 - SAND, WET, SOFT, FINE WITH SOME SILT MEDIUM BROWN.	100%	J-17	
	26.0'		SAND, SOFT, WET, MEDIUM, WITH A LITTLE SILT AND GRAVEL GRAYISH BROWN.	100%	J-18	
	28.0'		SAME AS JAR-18	100%	J-19	
			SAME AS JAR-18	100%	J-20 HTAW 1600 HRS	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03- 33

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 33		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8-19-03 / COMPLETED 8-19-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Gaynor	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL, GRASS AND ROOT MAT, SAND, DAMP, SOFT, MEDIUM DARK BROWN. .3 SAND, WET, SOFT, MEDIUM TO COARSE, TR GRAVEL, MEDIUM BROWN.	87%	J-1
	2.0'		SAND, WET, SOFT, MEDIUM TO COARSE, TR GRAVEL WEAKLY MOTTLED, MEDIUM BROWNISH	100%	J-2
	4.0'		SAME AS JAR-2	100%	J-3
			SAME AS JAR-2 5.7 SILTY SAND, FINE, WET SOFT MEDIUM GRAY.	100%	J-4
	6.0'		SAME AS JAR-2	100%	J-5 HYDRO 1100 HRS.
	8.0'		CLAYEY SILT, WET, SOFT, TR SAND, FINE TO MEDIUM, MEDIUM GRAY.	100%	J-6
			SAME AS JAR-6	100%	J-7
	10.0'		CLAYEY SILT, WET, SOFT, MEDIUM GRAY.	100%	J-8
	12.0'		SAME AS JAR-8	100%	J-9
	14.0'		SAME AS JAR-8	100%	J-10
			CLAY, WET, SOFT, TR SILT, TR SHELL FRAGMENTS COARSE, DARK GRAY	100%	J-11
	16.0'		SAME AS JAR-11	100%	J-12
	18.0'		SAME AS JAR-11	100%	J-13
	20.0		SAME AS JAR-11 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	2,2,3	NA
J-2	1.5-3.0	1,1,3	NA
J-3	3.0-4.5	4,2,2	NA
J-4	4.5-6.0	WOH,1,1	NA
J-5	6.0-7.5	1,WOH,WOH	NA
J-6	7.5-9.0	1,1,1	<.5,<.5,<.5
J-7	9.0-10.5	WOH,WOH,WOH	<.5,<.5,<.5
J-8	10.5-12.0	WOH,WOH,WOH	<.5,<.5,<.5
J-9	12.0-13.5	WOH,WOH,WOH	<.5,<.5,<.5
J-10	13.5-15.0	WOH,WOH,WOH	<.5,<.5,<.5
J-11	15.0-16.5	WOH,WOH,WOH	<.5,<.5,<.5
J-12	16.5-18.0	WOH,WOH,WOH	<.5,<.5,<.5
J-13	18.0-19.5	WOH,WOH,WOH	<.5,1.0,<.5
J-14	19.5-21.0	WOH,WOH,WOH	<.5,<.5,<.5
J-15	21.0-22.5	WOH,WOH,WOH	<.5,<.5,<.5
J-16	22.5-24.0	WOH,WOH,WOH	.5,.5,<.5
J-17	24.0-25.5	WOH,WOH,WOH	.5,.5,<.5
J-18	25.5-27.0	WOH,WOH,WOH	<.5,<.5,NA
J-19	27.0-28.5	WOH,WOH,1	NA
J-20	28.5-30.0	WOH,WOH,3	.5,<.5,1.0

Ground Water Readings

Encountered: 5.0'
Completion: 23.3'
24 hours: 3.1'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 33

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-33
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-11	100%	J-14 (GWM)	
	22.0'		SAME AS JAR-11	100%	J-15	
	24.0'		CLAY, LT. SOFT, TR SILT, DARK GRAY WITH A LITTLE PEAT, COARSE, DARK BROWN	100%	J-16	
			SAME AS JAR-11	100%	J-17	
	26.0'		SILTY CLAY, WET, SOFT, TR SHELL FRAGMENTS COARSE MEDIUM GRAY	100%	J-18	
			26.5 - CLAYEY SAND, WET, SOFT, MEDIUM, TR SILT, MEDIUM GRAY; CLAYEY SAND, WET, SOFT, MEDIUM, TR SILT MEDIUM GRAY.	100%	J-19	
	28.0'		SAME AS JAR-19	100%	J-20 NTW 1410 HRS	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-34

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-34		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-14-03	COMPLETED 8-14-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Spitz	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		TOPSOIL AND ROOT MAT, SAND, MEDIUM DAMP, TO DRY, WITH SOME GRAVEL, MOTTLED, MEDIUM BROWN	100%	J-1	Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAND, DAMP, SOFT, MEDIUM, TR SILT, TR GRAVEL GRAY.	100%	J-2	
	4.0'		SAME AS JAR-2	100%	J-3	
			SAND, DAMP, SOFT, MEDIUM TR SILT, TR GRAVEL, TR CLAY, GRAY.	80%	J-4	
	6.0'		SAND, DAMP, SOFT, COARSE, TR SILT, WITH SOME CARBONIZED DOBRIS MATERIAL BLACK GWT 7.5'	80%	J-5	
	8.0'		SAND, WET, SOFT, COARSE. TR SILT, BLACK.	100%	J-6 RTRN 1430	
	10.0'		SAME AS JAR-6	100%	J-7	
			SAME AS JAR-6	100%	J-8	
	12.0'		SAME AS JAR-6 12.5 - SILT, DAMP, SOFT, WITH TR CLAY, TR SAND FINE. MEDIUM GRAY.	80%	J-9	
	14.0'		SILT, DAMP, SOFT WITH TR CLAY, TR SAND FINE MEDIUM GRAY	73%	J-10	
	16.0'		SAME AS JAR-10	100%	J-11	
			SAME AS JAR-10	100%	J-12	
	18.0'		SAME AS JAR-10	100%	J-13	
				100%	J-14	
	20.0		CONTINUED			

Samples

JAR#	DEPTH	BLOW COUNT	PENETROMETER
J-1	0.0-1.5	5,10,11	NA
J-2	1.5-3.0	5,8,7	NA
J-3	3.0-4.5	5,6,5	NA
J-4	4.5-6.0	4,2,2	NA
J-5	6.0-7.5	5,5,8	NA
J-6	7.5-9.0	5,11,8	NA
J-7	9.0-10.5	5,5,5	NA
J-8	10.5-12.0	5,11,15	NA
J-9	12.0-13.5	3,2,1	NA, <.5, <.5
J-10	13.5-15.0	wet, wet, 1	<.5, <.5, <.5
J-11	15.0-16.5	wet, wet, wet	<.5, <.5, <.5
J-12	16.5-18.0	wet, wet, 2	1.5, 1.0, 1.0
J-13	18.0-19.5	wet, wet, 2	<.5, 1.0, 1.0
J-14	19.5-21.0	1,1,3	NA
J-15	21.0-22.5	1,2,10	NA
J-16	22.5-24.0	5,4,3	NA
J-17	24.0-25.5	3,1,6	NA
J-18	25.5-27.0	8,11,15	NA
J-19	27.0-28.5	17,19,27	NA
J-20	28.5-30.0	21,22,22	NA

Ground Water Readings

Encountered: 7.5'
Completion: 22.0'
24 hours: 7.6'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 72 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-34

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-34
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SILTY SAND, DAMP, SOFT, FINE TO MEDIUM, TR SHELL FRAGMENTS COARSE, MEDIUM GRAY.	100%	J-14 (GW7)	
	22.0'		SILTY SAND, DAMP, SOFT TO FIRM MEDIUM, TR SHELL FRAGMENTS COARSE, TR CLAY, MEDIUM GRAY TO BROWN.	100%	J-15	
	24.0'		SAND, WET, SOFT, MEDIUM WITH TR SILT, TR CLAY MEDIUM BROWN.	100%	J-16	
	26.0'		SAND, WET, SOFT, MEDIUM WITH TR SILT, TR CLAY, AND A LITTLE GRAVEL, MEDIUM BROWN	100%	J-17	
	28.0'		GRAVELLY SAND, WET, SOFT, MEDIUM, TR SILT. MEDIUM BROWN.	100%	J-18	
			SAME AS JAR-18	100%	J-19	
			SAME AS JAR-18	100%	J-20 HTAW 1615	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-34

Hole No. LSP-03-35

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 35		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-10-03	COMPLETED 8-10-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Spahr	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		SAND, DAMP, SOFT, MEDIUM, TR SILT, MEDIUM GRAY TO LIGHT BROWN	100%	J-1
	2.0'		SAND, DAMP, SOFT, MEDIUM; MED, DK GRAY	100%	J-2
	4.0'		SAME AS JAR-2 4.0 - SAND, LOOSE, DAMP, SOFT. TR PEAT. DARK BROWN PARTLY CARBONIZED.	100%	J-3
			SAND, DAMP, SOFT, COARSE WITH A LITTLE GRAVEL. TR COAL FRAGMENTS. DARK BROWN TO BLACK	100%	J-4
	6.0'		SAME AS JAR-4	100%	J-5 HTAW 1000 HAS
	8.0'		SAND, FIRM, DAMP, CEMENTED, MEDIUM, TAN TO LIGHT BROWN, A LITTLE CARBONIZED MATERIAL.	100%	J-6
			SAND, SOFT, DAMP TO WET COARSE, LIGHT BROWN TO BLACK. GWE 9.7'	87%	J-7
	10.0'		SAND, SOFT, WET, COARSE, TR SILT, DARK BROWN TO BLACK.	100%	J-8
	12.0'		SAND, SOFT, WET, COARSE DULL BROWNISH GRAY	100%	J-9
	14.0'		SAME AS JAR-9	87%	J-10
			SAME AS JAR-9	87%	J-11
	16.0'		SAND, SOFT, WET, COARSE DULL BROWNISH GRAY WITH TR CLAY, BLACK.	87%	J-12
	18.0'		SAND, SOFT WET, COARSE, DULL BROWNISH GRAY, WITH TR CLAY, BLACK WITH TR SHELL FRAGMENTS	100%	J-13
	20.0		19.2 - SAND, MEDIUM, WET, SOFT, TR SILT, MEDIUM BROWN.	80%	J-14
			CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0–1.5	9,7,8	NA
J-2	1.5-3.0	4,7,6	NA
J-3	3.0-4.5	4,3,3	NA
J-4	4.5-6.0	5,6,10	NA
J-5	6.0-7.5	9,8,4	NA
J-6	7.5-9.0	16,24,24	NA
J-7	9.0-10.5	4,4,5	NA
J-8	10.5-12.0	8,7,6	NA
J-9	12.0-13.5	5,4,4	NA
J-10	13.5-15.0	4,5,4	NA
J-11	15.0-16.5	6,5,6	NA
J-12	16.5-18.0	4,7,7	NA
J-13	18.0-19.5	5,1,3	NA
J-14	19.5-21.0	8,8,10	NA
J-15	21.0-22.5	6,10,4	3.0,3.7,4.0
J-16	22.5-24.0	8,5,5	NA
J-17	24.0-25.5	4,4,5	1.5,1.0,1.0
J-18	25.5-27.0	5,5,10	NA
J-19	27.0-28.5	2,3,20	NA
J-20	28.5-30.0	5,3,8	NA

Ground Water Readings

Encountered: 9.7'
Completion: 12.0'
24 hours: 10.1'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 79 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 35

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-35
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAND, WET, SOFT, MEDIUM TO SILT, MEDIUM BROWN	80%	J-14 (CW)	
	22.0'		SILT, WET, SOFT, WITH A LITTLE CLAY, TR SAND, FINE DULL ORANGISH BROWN.	82%	J-15	
			SAND, WET, SOFT, FINE, WITH SOME SILT, TR CLAY. DULL MEDIUM BROWN.	54%	J-16	
	24.0'		CLAY, WITH SOME SILT, TR SAND FINE MEDIUM BROWN.	84%	J-17	
	26.0'		SAND, FINE, WET, SOFT, WITH SOME SILT, TR CLAY MEDIUM BROWN.	80%	J-18	
	28.0'		SAME AS JAL-18	93%	J-19	
			SAME AS JAL-18	160%	J-20 HAW 1150 HAS	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801)

PROJECT Liberty St Pk Jersey City, NJ

HOLE NO. LSP-03-35

Hole No. LSP-03-36

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 36		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE	STARTED 8-14-03 / COMPLETED 8-14-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E [illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL AND NOT MOI. SILT, WITH SOME SAND, FINE, TR GRAVEL SOFT, DAMP TO DRY, MEDIUM BROWN.	100%	J-1
	2.0'		SILT WITH SOME SAND FINE, MEDIUM BROWN DAMP TO DRY, TR GRAVEL.	100%	J-2
			SAME AS JAR-2		
	4.0'		4.0 - SAND, LOOSE, DAMP, COARSE, CARBONIZED MATERIAL	80%	J-3
			SAND, LOOSE, DAMP, COARSE, WITH CARBONIZED DEBRIS	87%	J-4
	6.0'		SAME AS JAR-4	87%	J-5
	8.0'		SAME AS JAR-4	77%	J-6 MRW 0810
			GWE - 9.0' SAND, LOOSE, WET, COARSE WITH CARBONIZED DEBRIS	100%	J-7
	10.0'		SAME AS JAR-7 11.7 SAND, FINE, WET, SOFT, TR SILT, LIGHT GRAY.	100%	J-8
	12.0'		SILTY CLAY, DAMP, SOFT, TR SAND; FINE, MEDIUM GRAY TR SHELL FRAGMENTS, COARSE	100%	J-9
	14.0'		SAME AS JAR-9	100%	J-10
	16.0'		SAME AS JAR-9	100%	J-11
			SAME AS JAR-9	100%	J-12
	18.0'		SAME AS JAR-9	100%	J-13
	20.0		SAME AS JAR-9 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	5,9,9	NA
J-2	1.5-3.0	8,6,5	NA
J-3	3.0-4.5	5,5,5	NA
J-4	4.5-6.0	10,3,4	NA
J-5	6.0-7.5	7,5,4	NA
J-6	7.5-9.0	5,3,2	NA
J-7	9.0-10.5	23,5,4	NA
J-8	10.5-12.0	5,6,7	NA
J-9	12.0-13.5	1,1,1	<.5,1.0,1.5
J-10	13.5-15.0	1,1,1	NA, .5, .5
J-11	15.0-16.5	WOH,WOH,WOH	<.5,NA,<.5
J-12	16.5-18.0	WOH,WOH,WOH	<.5,<.5,<.5
J-13	18.0-19.5	WOH,WOH,WOH	<.5,<.5,<.5
J-14	19.5-21.0	WOH,WOH,WOH	<.5,<.5,<.5
J-15	21.0-22.5	WOH,1,1	<.5,<.5,<.5
J-16	22.5-24.0	WOH,1,1	<.5,<.5,<.5
J-17	24.0-25.5	WOH,2,2	1.5,1.5,1.5
J-18	25.5-27.0	WOH,2,2	1.5,1.0,<.5
J-19	27.0-28.5	5,9,9	NA
J-20	28.5-30.0	6,7,9	NA

Ground Water Readings

Encountered: 9.0'
Completion: 21.7'
24 hours: 9.6'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP 03 36

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-36
1. PROJECT Liberty State Park, Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-9	100%	J-14 (CONT)	
	22.0'		SAME AS JAR-9	100%	J-15	
	24.0'		SAME AS JAR-9 23.8 - PEAT, SOFT FIBROUS, COARSE DARK BROWN.	100%	J-16	
			PEAT, WET, FIBROUS, COARSE WITH SOME CLAY, DARK BROWN TO GRAY.	100%	J-17	
	26.0'		SAME AS JAR-17 26.3 SILT, WET, SOFT, WITH SOME CLAY, AND SAND FINE. MEDIUM GRAY.	100%	J-18	
	28.0'		SILT, WET, SOFT, WITH SOME CLAY AND SAND, FINE MEDIUM GRAY.	100%	J-19	
			SAME AS JAR-19	100%	J-20 HTAW 1130	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-37
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-13	100%	J-14 (EWI)	
	22.0'		PROBABLE BUILDING DEBRIS - NO SAMPLE.	0%	J-15	
	24.0'		SAME AS JAR-13	100%	J-16	
	26.0'		SAME AS JAR-13	100%	J-17	
	28.0'		SAME AS JAR-13	100%	J-18	
	30.0'		SAME AS JAR-13	100%	J-19	
	32.0'		BOH - 30.0'	100%	J-20 HTLW 1010	
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801)

PROJECT Liberty St Pk Jersey City, NJ | HOLE NO. LSP-03-37

Hole No. LSP-03-38

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) ~	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-38		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES ~	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 8-9-03	COMPLETED 8-9-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE ~	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING ~ %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W S Sy	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL AND ORGANIC MATERIAL, WOOD FRAGMENTS, A LITTLE SILT, TR CLAY, TR SAND, TR COBBLE. DAMP SOFT SHOE DESTROYED ON COBBLE.	20%	J-1
	2.0'		SAND, DAMP, SOFT. MEDIUM TO COARSE, TR GRAVEL, BLACK TO REDDISH BROWN.	73%	J-2
	4.0'		SAND, DAMP, SOFT, MEDIUM TO COARSE, TR GRAVEL, TR SILT, TR CLAY, BLACK TO DULL ORANGISH BROWN.	80%	J-3
			GW @ 5.4 SAND, WET, SOFT, COARSE, TR SILT, TR CLAY, ORANGISH BROWN 5.4 - WOOD FRAGMENT PLUGGING SHOE.	80%	J-4
	6.0'		SAND, WET, SOFT, MEDIUM TO COARSE LIGHT GRAY TO MEDIUM BROWN TO REDDISH BROWN TO BLACK.	100%	J-5 HTAW #930
	8.0'		SAND, WET, SOFT, MEDIUM, TR COARSE TO GRAVEL TR SHELL FRAGMENTS' COARSE DULL GRAYISH BROWN	100%	J-6
	10.0'		SAND, WET, SOFT, TR SILT, MEDIUM, DULL GRAYISH BROWN.	73%	J-7
			SAME AS JAR-7	100%	J-8
	12.0'		SAME AS JAR-7	100%	J-9
	14.0'		SILT WITH SOME SAND, FINE. AND A LITTLE CLAY MEDIUM GRAY.	100%	J-10
	16.0'		SILT, WITH SOME SAND, FINE. AND A LITTLE CLAY, TR SHELL FRAGMENTS COARSE TR GRAVEL MEDIUM GRAY	100%	J-11
			SAME AS JAR-11	100%	J-12
	18.0'		SAME AS JAR-11	100%	J-13
				100%	J-14
	20.0		CONTINUED		

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.2	1,1,100/2	NA
J-2	1.5-3.0	2,2,7	NA
J-3	3.0-4.5	4,4,7	NA
J-4	4.5-6.0	1,2,4	NA
J-5	6.0-7.5	7,6,6	NA
J-6	7.5-9.0	2,2,3	NA
J-7	9.0-10.5	WH4,3	NA
J-8	10.5-12.0	3,WH,WH	NA,NA,<.5
J-9	12.0-13.5	WH,WH,WH	NA
J-10	13.5-15.0	1,1,1	<.5,<.5,<.5
J-11	15.0-16.5	WH,WH,WH	<.5,<.5,<.5
J-12	16.5-18.0	WH,1,1	<.5,<.5,<.5
J-13	18.0-19.5	WH,WH,WH	<.5,<.5,<.5
J-14	19.5-21.0	WH,WH,WH	<.5,<.5,<.5
J-15	21.0-22.5	WH,WH,WH	<.5,<.5,<.5
J-16	22.5-24.0	WH,WH,WH	<.5,<.5,<.5
J-17	24.0-25.5	WH,WH,WH	<.5,<.5,<.5
J-18	25.5-27.0	WH,1,2	<.5,<.5,<10
J-19	27.0-28.5	WH,1,1	<.5, NA, NA
J-20	28.5-30.0	1,1,2	NA

Ground Water Readings

Encountered: 5.4'
Completion: 30.0'
24 hours: 9.6'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-38

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-38
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		CLAY, SOFT, WET, TR. SHELL FRAGMENTS COARSE DARK GRAY	100%	J-14 (LWD)	
	22.0'		SAME AS JAR-14	100%	J-15	
	24.0'		SAME AS JAR-14	100%	J-16	
			SAME AS JAR-14	100%	J-17	
	26.0'		SAME AS JAR-14 26.5- CLAY, WITH SOME SAND, MEDIUM, SOFT, SAND, WEAKLY MOTLED ORANGISH BROWN FROM DARK GRAY.	100%	J-18	
	28.0'		SAME AS BOTTOM OF JAR-18 27.5- CLAYEY SAND, WET, SOFT, MEDIUM DARK GRAY	100%	J-19	
			SAME AS BOTTOM OF JAR-19	100%	J-20 HPW 1330HRS	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Hole No. LSP-03-39

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03-39		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9-6-03	COMPLETED 9-6-03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR WE Bobb	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0.0'		TOPSOIL-GRASS AND ROOT MAT SAND, FINE TR SILT, TR CLAY, DAMP, SOFT, BROWN	100%	J-1
			.8 SAND COARSE, SOFT, LOOSE, TR SILT, TR CLAY, TR GRAVEL BLACK.		
	2.0'		SAME AS BOTTOM OF JAR-1 2.6 SILT, FIRM DAMP, WITH SOME CLAY REDDISH BROWN	40%	J-2
			SAME AS BOTTOM OF JAR-2	67%	J-3
	4.0'		GWE 4.5' SAND, WET, SOFT, COARSE, TR GRAVEL BLACK.	83%	J-4
	6.0'		SAME AS JAR-4	73%	J-5
			SAND, WET, SOFT, MEDIUM TR COARSE, TR SILT DARK GRAY	80%	J-6 HTAW 1420
	8.0'		SAME AS JAR-6	40%	J-7
	10.0'		SAME AS JAR-6	54%	J-8
	12.0'		SAME AS JAR-6	46%	J-9
	14.0'		SAME AS JAR-6	67%	J-10
			SAME AS JAR-6	27%	J-11
	16.0'		SAME AS JAR-6		
			17.0 - SILT, WET, SOFT, WITH A LITTLE CLAY TR SAND FINE MEDIUM GRAY.	73%	J-12
	18.0'		SAND, WET, SOFT, MEDIUM WITH SOME SILT, TR CLAY MEDIUM GRAY	100%	J-13
	20.0		SAME AS JAR-13 CONTINUED	100%	J-14

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".

Samples

JAR#	DEPTH	BLOW COUNT	PENETRO-METER
J-1	0.0-1.5	1,6,8	NA
J-2	1.5-3.0	8,6,9	NA
J-3	3.0-4.5	3,2,5	NA
J-4	4.5-6.0	1,1,1	NA
J-5	6.0-7.5	1,WOH,1	NA
J-6	7.5-9.0	WOR,1,3	NA
J-7	9.0-10.5	1,1,1	NA
J-8	10.5-12.0	WOR,1,WOH	NA
J-9	12.0-13.5	WOH,WOH,1	NA
J-10	13.5-15.0	WOH,WOH,WOH	NA
J-11	15.0-16.5	WOH,WOH,WOH	NA
J-12	16.5-18.0	WOH,WOH,WOH	NA,<5,<5
J-13	18.0-19.5	WOH,WOH,WOH	NA
J-14	19.5-21.0	WOH,2,1	NA
J-15	21.0-22.5	WOH,1,1	NA
J-16	22.5-24.0	1,1,2	NA
J-17	24.0-25.5	1,4,5	NA
J-18	25.5-27.0	1,5,10	NA
J-19	27.0-28.5	3,7,7	NA
J-20	28.5-30.0	5,10,12	NA

Ground Water Readings

Encountered: 4.5'
Completion: 11.1'
24 hours: 4.5'

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03-39

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. LSP-03- 39

1. PROJECT Liberty State Park, Jersey City, NJ | 2. INSTALLATION Baltimore District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAL-17	100%	J-14 (LOW)	
	22.0'		SAME AS JAL-13	100%	J-15	
			SAME AS JAL-13	100%	J-16	
	24.0'		SAME AS JAL-17 24.0- SAND, WET, SOFT, WITH SOME GRAVEL, TR SILT. DULL ARROW WITH GRAY.	100%	J-17	
	26.0'		SAME AS BOTTOM OF JAL-17	100%	J-18	
	28.0'		SAME AS BOTTOM OF JAL-17	100%	J-19	
			SAME AS BOTTOM OF JAL-17	100%	J-20 HTW 1530	
	30.0'		BOH - 30.0'			
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) | PROJECT Liberty St Pk Jersey City, NJ | HOLE NO. LSP-03- 39

Hole No. LSP-03-40

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park		10. SIZE AND TYPE OF BIT 2 ¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) –	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME – 750	
4. HOLE NO. (As shown on drawing title and file number) LSP-03- 40		13. TOTAL NO. OF OVER-BURDEN SAMPLS TAKEN	DISTURBED 20 / UNDISTURBED 0
5. NAME OF DRILLER Bobby Creamer		14. TOTAL NO. OF CORE BOXES –	15. ELEVATION OF GROUND WATER See Remarks
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL		16. DATE HOLE STARTED 9- 6 - 03	COMPLETED 9- 6 - 03
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE –	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING – %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR W E Bahr	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0'		SAND, COARSE, DAMP, SOFT TR MEDIUM TO FINE, TR SILT, BLACK.	80%	J-1	Boring was drilled using 2¼" Hollow Stem Augers. Sampled using Standard SPT, 1 3/8" ID split spoon driven with a 140 lb. Hammer dropped 30".
	2.0'		SAME AS JAR-1 2.5 - SAND, DAMP, SOFT, MEDIUM TR SILT, TR GRAVEL MEDIUM BROWN.	67%	J-2	**Samples** JAR# DEPTH BLOW COUNT PENETRO-METER
	4.0'		SAME AS JAR-1	54%	J-3	J-1 0.0-1.5 J-2 1.5-3.0
			SAND, WET, SOFT, MEDIUM, TR SILT, TR GRAVEL GRAY, GWE 4.2'	67%	J-4	J-3 3.0-4.5 J-4 4.5-6.0
	6.0'		SAME AS JAR-4	82% HRW 0935	J-5	J-5 6.0-7.5 J-6 7.5-9.0 J-7 9.0-10.5
	8.0'		SAND, WET, SOFT, MEDIUM, TR SILT, TR GRAVEL, TR COBBLE, GRAY	54%	J-6	J-8 10.5-12.0 J-9 12.0-13.5
			SAND, WET, SOFT, MEDIUM TR COARSE, BLACK.	80%	J-7	J-10 13.5-15.0 J-11 15.0-16.5
	10.0'		SAME AS JAR-7	47%	J-8	J-12 16.5-18.0 J-13 18.0-19.5 J-14 19.5-21.0
	12.0'		SAME AS JAR-7	60%	J-9	J-15 21.0-22.5 J-16 22.5-24.0
	14.0'		SAME AS JAR-7	27%	J-10	J-17 24.0-25.5 J-18 25.5-27.0 J-19 27.0-28.5
			SAND, WET, SOFT, MEDIUM, TR COARSE, TR SILT, TR CLAY, GRAY.	100%	J-11	J-20 28.5-30.0 Ground Water Readings
	16.0'		SAME AS JAR-11	100%	J-12	Encountered: 4.2' Completion: 11.8' 24 hours: 26'
	18.0'		SAME AS JAR-11	100%	J-13	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
			SAME AS JAR-11	100%	J-14	
	20.0		CONTINUED			

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT Liberty State Pk Jersey City, NJ | HOLE NO. LSP-03- 40

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE	Hole No. LSP-03-40
1. PROJECT Liberty State Park Jersey City, NJ	2. INSTALLATION Baltimore District	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0'		SAME AS JAR-4	100%	J-14 (Lost)	
	22.0'		SAME AS JAR-11	100%	J-15	
	24.0'		SAME AS JAR-11	100%	J-16	
	26.0'		SAME AS JAR-11	100%	J-17	
	28.0'		SAME AS JAR-11	100%	J-18	
			SAME AS JAR-11	100%	J-19	
	30.0'		BOH - 30.0'	100%	J-20 HTAW 1045	
	32.0'					
	34.0'					
	36.0'					
	38.0'					
	40.0'					
	42.0'					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM JUN 67 1836-A (ER 1110-1-1801) PROJECT Liberty St Pk Jersey City, NJ HOLE NO. LSP-03-40

Hole No. CA04-1

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE	SHEET 1 OF 2 SHEETS

1. PROJECT Liberty State Park- Additional Borings	10. SIZE AND TYPE OF BIT 2¼" HSA
2. LOCATION (Coordinates or Station) Jersey City, NJ	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY CENAB	12. MANUFACTURER'S DESIGNATION OF DRILL CME750
4. HOLE NO. (As shown on drawing title and file number) CA04-1	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 20; UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER See Remarks
	16. DATE HOLE: STARTED 2/7/04; COMPLETED 2/7/04
7. THICKNESS OF OVERBURDEN 30.0'	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK N/A	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 30.0'	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	1		Gray and Orangish Brown, Sl. Moist CLAY w/trace roots	87	J-1
	2		Same As Above top 1.0' (Not in Jar) Black, Dry Sandy Gravel Fragments (mostly coal)	100	J-2
	3–4		Dark Brown, Moist Silty SAND w/trace gravel and a piece of wood	87	J-3
	5		Dark Brown, Wet Silty SAND w/some gravel and a piece of wood.	67	J-4
	6–7		Same As Above	80	J-5
	8		Black, Wet Gravel and Coal Fragments in Black SAND	93	J-6
	9–10		Dark Gray, Wet Fine to Coarse SAND w/trace grave fragments and a piece of wood.	100	J-7
	11–12		Dark Gray, Wet, Fine to Coarse SAND w/some gravel fragments	100	J-8
	13		No Recovery	0	J-9
	14–15		Med Dark Gray to Black Wet fine SAND w/some silt	28	J-10
	16		Med Dark Gray and Black, Moist Soft Silty CLAY	100	J-11
	17–18		Same As J-11 w/trace Shell fragments	100	J-12
	19		Same As J-12	100	J-13

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)

Boring was drilled w/the CME750 (Swamp Buggy) using 2¼" Hollow Stem Augers.

Samples were obtained by SPT method (1⅜" I.D. Split-Spoon driven 18 inches by a 140lb hammer w/a 30" drop).

SAMPLES

#	Depth	Blow Count
J-1	0.0-1.5	2-2-2
J-2	1.5-3.0	2-3-6
J-3	3.0-4.5	2-4-9
J-4	4.5-6.0	2-2-6
J-5	6.0-7.5	4-5-10
J-6	7.5-9.0	9-14-9
J-7	9.0-10.5	11-6-4
J-8	10.5-12.0	1-2-3
J-9	12.0-13.5	2-1-WH
J-10	13.5-15.0	WH/1.5'
J-11	15.0-16.5	
J-12	16.5-18.0	
J-13	18.0-19.5	
J-14	19.5-21.0	
J-15	21.0-22.5	
J-16	22.5-24.0	
J-17	24.0-25.5	
J-18	25.5-27.0	
J-19	27.0-28.5	
J-20	28.5-30.0	

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

H_2O Info

Enc: 5.5'

Comp: 11.4'
1640hrs on 2/7/04

24hr: 4.8'
0730hrs on 2/8/04

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT LSP-Additional Borings | HOLE NO. CA04-1

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. CA04-1

PROJECT: Liberty State Park-Additional Borings | INSTALLATION: Baltimore | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	21		Med. Gray, Moist, Soft silty CLAY w/ trace shell frags	100	J-14	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	22		Same as J-14 (w/trace peat)	100	J-15	
	23		Same As J-15	100	J-16	
	24					
	25		Same As J-15	100	J-17	
	26		Same As J-15	100	J-18	
	27		Same As J-15	67	J-19	
	28					
	29		Same As J-15	100	J-20	
	30		BOH 30.0'			

ENG FORM 1836-A JAN 67 (ER 1110-1-1801) GPO 1980 OF-628-603 | PROJECT: LSP-Additional Borings | HOLE NO. CA04-1

Hole No. CA04-2

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME750	
4. HOLE NO. (As shown on drawing title and file number) CA04-2		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 20	UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
		16. DATE HOLE: STARTED 2/7/04	COMPLETED 2/7/04
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR Jack J. Fuch	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		Dark Brown and Gray, Moist, Moderately Hard CLAY w/trace sand and roots	100	J-1	Boring was drilled w/the CME750 (Swamp Buggy) using 2¼" Hollow Stem Augers. Samples were obtained by SPT method (1⅜" I.D. Split-Spoon driven 18 inches by a 140lb hammer w/a 30" drop).
	2		Med Gray and Brown, Moist, Mottled Soft Silty CLAY w/trace mica	100	J-2	
	3		Black, Wet Coarse Grain SAND and Debris	100	J-3	SAMPLES # / Depth / Blow Count: J-1 0.0-1.5 3-2-1; J-2 1.5-3.0 3-3-3; J-3 3.0-4.5 WH-9-10; J-4 4.5-6.0 5-4-7; J-5 6.0-7.5 4-10-16; J-6 7.5-9.0 7-7-6; J-7 9.0-10.5 3-3-1; J-8 10.5-12.0 4-1-2; J-9 12.0-13.5 WH/1.5; J-10 13.5-15.0; J-11 15.0-16.5; J-12 16.5-18.0; J-13 18.0-19.5; J-14 19.5-21.0; J-15 21.0-22.5; J-16 22.5-24.0; J-17 24.0-25.5; J-18 25.5-27.0; J-19 27.0-28.5; J-20 28.5-30.0
	4		Same As J-3 w/trace clay	100	J-4	
	5		Black, Bluish Gray, and Brown, Wet Coarse Grain SAND w/tr. gravel (coal frags.) and misc. debris	100	J-5	
	6		Black, Wet Gravel (Coal Frags) w/some sand	100	J-6	
	7		Same As J-6	100	J-7	
	8		Same As J-6 (top 0.5') (NOT IN JAR) Med. Gray, Moist CLAY w/some Sand + gravel fragments	100	J-8	
	9		Med Gray and Black, Moist, Soft Silty CLAY w/trace shell fragments	100	J-9	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	10		Same As J-9 * Majority of this sample used for HTRW analysis	80	J-10	
	11		Same As J-9	87	J-11	
	12		Same As J-9 (w/trace peat)	100	J-12	H_2O Info: Enc: 4.0'; Comp: 10.2' 2/9/04 @ 1430hrs; 24hr: 4.7' 2/8/04 @ 1020hrs
	13		Same As J-12	100	J-13	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT LSP-Additional Borings HOLE NO. CA04-2

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. CA04-2

PROJECT: Liberty State Park-Additional Borings | INSTALLATION: Baltimore | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same As J-12	100	J-14	
	21					
			Same As J-12	100	J-15	
	22					
	23		Same As J-12	100	J-16	
	24					
	25		Same As J-12 (w/trace peat and mica)	100	J-17	
	26		Same As J-17	100	J-18	
	27					
	28		Same As J-17	100	J-19	
	29		Same As J-17	100	J-20	
	30		BOH 30.0'			

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1960 OF-628-603 | PROJECT LSP-Additional Borings | HOLE NO. CA04-2

Hole No. CA04-3

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE	SHEET 1 OF 2 SHEETS

1. PROJECT Liberty State Park- Additional Borings	10. SIZE AND TYPE OF BIT 2¼" HSA
2. LOCATION (Coordinates or Station) Jersey City, NJ	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY CENAB	12. MANUFACTURER'S DESIGNATION OF DRILL CME750
4. HOLE NO. (As shown on drawing title and file number) CA04-3	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 20; UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER See Remarks
7. THICKNESS OF OVERBURDEN 30.0	16. DATE HOLE: STARTED 2/7/04; COMPLETED 2/7/04
8. DEPTH DRILLED INTO ROCK N/A	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE 30.0'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR Jack L. Auch

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		Dark Brown and Black, Moist, Soft CLAY w/trace rock fragments, Sand and roots	100	J-1	Boring was drilled w/the CME750 (Swamp Buggy) using 2¼" Hollow Stem Augers. Samples were obtained by SPT method (1 3/8" I.D. split-Spoon driven 18 inches by a 140lb hammer w/a 30" drop).
	2		Same As Above	100	J-2	
	3		Black, Moist, Soft CLAY w/some sand, peat, and small rock frags. (strong petroleum-like smell)	100	J-3	SAMPLES
	4					
	5		Black, Wet Small Gravel (Coal Frags) w/some Sand and trace clay	100	J-4	
	6		Same As J-4	100	J-5	
	7					
	8		Same As J-4 (No Clay)	100	J-6	
	9		Black, Wet Gravelly SAND w/some silt	67	J-7	
	10					
	11		Black, Wet, Small Gravel (Coal Fragments) w/ some sand	93	J-8	
	12		Same As J-8	100	J-9	
	13					
	14		Same As J-8 * All of Sample used for HTRW analysis	40	J-10	
	15					
	16		Dark Gray, Wet, Fine to Coarse grain SAND w/trace gravel and shell fragments	67	J-11	
	17		Dark Gray, Wet, Fine SAND w/trace silt and shell fragments	73	J-12	
	18					
	19		Med and Dark Gray, Moist, Soft silty CLAY w/trace small shell fragments	100	J-13	

#	Depth	Blow Count
J-1	0.0-1.5	3-1-2
J-2	1.5-3.0	3-2-2
J-3	3.0-4.5	3-3-5
J-4	4.5-6.0	2-4-5
J-5	6.0-7.5	3-6-4
J-6	7.5-9.0	2-3-7
J-7	9.0-10.5	1-2-2
J-8	10.5-12.0	2-2-2
J-9	12.0-13.5	4-4-5
J-10	13.5-15.0	3-4-5
J-11	15.0-16.5	5-2-2
J-12	16.5-18.0	2-1-2
J-13	18.0-19.5	WH/1.5
J-14	19.5-21.0	
J-15	21.0-22.5	
J-16	22.5-24.0	
J-17	24.0-25.5	
J-18	25.5-27.0	
J-19	27.0-28.5	
J-20	28.5-30	

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

H_2O INFO

ENC: 6.2'

COMP: 27.2' 1030hrs on 2/7/04

24Hr: 5.2' 0750hrs on 2/8/04

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT LSP-Additional Borings | HOLE NO. CA04-3

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. CAD4-3

PROJECT: Liberty State Park-Additional Borings | INSTALLATION: Baltimore | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same As J-13 (strong petroleum smell)	100	J-14	
	21					
	22		Med Gray, Moist, Soft Silty CLAY w/trace shell fragments and peat	100	J-15	
	23		Dark Gray, Moist, Soft Silty CLAY w/trace shell fragments, peat and mica	100	J-16	
	24					
	25		Med Gray, Moist, Soft Silty CLAY w/trace peat and shell fragments	28	J-17	
	26		Same As J-17	100	J-18	
	27					
	28		Same As J-17	100	J-19	
	29		Same As J-17	100	J-20	
	30		BOH 30.0'			

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-626-603 | PROJECT LSP-Additional Borings | HOLE NO. CAD4-3

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE — Hole No. CA04-4

PROJECT: Liberty State Park-Additional Borings — INSTALLATION: Baltimore — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same As J-13 w/a strong petroleum type smell	100	J-14	
	21		Same As J-14			
	22			100	J-15	
	23			100	J-16	
	24					
	25			100	J-17	
	26			100	J-18	
	27					
	28			100	J-19	
	29			100	J-20	
	30		BOH 30.0'			

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-2801) GPO 1980 OT-628-503 — PROJECT LSP-Additional Borings — HOLE NO. CA04-4

Hole No. CA04-5

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE	SHEET 1 OF 2 SHEETS
1. PROJECT Liberty State Park- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME750	
4. HOLE NO. (As shown on drawing title and file number) CA04-5		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 20	UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
		16. DATE HOLE: STARTED 2/5/04	COMPLETED 2/5/04
7. THICKNESS OF OVERBURDEN 30.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 30.0'		19. SIGNATURE OF INSPECTOR Jana J. Anderson	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	1		Dark Brown and Gray, Dry, Mod. Soft CLAY w/trace roots and sand	100	J-1
	2		Same As Above top 1.0' (Not in Jar) Dark Brown and Black, Dry SAND w/some burned wood (strong petro like smell)	100	J-2
	3		Dark Brown and Black, Moist Fine SAND, Burned Wood, Coal Fragments and trace mica	100	J-3
	4				
	5		Dark Brown and Red-Brown, Moist Coarse SAND w/piece of burned wood	100	J-4
	6		Light Brown, Wet, Fine to Coarse Grain SAND	100	J-5
	7				
	8		Med to Dark Gray, Wet, Fine SAND w/trace Coarse sand and mica	100	J-6
	9		Reddish Brown and Black, Wet Fine to Coarse SAND	100	J-7
	10				
	11		Greenish Brown and Gray, Wet (soupy) SAND w/some silt and a piece of gravel	47	J-8
	12		Med. Dark Gray, Moist Silty CLAY w/trace sand and mica	80	J-9
	13				
	14		Med. Gray, Moist, Soft Silty CLAY * Majority of this sample was used for HTRW analysis	100	J-10
	15		Med and Very Dark Gray, Moist, Soft, Semi-Striated Silty CLAY w/strong petroleum type odor	100	J-11
	16				
	17		Med. Dark Gray, Moist, Soft Silty CLAY w/trace Fine Shell fragments and strong petro-like odor	100	J-12
	18				
	19		Same As J-12	100	J-13

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Boring was drilled w/the CME750 (Swamp Buggy) using 2¼" Hollow Stem Augers. Samples were obtained by SPT method (1⅜" I.D. Split-Spoon driven 18 inches by a 140lb hammer w/a 30" drop).

SAMPLES

#	Depth	Blow Count
J-1	0.0-1.5	4-2-2
J-2	1.5-3.0	2-2-9
J-3	3.0-4.5	8-7-11
J-4	4.5-6.0	5-6-10
J-5	6.0-7.5	6-10-10
J-6	7.5-9.0	WH/1.0-3
J-7	9.0-10.5	3-2-2
J-8	10.5-12.0	4-2-2
J-9	12.0-13.5	3-2-1
J-10	13.5-15.0	WH/1.5
J-11	15.0-16.5	
J-12	16.5-18.0	
J-13	18.0-19.5	
J-14	19.5-21.0	
J-15	21.0-22.5	
J-16	22.5-24.0	
J-17	24.0-25.5	
J-18	25.5-27.0	
J-19	27.0-28.5	
J-20	28.5-30.0	

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Water Info

ENC: 8.0'

COMPLETION: 28.1
1230hrs on 4/5/04

24 Hr: 6.2'
0715hrs on 4/6/04

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT LSP- Additional Borings | HOLE NO. CA04-5

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE — Hole No. CA04-5

PROJECT Liberty State Park-Additional Borings — INSTALLATION Baltimore — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same As J-12 w/ trace cinders	100	J-14	
	21					
	22		Same As J-12	100	J-15	
	23			100	J-16	
	24					
	25			100	J-17	
	26			100	J-18	
	27					
	28			100	J-19	
	29			100	J-20	
	30		BOH 30.0'			

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1960 OF-828-603 — PROJECT LSP-Additional Borings — HOLE NO. CA04-5

Hole No. CA04-6

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE	SHEET 1 OF 2 SHEETS

1. PROJECT LSP- ADDITIONAL BORINGS	10. SIZE AND TYPE OF BIT 3 1/4" HSA
2. LOCATION (Coordinates or Station) Jersey City, NJ	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY CENAB	12. MANUFACTURER'S DESIGNATION OF DRILL CME750
4. HOLE NO. (As shown on drawing title and file number) CA04-6	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 20; UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN 30.0'	16. DATE HOLE: STARTED 2/4/04; COMPLETED 2/5/04
8. DEPTH DRILLED INTO ROCK N/A	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE 30.0'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		Dark Brown to Black, Wet SAND w/peat and trace roots	93	J-1	Boring was drilled with the CME 750 (Swamp Buggy) using 3 1/4" Hollow Stem Augers. Samples were obtained by SPT method (1 3/8" I.D. Split-Spoon driven 18 inches by 140 pound hammer w/a 30" drop).
	2		Dark Brown, Wet, Fine SAND w/trace silt	40	J-2	
	3		Same as J-2			
	4			87	J-3	SAMPLES # Depth BlowCount J-1 0.0-1.5 4-3-5 J-2 1.5-3.0 5-5-4 J-3 3.0-4.5 3-2-3 J-4 4.5-6.0 4-3-2 J-5 6.0-7.5 WH/1.0'-1 J-6 7.5-9.0 WH/1.5 J-7 9.0-10.5 WH/1.5 J-8 10.5-12.0 J-9 12.0-13.5 J-10 13.5-15.0 J-11 15.0-16.5 J-12 16.5-18.0 WR/1.0-WH J-13 18.0-19.5 WH/1.5' J-14 19.5-21.0 J-15 21.0-22.5 J-16 22.5-24.0 J-17 24.0-25.5 J-18 25.5-27.0 J-19 27.0-28.5 J-20 28.5-30.0
	5		Same as J-2	100	J-4	
	6		Same as J-2			
	7			100	J-5	
	8		Same as J-2			
	9			100	J-6	
	10		Same as J-2			
	11			33	J-7	
	12		Same as J-2	54	J-8	
	13		Med. to Dark Gray, Moist, Very Soft Silty CLAY w/trace fine shell fragments.	100	J-9	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	14		Same as J-9 * Some of sample used for HTRW analysis	100	J-10	
	15					
	16		Same as J-9	100	J-11	
	17		Same as J-9	100	J-12	H_2O Info Enc: ≈1.0' Completion: 2/4@0930hrs 24' 24hr: 2.0' 2/5@0800hrs
	18					
	19		Same as J-9	100	J-13	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LSP-Additional Borings | HOLE NO. CA04-6

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE — Hole No. CA04-6

PROJECT: LSP- Additional Borings — INSTALLATION: Baltimore — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same as J-9	100	J-14	
	21					
			Same as J-9	100	J-15	
	22					
	23		Same as J-9 (Clay is a little firmer, but still considered soft)	100	J-16	
	24					
			Same as J-16	100	J-17	
	25					
	26		Same as J-16	100	J-18	
	27					
			Same as J-16	100	J-19	
	28					
	29		Same as J-16	100	J-20	
	30		BOH 30.0'			

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-628-603 — PROJECT: LSP-Additional Borings — HOLE NO. CA04-6

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE **Hole No.** CA04-6

PROJECT LSP- Additional Borings INSTALLATION Baltimore SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Same as J-9	100	J-14	
	21					
			Same as J-9	100	J-15	
	22					
	23		Same as J-9 (Clay is a little firmer, but still considered soft)	100	J-16	
	24					
			Same as J-16	100	J-17	
	25					
	26		Same as J-16	100	J-18	
	27					
			Same as J-16	100	J-19	
	28					
	29		Same as J-16	100	J-20	
	30		BOH 30.0'			

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-2801) GPO 1980 OF-628-602 PROJECT LSP-Additional Borings HOLE NO. CA04-6

Hole No. NC04-1

DRILLING LOG	DIVISION NRD	INSTALLATION Raritan District	SHEET 1 OF 2 SHEETS

1. PROJECT: LSP - Additional Borings
2. LOCATION (Coordinates or Station): Jersey City - NJ
3. DRILLING AGENCY: CENAB-EN-GGE
4. HOLE NO. (As shown on drawing title and file number): NC04-1
5. NAME OF DRILLER: ALBERT McNamara
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 21.0'
8. DEPTH DRILLED INTO ROCK: Ø
9. TOTAL DEPTH OF HOLE: 21.0
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Acker Tripod
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 13; UNDISTURBED Ø
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 2-7-04; COMPLETED 2-7-04
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: William J. Merritt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		BLACK SANDY CLAY - trace wood & organics - wet	27	J-1	Holes drilled using NWJ casing & Pressured Water. Standard Penetration Test conducted using 1 3/8" split-spoon driven by 140 lb. manual hammer with 30" drop. Blow count conducted in 6" intervals for total 18" advance per sample.
	2			20	J-2	
	3		wet			
	4		wet	33	J-3	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	5		GRAY-BLACK CLAY	73	J-4	
	6		wet			
	7		wet	80	J-5	
	8			87	J-6	
	9		wet			
	10		GRAY-BLACK Silty CLAY	100	J-7	
	11		wet			
	12		- Rust like markers - wet	100	J-8	
	13		wet	100	J-9	
	14		- with wood - - ENVIRONMENTAL SAMPLE wet	100		
	15					
	16		- with Organics - wet	27	J-10	
	17		- with Organics - wet	53	J-11	
	18		- trace shells - wet	100	J-12	
	19			100	J-13	
	20					

DEPTH	JAR	BLOW COUNT	PENETROMETER
0.0-1.5	1	WR/1.5	
1.5-3.0	2	WR/1.5	
3.0-4.5	3	WR/1.5	
4.5-6.0	4	1/1.5	
6.0-7.5	5	WR/1.5	
7.5-9.0	6	WR/1.5	
9.0-10.5	7	WR/1.5	
10.5-12.0	8	WR/0.5 - WH/1.0	
12.0-13.5	9	WH/1.5	
13.5-15.0		13-8-1	
15.0-16.5	10	WH/1.5	
16.5-18.0	11	WH/1.5	
18.0-19.5	12	WH/1.5	
19.5-21.0	13	WH/1.5	

	Time	WATER Depth
START	0940	7.9'
STOP	1420	3.9'

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: LSP Additional Borings | HOLE NO. NC04-1

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. NC04-1

PROJECT: L.S.P.-Additional Borings | INSTALLATION: Baltimore District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			- trace shells - wet	100	J-13	
	21		BOH - 21.0'			
	22					
	23					

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1966 OF-620-603

PROJECT: L.S.P.-Add. Borings | HOLE NO. NC04-1

Hole No. NC04-2

DRILLING LOG	DIVISION NAD	INSTALLATION Baltimore District	SHEET 1 OF 2 SHEETS

1. PROJECT: L.S.P. - Additional Borings
2. LOCATION (Coordinates or Station): Jersey City - NJ
3. DRILLING AGENCY: CENAB-EN-GGE
4. HOLE NO. (As shown on drawing title and file number): NC04-2
5. NAME OF DRILLER: Albert McNamara
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 21.0'
8. DEPTH DRILLED INTO ROCK: Ø
9. TOTAL DEPTH OF HOLE: 21.0'
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Acker
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 12; UNDISTURBED Ø
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 2-7-04; COMPLETED 2-7-04
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: William J. Merrill

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
	0–1		BLACK CLAY with wood & Debris (wet)	27	J-1
	2–3			No Sample	
	3–5		BLACK SANDY CLAY (wet)	80	J-2
	5–6		(wet)	73	J-3
	6–9		BLACK CLAY - with Coal - (wet)	67	J-4
	8–9			33	J-5
	9.0–9.1		GRAVEL		
	9–13		BLACK & GRAY CLAY (wet); GRAY CLAY 10.5–10.6 Debris (wet); 12.0–12.2 Debris (wet)	100	J-6
	11–13			67	J-7
	12–13			67	J-8
	13–16		(wet)	100	Extra
	16–18		(wet) - Trace Shells - (wet)	100	J-9
	17–18			100	J-10
	18–19		(wet)	100	J-11
	19–20		(wet)	100	J-12

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

Hole was drilled using NWJ Casing & Pressurized Water. Standard Penetration Test conducted using 1 3/8" split spoon, driven by 140lb manual hammer with 30" drop. Blow Count conducted in 6" intervals for total 1 1/2' advance per sample.

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

DEPTH	JAR	BLOW COUNT	Penetrometer
0.0–1.5	1	WR-1-1	
1.5–3.0		WR-WH/1.0	
3.0–4.5	2	WH/1.5	0.5 0.5 0.5
4.5–6.0	3	WR/1.5	0.5 0.5 0.5
6.0–7.5	4	WR/1.5	
7.5–9.0	5	WR-1-1	
9.0–10.5	6	WH/1.5	
10.5–12.0	7	1-1-WR	0.5 0.5 0.5
12.0–13.5	8	WR/1.5	0.5 0.5 0.5
13.5–15.0		WR/1.5	0.5 0.5 0.5
15.0–16.5	9	WR/1.0 WH/0.5	0.5 0.5 0.5
16.5–18.0	10	WH/1.5	
18.0–19.5	11	WR/1.5	0.5 0.5 0.5
19.5–21.0	12	WR WH/1.0	0.5 0.5 0.5

	WATER DEPTH	Time
START	5.4	1442
STOP	6.5	1640

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: L.S.P. - Add. Borings | HOLE NO. NC04-2

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE **Hole No.** NC04-2

PROJECT L.S.P. - Additional Borings INSTALLATION L. [illegible] District SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				100	J-12	
	21		BOH-21.0			
	22					

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OF-6 8-603 PROJECT L.S.P. HOLE NO. NC04-2

Hole No. NC04-3

DRILLING LOG	DIVISION NAD	INSTALLATION Patterson District	SHEET 1 OF 2 SHEETS

1. PROJECT L.S.P. - Additional Borings	10. SIZE AND TYPE OF BIT 2 1/4" HSA
2. LOCATION (Coordinates or Station) Jersey City, N.J.	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY CENAB-EN-GGE	12. MANUFACTURER'S DESIGNATION OF DRILL CME 45
4. HOLE NO. (As shown on drawing title and file number) NC04-3	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 14; UNDISTURBED Ø
5. NAME OF DRILLER Albert McNamara	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 2-9-04; COMPLETED 2-9-04
7. THICKNESS OF OVERBURDEN 21.0'	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK Ø	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 21.0'	19. SIGNATURE OF INSPECTOR William J. Murred

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0-0.1 GRASS			Hole drilled with CME45 using 2 1/4" Hollow Stem Augers. Standard Penetration Test conducted using 1 3/8" split-spoon, driven by automatic hammer. Blow count conducted in 6" intervals for total 1 1/2' advance per sample interval
	1		Brown SAND with Gravel Frozen	100	J-1	
	2		Frozen	100	J-2	
	3		Dry	67 / 100	J-3	
	4		BLACK SAND & Coal Dry	33		
	5		BLACK SANDY CLAY with Coal & wood Dry	100	J-4	
	6		BLACK COAL DUST & SAND 2.2-2.5 - wood wet	100	J-5	
	7					
	8		WOOD WET	100	J-6	
	9			100	J-7	
	10		WET			
	11		WET	67	J-8	
	12			100	J-9	
	13		WET			
	14		WET	60	J-10	
	15			53	J-11	
	16		WET			
	17		BLACK water smells of wood products		J-12	Water encountered - 5.9' Complete - 5.6' 24 hr - 5.9'
	18					
	19		- ENVIRONMENTAL SAMPLES -		J-13	
			WOOD wet	27	J-14	

DEPTH	JAR	BLOW COUNT	Pene-tro-meter
0.0-1.5	1	16-13-12	
1.5-3.0	2	8-15-18	
3.0-4.5	3	14-17-23	
4.5-6.0	4	13-13-11	
6.0-7.5	5	9-9-15	
7.5-9.0	6	22-32-18	
9.0-10.5	7	5-11-11	
10.5-12.0	8	42-11-10	
12.0-13.5	9	2-2-9	
13.5-15.0	10	4-3-2	
15.0-16.5	11	2-2-2	
16.5-18.0	12	WH/1.5	
18.0-19.5	13	WH/1.5	
19.5-21.0	14	10-49-24	

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT L.S.P. - Add. Borings HOLE NO. NC04-3

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | Hole No. NC04-3

PROJECT L.S.P. - Additional Borings | INSTALLATION Baltimore District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Wood wet	27	J-14	
	21		BOH -21.0'			
	22					

PRELIMINARY
INSPECTOR'S LOG
CLASSIFICATION
NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1980 OP-620-103 | PROJECT L.S.P. | HOLE NO. NC04-3

Hole No. NC04-4

DRILLING LOG	DIVISION NAD	INSTALLATION Baltimore District	SHEET 1 OF 2 SHEETS

1. PROJECT: L.S.P. Additional Borings
2. LOCATION (Coordinates or Station): Jersey City, N.J.
3. DRILLING AGENCY: CENAB-EN-GGE
4. HOLE NO. (As shown on drawing title and file number): NC04-4
5. NAME OF DRILLER: Albert McNamara
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 21.0'
8. DEPTH DRILLED INTO ROCK: Ø
9. TOTAL DEPTH OF HOLE: 21.0'
10. SIZE AND TYPE OF BIT: 2¼" HSA
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 14; UNDISTURBED Ø
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 2-9-04; COMPLETED 2-9-04
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: William J. Merrano

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		0.0-0.1 GRASS			Hole drilled with CME 45 using 2¼" Hollow Stem Augers. Standard Penetration Tests conducted using 1⅜" Split Spoon, driven by automatic hammer. Blow Count conducted in 6" intervals for total 18" advance per interval
	1		Brown Clayey SAND with Gravel — Frozen	100	J-1	
	2		Frozen	100	J-2	
	3		Moist	47		
	4		BLACK Silty Fine SAND w/ Coal & Rock Frags. — Damp	100 / 53	J-3	
	5		Red Gravel & Coal with SAND — wet	100	J-4	
	6		BLACK CLAYEY SAND 6.0-6.3 moist			
	7		BLACK Gravel & Coal — wet	73	J-5	
	8		BLACK Debris — wet	100	J-6	
	9					
	10		wet	73	J-7	
	11		BLACK Coarse SAND with Debris — wet	60	J-8	
	12					
	13		wet	13	J-9	
	14		~ENVIRONMENTAL SAMPLE~ — wet	20	J-10	
	15					
	16		wet	67	J-11	
	17		wet	60	J-12	
	18					
	19		wet	100	J-13	
			wet	33	J-14	
	20					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

Depth ft	JAR	Blow Count	Pene-tro-meter
0.0-1.5	1	14-31-30	
1.5-3.0	2	14-15-14	
3.0-4.5	3	11-13-11	
4.5-6.0	4	6-9-9	
6.0-7.5	5	2-4-8	
7.5-9.0	6	2-5-2	
9.0-10.5	7	WH-1-1	
10.5-12.0	8	1-2-2	
12.0-13.5	9	1-1-2	
13.5-15.0	10	1-1-1	
15.0-16.5	11	1.0-0.5	
16.5-18.0	12	1-1-1	
18.0-19.5	13	1-1-1	
19.5-21.0	14	1.0-0.5	

WATER ENCOUNTERED - 6.0'
Complete - 6.3'
24 hr - 6.3'

WATER ELEVATIONS INFLUENCED BY Tide.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: L.S.P. Add Borings | HOLE NO. NC04-4

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE | **Hole No.** NC04-4

PROJECT: L.S.P. Additional Borings | INSTALLATION: Baltimore District | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			wet	33	J-14	
	21		Bott -21.0'			
	22					

PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1800 OF-620-SC 1 | PROJECT: L.S.P. | HOLE NO. NC04-4

Hole No. NC04-5

DRILLING LOG	DIVISION NAD	INSTALLATION Philadelphia District	SHEET 1 OF 2 SHEETS
1. PROJECT L.S.P. - Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City - NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB-EN-GGE		12. MANUFACTURER'S DESIGNATION OF DRILL CME 45	
4. HOLE NO. (As shown on drawing title and file number) NC04-5		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 14	UNDISTURBED Ø
5. NAME OF DRILLER Albert McNamara		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE: STARTED 2-8-04	COMPLETED 2-8-04
7. THICKNESS OF OVERBURDEN 21.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK Ø		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 21.0'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		Brown Clayey Sand with gravel, roots, wood & coal 0.0 - 0.1 - grass Frozen	100	J-1	Hole was drilled using CME 45 with 2¼" Hollow Stem Augers. Standard Penetration Test conducted using 1⅜" Spl. Spoon, driven by automatic hammer. Blow count conducted in 6" intervals for total 1½' advance per sample.
	2		Frozen	100	J-2	
	3		Brown Coarse - Fine Sand with Gravel, wood & roots. Dry	73	J-3	PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	4		BLACK Medium - Fine Sand with Coal, Brick, Gravel & Wood Dry	87	J-4	
	5			73	J-5	
	6		wet	7	J-6	
	7		wet	13	J-7	
	8		wet	27	J-8	
	9		wet	33	J-9	
	10		wet	46	J-10	
	11		wet	67	J-11	
	12		- most of sample wood - wet	67	J-12	
	13		wet	20	J-13	
	14		wet	20	J-14	

Depth	Jar	Blow count	Penetrometer
0.0-1.5	1	12-15-16	
1.5-3.0	2	9-10-12	
3.0-4.5	3	7-17-100	
4.5-6.0	4	20-11-18	
6.0-7.5	5	6-6-13	
7.5-9.0	6	7-8-9	
9.0-10.5	7	3-4-12	
10.5-12.0	8	8-5-13	
12.0-13.5	9	2-2-6	
13.5-15.0	10	1/10-1/5	
15.0-16.5	11	1/10-0.5	
16.5-18.0	12	1/10-13	
18.0-19.5	13	2-5-2	
19.5-21.0	14	1-5-2	

Water encountered - 7.5'
completed - 7.8'
24 hr - 8.0

Water elevations are effected by tides.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT L.S.P. Add. Borings | HOLE NO. NC04-5

HOLE NO. [illegible]

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT LSP- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME 750	
4. HOLE NO. (As shown on drawing title and file number) BA04-1		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED Ø / UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
		16. DATE HOLE	STARTED 2/9/04 / COMPLETED 2/9/04
7. THICKNESS OF OVERBURDEN 20.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 20.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		Surface to 4.0': Black, Dry SAND w/ Coal Fragments			Auger Boring was drilled w/ the CME750 Swamp Buggy Using 2¼" Hollow Stem Augers. No SPT samples were obtained from this boring. Described soils were taken off of the auger flights (cuttings). At the following depths we took split spoon samples to verify cuttings. 10.0-11.5 15.0-16.5 18.0-19.5
	2					
	3					
	4		4.0'-6.0': Med Brown, Wet, Fine SAND w/ trace to some silt			
	5					
	6		≈6.0'-14.0': Med Gray, Wet, Fine to Med. SAND w/ trace silt			
	7					
	8					
	9					
	10					
	11					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	12					
	13					
	14		14.0'-18.0': Med Dark Gray, Moist Silty CLAY w/ trace shell fragments			
	15					
	16					
	17					H_2O Info ENC: ≈ 5.0'
	18		≈18.0'-20.0': Dark Brown, moist Clayey SILT w/ Strong organic odor.			Completion: 3.7'
	19					24hr: Not taken
	20		BOH: 20.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LIBERTY STATE PARK | HOLE NO. BA04-1

ENG FORM NO. [illegible]

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT LSP- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAP		12. MANUFACTURER'S DESIGNATION OF DRILL CME 750	
4. HOLE NO. (As shown on drawing title and file number) BA04-2		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED Ø; UNDISTURBED Ø	
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
		16. DATE HOLE: STARTED 2/9/04; COMPLETED 2/9/04	
7. THICKNESS OF OVERBURDEN 20.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 20.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Surface to ≈5.0' Coal Fragments w/some fine black sand			Auger Boring was drilled w/the CME750 Swamp Buggy Using 2¼" Hollow Stem Augers. No SPT samples were obtained from this boring. Described soils were taken off of the auger flights (cuttings). At the following depths we took split spoon samples to verify: 10.0'-11.5, 15.0'-16.5', 18.0'-19.5'
	1					
	2					
	3					
	4					
	5		5.0'-7.0' Med Gray, Wet, Soft Sandy CLAY			
	6					
	7		7.0-13.0' Med to Dark Gray, Moist CLAY w/trace fine sand layers.			
	8					
	9					
	10					
	11					
	12					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	13		13.0'-14.0' Med Gray, Moist Sandy CLAY			
	14					
	15		15.0'-16.5' Med Gray, Moist Silty CLAY w/some fine sand and gravel			
	16					
	17					Water Info.
	18		18.0'-19.5' Med Gray and Brown Wet Sandy SILT			ENC: ≈4.0'
	19					Completion: 2.4'
						24hr: NOT TAKEN
	20		BOH: 20.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LIBERTY STATE PARK | HOLE NO. BA04-2

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT LSP- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME 750	
4. HOLE NO. (As shown on drawing title and file number) BAØ4-3		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED Ø / UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 2/10/04 / COMPLETED 2/10/04
7. THICKNESS OF OVERBURDEN 20.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 20.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Surface to 3.0': Dark Brown, Dry Gravelly SAND			Auger Boring was drilled w/ the CME 750 Swamp Buggy Using 2¼" Hollow Stem Augers. No SPT samples were obtained from this boring. Described soils were taken off of the auger flights (cuttings). At the following depths we took split spoon samples to verify: 15.0'-16.5' 18.0'-19.5'
	1					
	2					
	3		3.0'-8.0' Dark Gray and Black Clayey SAND w/ Coal Fragments and Gravel			
	4					
	5					
	6					
	7					
	8		8.0'-12.0' Med Brown, Wet. Fine to Med SAND w/ some gravel			
	9					
	10					
	11					
	12		12.0'-14.0' Dark Brown, Fine to Med SAND w/some silt and gravel			PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	13					
	14		14.0'-18.5'; Dark Gray, Slightly Moist, Mod. Soft CLAY			
	15					
	16					
	17					H_2O Info
	18		18.5'-20.0': Light Reddish Brown Dry Compacted silty SAND w/some gravel			Enc: 9.0' Comp: 8.2' 24hr: NOT TAKEN
	19					
	20		BOH: 20.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LIBERTY STATE PARK | HOLE NO. BAØ4-3

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT LSP- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME 750	
4. HOLE NO. (As shown on drawing title and file number) BA04-4		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED Ø / UNDISTURBED Ø
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
7. THICKNESS OF OVERBURDEN 20.0'		16. DATE HOLE	STARTED 2/10/04 / COMPLETED 2/10/04
8. DEPTH DRILLED INTO ROCK N/A		17. ELEVATION TOP OF HOLE	
9. TOTAL DEPTH OF HOLE 20.0'		18. TOTAL CORE RECOVERY FOR BORING %	
		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		Surface to 4.5'; Dark Brown, Dry Gravelly SAND			Auger Boring was drilled w/ the CME 750 Swamp Buggy Using 2¼" Hollow Stem Augers. No SPT samples were obtained from this boring. Described soils were taken off of the auger flights (cuttings). At the following depths we took split spoon samples to verify: 10.0'-11.5', 15.0'-16.5', 18.0'-19.5'
	2					
	3					
	4		4.5'-7.0'; Same As Above but w/ bigger gravels			
	5					
	6					
	7		7.0'-11.5'; Med Gray, Moist Soft Silty CLAY w/ trace Shell fragments			
	8					
	9					
	10					
	11					
	12					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	13					
	14					
	15		15.0'-16.5'; Same As Above but Dark Gray w/ trace Mica			
	16					
	17					H_2O Info
	18		18.5'-20.0'; Light Reddish Brown, Dry Fine SAND w/ some silt and trace gravel.			ENC: ≈ 8.0'
	19					COMP: 10.7'
	20		BOH: 20.0'			24hr: NOT TAKEN

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LIBERTY STATE PARK | HOLE NO. BA04-4

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT LSP- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME 750	
4. HOLE NO. (As shown on drawing title and file number) BA04-5		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED Ø; UNDISTURBED Ø	
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
		16. DATE HOLE: STARTED 2/9/04; COMPLETED 2/9/04	
7. THICKNESS OF OVERBURDEN 20.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 20.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Surface to 3.0': Brown, Dry Gravelly SAND			Auger Boring was drilled w/ the CME750 Swamp Buggy Using 2¼" Hollow Stem Augers.
	1					
	2					No SPT samples were obtained from this boring. Described soils were taken off of the auger flights (cuttings). At the following depths we took splitspoon samples to verify: 10.0'-11.5', 15.0'-16.5', 18.0'-19.5'
	3		3.0'-7.0': Black, Dry Coal Fragments w/ some Black Sand			
	4					
	5					
	6					
	7		7.0'-10.0': Black and Med Gray Fine-Med SAND w/ tr. Coal fragments			
	8					
	9					
	10		10.0'-14.0': Med Gray, Wet Fine to Coarse SAND w/a few pieces of gravel			
	11					
	12					
	13					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	14		14.0-18.0': Med Gray, Wet Silty Fine SAND			
	15					
	16					
	17					H_2O Info
	18		18.0'-20.0' Med Gray and Black, Moist Silty CLAY			ENC: ≈ 8.0'
	19					COMP: 7.3'
	20		BOH: 20.0'			24hr: NOT TAKEN

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LIBERTY STATE PARK | HOLE NO. BA04-5

DRILLING LOG	DIVISION NAD	INSTALLATION BALTIMORE DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT LSP- Additional Borings		10. SIZE AND TYPE OF BIT 2¼" HSA	
2. LOCATION (Coordinates or Station) Jersey City, NJ		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY CENAB		12. MANUFACTURER'S DESIGNATION OF DRILL CME 750	
4. HOLE NO. (As shown on drawing title and file number)	BA04-6	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED Ø; UNDISTURBED Ø	
5. NAME OF DRILLER BOBBY CREAMER		14. TOTAL NUMBER CORE BOXES: N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks	
		16. DATE HOLE: STARTED 2/10/04; COMPLETED 2/10/04	
7. THICKNESS OF OVERBURDEN 20.0'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK N/A		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 20.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	1		Surface to 2.0': Brown, Dry Gravelly SAND w/ trace clay			Auger Boring was drilled w/ the CME750 Swamp Buggy using 2¼" Hollow Stem Augers.
	2		2.0'-8.0' Med Brown, Fine SAND w/trace silt and a few pieces of gravel			No SPT samples were obtained from this boring. Described soils were taken off of the auger flights (cuttings). At the following depths we took splitspoon samples to verify: 5.0'-6.5', 10.0'-11.5', 15.0'-16.5, 18.0'-19.0'
	3					
	4					
	5					
	6					
	7					
	8		8.0'-17.0' Med Gray, wet fine to Coarse SAND w/ Some gravel			
	9					
	10					
	11					
	12					
	13					PRELIMINARY INSPECTOR'S LOG CLASSIFICATION NOT FINAL
	14					
	15					
	16					
	17		17.0'-20.0' Dark Gray, Moist, soft silty CLAY			H_2O Info
	18					Enc: 2.8'
	19					Comp: 3.7'
	20		BOH: 20.0'			24hr: NOT TAKEN

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT LIBERTY STATE PARK | HOLE NO. BA04-6

APPENDIX B
FINAL DRILL LOGS

LIBERTY STATE PARK
JERSEY CITY, NEW JERSEY

SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING AUG. & SEPT. 2003 AND FEB. 2004.

2. DRILL HOLES (DH) WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE (SPT, ASTM - 1586) USING A 1-3/8"ID SPLIT SPOON SAMPLER. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THESE HOLES WERE POWER AUGERED BETWEEN SAMPLES UNLESS OTHERWISE INDICATED. BLOW COUNTS SHOWN ARE FOR 0.5' OF DRIVE, UNLESS OTHERWISE INDICATED.

   BORINGS NC-04-01 & NC-04-02 WERE DRILLED BY AN ACKER TRIPOD. RIG MOUNTED ON A BARGE IN THE NORTH COVE.

   WH - DENOTES WEIGHT OF HAMMER
   WR - DENOTES WEIGHT OF ROD

3. BLOW COUNTS REQUIRED TO ADVANCE SAMPLE SPOON ARE SHOWN IN COLUMN (a).

4. COLUMN (b) SHOWS THE NATURAL WATER CONTENTS IN PERCENT OF DRY WEIGHT OF THOSE SAMPLES TESTED.

5. SOIL DESCRIPTIONS ARE SHOWN IN COLUMN (c).

6. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487/2488), EXCEPT THOSE INDICATED THUS (**), WHICH ARE FIELD INSPECTOR'S CLASSIFICATIONS.

7. GROUNDWATER DEPTHS ARE INDICATED ON THE LOGS AS ▽, ▼ & ▼ ARE SHOWN IN COLUMN (d). PERTINENT DATA FOR THESE READINGS ARE SHOWN AT THE BOTTOM OF LOG UNDER GROUNDWATER DATA OR ADDITIONAL GROUNDWATER DATA. THESE READINGS MAY VARY DEPENDING UPON SEASONS AND AMOUNT OF RAINFALL.

   NE - INDICATES GROUNDWATER NOT ENCOUNTERED
   NT - INDICATES GROUNDWATER READING NOT TAKEN

8. FOR DRILL HOLES NC-04-01 & NC-04-02, DEPTH OF HARBOR SHOWN ON EACH BORING LOG WAS DETERMINED BY SOUNDING WITH WEIGHTED TAPE MEASURE TO TOP OF SEDIMENT PRIOR TO SAMPLING. NO GROUNDWATER READINGS WERE TAKEN IN NC-04-01 & NC-04-02 SINCE EXPLORATION WAS LOCATED IN THE NORTH COVE. START OF BORING (0.0), REPRESENTS THE BOTTOM OF NORTH COVE.

9. ELEVATIONS SHOWN ON THE BORING LOGS ARE GROUND SURFACE ELEVATIONS AT THE TIME OF EXPLORATION. THEY WERE DETERMINED BY SURVEY. VERTICAL DATUM: NAVD 88. HORIZONTAL DATUM: NORTH AMERICAN 1983 DATUM, NEW JERSEY STATE PLANE COORDINATE SYSTEM.

10. FOR LOCATIONS OF SUBSURFACE EXPLORATIONS, SEE BORING LOCATION PLAN.

STA.
OFFSET:
TOP ELEV: 6.9

Liberty State Park
New Jersey

N 683832.05
E 616002.71
COMPLETED: August 27, 2003

LSP-03-1
1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, black, silty fine SAND w/roots, grass & wood (SM)		3-3-4	
3.00	Moist, black, silty coarse SAND w/wood & glass (SM)		3-2-2	
7.50	Wet, v. dk. gray, silty coarse SAND (SM) 3.0'-4.5' - w/glass & roots 4.5'-6.0' - w/wood 6.0'-7.5' - w/tar paper		3-2-1 3-2-4 3-2-2	
9.00	Wet, v. dk. grayish brown, silty med. SAND w/gravel (SM)		2-1-4	
10.50	Wet, gray & brown, silty fine SAND (SM)		8-4-4	
12.00	Wet, grayish brown, silty v. fine SAND (SM)		8-9-7	
15.00	Wet, dk. grayish brown, poorly graded GRAVEL w/silt & sand (GP-GM)		23-29-21 9-26-27	
18.00	Wet, dk. grayish brown, poorly graded coarse SAND w/silt & gravel (SP-SM)		12-13-21 3-4-16	
19.50	Wet, brown, silty GRAVEL w/sand (GM)		9-21-22	
21.00	Wet, brown, poorly graded GRAVEL w/silt & sand (GP-GM)		9-30-15	
22.50	Wet, brown, poorly graded med. SAND (SP)		6-11-6	
25.50	Wet, brown, poorly graded med - coarse SAND (SP)		22-35-25 5-13-38	
26.40	Wet, brown, poorly graded med. SAND w/silt (SP-SM)		32-50/.4	
	BOTTOM OF HOLE			

5 10 15 20 25

LSP-03-1
GROUNDWATER DATA
WHILE DRILLING: 3.0
ON COMPLETION: 3.0
24 Hr. READING: 2.8

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA. | Liberty State Park | N 683517.39 | **LSP-03-2**
OFFSET: | New Jersey | E 616362.33 | **1 of 2**
TOP ELEV: 7.4 | COMPLETED: August 13, 2003

DEPTH(ft)	(c)	(d)		(a)	(b)
	Moist, grayish brown, soft lean CLAY w/grass & roots (CL)			1-9-9	
1.13	Moist, black, silty coarse SAND (SM) 1.125'-1.5' - w/glass & coal frags. 1.5'-3.0' - w/gravel			12-10-7	
3.00	Wet, v. dk. grayish brown, silty coarse SAND (SM) [SAND IS CINDERS]			2-2-2	
4.50	Wet, v. dk. gray, silty coarse SAND (SM) 4.5'-6.0' - w/gravel 7.5'-9.0' - w/grass 9.0'-12.0' - w/gravel & grass		5	1-1-1	
				1-1-1	
				WH-WH-1	
			10	1-1-1	
				WH-1-1	
12.00	Wet, black, silty coarse SAND w/gravel (SM)			1-1-2	
13.50	V. moist, dk. grayish brown, poorly graded med. SAND w/silt (SP-SM)			1-1-WH	
14.25	V. moist, dk. gray, soft lean CLAY (CL)				
15.00	V. moist, dk. grayish brown, poorly graded med. SAND w/silt (SP-SM)		15	WH-WH-WH	
16.50	V. moist, v. dk. gray, soft - firm lean CLAY (CL) 18.0'-19.5' - w/sand			WH-WH-WH	
				WH-1-3	
19.50	Wet, dk. grayish brown, poorly graded SAND w/silt (SP-SM)				

LSP-03-2
GROUNDWATER DATA
WHILE DRILLING: 4.0
ON COMPLETION: 10.6
24 Hr. READING: 3.7

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 46/04 09:15

STA.	Liberty State Park	N 683517.39	**LSP-03-2**
OFFSET:	New Jersey	E 616362.33	**2 of 2**
TOP ELEV: 7.4		COMPLETED: August 13, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
21.00	Wet, dk. grayish brown, poorly graded SAND w/silt (SP-SM) *(continued from previous page)*		1-2-2	
22.50	V. moist, dk. grayish brown, silty fine - med. SAND (SM)		1-2-2	
25.50	Wet, dk. grayish brown, silty fine - med. SAND (SM)	25	2-2-2 4-6-6	
28.50	V. moist, brown, silty fine SAND (SM)		6-9-9 6-8-9	
30.00	V. moist, brown, poorly graded med. SAND w/silt (SP-SM)		8-9-11	
	BOTTOM OF HOLE	30 35 40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA. | Liberty State Park | N 683192.86 | **LSP-03-3**
OFFSET: | New Jersey | E 617998.45 | **1 of 2**
TOP ELEV: 7.1 | COMPLETED: August 13, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. grayish brown, hard lean CLAY w/sand (CL)		2-4-4	
1.50	Moist, black, silty coarse SAND w/gravel (SM) [SAND IS CINDERS]		13-14-11	
3.00	Moist, dk. grayish brown, silty med. SAND w/gravel (SM)		3-6-12	
4.50	Wet, black & brown, silty med. coarse SAND w/gravel (SM)	▽ 5	12-14-8	
6.00	Wet, black, poorly graded coarse SAND (SP-SM) 6.0'-9.0' - w/silt & gravel 9.0-10.5' - w/silt		4-5-8	
			12-7-9	
		10	1-1-1	
10.50	Wet, black, silty med. coarse SAND (SM) 19.5'-21.0' - w/gravel		7-4-4	
			1-1-1	
			1-2-1	

LSP-03-3
GROUNDWATER DATA
▽ WHILE DRILLING: 5.3
▽ ON COMPLETION: 24.73
▽ 24 Hr. READING: 20.56

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 683192.86	**LSP-03-3**
OFFSET:	New Jersey	E 617998.45	**2 of 2**
TOP ELEV: 7.1		COMPLETED: August 13, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, black, silty med. coarse SAND (SM) 19.5'-21.0' - w/gravel *(continued from previous page)*		WH-1-2 1-1-2 1-2-1 1-1-1	
21.00	V. moist, grayish brown, silty coarse SAND w/clay lense (SM)		1-1-1	
22.50	V. moist, dk. greenish gray, soft lean CLAY w/sand (CL)		1-1-WH	
24.00	V. moist, v. dk. gray, soft lean CLAY (CL)		WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH	
30.00	BOTTOM OF HOLE			

20 25 30

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 682884.31	**LSP-03-4**
OFFSET:	New Jersey	E 618440.32	**1 of 2**
TOP ELEV: 5.0		COMPLETED: August 28, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. yellowish brown, silty med - fine SAND w/trace of cinders, roots & gravel (SM)		9-11-10	
1.50	Moist, v. dk. grayish brown, silty med - fine SAND w/trace of cinders & gravel (SM)		8-12-14	
3.00	Wet, dk. gray, med - fine SAND w/trace of cinders & gravel (SM)	▽	3-6-7	
		5	7-4-4	
6.00	Wet, v. dk. gray, silty GRAVEL w/sand (GM)		6-3-2	
7.50	Wet, v. dk. gray, silty coarse - fine SAND w/gravel (SM)		5-4-4	
9.00	Moist, dk. grayish brown, fat CLAY (CH) 9.0'-10.5' - w/sand & trace of gravel 10.5'-12.0' - w/sand 12.0'-15.0' - w/trace of sand & shell frags. 15.0'-16.5' - w/sand, trace of shell frags., & gravel 16.5'-18.0' - w/sand, trace of shell frags. 18.0'-19.5' - w/trace of sand & shell frags. 19.5'-30.0' - w/trace of shell frags.		2-1-2	
		10	3-1-1	
			WH-WH-WH	
			WH-WH-WH	
		15	WR-WR-WR	
			WR-WR-WR	
			WR-2-1	

LSP-03-4
GROUNDWATER DATA
▽ WHILE DRILLING: 3.0
▼ ON COMPLETION: 3.2
▼ 24 Hr. READING: 3.2

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.	Liberty State Park	N 682884.31	**LSP-03-4**
OFFSET:	New Jersey	E 618440.32	**2 of 2**
TOP ELEV: 5.0		COMPLETED: August 28, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. grayish brown, fat CLAY (CH)		3-1-1	
	9.0'-10.5' - w/sand & trace of gravel			
	10.5'-12.0' - w/sand			
	12.0'-15.0' - w/trace of sand & shell frags.		WR-WR-WR	
	15.0'-16.5' - w/sand, trace of shell frags., & gravel			
	16.5'-18.0' - w/sand, trace of shell frags.			
	18.0'-19.5' - w/trace of sand & shell frags.		WR-WR-WR	
	19.5'-30.0' - w/trace of shell frags. *(continued from previous page)*			
		25	WR-WR-WR	
			WR-WR-WR	
			WR-WR-WR	
			WR-WR-WR	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.
OFFSET:
TOP ELEV: 9.8

Liberty State Park
New Jersey

N 682589.51
E 618535.56
COMPLETED: August 11, 2003

LSP-03-5
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, brown, silty fine SAND w/gravel, roots & grass (SM) [GRAVEL IS SANDSTONE FRAGMENTS]		2-42-24	
3.00	Moist, black, poorly graded coarse SAND w/silt (SP-SM)		8-12-14	
4.50	Wet, v. dk. gray, poorly graded GRAVEL w/silt & sand (GP-GM)	▼	7-27-21	
6.00	Wet, v. dk. gray, poorly graded coarse SAND (SP)		13-8-5	
7.50	Wet, black, poorly graded GRAVEL w/silt & sand (GP-GM)		3-1-1	
9.00	Wet, gray, silty med. SAND w/trash (SM)		WH-WH-1	
12.00	V. moist, black, soft fat CLAY w/sand & shell frags. (CH)		1-1-WH WH-WH-WH	
	V. moist, dk. gray, soft fat CLAY (CH) 12.0'-19.5' - w/trace of shell frags. 22.5'-27.0' - w/trace of shell frags.		WH-WH-WH WR-WR-WH WH-WH-1 WH-WH-WH WH-WH-WH	

5
10
15

LSP-03-5
GROUNDWATER DATA
▽ WHILE DRILLING: 3.5
▼ ON COMPLETION: 30.0
▼ 24 Hr. READING: 3.45

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 46/04 09:16

STA.	Liberty State Park	N 682589.51	**LSP-03-5**
OFFSET:	New Jersey	E 618535.56	**2 of 2**
TOP ELEV: 9.8		COMPLETED: August 11, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, dk. gray, soft fat CLAY (CH) 12.0'-19.5' - w/trace of shell frags. 22.5'-27.0' - w/trace of shell frags. *(continued from previous page)*		WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH WR-WH-WH WH-WH-WH	
30.00	BOTTOM OF HOLE			

25

30

35

40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682834.71	**LSP-03-6**
OFFSET:	New Jersey	E 615902.62	**1 of 2**
TOP ELEV: 7.6		COMPLETED: August 23, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty SAND (SM) 0.0'-3.0' - w/gravel 3.0'-4.5' - w/gravel & brown clay lens [SAND & GRAVEL SIZE PARTICLES ARE A MIXTURE OF CINDERS]		7-11-6 5-4-7 4-6-4	
4.50	Wet, v. dk. gray, clayey SAND w/trace of gravel (SC) [SAND & GRAVEL SIZE PARTICLES ARE A MIXTURE OF CINDERS]		3-1-2	
6.00	Wet, v. dk. gray, silty SAND w/gravel (SM)		2-5-5	
7.50	Wet, v. dk. gray, clayey SAND w/gravel & trace of cinders (SC)		1-1-1 WH-WH-WH	
10.50	V. moist, v. dk. gray, clayey SAND (SC) 10.5'-12.0' - w/trace of cinders 12.0'-13.5' - w/gravel & pieces of wood		WH-WH-2 WH-1-2	
13.50	Wet, v. dk. gray, silty, SAND w/gravel & clay lens and trace of shells & wood (SM) [SAND & GRAVEL SIZE PARTICLES ARE A MIXTURE OF CINDERS]		2-1-1	
15.00	Moist, v. dk. gray, poorly graded SAND w/silt (SP-SM)		WH-WH-WH	
16.50	Moist, grayish brown, silty SAND w/trace of organic material (SM)		WH-WH-WH	
18.00	Moist to wet, dk. gray, silty SAND (SM) 18.0'-19.5' - w/trace of organic material 22.5'-24.0' - w/gravel		WH-WH-1	

5 — 10 — 15

LSP-03-6
GROUNDWATER DATA
WHILE DRILLING: 4.3
ON COMPLETION: 10.8
24 Hr. READING: 10.5

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682834.71	**LSP-03-6**
OFFSET:	New Jersey	E 615902.62	**2 of 2**
TOP ELEV: 7.6		COMPLETED: August 23, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist to wet, dk. gray, silty SAND (SM) 18.0'-19.5' - w/trace of organic material 22.5'-24.0' - w/gravel *(continued from previous page)*		2-2-3 WH-2-28 7-23-15	
24.00	Wet, dk. gray, clayey SAND w/gravel (SC)	25	3-6-4	
25.50	Moist, brown, clayey SAND w/gravel (SC)		7-11-9	
27.00	Wet, brown, silty SAND (SM) 27.0'-28.5' - w/gravel 28.5'-30.0' - w/trace of gravel		4-6-6 5-9-7	
30.00	BOTTOM OF HOLE	30 35 40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.	Liberty State Park	N 682579.04	**LSP-03-7**
OFFSET:	New Jersey	E 616800.75	**1 of 2**
TOP ELEV: 6.5		COMPLETED: September 3, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, poorly graded SAND w/silt, gravel & trace of cinders (SP-SM)		2-4-4	
1.50				
	Not Sampled		5-3-3	
3.00				
	Wet, dk. grayish brown, silty GRAVEL w/sand (GM)		3-2-2	
			2-2-1	
			2-2-3	
7.50				
	Wet, dk. gray, silty med - fine SAND w/gravel (SM)		2-1-1	
9.00				
	V. moist, dk. grayish brown, sandy lean to fat CLAY w/trace of gravel (CL/CH)		1-1-1	
10.50				
	Moist, dk. grayish brown, fat CLAY w/trace of sand & shell frags. (CH)		WH-WH-1	
			WH-1-2	
			WH-WH-WH	
			WH-WH-WH	
			WH-WH-WH	
			WR-WR-WR	

5

10

15

LSP-03-7
GROUNDWATER DATA
WHILE DRILLING: 3.0
ON COMPLETION: 4.6
24 Hr. READING: 2.6

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682579.04	**LSP-03-7**
OFFSET:	New Jersey	E 616800.75	**2 of 2**
TOP ELEV: 6.5		COMPLETED: September 3, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. grayish brown, fat CLAY w/trace of sand & shell frags. (CH) *(continued from previous page)*		WR-WR-WR	
			WR-WR-WR	
			WR-WR-WR	
24.00	V. moist, dk. grayish brown, clayey med - fine SAND (SC)		WR-WR-WR	
25.50	Wet, dk. grayish brown, silty med - fine SAND (SM)	25	WH-WH-WH	
			3-3-4	
			3-3-3	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682280.47	**LSP-03-8**
OFFSET:	New Jersey	E 615978.02	**1 of 2**
TOP ELEV: 6.7		COMPLETED: September 3, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, poorly graded coarse - fine SAND w/silt, gravel & trace of roots (SP-SM)		4-3-4	
1.50	Moist to wet, grayish brown, poorly graded med - fine SAND (SP-SM) 1.5'-3.0' - w/silt, gravel & trace of roots 3.0'-4.5' - w/silt		4-7-1	
			4-5-4	
4.50	V. moist, dk. grayish brown, sandy lean to fat CLAY w/trace of gravel (CL/CH)		1-2-1	
6.00	Moist, dk. gray, fat CLAY (CH) 6.0'-7.5' - w/sand & trace of gravel 7.5'-12.0' - w/sand		2-1-1	
			WH-WH-1	
			2-1-1	
			1-1-1	
12.00	Moist, dk. grayish brown, fat CLAY w/sand & trace of gravel (CH)		2-4-4	
13.50	Moist, dk. gray, fat CLAY w/sand, trace of gravel & wood pieces (CH)		3-1-1	
15.00	Moist, dk. grayish brown, fat CLAY w/trace of sand (CH)		3-5-1	
			3-2-2	
18.00	Moist, dk. gray, fat CLAY w/sand, trace of gravel & wood pieces (CH)		4-1-1	
19.50	Moist, dk. grayish brown, fat CLAY w/trace of sand (CH)			

5 10 15

LSP-03-8
GROUNDWATER DATA
WHILE DRILLING: 4.0
ON COMPLETION: 5.7
24 Hr. READING: 3.7

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fisb Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682280.47	**LSP-03-8**
OFFSET:	New Jersey	E 615978.02	**2 of 2**
TOP ELEV: 6.7		COMPLETED: September 3, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
21.00	Moist, dk. grayish brown, fat CLAY w/trace of sand (CH) *(continued from previous page)*		4-5-7	
22.50	Moist, dk. grayish brown, sandy fat CLAY w/trace of wood pieces (CH)		3-3-3	
25.50	Wet, dk. grayish brown, poorly graded med - fine SAND w/silt (SP-SM)	25	6-3-1 WR-WR-WR	
27.00	Wet, dk. yellowish brown, silty med - fine SAND (SM)		7-3-1	
28.50	Wet, dk. grayish brown, silty med - fine SAND (SM)		11-14-9	
30.00	Wet, dk. grayish brown, poorly graded SAND w/silt (SP-SM)		10-6-5	
	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682011.33	**LSP-03-9**
OFFSET:	New Jersey	E 614838.20	**1 of 2**
TOP ELEV: 11.6		COMPLETED: August 21, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty coarse SAND w/roots (SM) [SAND IS MOSTLY CINDERS]		7-10-12	
1.50	V. moist, grayish brown, sitly coarse SAND w/gravel, wood & bricks (SM)	▽	4-8-7	
3.00	Wet, dk. gray, poorly graded med. SAND w/silt (SP-SM)		10-11-4	
4.50	Wet, dk. gray, soft fat CLAY (CH) 10.5'-13.5' - w/sand & trace of shells	▼	1-WH-1	
			WH-WH-WH	
			2-1-2	
			2-1-1	
		▼	WH-1-1	
			1-3-1	
13.50	V. moist, dk. gray, clayey fine SAND (SC)		2-2-12	
15.00	V. moist, brown, clayey med - coarse SAND w/gravel (SC/SM)		10-16-36	
			16-32-20	
18.00	Wet, brown, silty fine SAND (SM)		2-1-2	
19.50	Wet, brown, clayey fine SAND (SC)			

5 10 15

LSP-03-9
GROUNDWATER DATA
▽ WHILE DRILLING: 2.1
▼ ON COMPLETION: 11.5
▼ 24 Hr. READING: 4.7

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682011.33	**LSP-03-9**
OFFSET:	New Jersey	E 614838.20	**2 of 2**
TOP ELEV: 11.6		COMPLETED: August 21, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, brown, clayey fine SAND (SC) *(continued from previous page)*		24-32-8	
21.00				
	Wet, brown, silty v. fine SAND (SM)		23-9-7	
22.50				
	Wet, brown, sandy SILT (ML)		8-15-16	
24.00				
	Wet, brown, silty fine SAND w/gravel (SM)	25	8-15-23	
25.50				
	Wet, brown, silty GRAVEL w/sand (GM)		8-12-21	
			18-15-21	
			15-32-32	
30.00		30		
	BOTTOM OF HOLE			
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA. | Liberty State Park | N 681879.58 | **LSP-03-10**
OFFSET: | New Jersey | E 616168.43 | **1 of 2**
TOP ELEV: 9.1 | COMPLETED: September 7, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. grayish brown, silty med - coarse SAND w/gravel (SM)		3-8-21	
1.50	Moist to v. moist, brown, poorly graded med. SAND w/silt (SP-SM)		18-12-13	
			18-8-3	
4.50	Wet, brown, silty med. SAND (SM)		2-1-1	
6.00	Wet, dk. gray, soft fat to lean CLAY w/sand (CL)		1-WH-WH	
7.50	Wet, dk. gray, poorly graded med. SAND w/silt (SP-SM)		2-3-3	
			3-2-3	
			6-4-3	
			WH-WH-WH	
14.40			1-1-WH	
15.00	Wet, black, soft fat to lean CLAY (CH/CL)			
	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH)		WH-WH-WH	
			WH-WH-WH	
18.00	Wet, dk. gray, soft fat CLAY w/trace of shells (CH)		WH-WH-WH	

5 10 15

LSP-03-10
GROUNDWATER DATA
WHILE DRILLING: 4.0
ON COMPLETION: 5.7
24 Hr. READING: 4.0

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681879.58	**LSP-03-10**
OFFSET:	New Jersey	E 616168.43	**2 of 2**
TOP ELEV: 9.1		COMPLETED: September 7, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, dk. gray, soft fat CLAY w/trace of shells (CH) *(continued from previous page)*		WH-WH-WH	
			WH-WH-WH	
22.50	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH)		WH-WH-2	
24.00	Wet, black, soft fat to lean CLAY w/sand lens (CH/CL)	25	WH-WH-WH	
25.50	Wet, dk. gray, silty med. SAND (SM)		WH-WH-1	
27.00	Wet, brown, poorly graded med. SAND w/silt (SP-SM)		1-2-4	
28.50	Wet, dk. gray, poorly graded med. SAND w/silt (SP-SM)		2-2-4	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681149.50	**LSP-03-11**
OFFSET:	New Jersey	E 615521.94	**1 of 2**
TOP ELEV: 7.9		COMPLETED: August 25, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty SAND w/cinders & trace of roots (SM)		1-2-2	
1.50	Moist, brown, poorly graded SAND (SP-SM) 1.5'-6.0' - w/silt 6.0'-9.0' - w.trace of shells		2-3-3	
			1-2-1	
		5	WH-1-WH	
			WH-WH-WH	
			WH-WH-WH	
9.00	Wet, v. dk. gray, silty fine SAND w/trace of coal & shells (SM)		WH-WH-WH	
10.50	V. moist, v. dk. gray, clayey fine SAND w/trace of shells & coal (SM/SC)	10	WH-WH-1	
12.00	V. moist, v. dk. gray, clayey SAND w/trace of shells (SC/CL)		1-1-1	
13.50	Moist, dk. gray, sandy fat CLAY w/trace of shells (CH)		WH-WH-WH	
15.00	Moist, v. dk. gray, soft fat CLAY w/sandy trace of shells (CH)	15	WH-WH-WH	
16.50	Moist, v. dk. gray, soft fat CLAY w/trace of sand & shells (CH)		WH-WH-WH	
			WH-WH-WH	

LSP-03-11
GROUNDWATER DATA
WHILE DRILLING: 3.0
ON COMPLETION: 13.8
24 Hr. READING: 3.2

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA. Liberty State Park N 681149.50 **LSP-03-11**
OFFSET: New Jersey E 615521.94 **2 of 2**
TOP ELEV: 7.9 COMPLETED: August 25, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. gray, soft fat CLAY w/trace of sand & shells (CH) *(continued from previous page)*		WH-WH-WH	
21.00	Moist, dk. to v. dk. gray, clayey SAND (SC) 21.0'-24.0' - w/trace of shells		WH-WH-WH	
			WH-WH-WH	
		25	WH-WH-1	
25.50	Wet, brown, poorly graded SAND w/silt (SP-SM)		1-2-2	
			1-3-4	
			2-2-4	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 681514.55	**LSP-03-12**
OFFSET:	New Jersey	E 616749.81	**1 of 2**
TOP ELEV: 8.7		COMPLETED: August 23, 2003	

DEPTH(ft)	(c)	(d)		(a)	(f)
	Approx. 50 grams - mixture of grass, 4 pieces of gravel, sand & clay			4-2-3	
1.50	Moist, dk. gray, lean CLAY w/trace of roots & sand (CL)			1-2-5	
3.00	Moist, brown, silty SAND w/trace of gravel (SM)	▼		2-8-10	
4.50	Moist, grayish brown, silty SAND w/trace of brick frags. (SM)		5	5-7-6	
6.00	V. moist, dk. gray, clayey SAND w/trace of gravel & cinders (SC)	▽		5-7-4	
7.50	Moist, v. dk. gray, sandy, soft fat CLAY w/ trace of gravel (CH)			WH-1-1	
9.00	Moist, v. dk. gray, soft fat CLAY w/trace of sand & shells (CH)	▼	10	1-1-1	
				1-1-1	
				7-5-4	
13.50	V. moist, v. dk. gray, clayey SAND w/trace of brick frags. & gravel (SC)			4-4-3	
			15	3-4-2	
16.50	V. moist, black & brown, clayey SAND (SC)			1-1-WH	
18.00	Moist, dk. gray, sandy, soft fat CLAY (CH)			WH-1-WH	
19.50					

LSP-03-12
GROUNDWATER DATA
▽ WHILE DRILLING: 6.8
▼ ON COMPLETION: 10.2
▼ 24 Hr. READING: 3.4

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681514.55	**LSP-03-12**
OFFSET:	New Jersey	E 616749.81	**2 of 2**
TOP ELEV: 8.7		COMPLETED: August 23, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, soft fat CLAY (CL) 21.0'-22.5' - w/trace of shells *(continued from previous page)*		1-1-1 WH-WH-1 WH-1-WH WH-WH-1 WH-WH-1 WH-WH-1 WH-WH-WH	
30.00	BOTTOM OF HOLE			

25
30
35
40

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA. | Liberty State Park | N 683740.03 | **LSP-03-13**
OFFSET: | New Jersey | E 615450.42 | **1 of 1**
TOP ELEV: 9.9 | COMPLETED: August 27, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, v. dk. gray, silty SAND w/trace of gravel, roots & grass (SM)		3-7-9	
3.00	Not Sampled			
4.50	Moist, v. dk. gray, silty SAND w/gravel & trace of cinders & wood (SM)		13-13-15	
6.00	Moist, brown, clayey fine SAND w/trace of gravel (SC/SM)		5-9-8	
7.50	Moist, grayish brown, silty fine SAND (SM)		5-6-6	
10.50	Moist, brown, silty fine SAND (SM) 9.0'-10.5' - w/1 large rock frag.		10-11-15 5-15-8	
12.00	20 grams of silty SAND & gravel frags		4-8-10	
16.50	V. moist, brown, clayey SAND w/gravel (SC/GC)		7-18-16 11-11-10 8-17-21	
21.30	V. moist to wet, brown, silty SAND w/gravel (SM)		6-13-22 6-11-15 5-13-19 50/3	
	BOTTOM OF HOLE Note: Jar 6 - 8 don't contain a representative sample to test.			

5 10 15 20

LSP-03-13
GROUNDWATER DATA
▽ WHILE DRILLING: 9.0
▼ ON COMPLETION: 6.6
▼ 24 Hr. READING: 4.4

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA. | Liberty State Park | N 683756.67 | **LSP-03-14**
OFFSET: | New Jersey | E 615727.44 | **1 of 1**
TOP ELEV: 8.0 | COMPLETED: August 11, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty med. to coarse SAND w/trace of gravel, cinders & glass (SM) [SAND & GRAVEL SIZE PARTICLES ARE CINDERS]		2-3-3	
			8-11-9	
			7-9-4	
4.50	V. moist to wet, black clayey SAND w/gravel & glass (SC) [SAND & GRAVEL SIZE PARTICLES ARE CINDERS]	5	4-3-3	
			5-2-1	
7.50	V. moist, dk. gray, silty SAND (SM/SC)		1-1-4	
9.00	18 grams of moist, dk. gray, silty SAND (SM)	10	6-6-7	
10.50	Wet, v. dk. gray, clayey SAND w/gravel & glass (SC)		4-5-5	
			4-4-6	
13.50	Moist to wet, grayish brown, silty fine SAND (SM)	15	2-2-2	
			2-4-6	
16.50	Wet, brown, silty med-coarse SAND (SM)		6-9-11	
18.00	Moist, brown, poorly graded SAND (SP-SM)		3-8-13	
19.50	Moist, brown, silty SAND (SM) 19.5'-24.0' - w/gravel 24.0'-27.0' - w/trace of gravel	20	4-17-16	
			2-7-11	
			4-10-9	
		25	21-17-26	
			11-14-24	
27.00	Mixture of 4 rock frags. & sand		6-100/.4	
27.90	BOTTOM OF HOLE			

LSP-03-14
GROUNDWATER DATA
WHILE DRILLING: 3.0
ON COMPLETION: 2.8
24 Hr. READING: 1.2

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 683548.62	**LSP-03-15**
OFFSET:	New Jersey	E 616161.42	**1 of 2**
TOP ELEV: 7.1		COMPLETED: August 20, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. brown, silty fine SAND w/roots & grass (SM)		3-5-6	
1.50	Moist, black, poorly graded GRAVEL w/silt & sand (GP-GM)		15-11-16	
3.00	V. moist, black & reddish brown, silty coarse SAND (SM)	▼	6-4-3	
4.50	Wet, black, silty med - coarse SAND w/gravel (SM)	▽	3-2-1	
6.00	Wet, v. dk. gray, silty med - coarse SAND w/gravel (SM)		3-1-2	
			1-1-1	
			1-2-1	
			WH-1-1	
12.00	Wet, v. dk. gray, silty med. SAND (SM)		WH-1-1	
13.50	Wet, dk. gray to v. dk. gray, silty fine SAND (SM)		WH-1-1	
			2-2-2	
		▼	WH-1-3	
			2-1-2	

5 10 15

LSP-03-15
GROUNDWATER DATA
▽ WHILE DRILLING: 5.3
▼ ON COMPLETION: 17.7
▼ 24 Hr. READING: 3.2

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 683548.62	**LSP-03-15**
OFFSET:	New Jersey	E 616161.42	**2 of 2**
TOP ELEV: 7.1		COMPLETED: August 20, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
21.00	Wet, dk. gray to v. dk. gray, silty fine SAND (SM) *(continued from previous page)*		1-1-3	
24.00	Wet, olive gray, silty v. fine SAND (SM)		2-1-1 3-4-5	
25.50	Wet, brown, silty med. SAND (SM)	25	3-5-5	
27.00	Wet, brown, silty v. fine SAND (SM)		5-6-8	
28.50	Wet, brown, silty v. fine - med. SAND (SM)		4-5-5	
30.00	Wet, brown, soft lean CLAY (CL/ML)	30	4-7-9	
	BOTTOM OF HOLE	35 40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA. | Liberty State Park | N 683160.31 | **LSP-03-16**
OFFSET: | New Jersey | E 616573.93 | **1 of 2**
TOP ELEV: 6.6 | COMPLETED: August 12, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist to wet, black, poorly graded coarse SAND (SP-SM) 0.0'-1.5' - w/silt, grass & roots 1.5'-4.5' - w/silt & gravel [SAND IS MOSTLY CINDERS]		3-4-3	
1.50			3-3-1	
			6-1-1	
	Wet, black, silty coarse SAND w/gravel (SM)	5	1-WH-WH	
6.00				
	Wet, v. dk. grayish brown, silty med. SAND w/trace of gravel (SM)		WR-WR-WR	
			WH-WH-1	
9.00				
	Wet, v. dk. brown, silty coarse SAND w/trace of wood pieces (SM)	10	1-WH-1	
			WH-1-WH	
			WH-WH-WH	
13.50				
	EMPTY JAR		WH-WH-WH	
15.00				
	Wet, black, silty fine SAND (SM)	15	WH-WH-WH	
16.50				
	Wet, dk. greenish gray, soft fat CLAY w/trace of sand (CH)		WH-WH-WH	
			WH-WH-WH	
19.50				
	Wet, v. dk. gray, soft fat CLAY (CH)			

LSP-03-16
GROUNDWATER DATA
WHILE DRILLING: 2.4
ON COMPLETION: 16.4
24 Hr. READING: 13.2

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 683160.31	**LSP-03-16**
OFFSET:	New Jersey	E 616573.93	**2 of 2**
TOP ELEV: 6.6		COMPLETED: August 12, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
21.00	Wet, v. dk. gray, soft fat CLAY (CH) *(continued from previous page)*		WH-WH-WH	
22.50	Wet, dk. gray, clayey fine to med. SAND (SC)		WH-1-1	
25.50	Wet, v. dk. gray, poorly graded med - coarse SAND w/silt (SP-SM)		2-4-2 1-1-2	
27.00	Wet, brown, poorly graded med. SAND w/gravel (SP-SM)		3-4-8	
28.50	Wet, brown, silty med. SAND w/gravel (SM)		5-7-8	
30.00	Wet, brown, silty fine SAND (SM)		4-8-11	
	BOTTOM OF HOLE			

25 30 35 40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682979.20	**LSP-03-17**
OFFSET:	New Jersey	E 616986.62	**1 of 2**
TOP ELEV: 6.8		COMPLETED: August 28, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty SAND (SM) 0.0'-1.5' - w/trace of gravel, grass, cinders & glass 1.5'-3.0' - w/trace of gravel & coal [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		2-5-5 3-7-10	
3.00	V. moist to wet, v. dk. gray, silty SAND (SM) 3.0'-4.5' - w/gravel 4.5'-6.0' - w/gravel & trace of glass [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		9-11-12 9-6-13	
6.00	[GRAVEL = 3/4" DIAMETER PIECES OF CEMENTED SAND GRAINS] Moist, dk. brown, silty SAND (SM)		5-11-10	
7.50	Mixture of brick fragments, silty sand & cinders		5-4-2	
9.00	V. moist, v. dk. gray, clayey SAND w/trace of gravel (SC) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		2-1-2	
10.50	Wet, black, silty SAND (SM) 10.5'-13.5' - w/trace of gravel, glass & wood 13.5'-15.0' - w/trace of gravel, glass, decaying material & shell frags. 15.0'-19.5' - w/trace of gravel, glass, wood & shell frags. [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		2-1-1 2-1-1 2-1-2 2-1-2 4-4-3 3-3-2	
19.50				

5 10 15

LSP-03-17
GROUNDWATER DATA
WHILE DRILLING: 3.0
ON COMPLETION: 3.6
24 Hr. READING: 3.0

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet

GEO-2 LIBERTY STATE PARK.GPJ ARBOA 09/15

STA.	Liberty State Park	N 682979.20	**LSP-03-17**
OFFSET:	New Jersey	E 616986.62	**2 of 2**
TOP ELEV: 6.8		COMPLETED: August 28, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, v. dk. gray, soft fat CLAY (CH) 19.5'-21.0' - w/trace of sand, gravel, brick frags., wood & 1 piece of leather 21.0'-22.5' - w/trace of sand, shell & brick frags. &1 piece of leather 22.5'-27.0' - w/trace of organics 27.0'-30.0' - w/trace of sand & shell frags. [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL] *(continued from previous page)*		4-1-1 1-1-2 WR-WH-WH WR-3-1 WR-WR-WR WR-WR-WR WR-WR-WR	
30.00	BOTTOM OF HOLE			

25

30

35

40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.
OFFSET:
TOP ELEV: 9.1

Liberty State Park
New Jersey

N 682828.57
E 617431.16
COMPLETED: August 25, 2003

LSP-03-18
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Approx. 14 grams - Mixture of grass, sand & 2 pieces of gravel		4-4-4	
1.50	Moist, grayish brown, lean CLAY w/trace of roots (CL)		2-2-2	
			3-3-7	
4.50	Moist to wet, black, silty med to coarse SAND (SM) 6.0'-7.5' - Moist, w/trace of gravel 7.5'-9.0' - Moist 9.0'-12.0' - Wet, w/trace of gravel [SAND SIZE PARTICLES ARE CINDERS] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF CINDERS & GRAVEL]		5-10-11	5
			9-15-24	
			4-10-10	
			4-10-8	10
			3-16-24	
12.00	Moist, dk. gray, fat CLAY w/trace of sand & decaying material (CH)		4-1-1	
13.50	Moist, dk. gray, soft fat CLAY w/trace of shells (CH)		1-1-1	
			1-2-1	15
			1-2-2	
			1-1-1	

LSP-03-18
GROUNDWATER DATA
WHILE DRILLING: 5.9
ON COMPLETION: 20.6
24 Hr. READING: 5.4

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682828.57	**LSP-03-18**
OFFSET:	New Jersey	E 617431.16	2 of 2
TOP ELEV: 9.1		COMPLETED: August 25, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, soft fat CLAY w/trace of shells (CH) *(continued from previous page)*	▽	WH-I-2	
			WH-WH-2	
			WH-WH-2	
		25	WH-WH-WH	
			WR-WR-WH	
			WH-WH-WH	
			WH-WH-WH	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 682477.62	**LSP-03-19**
OFFSET:	New Jersey	E 617933.69	**1 of 2**
TOP ELEV: 7.4		COMPLETED: August 26, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Sl. moist, dk. yellowish brown, silty med to fine SAND w/gravel, cinders & organic material (SM)		4-7-3	
1.50	Moist, v. dk. grayish brown, silty med to fine SAND w/trace of gravel, cinders & orgainic material (SM)		9-9-9	
3.00	Wet, dk. to v. dk. grayish brown, silty coarse to fine SAND w/gravel (SM)		8-11-14	
		5	14-14-15	
6.00	Wet, gray, silty GRAVEL w/sand (GM)		6-5-5	
7.50	Wet, gray, silty SAND w/gravel (SM)		2-2-2	
9.00	V. moist, dk. gray, sandy lean to fat CLAY w/trave of gravel & shell frags. (CL/CH)	10	1-1-1	
			2-1-1	
12.00	Moist, dk. grayish brown, fat CLAY w/trace of sand & shell frags. (CH)		WH-WH-WH	
13.50	Moist, dk. gray, fat CLAY w/trace of sand & shell frags. (CH)		WH-WH-WH	
		15	WR-WR-3	
			WR-WR-WH	
			WH-2-2	

LSP-03-19
GROUNDWATER DATA
WHILE DRILLING: 4.0
ON COMPLETION: 27.3
24 Hr. READING: 4.3

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Estes

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-27			
Jar-1	0.0-1.5	moist dk yel brn silty sand (2) w/gravel trace of roots	(SM)
Jar-2	1.5-3.0	moist blk poorly graded sand (1)(3) w/ silt and gravel	(SP-SM)
Jar-3	3.0-4.5	very moist gry brn silty sand (2) trace of gravel	(SM)
Jar-4	4.5-6.0	wet brn silty sand (2)	(SM)
Jar-5	6.0-7.5	very moist gry brn sandy silt w/gravel	(ML)
Jar-6	7.5-9.0	wet dk gry brn silty sand (3) w/gravel	(SM)
Jar-7	9.0-10.5	ditto (3)	(SM)
Jar-8	10.5-12.0	very moist dk gry brn sandy lean clay w/gravel	(CL)
Jar-9	12.0-13.5	moist dk gry brn fat clay w/sand trace of gravel	(CH)
Jar-10	13.5-15.0	moist dk gry brn fat clay (4) trace of sand	(CH)
Jar-11	15.0-16.5	ditto (4)	(CH)
Jar-12	16.5-18.0	moist dk gry ditto (4)	(CH)
Jar-13	18.0-19.5	ditto (4)	(CH)
Jar-14	19.5-21.0	ditto (4)	(CH)
Jar-15	21.0-22.5	moist dk gry brn sandy lean clay	(CL)
Jar-16	22.5-24.0	wet gry brn silty sand (2)	(SM)
Jar-17	24.0-25.5	ditto (2)	(SM)
Jar-18	25.5-27.0	ditto (2)	(SM)
Jar-19	27.0-28.5	very moist gry brn poorly graded sand (1) w/silt	(SP-SM)
Jar-20	28.5-30.0	wet gry brn silty sand (5)	(SM)

(1) contains cinders
(2) medium to fine sand
(3) coarse to fine sand
(4) trace of shell fragments
(5) fine sand

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-26			
Jar-1	0.0-1.5	Moist, Black, Silty, SAND (1) with Gravel (2)	(SM)
Jar-2	1.5-3.0	Ditto (1) with Gravel (2)	(SM)
Jar-3	3.0-4.5	Wet, Black, Poorly Graded SAND (1) with Silt and Gravel (2)	(SP-SM)
Jar-4	4.5-6.0	Moist, DK Gray, SOFT FAT CLAY with Sand & 1 piece of Cemented Sand	(CH)
Small Sample, Jar-5	6.0-7.5	Wet, V. DK Gray, Silty, SAND (1) Trace of Gravel (2)	(SM)
Small Sample Jar-6	7.5-9.0	Moist, V. DK, Gray, SOFT FAT CLAY	(CH)
Jar-7	9.0-10.5	Ditto	(CH)
Jar-8	10.5-12.0	Ditto	(CH)
Jar-9	12.0-13.5	Ditto	(CH)
Jar-10	13.5-15.0	Ditto Trace of Glass	(CH)
Jar-11	15.0-16.5	Ditto Trace of Shells	(CH)
Jar-12	16.5-18.0	Ditto	(CH)
Jar-13	18.0-19.5	Ditto Trace of Shells	(CH)
Jar-14	19.5-21.0	Ditto Trace of Decaying Material	(CH)
Jar-15	21.0-22.5	V. Moist, DK Gray, Silty, SAND	(SM)
Jar-16	22.5-24.0	Wet, DK Gray, Silty, SAND Trace of Gravel	(SM)
Jar-17	24.0-25.5	Moist, Brown, Poorly Graded SAND	(SP-SM)
Jar-18	25.5-27.0	Ditto	(SP-SM)

(1) Sand size particles are a mixture of Sand, Cinders and Coal.

(2) Gravel size particles are a mixture of Gravel, Cinders and Coal.

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-25			
Jar-1	0.0-1.5	Moist, Black, silty, SAND① with Gravel②	(SM)
Jar-2	1.5-3.0	Ditto① with Gravel②, Brick Frags	(SM)
Jar-3	3.0-4.5	Moist, DK Gray, clayey, SAND Trace of Gravel	(SC)
Jar-4	4.5-6.0	3 pieces of Cemented Sand Grains	—
Jar-5	6.0-7.5	Moist, DK. Grayish Brown, silty, SAND with Gravel + Wood	(SM)
Jar-6	7.5-9.0	A Dirty Jar	—
very small Jar-7	9.0-10.5	Moist, DK Gray, clayey, SAND Trace of Gravel	(SC)
Jar-8	10.5-12.0	Moist, DK Gray, SOFT FAT CLAY Trace of Sand	(CH)
Jar-9	12.0-13.5	Ditto Trace of Sand + Gravel	(CH)
Jar-10	13.5-15.0	Ditto Trace of Shells	(CH)
Jar-11	15.0-16.5	Ditto	(CH)
Jar-12	16.5-18.0	Moist, DK. Gray + Black, SOFT FAT Clay W/ organic material Trace of Shells	(CH)
Jar-13	18.0-19.5	Wet, DK. Gray, Poorly Graded SAND with silt	(SP-SM)
Jar-14	19.5-21.0	Ditto	(SP-SM)
Jar-15	21.0-22.5	Wet, DK Gray, Silty, SAND	(SM)
Jar-16	22.5-24.0	Moist, DK Grayish Brown, Silty, SAND Tr. of Gravel + Shells	(SM)
Jar-17	24.0-25.5	Ditto Trace of Gravel	(SM)
Jar-18	25.5-27.0	Wet, DK Grayish Brown, Silty, SAND Tr. of Gravel + Shells	(SM)
Jar-19	27.0-28.5	Ditto Trace of Shells + Gravel	(SM)
Jar-20	28.5-30.0	Ditto Trace of Gravel	SM/SC
		① Sand size particles are a mixture of Sand, Cinders	
		and Coal.	
		② Gravel size particles are a mixture of Gravel, Cinders	
		and Coal.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-24			
small Jar-1	0.0-1.5	Moist, V. Dk. Grayish Brown, Silty, SAND (1) with Gravel (2) + Grass	(SM)
Jar-2	1.5-3.0	Moist, Dark Grayish Brown, Clayey, SAND Trace of Roots	(SC)
Jar-3	3.0-4.5	Moist, V. Dark Gray, Sandy, LEAN CLAY Trace of Wood	(CL)
Jar-4	4.5-6.0	Moist, Black + V.D. Gray, FAT CLAY with Sand (1) + Gravel (2)	(CH)
Jar-5	6.0-7.5	Wet, Black, Silty, SAND (1) with Gravel (2)	(SM)
very small Jar-6	7.5-9.0	Ditto (1)	(SM)
small Jar-7	9.0-10.5	Ditto (1) With Gravel (2), Piece of Leather	(SM)
very small Jar-8	10.5-12.0	Ditto (1) Trace of Gravel (2)	(SM)
small Jar-9	12.0-13.5	Ditto (1) with Gravel (2), Trace of Wood	(SM)
Jar-10	13.5-15.0	Moist, Very Dark Gray, Sandy (1), FAT CLAY Trace of Organics	(CH)
Jar-11	15.0-16.5	Wet, Ditto (1) Trace of Gravel (2) + Organics	(CH)
Jar-12	16.5-18.0	Moist, Dark Gray, SOFT FAT CLAY Trace of Shells	(CH)
Jar-13	18.0-19.5	Ditto Trace of Shells	(CH)
Jar-14	19.5-21.0	Ditto " " "	(CH)
Jar-15	21.0-22.5	Ditto " " "	(CH)
Jar-16	22.5-24.0	Ditto " " "	(CH)
Jar-17	24.0-25.5	Ditto " " "	(CH)
Jar-18	25.5-27.0	Ditto " " "	(CH)
Jar-19	27.0-28.5	Ditto " " "	(CH)
Jar-20	28.5-30.0	Ditto " " "	(CH)

(1) Sand size particles are a mixture of Sand and Cinders.

(2) Gravel size particles are a mixture of Gravel and Cinders.

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-23			
Jar-1	0.0-1.5	Moist, Very Dark Gray, silty, SAND ① Trace of Gravel ②	(SM)
Jar-2	1.5-3.0	Ditto ① " " ②	(SM)
very small Jar-3	3.0-4.5	Wet, Very Dark Gray, silty, GRAVEL ② with Sand ①	(GM)
small Jar-4	4.5-6.0	Wet, Very Dark Gray, silty, SAND ① Trace of Gravel ②	(SM)
very Small Jar-5	6.0-7.5	Ditto ① Trace of Gravel ②	(SM)
very Small Jar-6	7.5-9.0	Ditto ① Trace of Gravel ②	(SM)
Small Jar-7	9.0-10.5	Moist, Dark Gray, SOFT FAT CLAY Trace of Gravel, SAND + Shell Frags	(CH)
Jar-8	10.5-12.0	Moist, Dark Gray, SOFT FAT CLAY Trace of Gravel	(CH)
Jar-9	12.0-13.5	Ditto	(CH)
Jar-10	13.5-15.0	Ditto	(CH)
Jar-11	15.0-16.5	Ditto with Organic Material	(CH)
Jar-12	16.5-18.0	Moist, Very Dark Gray, Clayey, fine SAND with Organic Material	(SC)
Jar-13	18.0-19.5	Moist, Very Dark Gray, Clayey, FINE SAND	(SC)
Jar-14	19.5-21.0	Wet, Dark Gray, Poorly Graded SAND with silt	(SP-SM)
Jar-15	21.0-22.5	Ditto	(SP-SM)
Jar-16	22.5-24.0	Very Moist, Dark Gray, Poorly Graded SAND with Silt + Brick Frags	(SP-SM)
Jar-17	24.0-25.5	Ditto with Silt, Trace of Brick Frags + Gravel	(SP-SM)
Jar-18	25.5-27.0	Wet, Dark Gray, silty, SAND Trace of Gravel	(SM)
Jar-19	27.0-28.5	Moist, Dark Gray, silty, SAND Trace of Gravel	(SM)
Jar-20	28.5-30.0	Ditto Trace of Gravel	(SM)
		① Sand size particles are a mixture of Sand, Cinders	
		and Coal.	
		② Gravel size particles are a mixture of Sand,	
		Cinders and Coal.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-20			
Jar-1	0.0-1.5	Moist brown silty fine sand w/ roots & grass	(SM)
Jar-2	1.5-3.0	Moist brown silty med sand	(SM)
Jar-3	3.0-4.5	V. moist -ditto-	(SM)
Jar-4	4.5-6.0	Moist black silty med-coarse sand (tr. wood brick)	(SM)
Jar-5	6.0-7.5	Wet black silty coarse sand w/ wood	(SM)
Jar-6	7.5-9.0	TOO SMALL TO CLASSIFY	—
Jar-7	9.0-10.5	Mixture of wood, gravel, sand & silt	—
Jar-8	10.5-12.0	Wet v. dk brn silty coarse sand w/ lg. amt. of wood	(SM)
Jar-9	12.0-13.5	Wet v. dk brn silty coarse sand w/ gravel & wood	(SM)
Jar-10	13.5-15.0	6" piece of wood w/ Tr. of sand & silt	—
Jar-11	15.0-16.5	Wet black silty fine sand w/ gravel (Tr. wood)	(SM)
Jar-12	16.5-18.0	Wet black silty fine sand (Tr. wood)	(SM)
Jar-13	18.0-19.5	Wet black silty fine-med sand (Tr. gravel)	(SM)
Jar-14	19.5-21.0	V. moist black soft fat to lean clay	CH/CL
Jar-15	21.0-22.5	V. moist black soft fat clay	(CH)
Jar-16	22.5-24.0	-ditto-	(CH)
Jar-17	24.0-25.5	-ditto-	(CH)
Jar-18	25.5-27.0	-ditto-	(CH)
Jar-19	27.0-28.5	-ditto-	(CH)
Jar-20	28.5-30.0	V. moist dk greenish gray soft fat clay	(CH)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Estes

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-19			
Jar-1	0.0-1.5	slightly moist dK yel brn silty sand ①②③ w/gravel	(SM)
Jar-2	1.5-3.0	moist very dK gry brn ditto ①②③	(SM)
Jar-3	3.0-4.5	wet very dK gry brn silty sand ④ w/gravel	(SM)
Jar-4	4.5-6.0	wet dK gry brn ditto ④	(SM)
very small sample Jar-5	6.0-7.5	wet gry silty gravel w/sand	(GM)
Jar-6	7.5-9.0	wet gry silty sand ④ w/gravel	(SM)
Jar-7	9.0-10.5	very moist dK gry sandy lean to fat clay trace of gravel	CL/CH
Jar-8	10.5-12.0	ditto ⑤	CL/CH
Jar-9	12.0-13.5	moist dK gry brn fat clay ⑤ trace of sand	(CH)
Jar-10	13.5-15.0	moist dK gry ditto ⑤	(CH)
Jar-11	15.0-16.5	ditto ⑤	(CH)
Jar-12	16.5-18.0	ditto ⑤	(CH)
Jar-13	18.0-19.5	ditto ⑤	(CH)
Jar-14	19.5-21.0	ditto ⑤	(CH)
Jar-15	21.0-22.5	ditto ⑤	(CH)
Jar-16	22.5-24.0	ditto ⑤	(CH)
Jar-17	24.0-25.5	ditto ⑤	(CH)
Jar-18	25.5-27.0	ditto ⑤	(CH)
Jar-19	27.0-28.5	ditto ⑤	(CH)
Jar-20	28.5-30.0	ditto ⑤	(CH)

① medium to fine sand
② trace of organic material
③ trace of cinders
④ coarse to fine sand
⑤ trace of shell fragments

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-18		Approx 14grams ∇	
Jar-1	0.0-1.5	Mixture of Grass, Sand, (2) pieces of Gravel	—
Jar-2	1.5-3.0	Moist, Grayish Brown, LEAN CLAY Trace of roots	(CL)
Jar-3	3.0-4.5	(Very Small Sample) Ditto Trace of Roots	(CL)
Jar-4	4.5-6.0	Moist, Black, silty, Med to Coarse SAND *	(SM)
Jar-5	6.0-7.5	Ditto ① Trace of Gravel ②	(SM)
Jar-6	7.5-9.0	(Very Small Sample) Ditto ①	(SM)
Jar-7	9.0-10.5	Wet, Ditto ① Trace of Gravel ②	(SM)
Jar-8	10.5-12.0	Moist, Ditto ① Trace of Gravel ②	(SM)
Jar-9	12.0-13.5	Moist, Dark Gray, FAT CLAY Tr. of Sand + Decaying Matl	(CH)
Jar-10	13.5-15.0	Moist, Dark Gray, SOFT FAT CLAY Trace of Shells	(CH)
Jar-11	15.0-16.5	Ditto " " "	(CH)
Jar-12	16.5-18.0	Ditto " " "	(CH)
Jar-13	18.0-19.5	Ditto " " "	(CH)
Jar-14	19.5-21.0	Ditto " " "	(CH)
Jar-15	21.0-22.5	Ditto " " "	(CH)
Jar-16	22.5-24.0	Ditto " " "	(CH)
Jar-17	24.0-25.5	Ditto " " "	(CH)
Jar-18	25.5-27.0	Ditto " " "	(CH)
Jar-19	27.0-28.5	Ditto " " "	(CH)
Jar-20	28.5-30.0	Ditto " " "	(CH)

① Sand size particles are Cinders
② Gravel size particles are a Mixture of Cinders and Gravel

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-17			
Jar-1	0.0-1.5	Moist, Black, silty, SAND ① Trace of Gravel ②, Grass, Glass, Cinders	(SM)
Jar-2	1.5-3.0	Moist, Black, silty, SAND ① Trace of Gravel ② and Coal	(SM)
Jar-3	3.0-4.5	V. Moist, Very Dark Gray, silty, SAND ① with Gravel ③	(SM)
Jar-4	4.5-6.0	Wet, V. Dark Gray, silty, SAND ① with Gravel ② Tr. Glass	(SM)
Small Sample Jar-5	6.0-7.5	Moist, Dark Brown, silty SAND	(SM)
V. small Sample Jar-6	7.5-9.0*	Mixture of Brick Fragments, Silty SAND ①, Cinders	—
Jar-7	9.0-10.5	V. Moist, Very Dk Gray, Clayey, SAND ① Tr. of Gravel ②	(SC)
Jar-8	10.5-12.0	Wet, Black, silty, SAND ① Tr. of Gravel ②, Glass	SM/SC
Jar-9	12.0-13.5	Wet, Black, silty, SAND ① Trace of Gravel ②, Glass, Wood	(SM)
Jar-10	13.5-15.0	Ditto w/Gravel ②, Glass, Decaying Matrl, Shell Frags. Glass	(SM)
Jar-11	15.0-16.5	Ditto w/Gravel ②, Glass, Wood, Shell Frags	(SM)
Small Sample Jar-12	16.5-18.0	Ditto " " " " "	(SM)
Jar-13	18.0-19.5	Ditto " " " " "	(SM)
Jar-14	19.5-21.0	V. Moist, V. Dk. Gray, SOFT FAT CLAY Tr. of Sand ①, Gravel ②, Wood, Leather, Brick Frags	(CH)
Jar-15	21.0-22.5	Ditto Trace of Sand ①, Brick Frags, Shell Frags + Piece of Leather	(CH)
Jar-16	22.5-24.0	V. Moist, V. Dk. Gray, SOFT, FAT CLAY Trace of Organics	(CH)
Jar-17	24.0-25.5	Ditto	(CH)
Jar-18	25.5-27.0	Ditto	(CH)
Jar-19	27.0-28.5	V. Moist, V. Dk. Gray, SOFT FAT CLAY Tr. of Shell Frags + SAND	(CH)
Jar-20	28.5-30.0	Ditto Trace of Shell Frags	(CH)
		① Sand size particles are a mixture of Sand, Cinders and Coal	
		② Gravel size particles are a mixture of Gravel, Cinders and coal	
		③ Gravel = 3/4" diameter pieces of Cemented Sand Grains.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-16			
Jar-1	0.0-1.5	Moist black poorly graded coarse sand ① w/ silt (grass & roots)	(SP-SM)
Jar-2	1.5-3.0	Wet black poorly graded coarse sand ① w/ silt	(SP-SM)
Jar-3	3.0-4.5	- ditto - w/ silt & grav	(SP-SM)
Jar-4	4.5-6.0	Wet black silty coarse sand w/ gravel	(SM)
v. small sample Jar-5	6.0-7.5	Wet v. dk grayish brn silty med sand (Tr. grav)	(SM)
small sample Jar-6	7.5-9.0	- ditto -	(SM)
v. small sample Jar-7	9.0-10.5	Wet v. dk brn silty coarse sand (Tr wood pieces)	(SM)
Jar-8	10.5-12.0	- ditto - w/ pieces of wood	(SM)
v. small sample Jar-9	12.0-13.5	- ditto - w/ "	(SM)
Jar-10	13.5-15.0	EMPTY JAR	—
v. small sample Jar-11	15.0-16.5	Wet black silty fine sand	(SM)
Jar-12	16.5-18.0	Wet dk greenish gray soft fat clay (Tr. sd)	(CH)
Jar-13	18.0-19.5	V. moist - ditto -	(CH)
Jar-14	19.5-21.0	Wet v. dk gray soft fat clay	(CH)
Jar-15	21.0-22.5	Wet dk gray clayey fine to med sand	(SC)
Jar-16	22.5-24.0	Wet v. dk gray poorly graded coarse sand w/ silt	(SP-SM)
Jar-17	24.0-25.5	ditto - (med)	(SP-SM)
Jar-18	25.5-27.0	Wet brown poorly graded med sand w/ silt	(SP-SM)
Jar-19	27.0-28.5	Wet brown silty med sand w/ gravel	(SM)
v. small sample Jar-20	28.5-30.0	Wet brown silty fine sand	(SM)
		① SAND IS MOSTLY CINDERS	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-15			
Jar-1	0.0-1.5	Moist dk brn silty fine sand w/ roots + grass	(SM)
Jar-2	1.5-3.0	Moist black poorly graded grav w/ silt + sand	(GP-GM)
Jar-3	3.0-4.5	V. moist black + rd. brn silty coarse sand	(SM)
Jar-4	4.5-6.0	Wet black silty med-coarse sand w/ gravel	(SM)
Jar-5	6.0-7.5	Wet v. dk gray -ditto-	(SM)
Jar-6	7.5-9.0	-ditto-	(SM)
Jar-7	9.0-10.5	-ditto-	(SM)
Jar-8	10.5-12.0	-ditto-	(SM)
Jar-9	12.0-13.5	Wet v. dk gray silty med sand	(SM)
Jar-10	13.5-15.0	Wet v. dk gray silty fine sand	(SM)
Jar-11	15.0-16.5	Wet dk gray -ditto-	(S.
Jar-12	16.5-18.0	-ditto-	(SM)
Jar-13	18.0-19.5	-ditto-	(SM)
Jar-14	19.5-21.0	-ditto-	(SM)
Jar-15	21.0-22.5	Wet olive gray silty v. fine sand	(SM)
Jar-16	22.5-24.0	-ditto-	(SM)
Jar-17	24.0-25.5	Wet brown silty med sand	(SM)
Jar-18	25.5-27.0	Wet brown silty v. fine sand	(SM)
Jar-19	27.0-28.5	Wet brown silty v. fine-med sand	(SM)
Jar-20	28.5-30.0	Wet brown soft lean clay	CL/ML

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-14			
Jar-1	0.0-1.5	Moist, Black, Silty, Med + Coarse SAND Tr. of Gravel Cinders Glass	(SM)
Jar-2	1.5-3.0	Moist, Black, Silty, Med-Coarse SAND ① w/Gravel ② Tr. Glass	(SM)
Jar-3	3.0-4.5	Ditto ① ② " " Tr. Glass + Wood	(SM)
Jar-4	4.5-6.0	V. Moist, Black, clayey, SAND ① with Gravel ② & Glass	(SC)
Small Sample Jar-5	6.0-7.5	Wet, Black, Clayey, SAND ① with Gravel ② Tr. Glass	(SC)
Jar-6	7.5-9.0	V. Moist, DK. Gray, Silty, SAND	SM/SC
V. Small Sample Jar-7	9.0-10.5	18 grams of Moist, DK Gray, Silty, SAND	(SM)
Jar-8	10.5-12.0	Wet, V. DK Gray, Clayey, SAND with Gravel & Glass	SC/SM
Jar-9	12.0-13.5	Ditto with Gravel Tr. of Glass	(SC)
Small Sample Jar-10	13.5-15.0	Moist, Grayish Brown, silty, fine SAND	(SM)
Jar-11	15.0-16.5	Wet, Ditto	(SM)
Jar-12	16.5-18.0	Wet, Brown, Silty, Med-Coarse SAND	(SM)
Jar-13	18.0-19.5	Moist, Brown, Poorly Graded SAND	(SP-SM)
Jar-14	19.5-21.0	Moist, Brown, Silty, SAND With Gravel	(SM)
Jar-15	21.0-22.5	Ditto " "	(SM)
Jar-16	22.5-24.0	Ditto " "	(SM)
Jar-17	24.0-25.5	Ditto Tr. Gravel	(SM)
Small Sample Jar-18	25.5-27.0	Ditto No Gravel	(SM)
Jar-19	27.0-28.5	Mixture of (4) rock Frags + Sand	—
		① Sand size particles are Cinders.	
		② Gravel size particles are Cinders.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANK's

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-13			
Jar-1	0.0-1.5	Moist, Very Dark Gray, Silty, SAND Trace of Gravel, Roots Grass	(SM)
Jar-2	1.5-3.0	NO SAMPLE	—
Jar-3	3.0-4.5	Moist, Very Dark Gray, Silty, SAND w/Gravel, Tr. of Cinders or Wood	(SM)
Jar-4	4.5-6.0	Moist, Brown, Clayey, Fine SAND Tr. of Gravel	SC/SM
Jar-5	6.0-7.5	Moist, Grayish Brown, Silty, Fine SAND	(SM)
very Very Small Jar-6	7.5-9.0 *	Moist, Brown, Silty, Fine SAND	(SM)
very, very small Jar-7	9.0-10.5 *	Moist, Brown, Silty, FINE SAND w/(1) Large Rock Frag	(SM)
Jar-8	10.5-12.0	20grams of Silty, Sand and gravel Frags	—
Small Sample Jar-9	12.0-13.5	Very Moist, Brown, clayey, SAND with Gravel	SC/GC
very Small Jar-10	13.5-15.0	Ditto	SC/GC
Jar-11	15.0-16.5	V. Moist, Brown, clayey, SAND with Gravel	(SC)
Small Sample Jar-12	16.5-18.0	V. Moist, Brown, Silty, SAND	(SM)
Jar-13	18.0-19.5	V. Moist, Brown, Silty, SAND with Gravel	(SM)
Jar-14	19.5-21.0	Wet, Brown, silty, SAND with Gravel	(SM)
Jar-15	21.0-21.3	Ditto	(SM)
		* NOTE: Jar 6 - 8 don't Contain a representative Sample to test.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-12		Approx. 50grams	
Jar-1	0.0-1.5	Mixture of Grass, 4 pieces of Gravel, Sand + Clay	—
Jar-2	1.5-3.0	Moist, Dk. Gray, LEAN CLAY Trace of Roots + Sand	(CL)
Jar-3	3.0-4.5	Moist, Brown, Silty, SAND Trace of Gravel	(SM)
Jar-4	4.5-6.0	Moist, Grayish Brown, Silty SAND Trace of Brick Frags	(SM)
Jar-5	6.0-7.5	V. Moist, Dk. Gray, Clayey, SAND Trace of Gravel cinders	(SC)
Jar-6	7.5-9.0	Moist, Very, Dk. Gray, Sandy, SOFT FAT CLAY Tr. Grav	(CH)
Jar-7	9.0-10.5	Moist, V. Dk. Gray, SOFT FAT CLAY Tr. Sand	(CH)
Jar-8	10.5-12.0	Ditto Trace of Sand + Shells	(CH)
Jar-9	12.0-13.5	Ditto " " "	(CH)
Jar-10	13.5-15.0	V. Moist, V. Dk Gray, Clayey, SAND Tr. Brick Frags	(SC)
Jar-11	15.0-16.5	V. Moist, V. Dk Gray, Clayey, SAND Tr. of Gravel	(SC)
Jar-12	16.5-18.0	V. Moist, Black + Brown, Clayey, SAND	(SC)
Jar-13	18.0-19.5	Moist, Dk. Gray, Sandy, SOFT FAT CLAY	(CH)
Jar-14	19.5-21.0	Moist, Dark Gray, SOFT FAT CLAY	(CH)
Jar-15	21.0-22.5	Ditto Trace of Shells	(CH)
Jar-16	22.5-24.0	Ditto	(CH)
Jar-17	24.0-25.5	Ditto	(CH)
Jar-18	25.5-27.0	Ditto	(CH)
Jar-19	27.0-28.5	Ditto	(CH)
Jar-20	28.5-30.0	Ditto	(CH)

STA.	Liberty State Park	N 681938.08	**CA-04-04**
OFFSET:	New Jersey	E 617114.38	**2 of 2**
TOP ELEV: 9.2		COMPLETED: February 5, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, dk. gray & black, soft fat CLAY wtrace of shells (CH) [petroleum odor] *(continued from previous page)*		WH/1.5	
21.00	V. moist, black, soft fat CLAY w/trace of shells (CH)		WH/1.5	
22.50	V. moist, v. dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
		25	WH/1.5	
			WH/1.5	
			WH/1.5	
			WH/1.5	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.
OFFSET:
TOP ELEV: 9.2

Liberty State Park
New Jersey

N 681938.08
E 617114.38
COMPLETED: February 5, 2004

CA-04-04
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, v. dk. grayish brown, sandy lean CLAY w/roots, cinders & concrete frags. (CL)		6-9-3	
3.00	Moist, v. dk. grayish brown, clayey SAND w/gravel & cinders (SC)		2-2-3	
4.50	75 grams of concrete frags, pieces of wood & sand		WH/1.0-5	
7.50	Wet, v. dk. gray & black, silty SAND w/gravel, cinders & organic material (SM)		3-4-4 4-4-5	5
9.00	Wet, dk. grayish brown, poorly graded SAND w/silt & trace of gravel (SP-SM)		3-5-7	
10.50	Wet, dk. grayish brown, silty SAND w/gravel & shells (SW-SM)		2-2-5	10
12.00	Moist, dk. grayish brown, silty SAND w/gravel & cinders (SM)		3-2-2	
13.50	Wet, v. dk. gray, poorly graded, med. SAND w/silt (SP-SM)		4-4-3	
15.50	EMPTY JAR		WH/1.5	15
16.50	V. moist, dk. gray & black, soft fat CLAY (MH)		WH/1.5	
18.00	V. moist, dk. gray & black, soft fat CLAY w/trace of shells (CH)		WH/1.5	
19.50	V. moist, dk. gray & black, soft fat CLAY CH) [petroleum odor]		WH/1.5	

CA-04-04
GROUNDWATER DATA
WHILE DRILLING: 7.1
ON COMPLETION: 28.3
24 Hr. READING: 7.6

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682461.27	**CA-04-03**
OFFSET:	New Jersey	E 617438.02	**2 of 2**
TOP ELEV: 10.0		COMPLETED: February 7, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, v. dk. gray, soft fat CLAY w/trace of shells (CH) *(continued from previous page)*		WH/1.5	
			WH/1.5	
			WH/1.5	
		25	WH/1.5	
			WH/1.5	
		▼	WH/1.5	
			WH/1.5	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682461.27	**CA-04-03**
OFFSET:	New Jersey	E 617438.02	**1 of 2**
TOP ELEV: 10.0		COMPLETED: February 7, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, v. dk. grayish brown, silty med. SAND w/trace of roots (SM)		3-1-2	
1.50	Moist, v. dk. grayish brown, sandy SILT w/twigs & roots (ML)		3-2-2	
3.00	V. moist, black, soft lean CLAY w/sand & trace of roots (CL) [petroleum odor]		3-3-5	
4.50	Wet, black, poorly graded coarse SAND (SW-SM) [SAND IS CINDERS]	5	2-4-5	
			3-6-4	
7.50	Wet, black, poorly graded coarse SAND w/gravel (SP) [SAND & GRAVEL ARE CINDERS]		2-3-7	
9.00	Wet, black, poorly raded coarse SAND w/silt (SP-SM) [SAND IS CINDERS]	10	1-2-2	
			2-2-2	
			4-4-5	
13.50	EMPTY JAR		3-4-5	
15.00	Wet, black, poorly graded, med. SAND w/silt (SP-SM)	15	5-2-2	
			2-1-2	
18.00	V. moist, black & dk. gray, soft lean CLAY w/trace of shell frags. (CL)		WH/1.5	
19.50	V. moist, v. dk. gray, soft fat CLAY w/trace of shells (CH)			

CA-04-03
GROUNDWATER DATA
WHILE DRILLING: 6.2
ON COMPLETION: 27.2
24 Hr. READING: 5.2

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682731.06	**CA-04-02**
OFFSET:	New Jersey	E 617641.69	**2 of 2**
TOP ELEV: 8.8		COMPLETED: February 7, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. gray, soft fat CLAY w/trace of shells (CH) *(continued from previous page)*		WH/1.5	
			WH/1.5	
			WH/1.5	
		25	WH/1.5	
			WH/1.5	
			WH/1.5	
30.00			WH/1.5	
	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09.14

STA.
OFFSET:
TOP ELEV: 8.8

Liberty State Park
New Jersey

N 682731.06
E 617641.69
COMPLETED: February 7, 2004

CA-04-02
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, sandy lean CLAY w/coal frags. & roots (ML)		3-2-1	
1.50	Moist, dk. gray, lean CLAY w/trace of fine sand (CL)		3-3-3	
3.00	Wet, black, silty SAND w/coal & cinders (SM)		WH-9-10	
		5	5-4-7	
6.00	Wet, lt. gray to black, silty SAND w/coal & cinders (SM)		4-10-16	
7.50	Wet, v. dk. gray, silty SAND w/gravel, coal frags. & cinders (SM)		7-7-6	
		10	3-3-1	
10.50	Moist, dk. gray, clayey SAND w/cinders & coal frags. (SC)		4-1-2	
12.00	Moist, v. dk. gray, fat CLAY w/trace of sand (CH)		WH/1.5	
13.50	EMPTY JAR		WH/1.5	
15.00	Moist, dk. grayish brown & black, fat CLAY (MH)	15	WH/1.5	
16.50	Moist, v. dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
			WH/1.5	

CA-04-02
GROUNDWATER DATA
▽ WHILE DRILLING: 4.0
▼ ON COMPLETION: 10.2
▼ 24 Hr. READING: 4.7

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:14

STA. Liberty State Park N 682986.23 **CA-04-01**
OFFSET: New Jersey E 617851.94 **2 of 2**
TOP ELEV: 9.2 COMPLETED: February 7, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH) *(continued from previous page)*		WH/1.5	
			WH/1.5	
			WH/1.5	
24.00	V. moist, dk. gray, soft fat CLAY (CH)	25	WH/1.5	
25.50	V. moist, dk. gray, soft fat CLAY (CH)		WH/1.5	
			WH/1.5	
			WH/1.5	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:14

LIBERTY STATE PARK
JERSEY CITY, NEW JERSEY

SUBSURFACE EXPLORATION NOTES

1. EXPLORATION WAS PERFORMED DURING AUG. & SEPT. 2003 AND FEB. 2004.

2. DRILL HOLES (DH) WERE ACCOMPLISHED BY STANDARD PENETRATION TEST PROCEDURE (SPT, ASTM - 1586) USING A 1-3/8"ID SPLIT SPOON SAMPLER. SAMPLE SPOONS WERE ADVANCED BY A 140# HAMMER FALLING 30". THESE HOLES WERE POWER AUGERED BETWEEN SAMPLES UNLESS OTHERWISE INDICATED. BLOW COUNTS SHOWN ARE FOR 0.5' OF DRIVE, UNLESS OTHERWISE INDICATED.

   BORINGS NC-04-01 & NC-04-02 WERE DRILLED BY AN ACKER TRIPOD. RIG MOUNTED ON A BARGE IN THE NORTH COVE.

   WH - DENOTES WEIGHT OF HAMMER
   WR - DENOTES WEIGHT OF ROD

3. BLOW COUNTS REQUIRED TO ADVANCE SAMPLE SPOON ARE SHOWN IN COLUMN (a).

4. COLUMN (b) SHOWS THE NATURAL WATER CONTENTS IN PERCENT OF DRY WEIGHT OF THOSE SAMPLES TESTED.

5. SOIL DESCRIPTIONS ARE SHOWN IN COLUMN (c).

6. SOIL DESCRIPTIONS ARE LABORATORY CLASSIFICATIONS BASED ON THE UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487/2488), EXCEPT THOSE INDICATED THUS (**), WHICH ARE FIELD INSPECTOR'S CLASSIFICATIONS.

7. GROUNDWATER DEPTHS ARE INDICATED ON THE LOGS AS ▽, ▼ & ▼ ARE SHOWN IN COLUMN (d). PERTINENT DATA FOR THESE READINGS ARE SHOWN AT THE BOTTOM OF LOG UNDER GROUNDWATER DATA OR ADDITIONAL GROUNDWATER DATA. THESE READINGS MAY VARY DEPENDING UPON SEASONS AND AMOUNT OF RAINFALL.

   NE - INDICATES GROUNDWATER NOT ENCOUNTERED
   NT - INDICATES GROUNDWATER READING NOT TAKEN

8. FOR DRILL HOLES NC-04-01 & NC-04-02, DEPTH OF HARBOR SHOWN ON EACH BORING LOG WAS DETERMINED BY SOUNDING WITH WEIGHTED TAPE MEASURE TO TOP OF SEDIMENT PRIOR TO SAMPLING. NO GROUNDWATER READINGS WERE TAKEN IN NC-04-01 & NC-04-02 SINCE EXPLORATION WAS LOCATED IN THE NORTH COVE. START OF BORING (0.0), REPRESENTS THE BOTTOM OF NORTH COVE.

9. ELEVATIONS SHOWN ON THE BORING LOGS ARE GROUND SURFACE ELEVATIONS AT THE TIME OF EXPLORATION. THEY WERE DETERMINED BY SURVEY. VERTICAL DATUM: NAVD 88. HORIZONTAL DATUM: NORTH AMERICAN 1983 DATUM, NEW JERSEY STATE PLANE COORDINATE SYSTEM.

10. FOR LOCATIONS OF SUBSURFACE EXPLORATIONS, SEE BORING LOCATION PLAN.

STA.	Liberty State Park	N 682836.04	**LSP-03-40**
OFFSET:	New Jersey	E 616405.06	**2 of 2**
TOP ELEV: 6.2		COMPLETED: September 6, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, v. dk. gray, poorly graded med. SAND w/silt (SP-SM) 19.5'-21.0' med - coarse SAND *(continued from previous page)*		1-2-2	
			WH-1-2	
22.50	V. moist, brown, poorly graded med. SAND (SP)		3-1-2	
24.00	Wet, dk. gray, silty med. SAND (SM)		4-3-2	
25.50	Wet, dk. gray, poorly graded med. SAND w/silt (SP-SM)	25	3-3-1	
			wh-1-2	
28.50	Wet, brown, poorly graded med. SAND w/silt (SP-SM)		2-4-3	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682836.04	**LSP-03-40**
OFFSET:	New Jersey	E 616405.06	**1 of 2**
TOP ELEV: 6.2		COMPLETED: September 6, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, black, poorly graded coarse SAND w/silt (SP-SM) [SAND IS MOSTLY CINDERS]		1-1-3	
1.50	Wet, brown, silty med. SAND w/trace of gravel (SM/ML)		3-2-2	
3.00	Wet, black & brown, silty coarse SAND w/pieces of wood (SM)		2-1-2	
4.50	Wet, v. dk. gray, silty coarse SAND w/gravel (SM)	5	1-1-WH	
			1-1-1	
7.50	Wet, v. dk. gray, poorly graded coarse SAND w/silt (SP-SM)		2-1-2	
		10	1-1-1	
			1-1-WH	
			WH-WH-1	
13.50	Wet, v. dk. gray, silty med. SAND w/gravel (SM)		WH-WH-WH	
15.00	Wet, dk. gray, soft sandy lean CLAY (CL)	15	WH-WH-WH	
16.50	Wet, dk. gray, clayey coarse SAND (SC)		WH-2-2	
18.00	Wet, v. dk. gray, poorly graded med. SAND w/silt (SP-SM) 19.5'-21.0' med - coarse SAND		2-2-3	

LSP-03-40
GROUNDWATER DATA
WHILE DRILLING: 4.2
ON COMPLETION: 11.8
24 Hr. READING: 2.8

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 46604 09-16

STA.	Liberty State Park	N 683052.45	**LSP-03-39**
OFFSET:	New Jersey	E 616234.58	**2 of 2**
TOP ELEV: 7.6		COMPLETED: September 6, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, dk. gray, silty fine SAND (SM) 24.0'-25.5' - w/trace of gravel *(continued from previous page)*		WH-2-1 WH-1-1 1-1-2 1-4-5 1-5-10 3-7-7	
28.50	Wet, brown, poorly graded med. SAND w/silt (SP-SM)		5-10-12	
30.00	BOTTOM OF HOLE			

25 — 30 — 35 — 40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.
OFFSET:
TOP ELEV: 7.6

Liberty State Park
New Jersey

N 683052.45
E 616234.58
COMPLETED: September 6, 2003

LSP-03-39
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. brown, silty med. SAND w/grass & roots (SM)		1-6-8	
1.50	Moist, weak red & black, silty coarse SAND (SM)		8-6-9	
3.00	V. moist, reddish brown, silty GRAVEL w/sand (GM)		3-2-5	
4.50	Wet, black, silty coarse SAND w/trace of sticks (SM) 6.0'-7.5' - w/gravel		1-1-1	
		5	1-WH-1	
			WR-1-3	
		10	1-1-1	
10.50	Wet, dk. gray, silty coarse SAND w/glass & other debris (SM)		WR-1-WH	
12.00	Wet, dk. gray, silty med. SAND w/trace of gravel (SM)		WH-WH-1	
13.50	Wet, dk. gray, silty fine - med. SAND (SM)		WH-WH-WH	
15.00	Wet, dk. gray, silty coarse SAND (SM)	15	WH-WH-WH	
			WH-WH-WH	
18.00	Wet, dk. greenish gray, soft fat CLAY (CH)		WH-WH-WH	
19.50				

LSP-03-39
GROUNDWATER DATA
WHILE DRILLING: 4.8
ON COMPLETION: 11.1
24 Hr. READING: 4.5

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet, _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 680654.68	**LSP-03-38**
OFFSET:	New Jersey	E 615601.34	**2 of 2**
TOP ELEV: 9.4		COMPLETED: August 9, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, black, soft fat CLAY (CH) *(continued from previous page)*		WH-WH-WH	
21.00	V. moist, dk. gray, soft fat CLAY (CH)		WH-WH-WH	
			WH-WH-WH	
		25	WH-WH-WH	
			WH-1-2	
			WH-1-1	
28.50	Wet, dk. gray, clayey fine SAND (SC)		1-1-2	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA. | Liberty State Park | N 680654.68 | **LSP-03-38**
OFFSET: | New Jersey | E 615601.34 | **1 of 2**
TOP ELEV: 9.4 | COMPLETED: August 9, 2003

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, black, silty fine - med SAND w/roots, grass, sticks & gravel (SM)		1-1-100/.4	
1.50	Moist, black & reddish brown, silty coarse SAND w/sticks & roots (SM)		2-2-7	
3.00	V. moist, black, silty coarse SAND (SM)		4-4-7	
4.50	V. moist, black & strong brown, silty coarse SAND w/wood & decayed organics (SM)	▽	2-2-4	
6.00	Wet, dk. grayish brown, silty med - coarse SAND (SM)		7-8-6	
7.50	Wet, dk. gray, silty fine SAND (SM) 7.5'-10.5' - w/shell frags. 10.5'-13.5' - w/shell frags. & clay lens		2-2-3	
		▼	WH-1-1	
			3-WH-WH	
			WH-WH-WH	
13.50	V. moist, dk. gray, soft SILT (ML) 15.0'-16.5' - w/sand		1-1-1	
			WH-WH-WH	
16.50	V. moist, dk. gray, sandy SILT (ML)		WH-1-1	
18.00	V. moist, dk. gray, soft lean CLAY (CL)		WH-WH-WH	
19.50	V. moist, black, soft fat CLAY (CH)			

5 — 10 — 15

LSP-03-38
GROUNDWATER DATA
▽ WHILE DRILLING: 5.4
▼ ON COMPLETION: 30.0
▼ 24 Hr. READING: 9.6

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.	Liberty State Park	N 680938.01	**LSP-03-37**
OFFSET:	New Jersey	E 614681.62	**2 of 2**
TOP ELEV: 10.9		COMPLETED: August 27, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, greenish black, soft fat CLAY (CH) *(continued from previous page)*		WH-2-5	
21.00				
	EMPTY JAR			
22.50				
	V. moist, greenish black, soft fat CLAY w/trace of shells (CH)		2-2-2	
		25	4-2-3	
			2-1-2	
			4-3-5	
28.50				
	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH)		2-2-2	
30.00		30		
	BOTTOM OF HOLE			
		35		
		40		

STA.
OFFSET:
TOP ELEV: 10.9

Liberty State Park
New Jersey

N 680938.01
E 614681.62
COMPLETED: August 27, 2003

LSP-03-37
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty med. SAND w/gravel & pieces of wood (SM)		3-16-14	
			21-8-8	
3.00	Wet, brown, poorly graded med. SAND w/silt (SP-SM)		5-7-9	
			3-3-4	
6.00	Wet, brown, silty fine SAND (SM)		7-5-7	
7.50	Wet, dk. grayish brown, poorly graded med. SAND w/silt (SP-SM)		7-9-12	
			7-11-10	
			9-5-5	
12.00	Wet, black, soft fat CLAY w/silt lens (CH)		2-2-3	
13.50	Wet, greenish black, soft fat CLAY (CH)		WH-WH-2	
			WH-WH-2	
			WR-WR-WR	
			2-1-1	

5
10
15

LSP-03-37
GROUNDWATER DATA
WHILE DRILLING: 6.0
ON COMPLETION: 9.6
24 Hr. READING: 6.6

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.	Liberty State Park	N 681220.84	**LSP-03-36**
OFFSET:	New Jersey	E 614399.83	**2 of 2**
TOP ELEV: 11.9		COMPLETED: August 14, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, soft fat CLAY (CH) 16.5'-18.0' - w/trace of sand & shells 18.0'-19.5' - w/trace of shells 22.5'-24.0' - w/trace of shells & organic material *(continued from previous page)*		WH-WH-WH WH-1-1 WH-1-1	
24.00	Moist, black, SILT (ML/OL) [SAMPLE IS MOSTLY ORGANIC MATERIAL]		WH-2-2	
25.50	Moist, dk. gray & black, sandy fat CLAY w/organic material (CH)		WH-2-2	
27.00	Moist, dk. grayish brown, clayey SAND w/gravel (SC)		5-9-9	
28.50	Moist, brown, sandy CLAY w/trace of gravel (CL/SC)		6-7-9	
30.00	BOTTOM OF HOLE			

25 30 35 40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 681220.84	**LSP-03-36**
OFFSET:	New Jersey	E 614399.83	**1 of 2**
TOP ELEV: 11.9		COMPLETED: August 14, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, brown, clayey SAND w/trace of gravel (SC/SM)		5-9-9	
1.50	Moist, dk. brown, silty SAND w/trace of gravel (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		8-6-5	
			5-5-5	
4.50	Moist, black, silty SAND w/trace of gravel (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]	5	10-3-4	
6.90			7-5-4	
7.50	Moist, grayish brown, silty fine SAND (SM/SC)			
	Wet, black, silty SAND (SM) 7.5'-9.0' - w/gravel [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		5-3-2	
		10	23-8-4	
12.00			5-6-7	
	Moist, dk. gray, soft fat CLAY (CH)		1-1-1	
14.25			1-1-1	
15.00	Moist, dk. gray, silty SAND w/trace of shells (SM)			
15.90	Moist, dk. gray, clayey SAND w/trace of shells (SC)	15	WH-WH-WH	
	Moist, dk. gray, soft fat CLAY (CH) 16.5'-18.0' - w/trace of sand & shells 18.0'-19.5' - w/trace of shells 22.5'-24.0' - w/trace of shells & organic material		WH-WH-WH	
			WH-WH-WH	

LSP-03-36
GROUNDWATER DATA
▽ WHILE DRILLING: 9.0
▼ ON COMPLETION: 21.7
▼ 24 Hr. READING: 9.6

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 681672.49	**LSP-03-35**
OFFSET:	New Jersey	E 613786.85	**2 of 2**
TOP ELEV: 12.5		COMPLETED: August 10, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, brown, silty SAND w/trace of gravel (SM) *(continued from previous page)*		8-8-10	
21.00	V. moist, brown, silty fine SAND w/trace of sand (SM)		6-10-11	
			8-9-9	
24.00	V. moist, brown, fine sandy lean CLAY w/trace of gravel (CL)	25	WH-4-9	
			5-5-10	
			2-30-20	
28.50	Moist, brown, silty SAND w/trace of gravel (SM)		8-3-8	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 681672.49	**LSP-03-35**
OFFSET:	New Jersey	E 613786.85	**1 of 2**
TOP ELEV: 12.5		COMPLETED: August 10, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. brown, silty SAND (SM) 0.0'-3.0' - w/trace of gravel 3.0'-4.5' - w/cinders, glass & roots		9-7-8 4-7-6 4-3-3	
4.50	Moist to wet, black, silty SAND w/gravel (SM) 6.0'-9.0' - w/concrete frags. [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]	5 10	5-6-10 9-8-24 16-24-24 4-4-5	
10.50	Wet, dk. gray to v. dk. gray, poortly graded SAND w/silt & gravel (SP-SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]	15	8-7-6 5-4-4 4-5-4 6-5-6 4-7-7	
18.00	V. moist, v. dk. gray & brown, silty SAND w/trace of gravel & shells (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL]		5-1-3	
19.50	Wet, brown, silty SAND w/trace of gravel (SM)			

LSP-03-35
GROUNDWATER DATA
WHILE DRILLING: 9.7
ON COMPLETION: 12.6
24 Hr. READING: 10.1

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.	Liberty State Park	N 680785.99	**LSP-03-34**
OFFSET:	New Jersey	E 614318.55	**2 of 2**
TOP ELEV: 13.2		COMPLETED: August 14, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, yellowish brown & gray, clayey SAND w/trace of shells (SC) *(continued from previous page)*		1-1-3	
		▼	1-7-10	
22.50	Moist, brown, clayey SAND (SC) 24.0'-25.5' - w/trace of gravel 25.5'-30.0' - w/gravel		5-4-3	
		25	3-1-6	
			9-11-15	
			27-19-24	
			21-22-22	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.	Liberty State Park	N 680785.99	**LSP-03-34**
OFFSET:	New Jersey	E 614318.55	**1 of 2**
TOP ELEV: 13.2		COMPLETED: August 14, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. brown, silty SAND w/gravel (SM) 0.0'-1.5' - w/trace of clay & roots 1.5'-3.0' - w/trace of clay 4.5'-6.0' - w/trace of clay		5-10-11 8-8-7 5-6-5 4-2-2	
6.00				
	Moist, black & brown, silty SAND w/gravel, pieces of wood, roots & cinders (SM)		5-5-8	
7.50				
	Moist, v. dk. brown, silty SAND w/trace of cinders, roots & gravel (SM)		5-11-8	
9.00				
	Moist to wet, black, silty SAND w/gravel (SM) 9.0'-10.5' - Wet 10.5'-12.0' - Moist SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		5-5-5 5-11-15	
12.00				
	Moist, dk. gray, soft fat CLAY w/trace of sand (CH) 18.0'-19.5' - w/trace of sand & shells [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL]		3-2-1 WH-WH-1 WH-WH-WH WH-WH-2 WH-WH-2	
19.50				
	Moist, yellowish brown & gray, clayey SAND w/trace of shells (SC)			

5 10 15

LSP-03-34
GROUNDWATER DATA
▽ WHILE DRILLING: 7.5
▼ ON COMPLETION: 22.0
▼ 24 Hr. READING: 7.6

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 46/04.09.16

STA.	Liberty State Park	N 680802.27	**LSP-03-33**
OFFSET:	New Jersey	E 615968.93	**2 of 2**
TOP ELEV: 6.7		COMPLETED: August 19, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist to v. moist, dk. gray, soft fat CLAY (CH) 10.5'-13.5' - Moist, w/fine sand 15.0'-16.5' - Moist, w/trace of shells 19.5'-25.5' - Moist, w/trace of shells 25.5'-27.0' - V. moist, w/fine sand *(continued from previous page)*	▼	WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH	
25.50	V. moist, dk. gray, soft fat CLAY w/fine sand (CH)		WH-WH-WH	
27.00	V. moist, v. dk. gray, clayey SAND (SC) 28.5'-30.0' - w/pieces of wood		WH-WH-1 WH-WH-3	
30.00	BOTTOM OF HOLE			

25 30 35 40

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.
OFFSET:
TOP ELEV: 6.7

Liberty State Park
New Jersey

N 680802.27
E 615968.93
COMPLETED: August 19, 2003

LSP-03-33
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, dk. brown, poorly graded SAND w/silt & gravel (SP-SM) 0.0'-1.5' - w/trace of roots		2-2-3 1-5-3 4-2-2	
4.50	Wet, dk. brown, silty SAND w/gravel (SM)	5	WH-1-1	
6.00	V. moist, gray & brown, silty SAND w/trace of shells (SM)		1-WH-WH	
7.50	V. moist, dk. gray, sandy fat CLAY (CH)		1-1-1 WH-WH-WH	
10.50	Moist to v. moist, dk. gray, soft fat CLAY (CH) 10.5'-13.5' - Moist, w/fine sand 15.0'-16.5' - Moist, w/trace of shells 19.5'-25.5' - Moist, w/trace of shells 25.5'-27.0' - V. moist, w/fine sand	10 15	WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH WH-WH-WH	

LSP-03-33
GROUNDWATER DATA
WHILE DRILLING: 5.0
ON COMPLETION: 23.3
24 Hr. READING: 3.1

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 680562.34	**LSP-03-32**
OFFSET:	New Jersey	E 614827.68	**2 of 2**
TOP ELEV: 8.2		COMPLETED: August 20, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
21.00	Moist, dk. gray, fat CLAY w/trace of shell frags. (CH) *(continued from previous page)*		WH-WH-WH	
22.50	Moist, v. dk. gray, elastic SILT w/trace of sand (MH)		WH-WH-WH	
24.00	Moist, dk. gray, sandy lean CLAY w/trace of sand (CL)		WH-WH-1	
25.50	Moist, grayish brown, silty fine SAND w/trace of gravel (SM)	25	8-11-15	
27.00	V. moist, brown, clayey med to fine SAND w/gravel (SC)		11-9-8	
28.50	Wet, brown, silty med to fine SAND w/gravel (SM)		5-6-12	
30.00	Wet, grayish brown, med to fine SAND (SM)		5-6-10	
	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:16

STA.
OFFSET:
TOP ELEV: 8.2

Liberty State Park
New Jersey

N 680562.34
E 614827.68
COMPLETED: August 20, 2003

LSP-03-32
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. gray, silty coarse to fine SAND w/gravel & cinders (SM)		4-6-6	
			6-6-5	
3.00				
	Moist, dk. grayish brown, silty coarse to fine SAND w/gravel & cinders (SM)	▽	6-5-6	
4.50				
	Wet, grayish brown, poorly graded med to fine SAND w/silt (SP-SM)	▼	5-6-7	
6.00				
	Wet, grayish brown, silty med to fine SAND (SM)		3-4-2	
7.50				
	V. moist, dk. grayish brown, sandy lean CLAY w/trace of gravel (CL)		WH-WH-1	
9.00				
	Moist, dk. gray, lean to fat CLAY w/trace of sand (CL)		WH-WH-WH	
10.50				
	V. moist, dk. gray, sandy lean CLAY w/trace of gravel (CL)	▼	WH-WH-WH	
12.00				
	V. moist, dk. gray, fat CLAY w/sand (CH)		WH-WH-WH	
13.50				
	Moist, dk. gray, lean to fat CLAY w/sand (CL/CH)		WH-WH-WH	
15.00				
	Moist, dk. grayish brown, fat CLAY (CH) 15.0'-16.6' - w/trace of sand 16.5'-18.0' - w/trace of shell frags.		WH-WH-WH	
			WH-WH-WH	
			WH-WH-WH	
19.50				
	Moist, dk. gray, fat CLAY w/trace of shell frags. (CH)			

5
10
15

LSP-03-32
GROUNDWATER DATA
▽ WHILE DRILLING: 3.8
▼ ON COMPLETION: 11.1
▼ 24 Hr. READING: 5.6

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:18

STA.	Liberty State Park	N 681126.58	**LSP-03-31**
OFFSET:	New Jersey	E 616796.40	**2 of 2**
TOP ELEV: 7.2		COMPLETED: August 20, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, dk. gray, soft fat CLAY (CH) 12.0-16.5' - w/sand & trace of shells 16.5'-24.0 - w/trace of shells *(continued from previous page)*		WH-1-1	
			WH-WH-WH	
			WH-WH-WH	
		25	WH-WH-WH	
			WH-WH-WH	
			WH-WH-WH	
			WH-WH-WH	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 681126.58	**LSP-03-31**
OFFSET:	New Jersey	E 616796.40	**1 of 2**
TOP ELEV: 7.2		COMPLETED: August 20, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, yellowish brown, silty SAND w/trace of gravel (SM)		12-6-7	
			7-11-11	
3.00	Moist to wet, brown, poorly graded SAND w/silt (SP-SM)		9-6-6	
			3-4-4	
			1-3-4	
			WH-WH-1	
9.00	Wet, grayish brown, poorly graded SAND w/silt & shells (SP-SM)		2-2-1	
10.50	Wet, dk. gray, sandy fat CLAY w/trace of shells (CH)		WH-1-1	
12.00	Wet, dk. gray, soft fat CLAY (CH) 12.0-16.5' - w/sand & trace of shells 16.5'-24.0 - w/trace of shells		1-1-1	
			2-2-2	
			1-2-2	
			WH-WH-WH	
			WH-WH-WH	

5 10 15

LSP-03-31
GROUNDWATER DATA
▽ WHILE DRILLING: 4.2
▼ ON COMPLETION: 18.1
▼ 24 Hr. READING: 3.1

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ AIBDM 09.15

STA.	Liberty State Park	N 681551.77	**LSP-03-30**
OFFSET:	New Jersey	E 616267.23	**2 of 2**
TOP ELEV: 7.6		COMPLETED: August 19, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, dk. gray, soft fat CLAY (CH) 16.5'-18.0' - w/sand *(continued from previous page)*		WH-WH-WH WH-WH-WH WH-WH-WH	
24.00	Wet, dk. gray, silty fine SAND (SM)		WH-WH-WH WH-WH-1 1-3-3 5-3-4	
30.00	BOTTOM OF HOLE			

25 30 35 40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.
OFFSET:
TOP ELEV: 7.6

Liberty State Park
New Jersey

N 681551.77
E 616267.23
COMPLETED: August 19, 2003

LSP-03-30
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. grayish brown, silty med. SAND w/grass & roots (SM)		4-1-4	
1.50	V. moist to wet, dk. yellowish brown, poorly graded med. SAND w/silt (SP-SM)		7-7-7	
			3-4-4	
4.50	Wet, dk. grayish brown, poorly graded med. SAND w/silt (SP-SM)	5	3-2-2	
6.00	Wet, brown, silty med. SAND (SM)		2-2-3	
7.50	Wet, dk. gray, soft lean CLAY (CL/ML)		WH-WH-WH	
9.00	Wet, dk. gray, soft fat CLAY (CH)	10	WH-WH-WH	
11.70			WH-2-2	
12.00	Wet, dk. gray, silty med. SAND (SM)			
	Wet, dk. gray, poorly graded med. SAND w/silt (SP-SM)		1-1-2	
15.00			WH-WH-WH	
	Wet, dk. grayish brown, poorly graded fine SAND w/silt (SP-SM)	15	WH-WH-WH	
16.50	V. moist, dk. gray, soft fat CLAY (CH) 16.5'-18.0' - w/sand		WH-WH-WH	
			WH-WH-WH	

LSP-03-30
GROUNDWATER DATA
WHILE DRILLING: 5.8
ON COMPLETION: 6.3
24 Hr. READING: 3.9

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681837.12	**LSP-03-29**
OFFSET:	New Jersey	E 615662.28	**2 of 2**
TOP ELEV: 7.7		COMPLETED: August 22, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. gray, soft fat CLAY (CH) 16.5'-18.0' - w/trace of sand, brick frags. & shells 18.0'-19.5' - w/brick frags 19.5'-22.5' - w/trace of organic material *(continued from previous page)*		2-1-2 1-2-2	
22.50	Moist, dk. gray, silty SAND (SM) 22.5'-24.0' - w/trace of organic material 27.0'-30.0' - w/trace of organic material		5-5-4 4-6-1	
		25	6-5-5 5-5-8	
30.00	BOTTOM OF HOLE	30	3-8-1	
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.
OFFSET:
TOP ELEV: 7.7

Liberty State Park
New Jersey

N 681837.12
E 615662.28
COMPLETED: August 22, 2003

LSP-03-29
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. grayish brown, poorly graded SAND (SP-SM) 0.0'-4.5' - trace of shells		5-4-5 5-5-4 4-4-4 2-3-2	
6.00	Wet, v. dk. gray, clayey SAND w/trace of shells (SC)		2-3-1	
7.50	Wet, v. dk. gray, sandy fat CLAY w/trace of shells (CH)		2-1-1	
9.00	Wet, v. dk. gray, clayey SAND w/trace of shells (SC)		3-3-5	
10.50	V. moist, v. dk. gray, soft fat CLAY (CH)		4-4-2	
11.63				
12.00	V. moist, v. dk. gray, silty SAND w/trace of shells (SM)			
	V. moist, v. dk. gray, soft fat CLAY w/sand (CH) 13.5-15.0' - w/shells & brick frags.		2-1-1 3-7-7	
15.00	20 grams of clay and 2 pieces of gravel		2-3-3	
16.50	Moist, v. dk. gray, soft fat CLAY (CH) 16.5'-18.0' - w/trace of sand, brick frags. & shells 18.0'-19.5' - w/brick frags 19.5'-22.5' - w/trace of organic material		4-2-2 2-2-2	

5
10
15

LSP-03-29
GROUNDWATER DATA
WHILE DRILLING: 4.5
ON COMPLETION: 12.5
24 Hr. READING: 12.6

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681500.68	**LSP-03-28**
OFFSET:	New Jersey	E 617241.08	**2 of 2**
TOP ELEV: 7.5		COMPLETED: August 26, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, black, soft fat CLAY (CH) *(continued from previous page)*		WH-WH-3	
21.00	V. moist, dk. gray, soft fat CLAY (CH)		WR-WH-2	
			WR-WR-WR	
		25	2-2-2	
			WH-3-2	
			WR-WR-WH	
28.50	EMPTY JAR		WR-WR-WH	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.
OFFSET:
TOP ELEV: 7.5

Liberty State Park
New Jersey

N 681500.68
E 617241.08
COMPLETED: August 26, 2003

LSP-03-28
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, dk. grayish brown, silty fine SAND w/roots & grass (SM)		4-8-6	
3.00	Moist, black, silty med - coarse SAND w/trace of grass (SM)		4-2-2	
4.50	V. moist, black, silty coarse SAND w/gravel (SM) [SAND IS MOSTLY CINDERS]		4-15-20	
6.00	V. moist, v. dk. brown, pooly graded coarse SAND w/silt (SP-SM)		11-15-12	5
9.00	Wet, dk. greenish gray, silty med SAND w/large piece of wood (SM)		5-10-12 6-10-11	
12.00	Wet, dk. gray, silty fine SAND w/clay lens (SM)		4-4-3 5-6-8	10
15.00	Wet, black, silty med to coarse SAND (SM)		7-8-3 4-4-3	
16.50	Wet, black, silty med. SAND w/clay lens (SM)		3-1-1	15
19.50	V. moist, black, soft fat to lean CLAY (CH/CL)		WH-WH-3 1-2-1	
	V. moist, black, soft fat CLAY (CH)			

LSP-03-28
GROUNDWATER DATA
▽ WHILE DRILLING: 6.0
▼ ON COMPLETION: 20.8
▼ 24 Hr. READING: 5.4

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682017.46	**LSP-03-27**
OFFSET:	New Jersey	E 616742.16	**2 of 2**
TOP ELEV: 7.6		COMPLETED: August 25, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, fat CLAY w/trace of sand & shell frags. (CH) *(continued from previous page)*		3-2-2	
21.00	Moist, dk. grayish brown, sandy lean CLAY (CL)		6-7-8	
22.50	Wet, grayish brown, silty med to fine SAND (SM)		3-2-3	
		25	5-2-9	
			2-7-7	
27.00	V. moist, grayish brown, poorly graded med to fine SAND w/silt (SP-SM)		2-4-6	
28.50	Wet, grayish brown, silty fine SAND (SM)		3-4-4	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.
OFFSET:
TOP ELEV: 7.6

Liberty State Park
New Jersey

N 682017.46
E 616742.16
COMPLETED: August 25, 2003

LSP-03-27
1 of 2

DEPTH(ft)	(c)	(a)
1.50	Moist, dk. yellowish brown, silty med to fine SAND w/gravel & trace of roots (SM)	6-6-5
3.00	Moist, black, poorly graded coarse to fine SAND w/cinders, silt & gravel (SP-SM)	11-13-13
4.50	V. moist, grayish brown, silty med to fine SAND w/trace of gravel (SM)	9-9-5
6.00	Wet, brown, silty med to fine SAND (SM)	3-5-10
7.50	V. moist, grayish brown, sandy SILT w/gravel (ML)	3-4-3
10.50	Wet, dk. grayish brown, silty coarse to SAND w/gravel (SM)	6-6-3 5-4-3
12.00	V. moist, dk. grayish brown, sandy lean CLAY w/gravel (CL)	3-3-3
16.50	Moist, dk. grayish brown, fat CLAY (CH) 12.0'-13.5' - w/sand & trace of gravel 13.5'-16.5' - w/trace of sand & shell frags.	1-1-2 21-3-3 3-3-2
	Moist, dk. gray, fat CLAY w/trace of sand & shell frags. (CH)	WH-WH-WH 2-2-1

(d) 5 10 15

(b)

LSP-03-27
GROUNDWATER DATA
WHILE DRILLING: 7.1
ON COMPLETION: 10.4
24 Hr. READING: 4.2

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682185.59	**LSP-03-26**
OFFSET:	New Jersey	E 616344.22	**1 of 1**
TOP ELEV: 6.7		COMPLETED: September 4, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty SAND w/gravel (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		4-7-11	
			9-7-6	
3.00	Wet, black, poorly graded SAND w/silt & gravel (SP-SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		4-4-3	
4.50			3-27-22	
6.00	Moist, dk. gray, soft fat CLAY w/sand & 1 piece of cemented sand (CH)		10-5-1	
7.50	Wet, v. dk. gray, silty SAND w/trace of gravel (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		WH-WH-WH	
	Moist, v. dk. gray, soft fat CLAY (CH) 13.5'-15.0' - trace of glass 15.0'-16.5' - trace of shells 18.0'-19.5' - trace of shells 19.5'-21.0' - trace of decaying material		WH-WH-WH	
			WH-WH-WH	
			WH-WH-1	
			WH-WH-WH	
			WR-WR-WR	
			WR-WR-WR	
			WR-WR-WR	
21.00	V. moist to wet, dk. gray, silty SAND (SM) 22.5'-24.0' - w/trace of gravel		WR-WR-WR	
			1-2-2	
24.00	Moist, brown, poorly graded SAND (SP-SM)		WH-WH-WH	
			5-6-7	
27.00	BOTTOM OF HOLE		5-11-13	

5, 10, 15, 20, 25

LSP-03-26
GROUNDWATER DATA
WHILE DRILLING: 2.6
ON COMPLETION: 4.5
24 Hr. READING: 1.8

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682458.36	**LSP-03-25**
OFFSET:	New Jersey	E 615633.10	**2 of 2**
TOP ELEV: 6.4		COMPLETED: September 3, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Wet, dk. gray, poorly graded SAND w/silt (SP-SM) *(continued from previous page)*		1-1-1	
21.00	Wet, dk. gray, silty SAND (SM)		4-6-7	
22.50	Moist, dk. grayish brown, silty SAND w/gravel & trace of shells (SM)		9-14-14	
		25	8-15-17	
25.50	Wet, dk. grayish brown, silty SAND (SM) 25.5'-28.5' - w/gravel & trace of shells 28.5'-30.0' - w/gravel		12-14-11	
			4-7-6	
			30-11-7	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682458.36	**LSP-03-25**
OFFSET:	New Jersey	E 615633.10	**1 of 2**
TOP ELEV: 6.4		COMPLETED: September 3, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, black, silty SAND w/gravel (SM) 1.5'-3.0' - brick frags [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS & COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL, CINDERS & COAL]		3-5-7 5-8-8	
3.00	Moist, dk. gray, clayey SAND w/trace of gravel (SC)		6-4-5	
4.50	3 pieces of cemented sand grains		6-8-6	
6.00	Moist, dk. grayish brown, silty SAND w/gravel & wood (SM)		6-4-27	
7.50	A DIRTY JAR		4-6-3	
9.00	Moist, dk. gray, clayey SAND w/trace of gravel (SC)		1-1-1	
10.50	Moist, dk. gray, soft fat CLAY w/trace of sand (CH) 12.0'-13.5' - trace of sand & gravel 13.5'-15.0' - trace of shells		WH-1-1 WR-WR-WR WR-WR-WR WR-WR-WR	
16.50	Moist, dk. gray & black, soft fat CLAY w/organic material & trace of shells (CH)		1-1-1	
18.00	Wet, dk. gray, poorly graded SAND w/silt (SP-SM)		WH-1-1	

5 — 10 — 15

LSP-03-25
GROUNDWATER DATA
WHILE DRILLING: 4.0
ON COMPLETION: 3.3
24 Hr. READING: 3.0

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682189.16	**LSP-03-24**
OFFSET:	New Jersey	E 617249.40	**2 of 2**
TOP ELEV: 10.3		COMPLETED: August 26, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, soft fat CLAY w/trace of shells (CH) *(continued from previous page)*		1-2-3	
			WH-2-3	
			WH-2-1	
		25	WH-2-2	
			WR-WR-WR	
			WH-WH-WH	
			WH-1-1	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 682189.16	**LSP-03-24**
OFFSET:	New Jersey	E 617249.40	**1 of 2**
TOP ELEV: 10.3		COMPLETED: August 26, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. grayish brown, silty SAND w/gravel & grass (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND & CINDERS] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL & CINDERS]		4-6-5	
1.50	Moist, dk. grayish brown, clayey SAND w/trace of roots (SC)		2-2-2	
3.00	Moist, v. dk. gray, sandy lean CLAY w/trace of wood (CL)		2-2-2	
4.50	Moist, black & v. dk. gray, fat CLAY w/sand & gravel (CH) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND & CINDERS] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL & CINDERS]		1-2-4	
6.00	Wet, black, silty SAND w/gravel (SM) 9.0'-10.5' - piece of leather 12.0'-13.5' - trace of wood [SAND SIZE PARTICLES ARE A MIXTURE OF SAND & CINDERS] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL & CINDERS]		5-4-3	
			5-4-3	
			2-2-2	
			2-2-4	
			10-7-5	
13.50	Moist to wet, v. dk. gray, sandy fat CLAY w/gravel & trace of organics (CH) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND & CINDERS] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF GRAVEL & CINDERS]		1-2-1	
			2-1-1	
16.50	Moist, dk. gray, soft fat CLAY w/trace of shells (CH)		2-1-1	
			WH-WH-WH	

5 — 10 — 15

LSP-03-24
GROUNDWATER DATA
WHILE DRILLING: 6.0
ON COMPLETION: 9.3
24 Hr. READING: 4.8

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet, _

GEO-2 LIBERTY STATE PARK.GPJ 4/5/04 09:15

STA.	Liberty State Park	N 682551.80	**LSP-03-23**
OFFSET:	New Jersey	E 616198.14	**2 of 2**
TOP ELEV: 6.4		COMPLETED: September 2, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist to wet, dk. gray, poorly graded SAND (SP-SM) *(continued from previous page)*		WH-WH-WH	
			WH-WH-WH	
	19.5'-22.5' - w/silt 22.5'-25.5' - w/silt, trace of brick frags. & gravel		8-6-5	
		25	5-5-5	
25.50	Moist to wet, dk. gray, silty SAND w/trace of gravel (SM)		10-8-11	
			9-7-11	
			8-10-12	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

STA.	Liberty State Park	N 682551.80	**LSP-03-23**
OFFSET:	New Jersey	E 616198.14	**1 of 2**
TOP ELEV: 6.4		COMPLETED: September 2, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, v. dk. gray, silty SAND w/trace of gravel (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS AND COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS AND COAL]		3-3-4 3-4-4	
3.00	Wet, v. dk. gray, silty GRAVEL w/sand (GM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS AND COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS AND COAL]		2-2-2	
4.50	Wet, v. dk. gray, silty SAND w/trace of gravel (SM) [SAND SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS AND COAL] [GRAVEL SIZE PARTICLES ARE A MIXTURE OF SAND, CINDERS AND COAL]	5	6-2-3 4-3-6 1-4-4	
9.00	Moist, dk. gray, soft fat CLAY (CH) 9.0'-10.5' - w/trace of gravel, sand & shell frags. 10.5'-15.0' - w/trace of gravel 15.0'-16.5' - w/organic material Moist, dk. gray, soft fat CLAY w/trace of gravel (CH)	10	2-1-1 1-1-1 1-WH-WH WR-WR-WR	
15.00	Moist, dk. gray, soft fat CLAY (CH) 16.0'-18.0' - w/organic material	15	2-1-2	
16.50	Moist, v. dk. gray, clayey fine SAND w/organic material (SC)		1-2-3	
18.00	Moist, v. dk. gray, clayey fine SAND (SC)		WH-WH-WH	
19.50	V. moist to wet, dk. gray, poorly graded SAND (SP-SM)			

LSP-03-23
GROUNDWATER DATA
WHILE DRILLING: 3.0
ON COMPLETION: 2.8
24 Hr. READING: 2.8

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet, _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09.15

STA.	Liberty State Park	N 682601.90	**LSP-03-20**
OFFSET:	New Jersey	E 618859.82	**2 of 2**
TOP ELEV: 9.9		COMPLETED: August 28, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	V. moist, black, soft fat to lean CLAY (CH/CL) *(continued from previous page)*		2-2-1	
21.00	V. moist, black, soft fat CLAY (CH)		1-1-1	
			WR-WR-2	
		25	WR-WR-WR	
			2-2-2	
			WR-WR-WR	
28.50	V. moist, dk. greenish gray, soft fat CLAY (CH)		WR-WR-WR	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682601.90	**LSP-03-20**
OFFSET:	New Jersey	E 618859.82	**1 of 2**
TOP ELEV: 9.9		COMPLETED: August 28, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, brown, silty fine SAND w/roots & grass (SM)		10-12-10	
4.50	Moist to v. moist, brown, silty med. SAND (SM)		5-6-8 3-6-11	
6.00	Moist, black, silty med - coarse SAND w/trace of wood & brick (SM)		19-13-5	
7.50	Wet, black, silty coarse SAND w/wood (SM)		12-12-10	
9.00	SAMPLE TOO SMALL TO CLASSIFY		1-7-29	
10.50	Mixture of wood, gravel, sand & silt		5-8-5	
13.50	Wet, v. dk. brown, silty coarse SAND w/gravel & large amounts of wood (SM)		9-7-16 5-8-8	
15.00	6" piece of wood w/trace of sand & silt		7-10-6	
18.00	Wet, black, silty fine SAND (SM) 15.0'-16.5' - w/gravel & trace of wood 16.5'-18.0' - w/trace of wood		5-8-8 4-3-4	
19.50	Wet, black, silty fine - med. SAND w/trace of gravel (SM)		4-6-8	
	V. moist, black, soft fat to lean CLAY (CH/CL)			

5 — 10 — 15

LSP-03-20
GROUNDWATER DATA
WHILE DRILLING: 7.5
ON COMPLETION: 5.8
24 Hr. READING: 5.6

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682477.62	**LSP-03-19**
OFFSET:	New Jersey	E 617933.69	**2 of 2**
TOP ELEV: 7.4		COMPLETED: August 26, 2003	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, fat CLAY w/trace of sand & shell frags. (CH) *(continued from previous page)*		WH-2-2	
			WH-2-2	
			2-2-2	
			WH-WH-2	
			WH-WH-WH	
			2-2-2	
			WH-WH-WH	
30.00	BOTTOM OF HOLE			

25

30

35

40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-28			
Jar-1	0.0-1.5	Moist dk grayish brn silty fine sand w/ roots grass	(SM)
Jar-2	1.5-3.0	Moist black silty med-coarse sand (Tr. grass)	(SM)
Jar-3	3.0-4.5	V moist black silty coarse sand[1] w/ gravel	(SM)
Jar-4	4.5-6.0	V. moist v. dk brn poorly graded coarse sand w/ silt	(SP-SM)
Jar-5	6.0-7.5	Wet dk greenish gray silty med sand w/ large pieces of wood	(SM)
Jar-6	7.5-9.0	-ditto- "	(SM)
Jar-7	9.0-10.5	Wet dk gray silty fine sand w/ clay lense	(SM)
Jar-8	10.5-12.0	-ditto- w/ " "	(SM)
Jar-9	12.0-13.5	Wet black silty med to coarse sand	(SM)
Jar-10	13.5-15.0	-ditto-	(SM)
Jar-11	15.0-16.5	Wet black silty med sand w/ clay lense	(SM)
Jar-12	16.5-18.0	V. moist black soft fat to lean clay	CH/CL
Jar-13	18.0-19.5	-ditto-	CH/CL
Jar-14	19.5-21.0	V. moist black soft fat clay	(CH)
Jar-15	21.0-22.5	V. moist dk gray soft fat clay	(CH)
Jar-16	22.5-24.0	-ditto-	(CH)
Jar-17	24.0-25.5	-ditto-	(CH)
Jar-18	25.5-27.0	-ditto-	(CH)
Jar-19	27.0-28.5	-ditto-	(CH)
Jar-20	28.5-30.0	EMPTY JAR	
		[1] Sand is mostly cinders	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-29			
Jar-1	0.0-1.5	Moist, DK. Grayish Brown, Poorly Graded SAND Tr. of Shells	(SP-SM)
Jar-2	1.5-3.0	Ditto with Shells	(SP-SM)
Jar-3	3.0-4.5	Ditto Trace of Shells	(SP-SM)
Jar-4	4.5-6.0	Ditto	(SP-SM)
Jar-5	6.0-7.5	Wet, V.DK. Gray, Clayey, SAND Trace of Shells	(SC)
Jar-6	7.5-9.0	Wet, V. DK. Gray, Sandy, FAT CLAY Trace of Shells	(CH)
Jar-7	9.0-10.5	Wet, V. DK. Gray Clayey, SAND Trace of Shells	(SC)
Jar-8	10.5-12.0	75% V. moist, V.DK. Gray, SOFT FAT CLAY 25% V. Moist, V. DK. Gray, Silty, SAND Trace of Shells	(CH) (SM)
Jar-9	12.0-13.5	V. Moist, V. DK. Gray, SOFT FAT CLAY with Sand	(CH)
Jar-10	13.5-15.0	Ditto with Sand, Tr. of Brick Frags, Shells +	(CH)
Jar-11	15.0-16.5	20 grams of Clay and 2 pieces of Gravel	—
Jar-12	16.5-18.0	Moist, V. DK Gray, SOFT FAT CLAY Tr. Brick Frags + sand + Shells	(CH)
Very Small Sample Jar-13	18.0-19.5	Ditto with Brick Fragments	(CH)
Jar-14	19.5-21.0	Ditto Trace of Organic Material	(CH)
Jar-15	21.0-22.5	Ditto Trace of Organic Material	(CH)
Jar-16	22.5-24.0	Moist, DK Gray, Silty, SAND Trace of Organic Matr'l	(SM)
Jar-17	24.0-25.5	Wet, DK. Gray, Silty, SAND	(SM)
Jar-18	25.5-27.0	Ditto	(SM)
Jar-19	27.0-28.5	Moist, DK Gray, Silty, SAND Trace of Organic Matr'l	(SM)
Small Sample Jar-20	28.5-30.0	Ditto	(SM)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-30			
Jar-1	0.0-1.5	Moist v. dk grayish brn silty med sand w/ grass roots	(SM)
Jar-2	1.5-3.0	V. moist dk yell brn poorly graded med sand w/ silt	(SP-SM)
Jar-3	3.0-4.5	Wet -ditto-	(SP-SM)
Jar-4	4.5-6.0	Wet dk grayish brn poorly graded med sand w/ silt	(SP-SM)
Jar-5	6.0-7.5	Wet brown silty med sand	(SM)
Jar-6	7.5-9.0	Wet dk gray soft lean clay	CL/ML
Jar-7	9.0-10.5	Wet dk gray soft fat clay	(CH)
Jar-8	10.5-12.0	80% -ditto- 20% wet dk Gray silty med sand	(CH) (SM)
Jar-9	12.0-13.5	Wet dk gray poorly graded med sand w/ silt	(SP-SM)
Jar-10	13.5-15.0	-ditto-	(SP-SM)
Jar-11	15.0-16.5	Wet dk grayish brn poorly graded fine sand w/ silt	(SP-SM)
Jar-12	16.5-18.0	V. moist dk gray soft fat clay w/ sand	CH
Jar-13	18.0-19.5	V. moist dk gray soft fat clay	(CH)
Jar-14	19.5-21.0	-ditto-	(CH)
Jar-15	21.0-22.5	-ditto-	(CH)
Jar-16	22.5-24.0	-ditto-	(CH)
Jar-17	24.0-25.5	Wet dk gray silty fine sand	(SM)
Jar-18	25.5-27.0	-ditto-	(SM)
Jar-19	27.0-28.5	-ditto-	(SM)
Jar-20	28.5-30.0	-ditto-	(SM)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-31			
Jar-1	0.0-1.5	Moist, Yellowish Brown, Silty, SAND Trace of Gravel	(SM)
Jar-2	1.5-3.0	Ditto Trace of Gravel	(SM)
Jar-3	3.0-4.5	Moist, Brown, Poorly Graded SAND with Silt	(SP-SM)
Jar-4	4.5-6.0	Ditto	(SP-SM)
Jar-5	6.0-7.5	Wet, Ditto	(SP-SM)
very small Jar-6	7.5-9.0	Wet, Ditto	(SP-SM)
Jar-7	9.0-10.5	Wet, Grayish Brown, Poorly Graded SAND with Silt + Shells	(SP-SM)
small Jar-8	10.5-12.0	Wet, Dk. Gray, Sandy, FAT CLAY Trace of Shells	(CH)
Jar-9	12.0-13.5	Wet, Dk. Gray, SOFT FAT CLAY with Sand + Shells	(CH)
Jar-10	13.5-15.0	Ditto with Sand + Shells	(CH)
Jar-11	15.0-16.5	Ditto with Sand + Shells	(CH)
Jar-12	16.5-18.0	Ditto Trace of Shells	(CH)
Jar-13	18.0-19.5	Ditto " " "	(CH)
Jar-14	19.5-21.0	Ditto " " "	(CH)
Jar-15	21.0-22.5	Ditto " " "	(CH)
Jar-16	22.5-24.0	Ditto " " "	(CH)
Jar-17	24.0-25.5	Ditto	(CH)
Jar-18	25.5-27.0	Ditto	(CH)
Jar-19	27.0-28.5	Ditto	(CH)
Jar-20	28.5-30.0	Ditto	(CH)

VISUAL-MANUAL CLASSIFICATIONS

(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Estes

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-32			
Jar-1	0.0-1.5	moist very dk gry silty sand ①② w/gravel	(SM)
Jar-2	1.5-3.0	ditto ①②	(SM)
Jar-3	3.0-4.5	moist dk gry brn ditto ①②	(SM)
Jar-4	4.5-6.0	wet gry brn poorly graded sand ③ w/silt	(SP-SM)
Jar-5	6.0-7.5	wet gry brn silty sand ③	(SM)
Jar-6	7.5-9.0	very moist dk gry brn sandy lean clay trace of gravel	(CL)
Jar-7	9.0-10.5	moist dk gry lean to fat clay trace of sand	(CL/CH)
Jar-8	10.5-12.0	very moist dk gry sandy lean clay trace of gravel	(CL)
Jar-9	12.0-13.5	very moist dk gry fat clay w/sand	(CH)
Jar-10	13.5-15.0	moist dk gry lean to fat clay w/sand	(CL/CH)
Jar-11	15.0-16.5	moist dk gry brn fat clay trace of sand	(CH)
Jar-12	16.5-18.0	ditto ④	(CH)
Jar-13	18.0-19.5	ditto	(CH)
Jar-14	19.5-21.0	moist dk gry ditto ④	(CH)
Jar-15	21.0-22.5	moist very dk gry elastic silt trace of sand	(MH)
Jar-16	22.5-24.0	moist dk gry sandy lean clay trace of gravel	(CL)
Jar-17	24.0-25.5	moist gry brn silty sand ⑤ trace of gravel	(SM)
Jar-18	25.5-27.0	very moist brn clayey sand ③ w/gravel	(SC)
Jar-19	27.0-28.5	wet brn silty sand ③ w/gravel	(SM)
Jar-20	28.5-30.0	wet gry brn ditto ③	(SM)

① contains cinders

② coarse to fine sand

③ medium to fine sand

④ trace of shell fragments

⑤ fine sand

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-33		Trace of roots	
Jar-1	0.0-1.5	Wet, Dark Brown, Poorly Graded SAND with silt + Gravel	(SP-SM)
Jar-2	1.5-3.0	Ditto with silt + Gravel	(SP-SM)
Jar-3	3.0-4.5	Ditto With Silt + Gravel	(SP-SM)
Jar-4	4.5-6.0	Wet, Dark Brown, Silty, SAND with Gravel	(SM)
Jar-5	6.0-7.5	V. Moist, Gray + Brown, Silty, SAND Trace of Shells	(SM)
Jar-6	7.5-9.0	V. Moist, DK Gray, Sandy, FAT CLAY	(CH)
Jar-7	9.0-10.5	Ditto	(CH)
Jar-8	10.5-12.0	Moist, DK Gray, SOFT FAT CLAY with Fine Sand	(CH)
Jar-9	12.0-13.5	Ditto " " "	(CH)
Jar-10	13.5-15.0	Ditto	(CH)
Jar-11	15.0-16.5	Ditto Trace of shells	(CH)
Jar-12	16.5-18.0	Ditto	(CH)
Jar-13	18.0-19.5	Ditto	(CH)
Jar-14	19.5-21.0	Ditto Trace of Shells	(CH)
Jar-15	21.0-22.5	Ditto Trace of Shells	(CH)
Jar-16	22.5-24.0	Ditto Trace of Shells	(CH)
Jar-17	24.0-25.5	Ditto Trace of Shells	(CH)
Jar-18	25.5-27.0	V. Moist, DK Gray, SOFT FAT CLAY with Fine Sand	(CH)
Jar-19	27.0-28.5	V. Moist, V. DK. Gray, Clayey, SAND	(SC)
Jar-20	28.5-30.0	Ditto with Pieces of Wood	(SC)

STA.
OFFSET:
TOP ELEV: 9.3

Liberty State Park
New Jersey

N 681689.74
E 616900.75
COMPLETED: February 5, 2004

CA-04-05
1 of 2

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, dk. gray, lean CLAY w/sand & roots (CL)		4-2-2	
3.00	Moist, v. dk. brown, silty SAND w/pieces of wood (SM) [petroleum odor]		2-2-9	
4.50	Moist, v. dk. brown, silty SAND w/pieces of wood, coal & cinders (SM) [petroleum odor]		8-7-11	
6.00	Moist, v. dk. grayish brown, silty SAND w/large piece of wood (SM)	5	5-6-10	
7.50	Moist, dk. grayish brown, silty SAND w/trace of gravel (SM)		6-10-10	
9.00	Wet, v. dk. grayish brown, silty SAND w/trace of gravel (SM)		WH/1.0-3	
10.50	Moist, dk. brown, silty SAND w/trace of gravel (SM)	10	3-2-2	
12.00	Wet, dk. gray, sandy SILT w/trace of gravel (ML)		4-2-2	
13.50	Moist, dk. grayish brown, sandy lean CLAY (CL)		3-2-1	
15.00	Moist, dk. gray, soft fat CLAY (CH)	15	WH/1.5	
19.50	Moist, dk. gray, soft fat CLAY w/trace of shells (MH)		WH/1.5	
			WH/1.5	
			WH/1.5	
	Moist, dk. gray, soft fat CLAY w/trace of shells & wood (CH)			

CA-04-05
GROUNDWATER DATA
WHILE DRILLING: 8.0
ON COMPLETION: 28.1
24 Hr. READING: 6.2

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet, _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681689.74	**CA-04-05**
OFFSET:	New Jersey	E 616900.75	**2 of 2**
TOP ELEV: 9.3		COMPLETED: February 5, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
21.00	Moist, dk. gray, soft fat CLAY w/trace of shells & wood (CH) *(continued from previous page)*		WH/1.5	
	Moist, dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
			WH/1.5	
25.50			WH/1.5	
	Moist, dk. gray, soft fat CLAY (CH)		WH/1.5	
28.50		▼	WH/1.5	
30.00	Moist, dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
	BOTTOM OF HOLE			

25

30

35

40

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 681256.92	**CA-04-06**
OFFSET:	New Jersey	E 616603.32	**1 of 2**
TOP ELEV: 6.6		COMPLETED: February 5, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Wet, v. dk. grayish brown, silty SAND w/gravel & pieces of wood (SM)		4-3-5	
3.00	Wet, dk. yellowish brown, poorly graded SAND w/silt (SP-SM)		5-5-4	
6.00	Wet, dk. yellowish brown, poorly graded SAND (SP-SM)		3-2-3 4-3-2	
9.00	Moist, dk. yellowish brown, poorly graded SAND (SP-SM)		WH/1.0-1 WH/1.5	
12.00	Wet, dk. yellowish brown, poorly graded SAND (SP-SM)		WH/1.5 WH/1.5	
13.50	Moist, dk. gray, soft lean CLAY (CL)		WH/1.5	
16.50	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5 WH/1.5	
18.00	V. moist, dk. gray, soft fat CLAY (CH)		WR/1.0-WH	
19.50	V. moist, dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
	Moist, dk. gray, soft fat CLAY (CH)			

5

10

15

CA-04-06
GROUNDWATER DATA
WHILE DRILLING: 1.0
ON COMPLETION: 2.4
24 Hr. READING: 2.0

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/8/04 09:15

STA.	Liberty State Park	N 681256.92	**CA-04-06**
OFFSET:	New Jersey	E 616603.32	**2 of 2**
TOP ELEV: 6.6		COMPLETED: February 5, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Moist, dk. gray, soft fat CLAY (CH) *(continued from previous page)*		WH/1.5	
			WH/1.5	
			WH/1.5	
		25	WH/1.5	
			WH/1.5	
			WH/1.5	
			WH/1.5	
30.00	BOTTOM OF HOLE	30		
		35		
		40		

STA.	Liberty State Park	N 682441.45	**NC-04-01**
OFFSET:	New Jersey	E 618911.02	**1 of 1**
TOP ELEV: 7.9		COMPLETED: February 7, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	North Cove Water depth @ 0940 Feb. 7, 2004 = -7.9' Water depth @ 1420 Feb. 7, 2004 = -3.9'	-5		
0.00	Wet, black, silty fine SAND w/pieces of wood (SM)	0	WR/1.5	
1.50	Wet, black, soft lean CLAY (CL)		WR/1.5	
3.00	Wet, v. dk. gray, soft fat CLAY (CH) [petroleum odor]		WR/1.5	
		5	1/1.5	
			WR/1.5	
			WR/1.5	
		10	WR/1.5	
12.00			WR/0.5 WH/1.0	
	Wet, dk. gray & black, soft fat CLAY (CH)		WH/1.5	
		15	13-8-1	
			WH/1.5	
18.00			WH/1.5	
19.50	Wet, dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
21.00	Wet, dk. gray, soft fat CLAY (CH)	20	WH/1.5	
	BOTTOM OF HOLE			

NC-04-01
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:15

STA.	Liberty State Park	N 682302.23	**NC-04-02**
OFFSET:	New Jersey	E 619381.51	**1 of 1**
TOP ELEV: 5.4		COMPLETED: February 7, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	North Cove Water depth @ 1442 Feb. 7, 2004 = -5.4' Water depth @ 1640 Feb. 7, 2004 = -6.5'			
0.00				
1.50	Wet, black, silty v. fine SAND w/pieces of wood (SM)		WR-1-1	
3.00	Wet, black, soft lean CLAY (CL) [petroleum odor]		WR-WH/1.0	
	Wet, black, soft fat CLAY (CH) [petroleum odor]		WR/1.5 WR/1.5 WR/1.5 WR-1-1	
9.75	Wet, black, soft fat CLAY w/trace of sand & gravel (CH) [petroleum odor]		WH/1.5 1-1-WR	
12.00	Wet, black, soft fat CLAY (CH)		WR/1.5	
14.25	Wet, dk. gray, soft fat CLAY (CH)		WR/1.5 WR/1.0-WH/0.5	
16.50	Wet, dk. gray, soft fat CLAY w/trace of shells (CH)		WH/1.5	
18.00	Wet, dk. gray, soft fat CLAY (CH)		WR/1.5 WR-WH/1.0	
21.00	BOTTOM OF HOLE			

-5, 0, 5, 10, 15, 20

NC-04-02
GROUNDWATER DATA
WHILE DRILLING:
ON COMPLETION:
Hr. READING:

Fill, Auger, SPT, RB, Cored, 300 lb, Tubex, Hand, Fish Tail, Vibra Core, Water Jet, _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.
OFFSET:
TOP ELEV: 6.4

Liberty State Park
New Jersey

N 682544.63
E 618700.83
COMPLETED: February 9, 2004

NC-04-03
1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Wet, dk. grayish brown, silty med. SAND w/trace of grass, roots & gravel (SM)		16-13-12	
3.00	Moist, v. dk. grayish brown, silty med. SAND w/gravel (SM)		8-15-18	
4.50	Moist, black, poorly graded, med. SAND w/silt & roots (SP-SM)		14-17-23	
6.00	Moist, black, sandy SILT (ML) [50% pieces of wood]		13-13-11	
7.50	V. moist, black, silty med.-coarse SAND w/gravel & wood (SM)		9-9-15	
9.00	100% WOOD		72-82-18	
10.50	Wet, black, silty med. SAND w/20% wood pieces (SM)		5-11-11	
12.00	Wet, black, silty med. SAND w/40% wood pieces (SM)		42-11-10	
13.50	Wet, black, silty med. SAND w/20% wood pieces (SM) [petroleum odor]		2-2-9	
15.00	Wet, black, silty med. SAND w/90% wood pieces (SM) [petroleum odor]		4-3-2	
16.50	Wet, black, silty med. SAND w/90% wood pieces (SM)		24-2-2	
19.50	EMPTY JAR		WH/1.5 WH/1.5	
21.00	100% WOOD		10-49-24	
	BOTTOM OF HOLE			

5 10 15 20 25

NC-04-03
GROUNDWATER DATA
WHILE DRILLING: 5.9
ON COMPLETION: 5.6
24 Hr. READING: 5.9

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA. | Liberty State Park | N 682668.42 | **NC-04-04**
OFFSET: | New Jersey | E 618819.14 | **1 of 1**
TOP ELEV: 6.4 | COMPLETED: February 9, 2004

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	V. moist, dk. grayish brown, silty med.-coarse SAND w/gravel & roots (SM)		14-31-30	
3.00	Moist, dk. brown, silty med. SAND w/gravel (SM)		14-15-14	
4.50	Moist, black, silty med. SAND w/trace of gravel (SM) [Some of the sand & gravel is coal fragments]		11-13-11	
6.00	Moist, black, silty med.-coarse SAND w/gravel (SM) [Some of the sand & gravel is coal fragments]		6-9-9	
7.50	Wet, black, poorly graded, coarse SAND w/silt (SP-SM)	▽ ▼ ▽	7-4-8	
10.50	Wet, v. dk. gray, silty coarse SAND w/gravel (SM)		2-5-2	
12.00	Wet, dk. gray, poorly graded, coarse SAND w/silt (SP-SM)		WH-1-1	
19.50	Wet, dk. gray, poorly graded, coarse SAND (SP-SM)		1-2-2	
21.00	Wet, dk. gray, poorly graded, coarse SAND w/silt & gravel (SP-SM)		1-1-2	
	BOTTOM OF HOLE		1-1-1	
			1/1.0-1/0.5	
			1-1-1	
			1-1-1	
			1/1.0-1/0.5	

5 10 15 20 25

NC-04-04
GROUNDWATER DATA
▽ WHILE DRILLING: 6.0
▼ ON COMPLETION: 6.7
▼ 24 Hr. READING: 6.3

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.
OFFSET:
TOP ELEV: 7.4

Liberty State Park
New Jersey

N 682601.71
E 619002.72
COMPLETED: February 8, 2004

NC-04-05
1 of 1

DEPTH(ft)	(c)	(d)	(a)	(b)
1.50	Moist, dk. grayish brown, silty fine SAND w/roots & grass (SM)		12-15-16	
3.00	Moist, dk. grayish brown, silty fine SAND w/piece of wood (SM)		9-10-12	
4.50	Moist, dk. grayish brown, silty fine SAND w/trace of gravel (SM)		7-17-100	
6.00	Moist, black, silty med. SAND w/gravel (SP-SM)		20-11-18	
7.50	Moist, black, silty coarse SAND w/pieces of wood (SM) [petroleum odor]		6-6-13	
9.00	Moist, v. dk. gray, silty med. SAND w/trace of gravel & wood (SM) [petroleum odor]	▽	7-8-9	
10.50	Wet, black, silty med. SAND w/50% pieces of wood (SM) [petroleum odor]		3-4-12	
12.00	Wet, black, poorly graded, med. SAND w/silt, gravel & 20% wood (SP-SM)		8-5-13	
13.50	Wet, black, silty med.-coarse SAND w/pieces of wood (SM)		2-7-6	
15.00	Wet, v. dk. gray, silty med. SAND w/trace of gravel (SM)		1/1.0-1/0.5	
16.50	Wet, v. dk. gray, poorly graded, med. SAND w/silt (SP-SM)		1/1.0-1/0.5	
18.00	Wet, v. dk. gray, poorly graded, coarse SAND w/silt & piece of wood (SP-SM)		1/1.0-13	
19.50	Wet, v. dk. gray, poorly graded, coarse SAND (SP-SM)		2-5-2	
21.00	WOOD w/trace of sand		1-5-2	
	BOTTOM OF HOLE			

5 10 15 20 25

NC-04-05
GROUNDWATER DATA
▽ WHILE DRILLING: 7.5
▽ ON COMPLETION: 7.8
▼ 24 Hr. READING: 8.0

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:16

STA.	Liberty State Park	N 682153.40	**BA-04-01**
OFFSET:	New Jersey	E 615159.08	**1 of 1**
TOP ELEV: 7.1		COMPLETED: February 9, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Dry, black, SAND w/coal fragments (**)			
4.00		▽		
	Wet, med. brown, fine SAND w/trace to some silt (**)	▽	5	
6.00				
	Wet, med. grey, fine to med. SAND w/trace of silt (**)		10	
14.00				
	Moist, med. dk. grey, silty CLAY w/trace of shell fragments (**)		15	
18.00				
	Moist, dk. brown, clayey SILT w/strong organic odor (**)			
20.00			20	
	BOTTOM OF HOLE Note: No SPT samples were obtained from this boring. Described soils were taken from the auger flights (cuttings).			
			25	

BA-04-01
GROUNDWATER DATA
▽ WHILE DRILLING: 5.0
▽ ON COMPLETION: 3.7
24 Hr. READING: NT

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:14

STA.	Liberty State Park	N 681882.18	**BA-04-02**
OFFSET:	New Jersey	E 614686.79	**1 of 1**
TOP ELEV: 7.4		COMPLETED: February 9, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Coal fragments w/some fine black sand (**)			
5.00	Wet, med. grey, soft sandy CLAY (**)			
7.00	Moist, med. to dk. grey, CLAY w/trace of fine sand layers (**)			
13.00	Moist, med. grey, sandy CLAY (**)			
14.50	Moist, med. grey, silty CLAY w/some fine sand & gravel (**)			
17.25	Wet, med. grey & brown, sandy SILT (**)			
20.00	BOTTOM OF HOLE Note: No SPT samples were obtained from this boring. Described soils were taken from the auger flights (cuttings).			

5 10 15 20 25

BA-04-02
GROUNDWATER DATA
WHILE DRILLING: 4.0
ON COMPLETION: 2.4
24 Hr. READING: NT

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:14

STA.	Liberty State Park	N 681669.09	**BA-04-03**
OFFSET:	New Jersey	E 614566.37	**1 of 1**
TOP ELEV: 9.4		COMPLETED: February 10, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Dry, dk. brown, gravelly SAND (**)			
3.00				
	Dk. grey & black, clayey SAND w/coal fragments & gravel (**)			
8.00				
	Wet, med. brown, fine to med. SAND w/some gravel (**)	▽ ▽		
12.00				
	Dk. brown, fine to med. SAND w/some silt & gravel (**)			
14.00				
	Sltightly moist, dk. grey, mod. soft CLAY (**)			
18.50				
	Dry, lt. reddish brown, compacted silty SAND w/some gravel (**)			
20.00				
	BOTTOM OF HOLE Note: No SPT samples were obtained from this boring. Described soils were taken from the auger flights (cuttings).			

5 10 15 20 25

BA-04-03
GROUNDWATER DATA
▽ WHILE DRILLING: 9.0
▽ ON COMPLETION: 8.2
24 Hr. READING: NT

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet

GEO-2 LIBERTY STATE PARK.GPJ 4/5/04 09:14

STA.	Liberty State Park	N 681444.47	**BA-04-04**
OFFSET:	New Jersey	E 614574.94	**1 of 1**
TOP ELEV: 8.2		COMPLETED: February 10, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
	Dry, dk. brown, gravelly SAND (**)			
4.50	Dry, dk. brown, large gravelly SAND (**)			
7.00	Moist, med. grey, soft, silty CLAY w/trace of shell fragments (**)			
13.25	Moist, dk. grey, soft, silty CLAY w/trace of mica (**)			
17.50	Dry, lt. reddish brown, fine SAND w/some silt & trace of gravel (**)			
20.00	BOTTOM OF HOLE Note: No SPT samples were obtained from this boring. Described soils were taken from the auger flights (cuttings).			

5 10 15 20 25

BA-04-04
GROUNDWATER DATA
WHILE DRILLING: 8.0
ON COMPLETION: 10.7
24 Hr. READING: NT

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:14

STA.	Liberty State Park	N 681162.64	**BA-04-05**
OFFSET:	New Jersey	E 614663.81	**1 of 1**
TOP ELEV: 11.3		COMPLETED: February 9, 2004	

DEPTH(ft)	(c)	(d)	(a)	(b)
3.00	Dry, brown, gravelly SAND (**)			
7.00	Dry, black, COAL FRAGMENTS w/some black sand			
10.00	Black & med. grey, fine-med. SAND w/trace of coal fragments (**)			
14.00	Wet, med. grey, fine to coarse SAND w/a few pieces of gravel (**)			
18.00	Wet, med. grey, silty fine SAND (**)			
20.00	Moist, med. grey & black, silty CLAY (**)			
	BOTTOM OF HOLE Note: No SPT samples were obtained from this boring. Described soils were taken from the auger flights (cuttings).			

5 10 15 20 25

BA-04-05
GROUNDWATER DATA
WHILE DRILLING: 8.0
ON COMPLETION: 7.3
24 Hr. READING: NT

Fill Auger SPT RB
Cored 300 lb Tubex Hand
Fish Tail Vibra Core Water Jet _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:14

STA.	Liberty State Park	N 680961.88	**BA-04-06**
OFFSET:	New Jersey	E 614884.18	**1 of 1**
TOP ELEV: 9.1		COMPLETED: February 10, 2004	

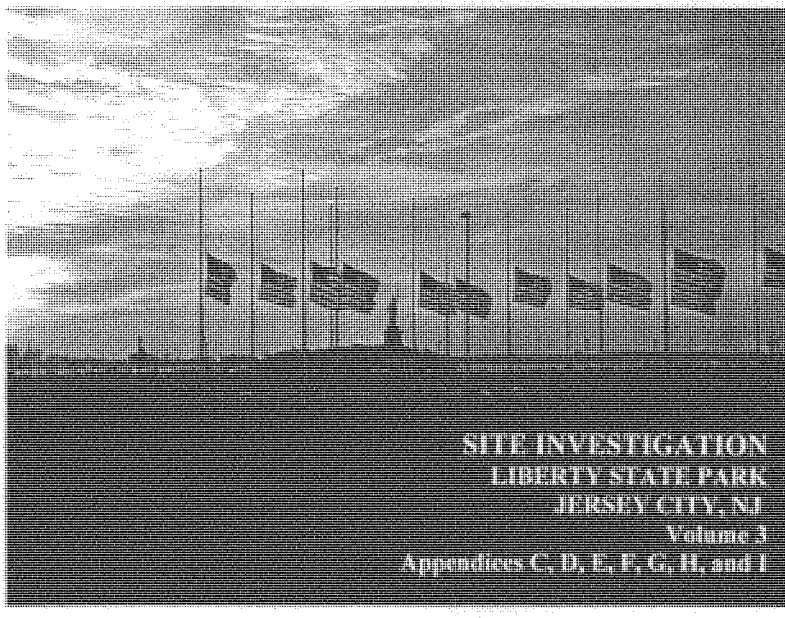
DEPTH(ft)	(c)	(d)	(a)	(b)
	Dry, brown, gravelly SAND w/trace of clay (**)			
2.00				
	Med. brown, fine SAND w/trace of silt & a few pieces of gravel (**)			
5				
8.00				
	Wet, med. grey, fine to coarse SAND w/some gravel (**)			
10				
15				
17.00				
	Moist, dk. grey, soft silty CLAY (**)			
20.00				
20	BOTTOM OF HOLE			
	Note: No SPT samples were obtained from this boring. Described soils were taken from the auger flights (cuttings).			
25				

BA-04-06
GROUNDWATER DATA
WHILE DRILLING: 2.8
ON COMPLETION: 3.7
24 Hr. READING: NT

Fill | Auger | SPT | RB
Cored | 300 lb | Tubex | Hand
Fish Tail | Vibra Core | Water Jet | _

GEO-2 LIBERTY STATE PARK.GPJ 4/6/04 09:14

US Army Corps
of Engineers
BALTIMORE DISTRICT



SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ
Volume 3
Appendices C, D, E, F, G, H, and I

Prepared by:
U.S. Army Corps of Engineers
Baltimore District
10 South Howard Street
Baltimore, MD 21201

Project Partner:
U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, NY 10278

April 2004

SITE INVESTIGATION
LIBERTY STATE PARK
JERSEY CITY, NJ

FINAL REPORT
Volume 3

TABLE OF CONTENTS

APPENDICES

Section	Title
C	Visual-Manual Soil Classifications
D	Geotechnical Testing Results
E	Permanent Piezometer As-Built Records
F	Permanent Piezometer Construction Schematics
G	Temporary Piezometer As-Built Records
H	Temporary Piezometer Construction Schematics
I	Changes in Groundwater Elevations in Permanent Piezometers

APPENDIX C
VISUAL-MANUAL SOIL CLASSIFICATIONS

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-01			
Jar-1	0.0-1.5	Moist black silty fine sand w/ roots glass wood	(SM)
Jar-2	1.5-3.0	Moist black silty coarse sand w/ wood glass	(SM)
Jar-3	3.0-4.5	Wet v. dk gray silty coarse sand w/ glass roots	(SM)
Jar-4	4.5-6.0	ditto – w/ wood	(SM)
Vi Small Jar-5 Sample	6.0-7.5	-ditto – w/ Tar paper	(SM)
Vi Small Jar-6 Sample	7.5-9.0	Wet v. dk grayish brn silty med sand w/ gravel	(SM)
Jar-7	9.0-10.5	Wet gray + brn silty fine sand	(SM)
Jar-8	10.5-12.0	Wet grayish brn silty v. fine sand	(SM)
Jar-9	12.0-13.5	Wet dk grayish brn poorly graded gravel w/ silt + sd	(GP-GM)
Jar-10	13.5-15.0	ditto	(GP-GM)
Jar-11	15.0-16.5	Wet dk grayish brn poorly graded coarse sand w/ silt gravel	(SP-S)
Jar-12	16.5-18.0	ditto w/ silt	(SP-SM)
Jar-13	18.0-19.5	Wet brown silty gravel w/ sand	(GM)
Jar-14	19.5-21.0	Wet brown poorly graded gravel w/ silt + sand	(GP-GM)
Jar-15	21.0-22.5	Wet brown poorly graded med sand	(SP)
Jar-16	22.5-24.0	-ditto – (med-coarse)	(SP)
Jar-17	24.0-25.5	ditto "	(SP)
Jar-18	25.5-26.4	Wet brown poorly graded med sand w/ silt	(SP-SM)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-02			
Jar-1	0.0-1.5	75% Moist grayish brn. silt + lean clay w/ Grass + roots 25% moist black silty coarse sand w/ glass + coal slags	(CL) (SM)
small sample Jar-2	1.5-3.0	Moist black silty coarse sand w/ gravel	(SM)
Jar-3	3.0-4.5	Wet v. dk grayish brn silty coarse sand ①	(SM)
Jar-4	4.5-6.0	Wet v. dk gray silty coarse sand w/ gravel	(SM)
Jar-5	6.0-7.5	- ditto -	(SM)
small sample Jar-6	7.5-9.0	Wet v. dk gray silty coarse sand w/ grass	(SM)
Jar-7	9.0-10.5	- ditto - w/ gravel + grass	(SM)
Jar-8	10.5-12.0	- ditto - " "	(SM)
Jar-9	12.0-13.5	Wet black silty coarse sand w/ gravel	(SM)
Jar-10	13.5-15.0	50% v. moist dk grayish brn poorly graded med sand w/ silt 50% v. moist dk gray soft lean clay	(SP-SM) (CL)
small sample Jar-11	15.0-16.5	V. moist dk grayish brn poorly graded med sand w/ silt	(SP-SM)
v. small sample Jar-12	16.5-18.0	V. moist v. dk gray soft - firm lean clay	(CL)
Jar-13	18.0-19.5	- ditto - w/ sand	(CL)
Jar-14	19.5-21.0	Wet dk grayish brn poorly graded sand w/ silt	(SP-SM)
Jar-15	21.0-22.5	V. moist dk grayish brn silty fine-med sand	(SM)
Jar-16	22.5-24.0	Wet - ditto -	(SM)
Jar-17	24.0-25.5	Wet - ditto -	(SM)
Jar-18	25.5-27.0	V. moist brown silty fine sand	(SM)
Jar-19	27.0-28.5	- ditto -	(SM)
Jar-20	28.5-30.0	V. moist brown poorly graded med sand w/ silt	(SP-SM)
		① Sand is cinders	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-03			
Jar-1	0.0-1.5	Moist dk grayish brn hard lean clay w/ sand	(CL)
Jar-2	1.5-3.0	Moist black silty coarse sand ① w/ gravel	(SM)
Jar-3	3.0-4.5	Moist dk grayish brn silty med sand w/ gravel	(SM)
Jar-4	4.5-6.0	Wet black + brn silty med-coarse sand w/ gravel	(SM)
Jar-5	6.0-7.5	Wet black poorly graded coarse sand w/ silt + grav.	(SP-SM)
Jar-6	7.5-9.0	-ditto-	(SP-SM)
Jar-7	9.0-10.5	Wet black poorly graded coarse sand w/ silt	(SP-SM)
Jar-8	10.5-12.0	Wet black silty med-coarse sand	SM
Jar-9	12.0-13.5	-ditto-	(SM)
Jar-10	13.5-15.0	-ditto-	(SM)
Jar-11	15.0-16.5	-ditto-	(SM)
Jar-12	16.5-18.0	-ditto	(SM)
Jar-13	18.0-19.5	-ditto-	(SM)
Jar-14	19.5-21.0	-ditto- w/ gravel	(SM)
Jar-15	21.0-22.5	V. moist grayish brn silty coarse sand w/ clay brix	(SM)
Jar-16	22.5-24.0	V. moist dk greenish gray soft lean clay w/ sand	(CL)
Jar-17	24.0-25.5	V. moist v. dk gray soft lean clay	(CL)
Jar-18	25.5-27.0	-ditto-	(CL)
Jar-19	27.0-28.5	V. moist v. dk gray soft lean clay	(CL)
Jar-20	28.5-30.0	-ditto-	(CL)
		① Sand is cinders	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Foster

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-04			
Jar-1	0.0-1.5	moist dk yel brn silty sand ①② trace of roots and gravel	(SM)
Jar-2	1.5-3.0	moist very dk gry brn silty sand ①③ w/gravel	(SM)
Jar-3	3.0-4.5	wet dk gry ditto ①③	(SM)
Jar-4	4.5-6.0	ditto ①②	(SM)
Small sample Jar-5	6.0-7.5	wet very dk gry silty gravel w/sand	(GM)
Small sample Jar-6	7.5-9.0	wet very dk gry silty sand ① w/gravel	(SM)
Small sample Jar-7	9.0-10.5	moist dk gry brn fat clay w/sand trace of gravel	(CH)
Jar-8	10.5-12.0	moist dk gry brn fat clay w/sand	(CH)
Jar-9	12.0-13.5	moist dk gry brn fat clay trace of sand	(CH)
Jar-10	13.5-15.0	ditto ①	(CH)
Jar-11	15.0-16.5	moist dk gry brn fat clay w/sand ④ trace of gravel	(CH)
Jar-12	16.5-18.0	moist dk gry brn fat clay w/sand	(CH)
Jar-13	18.0-19.5	moist dk gry brn fat clay ④ trace of sand	(CH)
Jar-14	19.5-21.0	ditto ④	(CH)
Jar-15	21.0-22.5	ditto ④	(CH)
Jar-16	22.5-24.0	ditto ④	(CH)
Jar-17	24.0-25.5	ditto ④	(CH)
Jar-18	25.5-27.0	ditto ④	(CH)
Jar-19	27.0-28.5	ditto ④	(CH)
Jar-20	28.5-30.0	ditto ④	(CH)
		① medium to fine sand	
		② coarse to fine sand	
		③ trace of cinders	
		④ trace of shell fragments	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-05			
Jar-1	0.0-1.5	Moist brown silty fine sand w/ gravel ① roots grass	(SM)
Jar-2	1.5-3.0	Moist black poorly graded coarse sand w/ silt	(SP-SM)
Small sample Jar-3	3.0-4.5	Wet v. dk gray poorly graded gravel w/ silt & sd	(GP-GM)
Jar-4	4.5-6.0	Wet v. dk gray poorly graded coarse sand	(SP)
Jar-5	6.0-7.5	Wet black poorly graded gravel w/ silt + sand	(GP-GM)
V. Small sample Jar-6	7.5-9.0	Wet gray silty med sand w/ Trash	(SM)
Jar-7	9.0-10.5	V. moist black soft fat clay w/ sand ②	(CH)
Small sample Jar-8	10.5-12.0	ditto ②	(CH)
Jar-9	12.0-13.5	V. moist dk gray soft fat clay ②	(CH)
Jar-10	13.5-15.0	ditto ②	(CH)
Jar-11	15.0-16.5	ditto ②	(C
Jar-12	16.5-18.0	ditto ②	(CH)
Jar-13	18.0-19.5	ditto ②	(CH)
Jar-14	19.5-21.0	ditto -	(CH)
Jar-15	21.0-22.5	ditto -	(CH)
Jar-16	22.5-24.0	ditto ②	(CH)
Jar-17	24.0-25.5	ditto - ②	(CH)
Jar-18	25.5-27.0	ditto ②	(CH)
Jar-18	25.5-27.0	ditto -	(CH)
Jar-19	27.0-28.5	ditto -	(CH)
Jar-20	28.5-30.0	ditto -	(CH)
		① Gravel is sandstone fragments	
		② TRACE of SHELL FRAGMENTS	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-06			
Jar-1	0.0-1.5	Moist, Black, silty, SAND (1) with Gravel (2)	(SM)
Jar-2	1.5-3.0	Moist, Black, silty SAND (1) with Gravel (2)	(SM)
Jar-3	3.0-4.5	Moist, Black, silty, SAND (1) with Gravel (2) and Brown Claylens	(SM)
Jar-4	4.5-6.0	Wet, V. Dark Gray, Clayey, SAND (1) Trace Gravel	(SC)
small sample Jar-5	6.0-7.5	Wet, Very Dark Gray, silty, SAND with Gravel	(SM)
Jar-6	7.5-9.0	Wet, V. Dark Gray, clayey, SAND with Gravel	(SC)
Jar-7	9.0-10.5	Ditto with Gravel Tr. Cinders	(SC)
Jar-8	10.5-12.0	V. Moist, V. Dark Gray, Clayey, SAND Trace of Cinders	SC/CL
Jar-9	12.0-13.5	Wet, V. Dark Gray, Clayey, SAND with Gravel, Pieces of Wood	SC/SM
Jar-10	13.5-15.0	Wet, V. D. Gray, Silty SAND (1) with Gravel (2) & Claylens, Tr. of Shells + Wood	(SM)
small sample Jar-11	15.0-16.5	Moist, V. D. Gray, Poorly Graded SAND with Silt	(SP-SM)
Jar-12	16.5-18.0	Moist, Grayish Brown, silty, SAND Trace of Organic Matr.	(SM)
Jar-13	18.0-19.5	Moist, D. Gray, silty, SAND Trace of Organic Matr.	(SM)
Jar-14	19.5-21.0	Wet, D. Gray, silty, SAND	(SM)
Jar-15	21.0-22.5	Ditto	(SM)
Jar-16	22.5-24.0	Wet, Dark Gray, silty, SAND with Gravel	(SM)
Jar-17	24.0-25.5	Wet, Dark Gray, Clayey, SAND with Gravel	(SC)
Jar-18	25.5-27.0	Moist, Brown, clayey, SAND with Gravel	(SC)
Jar-19	27.0-28.5	Wet, Brown, silty, SAND with Gravel	(SM)
Jar-20	28.5-30.0	Moist, Brown, silty, SAND Trace of Gravel	(SM)

(1) Sand size particles are a mixture of Cinders.

(2) Gravel size particles are a mixture of Cinders

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Estes

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-07			
Jar-1	0.0-1.5	moist dk gry poorly graded sand (1) w/silt and gravel	(SP-SM)
Jar-2	1.5-3.0	no sample	—
very small sample Jar-3	3.0-4.5	wet dk grybrn silty gravel w/sand	(GM)
Jar-4	4.5-6.0	ditto	(GM)
Jar-5	6.0-7.5	ditto	(GM)
small sample Jar-6	7.5-9.0	wet dk gry silty sand (2) w/gravel	(SM)
Jar-7	9.0-10.5	very moist dk grybrn sandy lean to fat clay trace of gravel	CL/CH
Jar-8	10.5-12.0	moist dk grybrn fat clay (3) trace of sand	(CH)
Jar-9	12.0-13.5	ditto (3)	(CH)
Jar-10	13.5-15.0	ditto (3)	(CH)
Jar-11	15.0-16.5	ditto (3)	(CH)
Jar-12	16.5-18.0	ditto (3)	(CH)
Jar-13	18.0-19.5	ditto (3)	(CH)
Jar-14	19.5-21.0	ditto (3)	(CH)
Jar-15	21.0-22.5	ditto (3)	(CH)
Jar-16	22.5-24.0	ditto (3)	(CH)
Jar-17	24.0-25.5	very moist dk grybrn clayey sand (2)	(SC)
Jar-18	25.5-27.0	wet dk grybrn silty sand (2)	(SM)
Jar-19	27.0-28.5	ditto (2)	(SM)
Jar-20	28.5-30.0	ditto (2)	(SM)

(1) trace of cinders
(2) medium to fine sand
(3) trace of shell fragments

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Estes

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-08			
Jar-1	0.0-1.5	moist blk poorly graded sand (1) w/silt and gravel trace roots	(SP-SM)
Jar-2	1.5-3.0	moist gry brn ditto (2)	(SP-SM)
Jar-3	3.0-4.5	wet gry brn poorly graded sand (2) w/silt	(SP-SM)
Jar-4	4.5-6.0	very moist dk gry brn sandy lean to fat clay trace of gravel	(CL/CH
Jar-5	6.0-7.5	moist dk gry fat clay w/sand trace of gravel	(CH)
Jar-6	7.5-9.0	moist dk gry fat clay w/sand	(CH)
Jar-7	9.0-10.5	ditto	(CH)
Jar-8	10.5-12.0	ditto	(CH)
Jar-9	12.0-13.5	moist dk gry brn fat clay w/sand trace of gravel	(CH)
Jar-10	13.5-15.0	moist dk gry fat clay w/sand (2) trace of gravel	(CH)
Jar-11	15.0-16.5	moist dk gry brn fat clay trace of sand	(CH)
Jar-12	16.5-18.0	ditto	(CH)
Jar-13	18.0-19.5	ditto (3)	(CH)
Jar-14	19.5-21.0	ditto	(CH)
Jar-15	21.0-22.5	moist dk gry brn sandy fat clay (3)	(CH)
Jar-16	22.5-24.0	wet dk gry brn poorly graded sand (2) w/silt	(SP-SM)
Jar-17	24.0-25.5	ditto (2)	(SP-SM)
Jar-18	25.5-27.0	wet dk yel brn silty sand (2)	(SM)
Jar-19	27.0-28.5	wet dk gry brn ditto (2)	(SM)
Jar-20	28.5-30.0	wet dk gry brn poorly graded sand (2) w/silt	(SP-SM)
		(1) coarse to fine sand	
		(2) medium to fine sand	
		(3) trace of wood pieces	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-09			
Jar-1	0.0-1.5	Moist black silty coarse sand w/ roots ①	(SM)
Jar-2	1.5-3.0	V. moist grayish brn silty coarse sand w/ grav (wood & brick)	(SM)
Jar-3	3.0-4.5	Wet dk gray poorly graded med sand w/ silt	(SP-SM)
Jar-4	4.5-6.0	Wet dk gray soft fat clay	(CH)
Jar-5	6.0-7.5	- ditto -	(CH)
Jar-6	7.5-9.0	- ditto -	(CH)
Jar-7	9.0-10.5	- ditto -	(CH)
Jar-8	10.5-12.0	V. moist dk gray soft fat clay w/ sand	(CH)
Jar-9	12.0-13.5	- ditto - (Tr. shells)	(CH)
Jar-10	13.5-15.0	V. moist dk gray clayey fine sand	SC
Jar-11	15.0-16.5	V. moist brn clayey med-coarse sand w/ gravel	SC/S
Jar-12	16.5-18.0	- ditto -	SC/SM
Jar-13	18.0-19.5	Wet brown silty fine sand	(SM)
Jar-14	19.5-21.0	Wet brown clayey fine sand	(SC)
Jar-15	21.0-22.5	Wet brown silty v. fine sand	(SM)
Jar-16	22.5-24.0	Wet brown sandy silt	(ML)
Jar-17	24.0-25.5	Wet brown silty fine sand w/ gravel	(SM)
Jar-18	25.5-27.0	Wet brown silty gravel w/ sand	(GM)
Jar-19	27.0-28.5	- ditto -	(GM)
Small sample Jar-20	28.5-30.0	- ditto -	(GM)
		① Sand is mostly cinders	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-10			
Jar-1	0.0-1.5	Moist v. dk grayish brn silty med-coarse sand w/ grav	(SM)
Jar-2	1.5-3.0	Moist brown poorly graded med sand w/ silt	(SP-SM)
Jar-3	3.0-4.5	V. moist - ditto -	(SP-SM)
Jar-4	4.5-6.0	Wet brown silty med sand	(SM)
Jar-5	6.0-7.5	Wet dk gray soft fat to lean clay w/ sand	(CL)
Jar-6	7.5-9.0	Wet dk gray poorly graded med sand w/ silt	(SP-SM)
Jar-7	9.0-10.5	- ditto -	(SP-SM)
Jar-8	10.5-12.0	- ditto -	(SP-SM)
Jar-9	12.0-13.5	- ditto -	(SP-SM)
Jar-11	15.0-16.5		
Jar-10	13.5-15.0	60% - ditto - 40% Wet black soft fat to lean clay	(SP-SM) CH/CL
Jar-11	15.0-16.5	V. moist dk gray soft fat clay (Tr. shells)	(CH)
Jar-12	16.5-18.0	- ditto -	(CH)
Jar-13	18.0-19.5	Wet - ditto -	(CH)
Jar-14	19.5-21.0	- ditto -	(CH)
Jar-15	21.0-22.5	- ditto -	(CH)
Jar-16	22.5-24.0	V. moist ditto	(CH)
Jar-17	24.0-25.5	Wet black soft fat to lean clay w/ sand lens	CH/CL
Jar-18	25.5-27.0	Wet dk gray silty med sand	(SM)
Jar-19	27.0-28.5	Wet brown poorly graded med sand w/ silt	(SP-SM)
Jar-20	28.5-30.0	Wet dk gray - ditto -	(SP-SM)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-11			
Very small sample Jar-1	0.0-1.5	Moist, Black, silty, SAND w/cinders Tr. of roots	(SM)
Small Jar-2	1.5-3.0	Moist, Brown, Poorly Graded SAND with silt	(SP-SM)
Jar-3	3.0-4.5	Ditto	(SP-SM)
Jar-4	4.5-6.0	Ditto	(SP-SM)
Jar-5	6.0-7.5	Wet, Brown, Poorly Graded SAND Trace of shells	(SP-SM)
Very small sample Jar-6	7.5-9.0	Ditto	(SP-SM)
Jar-7	9.0-10.5	Wet, V. Dark Gray, silty, Fine SAND Trace of Coal + Shells	(SM)
Jar-8	10.5-12.0	V. Moist, V. Dark Gray, clayey, Fine SAND Trace of Coal Shells	SM/SC
Jar-9	12.0-13.5	V. Moist, V. Dark Gray, clayey, SAND Trace of Shells	SC/CL
Jar-10	13.5-15.0	Moist, Dark Gray, Sandy, FAT CLAY Trace of Shells	(CH)
Jar-11	15.0-16.5	Moist, Very Dark Gray, SOFT FAT CLAY w/sandy, Tr. Shells	(CH)
Jar-12	16.5-18.0	Moist, V. Dark Gray, SOFT FAT CLAY Trace of Sand & Shells	(CH)
Jar-13	18.0-19.5	Ditto Trace of Sand & Shells	(CH)
Jar-14	19.5-21.0	Ditto Trace of Sand & Shells	(CH)
Jar-15	21.0-22.5	Moist, Dark Gray, Clayey, SAND Trace of Shells	(SC)
Jar-16	22.5-24.0	Ditto	(SC)
Jar-17	24.0-25.5	Moist, V. Dark Gray, Clayey, SAND	(SC)
Jar-18	25.5-27.0	Wet, Brown, Poorly Graded SAND with silt	(SP-SM)
Jar-19	27.0-28.5	Ditto	(SP-SM)
Small Sample Jar-20	28.5-30.0	Ditto	(SP-SM)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-34			
Jar-1	0.0-1.5	Moist DK Brown, Silty, SAND with Gravel, Trace of Roots + Clay	(SM)
Jar-2	1.5-3.0	Ditto with Gravel, Trace of Clay	(SM)
Jar-3	3.0-4.5	Ditto with Gravel	(SM)
Jar-4	4.5-6.0	Ditto with Gravel, Trace of Clay	(SM)
Jar-5	6.0-7.5	Moist, Black + Brown, Silty, SAND with Gravel + Piece of Wood + Roots + Cinders	(SM)
Very Small Jar-6	7.5-9.0	Moist, Very Dark Brown, Silty, SAND Trace of Roots + Cinders, Gravel	(SM)
Jar-7	9.0-10.5	Wet, Black, Silty, SAND ① with Gravel ②	(SM)
Jar-8	10.5-12.0	Moist, Black Silty, SAND ① with Gravel ②	(SM)
Jar-9	12.0-13.5	Moist, DK Gray, SOFT FAT CLAY Trace of Sand ①	(CH)
Jar-10	13.5-15.0	Ditto Trace of Sand ①	(CH)
Jar-11	15.0-16.5	Ditto " " "	(CH)
Jar-12	16.5-18.0	Ditto " " "	(CH)
Jar-13	18.0-19.5	Ditto Trace of Sand + Shells	(CH)
Jar-14	19.5-21.0	Moist, yell. Brn + Grey, clayey, SAND Trace of Shells	(SC)
Jar-15	21.0-22.5	Ditto	(SC)
Jar-16	22.5-24.0	Moist, Brown, clayey, SAND	SC/SM
Jar-17	24.0-25.5	ditto Trace of Gravel	SC/SM
Jar-18	25.5-27.0	ditto with Gravel	SC/SM
Jar-19	27.0-28.5	ditto with Gravel	SC/SM
Jar-20	28.5-30.0	ditto With Gravel	SC/SM

① Sand size particles are a mixture of Sand, Cinders and Coal.

② Gravel size particles are a mixture of Gravel, Cinders and Coal.

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: DANKO

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-35			
Jar-1	0.0-1.5	Moist, Dark Brown, Silty, SAND Trace of Gravel	(SM)
Jar-2	1.5-3.0	Ditto Trace of Gravel	(SM)
Jar-3	3.0-4.5	Ditto with Cinders, Glass + roots	(SM)
Jar-4	4.5-6.0	Moist, Black, Silty, SAND (1) with Gravel (2)	(SM)
very small Jar-5	6.0-7.5	Ditto (1) with Gravel (2) + pieces of Concrete Frags	(SM)
Jar-6	7.5-9.0	Ditto (1) with Gravel (2) + Concrete Fragments	(SM)
Jar-7	9.0-10.5	Wet, Black, Silty, SAND (1) with Gravel (2)	(SM)
Jar-8	10.5-12.0	Wet, V.Dk. Gray, Poorly Graded SAND (1) with Silt & Gravel (2)	(SP-SM)
Jar-9	12.0-13.5	Ditto (1) " " " (2)	(SP-SM)
Jar-10	13.5-15.0	Ditto (1) " " " (2)	(SP-SM)
Jar-11	15.0-16.5	Wet, Dk Gray, Poorly Graded SAND (1) with Silt	SP-SM
Jar-12	16.5-18.0	Ditto (1) with Silt + Gravel (2)	(SP-SM)
Jar-13	18.0-19.5	V. Moist, Dk Gray + Brown, Silty, SAND (1) Trace of Gravel + Shells	(SM)
Jar-14	19.5-21.0	Wet, Brown, Silty, SAND Trace of Gravel	(SM)
Jar-15	21.0-22.5	V. Moist, Brown, Silty, FINE SAND Trace of Sand	(SM)
Jar-16	22.5-24.0	Ditto Trace of Sand	(SM)
Jar-17	24.0-25.5	V. Moist, Brown, Fine Sandy, Lean CLAY Trace of Gravel	(CL)
Jar-18	25.5-27.0	Ditto Trace of Gravel	(CL)
Jar-19	27.0-28.5	Ditto Trace of Gravel	(CL)
very small Jar-20	28.5-30.0	Moist, Brown, Silty, SAND Trace of Gravel	(SM)
		(1) Sand size particles are a mixture of Sand, Cinders and Coal.	
		(2) Gravel size particles are a mixture of Gravel, Cinders and Coal.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: Danko

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-36			
Jar-1	0.0-1.5	Moist, Brown, clayey, SAND Trace of Gravel	SC/SM
Jar-2	1.5-3.0	Moist, DK Brown, silty, SAND ① Trace of Gravel ②	(SM)
Jar-3	3.0-4.5	Moist, DK Brown, silty, SAND ① with Gravel ②	SM/SC
Small Jar-4	4.5-6.0	Moist, Black, Silty, SAND ① Trace of Gravel ②	(SM)
Jar-5	6.0-7.5	60% moist, Black, silty SAND ① with Gravel ②	(SM)
		40% moist, Grayish Brown, silty FINE SAND	SM/SC
Small Jar-6	7.5-9.0	Wet, Black, silty, SAND ① with Gravel ②	(SM)
Jar-7	9.0-10.5	Ditto ① ②	(SM)
Jar-8	10.5-12.0	Ditto ① ②	(SM)
Jar-9	12.0-13.5	Moist, Dark Gray, SOFT FAT CLAY	(CH)
Jar-10	13.5-15.0	50% Ditto	(CH)
		50% moist, Dark Gray, silty, SAND Trace of Shells	(SM)
Jar-11	15.0-16.5	60% moist, Dark Gray, clayey, SAND Trace of Shells	(SC)
		40% moist, Dark Gray, SOFT FAT CLAY	(CH)
Jar-12	16.5-18.0	Moist, Dark Gray, SOFT FAT CLAY Trace of Sand + Shells	(CH)
Jar-13	18.0-19.5	Ditto Trace of Shells	(CH)
Jar-14	19.5-21.0	Ditto	(CH)
Jar-15	21.0-22.5	Ditto	(CH)
Jar-16	22.5-24.0	Ditto Trace of Shells + Organic Material	(CH)
Jar-17	24.0-25.5	Moist, Black, SILT (sample is mostly Organic Matr'l)	ML/OL
Jar-18	25.5-27.0	Moist, DK Gray + Black, sandy, FAT CLAY with Organic Matr'l	(CH)
Jar-19	27.0-28.5	Moist, DK. Grayish Brown, clayey, SAND with Gravel	(SC)
Jar-20	28.5-30.0	Moist, Brown, sandy, CLAY Trace of Gravel	CL/SC
		① Sand size particles are a mixture of Sand, Cinders and coal.	
		② Gravel size particles are a mixture of Gravel, Cinders and Coal.	

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-37			
Jar-1	0.0-1.5	Moist black silty med sand w/ gravel & pieces of wood	(SM)
Jar-2	1.5-3.0	-ditto- " "	(SM)
Jar-3	3.0-4.5	Wet brown poorly graded med sand w/ silt	(SP-SM)
Jar-4	4.5-6.0	-ditto-	(SP-SM)
Jar-5	6.0-7.5	Wet brown silty fine sand	(SM)
small sample Jar-6	7.5-9.0	Wet dk grayish brn poorly graded med sand w/ silt	(SP-SM)
Jar-7	9.0-10.5	-ditto-	(SP-SM)
Jar-8	10.5-12.0	-ditto-	(SP-SM)
Jar-9	12.0-13.5	Wet black soft fat clay w/ silt lense	(CH)
Jar-10	13.5-15.0	Wet greenish black soft fat clay	(CH)
Jar-11	15.0-16.5	-ditto-	(CH)
Jar-12	16.5-18.0	-ditto-	(CH)
Jar-13	18.0-19.5	-ditto-	(CH)
Jar-14	19.5-21.0	-ditto-	(CH)
Jar-15	21.0-22.5	EMPTY JAR	—
Jar-16	22.5-24.0	V. moist greenish black soft fat clay (Tr. shells)	(CH)
Jar-17	24.0-25.5	-ditto- "	(CH)
Jar-18	25.5-27.0	-ditto- "	(CH)
Jar-19	27.0-28.5	-ditto- "	(CH)
Jar-20	28.5-30.0	V. moist dk gray -ditto- "	(CH)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-38			
Jar-1	0.0-1.5	V. moist black silty fine-med sand w/ (roots grass sticks + grass V)	(SM)
Jar-2	1.5-3.0	Moist black + reddish brn silty coarse sand w/ sticks roots	(SM)
Jar-3	3.0-4.5	V. moist black silty coarse sand	(SM)
Jar-4	4.5-6.0	V. moist black + strong brn silty coarse sand w/ wood + decayed org.	(SM)
Jar-5	6.0-7.5	Wet dk grayish brn silty med-coarse sand	(SM)
Jar-6	7.5-9.0	Wet dk gray silty fine sand w/ shell frags.	(SM)
Jar-7	9.0-10.5	-ditto- "	(SM)
Jar-8	10.5-12.0	Wet dk gray silty fine sand w/ shell frags + clay lense	(SM)
Jar-9	12.0-13.5	-ditto- w/ " " & "	(SM)
Jar-10	13.5-15.0	V. moist dk gray soft silt	(ML)
Jar-11	15.0-16.5	V. moist dk gray soft silt w/ sand	(ML)
Jar-12	16.5-18.0	V. moist dk gray sandy silt	(ML)
Jar-13	18.0-19.5	V. moist dk gray soft lean clay	(CL)
Jar-14	19.5-21.0	V. moist black soft fat clay	(CH)
Jar-15	21.0-22.5	V. moist dk gray soft fat clay	(CH)
Jar-16	22.5-24.0	-ditto-	(CH)
Jar-17	24.0-25.5	-ditto-	(CH)
Jar-18	25.5-27.0	-ditto-	(CH)
Jar-19	27.0-28.5	-ditto-	(CH)
Jar-20	28.5-30.0	Wet dk gray clayey fine sand	(SC)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-39			
Jar-1	0.0-1.5	Moist v. dk brn silt med sand w/ grass + roots	(SM)
Jar-2	1.5-3.0	Moist weak red + black silty coarse sand	(SM)
Jar-3	3.0-4.5	V. moist reddish brn silty gravel w/ sand	(GM)
Jar-4	4.5-6.0	Wet black silty coarse sand (Tr. sticks)	(SM)
Jar-5	6.0-7.5	Wet black silty coarse sand w/ gravel (Tr. sticks)	(SM)
small sample Jar-6	7.5-9.0	Wet black silty coarse sand	(SM)
Jar-7	9.0-10.5	- ditto -	(SM)
Jar-8	10.5-12.0	Wet dk gray silty coarse sand w/ glass + other debris	(SM)
Jar-9	12.0-13.5	Wet dk gray silty med sand (Tr gravel)	(SM)
Jar-10	13.5-15.0	Wet dk gray silty fine - med sand	(SM)
Jar-11	15.0-16.5	Wet dk gray silty coarse sand	(SM
Jar-12	16.5-18.0	ditto	(SM)
Jar-13	18.0-19.5	Wet dk greenish gray soft fat clay	(CH)
Jar-14	19.5-21.0	Wet dk gray silty fine sand	(SM)
Jar-15	21.0-22.5	- ditto -	(SM)
Jar-16	22.5-24.0	- ditto -	(SM)
Jar-17	24.0-25.5	- ditto - (Tr gravel)	(SM)
Jar-18	25.5-27.0	- ditto - "	(SM)
Jar-19	27.0-28.5	Wet dk gray silty fine sand	(SM)
Jar-20	28.5-30.0	Wet brown poorly graded med sand w/ silt	(SP-SM)

VISUAL-MANUAL CLASSIFICATIONS
(Test method: ASTM D2488)

PROJECT: Liberty State Park **DATE:** Nov.2003

AREA: Jersey City, NJ Classified by: KUHN

Sample No.	Depth (ft.)	Visual Classification	Symbol
LSP-03-40			
Jar-1	0.0-1.5	V. moist black poorly graded coarse sand w/ silt ①	(SP-SM)
Jar-2	1.5-3.0	Wet brown silty med sand (Tr. grav)	SM/ML
Jar-3	3.0-4.5	Wet black + brn silty coarse sand w/ pieces of wood	(SM)
Jar-4	4.5-6.0	Wet v. dk gray silty coarse sand w/ gravel	(SM)
Jar-5	6.0-7.5	-ditto - "	(SM)
Jar-6	7.5-9.0	Wet v. dk gray poorly graded coarse sand w/ silt	(SP-SM)
Jar-7	9.0-10.5	-ditto -	(SP-SM)
Jar-8	10.5-12.0	-ditto -	(SP-SM)
Jar-9	12.0-13.5	-ditto -	(SP-SM)
Jar-10	13.5-15.0	Wet v. dk gray silty med sand w/ gravel	(SM)
Jar-11	15.0-16.5	Wet dk gray soft sandy lean clay	(CL)
Jar-12	16.5-18.0	Wet dk gray clayey coarse sand	(SC)
Jar-13	18.0-19.5	Wet v. dk gray poorly graded med sand w/ silt	(SP-SM)
Jar-14	19.5-21.0	ditto - (med - coarse)	(SP-SM)
Jar-15	21.0-22.5	-ditto - (med)	(SP-SM)
Jar-16	22.5-24.0	V. moist brown poorly graded med sand	(SP)
Jar-17	24.0-25.5	Wet dk gray silty med. sand	(SM)
Jar-18	25.5-27.0	Wet dk gray poorly graded med sand w/ silt	(SP-SM)
Jar-19	27.0-28.5	ditto -	(SP-SM)
Jar-20	28.5-30.0	Wet brown ditto -	(SP-SM)
		① SAND IS MOSTLY CINDERS	

VISUAL-MANUAL CLASSIFICATION
(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** DANKO

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
CAØ4-2			
JAR-1	0.0-1.5	Moist, Dk. Gray, Sandy, lean CLAY w/ Coal Frags & Roots	ML/CL
-2	1.5-3.0	Moist, DK Gray, LEAN CLAY Tr. Fine Sand	(CL)
-3	3.0-4.5	Wet, Black, silty, SAND w/ Coal + Cinders	(SM)
-4	4.5-6.0	Ditto w/ Coal + Cinders	(SM)
-5	6.0-7.5	Wet, lt. Gray to Black, silty, SAND w/ Coal + Cinders	(SM)
-6	7.5-9.0	Wet, Very Dk. Gray, silty, SAND w/ Gravel, Coal Frags, & Cinders	(SM)
-7	9.0-10.5	Ditto w/ Gravel, Coal Frag, & Cinders	(SM)
-8	10.5-12.0	Moist, DK. Gray, Clayey, SAND w/ Cinders + Coal Frags	(SC)
-9	12.0-13.5	Moist, V. DK. Gray, FAT CLAY Trace of Sand	(CH)
-10	13.5-15.0	EMPTY JAR	—
-11	15.0-16.5	Moist, Dk. Grayish Brown & Black, FAT CLAY	(CH)
-12	16.5-18.0	Moist, V. DK. Gray, SOFT FAT CLAY Tr. of Shells	(CH)
-13	18.0-19.5	Ditto Trace of Shells	(CH)
-14	19.5-21.0	Ditto Trace of Shells	(CH)
-15	21.0-22.5	Ditto Trace of Shells	(CH)
-16	22.5-24.0	Ditto Trace of Shells	(CH)
-17	24.0-25.5	Ditto Trace of Shells	(CH)
-18	25.5-27.0	Ditto Trace of Shells	(CH)
-19	27.0-28.5	Ditto Trace of Shells	(CH)
-20	28.5-30.0	Ditto Trace of Shells	(CH)

VISUAL-MANUAL CLASSIFICATION
(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
CAØ4-3			
JAR-1	0.0-1.5	V. moist v. dk grayish brn silty med sand (tr. roots)	(SM)
-2	1.5-3.0	Moist v. dk grayish brn sandy silt w/ twigs & roots	(ML)
-3	3.0-4.5	V. moist black soft lean clay w/ sand (tr roots petrol. odor)	(CL)
-4	4.5-6.0	Wet black poorly graded coarse sand ①	(SP)
-5	6.0-7.5	ditto ①	(SP)
-6	7.5-9.0	Wet black poorly graded coarse sand ② w/ gravel	(SP)
-7	9.0-10.5	Wet black poorly graded coarse sand ① w/ silt	(SP-SM)
-8	10.5-12.0	ditto ①	(SP-SM)
-9	12.0-13.5	ditto ①	(SP-SM)
-10	13.5-15.0	EMPTY JAR	—
-11	15.0-16.5	Wet black poorly graded med sand w/ silt	(SP-SM)
-12	16.5-18.0	ditto —	(SP-SM)
-13	18.0-19.5	V. moist black + dk gray soft lean clay (tr shell frag)	(CL)
-14	19.5-21.0	V. moist v. dk gray soft fat clay (tr shells)	(CH)
-15	21.0-22.5	ditto -	(CH)
-16	22.5-24.0	- ditto -	(CH)
-17	24.0-25.5	- ditto -	(CH)
-18	25.5-27.0	- ditto -	(CH)
-19	27.0-28.5	- ditto -	(CH)
-20	28.5-30.0	- ditto -	(CH)

① Sand is cinders
② Sand & gravel are cinders

VISUAL-MANUAL CLASSIFICATION
(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
CAØ4-4			
JAR-1	0.0-1.5	Moist, V. dk Grayish Brown, Sandy, LEAN CLAY w/ Roots Cinders Concrete Frags	(CL)
-2	1.5-3.0	Moist, V. dk. Grayish Brown, Clayey, SAND w/ Gravel & Cinders	(SC)
-3	3.0-4.5	75 grams of Concrete Frags, Pieces of WOOD & SAND	—
-4	4.5-6.0	Wet, V. dk. Gray & Black, Silty, SAND w/ organic MAT'L & Gravel & Cinders	(SM)
-5	6.0-7.5	Ditto w/ Gravel, Organic MAT'L & Cinders	(SM)
-6	7.5-9.0	Wet, dk. Grayish Brown, Poorly Graded SAND w/ s.lt Tr. Gravel	(SP-SM)
-7	9.0-10.5	Wet, dk. Grayish Brown, Silty, SAND w/ Gravel & Shells	(SM)
Small Sample-8	10.5-12.0	Moist, dk. Grayish Brown, Silty, SAND w/ Gravel & Cinders	(SM)
Small Sample-9	12.0-13.5	Wet v. dk gray poorly graded med sand w/ silt	(SP-SM)
-10	13.5-15.0	EMPTY JAR	—
-11	15.0-16.5	V. moist dk gray & black soft fat clay	(CH)
-12	16.5-18.0	- ditto - (tr shells)	(CH)
-13	18.0-19.5	V. moist dk gray & black soft fat clay ①	(CH)
-14	19.5-21.0	- ditto - (Tr shells)	(CH)
-15	21.0-22.5	V. moist black soft fat clay (Tr shells)	(CH)
-16	22.5-24.0	V. moist v. dk gray soft fat clay (Tr. shells)	(CH)
-17	24.0-25.5	- ditto - "	(CH)
-18	25.5-27.0	- ditto - "	(CH)
-19	27.0-28.5	- ditto - "	(CH)
-20	28.5-30.0	- ditto - "	(CH)

① Petroleum odor

VISUAL-MANUAL CLASSIFICATION
(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** DANIK

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
CAØ4-S			
JAR-1	0.0-1.5	Moist, DK Gray, LEAN CLAY w/Sand & Roots	(CL)
-2	1.5-3.0	Moist, V.DK Brown, Silty, SAND w/Pieces of Wood ①	(SM)
-3	3.0-4.5	Ditto w/Pieces of Wood, Coal & Cinders ①	(SM)
-4	4.5-6.0	Moist, V.DK. Grayish Brown, silty, SAND w/large piece of Wood	(SM)
-5	6.0-7.5	Moist, DK Grayish Brown, silty, SAND Trace of Gravel	(SM)
-6	7.5-9.0	Wet, V.DK. Grayish Brown, Silty, SAND Trace of Gravel	(SM)
-7	9.0-10.5	Moist, DK Brown, silty, SAND Trace of Gravel	(SM)
-8	10.5-12.0	Wet, DK Gray, Sandy, SILT Trace of Gravel	ML/SM
-9	12.0-13.5	Moist, DK Grayish Brown, Sandy, LEAN CLAY	(CL)
Small Sample -10	13.5-15.0	Moist, DK. Gray, SOFT FAT CLAY	(CH)
-11	15.0-16.5	Ditto Trace of Shells	(CH)
-12	16.5-18.0	Ditto Trace of Shells	(CH)
-13	18.0-19.5	Ditto Trace of Shells	(CH)
-14	19.5-21.0	Ditto Trace of Shells & Wood	(CH)
-15	21.0-22.5	Ditto Trace of Shells	(CH)
-16	22.5-24.0	Ditto Trace of Shells	(CH)
-17	24.0-25.5	Ditto Trace of Shells	(CH)
-18	25.5-27.0	Ditto No Shells	(CH)
-19	27.0-28.5	Ditto No Shells	(CH)
-20	28.5-30.0	Ditto Trace of Shells	(CH)
		① Petroleum Odor	

VISUAL-MANUAL CLASSIFICATION

(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** DANKO

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
CAØ4-6			
JAR-1	0.0-1.5	Wet, V.dark Grayish Brown, Silty, SAND w/ Gravel + pieces of wood	(SM)
Small Sample-2	1.5-3.0	Wet, DK Yellowish Brown, Poorly Graded SAND w/ silt	(SP-SM)
-3	3.0-4.5	Ditto	(SP-SM)
-4	4.5-6.0	Ditto	(SP-SM)
-5	6.0-7.5	Moist, Ditto	(SP-SM)
-6	7.5-9.0	Moist, Ditto	(SP-SM)
Small Sample 7	9.0-10.5	Wet, Ditto	(SP-SM)
-8	10.5-12.0	Wet, Ditto	(SP-SM)
-9	12.0-13.5	Moist, DK Gray, SOFT LEAN CLAY	(CL)
-10	13.5-15.0	Very Moist, DK Gray, SOFT FAT CLAY Trace of Shells	(CH)
-11	15.0-16.5	Ditto Trace of Shells	(CH)
-12	16.5-18.0	Ditto	(CH)
-13	18.0-19.5	Ditto Trace of Shells	(CH)
-14	19.5-21.0	Moist, DK Gray, SOFT FAT CLAY	(CH)
-15	21.0-22.5	Ditto	(CH)
-16	22.5-24.0	Ditto	(CH)
-17	24.0-25.5	Ditto	(CH)
-18	25.5-27.0	Ditto	(CH)
-19	27.0-28.5	Ditto	(CH)
-20	28.5-30.0	Ditto	(CH)

VISUAL-MANUAL CLASSIFICATION

(Test method: ASTM D 2488)

OJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
NCØ4-1			
JAR-1	0.0-1.5	Wet black silty fine sand w/ pieces of wood	(SM)
V. small sample-2	1.5-3.0	Wet black soft lean clay	(CL)
-3	3.0-4.5	Wet v. dk gray soft fat clay ①	(CH)
-4	4.5-6.0	- ditto - ①	(CH)
-5	6.0-7.5	- ditto - ①	(CH)
-6	7.5-9.0	- ditto - ①	(CH)
-7	9.0-10.5	- ditto - ①	(CH)
-8	10.5-12.0	- ditto - ①	(CH)
-9	12.0-13.5	Wet dk gray & black soft fat clay	(CH)
V. small sample-10	15.0-16.5	ditto	(CH)
-11	16.5-18.0	ditto -	(CH)
-12	18.0-19.5	Wet dk gray soft fat clay (Tr shells)	(CH)
-13	19.5-21.0	ditto -	(CH)

① Petroleum odor

VISUAL-MANUAL CLASSIFICATION

(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
NC04-2			
JAR-1	0.0-1.5	Wet black silty v. fine sand w/ pieces of wood	(SM)
-2	1.5-3.0	Wet black soft lean clay ①	(CL)
-3	3.0-4.5	Wet black soft fat clay ①	(CH)
-4	4.5-6.0	-ditto- ①	(CH)
-5	6.0-7.5	-ditto- ①	(CH)
-6	7.5-9.0	-ditto- ①	(CH)
-7	10.5-12.0	-ditto- ① (+ sand & gravel)	(CH)
-8	12.0-13.5	Wet black soft fat clay	(CH)
-9	15.0-16.5	Wet dk gray soft fat clay	(CH)
-10	16.5-18.0	-ditto- (+ shells)	(CH)
-11	18.0-19.5	-ditto-	(CH)
-12	19.5-21.0	-ditto-	(CH)

① Petroleum odor

VISUAL-MANUAL CLASSIFICATION
(Test method: ASTM D 2488)

JECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
NC04	-3		
JAR-1	0.0-1.5	Wet dk grayish brn silty med sand (Tr. gravel, roots, grass)	(SM)
-2	1.5-3.0	Moist v. dk grayish brn silty med sand w/ gravel	(SM)
-3	3.0-4.5	Moist black poorly graded med sand w/ silt + roots	(SP-SM)
-4	4.5-6.0	Moist black sandy silt [50% pieces of wood]	(ML)
-5	6.0-7.5	V. moist black silty med-coarse sand w/ gravel + wood	(SM)
-6	7.5-9.0	100% WOOD	—
-7	9.0-10.5	Wet black silty med sand w/ 20% wood pieces	(SM)
-8	10.5-12.0	ditto - w/ 40% " "	(SM)
-9	12.0-13.5	ditto - ① w/ 80% " "	(SM)
-10	13.5-15.0	ditto - ① w/ 90% "	(SM)
-11	15.0-16.5	ditto - w/ 90% " "	(SM)
-12	16.5-18.0	EMPTY JAR	—
-13	18.0-19.5	EMPTY JAR	—
-14	19.5-21.0	100% WOOD	—

① Petroleum odor

VISUAL-MANUAL CLASSIFICATION

(Test method: ASTM D 2488)

PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
NC04 - 4			
JAR - 1	0.0 - 1.5	V. moist dk grayish brn silty med-coarse sand w/ gravel roots	(SM)
- 2	1.5 - 3.0	Moist dk brn silty med sand w/ gravel	(SM)
- 3	3.0 - 4.5	Moist black silty med sand (tr. gravel) ①	(SM)
- 4	4.5 - 6.0	Moist black silty med-coarse sand w/ gravel ①	(SM)
- 5	6.0 - 7.5	Wet black poorly graded coarse sand w/ silt	(SP-SM)
- 6	7.5 - 9.0	Wet v. dk gray silty coarse sand w/ gravel	(SM)
- 7	9.0 - 10.5	- ditto -	(SM)
- 8	10.5 - 12.0	Wet dk gray poorly graded coarse sand w/ silt	(SP-SM)
V. small sample 9	12.0 - 13.5	- ditto -	(SP-SM)
V. small sample 10	13.5 - 15.0	- ditto -	(SP-SM)
V. small sample - 11	15.0 - 16.5	- ditto -	(SP-SM)
- 12	16.5 - 18.0	- ditto -	(SP-SM)
- 13	18.0 - 19.5	- ditto -	(SP-SM)
V. small sample 14	19.5 - 21.0	Wet dk gray poorly graded coarse sand w/ silt + grav.	(SP-SM)
		① Some of the sand and gravel is coal fragments	

VISUAL-MANUAL CLASSIFICATION

(Test method: ASTM D 2488)

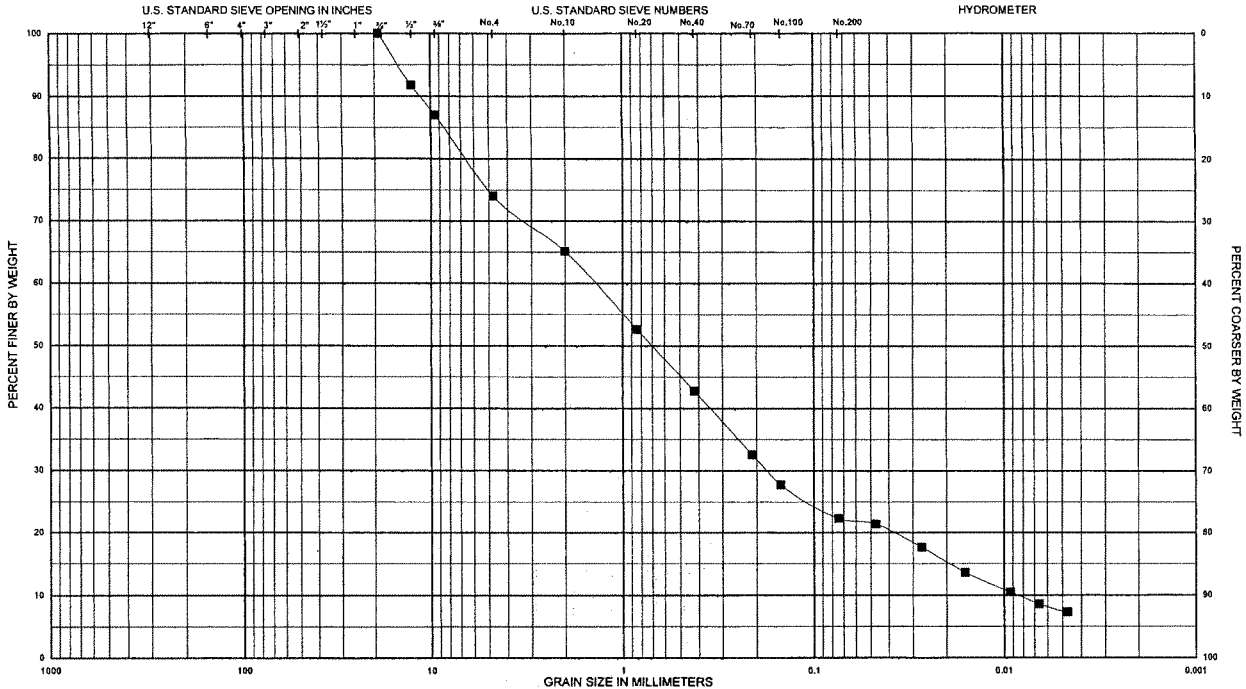
PROJECT: Liberty State Park **DATE:** Feb 2004

AREA: Additional Borings **CLASSIFIED BY:** KUHN

Jersey City, NJ

SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	SYMBOL
NCØ4 - 5			
JAR - 1	0.0 - 1.5	Moist dk grayish brn silty fine sand w/ roots grass	(SM)
- 2	1.5 - 3.0	- ditto - w/ piece of wood	(SM)
- 3	3.0 - 4.5	- ditto - w/ Tr. gravel	(SM)
- 4	4.5 - 6.0	Moist black silty med sand w/ gravel	(SM)
- 5	6.0 - 7.5	Moist black silty coarse sand w/ pieces of wood ①	(SM)
V. Small Sample - 6	7.5 - 9.0	Moist v. dk gray silty med sand (tr grav. & wood)	(SM)
- 7	9.0 - 10.5	Wet black silty med sand w/ 50% pieces of wood ①	(SM)
- 8	10.5 - 12.0	Wet black poorly graded med sand w/ silt + gravel + 30% wood	(SP-SM)
- 9	12.0 - 13.5	Wet black silty med-coarse sand w/ pieces of wood	(SM)
V. Small Sample 10	13.5 - 15.0	Wet v. dk gray silty med sand (tr gravel)	(SM)
that pie 11	15.0 - 16.5	Wet v. dk gray poorly graded med sand w/ silt	(SP-SM)
- 12	16.5 - 18.0	Wet v. dk gray poorly graded coarse sand w/ silt + piece of wood	(SP-SM)
- 13	18.0 - 19.5	- ditto -	(SP-SM)
- 14	19.5 - 21.0	WOOD w/ (Tr sand)	—
		① Petroleum odor	

APPENDIX D
GEOTECHNICAL TESTING RESULTS



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Silty sand with gravel (SM)	37.5	—	—	—

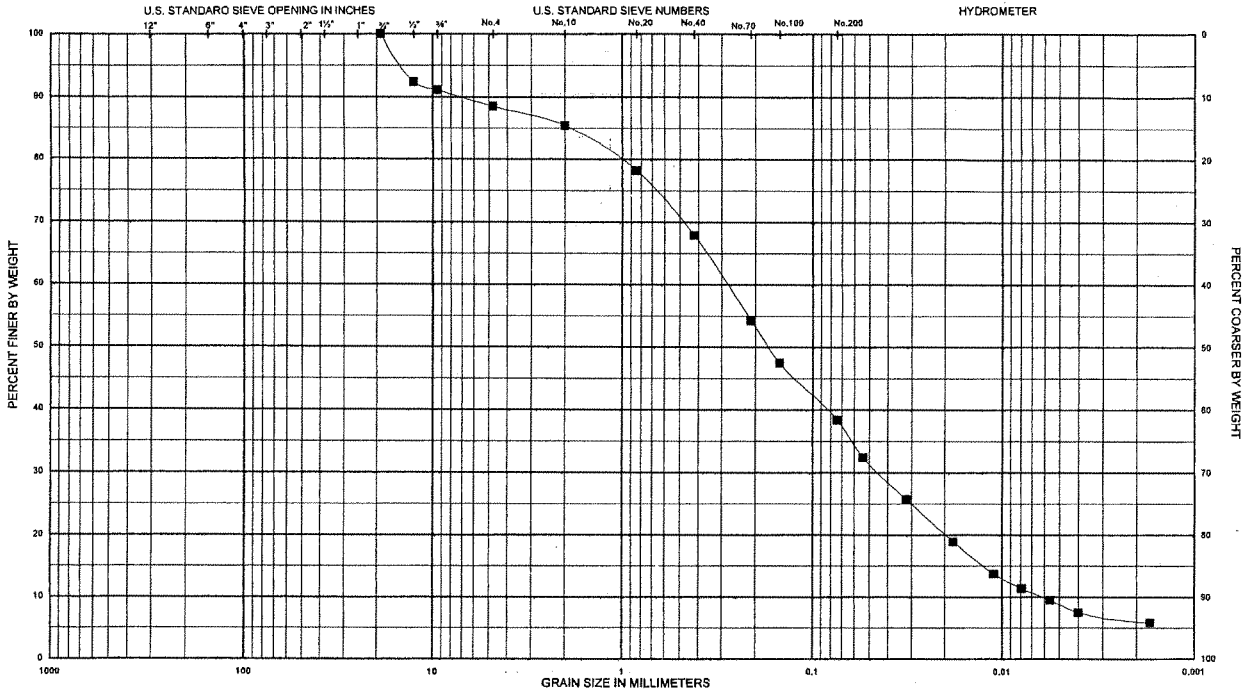
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-01

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand (tr. gravel)	(SM)	32.7	—	—	—

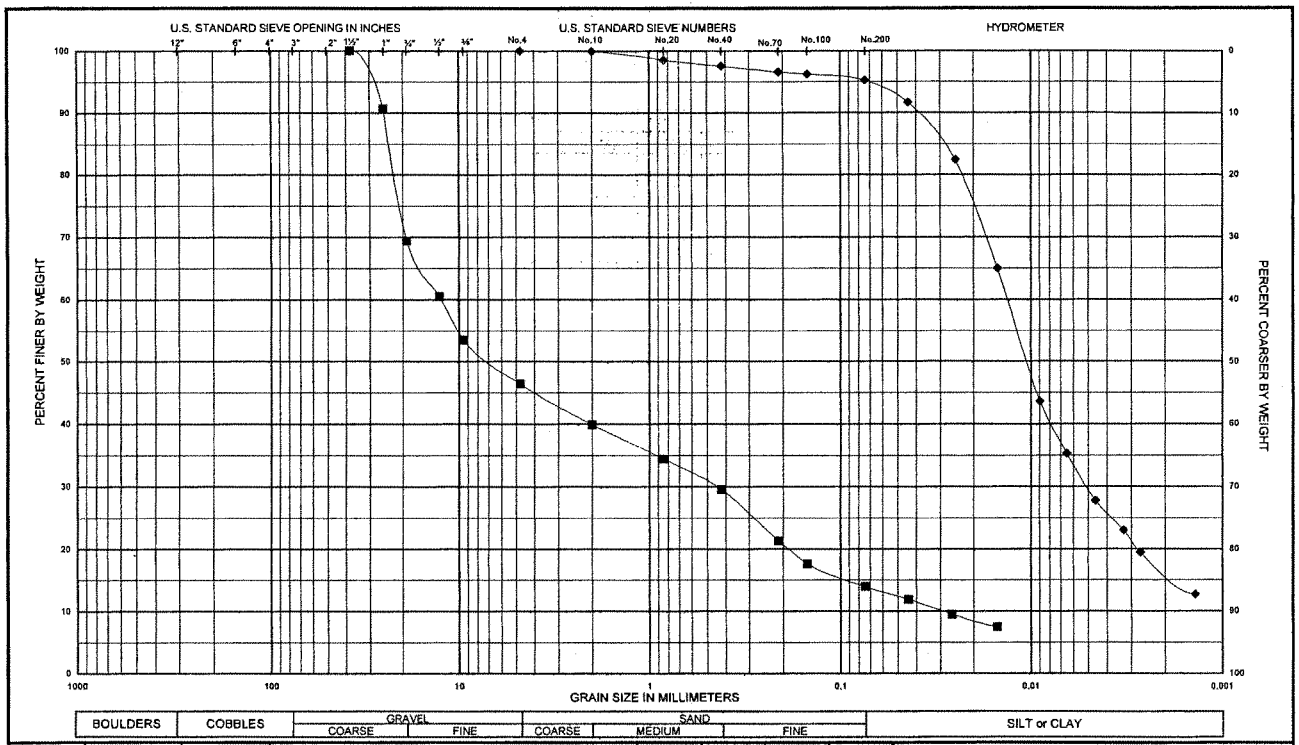
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-02

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty gravel with sand	(GM)	15.8	—	—	—
—◆—	Jar-17	24.0-25.5	Fat clay (tr. sand)	(CH)	54.2	68	30	38

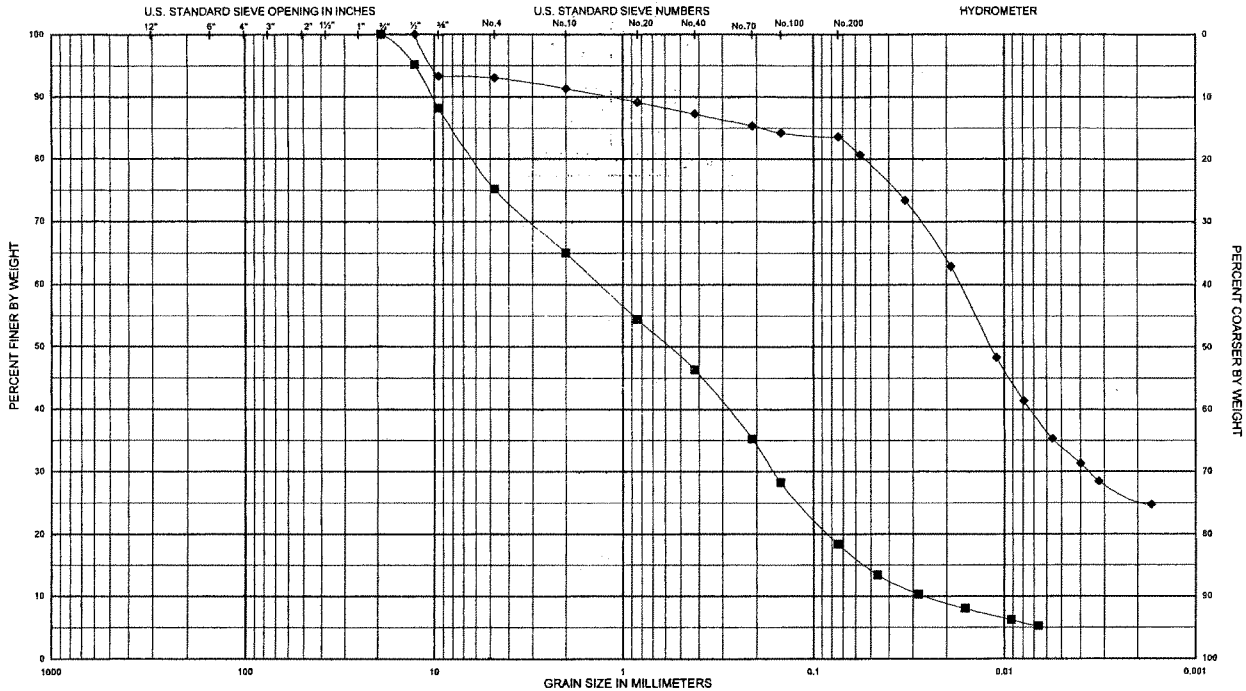
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-03

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand with gravel	(SM)	29.6	—	—	—
—◆—	Jar-8	10.5-12.0	Fat clay (tr. gravel & sand)	(CH)	57.1	68	31	37

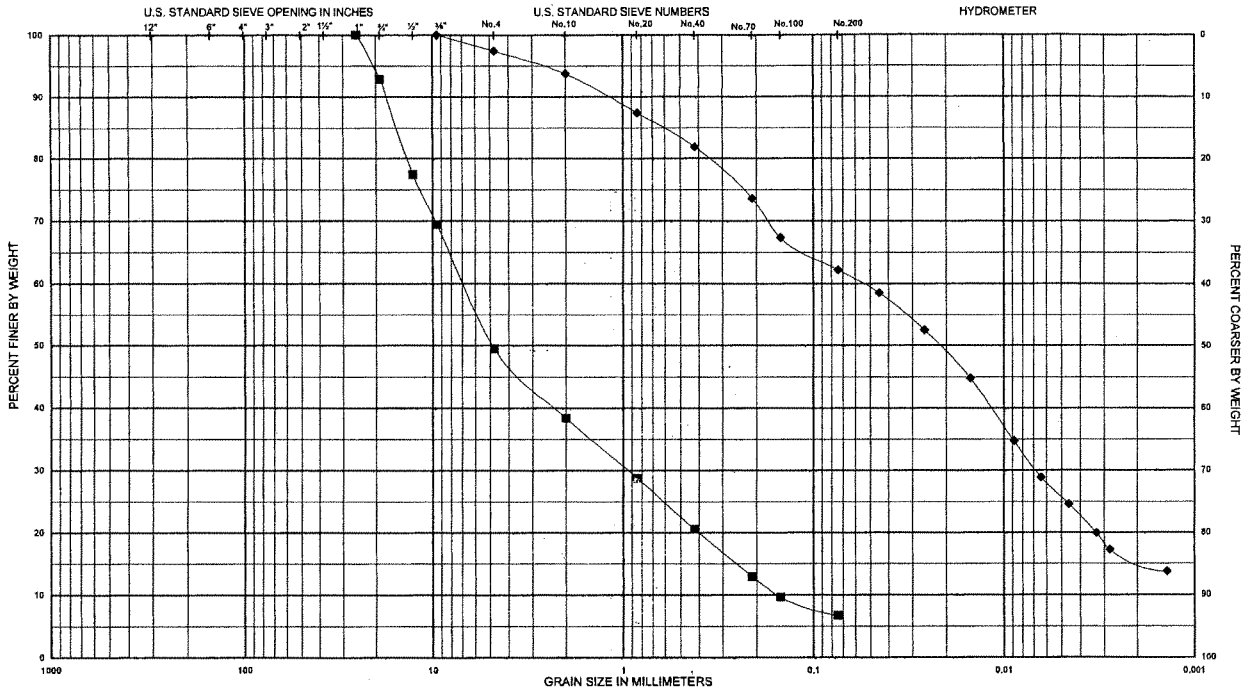
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-04

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Poorly graded gravel with silt and sand	(GP-GM)	9.6	—	—	—
—◆—	Jar-7	9.0-10.5	Sandy elastic silt (tr. gravel)	(MH)	60.5	74	39	35

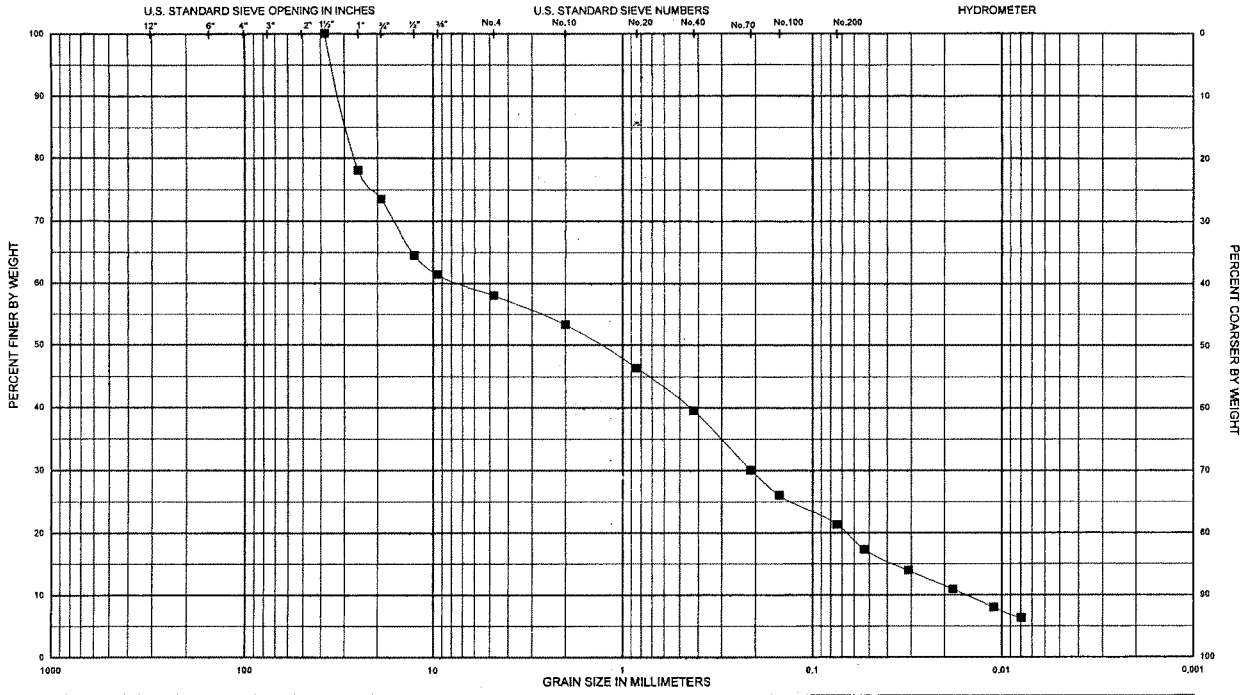
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-05

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Silty gravel with sand (GM)	11.4	—	—	—

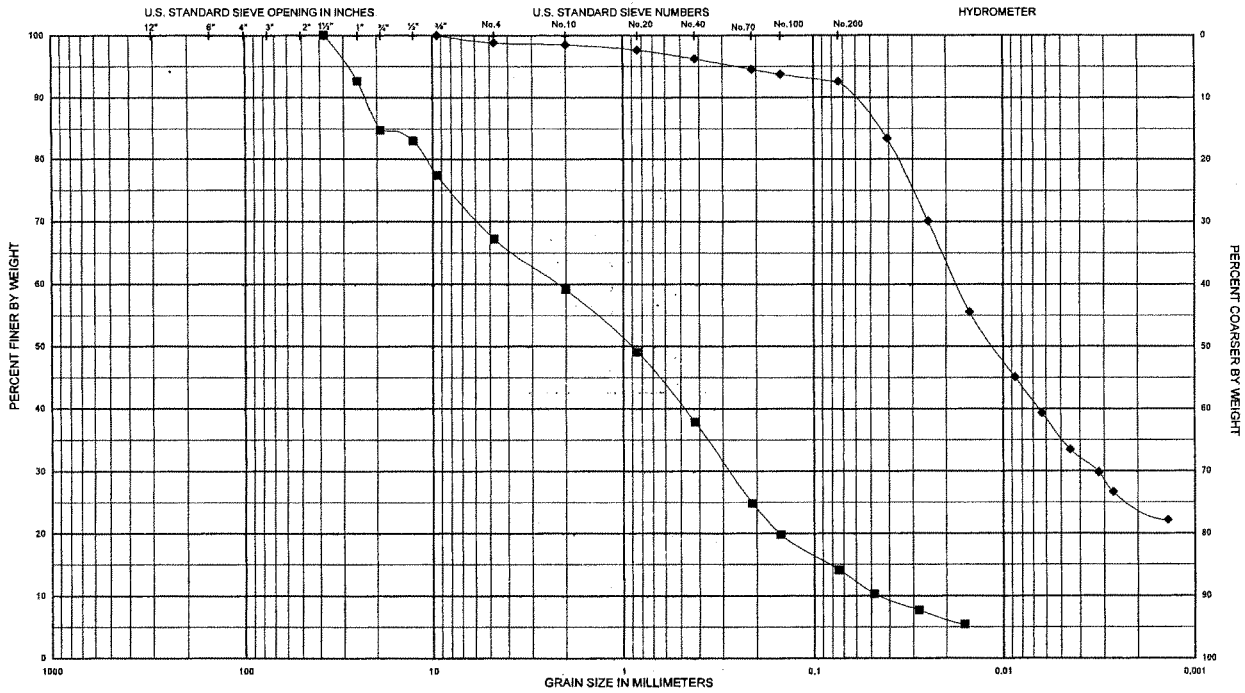
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-06

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand with gravel	(SM)	30.9	—	—	—
—◆—	Jar-8	10.5-12.0	Elastic silt (tr. gravel & sand)	(MH)	55.6	64	32	32

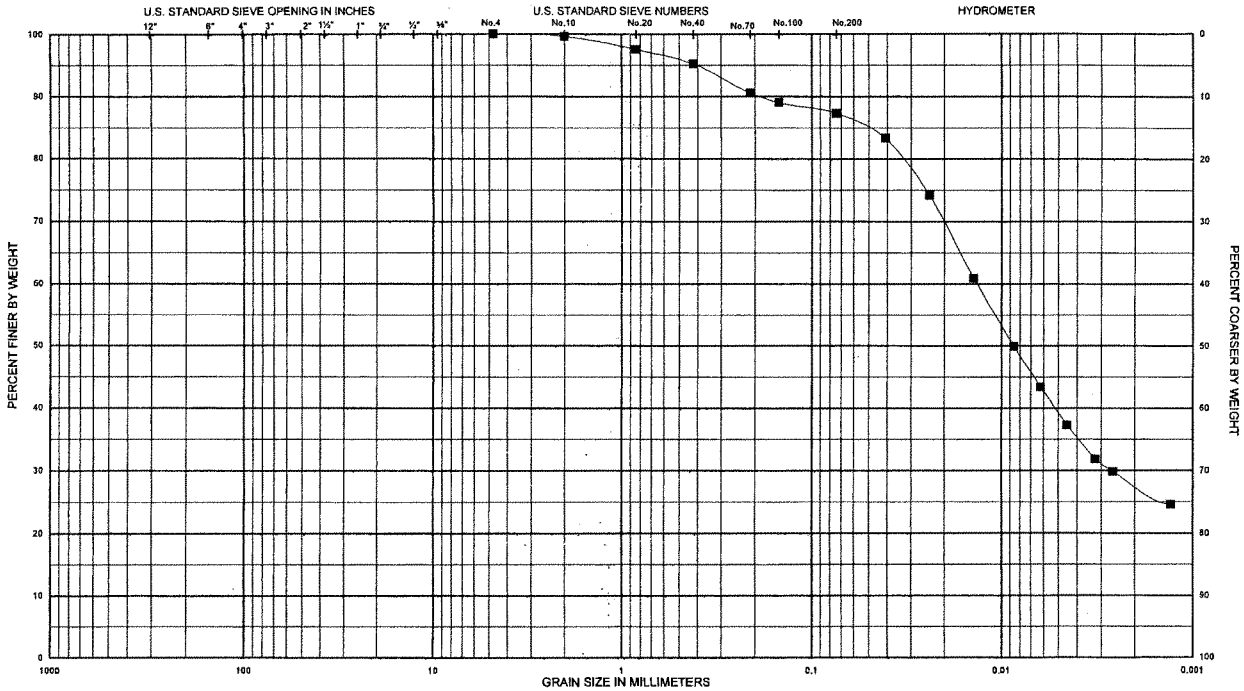
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-07

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-6	7.5-9.0	Fat clay (tr. sand) (CH)	47.9	62	28	34

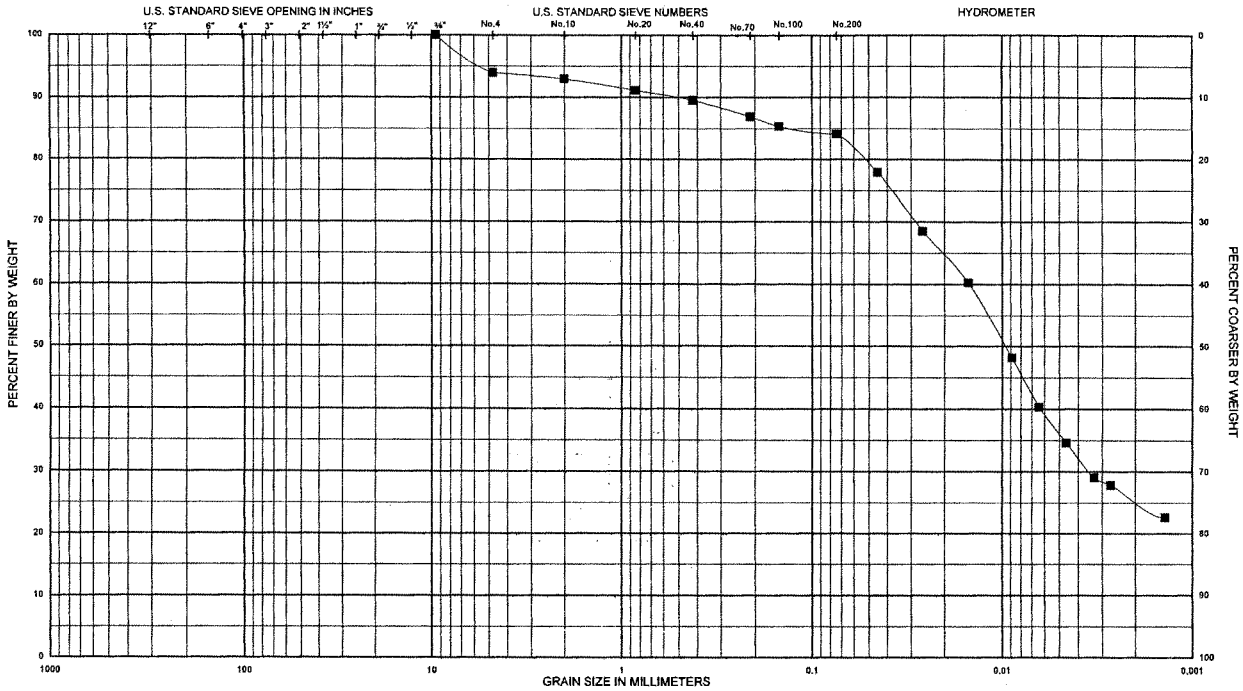
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-08

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-11	15.0-16.5	Fat clay (tr. gravel & sand) (CH)	64.0	75	32	43

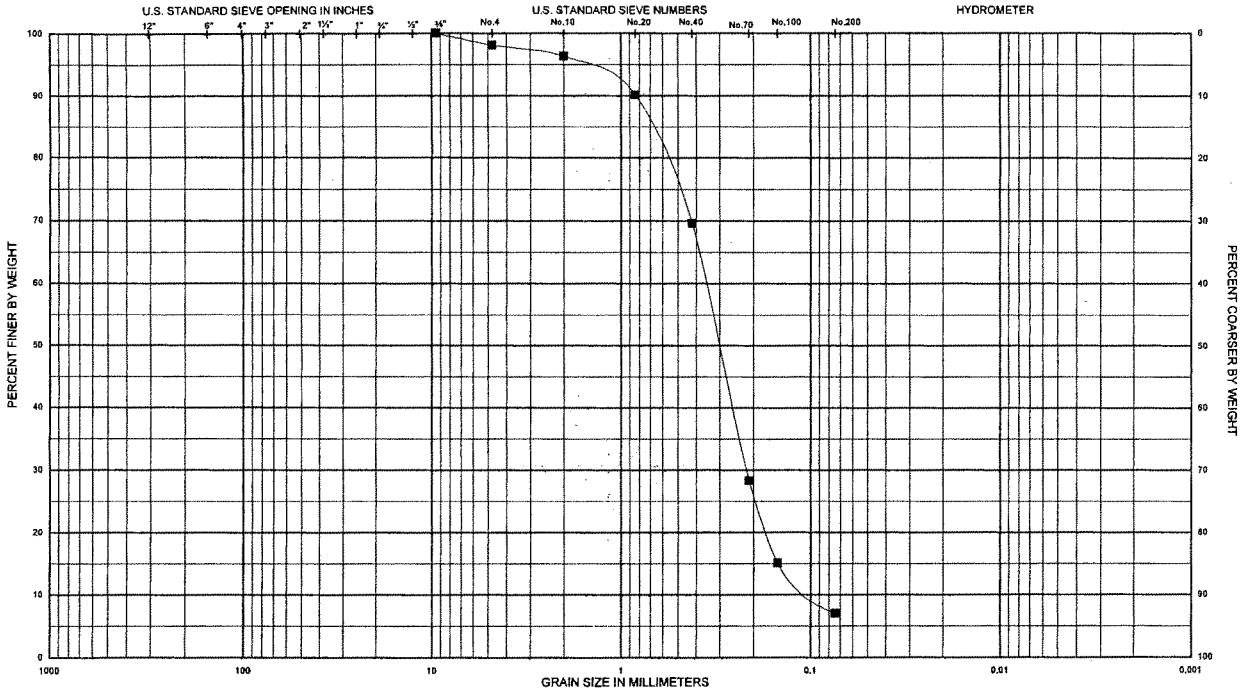
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-10

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Poorly graded sand with silt (tr. gravel) (SP-SM)	20.5	—	—	—

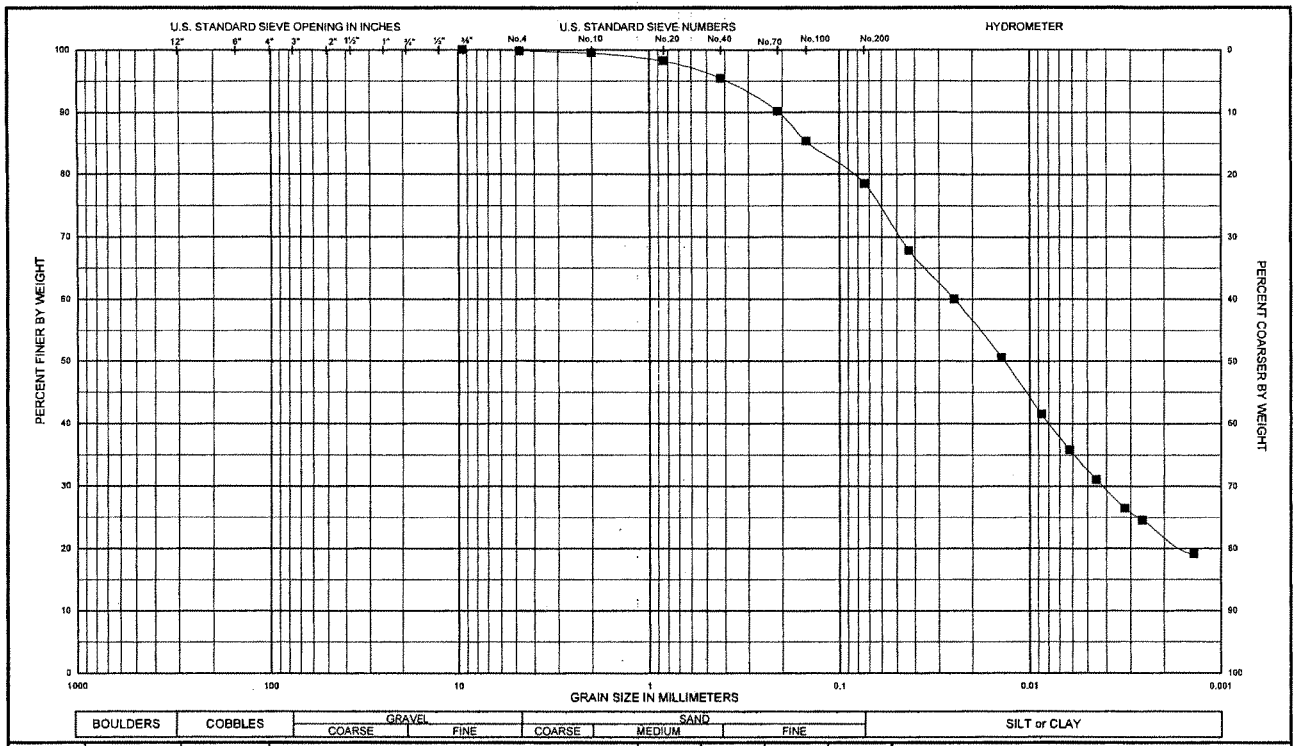
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-11

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-13	18.0-19.5	Fat clay with sand (CH)	58.2	64	30	34

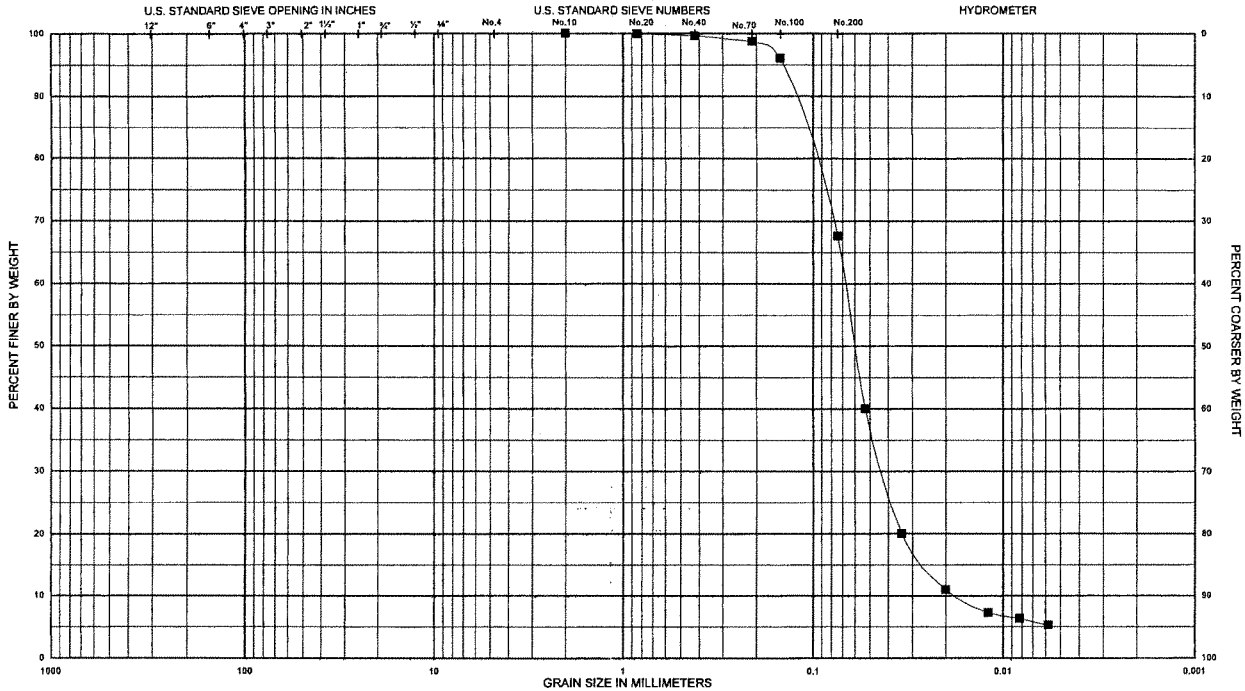
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-12

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-5	6.0-7.5	Sandy silt (ML)	22.2	—	—	—

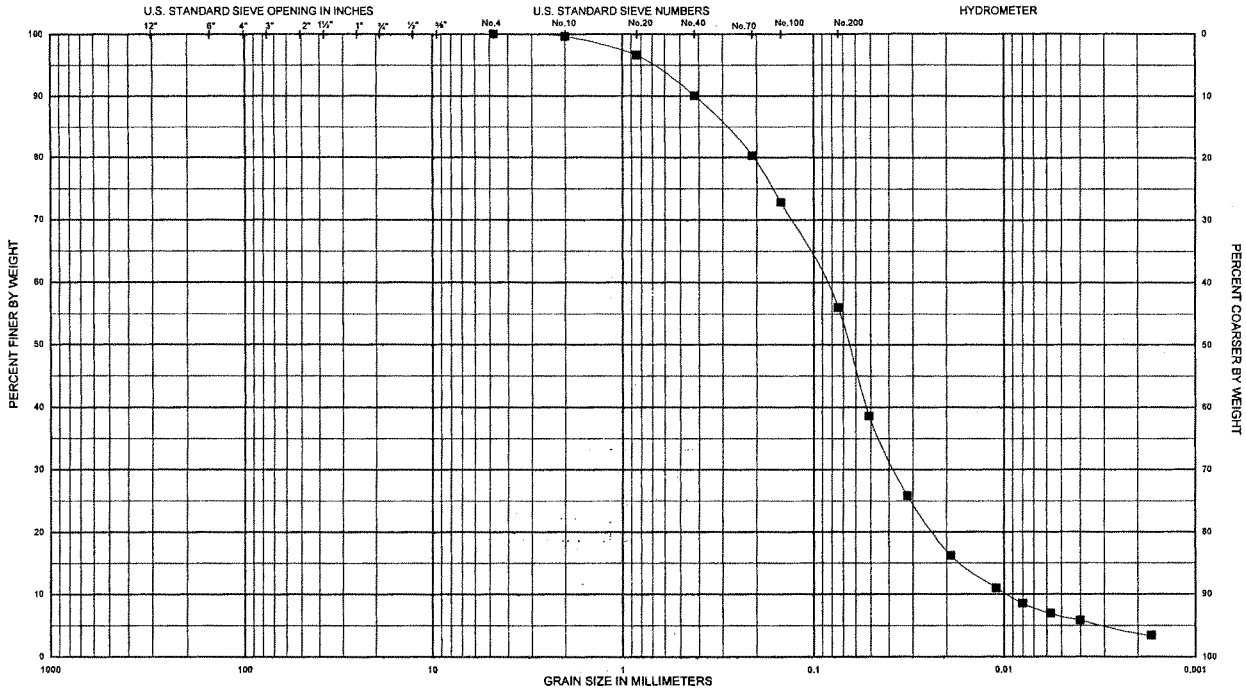
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-13

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-11	15.0-16.5	Sandy silt (ML)	21.1	—	—	—

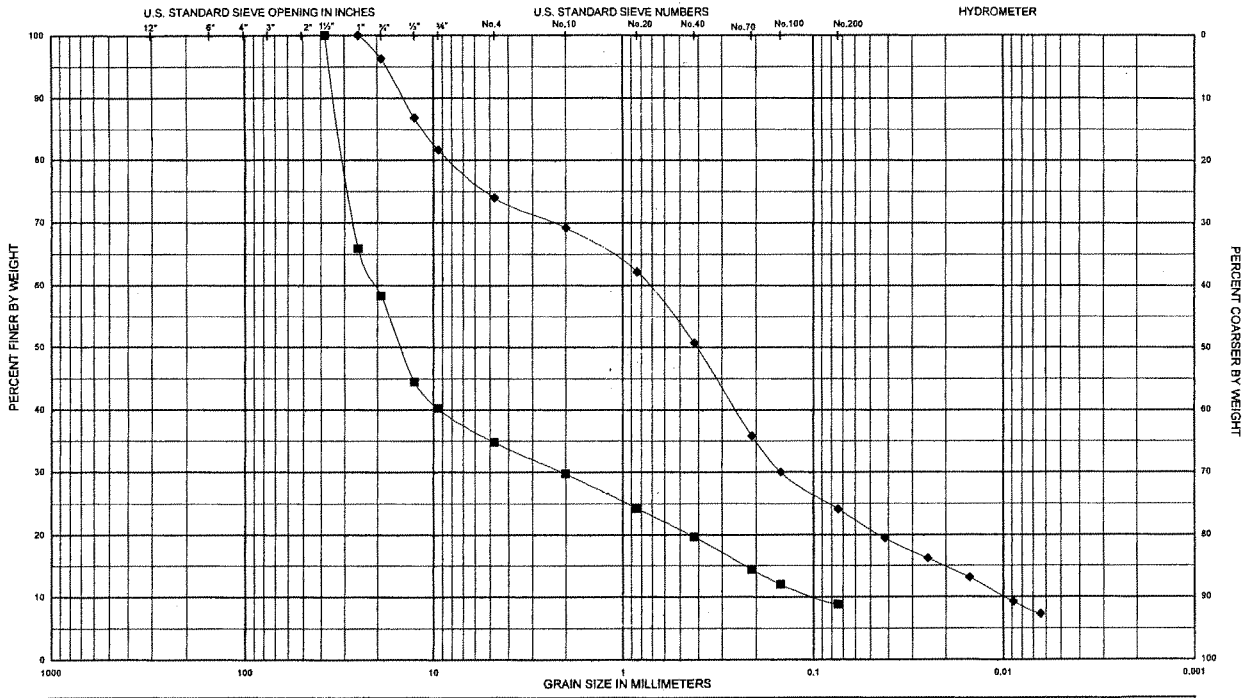
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-14

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-2	1.5-3.0	Well-graded gravel with silt and sand	(GW-GM)	6.0	—	—	—
—◆—	Jar-6	7.5-9.0	Silty sand with gravel	(SM)	39.8	—	—	—

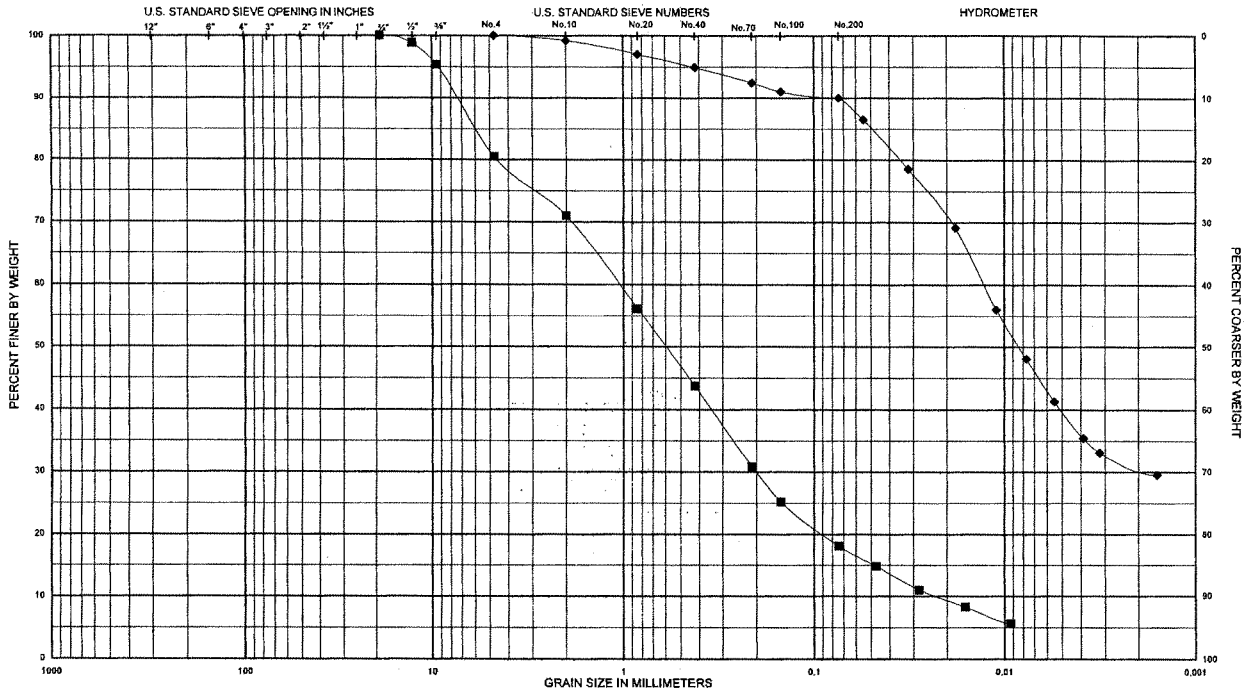
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-15

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-2	1.5-3.0	Silty sand with gravel	(SM)	29.4	—	—	—
—◆—	Jar-13	18.0-19.5	Fat clay (tr. sand)	(CH)	52.7	74	31	43

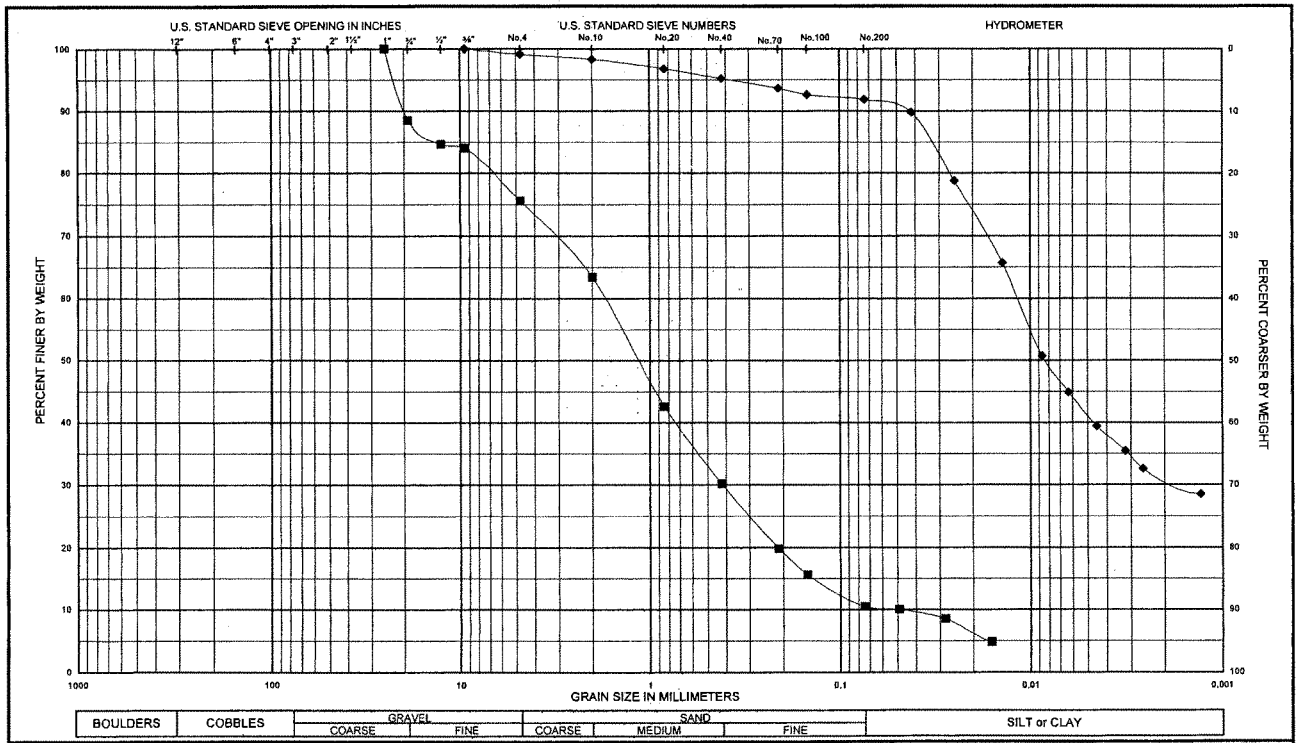
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-16

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Well-graded sand with silt and gravel	(SW-SM)	26.5	—	—	—
—◆—	Jar-16	22.5-24.0	Elastic silt (tr. sand)	(MH)	65.3	75	35	40

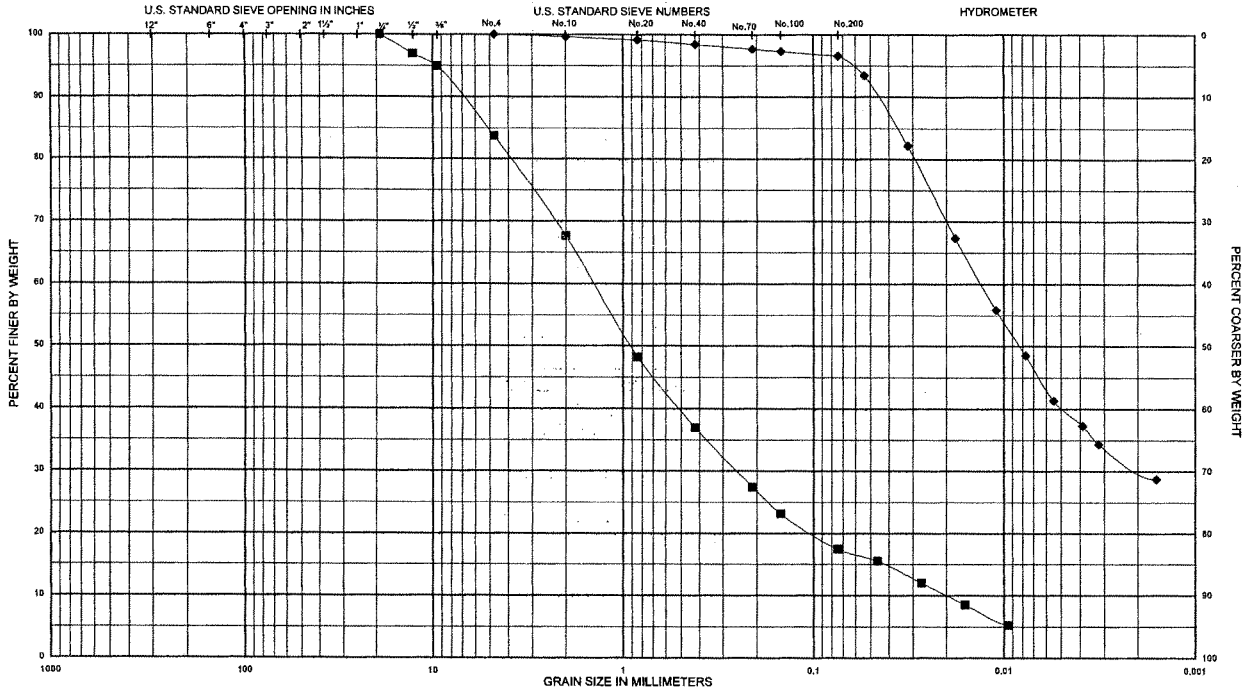
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-17

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand with gravel	(SM)	38.0	—	—	—
—◆—	Jar-15	21.0-22.5	Silt (tr. sand)	(ML)	55.3	41	31	10

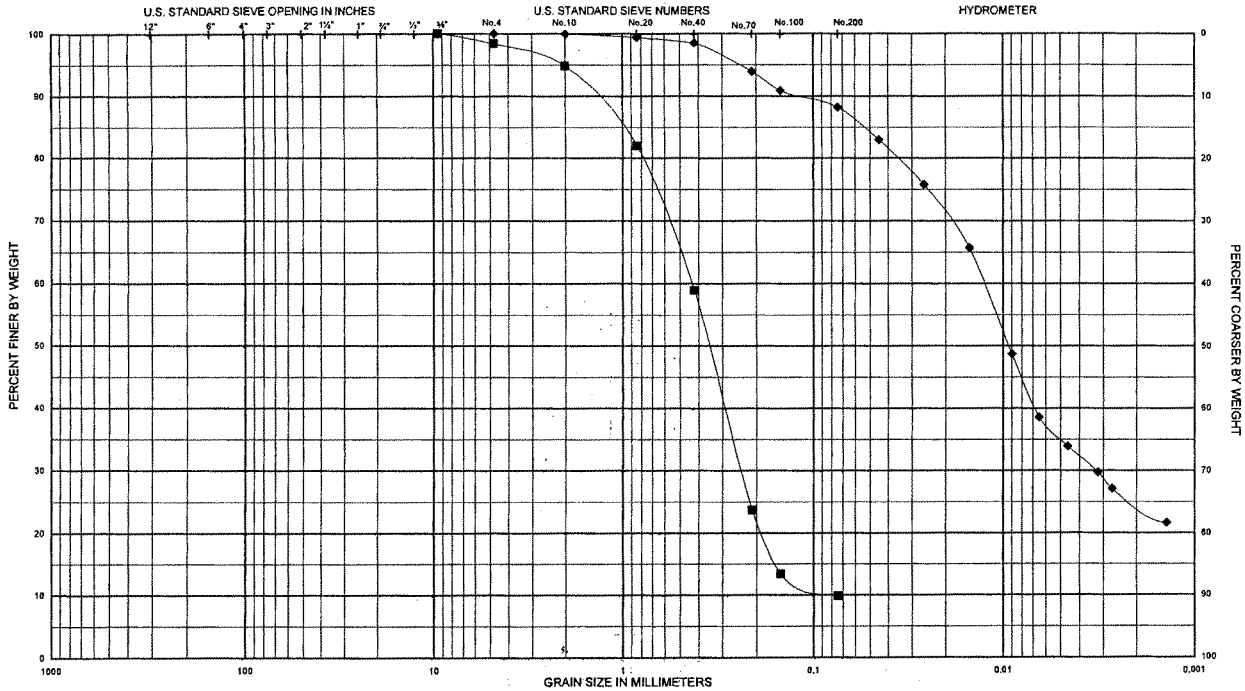
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-19

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-2	1.5-3.0	Poorly graded sand with silt (tr. gravel)	(SP-SM)	3.6	—	—	—
—◆—	Jar-15	21.0-22.5	Fat clay (tr. sand)	(CH)	75.7	92	38	54

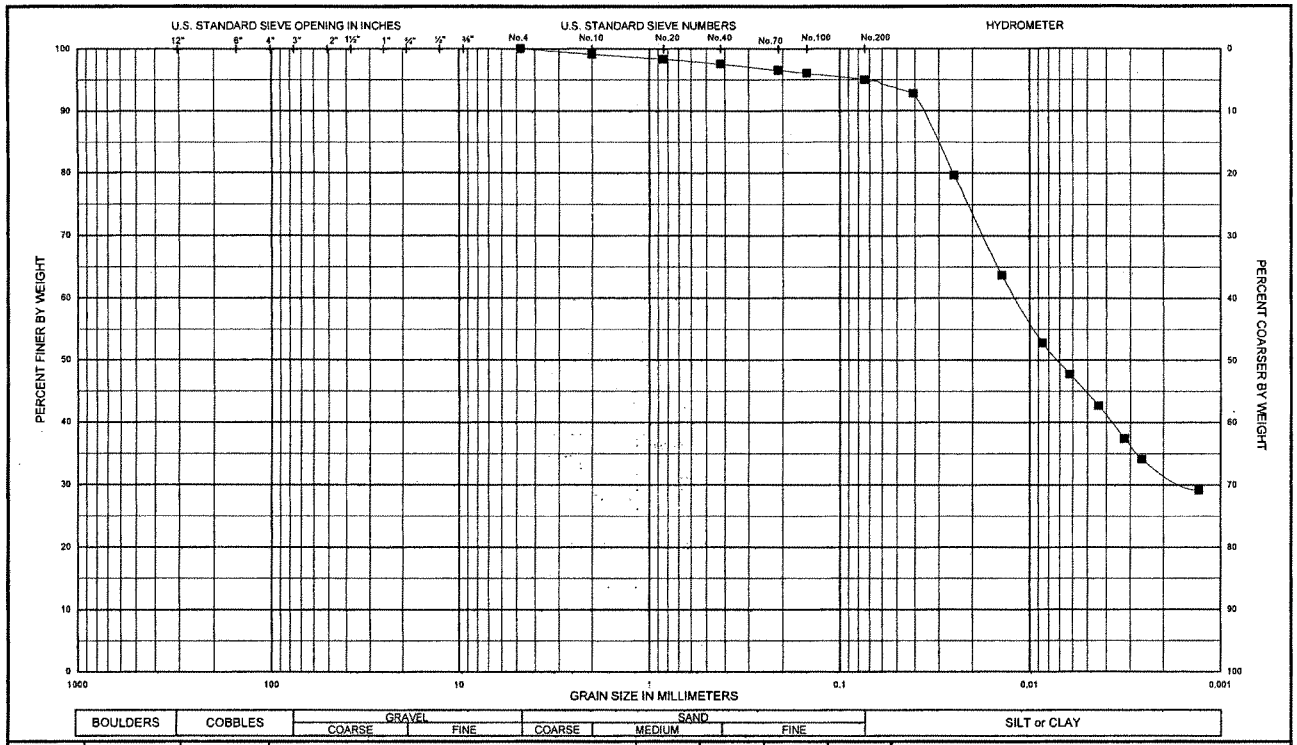
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-20

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-8	10.5-12.0	Elastic silt (tr. sand) (MH)	61.6	81	38	43

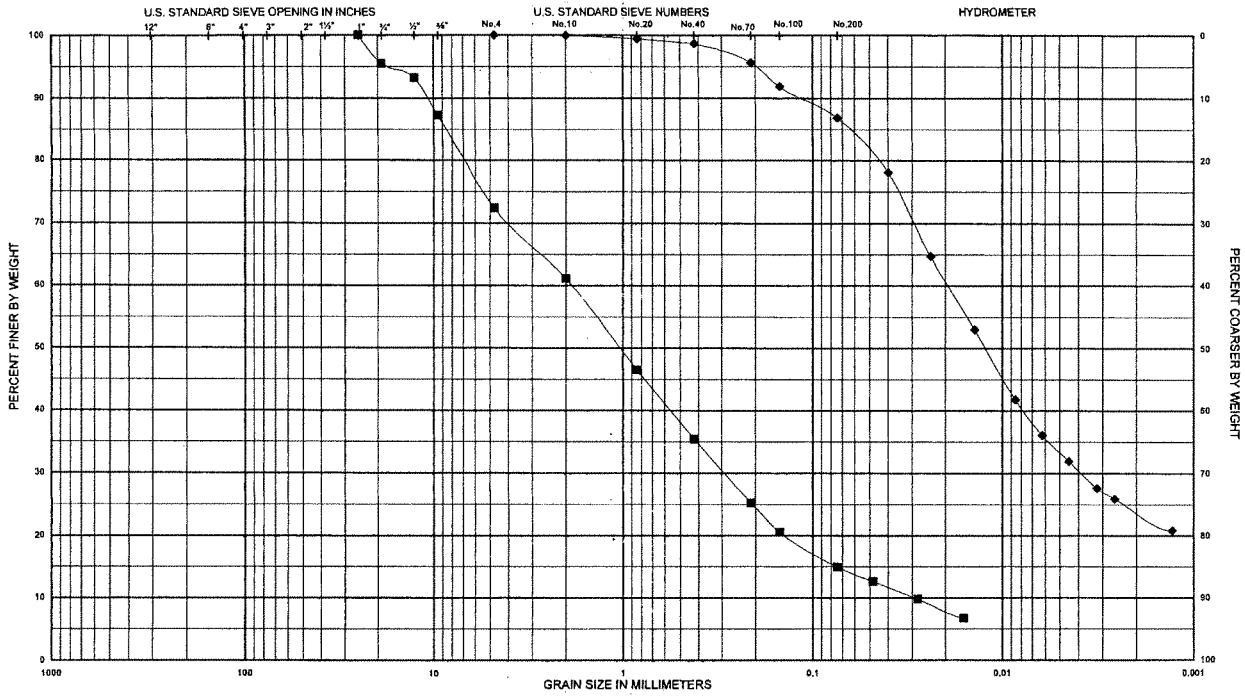
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-23

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-5	6.0-7.5	Silty sand with gravel	(SM)	32.7	—	—	—
—◆—	Jar-10	13.5-15.0	Lean clay (tr. sand)	(CL)	52.8	49	27	22

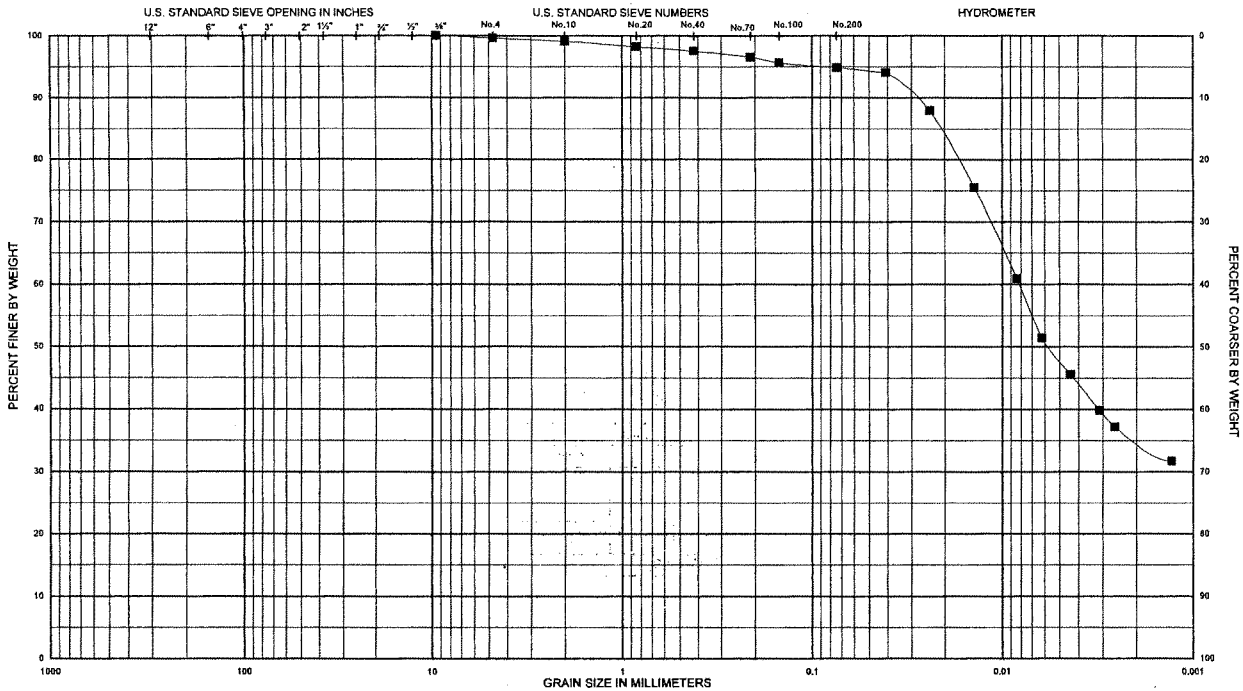
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-24

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-10	13.5-15.0	Fat clay (tr. sand) (CH)	68.7	83	36	47

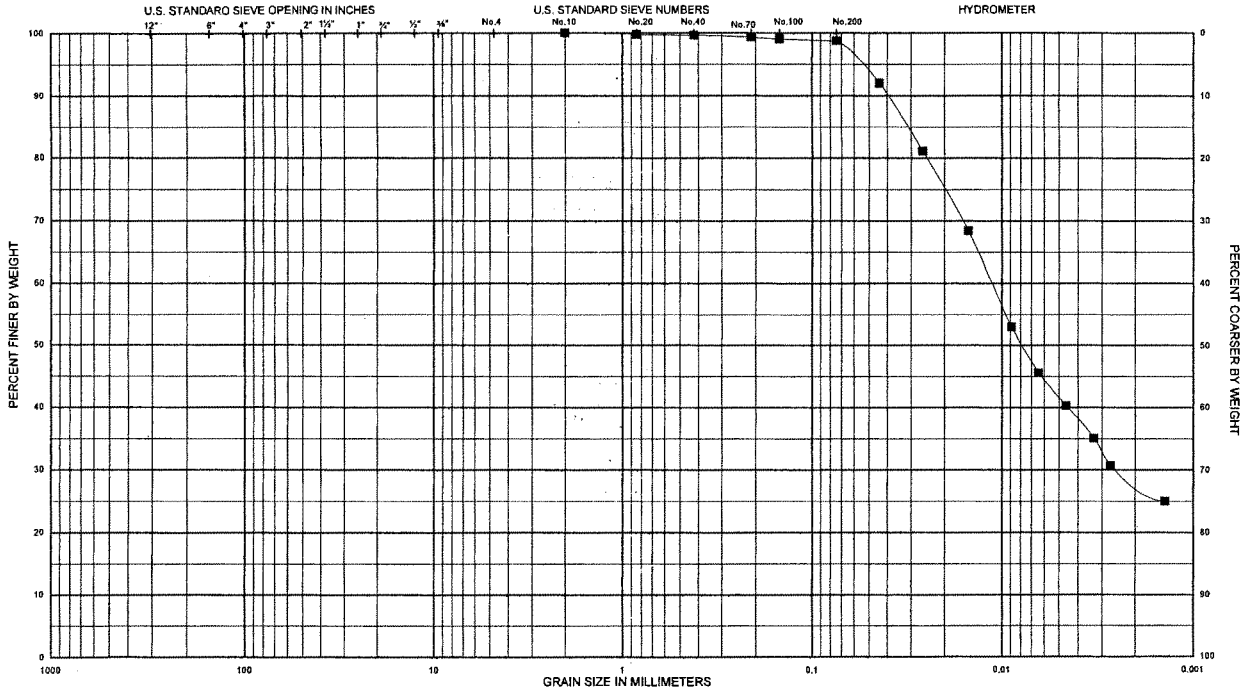
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-25

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-8	10.5-12.0	Fat clay (tr. sand) (CH)	69.8	80	35	45

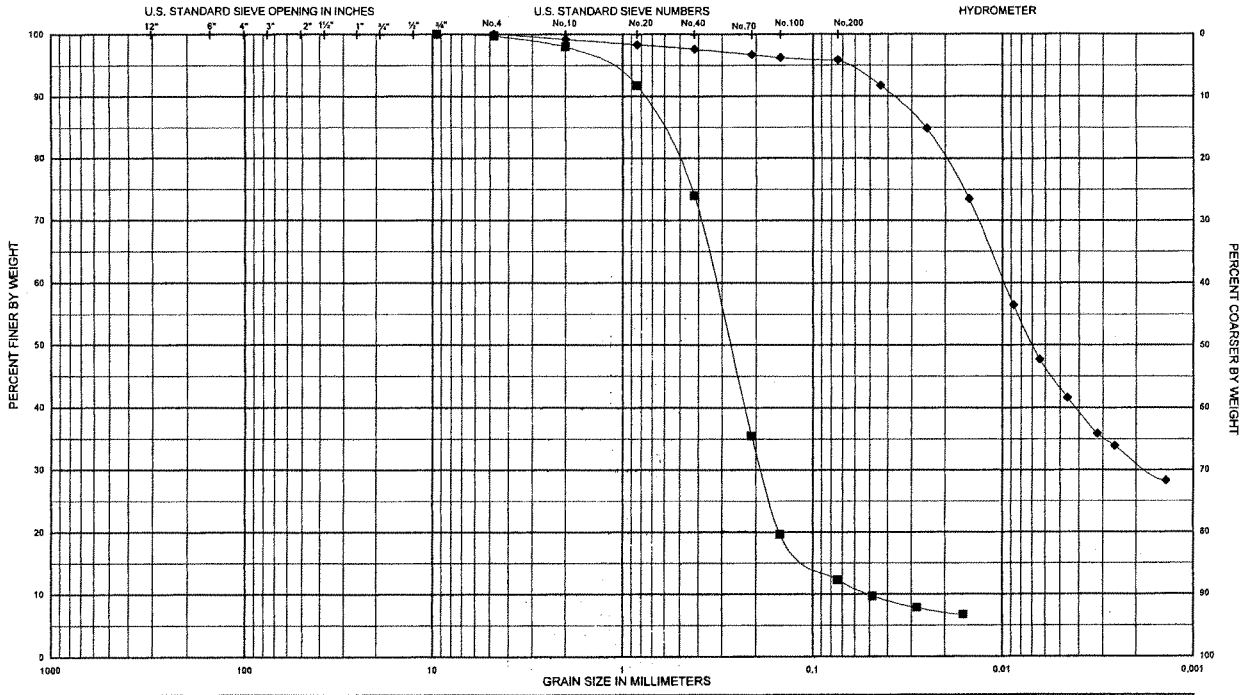
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-26

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand	(SM)	20.9	—	—	—
—◆—	Jar-9	12.0-13.5	Fat clay (tr. sand)	(CH)	59.4	69	33	36

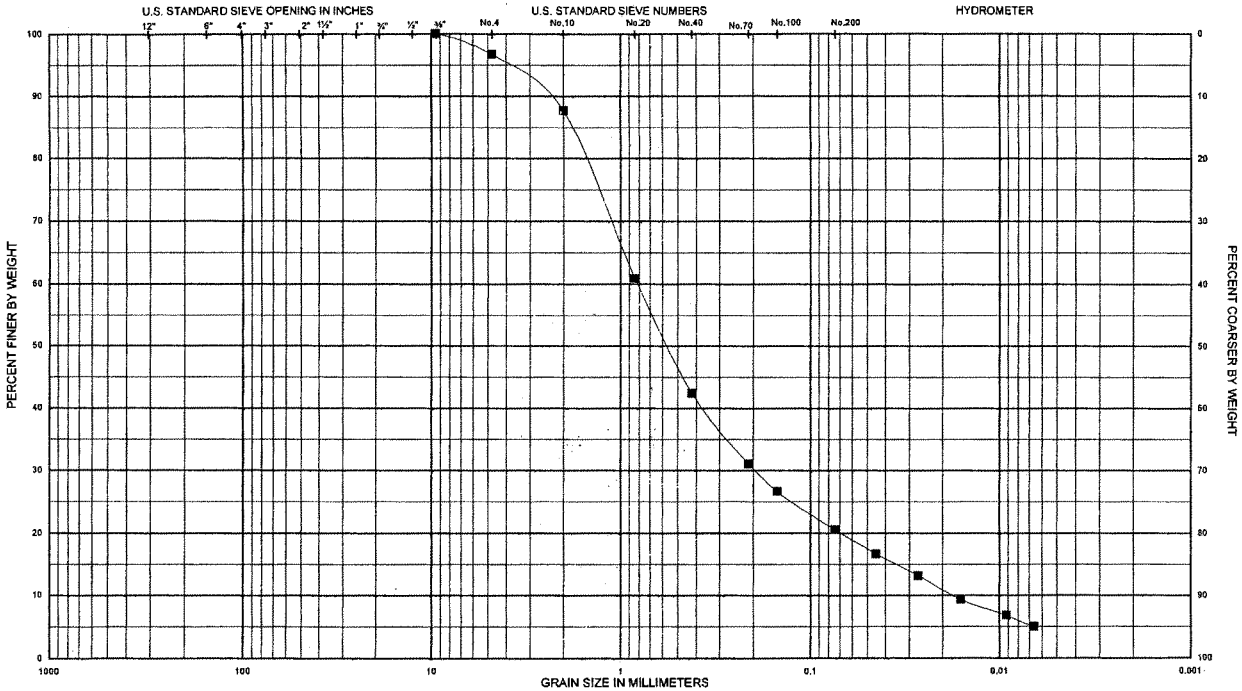
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-27

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand (tr. gravel) (SM)	17.6	—	—	—

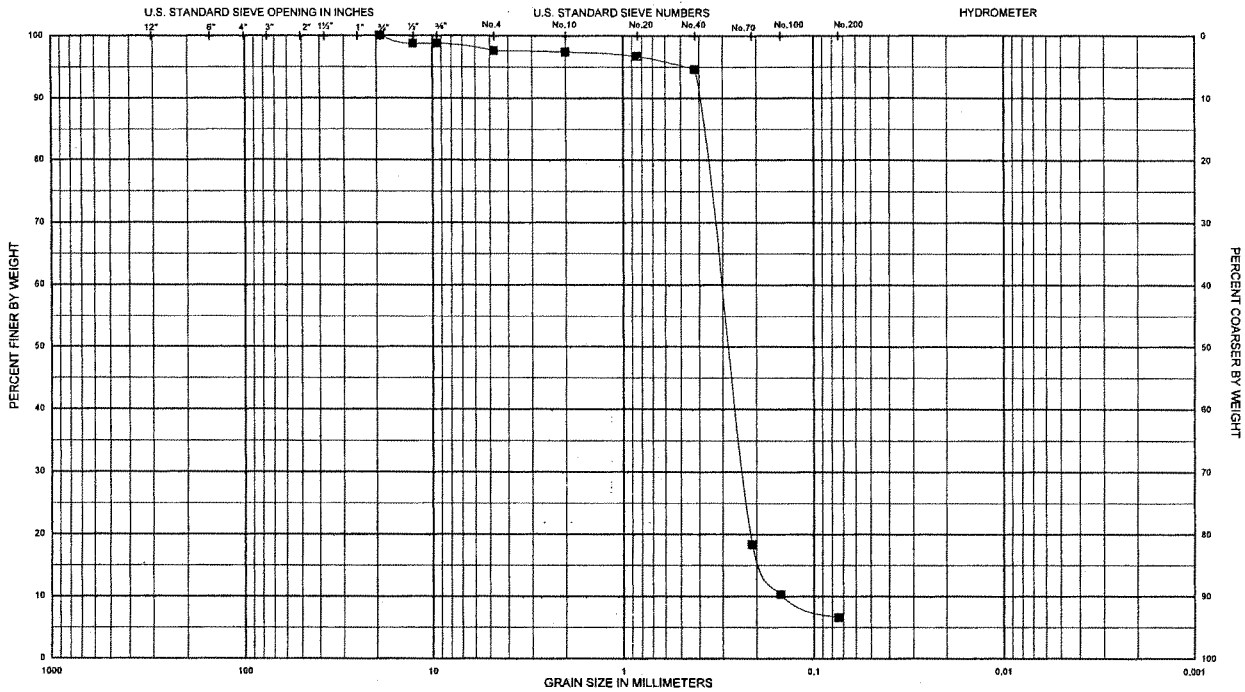
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-28

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Poorly graded sand with silt (tr. gravel) (SP-SM)	22.9	—	—	—

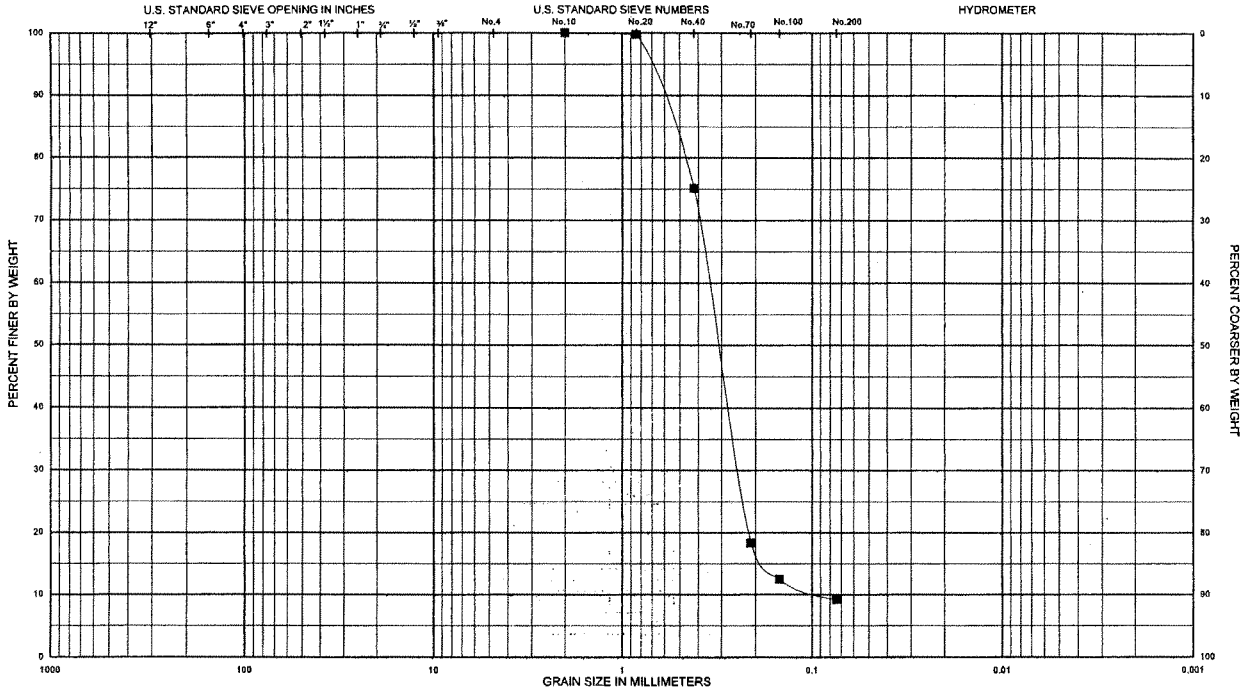
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-29

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-2	1.5-3.0	Poorly graded sand with silt (SP-SM)	12.6	—	—	—

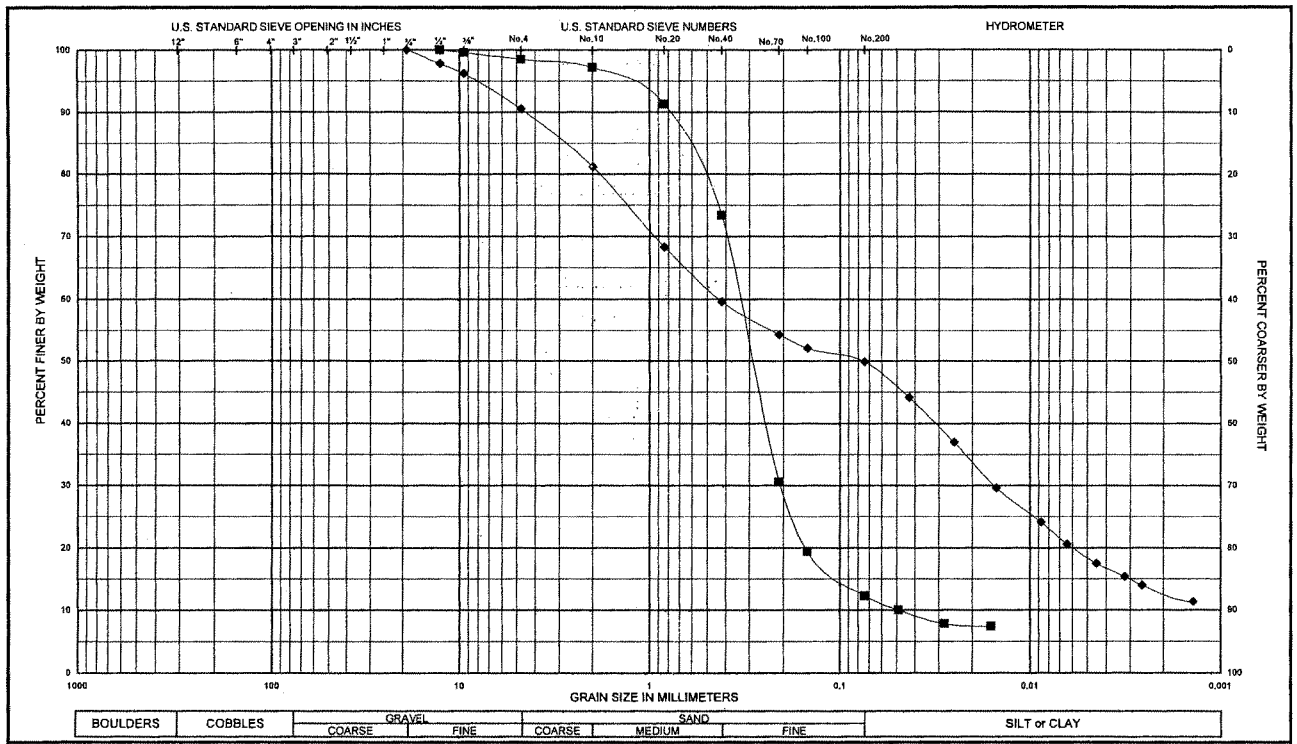
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-30

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Silty sand (tr. gravel)	(SM)	16.2	—	—	—
—◆—	Jar-10	13.5-15.0	Clayey sand (tr. gravel)	(SC-H)	38.0	55	28	27

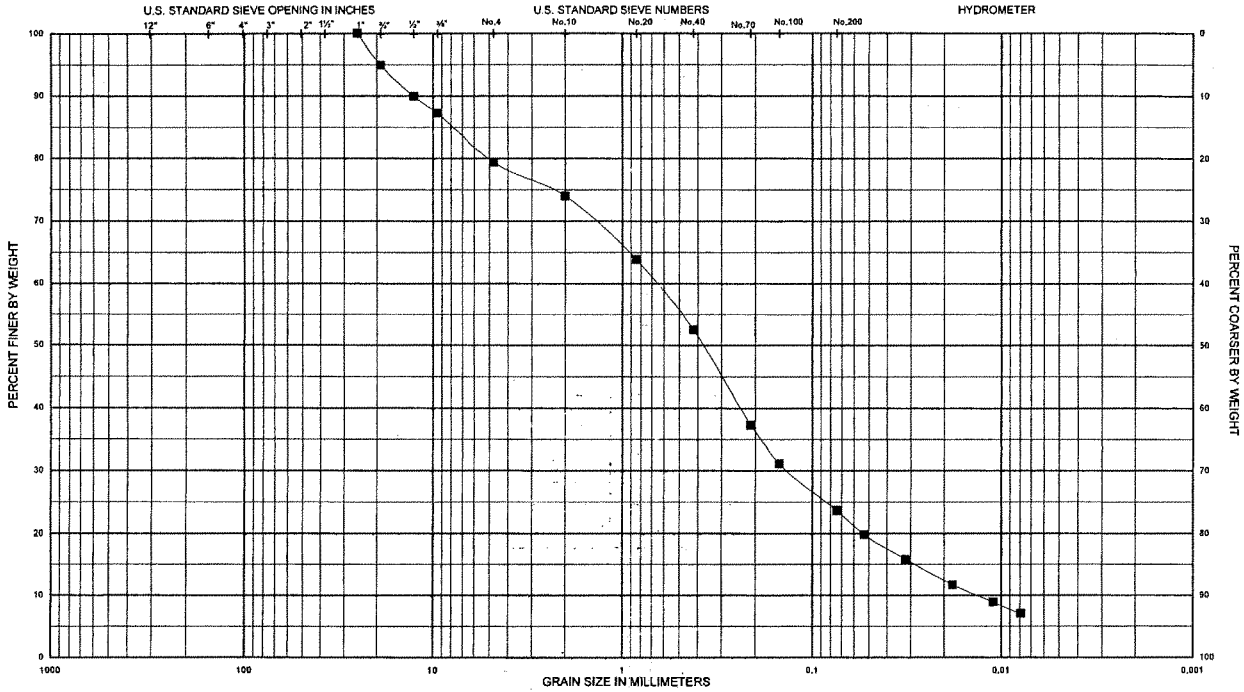
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-31

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Silty sand with gravel (SM)	21.0	—	—	—

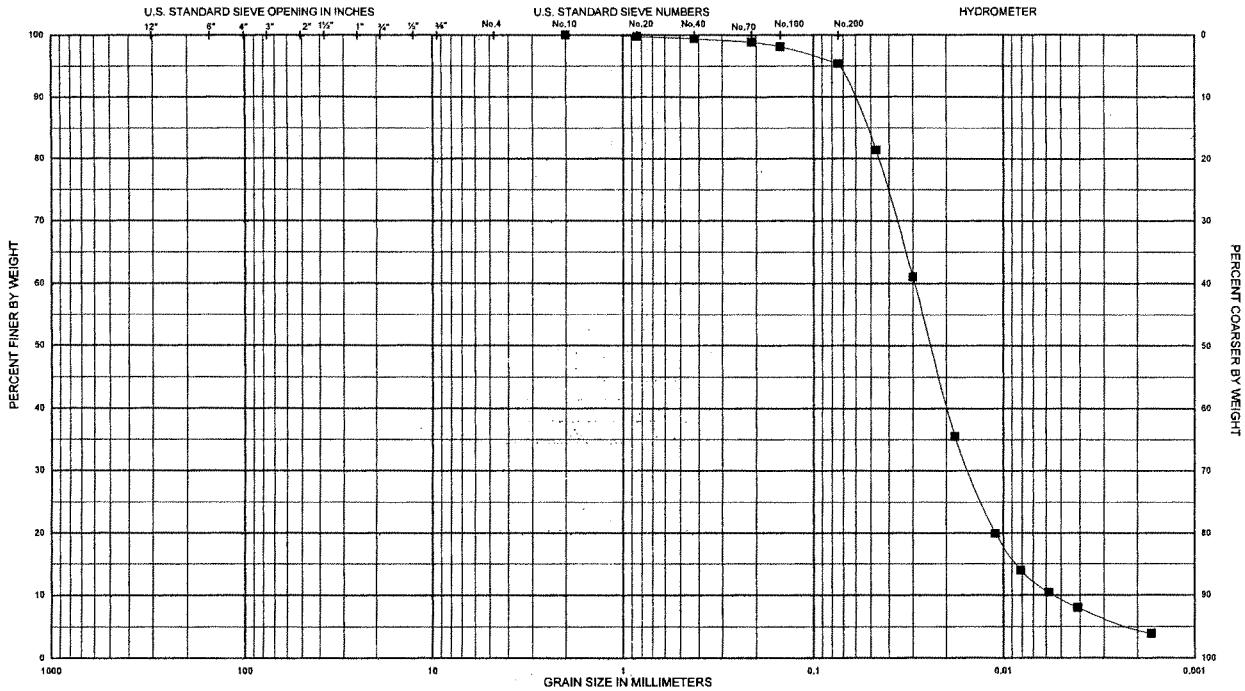
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-32

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-8	10.5-12.0	Silt (tr. sand) (ML)	49.9	46	33	13

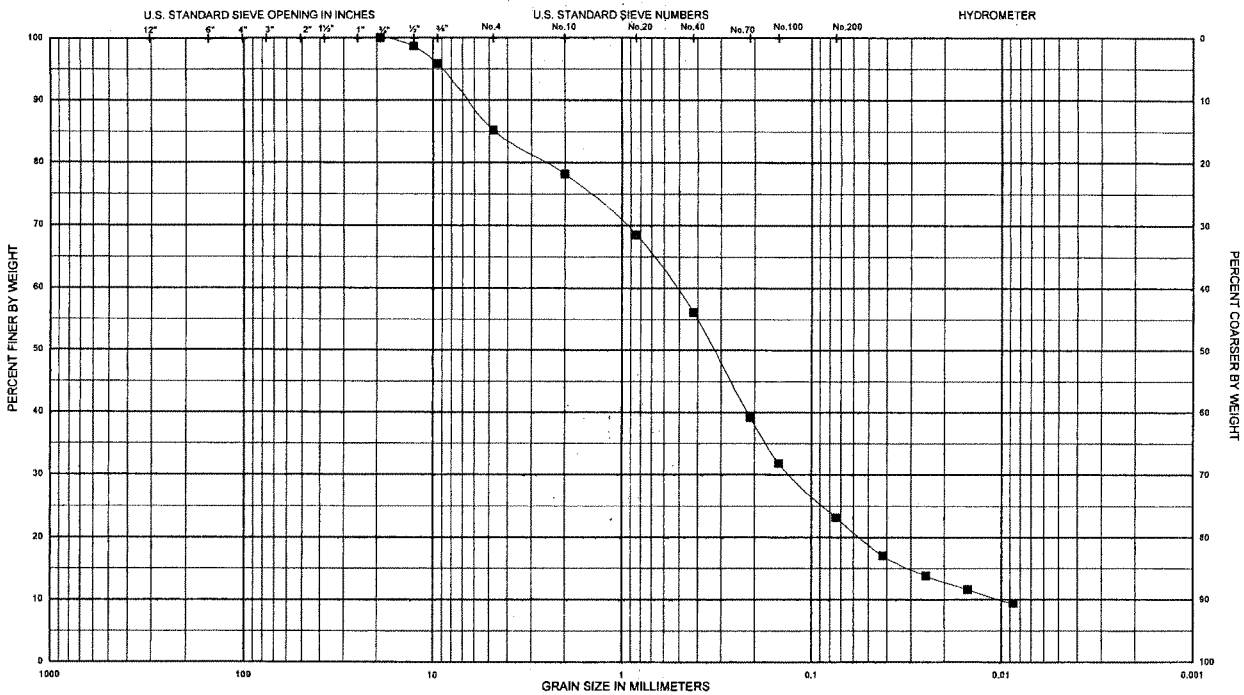
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-33

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Silty sand (tr. gravel) (SM)	9.2	—	—	—

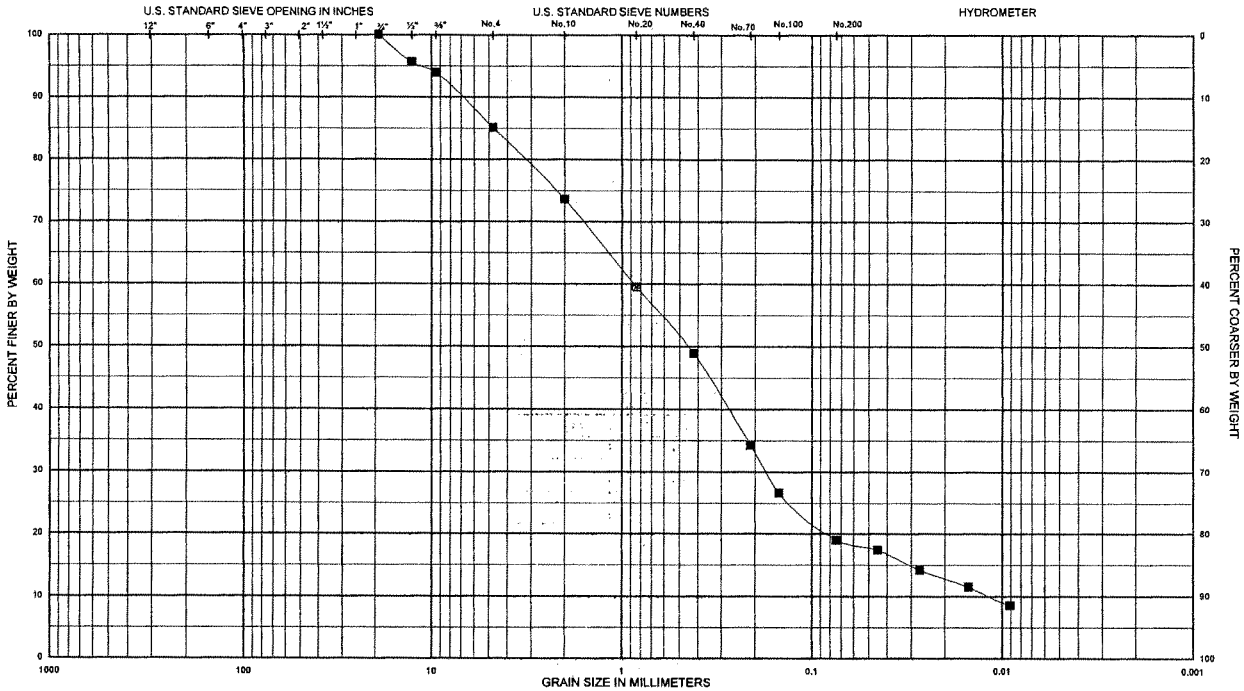
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-34

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)		Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand (tr. gravel)	(SM)	14.3	—	—	—

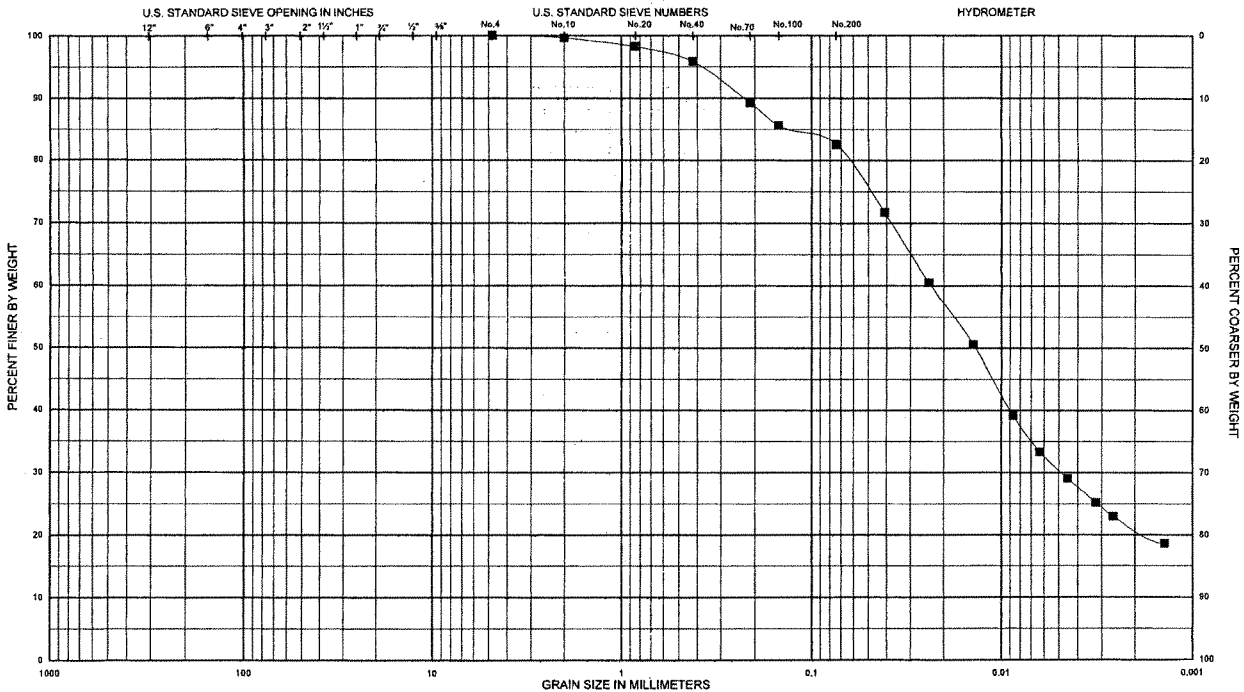
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-35

DATE: Apr 2004

ENG FORM 2087 — **GRADATION CURVES** — (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—●—	Jar-12	16.5-18.0	Fat clay with sand (CH)	45.2	56	28	28

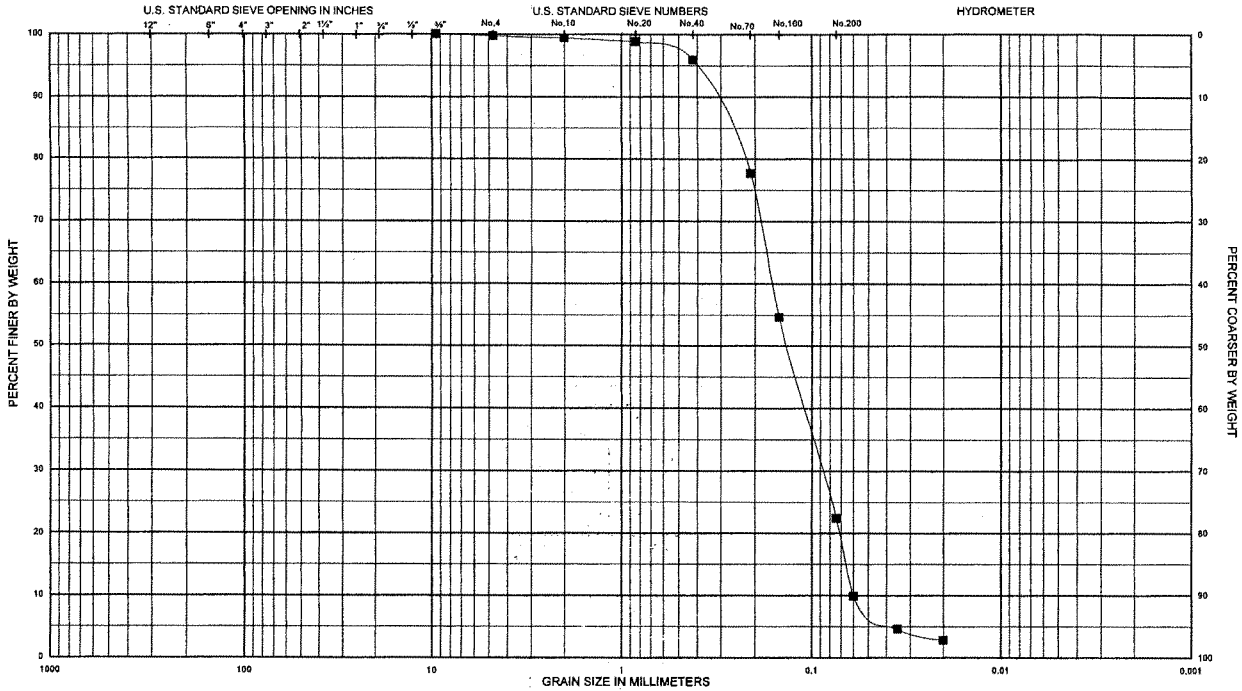
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-36

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-3	3.0-4.5	Silty sand (SM)	22.6	—	—	—

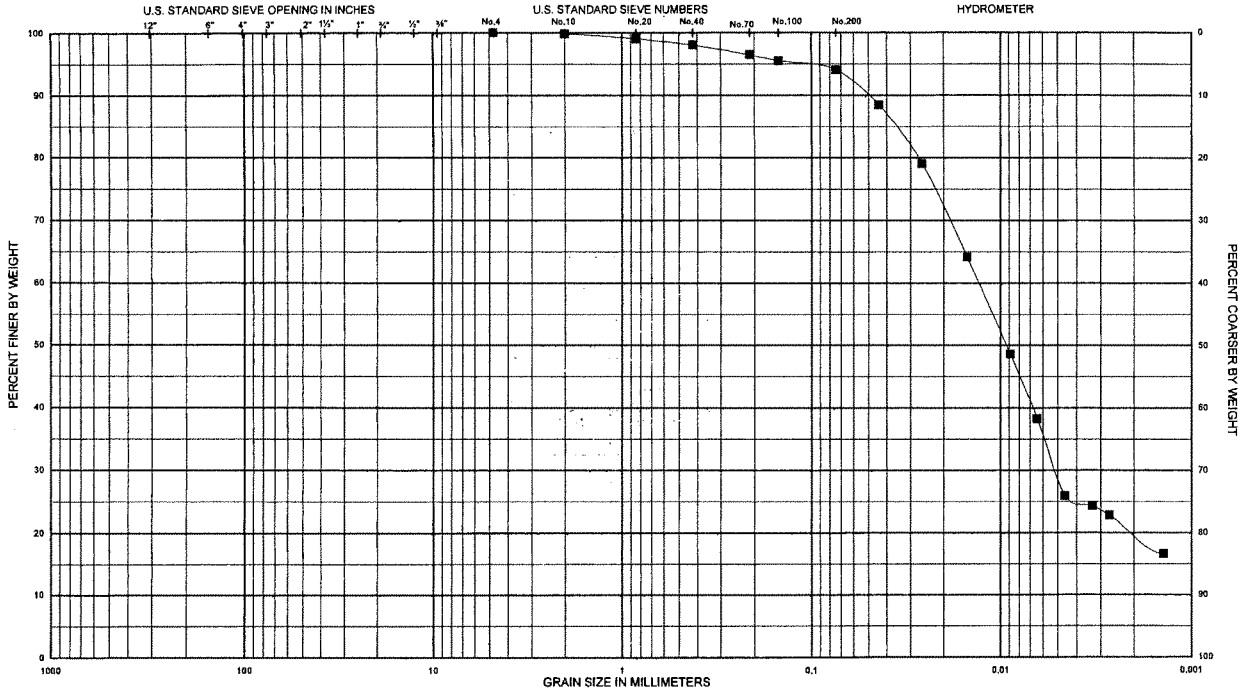
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-37

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-14	19.5-21.0	Fat clay (tr. sand) (CH)	63.4	74	32	42

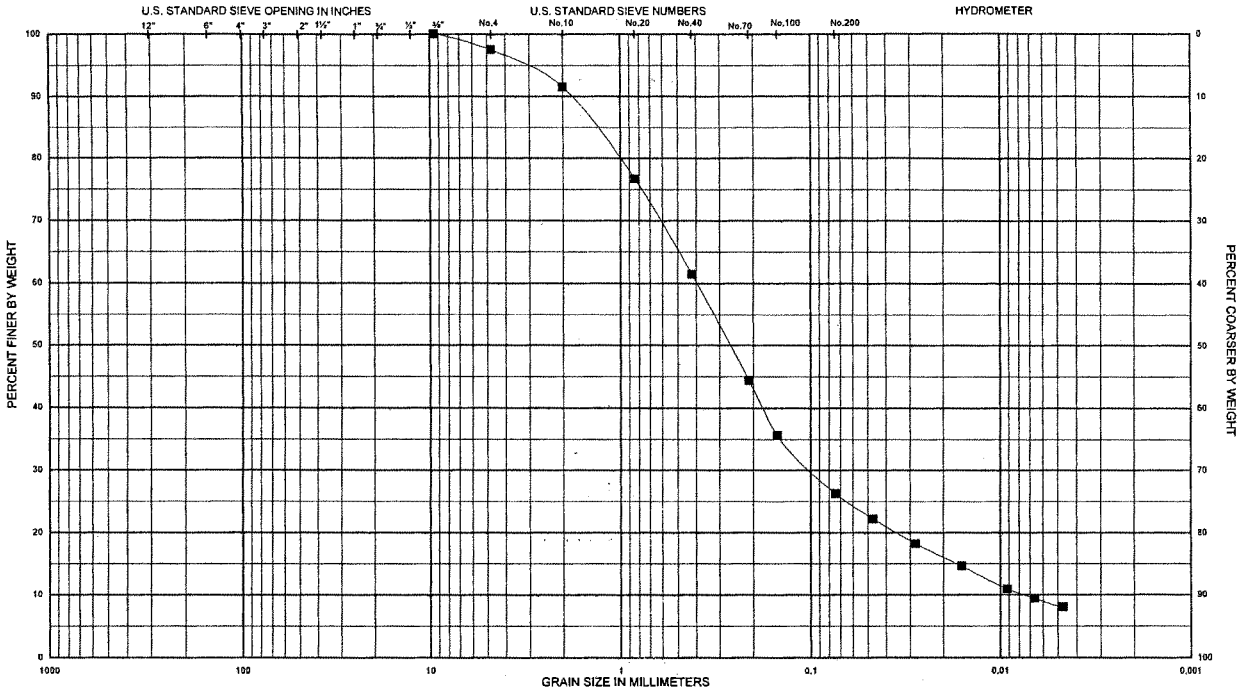
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-38

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-7	9.0-10.5	Silty sand (tr. gravel) (SM)	52.1	—	—	—

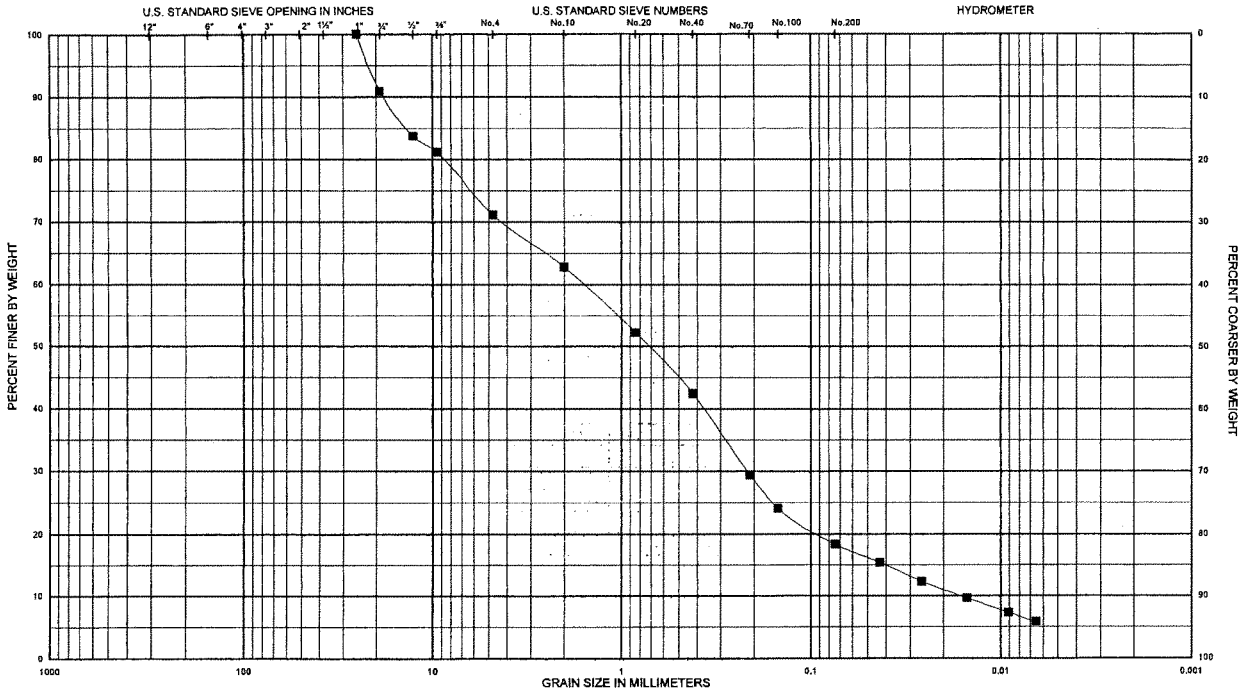
PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-39

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)



Legend	Sample No.	Depth (ft)	USCS Classification (ASTM D2487)	Nat w%	LL	PL	PI
—■—	Jar-4	4.5-6.0	Silty sand with gravel (SM)	38.1	—	—	—

PROJECT: Liberty State Park

AREA: Jersey City, NJ

Boring No.: LSP-03-40

DATE: Apr 2004

ENG FORM 2087 **GRADATION CURVES** (Sieve Analysis: ASTM D422)

Borehole	Jar No.	Depth	Liquid Limit	Plastic Limit	Plasticity Index	%<#200 Sieve	Class-ification	Water Content (%)	D60 % Finer	D30 % Finer	D10 % Finer
CA04-1	Jar-6	7.5-9.0				8	SW-SM	18.2	2.108	0.504	0.097
CA04-1	Jar-13	18.0-19.5	54	29	25	91	CH	59.7	0.017	0.004	
CA04-2	Jar-4	4.5-6.0				15	SM	37.8	1.788	0.323	0.016
CA04-2	Jar-11	15.0-16.5	60	35	25	92	MH	70.1	0.016	0.005	
CA04-3	Jar-4	4.5-6.0				10	SW-SM	31.1	2.623	0.493	0.050
CA04-3	Jar-14	19.5-21.0	56	29	27	83	CH	53.8	0.023	0.006	
CA04-4	Jar-7	9.0-10.5				11	SW-SM	25.4	0.575	0.232	0.060
CA04-4	Jar-11	15.0-16.5	54	31	23	83	MH	60.9	0.018	0.006	
CA04-5	Jar-6	7.5-9.0				35	SM	26.5	0.271	0.058	0.008
CA04-5	Jar-11	15.0-16.5	51	29	22	93	MH	54.9	0.014	0.005	
CA04-6	Jar-3	3.0-4.5				9	SP-SM	23.6	0.314	0.206	0.084
CA04-6	Jar-10	13.5-15.0	52	27	25	94	CH	59.4	0.014	0.003	
NC04-1	Jar-4	4.5-6.0	84	37	47	94	CH	125.0	0.011	0.003	
NC04-2	Jar-3	3.0-4.5	82	39	43	92	MH	103.5	0.014	0.004	
NC04-3	Jar-2	1.5-3.0				22	SM	9.6	0.601	0.125	0.013
NC04-4	Jar-2	1.5-3.0				26	SM	8.7	0.286	0.092	0.010
NC04-5	Jar-4	4.5-6.0				10	SP-SM	8.9	7.025	0.466	0.080

Summary of Laboratory Results

Sheet 1 of 1

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

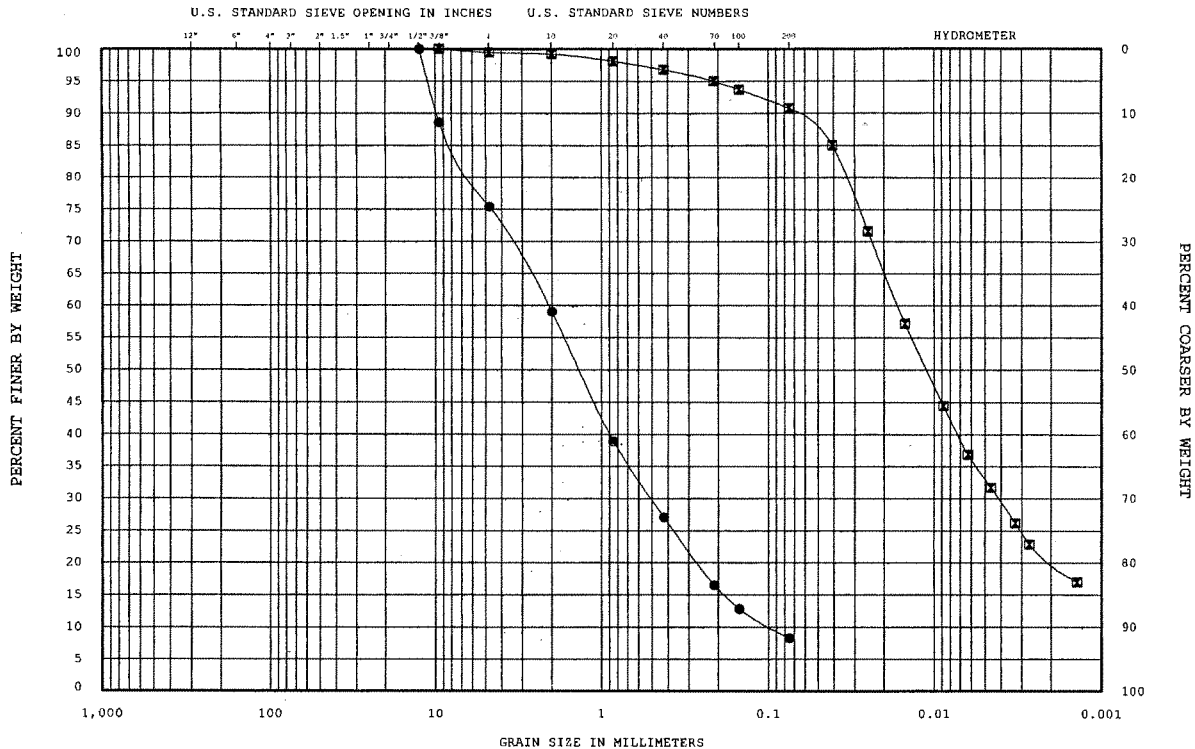
DATE: *Mar 04*

Borehole	Jar No.	Depth	Gravel	Sand	Fines	D5 % Finer	D10 % Finer	D16 % Finer	D25 % Finer	D30 % Finer	D50 % Finer	D60 % Finer	D75 % Finer	D84 % Finer	D95 % Finer	Class-ification
CA04-1	Jar-6	7.5-9.0	24.6	67.1	8.3		0.097	0.202	0.370	0.504	1.363	2.108	4.651	7.461	11.082	SW-SM
CA04-1	Jar-13	18.0-19.5	.5	8.7	90.8				0.003	0.004	0.011	0.017	0.028	0.040	0.212	CH
CA04-2	Jar-4	4.5-6.0	16.8	68.3	14.9		0.016	0.086	0.223	0.323	1.120	1.788	3.378	4.949	8.706	SM
CA04-2	Jar-11	15.0-16.5	.0	7.7	92.3			0.002	0.004	0.005	0.011	0.016	0.029	0.041	0.168	MH
CA04-3	Jar-4	4.5-6.0	24.9	64.8	10.3		0.050	0.157	0.333	0.493	1.696	2.623	4.731	6.606	10.256	SW-SM
CA04-3	Jar-14	19.5-21.0	.5	16.6	82.9			0.002	0.004	0.006	0.016	0.023	0.041	0.093	0.641	CH
CA04-4	Jar-7	9.0-10.5	19.3	70.0	10.7		0.060	0.127	0.203	0.232	0.372	0.575	2.349	6.526	20.037	SW-SM
CA04-4	Jar-11	15.0-16.5	4.8	12.2	83.0			0.002	0.005	0.006	0.012	0.018	0.035	0.094	4.112	MH
CA04-5	Jar-6	7.5-9.0	10.0	55.3	34.7		0.008	0.021	0.044	0.058	0.160	0.271	0.673	1.685	13.243	SM
CA04-5	Jar-11	15.0-16.5	1.0	5.9	93.1			0.002	0.004	0.005	0.010	0.014	0.021	0.031	0.158	MH
CA04-6	Jar-3	3.0-4.5	.5	91.0	8.5		0.084	0.130	0.181	0.206	0.274	0.314	0.385	0.465	0.889	SP-SM
CA04-6	Jar-10	13.5-15.0	.0	6.0	94.0				0.002	0.003	0.009	0.014	0.024	0.035	0.108	CH
NC04-1	Jar-4	4.5-6.0	.0	6.0	94.0				0.002	0.003	0.008	0.011	0.019	0.028	0.110	CH
NC04-2	Jar-3	3.0-4.5	1.3	6.7	92.0			0.002	0.003	0.004	0.010	0.014	0.024	0.036	0.185	MH
NC04-3	Jar-2	1.5-3.0	20.4	57.9	21.7		0.013	0.040	0.092	0.125	0.324	0.601	2.754	7.133	15.277	SM
NC04-4	Jar-2	1.5-3.0	7.2	67.3	25.5		0.010	0.032	0.072	0.092	0.200	0.286	0.596	1.510	6.237	SM
NC04-5	Jar-4	4.5-6.0	43.5	46.9	9.6		0.080	0.186	0.336	0.466	2.470	7.025	17.045	20.514	23.502	SP-SM

Summary of Laboratory Results

Sheet 1 of 1

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*
DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-6	7.5-9.0	WELL-GRADED SAND with SILT and GRAVEL	SW-SM	18.2			
—⊠—	Jar-13	18.0-19.5	FAT CLAY	CH	59.7	54	29	25

Remarks:

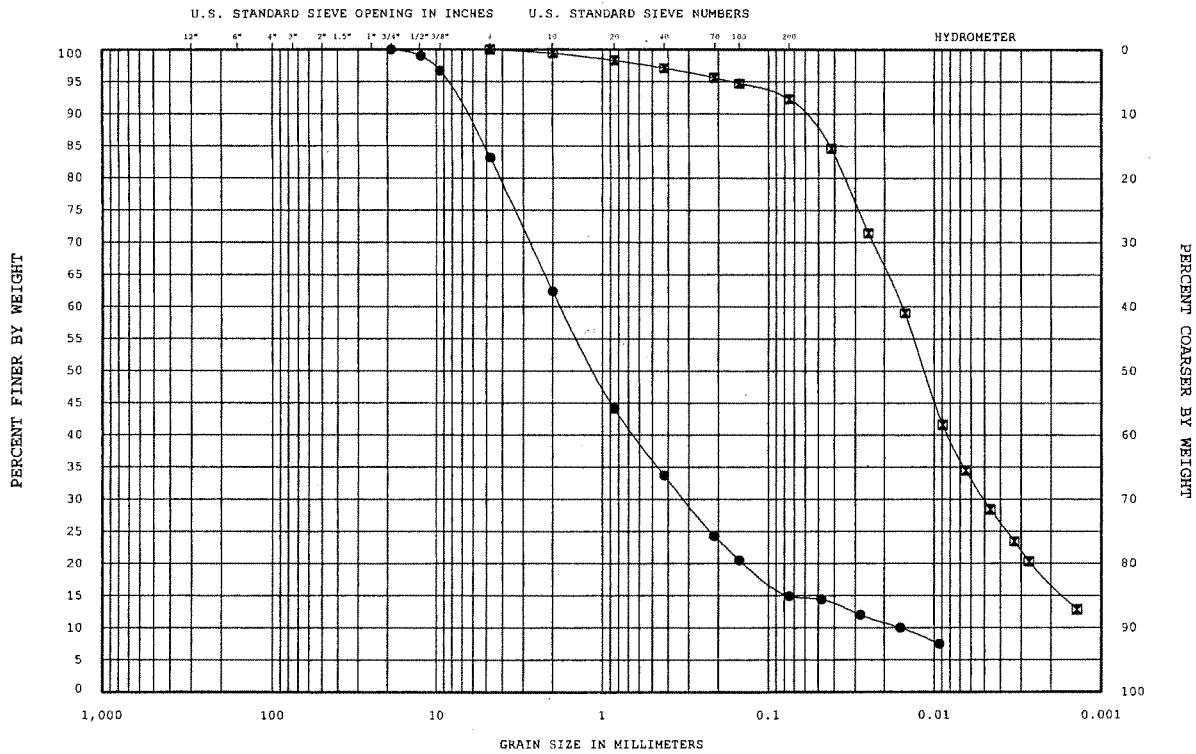
ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *CA04-1*

DATE: *Mar 04*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

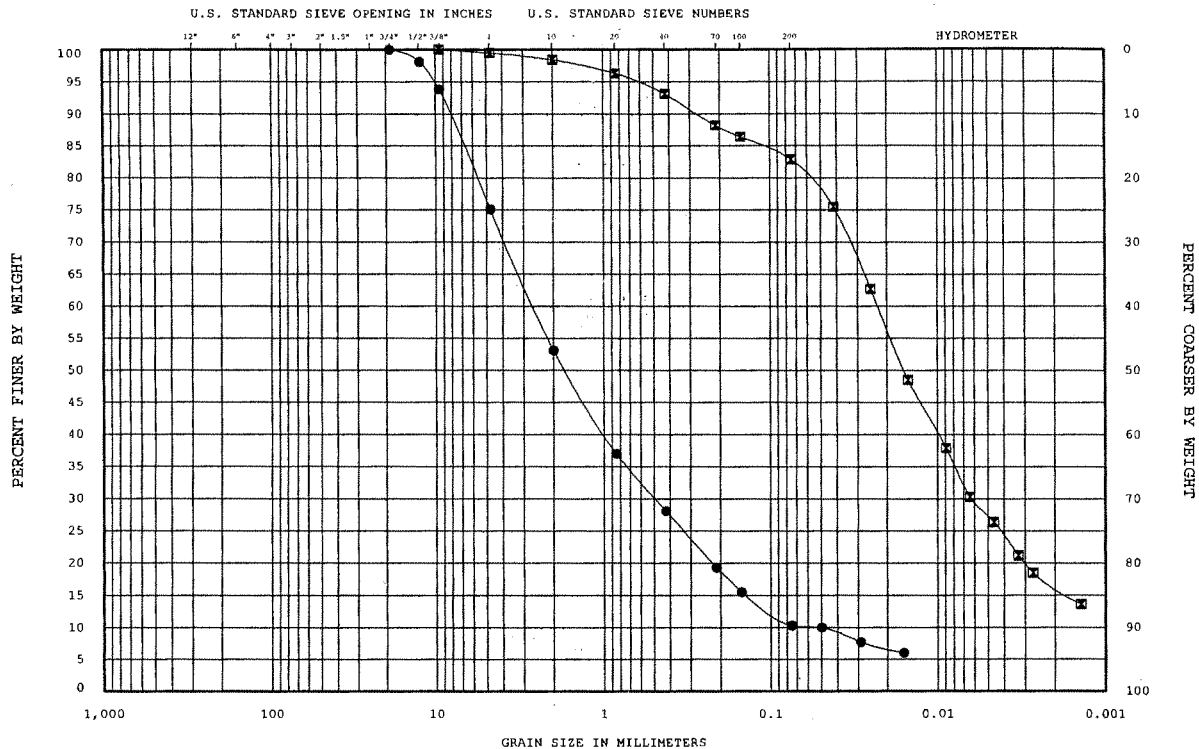
Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-4	4.5-6.0	SILTY SAND with GRAVEL	SM	37.8			
—⊠—	Jar-11	15.0-16.5	ELASTIC SILT	MH	70.1	60	35	25
— —								
— —								

Remarks:

ENG FORM ENG2687LIBERTY STATE PARK-ADD. BORINGS.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *CA04-2*
DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-4	4.5-6.0	WELL-GRADED SAND with SILT and GRAVEL	SW-SM	31.1			
—⊠—	Jar-14	19.5-21.0	FAT CLAY with SAND	CH	53.8	56	29	27
— —								
— —								

Remarks:

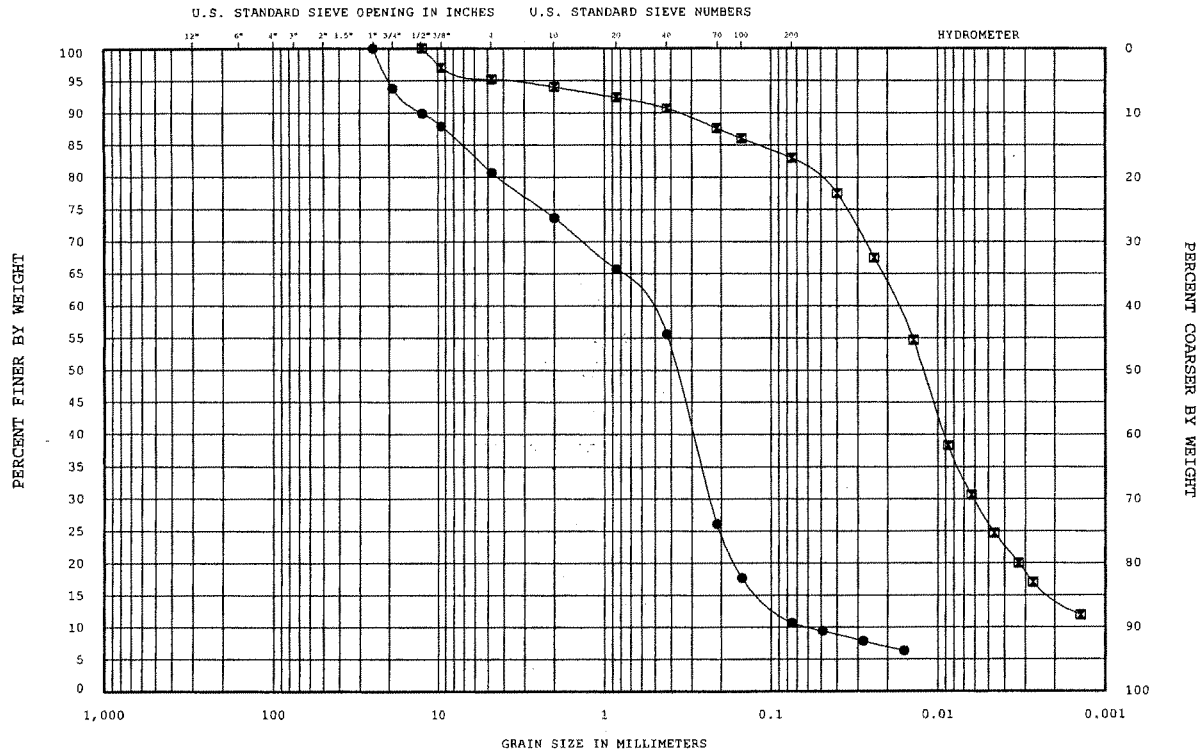
ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *CA04-3*

DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-7	9.0-10.5	WELL-GRADED SAND with SILT and GRAVEL	SW-SM	25.4			
—⊠—	Jar-11	15.0-16.5	ELASTIC SILT with SAND	MH	60.9	54	31	23
— —								
— —								

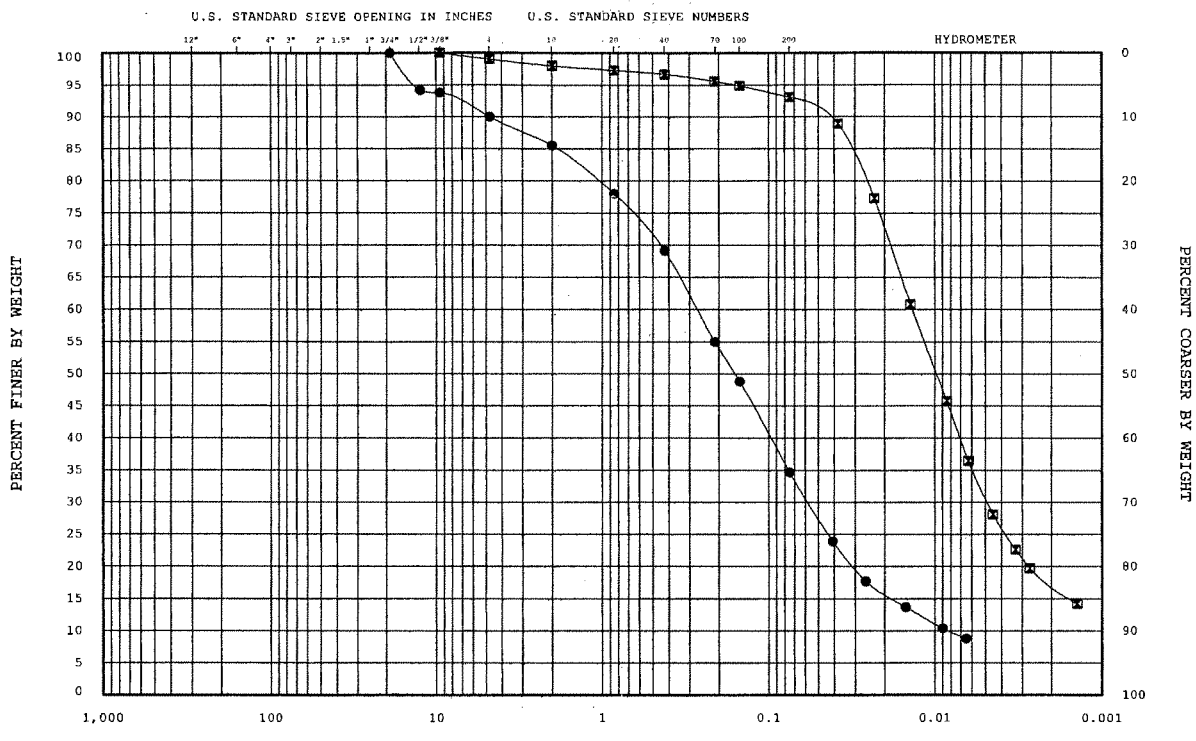
Remarks:

ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *CA04-4*
DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-6	7.5-9.0	SILTY SAND	SM	26.5			
—⊠—	Jar-11	15.0-16.5	ELASTIC SILT	MH	54.9	51	29	22

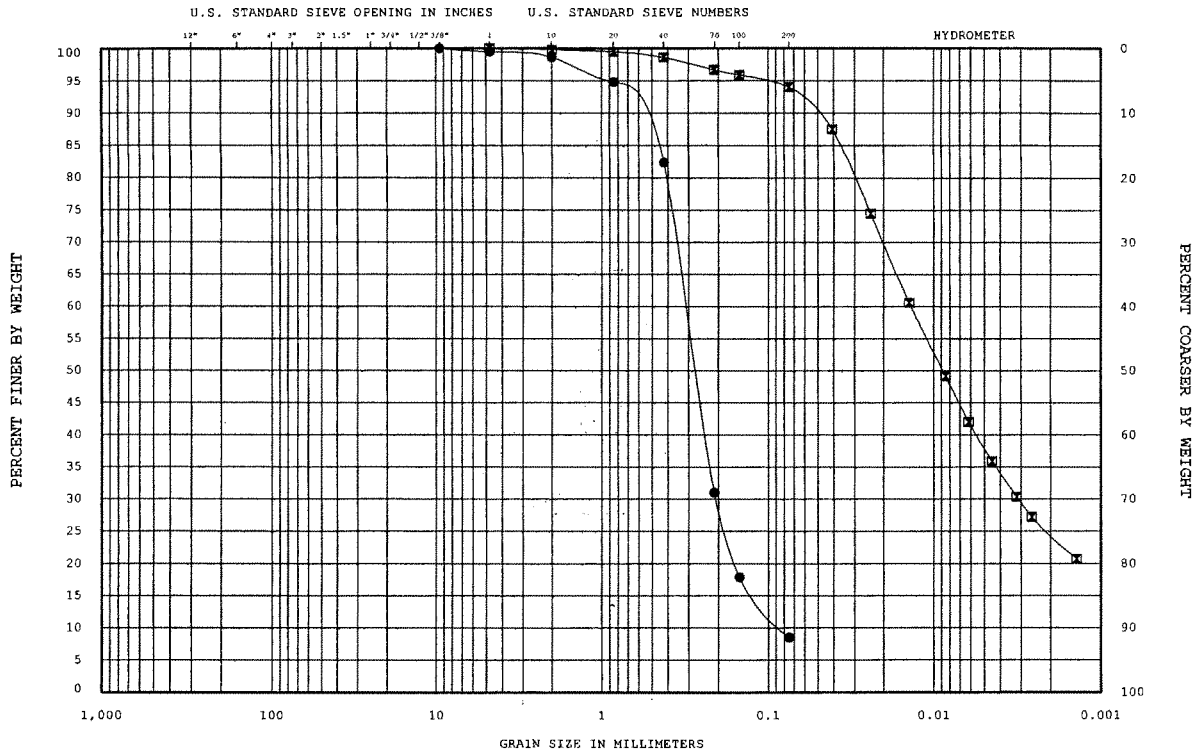
Remarks:

ENG FORM ENGZ097LIBERTY STATE PARK-ADD. BORING3.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *CA04-5*
DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	3.0-4.5	POORLY-GRADED SAND with SILT	SP-SM	23.6			
—⊠—	Jar-10	13.5-15.0	FAT CLAY	CH	59.4	52	27	25
— —								
— —								

Remarks:

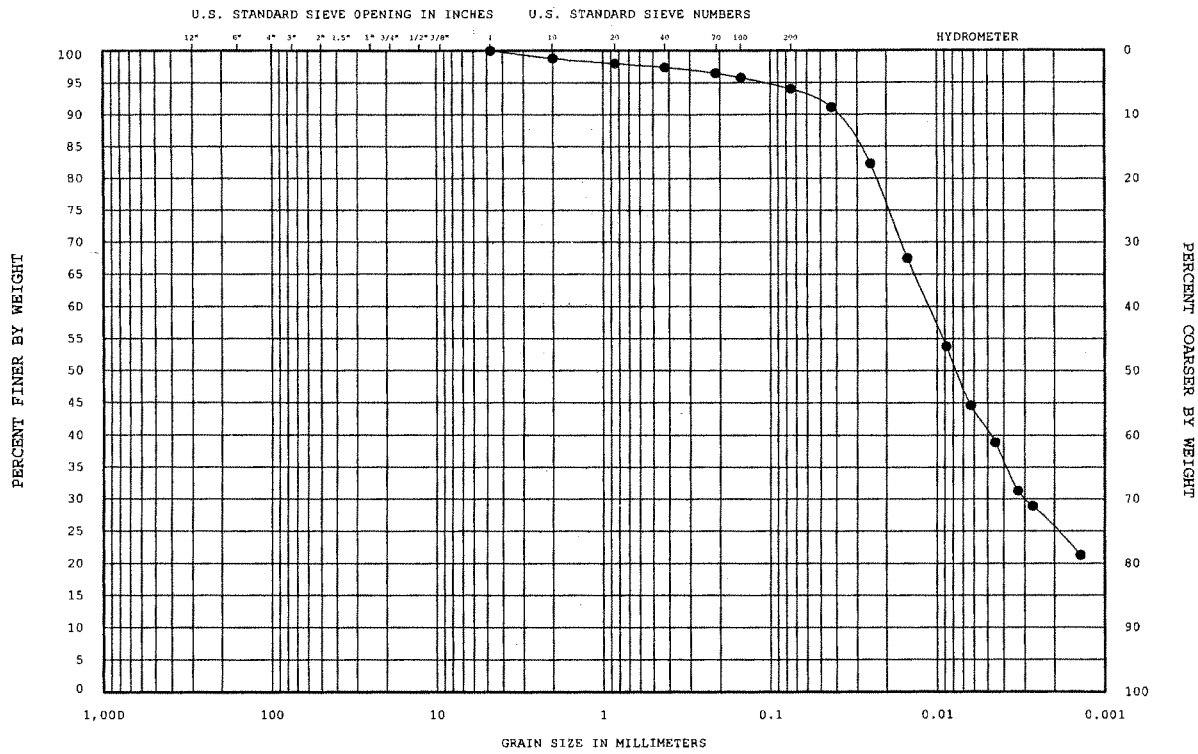
ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *CA04-6*

DATE: *Mar 04*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-4	4.5-6.0	FAT CLAY	CH	125.0	84	37	47
— —								
— —								
— —								

Remarks:

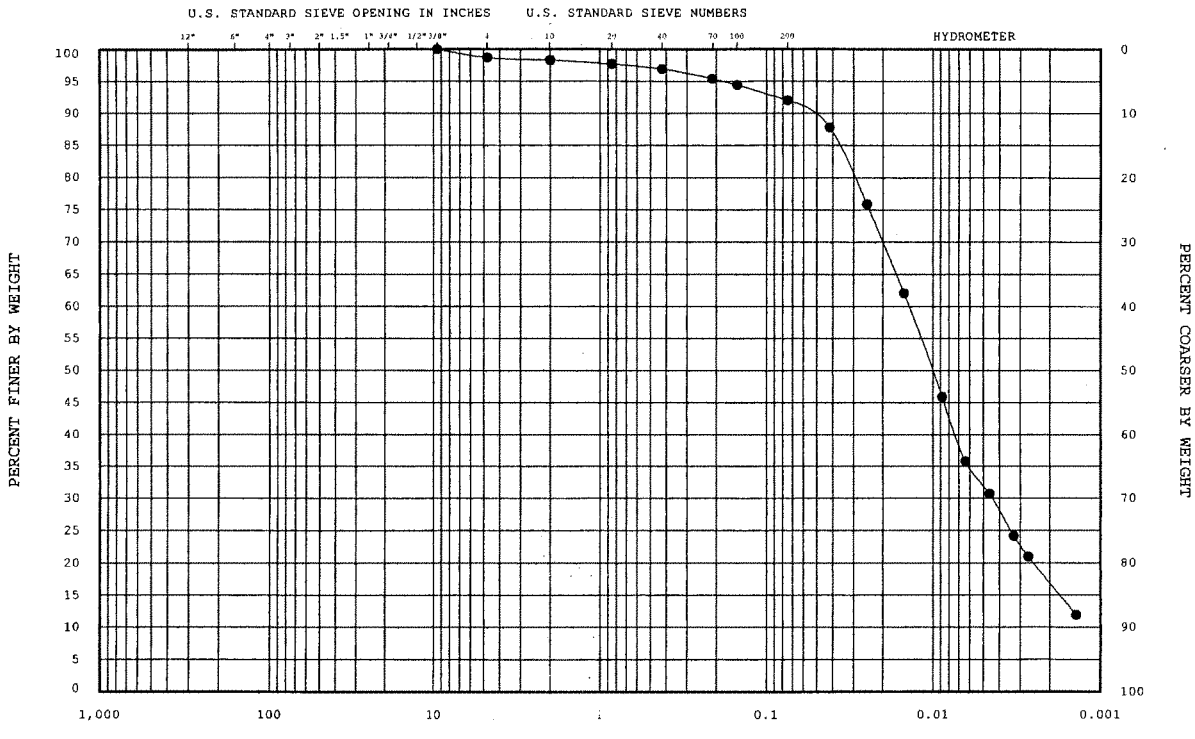
ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *NC04-1*

DATE: *Mar 04*



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-3	3.0-4.5	ELASTIC SILT	MH	103.5	82	39	43
— —								
— —								
— —								

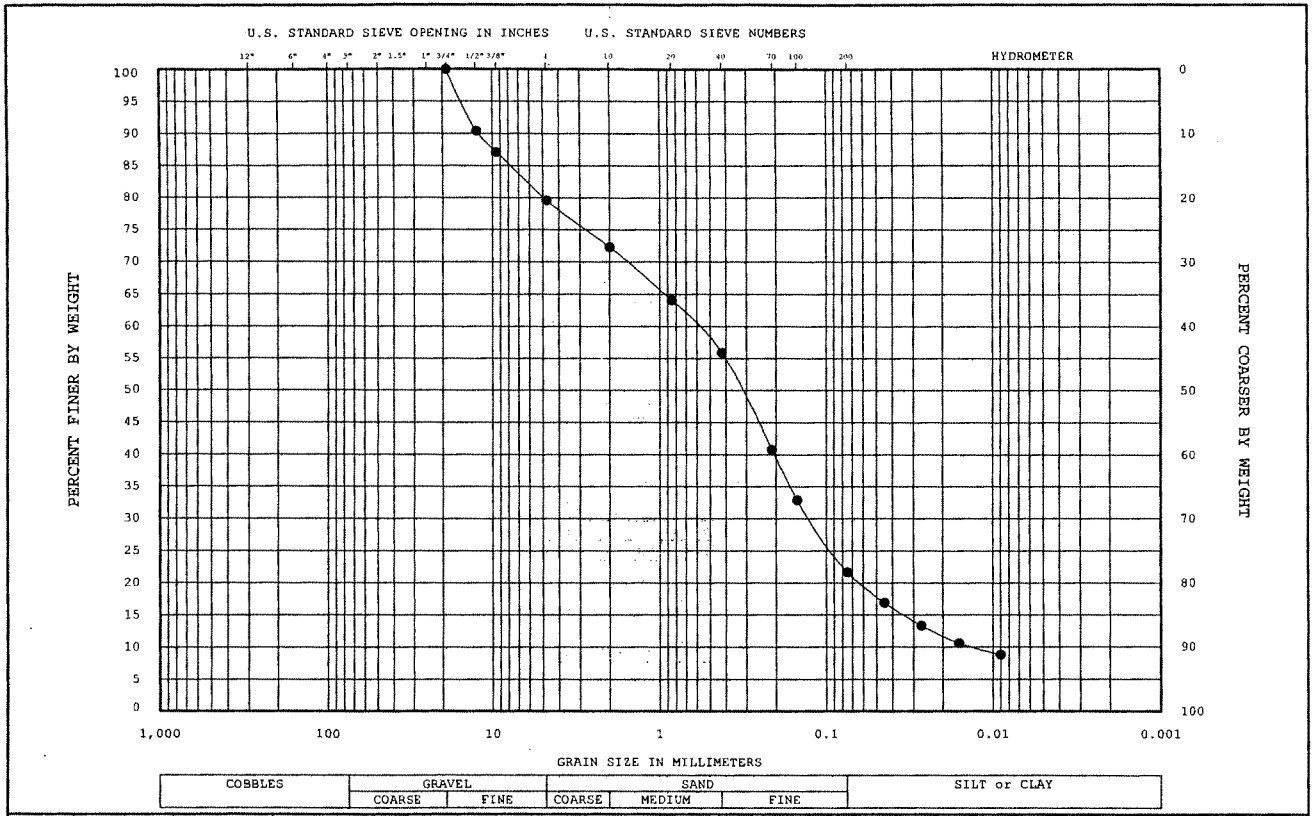
Remarks:

ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *NC04-2*

DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	1.5-3.0	SILTY SAND with GRAVEL	SM	9.6			
— —								
— —								
— —								

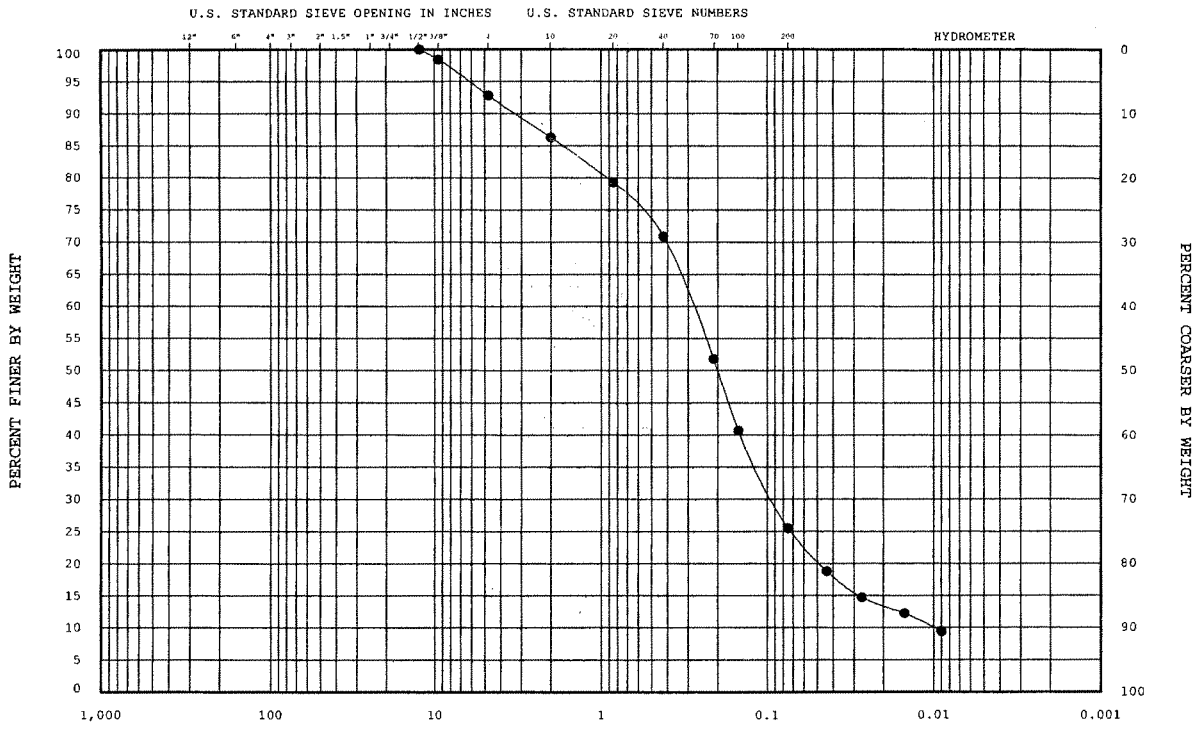
Remarks:

ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *NC04-3*

DATE: *Mar 04*



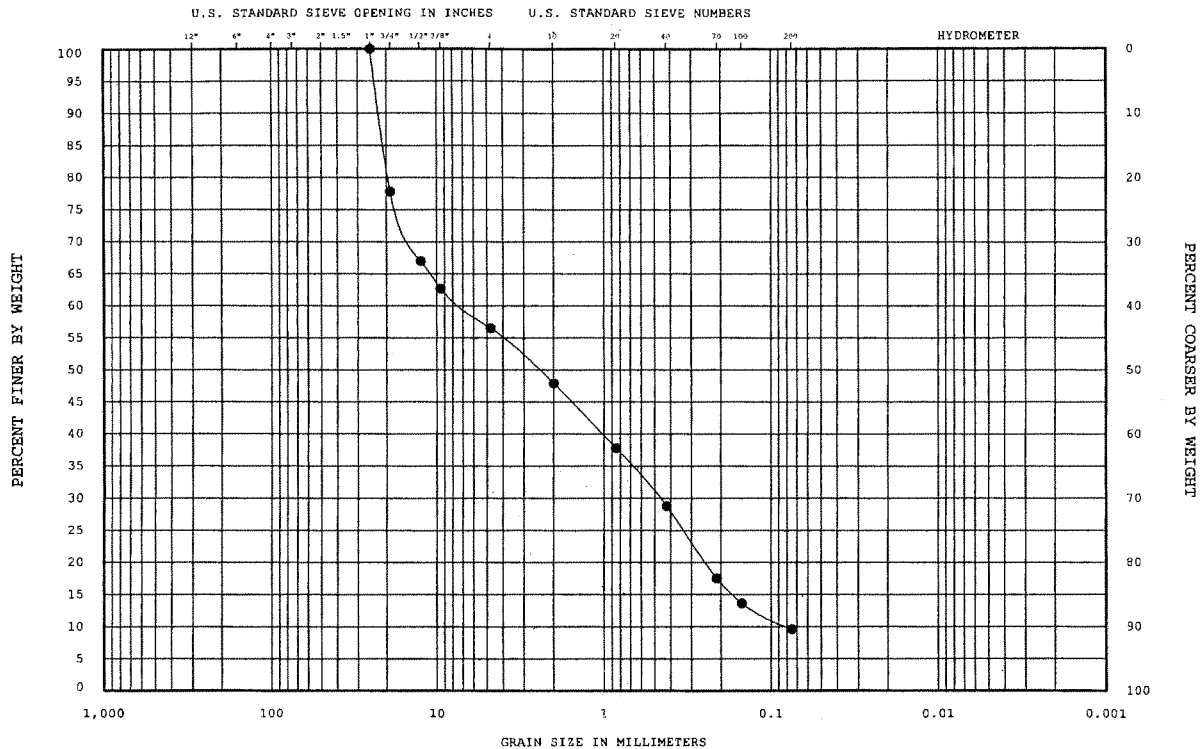
Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-2	1.5-3.0	SILTY SAND	SM	6.7			
— —								
— —								
— —								

Remarks:

ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *NC04-4*
DATE: *Mar 04*



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-4	4.5-6.0	POORLY-GRADED SAND with SILT and GRAVEL SP-SM	8.9			
— —							
— —							
— —							

Remarks:

ENG FORM ENG2087LIBERTY STATE PARK-ADD. BORINGS.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

PROJECT: *Liberty State Park - Additional Borings*
AREA: *Jersey City, NJ*

BORING NO.: *NC04-5*

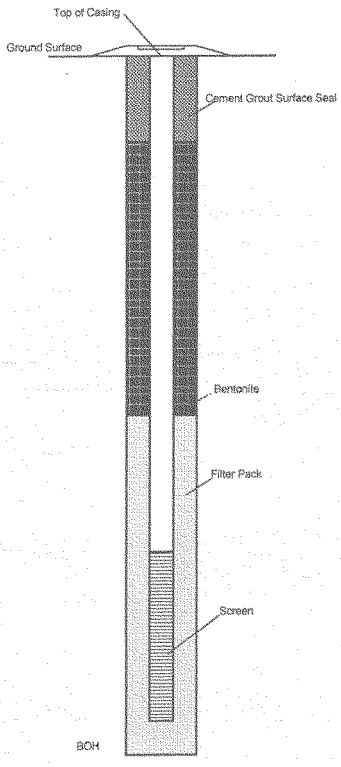
DATE: *Mar 04*

APPENDIX E
PERMANENT PIEZOMETER AS-BUILT RECORDS

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: LSP-03-01		LOCATION: Jersey City, NJ		DRILLER: B Creamer
PROJECT: Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 2.8'
DATE WELL COMPLETED:		SURFACE:	6.90'	DRILLING METHOD: HSA
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N683832.04799 E616002.71436
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.0'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	16.4'

* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

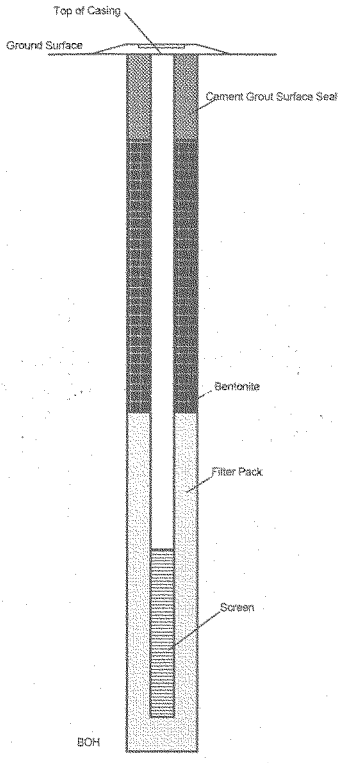
PROJECT Liberty State Park, Jersey City, NJ

HOLE NO.: LSP-03-01

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-02	LOCATION:	Jersey City, NJ	DRILLER: B Creamer	
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	3.7'
DATE WELL COMPLETED:		SURFACE:	7.37'	DRILLING METHOD: HSA	
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping	

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N683517.39349 E616362.32508
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.0'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	16.4'

* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

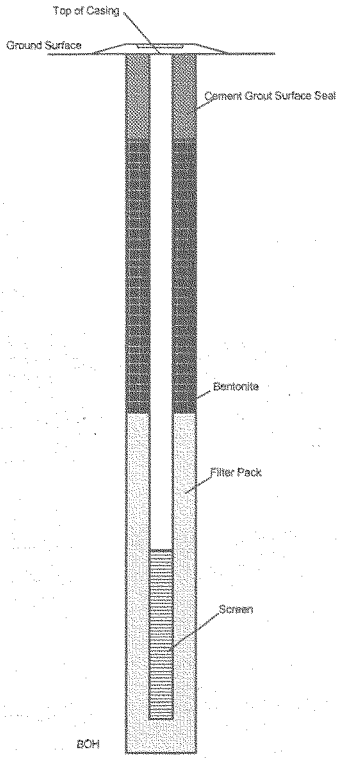
PROJECT Liberty State Park, Jersey City, NJ

HOLE NO.: LSP-03-02

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: LSP-03-03		LOCATION: Jersey City, NJ		DRILLER: B Creamer
PROJECT: Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 4.5'
DATE WELL COMPLETED:		SURFACE:	7.05'	DRILLING METHOD: HSA
DATE DEVEL. COMPLETED: 9/5/2003		TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N683192.86435 E617998.45475
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Concrete
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	7.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	17.0'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.4'

* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

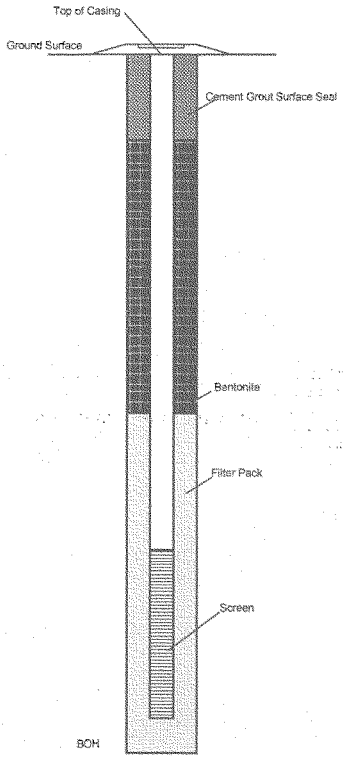
PROJECT Liberty State Park, Jersey City, NJ

HOLE NO.: LSP-03-03

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-04	LOCATION:	Jersey City, NJ	DRILLER: B Creamer	
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	3.2'
DATE WELL COMPLETED:		SURFACE:	5.04'	DRILLING METHOD: HSA	
DATE DEVEL. COMPLETED:	9/8/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping	

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N682884.30817 E618440.32038
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.0'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	16.4'

* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

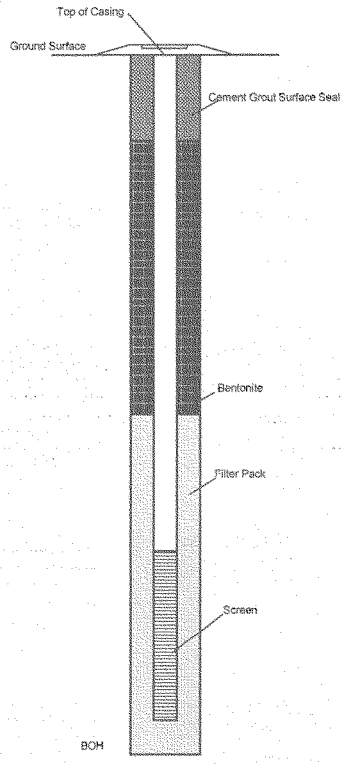
PROJECT Liberty State Park, Jersey City, NJ

HOLE NO.: LSP-03-04

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-05	LOCATION:	Jersey City, NJ		DRILLER: B Creamer
PROJECT:	Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 3.45'
DATE WELL COMPLETED:		SURFACE:	9.78'		DRILLING METHOD: HSA
DATE DEVEL. COMPLETED:	9/8/2003	TOP OF PVC CASING:	N/A		DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N682589.50605 E618535.55579
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.5'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.5'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.5'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	16.9'

* Depth to groundwater measured relative to ground surface

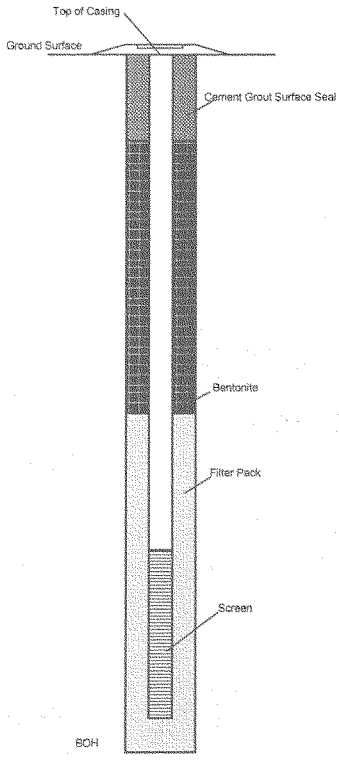
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-05

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: LSP-03-06		LOCATION: Jersey City, NJ		DRILLER: B Creamer
PROJECT: Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 4.02'
DATE WELL COMPLETED:		SURFACE:	7.56'	DRILLING METHOD: HSA
DATE DEVEL. COMPLETED: 9/6/2003		TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N682834.70794 E615902.61584
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.6'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.6'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.6'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.0'

* Depth to groundwater measured relative to ground surface

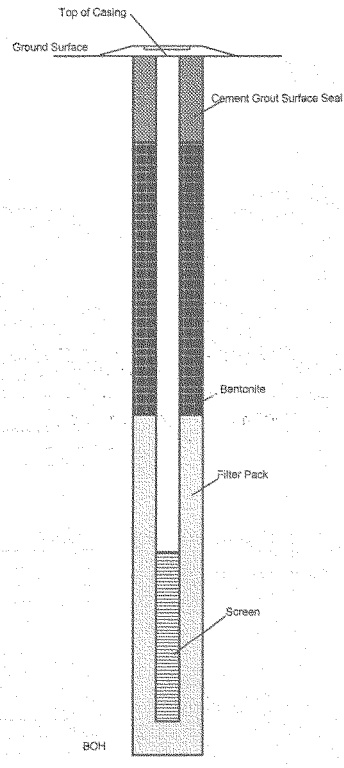
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-06

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: LSP-03-07		LOCATION: Jersey City, NJ		DRILLER: B Creamer
PROJECT: Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 2.6'
DATE WELL COMPLETED:		SURFACE:	6.53'	DRILLING METHOD: HSA
DATE DEVEL. COMPLETED: 9/10/2003		TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N682579.04042 E616800.74738
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	7.5'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	17.5'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.9'

* Depth to groundwater measured relative to ground surface

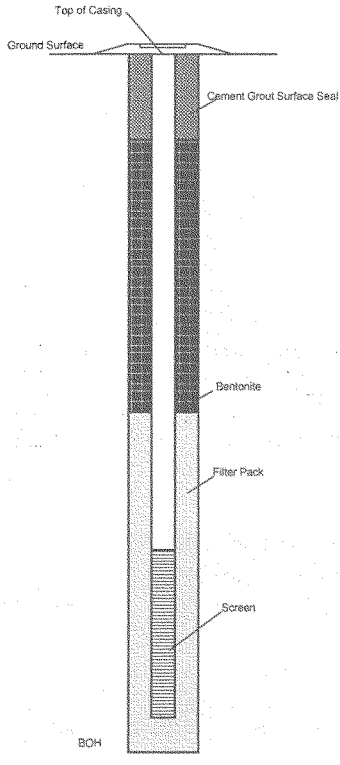
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ | HOLE NO.: LSP-03-07

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: LSP-03-08		LOCATION: Jersey City, NJ		DRILLER: B Creamer
PROJECT: Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 3.7'
DATE WELL COMPLETED:		SURFACE:	6.73'	DRILLING METHOD: HSA
DATE DEVEL. COMPLETED:	9/10/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N682288.46765 E615978.02068
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.5'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.5'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.5'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	16.9'

* Depth to groundwater measured relative to ground surface

USACE - Baltimore District

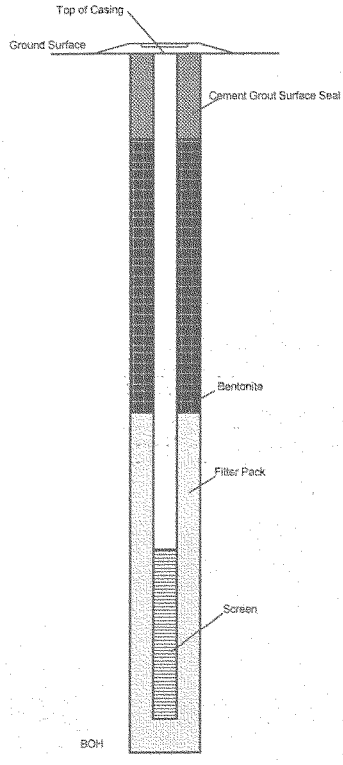
PROJECT Liberty State Park, Jersey City, NJ

HOLE NO.: LSP-03-08

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: LSP-03-09		LOCATION: Jersey City, NJ		DRILLER: B Creamer
PROJECT: Liberty State Park		ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 4.7'
DATE WELL COMPLETED:		SURFACE:	11.59'	DRILLING METHOD: HSA
DATE DEVEL. COMPLETED:	9/5/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N682011.33282 E614834.20085
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	4.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	7.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	17.0'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.4'

* Depth to groundwater measured relative to ground surface

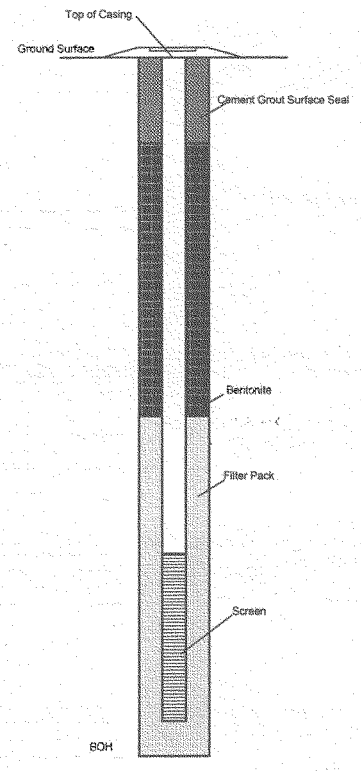
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-09

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-10	LOCATION:	Jersey City, NJ	DRILLER: B Creamer	
PROJECT:	Liberty State Park		ELEVATIONS (FT MSL)	DEPTH TO GW (FT)*:	4.0'
DATE WELL COMPLETED:		SURFACE:	9.05'	DRILLING METHOD: HSA	
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping	

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N681879.57853 E616168.43446
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	4.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	7.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	17.0'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.4'

* Depth to groundwater measured relative to ground surface

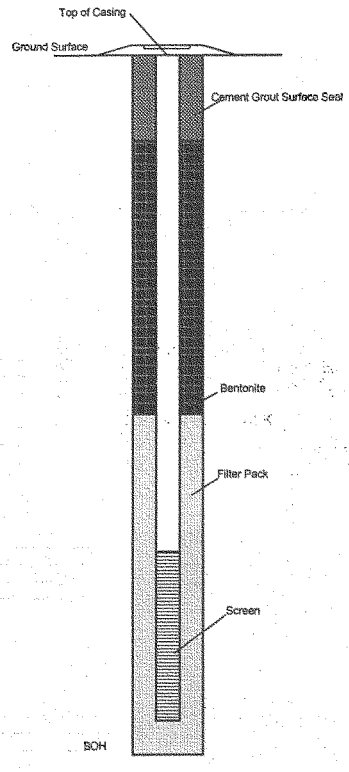
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-10

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-11	LOCATION:	Jersey City, NJ	DRILLER: B Creamer	
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	3.2'
DATE WELL COMPLETED:		SURFACE:	7.91'	DRILLING METHOD:	HSA
DATE DEVEL. COMPLETED:	9/5/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A	Actuator Pumping	

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N681150.51366 E615521.93360
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.5'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.5'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.5'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.6'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.6'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.0'

* Depth to groundwater measured relative to ground surface

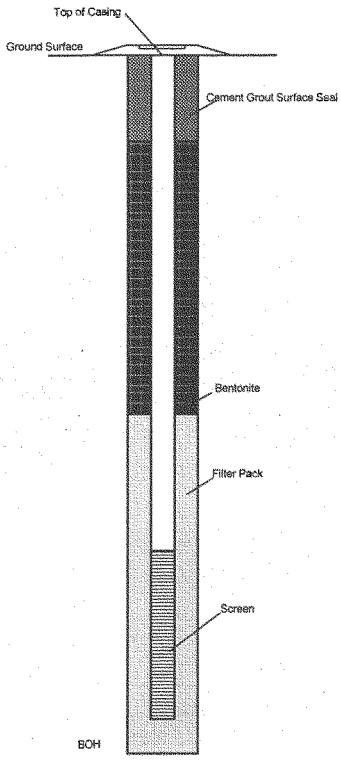
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-11

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-12	LOCATION:	Jersey City, NJ	DRILLER:	B Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	3.4'
DATE WELL COMPLETED:		SURFACE:	8.70'	DRILLING METHOD:	HSA
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR	W Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

PERMANENT PIEZOMETER



NTS

COORDINATES:	NJ State Plane N681514.54832 E616749.81368
DEPTH TO TOP OF CASING:	N/A
TYPE OF SURFACE SEAL:	Cement Grout
DEPTH OF SEAL:	1.0'
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
DEPTH TO TOP OF SEAL:	1.0'
TYPE OF SEAL:	Bentonite Pellets 5 Gals. Water
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand Bags
DEPTH TO TOP OF SCREEN:	6.6'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.6'
BOREHOLE DIAMETER:	10.25"
BOTTOM OF HOLE:	17.0'

* Depth to groundwater measured relative to ground surface

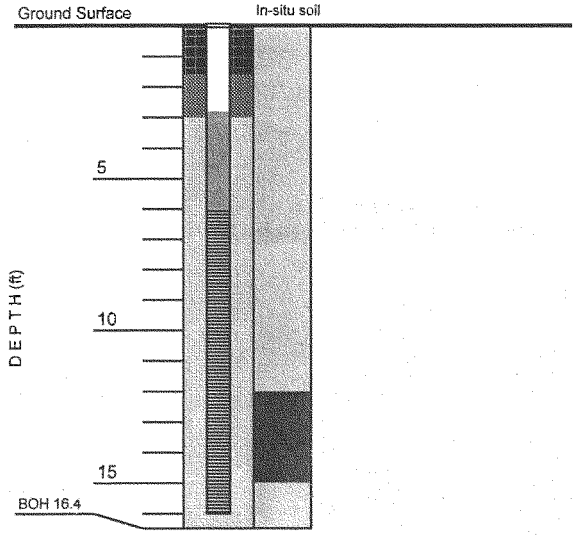
USACE - Baltimore District

PROJECT Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-12

APPENDIX F
PERMANENT PIEZOMETER CONSTRUCTION SCHEMATICS

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-01		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	6.90
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	4.10
		TOP OF WELL SCREEN:	0.90
DEPTH TO GROUNDWATER (FT)*:	2.8	BOTTOM OF WELL SCREEN:	-9.10



PERMANENT PIEZOMETER

LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

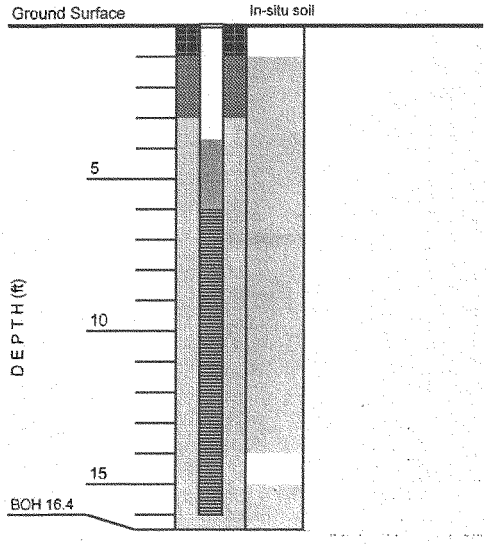
*Notes:
1. Depth to Groundwater (GW) measured relative to existing ground surface.
2. Groundwater reading taken at 24-hours after installation of piezometer.

USACE - Baltimore District

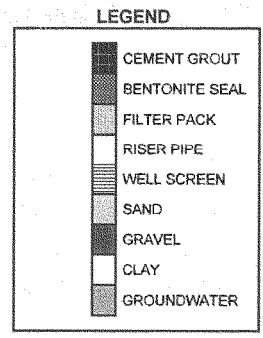
PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-01

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-02		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	7.37
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	3.67
		TOP OF WELL SCREEN:	1.37
DEPTH TO GROUNDWATER (FT):	3.7	BOTTOM OF WELL SCREEN:	-8.63



PERMANENT PIEZOMETER



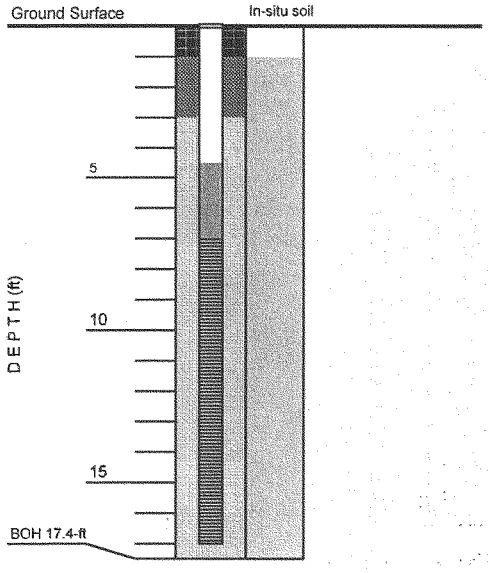
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-02

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-03		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	7.37
LOCATION:	JERSEY CITY, NJ	GROUNDWATER:	2.87
		TOP OF WELL SCREEN:	0.37
DEPTH TO GROUNDWATER (FT):	4.5	BOTTOM OF WELL SCREEN:	-9.63



PERMANENT PIEZOMETER

LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

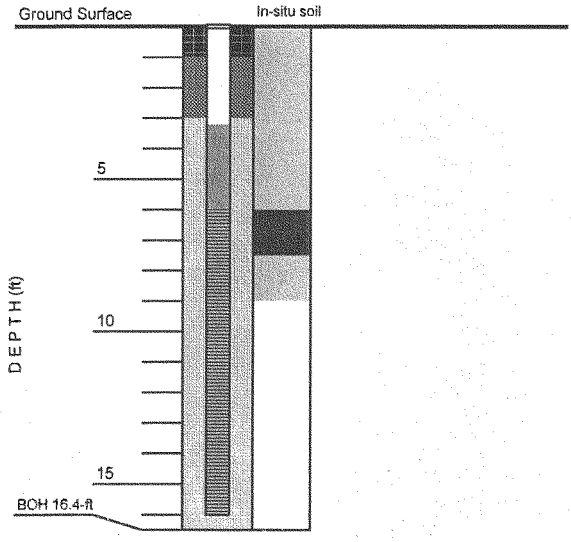
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-03

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-04		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	5.04
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	1.84
		TOP OF WELL SCREEN:	-0.96
DEPTH TO GROUNDWATER (FT):	3.2	BOTTOM OF WELL SCREEN:	-10.96



PERMANENT PIEZOMETER

LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

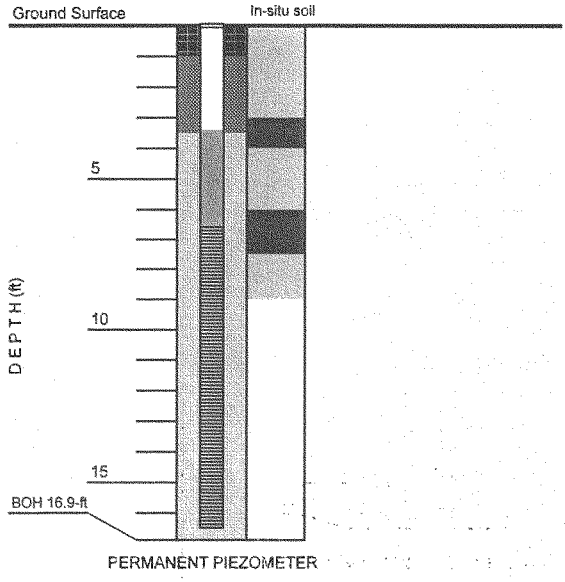
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

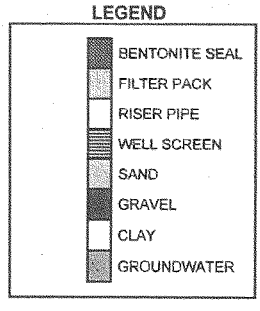
USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-04

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-05		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	9.78
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	6.33
		TOP OF WELL SCREEN:	3.28
DEPTH TO GROUNDWATER (FT):	3.45	BOTTOM OF WELL SCREEN:	-6.72





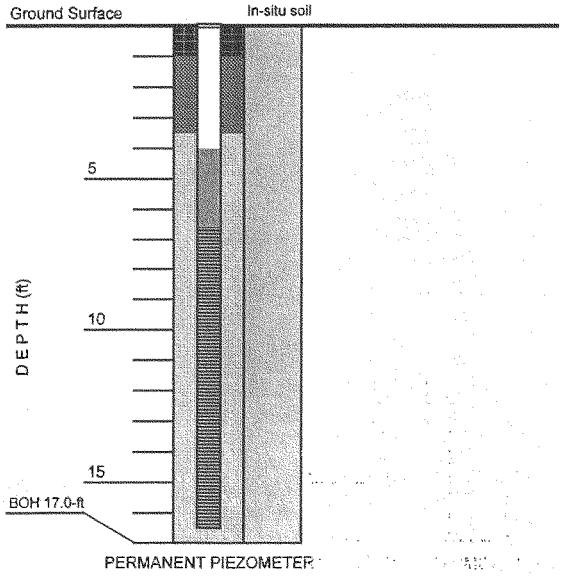
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

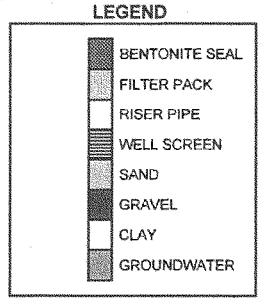
USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-05

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-06		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	9.78
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	5.76
		TOP OF WELL SCREEN:	3.18
DEPTH TO GROUNDWATER (FT):	4.02	BOTTOM OF WELL SCREEN:	-6.82





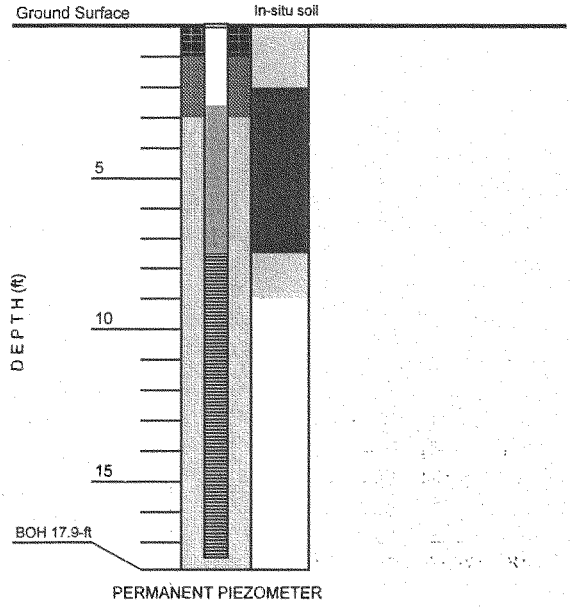
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK	LSP-03-06

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-07		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	6.53
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	3.93
		TOP OF WELL SCREEN:	-0.97
DEPTH TO GROUNDWATER (FT):	2.6	BOTTOM OF WELL SCREEN:	-10.97



LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

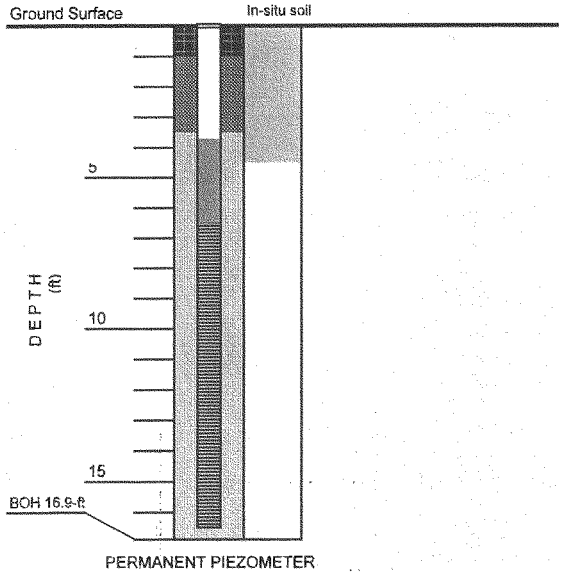
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

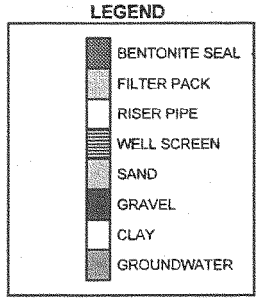
USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-07

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-08		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	6.73
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	3.03
		TOP OF WELL SCREEN:	0.23
DEPTH TO GROUNDWATER (FT): ▼	3.7	BOTTOM OF WELL SCREEN:	-9.77





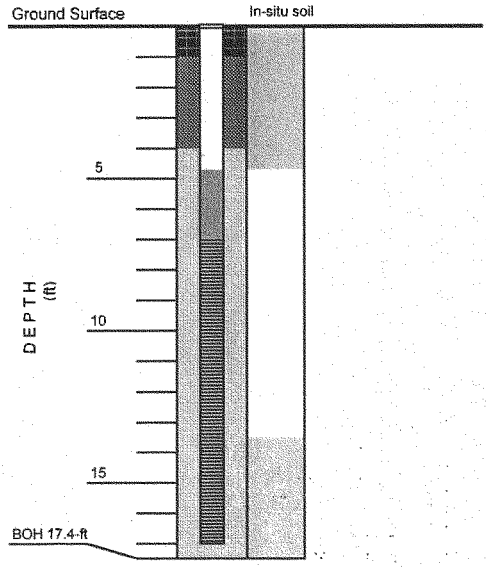
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

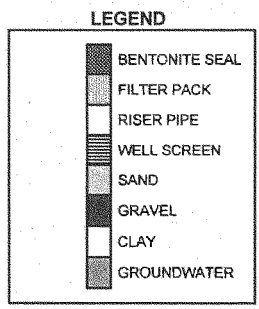
PROJECT:	HOLE NO.:
LIBERTY STATE PARK	LSP-03-08

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-09		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	11.59
LOCATION:	JERSEY CITY, NJ	GROUNDWATER:	6.89
		TOP OF WELL SCREEN:	4.59
DEPTH TO GROUNDWATER (FT):	4.7	BOTTOM OF WELL SCREEN:	-5.41



PERMANENT PIEZOMETER



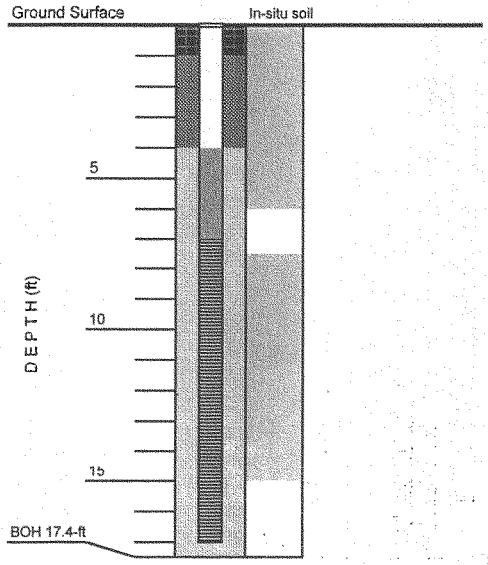
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

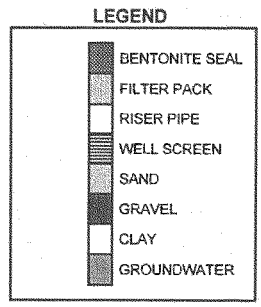
PROJECT:	HOLE NO.:
LIBERTY STATE PARK	LSP-03-09

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-10		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	9.05
LOCATION:	JERSEY CITY, NJ	GROUNDWATER:	5.05
		TOP OF WELL SCREEN:	2.05
DEPTH TO GROUNDWATER (FT):	4.0	BOTTOM OF WELL SCREEN:	-7.95



PERMANENT PIEZOMETER



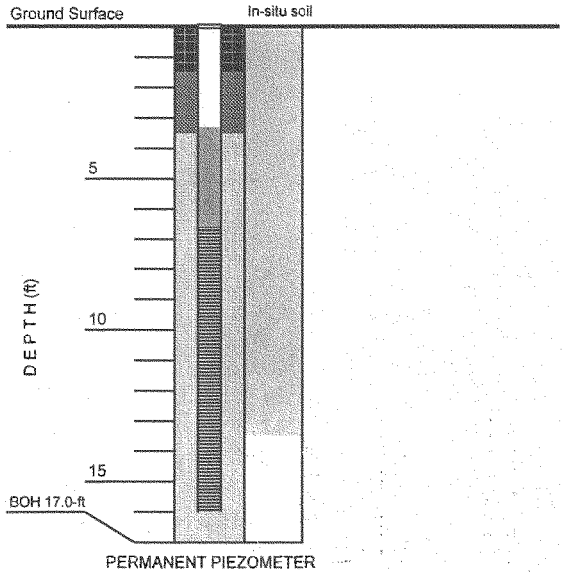
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

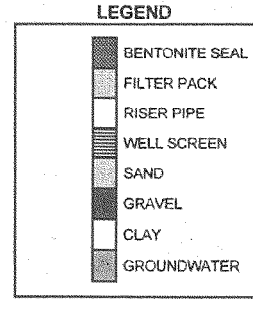
USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-10

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-11		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	7.91
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	4.71
		TOP OF WELL SCREEN:	1.31
DEPTH TO GROUNDWATER (FT):	3.2	BOTTOM OF WELL SCREEN:	-8.69





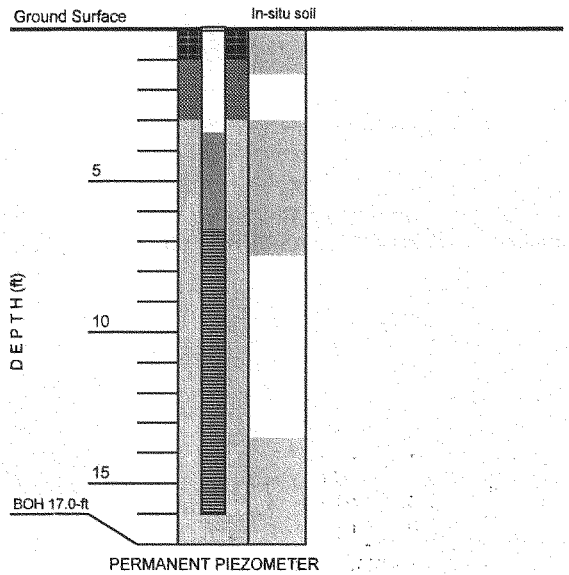
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-11

PIEZOMETER CONSTRUCTION SCHEMATIC

DRILL HOLE NUMBER LSP-03-12		ELEVATIONS (FT MSL)	
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	8.70
LOCATION:	JERSEY CITY, NJ	GROUNDWATER:	5.30
		TOP OF WELL SCREEN:	2.10
GROUNDWATER DEPTH (FT): ▼	3.4	BOTTOM OF WELL SCREEN:	-7.90



LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

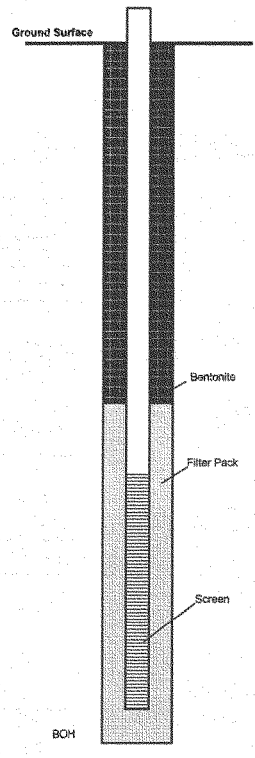
PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-12

APPENDIX G
TEMPORARY PIEZOMETER AS-BUILT RECORDS

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-17	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	3.0'
DATE WELL COMPLETED:	9/7/2003	SURFACE:	6.80'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 682979.20081
STICK UP TO TOP OF SURFACE CAS	E 616986.62282
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	3.0'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH OF SEAL:	3.0'
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	6.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.0'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	16.4'

* Depth to groundwater measured relative to ground surface

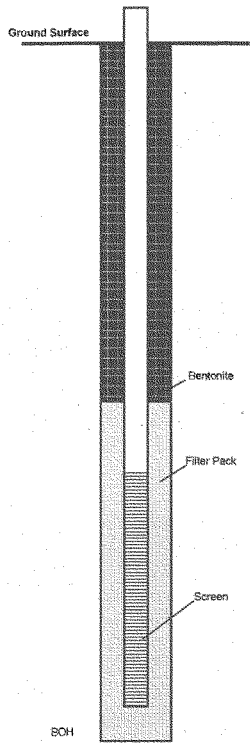
USACE - Baltimore District

PROJECT:	Liberty State Park, Jersey City, NJ	HOLE NO.:	LSP-03-17

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-19	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	4.3'
DATE WELL COMPLETED:	9/5/2003	SURFACE:	7.38'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 682477.62098
STICK UP TO TOP OF SURFACE CAS	E 617933.66717
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	4.0'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	4.0'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	7.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	17.0'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	17.4'

* Depth to groundwater measured relative to ground surface

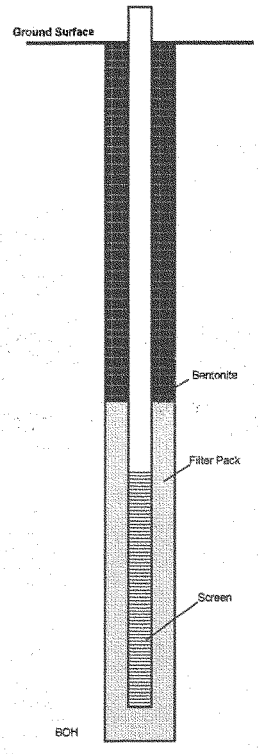
USACE - Baltimore District

PROJECT:	Liberty State Park, Jersey City, NJ	HOLE NO.:	LSP-03-19

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-24	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	4.8'
DATE WELL COMPLETED:	8/28/2003	SURFACE:	10.31'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/12/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 682189.16123
STICK UP TO TOP OF SURFACE CAS	E 617249.39812
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	5.0'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	5.0'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	8.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	18.0'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	18.4'

* Depth to groundwater measured relative to ground surface

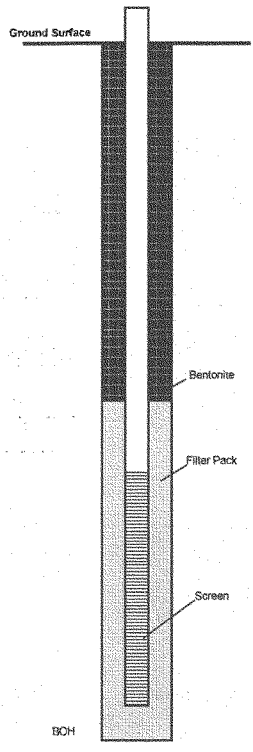
USACE - Baltimore District

PROJECT:	Liberty State Park, Jersey City, NJ	HOLE NO.:	LSP-03-24

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-28	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	5.4'
DATE WELL COMPLETED:	9/4/2003	SURFACE:	7.45'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/15/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 681500.67515
STICK UP TO TOP OF SURFACE CASE	E 617241.07892
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	5.0'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	5.0'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	8.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	18.0'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	18.4'

* Depth to groundwater measured relative to ground surface

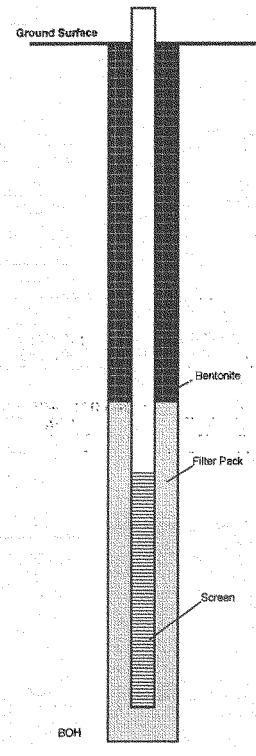
USACE - Baltimore District

PROJECT:	Liberty State Park, Jersey City, NJ	HOLE NO.:	LSP-03-28

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-31	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	3.1'
DATE WELL COMPLETED:	8/28/2003	SURFACE:	7.16'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/8/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 681126.57585
STICK UP TO TOP OF SURFACE CASE	E 616796.39857
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	3.0'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	3.0'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	6.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	16.0'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	16.4'

* Depth to groundwater measured relative to ground surface

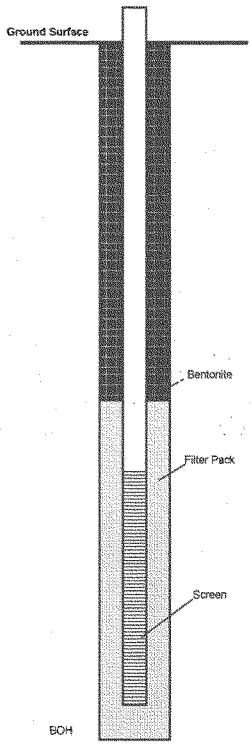
USACE - Baltimore District

PROJECT:	Liberty State Park, Jersey City, NJ	HOLE NO.:	LSP-03-31

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-32	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	5.5'
DATE WELL COMPLETED:	8/28/2003	SURFACE:	8.15'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/9/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 680562.33551
STICK UP TO TOP OF SURFACE CAS	E 614827.67803
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	5.5'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	5.5'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	8.5'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	18.5'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	18.9'

* Depth to groundwater measured relative to ground surface

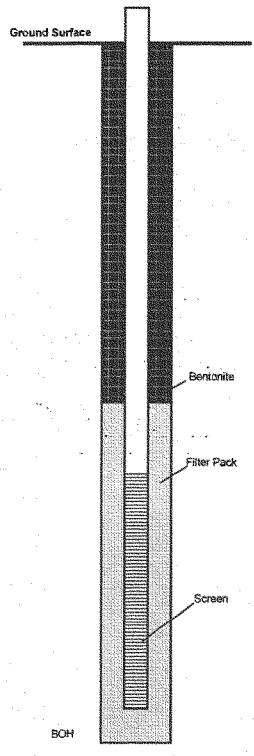
USACE - Baltimore District

PROJECT: Liberty State Park, Jersey City, NJ	HOLE NO.: LSP-03-32

AS BUILT MONITORING WELL RECORD

HOLE NUMBER:	LSP-03-38	LOCATION:	Jersey City, NJ	DRILLER:	Bobby Creamer
PROJECT:	Liberty State Park	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*:	9.6'
DATE WELL COMPLETED:	8/27/2003	SURFACE:	9.44'	DRILLING METHOD:	Augers
DATE DEVEL. COMPLETED:	9/12/2003	TOP OF PVC CASING:	N/A	DEVELOPMENT METHOD:	
INSPECTOR:	W. E. Shipley	TOP OF OUTER CASING:	N/A		Actuator Pumping

TEMPORARY PIEZOMETER



NTS

COORDINATES:	NJ State Plane 2900 NAD83
	N 680654.67995
STICK UP TO TOP OF SURFACE CAS	E 615601.34192
STICK UP TO TOP OF RISER PIPE:	2.5'
TYPE OF SURFACE SEAL:	Bentonite
DEPTH OF SEAL:	4.0'
I.D. OF SURFACE CASING:	N/A
TYPE OF SURFACE CASING:	N/A
I.D.OF RISER PIPE:	2"
TYPE OF RISER PIPE:	PVC
TYPE OF GROUT:	Bentonite
DEPTH TO TOP OF SEAL:	Surface
TYPE OF SEAL:	Bentonite
DEPTH TO TOP OF FILTER PACK:	4.0'
TYPE OF FILTER PACK:	#1 sand
DEPTH TO TOP OF SCREEN:	7.0'
TYPE OF SCREEN:	PVC
SLOT SIZE AND LENGTH:	10 slot 10'
I.D. OF SCREEN:	2"
DEPTH TO BOTTOM OF SCREEN:	17.0'
BOREHOLE DIAMETER:	7.25"
BOTTOM OF HOLE:	17.4

* Depth to groundwater measured relative to ground surface

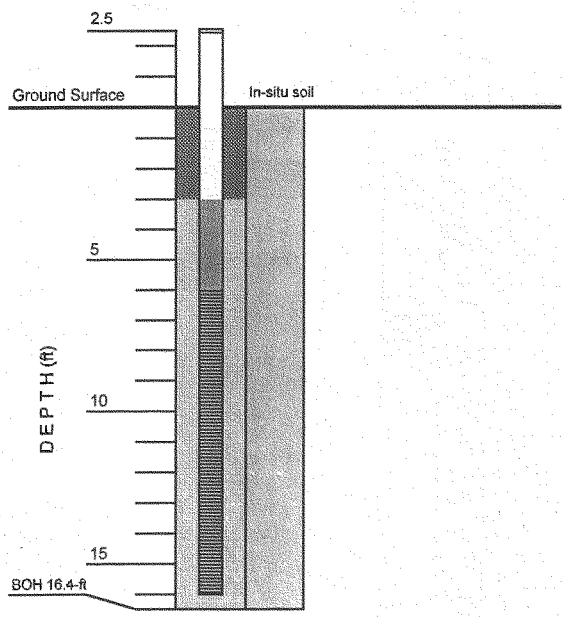
USACE - Baltimore District

PROJECT:	Liberty State Park, Jersey City, NJ	HOLE NO.:	LSP-03-38

APPENDIX H
TEMPORARY PIEZOMETER CONSTRUCTION SCHEMATICS

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-17		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	6.80
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	3.80
		TOP OF WELL SCREEN:	0.80
DEPTH TO GROUNDWATER (FT):	3.0	BOTTOM OF WELL SCREEN:	-9.20



TEMPORARY PIEZOMETER

LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

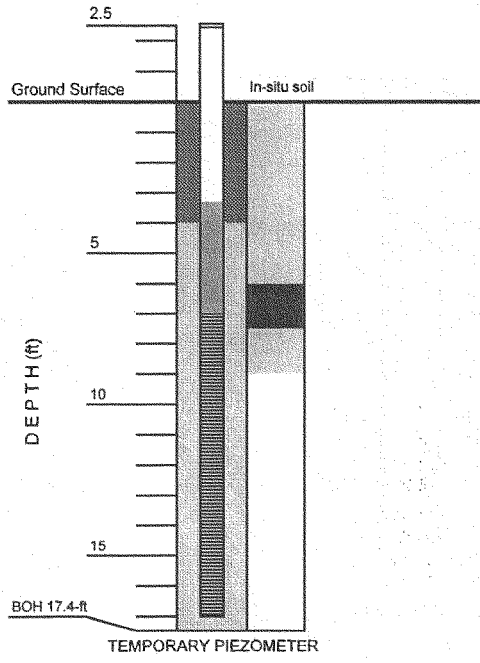
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-17

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-19		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	7.38
LOCATION:	JERSEY CITY, NJ	GROUNDWATER:	3.08
		TOP OF WELL SCREEN:	0.38
DEPTH TO GROUNDWATER (FT):	4.3	BOTTOM OF WELL SCREEN:	-9.62



LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

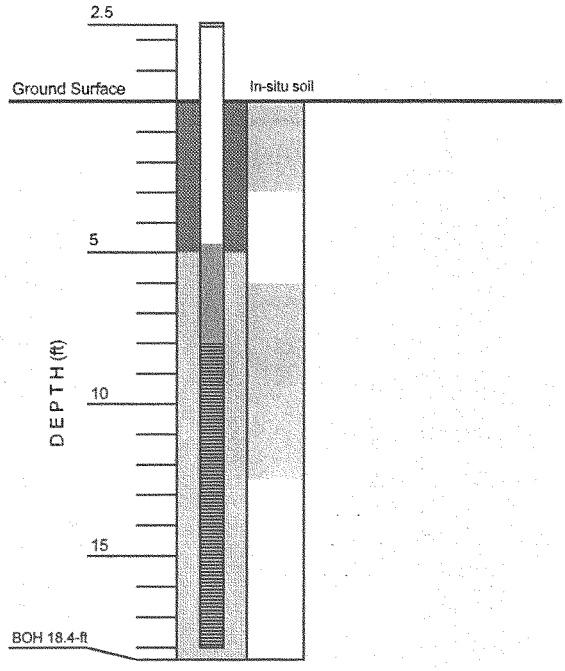
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

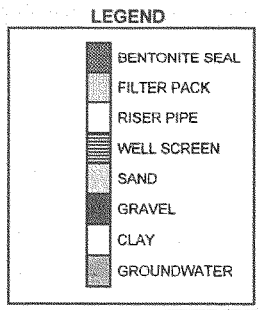
PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-19

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-24		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	10.31
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	5.51
		TOP OF WELL SCREEN:	2.31
DEPTH TO GROUNDWATER (FT):	4.8	BOTTOM OF WELL SCREEN:	-7.69



TEMPORARY PIEZOMETER



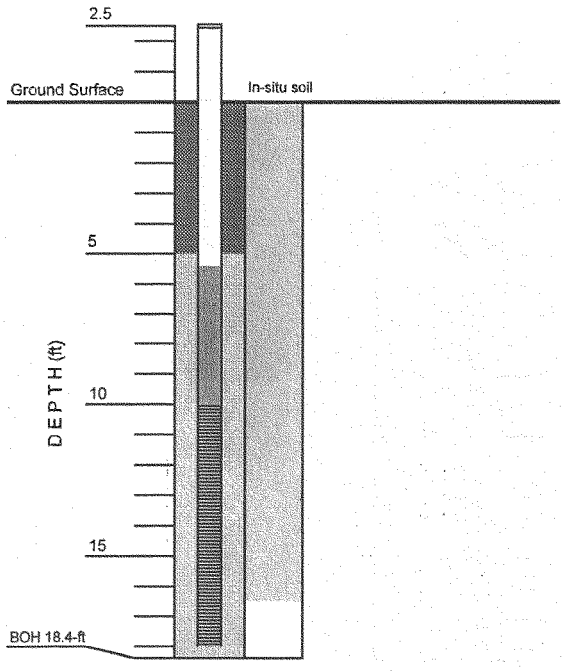
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-24

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-28		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	7.45
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	2.05
		TOP OF WELL SCREEN:	-0.55
DEPTH TO GROUNDWATER (FT):	5.4	BOTTOM OF WELL SCREEN:	-10.55



TEMPORARY PIEZOMETER

LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

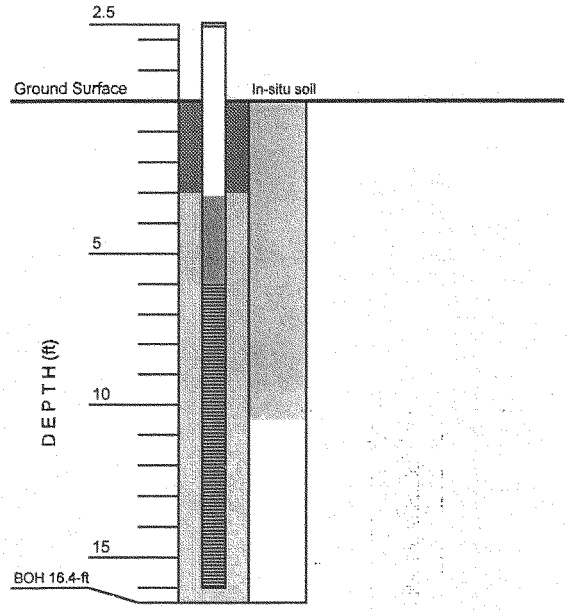
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-28

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-31		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	7.16
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	4.06
		TOP OF WELL SCREEN:	1.16
DEPTH TO GROUNDWATER (FT):	3.1	BOTTOM OF WELL SCREEN:	-8.84



TEMPORARY PIEZOMETER

LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

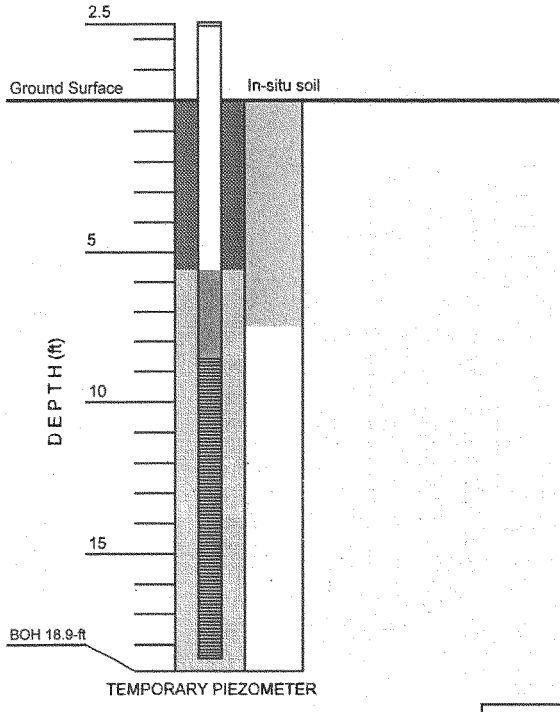
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-31

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-32		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	8.15
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	2.55
		TOP OF WELL SCREEN:	-0.35
DEPTH TO GROUNDWATER (FT):	5.6	BOTTOM OF WELL SCREEN:	-10.35



LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

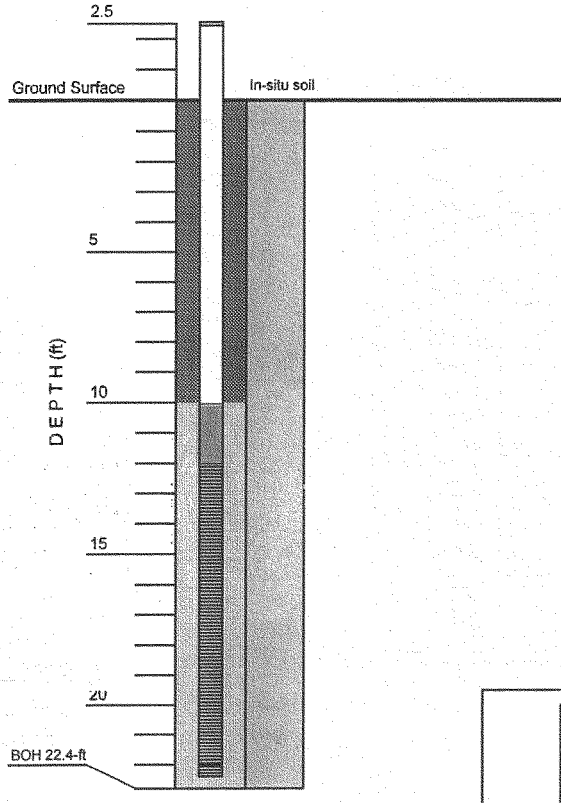
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

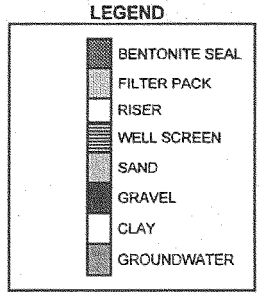
PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-32

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-35		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	12.46
LOCATION:	JERSEY CITY, NJ	GROUNDWATER (24-hour reading):	2.36
		TOP OF WELL SCREEN:	2.46
DEPTH TO GROUNDWATER (FT):	10.1	BOTTOM OF WELL SCREEN:	-9.54



TEMPORARY PIEZOMETER



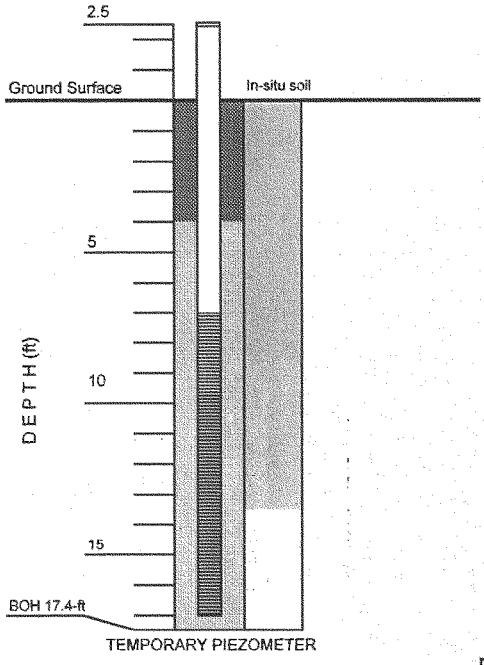
Notes:
2. Groundwater reading taken at 24-hour after installation of piezometer.

USACE - Baltimore District

PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-35

PIEZOMETER CONSTRUCTION SCHEMATIC

HOLE NUMBER:	LSP-03-38		ELEVATIONS (FT MSL)
PROJECT:	LIBERTY STATE PARK	GROUND SURFACE:	9.44
LOCATION:	JERSEY CITY, NJ	GROUNDWATER:	-0.16
		TOP OF WELL SCREEN:	2.44
DEPTH TO GROUNDWATER (FT):	9.6	BOTTOM OF WELL SCREEN:	-7.56



LEGEND

- BENTONITE SEAL
- FILTER PACK
- RISER PIPE
- WELL SCREEN
- SAND
- GRAVEL
- CLAY
- GROUNDWATER

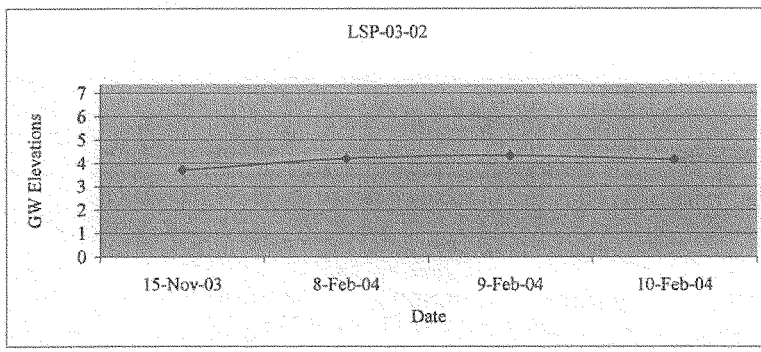
Notes:
1. Depth to groundwater measured relative to ground surface.
2. Groundwater reading taken at 24-hour after installation of piezometer.

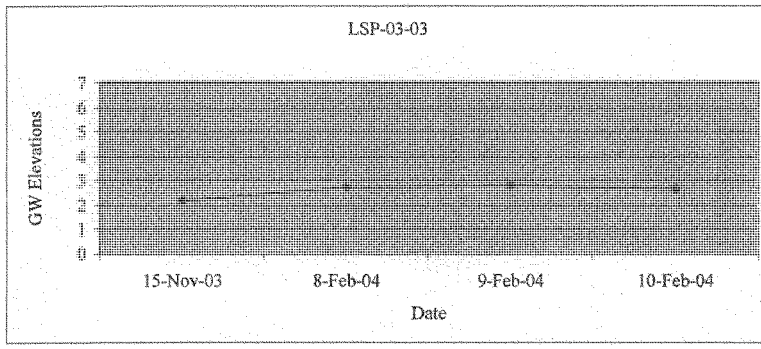
USACE - Baltimore District

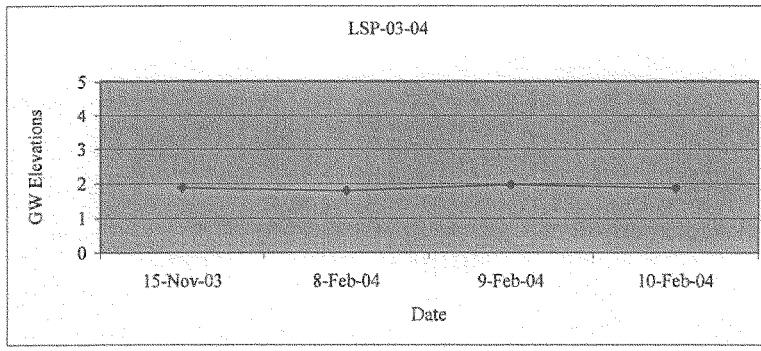
PROJECT:	HOLE NO.:
LIBERTY STATE PARK, Jersey City, NJ	LSP-03-38

APPENDIX I
CHANGES IN GROUNDWATER ELEVATIONS IN PERMANENT PIEZOMETERS

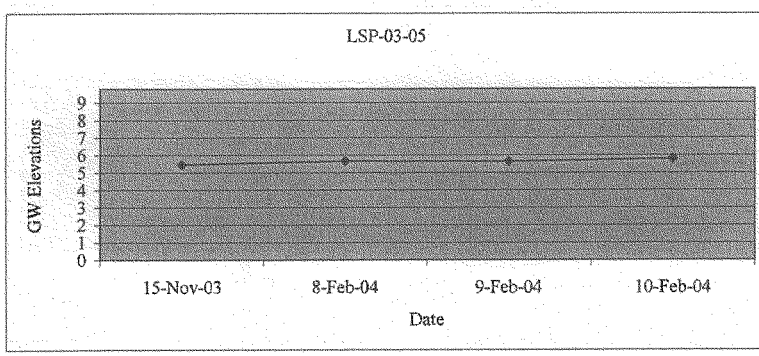
LIBERTY STATE PARK
CHANGES IN GROUNDWATER ELEVATIONS
PERMANENT PIEZOMETERS

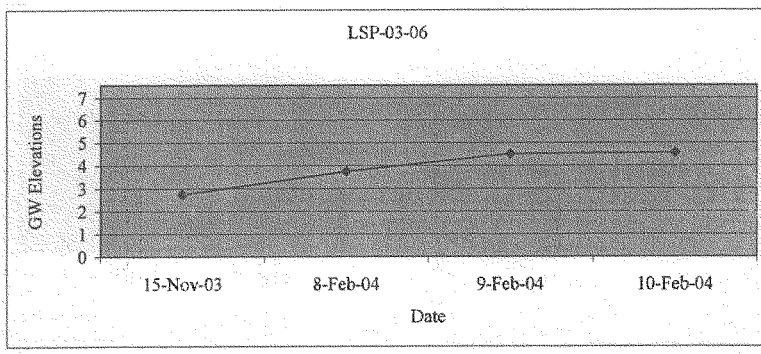


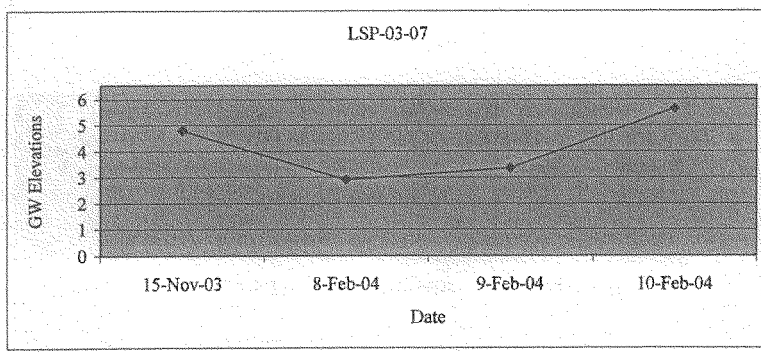




LIBERTY STATE PARK
CHANGES IN GROUNDWATER ELEVATIONS
PERMANENT PIEZOMETERS

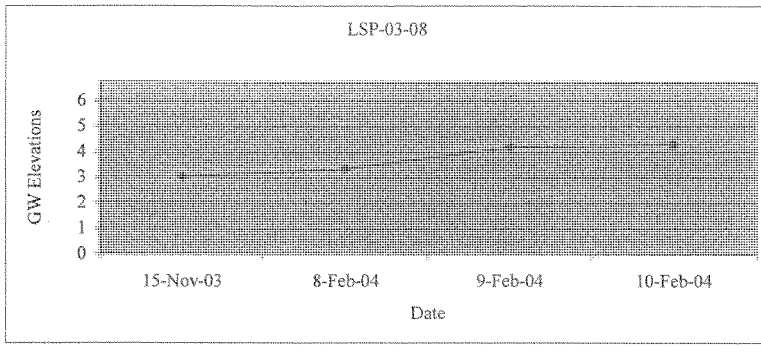


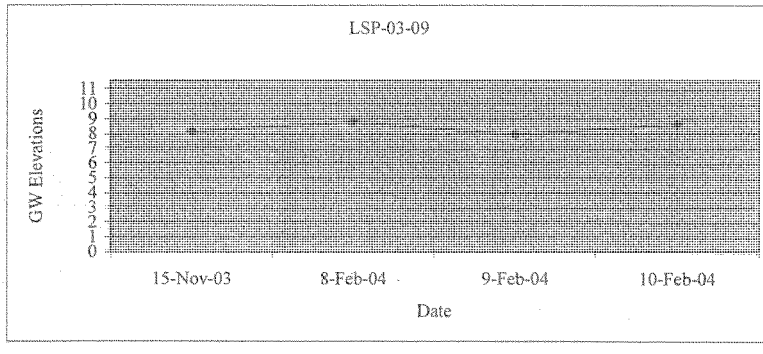


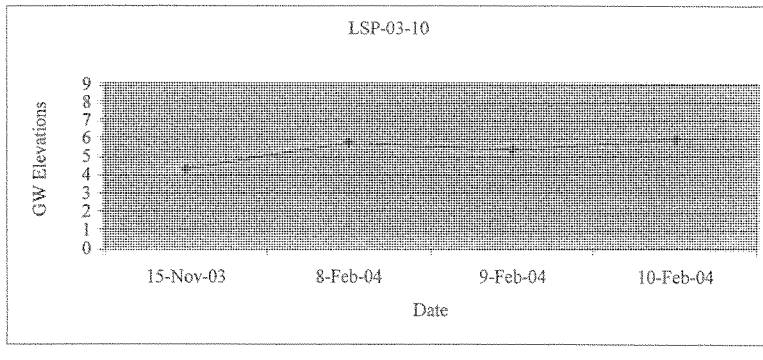


Note: Top of Graph Represents Top of Drill Hole Elevation

LIBERTY STATE PARK
CHANGES IN GROUNDWATER ELEVATIONS
PERMANENT PIEZOMETERS

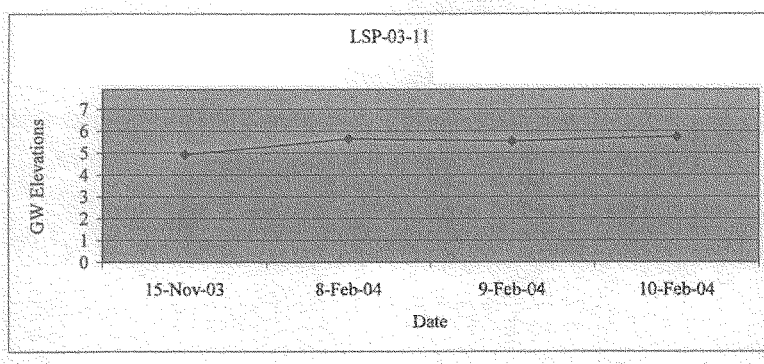


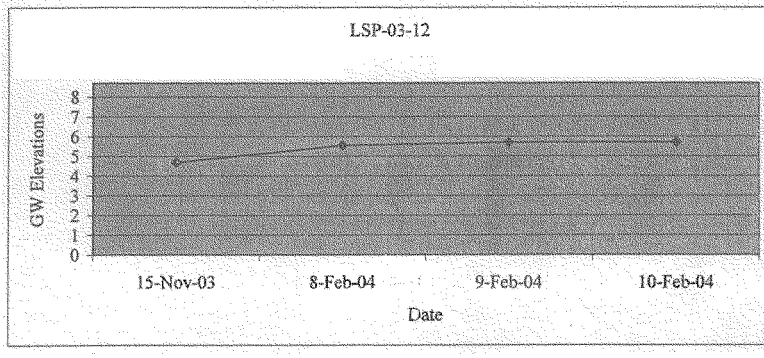




Note: Top of Graph Represents Top of Drill Hole Elevation

LIBERTY STATE PARK
CHANGES IN GROUNDWATER ELEVATIONS
PERMANENT PIEZOMETERS



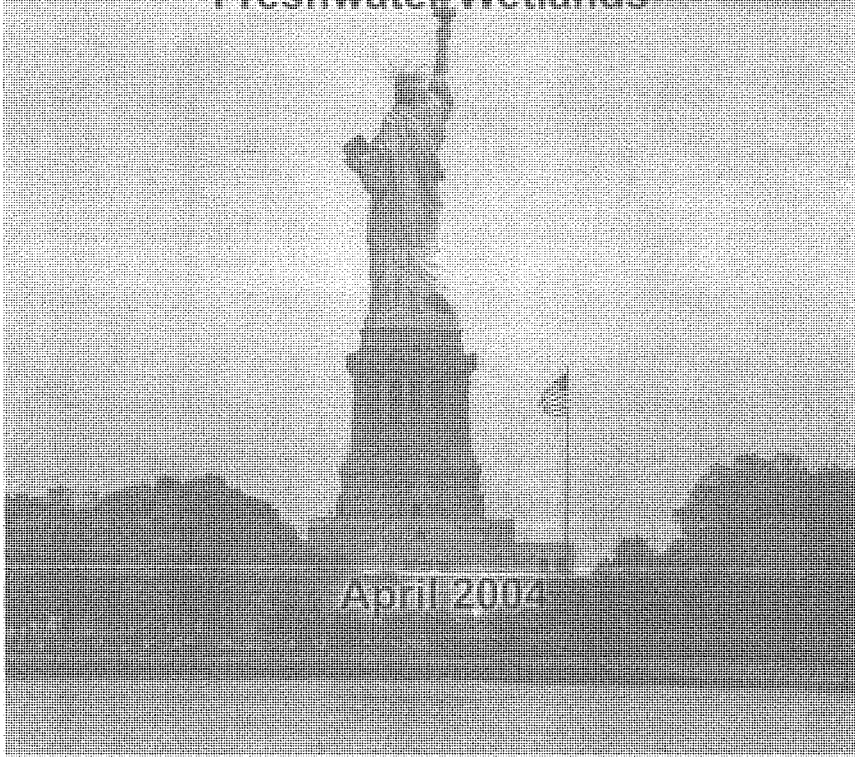


Note: Top of Graph Represents Top of Drill Hole Elevation

US Army Corps
of Engineers ®
New York District

THE PORT AUTHORITY OF NEW YORK

Liberty State Park Hydrology and Hydraulics of Freshwater Wetlands



April 2004

TABLE OF CONTENTS

1. INTRODUCTION 1
1.1. General 1
1.2. Study Area Location 1
1.3. Overall Study Background 2
1.4. Purpose 2
1.5. Freshwater History 2
1.6. Freshwater Project Objectives 3
1.7. Freshwater Project Constraints 4
2. SITE DESCRIPTION 6
2.1 General 6
2.2 Land Use 6
2.3 Soils 7
2.4 Topography 7
2.5 Existing Drainage 8
2.6 Groundwater Data 8
3. HYDROLOGIC ANALYSIS 9
3.1 General 9
3.2 Watershed Description 9
3.2.1 General 9
3.2.2 Liberty State Park 10
3.2.3 Liberty Science Center 10
3.2.4 Liberty Science Center Wetland 11
3.2.5 New Jersey Transit Light Rail Terminal 11
3.3 Climatology 11
3.3.2 Climate 11
3.3.3 Precipitation Data Used 12
3.3.4 Annual and Monthly Precipitation 14
3.4 Infiltration 14
3.4.2 Test Procedure 15
3.4.2 Results 15
3.4.3 Rates Used in the Analysis 17
3.5 Evapotranspiration 17
3.6 Estimated Runoff Volume 18
3.6.1 General 18
3.6.2 Simple Method 18
3.6.3 Annual Runoff 18
4. ENVIRONMENTAL DESIGN CRITERIA 21
4.1 Biological Considerations 21
4.1.1 Introduction 21
4.1.2 Wildlife Considerations 21
4.2 Minimum Water Requirements 22
5. Hydrologic Design Criteria 24
5.1. General 24
5.2. Hydrologic Setting 24
5.3. Flooding Duration and Timing 25
5.4. Water Depth 25
5.5. Flow Velocity 25

5.6. Flow Resistance 25
5.7. Hydraulic Retention Time (HRT) 26
5.8. Storage Capacity 26
5.9. Surface Area 26
5.10. Fetch 27
6. FRESHWATER WETLAND SYSTEM 28
6.1 Existing Freshwater Wetlands 28
6.2 Description of the Proposed Freshwater Wetland Components 28
6.3 Description of the Modeled Alternatives 32
7. HYDROLOGIC BUDGET ANALYSIS 35
7.1 Water Balance 35
7.2 Hydrologic Budget 35
8. HYDRAULIC ANALYSIS 37
8.1 General 37
8.2 Basis of Design 37
8.3 Hydraulic Design Criteria 38
8.3.1 Water Containment 38
8.3.2 Sediments and Debris 38
8.3.3 Design Event 39
8.3.4 Conduits 39
8.3.5 Materials 40
8.4 SWMM Model Development 41
8.4.1 General 41
8.4.2 RUNOFF Block 41
8.4.3 HYDRAULICS Block 45
8.4.4 ALTERNATIVES ANALYSIS 50
8.4.4.1 General 50
8.4.4.2 Alternative A – Addition of LSC Runoff 50
8.4.4.3 Alternative B – Addition of LSC and LSC Wetland Runoff 52
8.4.4.4 Alternative C – Additional Runoff and Enhanced LSC Wetland 52
8.4.5 Groundwater Impacts 40
8.4.6 10-year NJDOT Design Event Performance 53
9. SEDIMENT LOADING ESTIMATES 37
9.1 Methodology And Assumptions 56
9.2 Sediment Loading And Deposition Estimates 58
10. COST ANALYSIS 59
11. REFERENCES 60

1. INTRODUCTION

1.1. General

The New York District Corps of Engineers (hereafter referred to as the District) is presently conducting a Feasibility Study of ecosystem restoration opportunities within the Hudson-Raritan Estuary, which is delineated as the surrounding greater metropolitan New York City region, within an approximate 25-mile radius of the Statue of Liberty. During the reconnaissance phase, the District conducted an extensive restoration-opportunity identification and screening process within the study area, in cooperation with Federal and state resource agencies, and environmental interest groups. The reconnaissance study identified over 80 sites that may meet Federal budgetary criteria and were recommended for inclusion in the Feasibility Study. The non-Federal partner, the Port Authority of New York and New Jersey (PANYNJ), in consensus with the New York/New Jersey Harbor Estuary Program (HEP) Habitat Work Group and agencies from both states, identified 13 sites as initial Building Blocks of the Feasibility Study's Comprehensive Restoration Implementation Plan (CRIP).

Liberty State Park is the first Building Block to move forward with an individual Feasibility Study.

1.2. Study Area Location

Liberty State Park is located on a 1,122-acre site near the confluence of the Hudson River and the Upper New York Bay in Jersey City, New Jersey (see Figures 1-1 and 1-2.) It is bounded by Morris Canal to the north and Black Tom to the south. The east side of the park faces New York and New Jersey Harbor, and the west side is bounded by Phillip Street and the New Jersey Turnpike. The interior 215 acres of the park are restricted for public access due to the presence of sediment contaminants that exceed residential exposure levels. The overall study focuses on environmental restoration opportunities within the 215 acres and the existing wetland area adjacent to Liberty Science Center, which is immediately west of the park.

1.3. Overall Study Background

Environmental restoration opportunities being considered for Liberty State Park include the creation of a tidal marsh in the center of the park, and enhancements to the uplands and freshwater wetlands within the undeveloped area in the park. Materials will be excavated from the proposed tidal marsh area, capped and used to create a grassland berm in the southwestern section of the park. A narrow channel will connect the tidal marsh to the North Cove. Storm water will be collected from adjacent areas and will be diverted to feed freshwater wetlands on the site, creating shallow and deep emergent marshes. Nuisance plant species will be controlled, and native grasslands, shrublands and forests will be planted. The uniqueness of the three primary restoration components in analysis, function, and habitat, requires that each be evaluated separately. Therefore, the restoration feasibility analysis and evaluation has been broken into three separate components: (1) a tidal wetland, (2) a freshwater wetland system, and (3) upland areas.

1.4. Purpose

This report documents the analysis and evaluation of the feasibility of freshwater wetlands enhancement and restoration within Liberty State Park.

1.5. Freshwater History

Liberty State Park occupies an area previously dominated by intertidal mud flats and salt marshes. Since the cessation of rail operations, nature has begun to reclaim the area and successional forests and fields have begun to emerge in the undeveloped areas. Interspersed between the successional forest and fields, natural wetlands have emerged. Generally, these wetland areas have been increasing in number and size over the last few decades, based on

wetland delineations in 1990 and 2004. With the exception of the Liberty Science Center wetland, the growth of the wetlands has been a wholly natural, albeit slow, occurrence.

In the General Management Plan for the park (NJDEP, 2001), the NJDEP has expressed a desire to maintain and expand the wetland areas within the park to improve the natural habitat, increase the wildlife diversity, and assist nature in the reclamation of the park. The results of this analysis will assist in furthering that effort.

1.6. Freshwater Project Objectives

The southeast section of the 215-acre restricted area contains a significant number of small wetlands. The number of existing wetlands in this area and its distance from additional stormwater runoff sources preclude this area from consideration for wetlands enhancement. In the center of the park, a natural freshwater wetland area (shallow emergent marsh) exists immediately west of the 45-acre dredge spoil area being evaluated for saltwater wetland restoration (see Figure 1-3.) The enhancement and expansion of existing freshwater wetlands in the vicinity of this wetland has been proposed by the State of New Jersey as part of the overall Liberty State Park environmental restoration plan. The enhancement is expected to require additional water sources; thus, the Liberty State Park Science Center and the nearby New Jersey Transit (NJ Transit) Light Rail Terminal parking lot are being considered as potential sources of stormwater runoff.

An evaluation of the existing and potential sources of freshwater is necessary to determine the feasibility of the wetlands expansion. A hydrologic budget was developed to analyze the viability of various wetland restoration alternatives with regard to wetland sustainability. The objective of the hydraulic design process is to establish conduit dimensions for transporting stormwater runoff, evaluate the hydraulic impacts (e.g., flooding or draining) to existing areas, and analyze the expected hydraulic performance of the wetland system. The hydraulic performance of the system will help determine the target vegetative structure and wetland functions.

In this report, "conceptual plans" are referred to, which are preliminary scenarios used in an initial screening level of analysis. In Section 7 hydrologic budgets for these conceptual plans are discussed. In addition, a series of "alternatives" are also presented in Section 6, and a comparative hydraulic analysis for these alternatives using the SWMM model is performed in Section 8. Conceptual Plan 3 is the basis for Alternatives B and C.

1.7. Freshwater Project Constraints

Within Liberty State Park, the natural reclamation process is resulting in a gradual improvement of the environment. Outside the park is an urban environment, which has developed independent of the park ecological system. The intent of this project is to accelerate the natural reclamation processes in combination with restoring some of the historical ecological functions to the park through the redirection of some of the stormwater drainage from the adjacent, urban areas. However, the stormwater drainage in the urban environment has been designed to meet regulatory drainage requirements. Therefore, the effort to redirect the stormwater drainage requires marrying the hydrologic needs of the enhanced wetlands with the regulatory drainage requirements in the urban areas.

The stormwater drainage for the Liberty Science Center and parking lot, and the NJ Transit Light Rail Terminal and parking lot was not necessarily designed for wetland sustainability, but rather, it was designed for maximum drainage to prevent flooding. Any constrictions or diversion of flow from these urban sources will require that no induced flooding occurs up to the original design criteria.

Wetland hydraulic design is an iterative process, consisting of: (1) developing a proposed hydraulic design, (2) conducting a site drainage analysis and surface flow hydrodynamic analysis with the proposed features in place, (3) evaluation of the proposed design against the design criteria, and (4) modification of the proposed design. The development of the

proposed wetland alternatives was based on typical wetland environmental, hydrologic, and hydraulic design criteria.

2. SITE DESCRIPTION

2.1 General

Liberty State Park was an intertidal mud flat and salt marsh that was filled and used as a railroad yard during the growth of the New York City metropolitan area. A majority of the soils within the park consist of historic fill materials that were deposited to stabilize the surface between 1860 and 1919 (MacFarlane 2001). Materials from construction projects and refuse from New York City were also included in the fill material. Between 1864 and 1967, the Central Railroad of New Jersey (CRRNJ) used the site as a rail yard for both freight and passenger service. In 1967, the CRRNJ discontinued operations at the site, and over the next few years the land was abandoned and subsequently acquired by the New Jersey Department of Environmental Protection (NJDEP) Division of Parks and Forestry (NJDPF) (LSP 2003).

The 215-acre undeveloped area in the center of the park has remained undeveloped and access is restricted to the public due to the presence of polynuclear aromatic hydrocarbons (PAHs), pesticides, and metals that exceed the NJDEP residential clean up criteria (MacFarlane 2001). Some of the fill in the undeveloped area is comprised of materials dredged from the Upper Bay during construction of the LSP causeway.

2.2 Land Use

The area surrounding Liberty State Park is essentially fully developed. Commercial and industrial development is immediately adjacent to the park to the west and south. Due to the historic use of the park as a rail yard, there is little historic drainage from outside the park into the park. Recent construction, such as the Liberty Science Center and the New Jersey Transit Light Rail Terminal and parking lot, contribute stormwater runoff to the fringes of the park but not to the interior.

Review of aerial photographs and a field survey of the watershed confirmed the land use patterns.

2.3 Soils

The results of the geotechnical analysis indicate that the soils vary considerably across the site. Both fine-grained and course grained soils are present. Soils in virtually all of USCS soil classification are found on site. Based upon the material recovered from the drilling and sampling program, approximately 60% of the on-site soil is poorly graded/silty Sand and approximately 38% of the soil is Clay. At surface depths from 0.0-ft to 4.5-ft below grade, approximately 90% of the on-site soil is poorly graded/silty Sand and approximately 6% of the soil is Clay. Blow count analyses suggest that the soil be classified as 'loose,' although some 'very loose' and 'dense' soils were also encountered. Near surface excavation of this material should present no unusual excavation problems.

Specific soil samples in the vicinity of the proposed wetlands indicated a surface layer (0-4.5 ft) of silty Sand with Gravel, with a mixture of sand, gravel, cinders, and ash. Silty Sand is present below 4.5 feet to approximately 10 feet. In the vicinity of the shallow emergent marsh adjacent to the 45-acre dredge spoil site, a fat Clay layer was noted at a depth of approximately 7.5 feet.

2.4 Topography

The park is relatively level as a result of its historical use. Small, linear berms between the old railroad tracks were created during the construction of the railroad yard. Changes in elevation exist typically only as a result of the additional deposition of dredged materials or construction of dredged material containment berms following cessation of rail operations. Additional changes in the relief within the park occurred with the commencement of development of the park, which included the creation of the shorefront promenade and the removal of the pier system that serviced the rail operations.

Inland from the flat ground of the park, the elevations increase gradually. The slope of the land draining to the edge of the park generally ranges from only 0 to 2%. The highest point in the area which drains toward the park, with the exception of the nearby elevated NJ turnpike and Conrail rail line, is within the NJ Transit Light Rail parking lot, at 20.4 ft NAVD. The lowest point in the area is at the outlet to the Morris Canal, at elevation –1.56 ft NAVD. The slope of the drainage ditches on either side of Phillip Street is approximately 0.2 %.

2.5 Existing Drainage

As part of the data collection effort, planned and as-built drainage drawings were obtained for the Liberty Science Center, the NJ Transit Light Rail System terminal and parking lot, and Millenium Park, which is part of Liberty State Park. Historic drainage plans were also obtained from Liberty State Park for the drainage ditches along Phillip Street.

2.6 Groundwater Data

Piezometric groundwater levels are being measured by the USACE across the site. Synoptic groundwater readings were taken on 15 November 2003. A plan view of the groundwater contour map of the 15 November 2003 groundwater readings is shown in Figure 2-1. The results indicate that the groundwater table is relatively shallow throughout most of the site, with the exception of the southwestern corner of the park. These readings are consistent observations made during the NJDEP's previous soil sampling effort (NJDEP 1995) Groundwater sampling as part of this study is ongoing.

3. HYDROLOGIC ANALYSIS

3.1 General

This section presents basic hydrologic data, and its analysis and interpretation in conjunction with the development of proposed alternatives for the freshwater wetlands system. The basic hydrologic data analyzed herein includes precipitation, surface runoff, the development of annual and monthly runoff volumes, and runoff routing in the derivation of existing and improved conditions. Inflows include direct rainfall and snowmelt; rainfall and snowmelt runoff from tributary areas; and groundwater inflow. Outflows are evaporation; groundwater infiltration; and surface runoff. These computations were accomplished using two techniques, the Simple Method and a Stormwater & Wastewater Management Model (SWMM).

The Simple Method and SWMM were selected for this analysis in order to attempt to accurately predict and model runoff *volumes* available for input to the proposed wetlands. Other models, such as HEC-1, HEC-HMS, and TR-55 are typically event-driven models, more appropriate for drainage capacity design for predicted events. The Simple Method and SWMM model were used to model annual and monthly runoff volumes and detention within the proposed wetlands system.

3.2 Watershed Description

3.2.1 General

The watershed area considered in this analysis consists of four catchment areas: (1) the interior of Liberty State Park, (2) the Liberty Science Center and parking lot, (3) the existing wetland area immediately adjacent to the Science Center, and (4) the NJ Transit parking lot and adjacent drainage area.

3.2.2 Liberty State Park

Because of the lack of significant relief within the park and the presence of old berms, dredged material mounds, and other debris mounds, there are several small drainage areas within the park itself. As shown in Figure 1-3, the southwest portion of the 215-acre restricted area has numerous small drainage areas and several existing freshwater wetlands areas (the restricted area is delineated in Figure 3-1.) These numerous wetland areas will be retained in the proposed plan; therefore, wetland enhancement in this area is not necessary.

Near the center of the park, immediately adjacent to the 45-acre dredged spoils area (see Figure 1-3) is an existing shallow emergent marsh. North and west of this wetland is upland area. This upland area was the focus of this analysis as it presented a likely place for restoration due to the lack of existing freshwater wetlands and relatively close proximity to potential sources of additional freshwater runoff.

The drainage area for the existing, two-acre shallow emergent marsh is approximately 20 acres. This area is 100% pervious as it is entirely within the 215-acre restricted area. No additional impervious areas provide runoff to this area.

3.2.3 Liberty Science Center

The drainage area within the Liberty Science Center complex was divided into two main subcatchment areas: the Science Center parking lot and the Science Center itself, which consists of roof drains, walkways, and nearby mowed areas. The Science Center parking lot is approximately 10.4 acres, 89% of which is impervious. Along Phillip Street, within the 215-acre area, is a drainage ditch referred to as the East Ditch. This ditch primarily provides the conduit for runoff from the Liberty Science Center parking lot to the Morris Canal.

The drainage area of the Science Center itself is approximately 8.48 acres, with 50% impervious. Runoff from the LSC has two destinations: either to the West Ditch along Phillip Street or to the adjacent wetland.

3.2.4 Liberty Science Center Wetland

An existing wetland is currently located immediately north of the Liberty Science Center. The wetland area is approximately 2.3 acres in size, with an additional drainage area of 8.17 acres or a total of approximately 11.13 acres, of which 9% is impervious.

No drainage structures for the wetland were located during the data searches and field visits. Therefore, it is assumed that excess runoff in the wetland drains by flowing across the grassy area between the wetland and the west Phillip Street ditch. Topographic maps from the Liberty Science Center construction supported this conclusion by showing a small drainage depression across the grassy area.

3.2.5 New Jersey Transit Light Rail Terminal

Across the NJ Turnpike from the Liberty Science Center is the NJ Transit Light Rail Liberty State Park Station, which provides service to Bayonne, Jersey City and Hoboken. The terminal consists of an outdoor station and an approximately 800-car parking lot. The NJ Transit terminal area is divided into the three subcatchment areas: the parking lot and interior detention basin, the southern terminal area and detention basin, and the northern terminal area and drainage swale. The total drainage area is approximately 17.59 acres, of which 78% is impervious. The runoff from the entire drainage area is consolidated at a manhole which outlets into the LSC wetland through a 36-inch pipe. The descriptions of these subcatchment areas as well as the other existing subcatchment areas are shown in Table 3-1.

3.3 Climatology

3.3.1 Climate

The climate of Jersey City, New Jersey is characteristic of the Middle Atlantic seaboard. Marked changes in weather are frequent, particularly during the spring and fall. The winters are moderate, and the summers are hot and humid with frequent thunderstorms. Precipitation is also moderate, with about 45 inches falling annually, well distributed throughout the year. Summer totals of precipitation are slightly higher than those of winter. Average monthly temperature ranges from 38 to 78 degrees F with extremes ranging from 22 degrees below zero to 105 degrees F at Newark, NJ. The growing season averages 174 days and the mean annual relative humidity varies from 53 to 73 percent. Prevailing winds are from the northwest with an average annual velocity of approximately 10 miles per hour. The number of days with rainfall of 0.01 inch or greater averages about 122 per year.

The meteorological periods used in the hydrologic budget analysis are as follows:

- January – September 2003
- Last 10 years (1993-2002)
- Average of driest three years (1976, 1981, 2001)
- Average of wettest three years (1983, 1984, 1996)

The period of record from which dry and wet years were selected is 1971-2002. By developing a water budget for these various periods, the performance of alternative plans could be tested under a wide range of hydrologic conditions.

The meteorological parameters needed for the hydrologic budget calculations are precipitation, snowfall, temperature, and pan evaporation.

3.3.2 Precipitation Data Used

Monthly and hourly precipitation data was obtained from the National Climatic Data Center for the period 1948-2003 for Newark International Airport (cooperative station ID 286026), approximately 5 miles to the west of the study area.

Development of the hydrologic budget involved in quantifying sources of inflow or outflow to the deep emergent marsh. Runoff from the catchment (including snowmelt), direct precipitation on the wetlands, evapotranspiration, and groundwater inflow were defined by a combination of National Weather Service data, in situ measurements, and model results.

Total monthly precipitation for the first nine months of 2003 and ten preceding years are compared in Figure 3-1. The two periods have comparable rainfall, except for the months of June and August which were wetter in 2003. The monthly average precipitation for the wettest and driest three years was calculated for the period 1971 – 2002 and is shown in Figure 3-2. Although precipitation and snowfall data were also available for the period 1948-1970, since estimated pan evaporation data were not available for this earlier period the earlier period could not be used. Consequently, the period 1971 – 2002, for which all meteorological parameters (precipitation, snowfall, temperature, and pan evaporation) needed to develop the hydrologic budget were available, was used as the period of record to select dry and wet years.

Although some data for Jersey City were available, Newark Airport was selected as the data station. The reason for this choice is that the observation station at Jersey City was closed beginning in June 1997. Also, no evaporation estimates or evaporation data were available for Jersey City. Rather than mix data from two stations, Newark Airport data was used for all parameters for overall consistency. A comparison of monthly average precipitation amounts for 1993-1996, the period for which data were available for both stations, is shown in Figure 3-3. For most months other than October, the data suggest that, while the Jersey City meteorological station is closer to Liberty State Park, Newark Airport data is an acceptable surrogate.

Inflows in the hydrologic budget include precipitation falling directly on the wetland, surface water runoff, groundwater, and pumped flow. Both direct precipitation and surface water runoff may be composed of rainfall and snowmelt.

The equivalent precipitation from snowmelt was calculated using daily average temperature data from the period 1 January 1993 to 31 July 2003. For each of the twelve calendar months, the number of days where the daily average temperature exceeded 32° F was tallied. Thus, it was assumed that on days when the average temperature did not exceed 32° F, significant snowmelt did not occur. For each month, the percentage of total snow melting was then calculated. Different sets of snowmelt percentages were calculated for the last ten years, for a dry year within the data set (2001), and for a wet year within the data set (1996). Snowpack carried over from previous months was also included in the calculation. To account for snow falling directly on the wetland, the snowmelt was converted to equivalent rainfall. To account for snow falling elsewhere on the catchment, the total precipitation (rainfall plus equivalent precipitation from snowmelt) was input into the rainfall-runoff model.

3.3.3 Annual and Monthly Precipitation

The average annual precipitation for the study area is approximately 45.65 inches. The observed extreme annual values were 65.50 inches in 1983 and 31.44 inches in 2001. The monthly extremes ranged from 0.36 to 11.53 inches.

3.4 Infiltration

Subcatchment infiltration is the water that infiltrates into the ground and does not become runoff (directly) during a precipitation event. Due to the heterogeneous nature of the fill material within the park as a result of years of fill, an effort was made to measure infiltration rates within the limited-access area. A series of 11 double ring infiltrometer tests were conducted within the park at the locations shown in Figure 3-4.

In-situ infiltration rates were measured using a TURF-TEC double-ring infiltrometer. Of the 11 sites where measurements were taken, the mean infiltration rate was 32.0 in/hr, with individual rates varying between 4.5 to 59.4 in/hr. Seven of the results had rapid infiltration rates making accurate measurements difficult. Using the four most reliable results, which

were in the vicinity of the proposed wetlands (sites 5, 6, 10, 11 on Figure 3-4) the mean was 13.2 in/hr with an individual measurement range of 4.5 to over 30.0 in/hr. These results are consistent with similar testing of sandy/gravel sites reported in published literature (USEPA 1999).

3.4.1 Test Procedure

TURF-TEC Double-Ring Infiltrometers were used to measure the soil infiltration rates. These small devices have an inner ring about 64 mm (2.5 in.) in diameter and an outer ring about 110 mm (4.25 in.) in diameter. The water depth in the inner compartment starts at 125 mm (5 in.) at the beginning of the test, and the device is pushed into the ground 50 mm (2 in.). The rings are secured in a frame with a float in the inner chamber and a pointer next to a stop watch. These units are smaller than standard double-ring infiltrometers, but their ease of use allowed many tests during a single day.

First, the infiltrometer was pushed into the soil. Then, the inner and outer compartments of the infiltrometer were filled with clean water by first filling the inner compartment and then allowing it to overflow into the outer compartment. As soon as the measuring pointer reached the beginning of the unit's measuring scale, the timer was started. Readings of the water elevation change within the inner ring were taken every five minutes for 15 minutes. The maximum and minimum infiltration rates were calculated by curve-fitting Horton's Equation to the points using SigmaPlot®.

3.4.2 Results

The 5-minute interval data were then plotted to develop curves matching Horton's equations, as follows:

$$fp = fc + (fo-fc)e^{-kt} \qquad (3\text{-}1)$$

where:

fp = infiltration capacity into soil, ft/sec

fc = minimum or ultimate value of fp, ft/sec

fo = maximum or initial value of fp, ft/sec

t = time from beginning of storm, sec, and

k = decay coefficient, sec^{-1}

Infiltration starts at a rate of fo and decreases exponentially over time to a steady rate of fc. Using the curve fitting function of SigmaPlot®, an exponential decay curve (3 parameter) was fitted to the values and fc was determined. The measured infiltration rates were relatively high but varied greatly throughout the park and where consistent with published rates of hydraulic conductivity.

Since downward flow (through substrate) is controlled by hydraulic conductivity, K, the final, saturated (steady rate) fc is equivalent to K (USACE 1999).

Of the 11 sites where measurements were taken, 7 sites had rapid infiltration rates, making accurate measurements difficult. The rapid rates were most likely due to debris, gravel and rail bed material at the ground surface. The other four sites had initial infiltration rates ranging from 4.5 in/hr to 59.4 in/hr, with a mean of 32.0 in/hr.

Moisture content was not evaluated for this analysis; however, observations in the field at the time of the measurements indicated that the ground surface was relatively dry. Therefore, the low antecedent moisture would be expected to result in maximum initial infiltration rates.

From the measured results, it is clear that the soil on the surface of the park varies greatly and uniform infiltration and runoff does not occur.

3.4.3 Rates Used in the Analysis

The results of the geotechnical analysis indicate that the on-site soils beneath the surface also vary considerably across the site. Both fine-grained and course grained soils are present. Based upon the material recovered from the drilling and sampling program, from depths of 0.0-ft to 4.5-ft below grade approximately 90% of the on-site soil is poorly graded/silty Sand and approximately 6% of the soil is Clay. From these results, it was assumed that beneath an often coarser surface layer of debris and sandy gravel lays a relatively low-porosity silty Sand. In areas of existing wetlands, it is assumed that the wetlands are underlain by a more imperious clay or well-graded silty Sand layer.

For the SWMM modeling, the maximum and minimum infiltration rates of 4.5 and 0.02 inches per hour, respectively, were used within the wetland areas of park. These rates are typical of a relatively impervious clay or other geo-lining, as planned for the wetlands. The typical maximum and minimum values of 3.0 and 0.02 inches per hour, respectively were used for the pervious, mowed surfaces outside the park. These values are consistent for landscaped turf. The decay coefficient was set at 4 hr^{-1} which is equivalent to a decline in infiltration of 98 percent towards the limiting value after the first hour.

From the results of the analysis, it is assumed that due to the high infiltration rates and relatively shallow grades that there will be minimal runoff from the drainage areas within the park.

3.5 Evapotranspiration

Outflows may include surface water, groundwater, and evapotranspiration. Evapotranspiration is the combination of the net rate of vapor transfer (evaporation) and the transfer of moisture to the atmosphere by vegetation (transpiration). A model developed at the Northeast Regional Climate Center was used to provide estimates of monthly pan evaporation (DeGaetano 1994). The physically-based model relates net radiation, air density,

and soil moisture to evapotranspiration and was adapted and validated for use in the northeastern United States. Evaporation primarily is calculated as a function of shortwave and net long wave radiation. Evapotranspiration was then calculated as 75% of pan evaporation estimates based on research results by others (Hammer 1992, Hubbard et al. 1988).

3.6 Estimated Runoff Volume

3.6.1 General

Runoff volumes for the subcatchments in the study area were initially estimated using the Stormwater Manager's Resource Center's Simple Method. The Simple Method provides an easy way to evaluate potential runoff from the watershed using annual and monthly precipitation values.

3.6.2 Simple Method

The Simple Method (SMRC 2003) is generally used to estimate stormwater runoff pollutant loads for urban areas. For the hydrologic budget, the method was used to calculate runoff only; for sediment transport calculations described in Section 8.1 the Simple Method was also used to simulate total suspended solids. The technique requires a modest amount of information, including the subwatershed drainage area and impervious cover, and annual precipitation. With the Simple Method, the investigator can either break up land use into specific areas, such as residential, commercial, industrial, and roadway and calculate annual pollutant loads for each type of land, or utilize more generalized pollutant values for land uses such as new suburban areas, older urban areas, central business districts, and highways.

3.6.3 Annual Runoff

The Simple Method calculates annual runoff as a product of annual runoff volume, and a runoff coefficient (Rv). Runoff volume is calculated as:

$$R = P * P_j * Rv \qquad (3\text{-}2)$$

where:

R = annual runoff (inches)

P = annual rainfall (inches)

P_j = fraction of annual rainfall events that produce runoff (usually 0.9)

Rv = runoff coefficient

The runoff coefficient is calculated based on impervious cover in the subwatershed. The following equation best represents actual data:

$$Rv=0.05+0.9Ia \qquad (3\text{-}3)$$

where:

Ia = impervious fraction

The Simple Method provides reasonable estimates of stormwater runoff volumes. Unlike other hydrologic methods, preliminary volumes can be estimated based on average rainfall rather than specific storm events.

Computed volumes were checked by comparison to XP-SWMM model results. The scenario selected for this comparison was Alternative A (Liberty Science Center runoff added to the Deepwater Emergent Marsh (DEM)). Results are presented in Figure 3-5. The unusually low volume computed by XP-SWMM for June 1976 is due to relatively high evaporation rates during June. Also, there was minimal antecedent rainfall before major storms in June 1976, allowing for maximum storage in the wetlands and minimal discharge downstream. Although significant disparities between SWMM and Simple Method results are sometimes seen for individual months, the total yearly volumes for the simple method are only 12% higher than SWMM for 1976 and 15% lower than SWMM for 1983. In light of the inherent differences

between the two modeling approaches, these differences are relatively small. Therefore, the Simple Method results are validated by the SWMM computations.

In Figure 3-5, for both 1976 and 1983 XP-SWMM computed volumes are generally lower than Simple Method results for the warmer months of May – September, when evaporation is most significant. This difference is in part due to the fact that the XP-SWMM model includes evaporation but the Simple Method does not. However, calculations using the Simple Method results take evaporation into account in the hydrologic budget analysis, thereby accounting for this difference.

4. ENVIRONMENTAL DESIGN CRITERIA

4.1 Biological Considerations

4.1.1 Introduction

As indicated in the General Management Plans, NJDEP, 2001 and discussed in the regular LSP) feasibility study team meetings, water depth and drawdown must be controlled to the degree that will maintain a viable and attractive wetland and pond community and to provide wildlife habitat value to the park.

The deepwater emergent pond/wetland has been designed to provide a permanent source of water with a depth of approximately 4-6 feet.. This along with very shallow (5%) side slopes will provide a controlled proportion of deeper and shallower habitats throughout the growing season.

4.1.2 Wildlife Considerations

The Threatened and Endangered listed bird species do not have habitat requirements that include a specific hydroperiod. They can be expected to use wetland or upland habitats provided that the vegetative structure of these habitats meets their needs. For example, the northern harriers prefer grassland habitat with few trees and shrubs. Harriers will nest in both uplands or wetlands, but the pair nesting at Liberty State Park seems to prefer uplands for nesting. For winter roosts, harriers prefer upland sites. Many sources indicate harriers prefer to nest and roost in fields that are 50 acres or more in size; however, the species has also been documented to nest in habitat blocks as small as 20 acres.

Aside from the northern harrier, none of the other Threatened and Endangered bird species of special concern that were observed during inventory surveys have been documented as

breeding in the park. As mentioned previously, their use of habitat relies more on habitat with the correct vegetative structure and adequate food resources rather than hydroperiod.

One listed plant species, Torrey's rush, was found on the site. This species has hydrologic requirements and is adapted to specific types of soils. It is a facultative wetland (FACW) species, which means it has the probability of being found in a wetland 67-99% of the time. The Natural Resource Conservation Service's (NRCS) Plant Database indicates this species is adapted to medium to coarse-textured soils and has a low-tolerance for drought conditions. The NRCS lists the minimum and maximum amount of precipitation needed as 14 and 50 inches per year, respectively. The minimum root depth is 10 inches and the species is intolerant of both shade and salinity. This species was identified in a freshwater wetland on-site. That wetland area should be protected during construction while also considering the habitat requirements for the species when enhancing other freshwater wetland habitats on-site.

4.2 Minimum Water Requirements

The minimum water requirements for wetland sustainability are determined by a combination of factors that need to be balanced. In order to maintain a wetland with a permanent pool of water and sufficient flow to maintain good water quality, sufficient drainage area is required. Without supplementing the water supply through pumping, a minimum watershed of about ten acres is required for maintaining a year round permanent pool of approximately one acre. A second rule of thumb is that four acres of contributing watershed are needed for each acre-foot of storage (Md SCS, 1976; Schueler, 1987). For this plan, from five to nine acres of contributing urban watershed are available for each acre-ft of planned wetland storage. This range of ratios suggests that the watershed is sufficiently large to support the planned wetlands. Relying on a smaller watershed than this would make maintaining a permanent pool difficult and would produce large fluctuations in the water level due to evaporation and infiltration losses. Examination of the water balance diagrams (Figure 4-1 and Appendix A) indicates that the base flow entering the wetland would run out during the summer months,

and input cannot compensate for gradual drawdown. The result may be poor water quality, the production of algal matting and odor problems. During extremely dry periods such as 1976, it is possible that the existing wetland may completely dry up i.e., have almost no standing water yet still have saturated substrate as do most of the existing wetlands on the site.

5. HYDROLOGIC DESIGN CRITERIA

5.1. General

There are many hydrologic and hydraulic considerations important to wetland restoration and construction. The primary list of design criteria includes the following basic interrelated elements.

- Hydrologic setting,
- Flood duration and timing,
- Flooding depth,
- Flow velocities,
- Flow resistance,
- Hydraulic retention time,
- Storage capacity,
- Surface area,
- Fetch.

5.2. Hydrologic Setting

The hydrologic setting of the wetland describes the location of the wetland in relation to other waterbodies. The hydrologic setting is important to all wetland functions, but is of particular importance to groundwater recharge/discharge, sediment retention, flood-flow alteration, and production export. The existing and proposed freshwater wetlands within Liberty State Park are generally independent of any other waterbody (e.g., stream, river, lake, etc.). They occur in typically heterogeneous material which has a relatively shallow watertable. Thus, they are assumed to be influenced by a fluctuating watertable. The proposed wetlands would be

constructed in the same general area (park interior) as the existing wetland in similar substrate types.

5.3. Flooding Duration and Timing

The existing wetlands within Liberty State Park are typically seasonally wet (i.e., during the spring and fall), with the exception of the Liberty Science Center wetland, which is frequently flooded from runoff from the NJ Transit terminal and parking lot. Similarly, the drainage ditches along Phillip Street are frequently flooded with runoff from the Liberty Science Center. Based on the hydrologic budget analysis it is expected that diversion of stormwater runoff from the parking lots adjacent to the park into the proposed wetlands will result in the proposed wetlands maintaining measurable pool depths most of the year.

5.4. Water Depth

Water depth is an important factor in determining the types and extent of vegetation supported by the wetland. The existing wetlands are shallow, seasonal wetlands, most likely augmented by a rising watertable during the wet seasons of the year. The proposed wetland system would have both shallow and deep water areas to support a greater abundance of plants and wildlife than the existing wetlands.

5.5. Flow Velocity

Maintaining a low velocity related level of flowing water shear stress are important to several wetland functions. As a result of the shallow gradient of the park and the detention-design of the wetlands, velocities will be minimal.

5.6. Flow Resistance

The depth and velocity of the flow in the wetland are somewhat dependent on flow resistance. Like the flow velocity, flow resistance is not critical for the proposed designs due to the detention design of the proposed wetlands.

5.7. Hydraulic Retention Time (HRT)

The HRT is defined as the average amount of time that a parcel of water stays within the wetland before exiting. The HRT is the key design criteria for water quality enhancement functions such as sediment/toxicant removal and nutrient removal/transformation. For this analysis, the focus was on flood frequency and duration, and depth. Because the runoff from adjacent impervious surfaces quickly drained out of the system to New York and New Jersey Harbor under the existing conditions, a decrease in the HRT is not likely in the proposed wetlands. Rather, it is expected that the wetland system will cause a measurable increase in HRT, which will further result in improved water quality entering the Harbor. Obviously, excessive HRT in the wetland could result in wetland water quality problems such as low dissolved oxygen and the production of sulfide and methane gases. However, frequent runoff is expected to provide frequent flushing of the wetland system.

5.8. Storage Capacity

The Storage capacity is most important in the flood-flow alteration function because the amount of available storage in the wetland determines how much of the runoff can be routed into and through the wetlands. The storage capacity may also affect aquatic abundance/diversity, in that larger wetlands will have more potential for groundwater recharge, have greater volume and surface area and may support more aquatic organisms. Storage capacity was used in this analysis to reach design water surface elevations based on seasonal inflows.

5.9. Surface Area

The wetland bottom area is important for groundwater recharge and discharge. The groundwater recharge will be a function of the bottom area, water depth, permeability of underlying soils and location of the water table.

The surface area of the wetland also affects evapotranspiration which can be important for groundwater discharge and water quality functions. Ground water recharge was not a primary concern of the proposed designs; it is anticipated that the wetlands will be lined with a low permeability liner. Runoff inflows were expected to be sufficient to overcome evapotranspiration, even during the drier months of the year.

5.10. Fetch

Fetch is the length of open water available for wind-induced waves. Fetch is typically an important hydraulic consideration in wetlands because they are usually shallow water bodies which can be easily affected by wave action. The fetch of the wetland is especially important in sediment stabilization. Long fetches will produce erosion of the downwind shoreline. Fetch is also important to water quality concerns because the greater the fetch the better the reaeration. The relative small size of the proposed wetlands and the existence of surrounding upland forests is expected to limit the fetch and wind-induced wave impacts.

6. FRESHWATER WETLAND SYSTEM

6.1 Existing Freshwater Wetlands

The existing wetlands are classified as Shallow Emergent Marsh and are located in the center of the park. They are hydrologically isolated wetlands and receive runoff only from the interior of the park. These wetlands are described in detail in the Draft Liberty State Park Environmental Resources Inventory (USACE 2004). During a typical year, the surface water in the wetland disappears in the later months of summer, limiting the overall habitat value of the wetland. To improve the habitat value of wetland and the park as a whole, a year-round presence of freshwater is desired. Therefore, the focus of the design efforts is to create a year-round source of water for wildlife through the creation of a Deep Emergent Marsh system, which should maintain a measurable depth of water during dry periods or periods of below-average precipitation. In addition, varying water depths spatially through the created wetland system will help maintain more diverse habitats throughout the year and facilitate the movement of storm water through the system.

6.1.1 Existing Liberty Science Center Wetlands

The existing wetland adjacent to the Liberty Science Center consists of mostly one wetland zone which is dominated with a monoculture of common reed (*Phragmites australis*). The wetland functions primarily as a treatment wetland for runoff from the NJ Transit terminal and parking lot.

6.2 Description of the Proposed Freshwater Wetland Components

In order to maximize habitat function and value, the freshwater wetland system may have four primary components: (1) an enhanced Liberty State Park wetland, (2) a Biofilter (BF) wetland, (3) a Deep Emergent Marsh (DEM), and (4) natural connecting swales. The

proposed freshwater wetland system should be located in the center of the park, in close proximity to the proposed tidal wetland. Ideally, the DEM should be at least 400 or 500 feet away from the nearest road or heavily used area.

The proposed freshwater wetlands will contain a number of hydrologic/habitat zones, as follows:

Zone 1. Deep Water Pool (1-6 feet deep), to support submerged aquatic plants such as wild celery, sago pondweed, and redhead grass.

Zone 2. Shallow Water Bench (6-12 inches between groundwater level and the discharge invert), to support emergent aquatic plants. Proposed plants are obligates and are relatively intolerant to drawdowns. Typical plants in this zone include: Pickerelweed (*Pontederia cordata*), Duck potato, (*Sagittaria latifolia*), Three square (*Scirpus pungens* (*S. americanus*)), and Soft stem bulrush (*Scirpus validus*).

Zone 3. Shoreline Fringe. This is the regularly inundated area, which supports wet meadow scrub-shrub wetland, including plants such as sedges, switchgrass, and buttonbush. This zone is typically between the discharge invert and an overflow elevation.

Zone 4. Riparian Fringe. This is the periodically inundated area, which supports wet soils or scrub-shrub transition, including plants such as red osier dogwood, red maple, swamp oak. This zone is typically above the overflow elevation.

6.2.1 Enhanced LSC Wetland (Wetland 1)

The wetland will be enhanced through the removal of the common reed, regrading, and replanting. The enhanced wetland will contain Zones 2 through 5 as described above. Figures 6-1 and 6-2 (and B-1 in Appendix B) shows the enhanced LSC wetland. The area of the wetland will be 2.27 acres, and the perimeter 2,033 ft.

6.2.2 Biofilter Wetland. (Wetland 2)

The second wetland will be designed for water quality pre-treatment and contain wetland Zones 2 through 5 as described above. The wetland will provide pre-treatment by removing coarser sediments, trash, and debris. This pre-treatment should also provide for the significant removal of particulate pollutants. The deeper areas of the wetland will function as either a permanent pool or shallow marsh areas. The deep area will enhance the removal of soluble phosphorus and nitrogen. Figures 6-3 and 6-4 (and B-2 in Appendix B) shows the Biofilter wetland. The area of the wetland will be 0.79 acres, and the perimeter 1,442 ft.

6.2.3 Deepwater Emergent Marsh (Wetland 3)

As shown in Figure B-3 in Appendix B, the mean water elevation of the DEM will be approximately 5.0 ft NAVD with bottom elevation around 0.0 ft NAVD. The wetland area is about 1.8 acres and average volume is approximately 32,700 cubic feet. The perimeter is about 148 ft. these dimensions include all of the four wetland zones.

The DEM will include all four wetland zones discussed above.

The deep water areas of the wetland should be permanently flooded. The zone between the typical low level and the overflow outlet may be seasonally flooded. Above the overflow elevation will be a transition zone to upland areas. Figures 6-5 and 6-6 (and B-3 in Appendix B) shows the DEM.

The vegetative zones and elevations associated with each of the proposed wetlands are presented in Appendix C. These zones are portrayed in Figure 6-5. The area of the wetland will be 1.82 acres, and the perimeter 1,397 ft.

6.2.4 Connecting Swales

In order to limit structural components in the freshwater system, provide additional functional value, and maintain the ecological nature of the site, natural swales will connect the wetland system within the park.

Swale slopes should be graded as close to zero as drainage will permit. Between the biofilter (5.5) and the deep emergent marsh (5.0) there is a .5 foot elevation drop in about 400 feet or a slope of about 0.125%. Side slopes of the swale will be about 3:1 (h:v) or less. The swales will be planted with a dense cover of water tolerant, erosion resistant grass. This grass will not be mowed close to the ground to avoid impeding the filtering and hydraulic functions of the swale. Since the system will be using parking lot runoff, sensitive grass species with a low salt tolerance such as bluegrass, should be avoided. Reed canary grass is ideal but is also considered an invasive species.

6.2.5 Infiltration Basin

One method of returning excess stormwater to the interior of the site would be to direct this excess to an infiltration basin. This would ensure that the water is being discharged to an area with high permeability and allow quick groundwater recharge. Infiltration basins are also effective in removing both soluble and fine particulate pollutants that may still be in the stormwater discharged. The basin would be receiving this water during wet months and/or during larger storms. While this water will have been treated by the other constructed wetlands, during large storms the discharge may still contain some pollutants. In this case this basin would serve as a final polishing system along with providing control of peak discharges for large design storms. The high permeability soils are well suited for use as an infiltration basin with little soil augmentation required.

The infiltration basin, shown in Figures 6-7 and 6-8 (and in Figures B-3 and B-7 in Appendix B), would provide an impoundment by excavating the soil to an elevation of approximately elevation of 4.5 NAVD. The impoundment will store a defined quantity of about 3 acre feet of runoff, allowing it to slowly exfiltrate through the permeable soils of the basin floor. The floor would be graded as flat as possible and a dense native grass cover would be established to promote infiltration, add habitat value and bind up deposited sediments.

6.3 Description of the Modeled Alternatives

The alternatives considered in this analysis are modifications of one primary freshwater wetland system consisting of the three of the previously described components. The alternatives primarily differ in their source or sources of stormwater. The alternatives are shown in Table 6-1 and described in the following sections.

6.3.1 Alternative A

The primary alternative consists of a Deep Emergent Marsh and Biofilter wetland receiving stormwater input from the Liberty Science Center drainage area, which includes the Science Center and the adjacent parking lot as shown in Figure 6-9 (and B-4 in Appendix B). Stormwater will pass through the Biofilter wetland and eventually reach the DEM. Excess stormwater in the DEM will be routed back to the drainage ditch to the east of Phillip Drive through an 800-foot swale, for eventual discharge into the Morris Canal.

The Biofilter wetland will be upstream (west) of the DEM, connected by a 430-foot swale. The mean water elevation of the BF will be approximately 5.5 feet NAVD with bottom elevation of approximately 3.0 feet NAVD. The wetland area is about 0.8 acres and the storage volume is approximately 59,800 cubic feet. The perimeter is approximately 1,400 feet.

Four wetland communities will be established among the sequence of wetlands leading to the DEM. From the wetter to the drier zones these will include: (1) emergent marsh (semi-permanently flooded); (2) wet meadow (seasonally flooded); (3) scrub-shrub (temporarily flooded); and (4) forested (transitional zone) wetland communities.

6.3.2 Alternative B

The primary features of Alternative B are the same as Alternative A: a DEM and Biofilter, supplemented with stormwater runoff from the Liberty Science Center. In addition, excess stormwater stored in the existing Liberty Science Center wetland will be routed to the Biofilter wetland, as shown in Figures 6-10 (and B-5 in Appendix B).

Stormwater from the NJ Transit parking lot currently drains to the LSC wetland, which maintains a surface water elevation from 5.6 to 7.5 feet NAVD. Alternative 2 includes an overflow pipe with an invert of 6.5 feet NAVD at the LSC wetland, which will convey excess stormwater to a detention pool on the west side of Phillip street. From there, it will flow into the Biofilter wetland.

6.3.3 Alternative C

The primary features of Alternative C are the same as Alternative B: a DEM and Biofilter, supplemented with stormwater runoff from the Liberty Science Center and the LSC wetland. This alternative, as shown in Figures 6-11 (and B-6 in Appendix B), also includes the environmental enhancement of the LSC wetland.

The LSC wetland will be enhanced to improve the water quality treatment ability over the existing condition. The new mean water elevation will be approximately 6.5 feet NAVD with a bottom invert elevation at approximately 3.0 feet NAVD. The wetland area is about 2.3

acres and the storage volume is approximately 110,000 cubic feet. The perimeter is approximately 2,000 feet.

6.3.4 Alternative D

The primary features of Alternative D are the same as Alternative C: a DEM and Biofilter, supplemented with stormwater runoff from the Liberty Science Center and the enhanced LSC wetland. As shown in Figures 6-12 (and B-7 in Appendix B), instead of returning excess stormwater to the Phillips Drive Ditch and eventually to Morris Canal, this alternative will discharge the excess water into the interior of the Liberty State Park site.

The excess water will be discharged to an infiltration basin adjacent to the DEM. The new bottom elevation of the basin will be approximately 4.5 feet NAVD with an overflow invert elevation at approximately 6.0 feet NAVD. The basin area is about 2.2 acres and the storage volume is approximately 134881 cubic feet. The perimeter is approximately 1,703 feet. If water does go over the spillway it will be directed to the adjacent freshwater wetland.

7. HYDROLOGIC BUDGET ANALYSIS

7.1 Water Balance

To assure a predictable water supply and to assure viability of the restored wetland, multiple water sources can be utilized or developed for the wetland as a way of dealing with the uncertainty associated with rainfall frequency and groundwater levels (Pierce 1993). The hydrologic budget for a wetland area can be shown as:

$$I-Q = dS/dt \qquad (7\text{-}1)$$

where

I = Inflows
Q = outflows
dS/dt = change in water storage in the wetland per time

Inflows may include precipitation, surface water, and groundwater. Outflows may include surface water, groundwater, and evapotranspiration (Viessman 1977).

Monthly results are presented in the form of a bar chart showing the net total of inflows and outflows. An example of this format is shown in Figure 4-1 for existing conditions, Plan 1.

7.2 Hydrologic Budget

The hydrologic budgets for the matrix of combinations of meteorological conditions and restoration scenarios can be shown in a "balance sheet" format that summarizes yearly average inflows and outflows as well as the monthly average net flow through the wetland. The restoration scenarios considered are shown in Figure 7-1. Conceptual Plan 1 considers runoff from adjacent upland in Liberty State Park; Conceptual Plan 2 also covers runoff from

the Liberty Science Center parking lot and adjacent wetland areas; and Conceptual Plan 3 further includes New Jersey Transit property runoff.

Because of the wide range of infiltration rates measured in-situ and found in the literature, a sensitivity analysis was performed on the water budget for this parameter. Two analyses were performed, one for the year 2003 and one for the 1993-2002 ten-year period. In each instance, the monthly water budget was evaluated for infiltration rates of 0.00, 0.02, 0.04, and 0.08 in/hr. For a rate of 0.00, the water budget showed mostly positive net flow, i.e., inflows exceeded outflows, for most months. For a rate of 0.02, the budget showed a more likely balance of positive net flow during spring and fall but mostly negative flow during the summer. This pattern is corroborated by visual observations made during 2003. The higher rates of 0.04 and 0.08 produced unrealistically negative net flows. Likewise, substituting the average in-situ, measured initial infiltration rate of 32 in/hr produced excessively negative net flows. The probable reason for this result is that the site is characterized by high groundwater elevations which would possibly result in groundwater inflow to the deepwater emergent marsh. Consequently, although the soil exhibits high infiltration properties, groundwater probably is a source of inflow for the wetlands. Thus, an infiltration rate of 0.02 in/hr was used in the calculations.

Results for all combinations of meteorological periods and runoff scenarios are shown in Table 7-1. Summary sheets showing key budget assumptions, inputs, and results, and bar charts showing the resulting monthly water budgets are presented in Appendix A. As expected, the average monthly storage changes shown in Table 7-1 are successively higher for the driest three years, last ten years, current year, and wettest three years, reflective of changes in precipitation and resulting runoff.

The wetlands in the analysis were sized to ensure that minimum water levels required to maintain the vegetative structure could be maintained throughout the year. Spillways and weirs will be set at the appropriate elevations to maintain the design water surface elevations (WSELs).

8. HYDRAULIC ANALYSIS

8.1 General

For this analysis, the hydraulic evaluation of the proposed freshwater wetland alternatives was conducted using XP Software's Stormwater & Wastewater Management Model (XP-SWMM or SWMM). The SWMM results were used in conjunction with the hydrologic budget analysis to evaluate the potential performance of the proposed wetland alternatives.

8.2 Basis of Design

The analysis presented herein is based on the concepts and guidelines contained in U.S. Army Corps of Engineers' Engineer Research and Development Centers' *Wetlands Engineering Handbook* (USACE 2001).

Initial stormwater runoff volumes used in the hydrologic budget were estimated using the Simple Method. The Simple Method values were checked for reasonableness using the SWMM output (see the Hydrologic Budget Analysis presented in Section 7).

The performance of the existing and proposed conduits, such as pipes, drainage ditches, and swales integral to the freshwater wetland system were analyzed using SWMM. Typically, conduits proposed as additions to the existing drainage network were sized to convey the modeled volumes and maintain the wetland system target water surface elevations. The objective of the conduit sizing was not to provide drainage to meet any regulatory requirements (e.g., providing sufficient drainage for a specific frequency event), rather, the conduits were sized to adequately convey the typical runoff volumes without inducing flooding. The only design limitation was to ensure that changes in the drainage as a result of

the rerouting of runoff did not result in induced flooding in the drainage area during the 10-year NJDOT design event (NJDOT 2003; 5.25 in./24 hr).

8.3 Hydraulic Design Criteria

Man-made wetlands require means to control the quantity and depth of water at a given location. Consequently, hydraulic structures are a basic part of creating, restoring, and enhancing wetlands. The following sections describe the hydraulic design criteria and assumptions for the Liberty State Park freshwater wetlands system.

8.3.1 Water Containment

Due to the relatively flat topography of the site, the inverts of the existing drainage structures, and the distances between drainage areas and the wetlands, it is expected that the proposed wetlands would be constructed primarily by excavation. Levees or berms to retain water were not considered in the design with the exception of berms adjacent to outlet structures where it was necessary to direct and control outflow.

8.3.2 Sediments and Debris

Reduced flow velocities found in wetlands allow sediments transported into the wetland with the inflow to settle to the bottom. Trapped sediments eventually occupy part of the wetland volume, thereby reducing its effectiveness at removing future sediments from the inflow. Therefore, the inclusion of a forebay in the Biofilter wetland is necessary to trap incoming sediments and prevent them from settling in the main section of the wetland and potentially moving downstream to the deepwater wetland.

Wetlands immediately adjacent to impervious surfaces such as roadways and parking lots are also subject to the inclusion of debris and trash in stormwater runoff. The construction of a

forebay will also help capture debris which would otherwise enter the wetland system and potentially degrade habitat and threaten wildlife.

8.3.3 Design Event

Hydraulic drainage structures are typically designed to routinely pass flow up to some design event. For the proposed freshwater wetlands at Liberty State Park, the construction of the wetlands within the environmental area of the park reduces the need to design the wetlands for a specific event because any potential overflow of the wetlands would occur within the existing ecological area. The only area of concern is in the vicinity of Phillip Street, which may be impacted if the outflow structures cannot convey flow quickly enough during extreme precipitation events and flooding occurs. To reduce the potential for induced flooding during extreme events, the existing drainage ditches along Phillip Street will remain in place, separated from the wetland system by overflow berms or weirs. This will allow any overflow from the wetlands to drain through the drainage ditches before flooding the roadways.

Current New Jersey Department of Transportation guidance (NJDOT 2003) requires that longitudinal systems and cross drain pipes for land service highways be of sufficient capacity to pass the runoff from a storm with a 10-year recurrence interval. Therefore, the performance of the freshwater wetland system was analyzed to ensure that no induced roadway flooding occurs during the design event (5.25in/24hr).

8.3.4 Conduits

Ideally, the conduits between the wetlands and the outlets should be environmentally beneficial, that is, natural. Therefore, the wetland system was designed using natural, trapezoidal channels to convey flow within the park. These channels are expected to contain vegetative growth and were modeled using a roughness coefficient (Manning's n-value) to reflect vegetation similar to the vegetation presently in the existing drainage ditches within the park. Vegetated swales were designed with a 5-foot bottom width and 1:4 side slope. The

channels will initially be lined with grass; however, additional vegetation growth is expected over time. Flow under the roadways will be conveyed through pipes.

8.3.5 Materials

Pipes are needed to convey the flows beneath the roadways. For this analysis, it is assumed that the outlet pipes are reinforced concrete pipes (RCP). The outlet weirs within the wetlands will be constructed of natural materials, such as logs or stones.

8.3.6 Infiltration Basin

An infiltration basin is a facility constructed within highly permeable soils that provides temporary storage of runoff during rain events. The basin does not normally have a structural outlet to discharge runoff except during very high flow events. Instead, outflow from an infiltration basin is through the surrounding soil. Preliminary infiltration rates measured at the site indicate relatively high surface permeability; however, the permeability of the soils at and below the basin invert must be measured to ensure adequate basin performance. Typical tests such as a percolation test, pit-bailing test, or piezometer test, as outlined in N.J.A.C. 7:9A *Standards for Individual Subsurface Sewage Disposal Systems*, are necessary to ensure adequate soil permeability. For this analysis, a conservative infiltration rate of 1 in/hr was used based on preliminary infiltration measurements.

8.3.7 Groundwater

Preliminary data indicates that the groundwater table within Liberty State Park is relatively shallow. It is likely that the groundwater table may even rise above the lowest land surfaces within the park during the wettest periods of the year. However, there is not yet sufficient data to confirm this fact. Furthermore, there is no groundwater quality data available to date. Therefore, for this analysis it is assumed that the wetlands are constructed with a clay or other impervious liner to limit groundwater flow to the wetlands. Potential hydrostatic or buoyant forces on the liner as a result of groundwater are expected to be offset by the presence of

water within the wetlands. It is also assumed that groundwater will not impact the infiltration basin.

8.4 SWMM Model Development

8.4.1 General

The model used for the hydraulic analysis of the proposed wetlands alternatives is a version of the EPA-SWMM: XP-SWMM2000, version 8.52. This version of SWMM has both graphical input and output routines making it easier to make changes in the model and to visualize results. SWMM is a comprehensive model that can perform both hydrologic and hydraulic calculations.

The Liberty State Park SWMM used the RUNOFF and HYDRAULICS (known as EXTRAN in other versions) blocks. The HYDRAULICS block solves the complete St. Venant (Dynamic Flow) equations throughout the drainage network and includes modeling of backwater effects, flow reversal, surcharging, looped connections, pressure flow and tidal outfalls and interconnected ponds.

8.4.2 RUNOFF Block

The RUNOFF block of SWMM simulates the quantity of runoff. "The program accepts an arbitrary rainfall and makes a step by step accounting of infiltration losses in pervious areas, surface detention, overland flow and channel flow, leading to the calculation of a number of inlet hydrographs" (Huber et. al., 1988). The program generates hydrographs by a "non-linear reservoir" routing method, which is similar to the kinematic wave approach used in the US Army Corps of Engineer's HEC-1 model and other hydrologic simulation programs.

8.4.2.1 Non-linear Reservoir Representation

The areas selected to provide additional stormwater runoff to the proposed wetland system were divided into 6 subcatchments (see Figure 8-1) each with different hydraulic properties (i.e., slope, Manning's roughness coefficient, etc.) Each one of the subcatchments was further divided into pervious and impervious areas. SWMM uses a non-linear representation of each subcatchment to produce a hydrograph of a rainfall event utilizing a combination of a continuity equation and Manning's equation. According to Huber (1988) the continuity equation for a subarea is written as:

$$(dV/dt) = A(dd/dt) = Ai^{*} - Q \qquad (8\text{-}1)$$

where:

V	= Ad = volume of water on the subarea, ft^3
d	= water depth, ft
t	= time, sec.
A	= surface area of subarea, ft^2
i^*	= rainfall excess (rainfall/snowmelt intensity minus evaporation/infiltration rate, ft/sec)
Q	= outflow rate, cfs

The outflow is generated using Manning's equation:

$$Q = W\,(1.49/n)\,(d\text{-}dp)^{5/3}\,S^{1/2} \qquad (8\text{-}2)$$

where:

W	= subcatchment width, ft.,
n	= Manning's roughness coefficient,
dp	= depth of depression storage, ft.,

S = subcatchment slope, ft/ft

These equations are combined into one non-linear differential equation that may be solved for one unknown (depth) as follows:

$$dd/dt = i^* - [(1.49W)/(An)]\,(d\text{-}dp)^{5/3}\,S^{1/2} = i^* + WCON\,(d\text{-}dp)^{5/3} \qquad (8\text{-}3)$$

where:

$$WCON = (1.49WS^{1/2})/(An) \qquad (8\text{-}4)$$

This equation is then solved by a finite difference scheme at each time step to produce a hydrograph for a rainfall event.

8.4.2.2 Subcatchment data

The subcatchment data includes the area, percent impervious, slope, Manning's n-value (pervious and impervious), subcatchment width, depression storage, evaporation, and infiltration. The subcatchment data is shown in Table 3-1.

The subcatchment slope is the average slope of a typical overland flow path from the point of rainfall to the collection in a catch basin, channel, storm sewer, or detention basin. Drainage areas, flow paths, and slopes for each subcatchment were estimated based on the topographic mapping.

The subcatchment percent impervious represents the percent of impervious surface (such as parking lots and roadways) which are directly connected to the storm sewer system. The southern roof drains at the Liberty Science Center drain directly into the storm sewer system; therefore, these drainage areas were considered impervious. The northern roof drains empty into the LSC wetland area; therefore, these drainage areas were not considered impervious.

Each subcatchment is assigned two Manning's roughness coefficients: one for the pervious area and the other for the impervious area. The roughness coefficients for the pervious areas were between 0.05 to 0.1, and for impervious, coefficients were 0.014.

Depression storage represents the volume of water which does not run off and is not subject to infiltration. Depression storage also includes water that falls on tree canopies and does not reach the ground. Depression storage is typically used as a calibration parameter; however, because there is insufficient existing data to calibrate the model to, depression storage was not used in the analysis. However, because the primary drainage areas are predominantly impervious, depression storage would likely be minimal and have little impact on the analysis.

The subcatchment infiltration is the water that infiltrates into the ground. The maximum and minimum infiltration rates were set at 4.5 and 0.02 inches per hour for pervious surfaces within the park and 3.0 and 0.02 inches per hour for pervious surfaces outside the park. The pervious surfaces outside the park consist primarily of mowed grass or grass swales. The pervious surfaces inside the park are grasslands and upland forests. The decay coefficient was set at 4 hr^{-1}, which is equivalent to a decline in infiltration of 98 percent towards the minimum rate after the first hour. Use of these infiltration rates results in a majority of the rainfall events occurring throughout the year, which are less than 0.5 inches per hour, infiltrating into the soil of the pervious areas. For example, as shown in Figure 8-2, much of the rainfall from the 10-year/24-hour even infiltrates into a pervious soil surface (i.e., LSC wetland drainage area). In comparison, as shown in Figure 8-3 much of the rainfall falling on a primarily impervious surface (i.e., LSC parking lot) results in runoff.

Evaporation data in the model were applied to all the open water in drainage areas and natural channels within the network.

Evapotranspiration was not considered in the SWMM analysis. Because the drainage areas are primarily impervious, losses due to evaporation from the soil surface and transpiration

from vegetation, are negligible. It is also assumed that evaporation from open water areas within the channel and wetlands would be significantly greater than evapotranspiration from areas adjacent to the wetlands and channels. Furthermore, it is difficult to model the saturated soil zone without sufficient groundwater data.

8.4.3 HYDRAULICS Block

The HYDRAULICS block of the SWMM receives input flow hydrographs from the RUNOFF block and routes flow downstream, explicitly taking into account backwater conditions along the way. Parallel pipes, culverts, open channels, weirs, orifices, and detention ponds as well as complex hydraulic systems can all be modeled in this block. The HYDRAULICS block uses a node and conduit representation of the physical system. Channels, culverts and pipes are represented by conduits, and manholes, detention basins, ponds or boundaries between channel segments are represented by nodes.

The existing and proposed wetlands were modeled as natural channels within SWMM. Through the use of natural channel links, the wetland dimensions and subsequent storage, as well as flow of water through the wetlands, could be more accurately modeled. This helped make the model more representative of actual conditions at the site.

8.4.3.1 St. Venant equations

The HYDRAULICS block solves the one-dimensional non-steady state flow equations also known as the St. Venant or shallow water equations. The HYDRAULICS block solves a coupling of the continuity and momentum equations at each time step using a finite difference form of the following equation:

$$\frac{\partial Q}{\partial t} + \frac{gKQ|Q|}{R^{3/4}} - \frac{V\partial A}{\partial t} + \frac{Q\partial V}{\partial x} + gA\frac{\partial H}{\partial x} = 0 \qquad (8\text{-}5)$$

where:

Q	= discharge through the conduit
V	= velocity in the conduit
A	= cross-sectional area of the flow
H	= hydraulic head (invert elevation plus water depth)
R	= Hydraulic radius
t	= time
x	= distance
g	= acceleration due to gravity
K	= $(n/1.49)^2$ [for English units n = 1]
n	= Manning's roughness coefficient

8.4.3.2 Node and Conduit Data and Coefficients

There are a number of different parameters that must be encoded into the HYDRAULICS block so that it can accurately reflect the storm drainage system. These parameters include conduit lengths, sizes and shapes as well as node inverts and ground elevations. Conduit lengths and wetlands dimensions were developed using the topographic mapping. Typical conduit and node data for the alternatives are included in Appendices E and F (Alternative D output). The data are typical for each alternative.

To calculate friction losses, Manning's roughness coefficients (n-values) were assigned for all conduits. For this analysis, a value of 0.014 was utilized for the storm drainage pipes. For the open channels and drainage ditches, two n-values are used: 0.05 for mowed or short grass surfaces and 0.1 for long grass and weed areas, such as the drainage ditches along Phillip Street.

Entrance and exit loss coefficients, contraction and expansion coefficients, and bend losses in pipes were considered minimal and were not used in the model.

8.4.3.3 Infiltration Modeling

XP-SWMM contains a module for modeling infiltration and percolation as it relates to groundwater elevation. However, use of the module requires more groundwater data than was available. Additionally, the module contains several adjustment coefficients, which are best determined through calibration with known data. Because data was unavailable, the infiltration basin was modeled using an outlet orifice to represent infiltration (outflow) from the basin.

The outlet was sized for a maximum outflow of approximately 2 cfs at 1.5 feet of head, which is equivalent to 1 in/hr over the 2 acre infiltration basin (9 in. diameter orifice). One and one-half feet of head in the basin is a reasonable maximum level (approximately 6.0 ft NAVD) based on the system's design elevations.

8.4.3.4 Boundary Conditions

The one free flowing outlet in the model was at Morris Canal. Tidal influence was modeled at this outlet using the Mean High Water and Mean Low Water elevations, 2.19 feet NAVD and –2.38 feet NAVD, respectively. Initial results indicated that the tidal boundary condition only impacted ponding in the immediate vicinity of the outlet. Therefore, any minor changes in the tidal elevations would not be expected to impact the results.

8.4.3.5 HYDRAULICS network

A schematic of the Existing Conditions HYDRAULICS network, shown in Figure 8-4, includes the major nodes, channel, and pipe segments of the drainage system. Each of the six subwatersheds includes pipes and channels to route flows. In Figure 8-, the circles are model

nodes representing manholes or connections between open channel conduits. The lines are the links or conduits connect the nodes. The triangles represent storage nodes, such as detention basins and ditches.

Figures 8-5 and 8-6 show the SWMM networks for Alternatives A and Alternative B, respectively. The network for Alternative C is similar to Alternative B: only the dimensions of the Liberty Science Center wetland have changed. The nodes between the channel segments in the Biofilter wetland and Deep Emergent Marsh indicate changes in wetland or channel dimensions.

Figure 8-7 shows the SWMM network for Alternative D. Alternative D differs from Alternative C at the DEM outlet: the DEM outflow enters an infiltration basin, where groundwater recharge occurs. A second overflow outlet was added to the infiltration basin in the event inflow exceeds infiltration.

8.4.3.6 Calibration

No measured flow or water surface elevation data was available for the existing drainage system; therefore, calibration of the model was conducted using anecdotal information: model results were compared with observations made in the field during site visits and the environmental resources inventory work effort.

8.4.3.7 Hydrologic Risk and Uncertainty

Because the hydrologic budget was a volume-driven analysis, focused on monthly and annual runoff and storage volumes, the analysis of discrete storm events would not provide the necessary information to conduct the analysis over time. Furthermore, discrete runoff data would not provide the data needed to determine if there was sufficient annual runoff to support an additional wetland system in the park. Therefore, standard means of incorporating

hydrologic uncertainty into a discrete event analysis, such as changes in the period of record, were not possible.

Rather, using the continual rainfall-record modeling capability of SWMM, actual rainfall from known historic periods could be modeled and the performance of the existing and proposed conditions could be evaluated using realistic rainfall periods. Hydrologic uncertainty was incorporated into the analysis by modeling one extreme wet year and one extreme dry year of recorded rainfall, 1983 and 1976, respectively. Successful performance of the wetland system during these two events, particularly the dry year, would indicate that the system should function satisfactorily during an average precipitation year, which would have typical rainfall events and amounts somewhere between the two modeled years.

8.4.3.8 Infiltration Basin Performance Uncertainty

Many factors influence the rate of infiltration including: soil structure, condition of the soil surface, moisture content, and chemical and physical nature of the soil and water used in the analysis. Therefore, surface infiltration measurements made with double-ring infiltrometers typically provide data useful only for comparison to published sources (ASTM 1986). The unique characteristics of soils at the Liberty State Park site, namely, coarse, gravelly-material on the surface and poorly-graded, silty Sand underneath, indicate that the surface infiltration rate will likely be different from the subsurface (>12 in.deep) rate. However, subsurface infiltration data is unavailable at this time. Furthermore, groundwater movement and elevation are also unpredictable, especially in the future if the proposed tidal wetland is constructed.

The rapid infiltration rates measured at the soil surface are indicative of gravelly-sand at the soil surface; however, subsurface geotechnical analyses indicate the presence of poorly-graded silty Sand, which has a relatively low permeability. However, permeability tests were not conducted on the deeper material. Therefore, infiltration rates at the invert of the proposed infiltration basin must be estimated.

Minimum measured surface infiltration rates (fc) ranged from <4.5 in/hr to over 30 in/hr. However, due the variables stated above, the accuracy of those rates across the soil stratigraphy is uncertain. While coarse gravel and sand have extremely high infiltration rates, it is unclear how deep the high infiltration layer extends. Since infiltration generally decreases with depth, an estimated value of 1 in/hr was considered appropriate for the analysis. A more accurate measurement will be required during the next phase of the study.

The presence of groundwater at or near (or above) the invert of the infiltration basin will impact its performance; however, the actual change in groundwater elevation throughout the year is unknown. It is reasonable to assume that the construction of the proposed tidal wetland may impact (lower) the groundwater elevation, reducing its impact on the infiltration basin. For this analysis, it is assumed that there is no groundwater impact and infiltration is not limited. A change in the infiltration rate is included in the Sensitivity Analysis.

8.5 Alternatives Analysis

8.5.1 General

The four freshwater wetland system alternatives were each modeled with hydrologic input for a wet year and a dry year to evaluate performance. The success of an alternative was predicated on: (1) maintaining the water surface elevation within the Biofilter wetland throughout a majority of the year, (2) maintaining a measurable depth of water within the Deep Emergent Marsh (DEM) throughout the entire year, and (3) achieving some periodic outflow through the DEM overflow in order to achieve circulation or flushing of the DEM. Table 8-1 shows how each alternative performed in meeting the success criteria. Specific discussions of the performance of each alternative are included in the following sections.

8.5.2 Alternative A – Addition of LSC Runoff

As shown in Figure 8-8, during the wet year of precipitation, the Biofilter easily maintains a design water surface elevation (WSEL) of 5.5 feet NAVD. Periodic lowering of the WSEL during the drier summer months occurs for relatively short durations and elevation losses are less than 6 inches. Frequent elevation spikes are representative of the frequent runoff input from the Liberty Science Center. As shown in this and the remaining WSEL timelines, the initial elevation is the invert of the wetland or channel. This is a result of starting the SWMM model with no surcharging or initial data. Starting from a surcharged condition would not have a significant impact on the overall water surface elevations and only a minor impact on outflow volume results during the initial months of modeling.

As shown in Figure 8-9, the DEM also maintains a design WSEL of 5.0 feet NAVD during a majority of the wet year. The duration of the low WSEL during the drier summer months is longer in the DEM than in the Biofilter. However, the deepwater pool maintains a depth of almost 4 feet in the summer.

During a dry year, the Biofilter wetland maintains the 5.5 feet NAVD WSEL during a majority the year as shown in Figure 8-10. The reduced number of elevation spikes demonstrates that input is significantly reduced as a result of less rainfall. Because much of the rainfall occupies existing storage in the Biofilter, there is minimal overflow to the DEM.

As shown in Figure 8-11, the WSEL of the DEM is at the design elevation during a majority the dry year. However, overflow from the DEM is less frequent, as indicated by the limited number of times the WSEL exceeds 5.0 feet NAVD, and as shown in Figure 8-12.

During a wet year there is comparatively significant overflow from the DEM, as shown in Figure 8-13.

Overall, Alternative A meets all the performance criteria and can be expected to provide sufficient water to maintain each of the wetland Zones described in the Freshwater Components section of the report.

8.5.3 Alternative B – Addition of LSC and LSC Wetland Runoff

Like Alternative A, the Biofilter maintains a design WSEL of 5.5 feet NAVD throughout much of the year, as shown in Figures 8-14 and 8-15.

The addition of a second source of stormwater to the freshwater wetland system increases the time the DEM maintains the design WSEL and increases outflow from the DEM, improving circulation and flushing. As shown in Figure 8-16, the DEM maintains the design WSEL of 5.0 feet NAVD during most of the wet year of precipitation. Frequent increases in the WSEL above the outflow invert result in periodic flushing of the wetland, as shown in Figure 8-17.

As shown in Figure 8-18, even during the dry year the DEM WSEL is at the design elevation for 10 of 12 months. Overflow from the DEM is less frequent than during a wet year, but still significant, as shown in Figure 8-19.

The performance of Alternative B is similar to Alternative A; however, the increased flushing from the additional stormwater provided by the LSC wetland should improve the water quality in the DEM.

8.5.4 Alternative C – Additional Runoff and Enhanced LSC Wetland

Hydraulically, the performance of Alternative C is virtually identical to the performance of Alternative B. This occurs because the only modification in Alternative C relative to Alternative B is the dimensions of the LSC wetland. Although there is a significant improvement in habitat as a result of the enhancement, the changes in the storage dimensions are minor; therefore, they have little impact on the hydraulic performance of the alternative in comparison to Alternative B.

8.5.5 Alternative D – Alternative C with Infiltration Basin

Alternative D is similar to Alternative C, including an enhanced LSC wetland and additional stormwater runoff from the LSC parking lot and overflow from the LSC wetland. However, in this alternative, the DEM outflow enters an infiltration basin, where groundwater recharge occurs.

Like the other alternatives, the Biofilter maintains a design WSEL of 5.5 feet NAVD throughout much of the year, as shown in Figures 8-20 and 8-21. As shown in Figures 8-22 and 8-23, the DEM maintains the design WSEL of 5.0 feet NAVD during most of the wet year of precipitation and during the dry year the DEM WSEL is at the design elevation for 10 of 12 months.

Overflow from the DEM enters the infiltration basin and is lost from the system through infiltration. As shown in Figure 8-24, periods of higher rainfall surcharge the infiltration basin above the design WSEL of the DEM for brief periods of time. Infiltration for the basin, as modeled, is shown in Figure 8-25.

For the dry model year, input to the infiltration basin is less frequent (Figure 8-26). Subsequently, there is less infiltration (Figure 8-27).

8.5.6 10-year NJDOT Design Event Performance

The performance of the freshwater wetland system was evaluated to ensure that no induced roadway flooding occurs during the NJDOT roadway design event. The NJDOT design event is a 10-year/24-hour rainfall event of approximately 5.25 total inches of rainfall. Unlike the annual models, the design event was modeled using SWMM's "hot-start" feature, which enabled modeling of the events with antecedent conditions in the wetlands. Starting the

model with existing water in the wetland more realistically represents the behavior of the WSELs in the system.

The primary areas of concern in the wetland system are: 1) the Biofilter and, 2) the detention/ponding area west of Phillip Street (the upstream end of the Phillip Street pipe). Excessive backwater flooding in these areas could overtop Phillip Street as a result of the proposed wetland system.

As shown in Table 8-2, the WSELs of both the Biofilter and upstream detention area just reach the minimum curb height of 7.0 feet NAVD along Phillip Street as a result of the 10-year/24-hour storm runoff in each alternative. This is shown in Figures 8-26 through 8-31. The smoothness of the hydrograph changes between Figures 8-29 and 8-30 due to modifications in the time step, which were made to improve model performance.

From these results, it is assumed that flooding is not likely to occur at Phillip Street following a 10-year/24-hour storm event as a result of the freshwater wetland system construction.

8.6 Sensitivity Analysis

Preliminary plan formulation results indicate that Alternative D is the preferred freshwater wetlands plan. Uncertainty has been incorporated into the hydrology through the use of precipitation from extreme wet and dry years of record. Evaporation uncertainty is incorporated through the use of monthly averages. However, at this point in the analysis there is some degree of uncertainty associated with the potential infiltration of the proposed infiltration basin. Small changes in the infiltration rate are not expected to be critical to the wetland system performance; however, a sensitivity analysis is appropriate to demonstrate the impact of potential changes in filtration.

As defined, a sensitivity analysis is a technique of varying assumptions to examine the effects of alternative assumptions on the determined outcome. In this case, how the wetland system

will perform if the infiltration of the proposed infiltration basin is changed. To evaluate the system sensitivity to a change in the infiltration rate, the proposed infiltration rate was modeled during the wet year (1983) with an outlet sized for a maximum outflow of approximately 1 cfs at 1.5 feet of head, which is equivalent to maximum infiltration rate of 0.5 in/hr over the 2 acre infiltration basin or half of the assumed infiltration rate of 1 in/hr.

As shown in Figure 8-34, infiltration is half the rate originally modeled; however, the WSEL elevation increase in the infiltration basin is only approximately 0.4 feet during the largest storm (Figure 8-35). The greatest impact is a backwater impact into the DEM; however, this is minimal and quickly dissipates as the infiltration basin WSEL drops. It can be assumed that an increase in the infiltration rate will have the opposite effect on the WSEL of the infiltration basin and DEM during a given year. Regardless, minor changes in the infiltration rate should not detrimentally impact the freshwater system.

9. SEDIMENT LOADING ESTIMATES

The purpose of this analysis was to estimate the depositional rates in each of the three water bodies to be created in this project: the LSC Wetlands; the Biofilter; and the Deep Water Emergent Wetland. These projections are useful for determining the effort to be required to maintain the wetland depths in the future through dredging.

9.1 Methodology And Assumptions

9.1.1 Methodology

The monthly sediment loading is calculated as

$$L = Q * C * C_1 \qquad (9\text{-}1)$$

where

L	=	sediment loading (lbs/month)
Q	=	flow (m^3/month)
C	=	total suspended solids concentration (mg/l)
C_1	=	units conversion factor

The Simple Method was used to calculate monthly flows. In this respect, the sedimentation analysis was consistent with the runoff calculations for the hydrologic budget analysis. The solids settled in one of the water bodies is calculated as the solids loading passing through the water body times the solids removal efficiency (Schueler 1987):

$$S = L * R \qquad (9\text{-}2)$$

S = solids settled (pounds/month)

R = solids removal efficiency (%)

This method was used to calculate sediment deposition for three water bodies: the LSC wetland, the biofilter, and the deep water emergent wetland.

Solids loadings are passed downstream as determined in the conceptual plan. A diagram showing the solids routing for the proposed plan is presented in Figure 9-1. The breakdown of solids sources for each of the water bodies is:

1. LSC Wetland: NJ Transit parking lot runoff
2. Biofilter: Flow through LSC wetland and LSC parking lot runoff
3. Deep Water Emergent Wetland: flow through Biofilter and Upland Catchment runoff

Once the solids loading is calculated, the total deposition for that month can then be estimated:

$$D = L/\{?*A*(1-n)\} * C_2 \qquad (9\text{-}3)$$

where

D = sediment deposition (inches/month)

? = density (lb/ft^3)

A = surface area (acres)

n = porosity

C_2 = units conversion factor

9.1.2 Assumptions

Several simplifying assumptions were made to develop this analysis. It is assumed that each water body is at full capacity so that inflows are passed downstream within each month;

otherwise, a complete water balance would need to be developed for each water body. Another assumption is that results are time averaged over the one-month period. A suspended solids concentration of 31 mg/l was used, considered typical for urban runoff (Schueler 1987). Finally, because of the one-month time frame, storm-specific scouring is not specifically simulated. Instead, this effect is included in the overall solids removal efficiency, R, which is assumed to be 60%.

9.2 Sediment Loading And Deposition Estimates

Solids loadings and deposition rates are shown in Tables 9-1 and 9-2, respectively. The deposition rates for 1993-2002 are estimated at 0.0114 – 0.0462 inches/year for the three water bodies. The highest rates are for the average of the three wettest years (1983, 1984, and 1996), 0.0160 – 0.0647 inches/year.

10. COST ANALYSIS

First construction cost estimates were developed for each of the conceptual design alternatives. The cost estimating included direct construction expenditures such as demolition site work, landscaping, soil removal and disposal. The estimate also included indirect expenditures (soft costs) such as field engineering, administrative and legal costs. A contingency factor of 20% is also added. The costs were based on experience at other projects and published estimating tools, including RS Means©. The analysis was used to compare the estimated first construction costs for each of the four selected alternatives.

The estimated first costs of the alternatives are as follows:

- Alternative A: Deep Emergent Marsh, Liberty Science Center parking lot drainage (LSC) and Biofilter = $ 736,000.
- Alternative B: DEM, LSC, Biofilter, and Water from NJ Transit = $ 736,000.
- Alternative C: DEM, LSC, Biofilter, NJ Transit, and Enhanced LSC Wetland = $ 1,108,000.
- Alternative D: DEM, LSC, Biofilter, NJ Transit, Enhanced LSC Wetland and Infiltration Basin = $1,719,000.

Table 10-1 summarizes the comparative costs.

11. REFERENCES

Chow, Maidment, and Mays. 1988. *Applied Hydrology*. pp 108-117.

DeGaetano, A.T., K.L. Eggleston, and W.W. Knapp. 1994. Daily Evapotranspiration and Soil Moisture Estimates for the Northeastern United States. Northeast Regional Climate Center Research Series Publication No. RR 94-1.

Hammer, D.A. 1992. Creating Freshwater Wetlands. Lewis Publishers, Ann arbor, Michigan. 298 p.

Hubbard, D.E., J.L. Richardson, and D.D. Malo. 1988. Glaciated Prairie Wetlands: Soils, Hydrology, and Land Use Issues. P. 137-143 In: Kusler and Brooks 1988, Proceedings of the National Wetlands Symposium: Mitigation of Impacts and Losses, Association of State Wetland Managers, Berne, New York, Technical Report 3.

Huber W.C. and R.E. Dickinson. 1988. Storm Water Management Model, Version 4: Users Manual, US Environmental Protection Agency.

Liberty State Park (LSP) 2003. History of Liberty State Park. http://www.libertystatepark.com/1/lsp_history/history.htm

MacFarlane, D.W. 2001. The Ecology of Liberty State Park: A Historical Perspective

Maryland Soil Conservation Service (Md SCS). 1983. Maryland Specifications for Soil Erosion and Sediment Control. Maryland Water Resources, Administration. Annapolis Maryland.

NCDC. 2000. Hourly Precipitation Data (1948-1999).

NJDEP. 1995. Liberty State Park Soil Sampling Report.

NJDEP. 2003. New Jersey Stormwater Best Management Practice Manual, Draft February 2003.

NJDOT. 2003. New Jersey Department of Transportation Design Manual – Roadway.

Pierce, G. 1993. Planning Hydrology for Constructed Wetlands. Prepared by the Wetland Training Institute.

Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Prepared for Washington Metropolitan Water Resources Planning Board.

SMRC. 2003. Stormwater Manager's Resource Center website, www.stormwatercenter.net.

Turf-Tec International. 2003. Coral Springs FL.

USACE. 1999. Groundwater Hydrology (EM 1110-2-1421).

USACE. 2001. Wetlands Engineering Handbook (ERDC/EL TR-WRO-RE-21). Engineer Research and Development Center.

USACE. 2002. South River, Raritan River Basin Hurricane and Storm Damage Reduction and Ecosystem Restoration Draft Integrated Feasibility Report and Environmental Impact Statement – Hydrology, Hydraulics & Design Appendix.

USEPA. 1999. Infiltration Through Disturbed Urban Soils and Compost – Amended Soil Affects on Runoff Quality and Quantity (EPA/600/R-00/016).

Viessman, W., J.W. Knapp, G.L.Lewis, and T.E. Harbaugh. 1977. Introduction to Hydrology. Harper & Row Publishers. New York.

XP Software. 1999. XP-SWMM2000 Version 8.0, Stormwater & Wastewater Management Model, Getting Started Manual.

APPENDIX A

HYDROLOGIC BUDGET RESULTS

APPENDIX B

PLANS OF FRESHWATER WETLAND COMPONENTS AND MODELED ALTERNATIVES

APPENDIX C

WETLAND ZONES

APPENDIX D

COST SHEETS

APPENDIX E

ALTERNATIVE 4 SWMM HYDRAULIC OUTPUT - 1976

APPENDIX F

ALTERNATIVE 4 SWMM HYDRAULIC OUTPUT - 1983

LIST OF FIGURES

Figure 1-1. Location of Liberty State Park Restoration Site, Jersey City, New Jersey

Figure 1-2. Liberty State Park Study Area

Figure 1-3. Regulated wetlands within Project Site in Liberty State Park

Figure 1-4. Drainage area and proposed wetlands

Figure 2-1. Contoured groundwater levels (15 November 2003) and piezometer locations

Figure 3-1. Total monthly precipitation for 2003 and 1993-2002

Figure 3-2. Monthly precipitation for the average of three driest and three wettest years

Figure 3-3. Monthly precipitation for Jersey City and Newark Airport, 1993-1996

Figure 3-4. Locations of infiltration tests

Figure 3-5. Simple Method and XP-SWMM Results

Figure 4-1 Water balance for Alternative 1, 1993-2002 period

Figure 6-1. Liberty Science Center Wetland – Plan View

Figure 6-2. Liberty Science Center Wetland – Profile

Figure 6-3. Biofilter – Plan View

Figure 6-4. Biofilter – Profile

Figure 6-5. Deepwater Emergent Wetland – Plan View

Figure 6-6. Deepwater Emergent Wetland – Profile

Figure 6-7. Infiltration Basin – Plan View

Figure 6-8. Infiltration Basin – Profile

Figure 6-9. Freshwater Alternative Plan A

Figure 6-10. Freshwater Alternative Plan B

Figure 6-11. Freshwater Alternative Plan C

Figure 6-12. Freshwater Alternative Plan D

Figure 7-1. Wetland Restoration Plans

Figure 8-1. Drainage subcatchments area

Figure 8-2. LSC Wetland Rainfall/Infiltration: 10-year Event

Figure 8-3. LSC Parking Lot Rainfall/Infiltration: 10-year Event

Figure 8-4. Liberty State Park Existing Conditions SWMM Network

Figure 8-5. Liberty State Park Alternative A SWMM Network

Figure 8-6. Liberty State Park Alternative B SWMM Network

Figure 8-7. Liberty State Park Alternative D SWMM Network

Figure 8-8. Alternative A – Biofilter Wetland Performance 1983 (Wet)

Figure 8-9. Alternative A – Deepwater Emergent Marsh Performance 1983 (Wet)

Figure 8-10. Alternative A – Biofilter Wetland Performance 1976 (Dry)

Figure 8-11. Alternative B – Deepwater Emergent Marsh Performance 1976 (Dry)

Figure 8-12. Alternative A – DEM Overflow 1976 (Dry)

Figure 8-13. Alternative A – DEM Overflow 1983 (Wet)

Figure 8-14. Alternative B – Biofilter Performance 1983 (Wet)

Figure 8-15. Alternative B – Biofilter Performance 1976 (Dry)

Figure 8-16. Alternative B – Deepwater Emergent Marsh Performance 1983 (Wet)

Figure 8-17. Alternative B – DEM Overflow 1983 (Wet)

Figure 8-18. Alternative B – Deepwater Emergent Marsh Performance 1976 (Dry)

Figure 8-19. Alternative B – DEM Overflow 1976 (Dry)

Figure 8-20. Alternative D – Biofilter Performance 1983 (Wet)

Figure 8-21. Alternative D – Biofilter Performance 1976 (Dry)

Figure 8-22. Alternative D – Deepwater Emergent Marsh Performance 1983 (Wet)

Figure 8-23. Alternative D – Deepwater Emergent Marsh Performance 1976 (Dry)

Figure 8-24. Alternative D – Infiltration Basin WSEL (1983)

Figure 8-25. Alternative D – Infiltration from Basin (1983)

Figure 8-26. Alternative D – Infiltration Basin WSEL (1976)

Figure 8-27. Alternative D – Infiltration from Basin (1976)

Figure 8-28. Alternative A – Biofilter Wetland During a 10 year/24 hour event

Figure 8-29. Alternative A – LSC Detention Area During a 10 year/24 hour event

Figure 8-30. Alternative B – Biofilter Wetland During a 10 year/24 hour event

Figure 8-31. Alternative B – LSC Detention Area During a 10 year/24 hour event

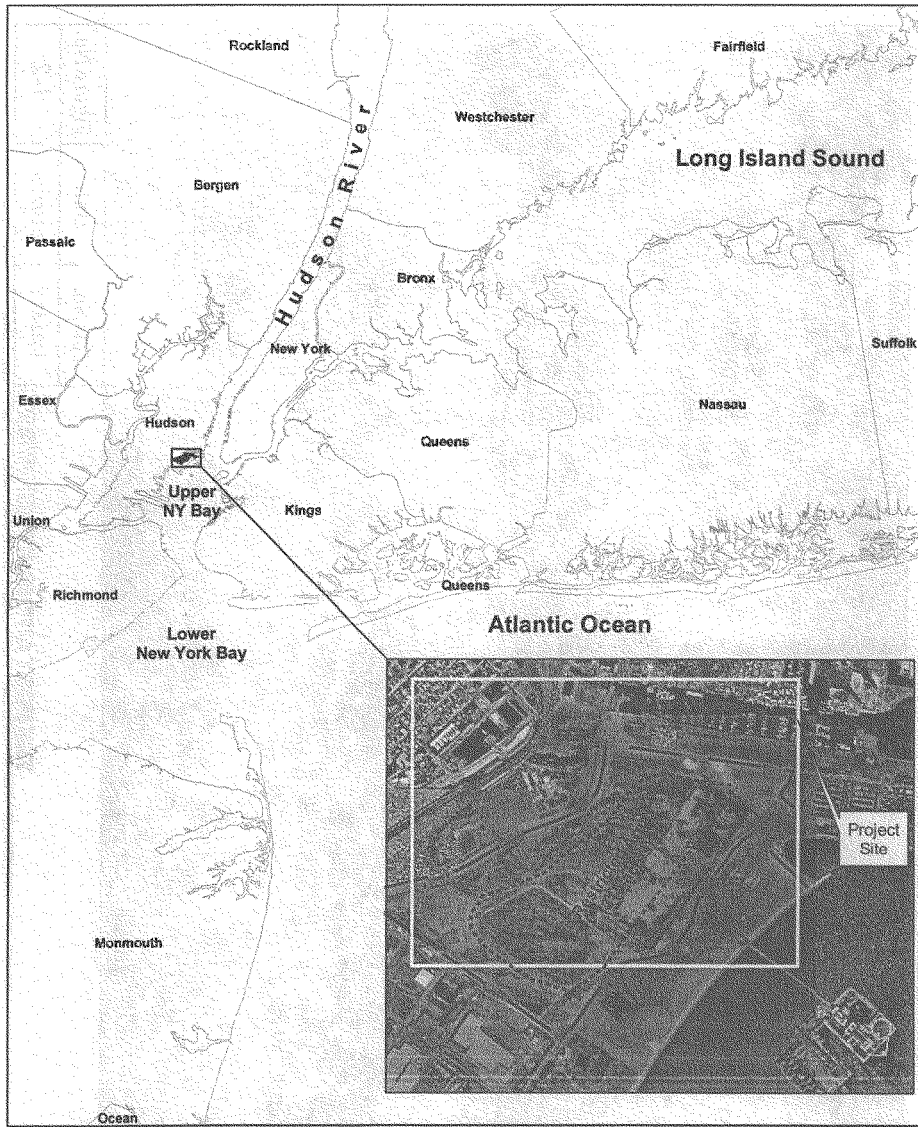
Figure 8-32. Alternative D – Biofilter Wetland During a 10 year/24 hour event

Figure 8-33. Alternative D – LSC Detention Arae During a 10 year/24 hour event

Figure 8-34. 1983: Infiltration Basin Sensitivity Analysis - Infiltration (Elevation and Flow)

Figure 8-35. 1983: Infiltration Basin Sensitivity Analysis - Infiltration (Stage)

Figure 9-1. Solids routing for the Proposed Plan



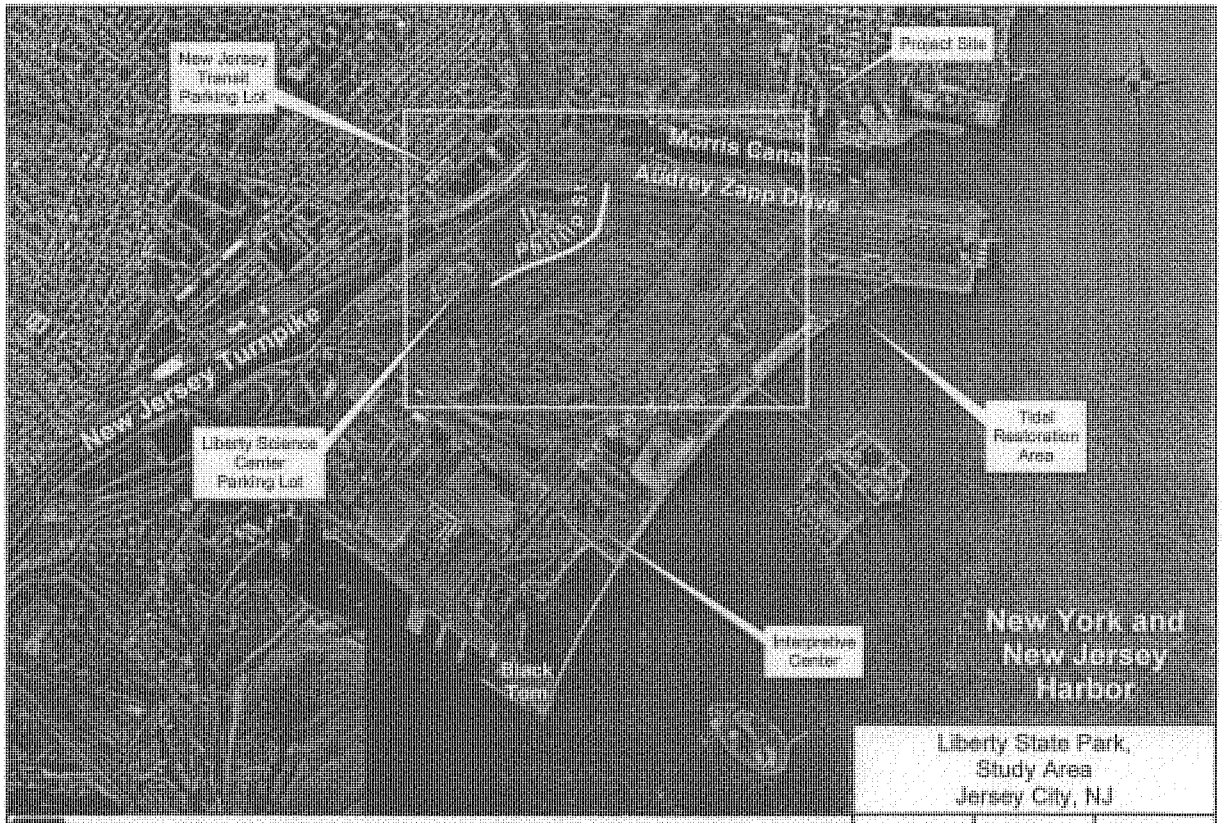
US Army Corps of Engineers®
New York District

THE PORT AUTHORITY OF NY & NJ

Map Source: ESRI
Aerial Photo Source: USACE

Location of
Liberty State Park
Restoration Site
Jersey City, NJ

Figure 1-1

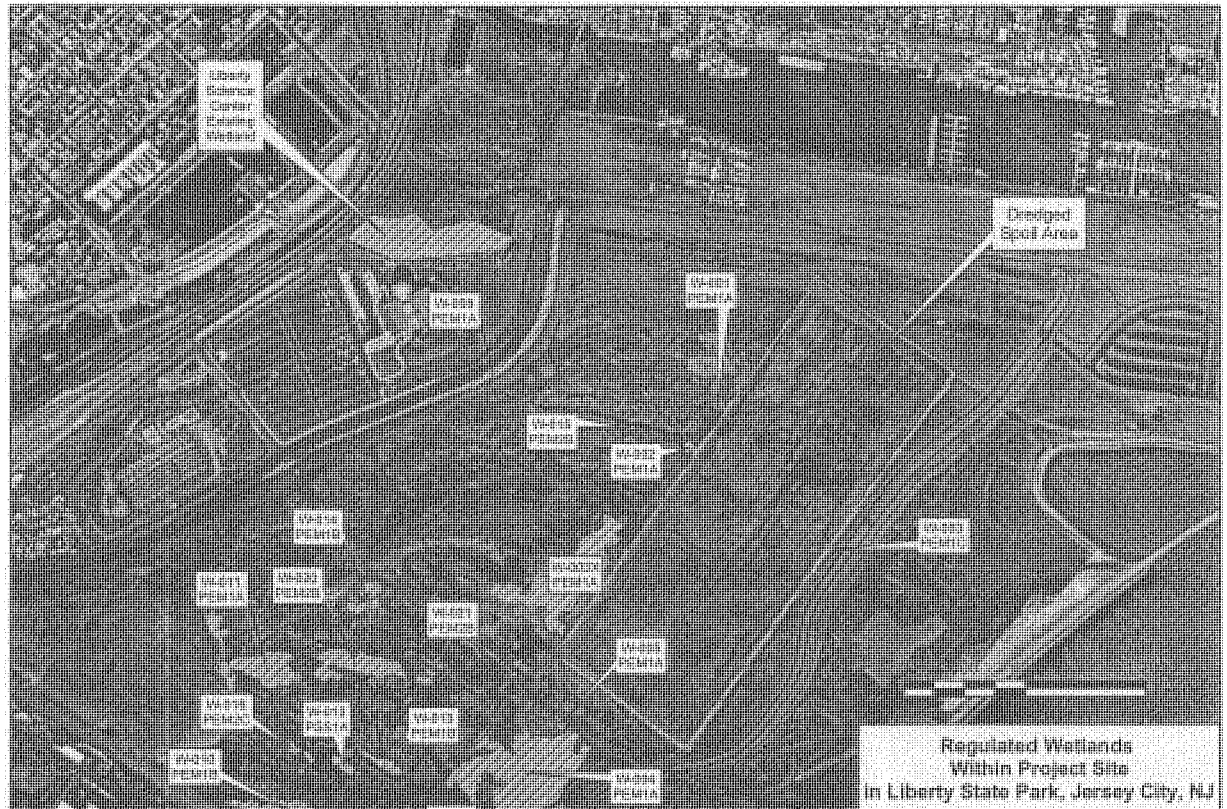


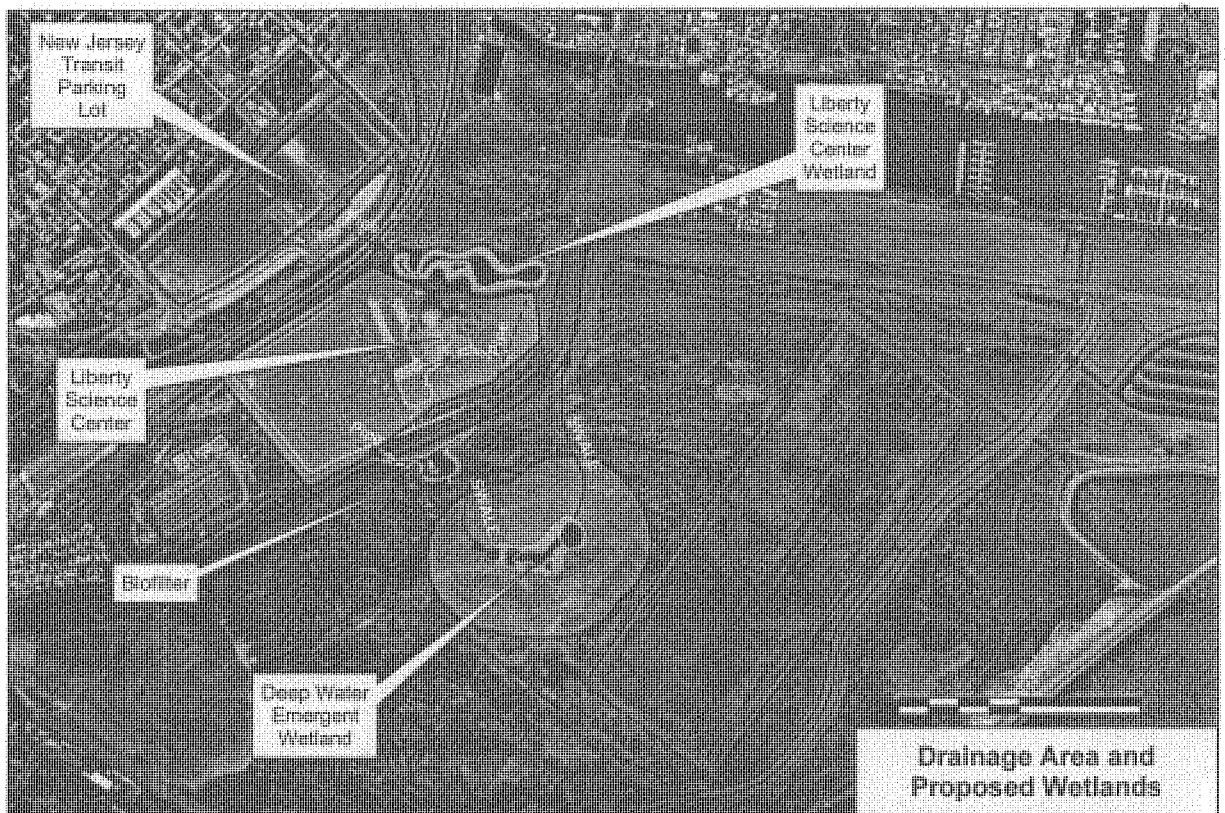
Liberty State Park, Study Area
Jersey City, NJ

Job No.	Date	Figure No.
1032-002	3/24/2004	1-2

US Army Corps of Engineers New York District

THE PORT AUTHORITY OF NY & NJ


Dredged Spoil Area
Regulated Wetlands
Within Project Site
in Liberty State Park, Jersey City, NJ
Job No.
Date
Figure No.
1-3
US Army Corps of Engineers
THE PORT AUTHORITY



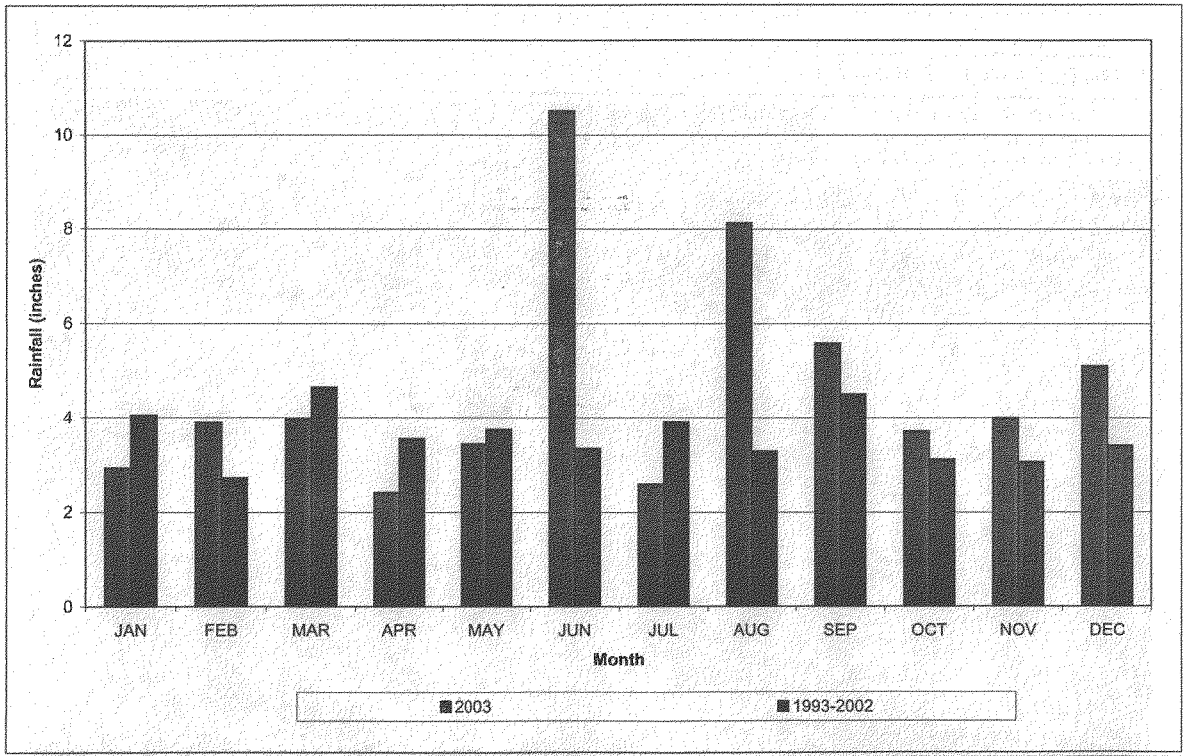
Drainage Area and Proposed Wetlands

Job No.	Date	Figure No.
1093-002	2/27/2004	1-4

US Army Corps of Engineers New York District

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

Contoured Groundwater Levels
(15 November 2003) and
Piezometer Locations
Job No.
Date
Figure No.
2-1
THE PORT AUTHORITY

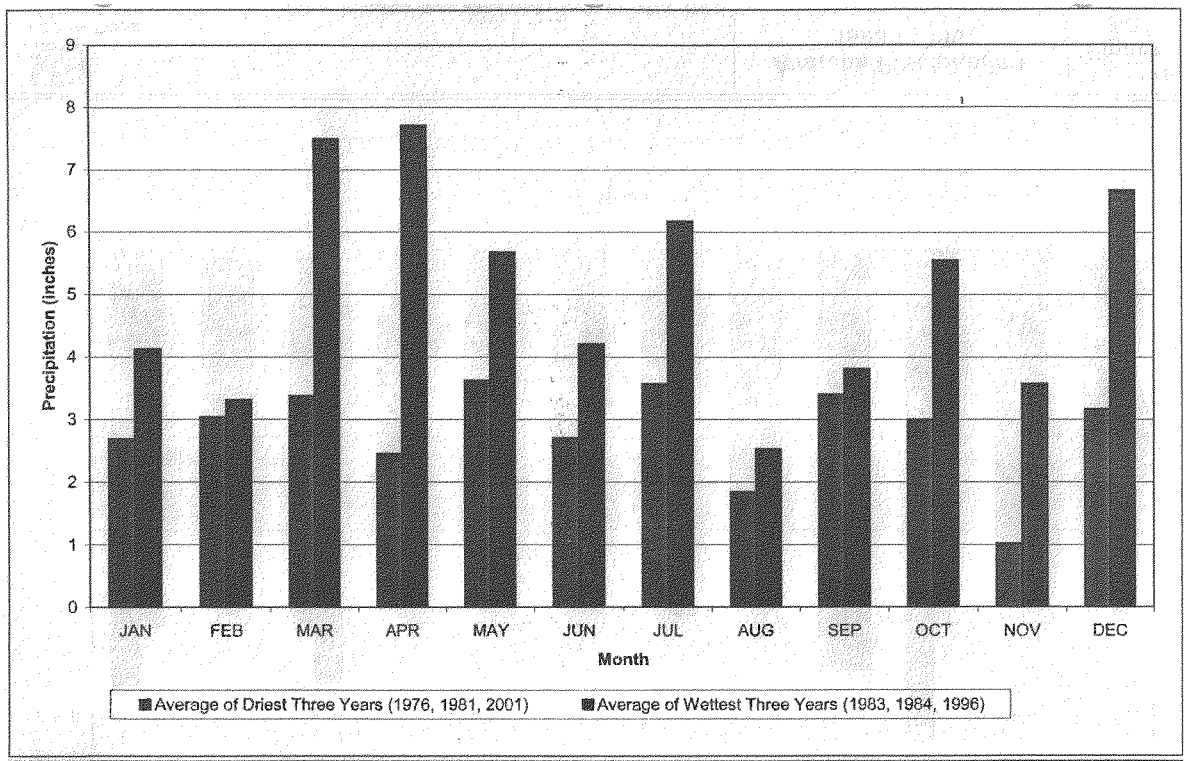


US Army Corps of Engineers®
New York D

THE PORT AUTHORITY OF NY & NJ

Newark Airport Monthly Average Precipitation

Figure 3-1

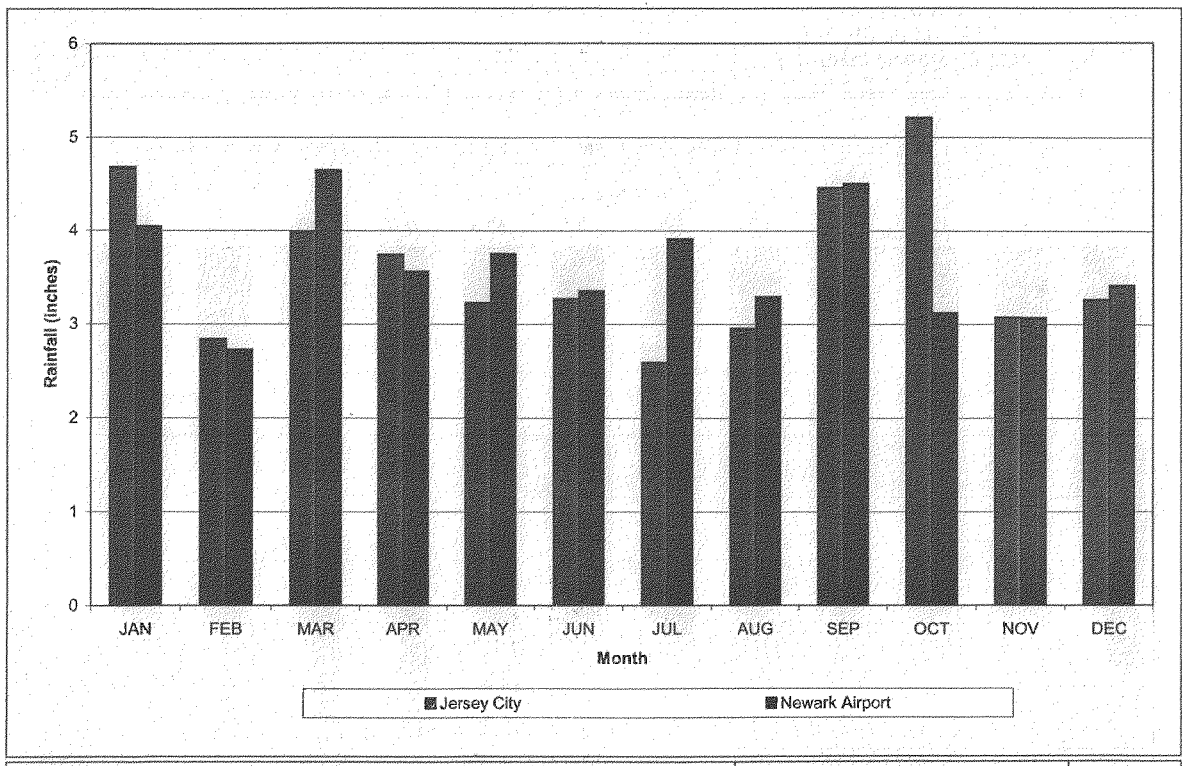


US Army Corps of Engineers
New York District

THE PORT AUTHORITY OF NY & NJ

Average Precipitation Period of Record 1971 - 2002

Figure 3-2

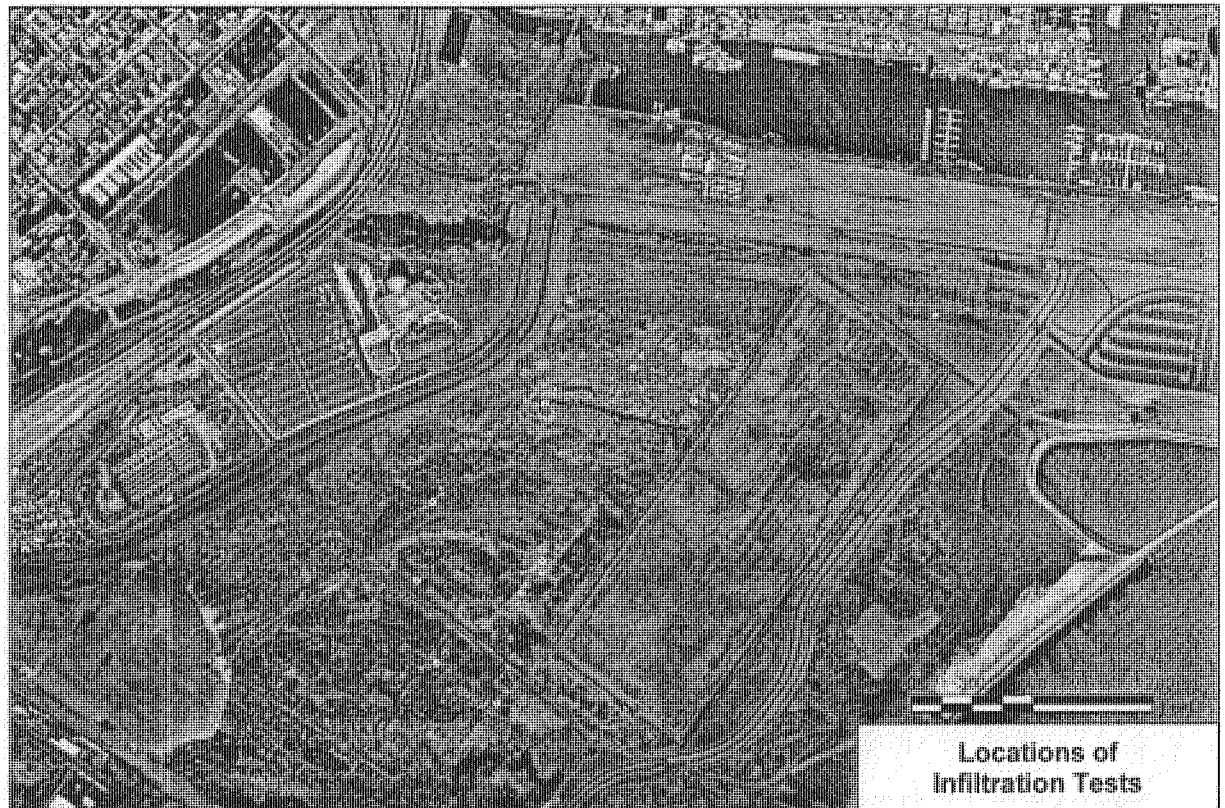


US Army Corps of Engineers
New York

THE PORT AUTHORITY OF NY & NJ

Average Precipitation 1993 - 1996

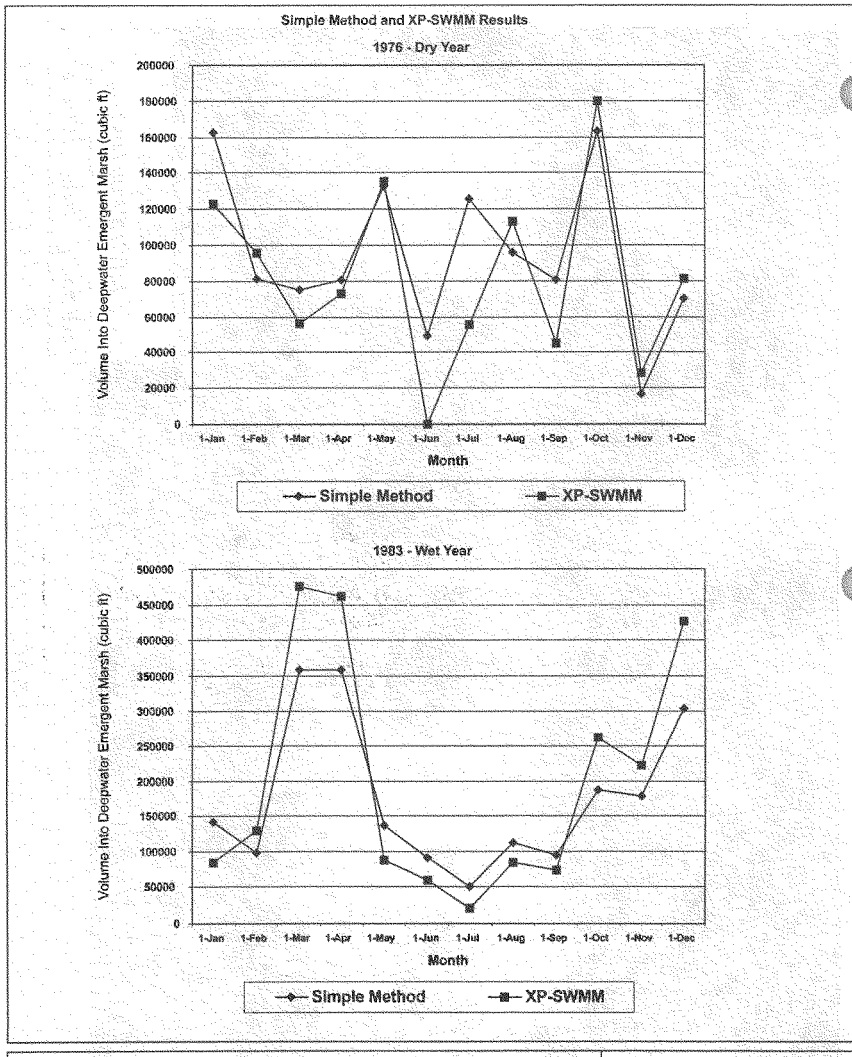
Figure 3-3



US Army Corps of Engineers
New York District

THE PORT AUTHORITY OF NY & NJ

Locations of Infiltration Tests		
Job No.	Date	Figure No.
1033-002	3/27/2004	3-4

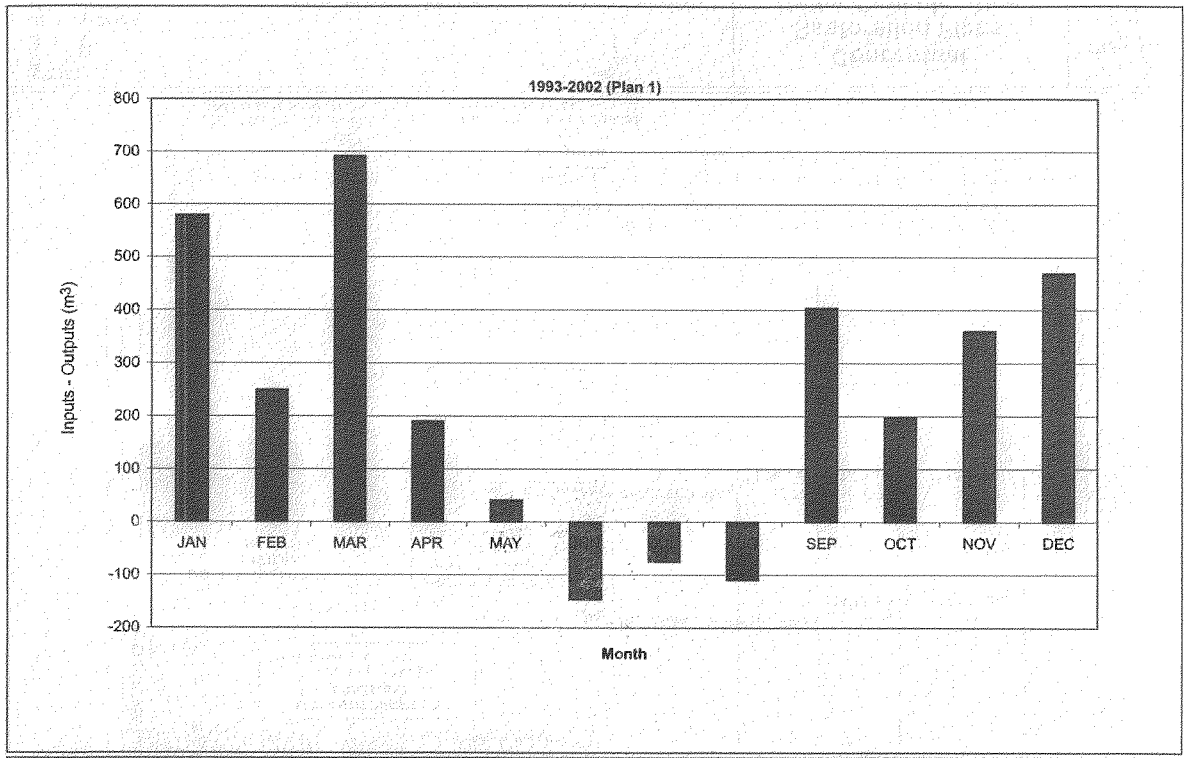


US Army Corps of Engineers®
New York District

THE PORT AUTHORITY OF NY & NJ

Simple Method and XP-SWMM Results

Figure 3-5

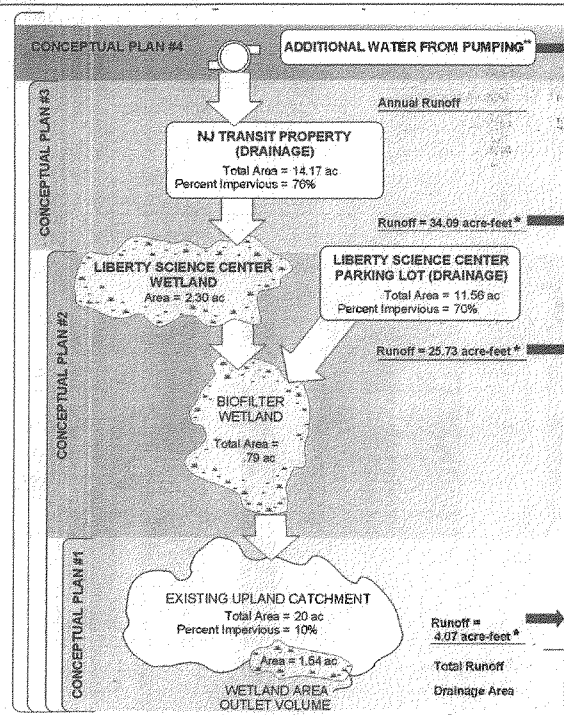


US Army Corps of Engineers®
New York District

THE PORT AUTHORITY OF NY & NJ

Water Budget (Inputs - Outputs)

Figure 4-1



	PLAN #1	PLAN #2	PLAN #3	PLAN #4	
ADDITIONAL WATER FROM PUMPING**				62.96 acre-ft or 56,202 gpd	
Runoff = 34.09 acre-feet *			34.09 (14.17 ac)	34.09 (14.17 ac)	
Runoff = 25.73 acre-feet *		25.73 (11.56 ac)	25.73 (11.56 ac)	25.73 (11.56 ac)	
Runoff = 4.07 acre-feet *	4.07 (25 ac)	4.07 (25 ac)	4.07 (25 ac)	4.07 (25 ac)	
Total Runoff	4.07	32.94	67.03	67.03 **	(acre-ft)
Drainage Area	25.0	36.6	50.7	25.0 **	(acre)

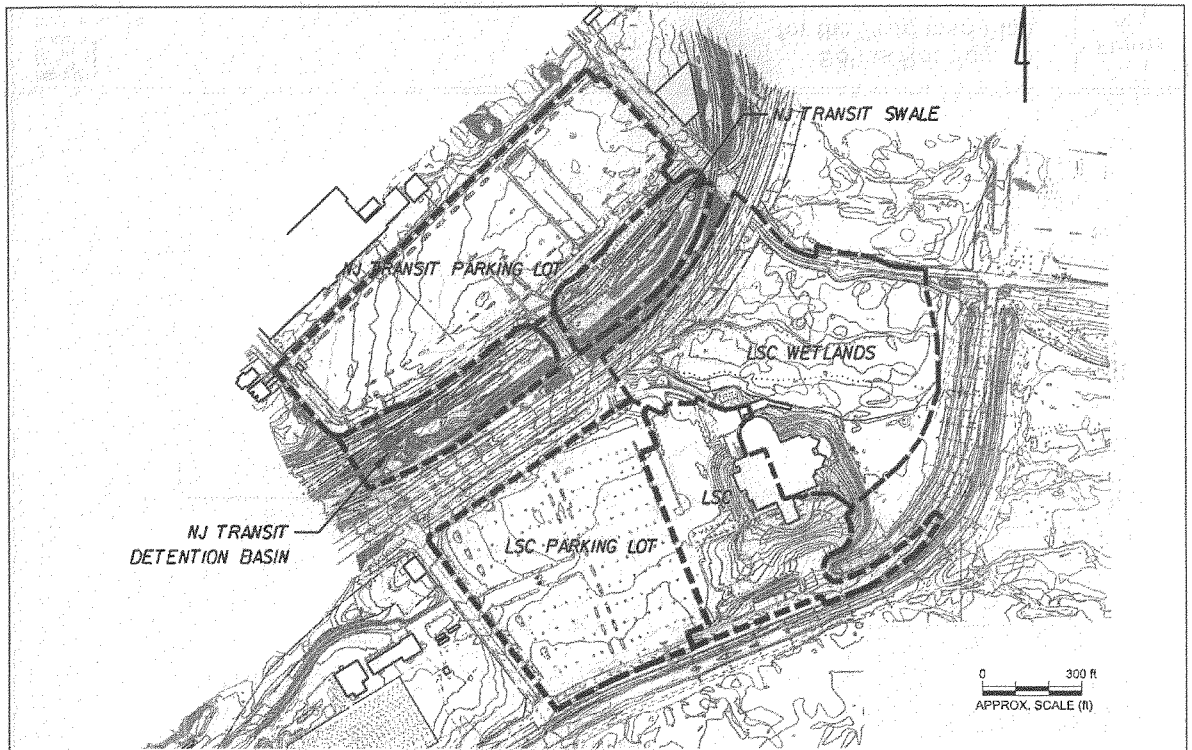
* Calculated from the annual average precipitation for the 1993-2002 period.
** Assumes the substitution of pumping for plan 2 and 3 elements.

US Army Corps of Engineers®
New York

THE PORT AUTHORITY OF NY & NJ

Conceptual Restoration Plans Under Consideration

Figure 7-1



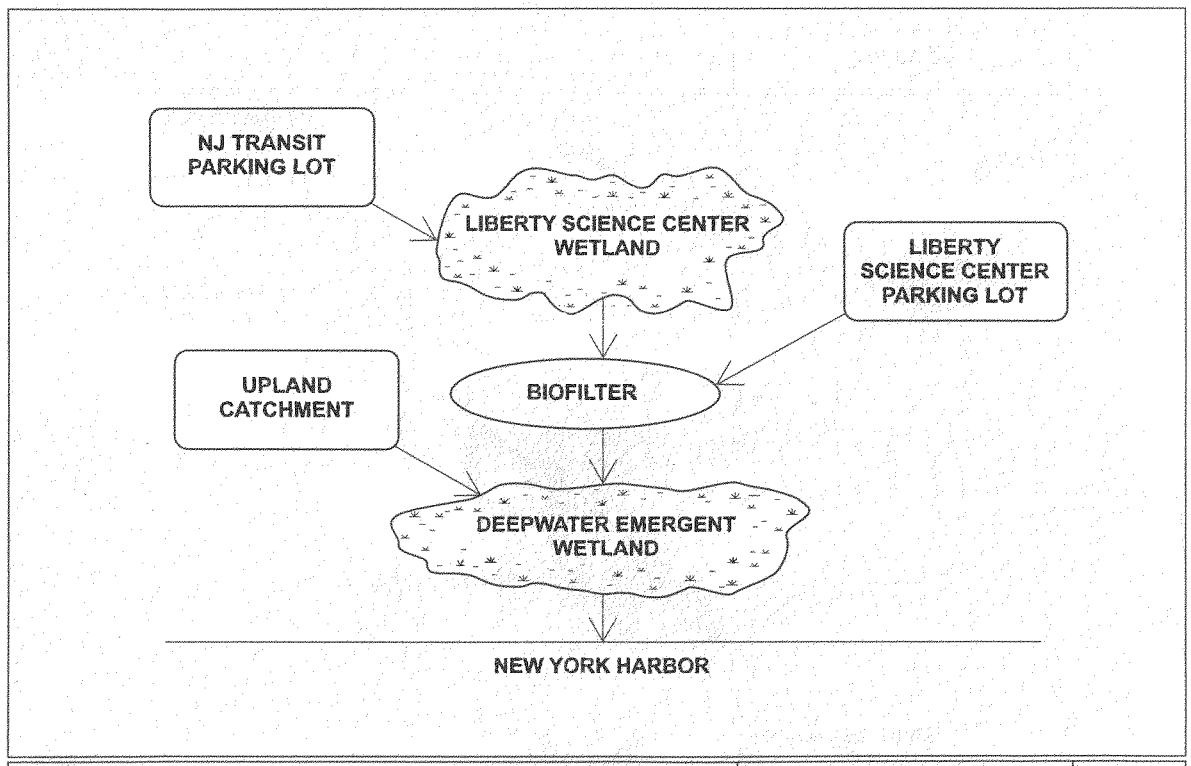
US Army Corps of Engineers®
New York District

Map Source: LMS (2003)
Aerial Photo Source: USACE (2002)

THE PORT AUTHORITY OF NY & NJ

Drainage Subcatchments Area

Figure 8-1



US Army Corps of Engineers®
New York

THE PORT AUTHORITY OF NY & NJ

Solids Routing for the Proposed Plan

Figure 9-1

LIST OF TABLES

Table 3-1 Description of existing drainage areas

Table 6-1 Freshwater wetland conceptual alternatives

Table 7-1 Hydrologic budget results

Table 8-1 Overall performance results of freshwater alternatives

Table 8-2 10-year NJDOT design event performance

Table 9-1 Estimated solids loading rates

Table 9-2 Estimated solids deposition rates

Table 10-1 Estimated first construction costs for freshwater wetland alternatives

TABLE 10-1

ESTIMATED FIRST CONSTRUCTION COSTS FRESHWATER WETLAND ALTERNATIVES, LIBERTY STATE PARK, NEW JERSEY

ALTERNATIVE	*DEEP WATER MARSH*	*BIOFILTER*	*LIBERTY SCIENCE CENTER WETLAND*	*INFILRATION BASIN*	*TOTAL DOLLARS*
A	**v**	**v**	**Absent**	**Absent**	**$477,863.**
B	**v**	**v**	**Existing**	**Absent**	**$551,756.**
C	**v**	**v**	**Enhanced**	**Absent**	**$764,994.**
D	**v**	**v**	**Enhanced**	**Present**	**$1,155,522.**
AVERAGE					**$737,533.**

Notes:

Cost estimates based on professional experience combined with standard cost estimates from published estimating tools such as RS Means©.

Table 3-1 - Description of Existing Drainage Areas					
Location	**Description**	**Size (ac)**	**Impervious Area (%)**	**Slope (%)**	**Width (ft)**
Liberty State Park	Existing wetland	20.01	0	1.0	-
	East Ditch	12.62	0	0.1	300
Science Center	Parking lot	10.40	89	0.5	700
	Science Center	6.47	34	1.0	550
LSC Wetland	Wetland	11.13	9	1.0	310
NJ Transit	Main lot	11.54	97	1.0	600
	Main Detention Basin	0.90	5	1.0	100
	Southern Detention Basin	2.75	40	1.0	185
	Northern Swale/Detention	2.40	55	1.0	170

Table 6-1. Freshwater Wetland Conceptual Alternatives:

Alt	*Main Wetland Complex*	*Plus*	*Connection*
A	Deep emergent marsh + biofilter with input from the Liberty Science Center drainage area		Swales. Overflow routed back to the existing drainage system.
B	Deep emergent marsh + biofilter with input from the Liberty Science Center drainage area	**Existing** LSC wetland with NY Transit drainage with excess flow routed to the biofilter	Swales. Overflow routed back to the existing drainage system.
C	Deep emergent marsh + biofilter with input from the Liberty Science Center drainage area	**Enhanced** LSC wetland with NY Transit drainage with excess flow routed to the biofilter	Swales. Overflow routed back to the existing drainage system.
D	Deep emergent marsh + biofilter with input from the Liberty Science Center drainage area	Enhanced LSC wetland with NY Transit drainage with excess flow routed to the biofilter	Overland flow conduits. Overflow routed to a recharge basin within the park.

TABLE 7-1

SUMMARY OF HYDROLOGIC BUDGET SCENARIO RESULTS

Average Monthly Storage Change (ft3):

Meteorologic Condition	**Plan 1**	**Plan 2**	**Plan 3**
Current Year	19,066	126,948	292,124
Last 10 Years (1993-2002)	7,775	81,735	205,421
Driest Three Years (1976, 1981, 2001)	266	51,789	148,307
Wettest Three Years (1983, 1984, 1996)	22,523	139,209	312,537

Table 8.1. Overall Performance Results of Freshwater Alternatives

Alternative	Maintains Biofilter WSEL	Maintains DEM Depth	Outflow from DEM
Alternative A	Yes	>3.5 feet	Infrequent
Alternative B	Yes	>4.0 feet	Frequent
Alternative C	Yes*	>4.0 feet*	Frequent*
Alternative D	Yes	>4.0 feet*	Frequent

*Similar performance to Alternative 2
WSEL: Water Surface Elevation
DEM: Deep Emergent Marsh

Table 8-2. 10-year NJDOT Design Event Performance

Alternative	Maximum WSEL - West of Phillip Street (ft NAVD)	Maximum WSEL – Biofilter (ft NAVD)
Alternative A	7.0	7.0
Alternative B*	7.0	7.0
Alternative D	6.8	6.7
*similar performance for Alternative C		

TABLE 9-1

PROJECTED SEDIMENT LOADINGS (POUNDS)

TSS Concentration: 31 mg/l (from Schueler Table 1.3; verified by Fig. 1.3)
Sediment removal effic 60.0%

2003:

Sediment transported (lbs)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
NJ Transit Pkg.Lot runoff	181	190	332	172	228	694	171	537	369				2874
LSC Wetland Solids Settled	108	114	199	103	137	416	103	322	222				1725
LSC Wetland Solids Flowing Through	72	76	133	69	91	278	68	215	146				1150
LSC Parking Lot runoff	136	144	251	130	172	524	129	405	279				2169
Biofilter Solids Settled	125	132	230	119	158	481	119	372	256				1992
Biofilter Solids Flowing Through	83	86	153	79	105	320	79	248	171				1328
Upland Catchment runoff	17	18	32	16	22	66	16	51	35				275
Deep Water Emergent Wetland Solids Settled	60	64	111	57	76	232	57	180	124				961
Deep Water Emergent Wetland Solids Flowing Through	40	42	74	38	51	155	38	120	82				641

Last 10 Years:

Sediment transported (lbs)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
NJ Transit Pkg.Lot runoff	247	174	334	244	248	222	259	218	298	206	203	218	2870
LSC Wetland Solids Settled	148	104	200	147	149	133	155	131	179	124	122	131	1722
LSC Wetland Solids Flowing Through	99	69	133	98	99	89	103	87	119	83	81	87	1148
LSC Parking Lot runoff	187	131	252	184	187	167	195	164	225	156	153	164	2186
Biofilter Solids Settled	171	120	231	169	172	154	179	151	205	143	141	151	1988
Biofilter Solids Flowing Through	114	80	154	113	115	102	119	101	136	95	94	101	1326
Upland Catchment runoff	24	17	32	23	24	21	25	21	28	20	19	21	274
Deep Water Emergent Wetland Solids Settled	83	58	112	82	83	74	87	73	100	69	68	73	960
Deep Water Emergent Wetland Solids Flowing Through	55	39	74	54	55	49	58	49	66	46	45	49	640

Average of Driest Three Years:

Sediment transported (lbs)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
NJ Transit Pkg.Lot runoff	156	205	237	168	240	179	236	122	225	198	68	207	2235
LSC Wetland Solids Settled	93	123	142	101	144	107	142	73	135	119	41	124	1344
LSC Wetland Solids Flowing Through	62	82	95	67	96	72	94	49	90	79	27	83	896
LSC Parking Lot runoff	117	155	178	127	181	135	178	92	170	150	51	156	1690
Biofilter Solids Settled	108	142	164	117	166	124	163	84	156	137	47	143	1552
Biofilter Solids Flowing Through	72	95	109	78	111	83	109	56	104	92	31	96	1034
Upland Catchment runoff	15	20	23	16	23	17	23	12	21	19	6	20	214
Deep Water Emergent Wetland Solids Settled	52	69	79	56	80	60	79	41	75	66	23	69	749
Deep Water Emergent Wetland Solids Flowing Through	35	46	53	38	53	40	53	27	50	44	15	46	499

Average of Wettest Three Years:

Sediment transported (lbs)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
NJ Transit Pkg.Lot runoff	208	207	543	544	375	278	408	167	252	367	236	438	4022
LSC Wetland Solids Settled	124	124	326	326	225	167	245	100	151	220	142	263	2413
LSC Wetland Solids Flowing Through	83	83	217	218	150	111	163	67	101	147	94	175	1608
LSC Parking Lot runoff	156	156	410	411	283	210	308	126	190	277	178	331	3035
Biofilter Solids Settled	143	143	376	377	260	193	282	116	175	254	164	304	2786
Biofilter Solids Flowing Through	95	96	251	251	173	129	188	77	116	169	109	202	1858
Upland Catchment runoff	20	20	52	52	36	27	39	18	24	35	23	42	384
Deep Water Emergent Wetland Solids Settled	69	69	182	182	125	93	136	56	84	123	79	147	1345
Deep Water Emergent Wetland Solids Flowing Through	46	46	121	121	84	62	91	37	56	82	53	98	897

TABLE 9-2

PROJECTED SEDIMENT DEPOSITION RATES (INCHES/MONTH)

Porosity:	0.825
Density [kg/m3]:	1,375
Surface areas (acres)	
Deep Water Wetland:	1.54
Biofilter:	0.79
LSC Wetland:	2.3

2003:

Sediment Depth (inches)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
LSC Wetland Solids Settled	0.0009	0.0009	0.0016	0.0008	0.0011	0.0033	0.0008	0.0026	0.0018				0.0138
Biofilter Solids Settled	0.0029	0.0031	0.0053	0.0028	0.0037	0.0112	0.0028	0.0086	0.0059				0.0463
Deep Water Emergent Wetland Solids Settled	0.0007	0.0008	0.0013	0.0007	0.0009	0.0028	0.0007	0.0021	0.0015				0.0115

Last 10 Years:

Sediment Depth (inches)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
LSC Wetland Solids Settled	0.0012	0.0008	0.0016	0.0012	0.0012	0.0011	0.0012	0.0010	0.0014	0.0010	0.0010	0.0010	0.0137
Biofilter Solids Settled	0.0040	0.0028	0.0054	0.0039	0.0040	0.0036	0.0042	0.0035	0.0048	0.0033	0.0033	0.0035	0.0462
Deep Water Emergent Wetland Solids Settled	0.0010	0.0007	0.0013	0.0010	0.0010	0.0009	0.0010	0.0009	0.0012	0.0008	0.0008	0.0009	0.0114

Average of Driest Three Years:

Sediment Depth (inches)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
LSC Wetland Solids Settled	0.0007	0.0010	0.0011	0.0008	0.0011	0.0009	0.0011	0.0006	0.0011	0.0009	0.0003	0.0010	0.0107
Biofilter Solids Settled	0.0025	0.0033	0.0038	0.0027	0.0039	0.0029	0.0038	0.0020	0.0036	0.0032	0.0011	0.0033	0.0360
Deep Water Emergent Wetland Solids Settled	0.0006	0.0008	0.0009	0.0007	0.0010	0.0007	0.0009	0.0005	0.0009	0.0008	0.0003	0.0008	0.0089

Average of Wettest Three Years:

Sediment Depth (inches)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
LSC Wetland Solids Settled	0.0010	0.0010	0.0026	0.0026	0.0018	0.0013	0.0020	0.0008	0.0012	0.0018	0.0011	0.0021	0.0193
Biofilter Solids Settled	0.0033	0.0033	0.0087	0.0088	0.0060	0.0045	0.0066	0.0027	0.0041	0.0059	0.0038	0.0071	0.0647
Deep Water Emergent Wetland Solids Settled	0.0008	0.0008	0.0022	0.0022	0.0015	0.0011	0.0016	0.0007	0.0010	0.0015	0.0009	0.0017	0.0160

LIST OF APPENDICES

Appendix A. Hydrologic Budget Results

Appendix B. Plans of Freshwater Wetland Components and Modeled Alternatives

Appendix C. Wetland Zones

Appendix D. Cost Sheets

Appendix E. Alternative 4 SWMM Hydraulic Output - 1976

Appendix F. Alternative 4 SWMM Hydraulic Output - 1983

Appendix C

Table C-1 Wetland Elevations

(note: all elevations are in feet NAVD, see legend at the bottom of the table)

Enhanced Liberty Science Center Wetland

Wetland #1 Areas	Basin #, Log Weir #	Surface Water Elevation	Invert Elevation	Elevation at Top of Weir	Estimated Groundwater Elevation
Forebay	B#1, IP#1***	5.6	6.5	7.5	3.25
	B#1, SW#1	6.5	6.5	7.5	3.25
LSC Wetland	B#2; OP#2	6.5	6.5	7.5	3.25
LSC Wetland	B#2; LW#1	6.5	6.5	7.5	3.25

Biofilter Wetland

Wetland #2 Areas	Basin #, Log Weir #	Surface Water Elevation	Invert Elevation	Elevation at Top of Weir	Estimated Groundwater Elevation
Forebay 1	B#3, IP #2****	4.4	5.5	6.5	3.0
Forebay 1	B#3, SW #2	5.5	5.5	6.5	3.0
Forebay 2	B#3, IP #3	5.57	5.5	6.5	3.0
Forebay 2	B#3, SW #3	5.5	5.5	6.5	3.0
BF Wetland	B#4; OP #4	5.5	5.5	6.5	3.0
BF Wetland	B#4; LW #2	5.5	5.5	6.5.	3.0

Deep Emergent Marsh Wetland

Wetland #3 Areas	Basin #, Log Weir #	Surface Water Elevation (mean)	Invert Elevation	Elevation at Top of Weir	Estimated Groundwater Elevation
Forebay	B#5, IP#5	5.0	5.0	6.0	3.5
Forebay	B#5, SW#5	5.0	5.0	6.0	3.5
DEM Wetland	B#6; LW#3	5.0	5.0	6.0	3.5
DEM Wetland	B#6; LW#4	5.0	5.0	6.0	3.5

Infiltration Basin

Infiltration Areas	Spill Way #	Ground Elevation	Invert Elevation	Elevation at Top of Weir	Estimated Groundwater Elevation
Infiltration Basin	B#5, IP#5	4.5	NA	6.5	3.5
	B#5, SW#5	4.5	NA	6.5	3.5

* mean surface elevation
** approximate groundwater elevation from geotech borings
*** the existing inlet from the NJ Transit lot is about 5.6. The USACE assumes this will remain unchanged.
**** the pipe from the LSC wetland will come under the road and enter the biofilter about 12 inches below the water elevation surface of the biofilter. Pipe invert is about 4.5 NAVD. Pipe may be two 9" dia. pipes.

Zone Designation:

LEGEND:

OP = Outlet Pipe
IP = Inlet Pipe
B = Basin
LW = Log Weir
SW = Stone Weir
ES = Emergency Spillway

Appendix C

Table C-2. Wetland Zones

Wetland Zones (Created Habitats)

ZONES	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6
Plant Community	Deepwater Habitat	Shallow Marsh Habitat	Shoreline Fringe	Safety Bench Riparian Fringe	Scrub-shrub transitional	Upland
Depth of standing water	1.5 to 6 feet	0.0 to 1.5 feet	-0.5 to .5 feet	-1.0 to 1.5 feet	1.5.0 to 3.0 feet	>3.0

(1) Zone 1. Deep Water Pool: (Deepwater Habitat)

a. 1.0 to 6 feet deep

b. Submerged Aquatic Plants

i. Wild celery

ii. Sago pondweed

iii. Redhead grass

c. Permanently Flooded - These are permanently flooded, although they may be exposed during extreme droughts. The deep emergent marsh is the only wetland were the depth exceeds 6 feet and is expected to be wet in all years. Open water bodies where the depth is less than 6.0 feet (e.g., areas in the deep emergent marsh wetland and shallow portions of the Liberty Science Wetland and the biofilter) are included in this category.

(2) **Zone 2: Shallow Water Bench (Shallow Marsh Habitat)**

a. 0.5- 1.0 feet (6 inches to 12 inches) deep

b. Emergent Aquatic Plans

a. Common three square

b. Soft stem bulrush

c. Lizard's tail.

c. Semi-permanently Flooded - Remains flooded throughout the growing season in most years. The surface of these wetlands become exposed to the air only during dry spells. Even then, the water table lies at or near the surface.

(3) **Zone 3. Shoreline Fringe (Wet Meadow Habitat)**

a. 0.0 to 0.5 feet (0 to 6 inches) deep

b. Emergent Aquatic Plants

a. Sedges

b. Switchgrass

c. Buttonbush

c. Seasonally Flooded - Typically has standing water visible for more than one month, but usually by late summer, such water is absent. At this time, however, the water table remains within 1.5 feet of the surface.

(4) **Zone 4. Riparian Fringe (Shrub Scrub Habitat)**

a. 0.0 to 1.5 feet above mean water elevation.

b. Shrubs and trees

a. Red osier dogwood

b. Red maple

c. Swamp oak

c. Temporarily Flooded - Flooding or ponding is brief (usually 2 weeks or less)

(5) Zone 5. Floodplain terrace

a. Moist Soils -

b. Shrub-scrub transitional Zone

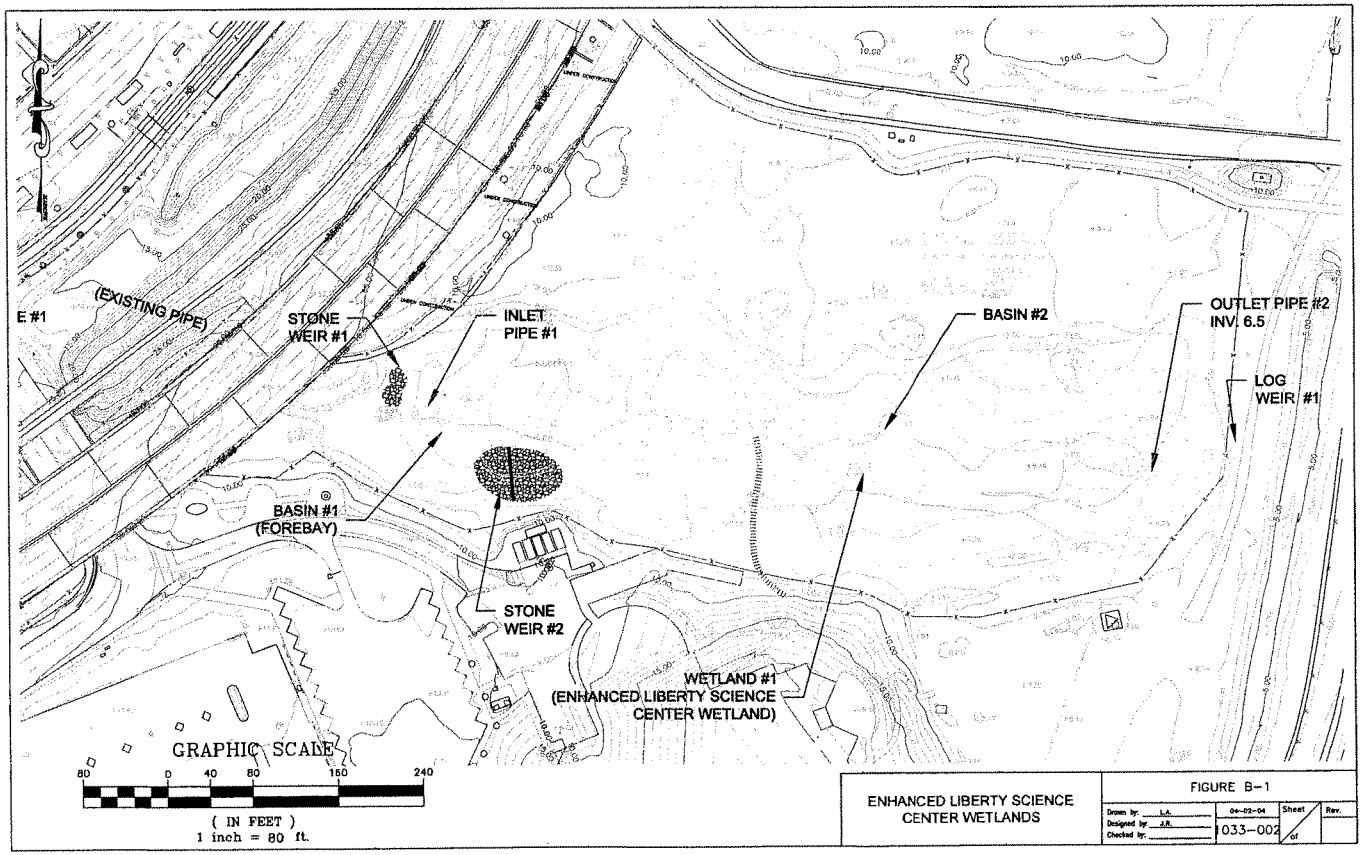
i. Silky dogwood

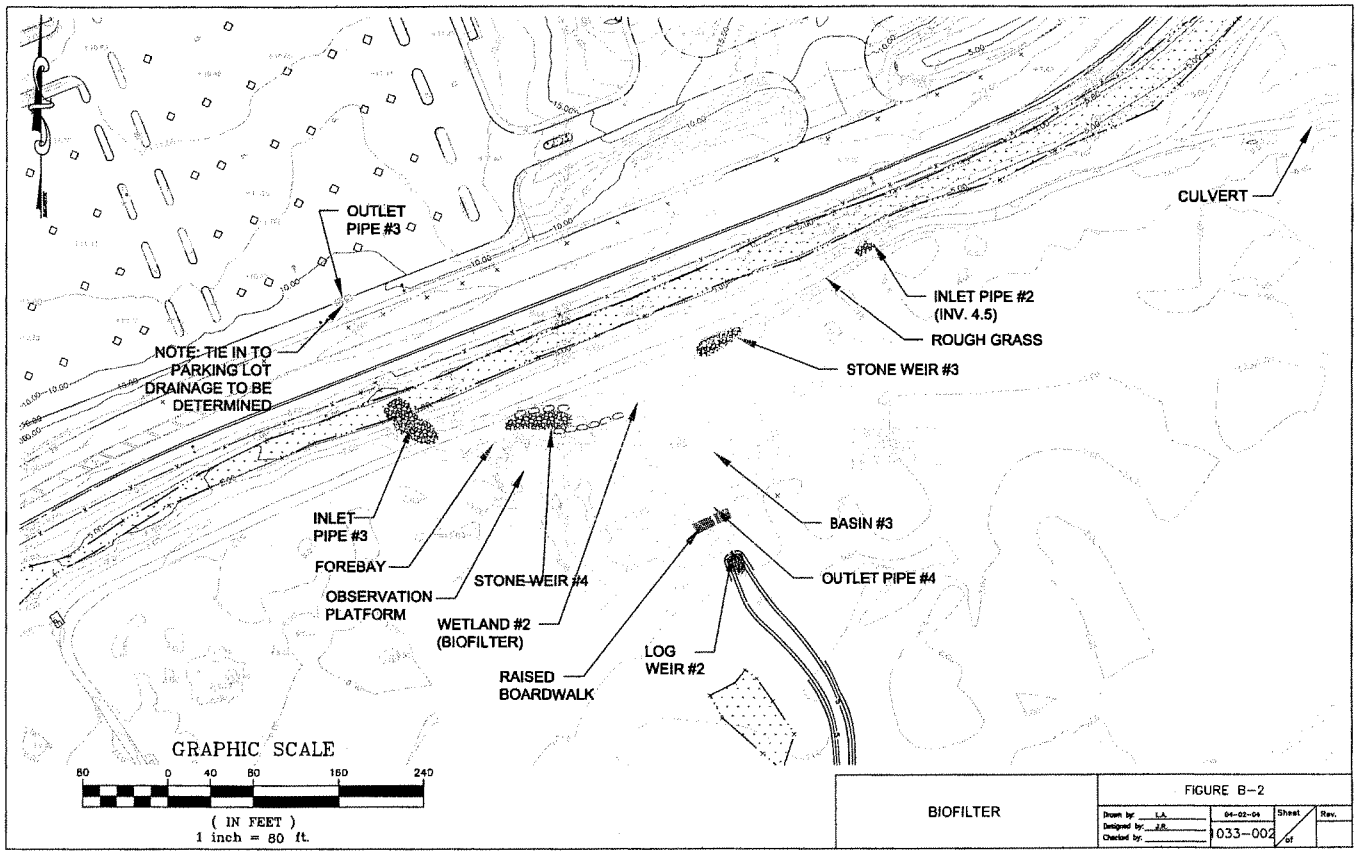
ii. Elderberry
iii. Red fescue grass
iv. Tulip tree
v. Willow oak

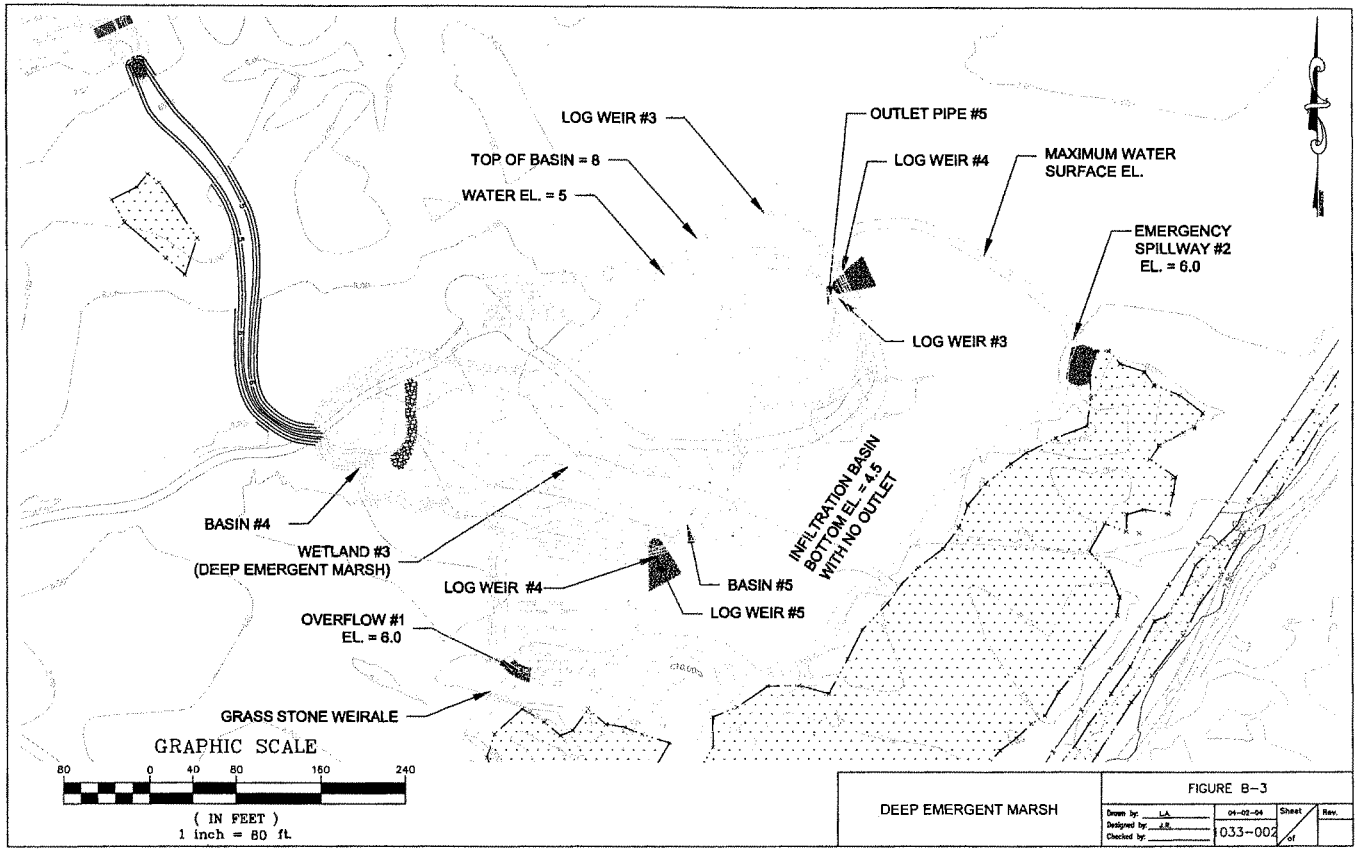
c. Infrequently inundated.

(6) Zone 6. Upland Slopes

a. Moist to dry soils
b. Shrubs, grasses and trees,
   i. Redtop
   ii. Tall fescue
   iii. Shadbush
   iv. Persimmons
   v. Chokecherry
   vi. American beech
c. Seldom or never inundated- Upland transitional zone, buffer to the wetland.


E #1
(EXISTING PIPE)
STONE WEIR #1
INLET PIPE #1
BASIN #2
OUTLET PIPE #2
INV. 6.5
LOG WEIR #1
BASIN #1 (FOREBAY)
STONE WEIR #2
WETLAND #1 (ENHANCED LIBERTY SCIENCE CENTER WETLAND)
GRAPHIC SCALE
80 0 40 80 160 240
(IN FEET)
1 inch = 80 ft.
ENHANCED LIBERTY SCIENCE CENTER WETLANDS
FIGURE B-1
Drawn by: L.A.
Designed by: J.R.
Checked by:
04-02-04
1033-002
Sheet
of
Rev.


OUTLET PIPE #3
NOTE: TIE IN TO PARKING LOT DRAINAGE TO BE DETERMINED
CULVERT
INLET PIPE #2 (INV. 4.5)
ROUGH GRASS
STONE WEIR #3
INLET PIPE #3
FOREBAY
OBSERVATION PLATFORM
STONE WEIR #4
WETLAND #2 (BIOFILTER)
RAISED BOARDWALK
LOG WEIR #2
BASIN #3
OUTLET PIPE #4
GRAPHIC SCALE
80 0 40 80 160 240
(IN FEET)
1 inch = 80 ft.
BIOFILTER
FIGURE B-2
Drawn by: L.A.
Designed by: J.R.
Checked by:
04-02-04
033-002
Sheet of
Rev.


LOG WEIR #3
OUTLET PIPE #5
TOP OF BASIN = 8
LOG WEIR #4
MAXIMUM WATER SURFACE EL.
WATER EL. = 5
EMERGENCY SPILLWAY #2 EL. = 6.0
LOG WEIR #3
INFILTRATION BASIN BOTTOM EL. = 4.5 WITH NO OUTLET
BASIN #4
WETLAND #3 (DEEP EMERGENT MARSH)
LOG WEIR #4
BASIN #5
LOG WEIR #5
OVERFLOW #1 EL. = 6.0
GRASS STONE WEIRALE
GRAPHIC SCALE
80 0 40 80 160 240
(IN FEET)
1 inch = 80 ft.
DEEP EMERGENT MARSH
FIGURE B-3
Drawn by: L.A.
Designed by: J.R.
Checked by:
04-02-04
1033-002
Sheet
of
Rev.

Hudson-Raritan Estuary, Liberty State Park

Ecosystem Restoration

Appendix F

Cost Estimate

DESCRIPTION OF COSTS

Implementation costs for each restoration scenario were calculated based on estimates of location, mobilization/demoblization, site access, site preparation and excavation, disposal, planting, erosion and sediment control and monitoring costs. These project construction costs were estimated as part of the planning phase for the purpose of determining project feasibility, and to provide a means of comparing proposed restoration options. The chosen alternative will be designed further, and the quantities and costs will be refined in the cost appendix. However, for the alternative analysis, all alternatives have the same quantity and cost assumptions. A contingency cost of 20% was included to account for uncertainties in the final design and/or implementation of the selected NER Plan. Preliminary Engineering and Design (PED) and Management during construction were assumed as 8% and 7% respectively, of the total construction costs. An escalation factor of 3% was included to project the present day construction costs to the estimated midpoint of construction. All labor, material, equipment, overhead, bond and profit costs were considered in the costs. The costs were based on the cost estimate on experience at other projects and published estimating tools such as RS Means©.

The following describes the assumptions considered in the calculation of costs.

Costs Associated with All Proposed Restoration Areas and Activities:

Real Estate and Location

- The local sponsor owned the site prior to the start of the project, so no real estate costs were considered. However, all costs include an area cost factor of 3.6% to account for the higher cost of living in the project area (RS Means©).

Mobilization/Demobilization

- Mobilization and demobilization costs were the lump sum costs associated with the initiation and cessation of activities at the site, including obtaining and transporting equipment, and the removal of temporary site features and equipment upon completion of the Project.

Staging/Storage/Refueling Area

- A 4 in layer of gravel in an estimated 2500 sf area within Liberty State Park would be placed over a flat area before heavy machinery arrived at the site.
- Temporary chain link fencing would be erected around the site.

Temporary Erosion and Sediment Control

- During the earth movement phase of the project, the erosion of sediment will be minimized by controlling the runoff and turbidity that leaves the site. Erosion and sediment control is assumed to be required along the perimeters of the work zones. They will include staked straw bales, reinforced silt fencing, sediment traps with filters and maintenance of control measures

Site Access

- New access roads and maintenance costs were projected for the project area. The use of timber mats were included to allow heavy construction equipment to traverse the unconsolidated marsh surface.

Clearing and Grubbing

- Site preparation included the costs associated with the removal of *Phragmities Australis* and other existing vegetation in the proposed regrading locations. The assumption was made that this task, to be done for the entire proposed site, will entail herbicide treatments, clearing of existing vegetation by mowing above grade, stockpiling, shreading, loading and hauling to a designated area in the park. Herbicide and mechanical removal techniques will be used. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material.
- The additional cost of excavation of thatch material, including the rhizomes when indicated and other root material, is included in the locations that do not have cut/fill activities. Herbicide and mechanical removal techniques will be used. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material.

Monitoring Project Site

- Monitoring costs were assumed to be 1% of construction costs.

Tidal Wetland Costs

Earthwork

- Earthwork costs assumed that in the proposed low and high marsh areas, 60% of the material being excavated would be dry, and 40% would be wet, which is based on when groundwater was encountered in the geotechnical borings taken in the Fall 2003. The material would be hauled 0.5 miles round trip or less. The excavation locations will be finely graded/shaped and surveyed. The deposition area will be roughly graded. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material. The volume of material to be excavated was calculated from the 2003 site survey. For the low and high marsh, the proposed excavation depths were based on excavating the site to the range in which *Spartina alternaflora* and *Spartina patens* will most likely thrive. These elevations are based on bio-benchmarking and tidal datum data, plus an additional foot to allow room for a cap of clean clay fill 1 ft deep to be placed in all excavated areas, and another foot to allow room for a cap of clean sand fill 1 ft deep. A survey crew will be on site to confirm cut and fill placement elevations.

Clean Clay and Sand Fill Placement

- 1 ft of clean clay fill will be placed in the channel, mudflat, low and high marsh areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications. The placed clay will be compacted to create an impervious subsurface.
- 1 ft of clean sand fill will be placed in the channel, mudflat, low and high marsh areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.
- 3 ft of clean sand fill will be placed in the upland scrub/shrub areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.

Dewatering

- Dewatering will be necessary due to the high water table. It is assumed that 4 dewatering systems will operate for 12 months in the proposed tidal wetland area.

Temporary Cofferdam at Tidal Inlet

- Temporary sheeting will be installed at the mouth of the main inlet to prevent tidal inundation into the site while the earthwork is being completed.

Rip-Rap and Filter Fabric

- Rip-Rap and geotextile filter fabric will be placed at the tidal creek opening to stabilize the side slopes of the inlet to the North Cove. The costs include labor, equipment and materials for loading, hauling and placement.

Planting

- The costs for plants within the low and high marsh zones were based on plugs to be planted 18 in o.c. The cost include the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control, weeding, watering and a restoration specialist. The high marsh will also have planted 100 shrubs/acre.
- The costs for plants within the maritime scrub/shrub zone were based on shrubs to be planted 8 ft o.c. The cost include the purchase of the shrubs, fertilizer, seeding, vector, pest control, weeding, watering and a restoration specialist.

Bird Control – Plant Protection

- The costs for protecting the young plugs from Waterfowl were based on methods used by the New York City Department of Parks and Recreation Department. Temporary goose exclusion fences will be placed at 25ft spacing intervals.

Upland Management Area and Disposal Area Costs

Top Soil/Sand Treatment

- It is assumed that either 2 ft of top soil, or 3 ft of clean sand fill will be placed in the upland management areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.

Planting

- The costs for plants within the maritime forest zone were based the following planting scheme;
    - Canopy trees 1.5-2 inches diameter, spaced 10 ft o.c., for 10% of the upland management area
    - Canopy trees, 1-4 ft diameter, spaced 10 ft o.c., for 30% of the upland management area
    - Canopy trees, 5-6 ft diameter, spaced 10 ft o.c., for 30% of the upland management area
    - Understory trees, spaced 10 ft o.c., for 20% of the upland management area
    - Ferns/Forbs, spaced 3 ft o.c., for 5% of the upland management area
    - Shrubs, spaced 8 ft o.c., for 5% of the upland management area
    - The cost for all of the upland management plants listed above include the purchase of the stock, fertilizer, seeding, vector, pest control, weeding, watering and a restoration specialist.

Disposal Area Costs

Top Soil

- It is assumed that 1 ft of top soil will be placed in the upland management areas. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications.

Planting

- Grass seed and fertilizer will be placed on the disposal berm. It will be watered, and a jute mesh will be placed on it to minimize erosion.

Fresh Water Wetland Area

Earthwork

- Earthwork costs assumed that in the proposed fresh water areas, 80 % of the material being excavated would be dry, and 20% would be wet, which is based on when groundwater was encountered in the geotechnical borings taken in the Fall 2003. This ratio will vary with the season and depend on when the actual construction is carried out. The material would be hauled 0.5 miles round trip or less. The excavation locations will be finely graded/shaped and surveyed. The deposition area will be roughly graded. Productivity is assumed to be at 82% to account for delays incurred while handling contaminated material.. The volume of material to be excavated was calculated from the 2003 site survey. The proposed regrading elevations are based on the existing drainage patterns within the site and the necessary hydrology to maintain the proposed ecosystems, plus an additional foot to allow room for a cap of clean clay fill 1 ft deep to be placed in all excavated areas, (and another foot to allow room for a cap of clean sand fill 1 ft deep on the average depending on specific soil conditions) A survey crew will be on site to confirm cut and fill placement elevations..
- Specialized equipment is needed to grade the wetland areas to 0.1 ft accuracy

Clean Clay and Sand Fill Placement

- 1 ft of clean clay fill will be placed in the drainage swales and area below Mean High Water.. The project expenses for this task include purchase/load/haul/spread/compact/shape the clean fill as per the plans and specifications. The placed clay will be compacted to create an impervious subsurface. Above this will be 6 inches of sandy loam or topsoil.

Dewatering

- Dewatering will be necessary due to the high water table. It is assumed that 4 dewatering systems will operate for 3 months.
- Planting
- The costs for plants within the biofilter are based on plugs to be planted 18 o.c . (The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control)
- The costs for plants within the deep emergent marsh are based on plugs to be planted 18 o.c (The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control)

- The costs for plants within the swales are based on seeding and net anchoring. (The cost includes seedbed prep, mulch, anchoring, fertilizer, one post germination watering)
- The costs for plants within the liberty science center wetland are based on plugs to be planted 18 o.c (The cost includes the purchase of the plug or peat pod stock, fertilizer, seeding, vector, pest control)

Bird Control – Plant Protection

- The costs for protecting the young plugs from Waterfowl were based on methods used by the New York City Department of Parks and Recreation Department. Temporary goose exclusion fences will be placed at 25ft spacing intervals.

Culverts

- The costs for the culverts assume they are 30 in diameter culverts, and it includes purchase, mob/demob, and installation.

Access Road:

Costs assume unbound base course of 1-1/2" stone base compacted 8" deep. ($9.00 per square yard [RS Means]. Assuming 9 foot wide access road or $9.00 per linear foot.

Biofilter:

Costs include:

- Excavation volume assume 3,541 CY based on over excavation by 1 foot (under excavation costs)
- Clearing and grubbing area .95 acres or 20% larger area then the area within mean high water level.(under clearing and grubbing)
- Existing topsoil to be stockpiled and used to dress Riparian zone.
- Assume an additional 6 inch topsoil layer

Infiltration Costs:

- For LSP a full infiltration basin design can be used since infiltration tests indicate extremely permeable soils.
- The only outlet is and emergency spillway which passes larger storm (greater then 2 year design storm) events .
- A rip-rap apron is needed near the inlet to reduce incoming runoff velocities to promote more uniform infiltration. There is no need for other features for routing stormflow or baseflow through the structure.

Components include:

- Flat basin floor roto-tilled to ensure high permeability
- Based on infiltration test minimum sand is required (assume 4" of sand added)
- Dense grass turf to be seeded throughout the basin bottom.
- Inlet structure from adjacent deep emergent marsh

- Rip –rap area around the inlet
- Erosion control mat along embankment
- Emergency spillway
- Excavation volume assume 4,995 CY. Overexcavation is not needed (under excavation costs)
- Clearing and grubbing area 2.64 acres. Assume 20% greater than

Infiltration Costs:

Infiltration costs are usually estimated based on the dry pond cost equation (Schueller, 1987); particularly for basing with greater the 10,000 cubic feet in volume. The following equation has been used:

C = 10.7 Vs**0.69

C=Cost in dollars
Vs = storage volume up to the crest of the of the emergency spillway in the basin (including any dead storage reserved for exfiltration purposes)

C = 10.7 (4,995)**0.69

Cost to construct is about $ 5,000.

Log Weirs:

25 Low weir is made up of three layers of logs; length vaires; 30 feet long

- Bottom layer; 3 logs 12 feet' long - 12-14" dia.
- 2nd layer 4 logs 6 ft long -10-14" dia.
- 3rd layer 2 logs 6 feet long - 8-12" dia.
- 4th layer 2 logs - 4 long; 4-6" dia.

Totals:	Number		Total Length				
12" dia.	3	12	36				
	4	6	24				
	2	6	12		Total		
6" diam	2	4	8	Unit c	Cost	Log Weir	
			80		Installed	Cost	$600

•

Assumes installation by (R-3) Crew; One forman ($50 per hour - $400 daily)
One laborer ($ 49. per hour; 394 daily)
.5 equip operator ($45.50 per hour; 181.60 per day)
One backhoe ($ 150/ day)
Labor hours 6 hours per weir Average assuming total $ 600.

Stone Weirs

Boulders set in place
6" gravel base

Assumes installation by (R-3) Crew; One formman ($50 per hour - $400 daily)
One laborer ($ 49. per hour; 394 daily)
.5 equip operator ($45.50 per hour; 181.60 per day)
One backhoe ($ 150/ day)
Labor hours 3. hours per stone weir Average assuming (3 weirs constructed/day
Material 150; labor 150; total $ 300.

Liberty State Park Ecosystem
Feasibility Phase
(Oct 2004 P.L.)

Project: Liberty State Park Ecosystem
Location: Hudson County

Account Number	Feature Description	Quantity	Unit	Unit Price	Total Cost ($)	Cont. ($)	Cont (%)	Total ($)
06	Fish & Wildlife Facility							
06.03.03	Sand Placement in North Cove							
16.03.03.20	Mob/Demob		ls		28,442	5,548	20%	33,990
06.03.03.37	Sand Placement	14455	cy	38.60	557,967	108,830	20%	666,797
06.03.04	Tidal Wetland & Disposal Area							
06.03.04.1	Disposal Area Berm							
06.03.04.1.01	Clearing and Crubbing	38.95	acr	4815.25	187,554	36,582	20%	224,136
06.03.04.1.02	Site Access	38.95	acr	8686.98	338,358	65,996	20%	404,354
06.03.04.1.05	Sddeding -Upland Fill	38.95	acr	3576.52	139,305	27,171	20%	166,476
06.03.04.1.08	Top Soil / Sand Treament	38.95	acr	53023.52	2,065,266	402,826	20%	2,468,092
06.03.04.1.10	Erosion and Sediment Control	38.95	acr	6672.30	259,886	50,690	20%	310,576
06.03.04.1.12	Monitoring		ls		30,413	5,932	20%	36,345
06.03.04.01	Tidal Wetland							
06.03.04.01.1	Bridge Construction	3600	sf	195.85	705,055	137,519	20%	842,574
06.03.04.01.2	Relocate Statue		ls		34,302	6,691	20%	40,993
06.03.04.01.3	Erosion and Sediment Control	36.14	acr	6672.29	241,137	47,033	20%	288,170
06.03.04.01.4	Clearing & Grubbing	36.14	acr	4815.24	174,023	33,943	20%	207,966
06.03.04.01.01	Staging Area	2500	sf	6.80	16,991	3,314	20%	20,305
06.03.04.010.3	Site Access	36.14	acr	8702.78	314,519	61,346	20%	375,865
06.03.04.01.04	Cofferdam at Inlets	6500	sf	43.85	285,054	55,599	20%	340,653
06.03.04.01.06	Dewatering	365	day	1961.89	716,090	139,672	20%	855,762
06.03.04.01.07	Earthwork-Dry	456427	bcy	11.57	5,281,002	1,030,048	20%	6,311,050
06.03.04.01.08	Earthwork-wet	304285	bcy	14.11	4,292,956	837,332	20%	5,130,288
06.03.04.01.09	Cleam Sand-Wetland	58306	cy	17.24	1,005,282	196,078	20%	1,201,360
06.03.04.01.11	Cleaning fill - Cohesive Material	58306	cy	17.24	1,005,282	196,078	20%	1,201,360
06.03.04.01.12	Rip-Rap at Inlet	452	cy	87.44	39,525	7,709	20%	47,234
06.03.04.01.13	Filer Fabric	678	sy	13.38	9,074	1,770	20%	10,844
06.03.04.01.16	Subgrade Preparation to Lower Porosity	36.14	acr	3834.65	138,584	27,031	20%	165,615
06.03.04.01.17	Fine Grading of Wetland	36.14	acr	11794.93	426,269	83,143	20%	509,412
06.03.04.01.21	Bird Control - Plant Protection	36.14	acr	6975.91	252,109	49,173	20%	301,282
06.03.04.01.23	Monitoring-Project Site		ls		145,452	28,370	20%	173,822
06.03.04.01.28	Low Marsh Plants	15.21	acr	39889.80	606,724	118,340	20%	725,064
06.03.04.01.33	High Marsh Plants	16.43	acr	42751.49	702,407	137,003	20%	839,410
06.03.04.03	Mob/Demob		ls		142,412	27,777	20%	170,189
06.03.05	Upland Management Area							
06.03.05.01	Clearing & Grubbing	131.8	acr	4815.15	634,637	123,785	20%	758,422
06.03.05.02	Site Access	131.8	acr	8464.44	1,115,613	217,598	20%	1,333,211
06.03.05.07	Monitoring		ls		17,502	3,414	20%	20,916
06.03.05.10	Mob/Demob				44,920	8,762	20%	53,682
06.03.15	Fresh Water Wetland							
06.03.15.1	Mob/Demob		ls		143,901	28,068	20%	171,969
06.03.15.01	Clearing & Grubbing	9.28	acr	4815.24	44,685	8,716	20%	53,401
06.03.15.02	New Culvers				102,138	19,922	20%	122,060
06.03.15.03	Inlet Connection Plus flow	5	ea	132.28	661	129	20%	790
06.03.15.04	Flow Dissapator	5	ea	396.62	1,983	387	20%	2,370
06.03.15.05	Timber Mats	0.24	acr	1320.19	317	62	20%	379
06..03.15.06	Erosion and Sediment Control		ls		89,925	17,540	20%	107,465
06..03.15.08	Earthwork-dry	18402	bcy	11.71	215,454	42,024	20%	257,478
06..03.15.09	Dewatering	90	day	1966.07	176,946	34,513	20%	211,459
06..03.15.09	Fine Grading of Wetland	7.73	acr	11794.89	91,175	17,783	20%	108,958
06..03.15.11	Tree	50	ea	333.35	16,668	3,251	20%	19,919
06..03.15.12	Shrubs	1.28	acr	96537.18	123,568	24,102	20%	147,670
06..03.15.13	Grassland /Herbaceous	25.65	msf	608.64	15,612	3,045	20%	18,657
06..03.15.14	Wildflowers	25.65	msf	80.27	2,059	402	20%	2,461
06..03.15.15	Bird Control - Plant Protection	11.75	acr	6975.88	81,967	15,987	20%	97,954
06..03.15.16	Monitoring		ls		13,223	2,579	20%	15,802
06..03.15.17	Cleaning fill - Cohesive Material	5751	cy	17.24	99,156	19,340	20%	118,496
06..03.15.18	Subgrade Preparation to Lower	7.73	acr	2991.01	23,120	4,510	20%	27,630
06..03.15.19	Stone Weir	3	ea	211.57	635	124	20%	759
06..03.15.20	Log Weirs	11	ea	618.87	6,808	1,328	20%	8,136
06..03.15.21	Access Road	2100	lf	30.64	64,338	12,549	20%	76,887
06..03.15.22	Raptor Perches	1	ea	99.46	99	19	19%	118
06..03.15.24	Raised Walks	200	lf		11,901	2,321	20%	14,222
06..03.15.26	Observation Decks	2	ea		33,828	6,598	20%	40,426
06..03.15.27	Earthwork-wet	4,600	bcy	14.95	68,755	13,411	20%	82,166
	Total Acct 06				23,383,033	4,560,813		27,943,846
01	Lands and Damages				25,000	5,000	20%	30,000
30	Engineering & Design				1,670,000	187,000	10%	2,057,000
31	Construction Management				1,830,000	366,000	20%	2,196,000
	Total				27,108,033	5,118,813		32,226,846

*** * *Liberty State Park Ecosystem * * ***

October 2004 P.L.

Project: Liberty State Park Ecosystem
Location: Hudson County, New Jersey

District: New York
POC: Emily Eng

		Current MCACES Estimate				.....Fully Funded Estimate.....				
Account Number	Feature Description	Cost ($K)	Cont. ($K)	Cont (%)	Total ($K)	Feature Midpoint	Midpt (%)	Cost ($K)	Cont ($K)	Total ($K)
06	Fish & Wildlife	23,383	4,561	19.50%	27,944	May-07	6.72%	24,954	5450	30,405
01	Lands and Damages	25	5	20.00%	30	Jul-06	20.26%	30	6	36
30	Engineering & Design	1,870	187	10.00%	2,057	Jul-06	20.26%	2,249	206	2,455
31	Construction Management	1,830	366	20.00%	2,196	Jul-08	31.76%	2,411	439	2,850
	Total	27,108	5,119		32,227			29,645	6101	35,746

Note: Inflation/escalation was developed using EM 1110-2-1304 dtd Sept 2004 & EC 11-2-187 Apr2005

Liberty State Park Ecosystem
Hudson County
New Jersey

Designed By: CENAN-EN-HH/DE
Estimated By: CENAN-EN-C

Prepared By: ES, JC

Preparation Date: 03/25/05
Effective Date of Pricing: 01/01/04

Sales Tax: 0.00%

This report is not copyrighted, but the information
contained herein is For Official Use Only.

M C A C E S for W i n d o w s
Software Copyright (c) 1985-1997
by Building Systems Design, Inc.
Release 1.2

As per TM on 6/23/04, the Tree removal, landscaping/planting, Top Soil/Sand Treament, Erosion and Sediment Control are deleted from the Upland Management Area

3/25/05 - The estimate is revised based on the comments from HQ & NAD (3/05), and commments from New England District(12/04)

According to Olivia Cackler,contruction date is assumeed on 4/06, the midpoint is on 5/07.

SUMMARY REPORTS — SUMMARY PAGE

PROJECT OWNER SUMMARY - Contract.....1
PROJECT OWNER SUMMARY - Element.....2
PROJECT OWNER SUMMARY - Level 5.....4
PROJECT INDIRECT SUMMARY - Contract.....7
PROJECT INDIRECT SUMMARY - Element.....8
PROJECT INDIRECT SUMMARY - Level 5.....10

DETAILED ESTIMATE — DETAIL PAGE

01. Lands and Damages
05. Administration.....1
06. Fish and Wildlife Facilities
03. Wildlife Facilities & Sanctuary
03. Sand Placement In North Cove
20. Mob/Demob.....2
37. Sand Placement in the North Cove.....3
04. Tidal Wetland & Disposal Area
1. Disposal Area Berm.....4
01. Tidal Wetland.....7
03. Mob/Demob.....17
05. Upland Management Area
01. Clearing & Grubbing.....19
02. Site Access.....20
07. Monitoring.....21
10. Mob & Demob.....22
15. Fresh Water Wetland
1. Mob/Demob.....23
01. Clearing & Grubbing.....25
02. New Culverts.....26
03. Inlet Connection plus flow.....27
04. Flow Dissapator.....28
05. Timber Mats.....29
06. Erosion and Sediment Control.....30
08. Earthwork-dry.....31
09. Dewatering.....32
10. Fine Grading of Wetland.....33
11. Tree.....34
12. Shrubs.....35
13. Grassland/Herbaceous.....36
14. Wildflowers.....37
15. Bird Control -Plant Protection.....38
16. Monitoring.....39
17. Clean fill - Cohesive Material.....40
18. Subgrade Preparation to Lower.....41
19. Stone Weir.....42
20. Log Weirs.....43
21. Access Road.....44
22. Raptor Perches.....45
24. Raised Walks.....46
26. Obervation Decks.....47

DETAILED ESTIMATE DETAIL PAGE

27. Earthwork-wet.....48
30. Planning, Engineering and Design.....49
31. Construction Management.....50

BACKUP REPORTS BACKUP PAGE

LABOR BACKUP.....1
EQUIPMENT BACKUP.....2

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Contract **

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01	Lands and Damages			42,000	8,400	50,400	
06	Fish and Wildlife Facilities			22,804,056	4,560,811	27,364,867	
30	Planning, Engineering and Design			1,820,000	182,000	2,002,000	
31	Construction Management			1,790,000	358,000	2,148,000	
TOTAL	Liberty State Park Ecosystem			26,456,056	5,109,211	31,565,267	

	QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01 Lands and Damages						
01_05 Administration			42,000	8,400	50,400	
TOTAL Lands and Damages			42,000	8,400	50,400	
06 Fish and Wildlife Facilities						
06_03 Wildlife Facilities & Sanctuary						
06_03.03 Sand Placement In North Cove						
06_03.03.20 Mob/Demob			27,738	5,548	33,286	
06_03.03.37 Sand Placement in the North Cove	14455	CY	544,151	108,830	652,981	45.17
TOTAL Sand Placement In North Cove	54.90	ACR	571,889	114,378	686,266	12500
06_03.04 Tidal Wetland & Disposal Area						
06_03.04. 1 Disposal Area Berm			2,945,985	589,197	3,535,182	
06_03.04.01 Tidal Wetland			15,985,965	3,197,193	19,183,158	
06_03.04.03 Mob/Demob			138,886	27,777	166,663	
TOTAL Tidal Wetland & Disposal Area			19,070,836	3,814,167	22,885,003	
06_03.05 Upland Management Area						
06_03.05.01 Clearing & Grubbing	131.80	ACR	618,923	123,785	742,708	5635.11
06_03.05.02 Site Access	131.80	ACR	1,087,990	217,598	1,305,588	9905.83
06_03.05.07 Monitoring			17,069	3,414	20,482	
06_03.05.10 Mob & Demob			43,808	8,762	52,570	
TOTAL Upland Management Area	54.90	ACR	1,767,790	353,558	2,121,348	38640
06_03.15 Fresh Water Wetland						
06_03.15. 1 Mob/Demob			140,338	28,068	168,406	
06_03.15.01 Clearing & Grubbing	9.28	ACR	43,579	8,716	52,295	5635.21
06_03.15.02 New Culverts	950.00	LF	99,609	19,922	119,531	125.82
06_03.15.03 Inlet Connection plus flow	5.00	EA	645	129	774	154.75
06_03.15.04 Flow Dissapator	5.00	EA	1,934	387	2,321	464.24
06_03.15.05 Timber Mats	0.24	ARC	309	62	371	1547.16
06_03.15.06 Erosion and Sediment Control			87,698	17,540	105,237	
06_03.15.08 Earthwork-dry	18402	BCY	210,119	42,024	252,143	13.70
06_03.15.09 Dewatering	90.00	DAY	172,565	34,513	207,078	2300.87
06_03.15.10 Fine Grading of Wetland	7.73	ACR	88,917	17,783	106,701	13803

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
06_03.15.11	Tree	50.00	EA	16,255	3,251	19,506	390.11
06_03.15.12	Shrubs	1.28	ACR	120,508	24,102	144,610	112977
06_03.15.13	Grassland/Herbaceous	25.65	MSF	15,225	3,045	18,270	712.29
06_03.15.14	Wildflowers	25.65	MSF	2,008	402	2,409	93.92
06_03.15.15	Bird Control -Plant Protection	11.75	ACR	79,937	15,987	95,925	8163.83
06_03.15.16	Monitoring			12,896	2,579	15,475	
06_03.15.17	Clean fill - Cohesive Material	5751.00	CY	96,701	19,340	116,041	20.18
06_03.15.18	Subgrade Preparation to Lower	7.73	ACR	22,548	4,510	27,058	3500.37
06_03.15.19	Stone Weir	3.00	EA	619	124	743	247.60
06_03.15.20	Log Weirs	11.00	EA	6,639	1,328	7,966	724.22
06_03.15.21	Access Road	2100.00	LF	62,745	12,549	75,295	35.85
06_03.15.22	Raptor Perches	1.00	EA	97	19	116	116.06
06_03.15.24	Raised Walks	200.00	LF	11,606	2,321	13,927	69.64
06_03.15.26	Obervation Decks	2.00	EA	32,990	6,598	39,588	19794
06_03.15.27	Earthwork-wet	4600.00	BCY	67,053	13,411	80,464	17.49
TOTAL	Fresh Water Wetland			1,393,541	278,708	1,672,250	
TOTAL	Wildlife Facilities & Sanctuary			22,804,056	4,560,811	27,364,867	
TOTAL	Fish and Wildlife Facilities			22,804,056	4,560,811	27,364,867	
30	Planning, Engineering and Design			1,820,000	182,000	2,002,000	
31	Construction Management			1,790,000	358,000	2,148,000	
TOTAL	Liberty State Park Ecosystem			26,456,056	5,109,211	31,565,267	

	QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01 Lands and Damages						
01_05 Administration			42,000	8,400	50,400	
TOTAL Lands and Damages			42,000	8,400	50,400	
06 Fish and Wildlife Facilities						
06_03 Wildlife Facilities & Sanctuary						
06_03.03 Sand Placement In North Cove						
06_03.03.20 Mob/Demob			27,738	5,548	33,286	
06_03.03.37 Sand Placement in the North Cove	14455	CY	544,151	108,830	652,981	45.17
TOTAL Sand Placement In North Cove	54.90	ACR	571,889	114,378	686,266	12500
06_03.04 Tidal Wetland & Disposal Area						
06_03.04. 1 Disposal Area Berm						
06_03.04. 1_ 01 Clearing and Grubbing	38.95	ACR	182,910	36,582	219,492	5635.21
06_03.04. 1_ 02 Site Access	38.95	ACR	329,980	65,996	395,977	10166
06_03.04. 1_ 05 Seeding-Upland Fill	38.95	ACR	135,856	27,171	163,027	4185.55
06_03.04. 1_ 08 Top Soil /Sand Treatment	38.95	AC	2,014,129	402,826	2,416,954	62053
06_03.04. 1_ 10 Erosion and Sediment Control	38.95	ACR	253,451	50,690	304,141	7808.49
06_03.04. 1_ 12 Monitoring			29,660	5,932	35,592	
TOTAL Disposal Area Berm			2,945,985	589,197	3,535,182	
06_03.04.01 Tidal Wetland						
06_03.04.01_ 1 Bridge Construction	3600.00	SF	687,597	137,519	825,116	229.20
06_03.04.01_ 2 Relocate Statue			33,453	6,691	40,143	
06_03.04.01_ 3 Erosion and Sediment Control	36.14	ACR	235,166	47,033	282,199	7808.49
06_03.04.01_ 4 Clearing & Grubbing	36.14	ACR	169,714	33,943	203,657	5635.21
06_03.04.01_ 01 Staging Area	2500.00	SF	16,570	3,314	19,883	7.95
06_03.04.01_ 03 Site Access	36.14	ACR	306,731	61,346	368,077	10185
06_03.04.01_ 04 Cofferdam at Inlets	6500.00	SF	277,996	55,599	333,595	51.32
06_03.04.01_ 06 Dewatering	365.00	DAY	698,359	139,672	838,030	2295.97
06_03.04.01_ 07 Earthwork-Dry	456427	BCY	5,150,242	1,030,048	6,180,290	13.54
06_03.04.01_ 08 Earthwork-Wet	304285	BCY	4,186,660	837,332	5,023,992	16.51
06_03.04.01_ 09 Clean Sand -Wetland	58306	CY	980,391	196,078	1,176,469	20.18
06_03.04.01_ 11 Clean fill -Cohesive Material	58306	CY	980,391	196,078	1,176,469	20.18
06_03.04.01_ 12 Rip-Rap at Inlet	452.00	CY	38,546	7,709	46,255	102.33
06_03.04.01_ 13 Filter Fabric	678.00	SY	8,849	1,770	10,619	15.66
06_03.04.01_ 16 Subgrade Preparation to Lower	36.14	AC	135,153	27,031	162,184	4487.66

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
06_03.04.01_ 17	Fine Grading of Wetland	36.14	ACR	415,714	83,143	498,857	13803
06_03.04.01_ 21	Bird Control-Plant Protection	36.14	AC	245,867	49,173	295,041	8163.83
06_03.04.01_ 23	Monitoring-Project Site			141,851	28,370	170,222	
06_03.04.01_ 28	Low Marsh Plants	15.21	ACR	591,701	118,340	710,042	46683
06_03.04.01_ 33	High Marsh Plants	16.43	ACR	685,015	137,003	822,018	50032
	TOTAL Tidal Wetland			15,985,965	3,197,193	19,183,158	
06_03.04.03	Mob/Demob			138,886	27,777	166,663	
	TOTAL Tidal Wetland & Disposal Area			19,070,836	3,814,167	22,885,003	
06_03.05	Upland Management Area						
06_03.05.01	Clearing & Grubbing	131.80	ACR	618,923	123,785	742,708	5635.11
06_03.05.02	Site Access	131.80	ACR	1,087,990	217,598	1,305,588	9905.83
06_03.05.07	Monitoring			17,069	3,414	20,482	
06_03.05.10	Mob & Demob			43,808	8,762	52,570	
	TOTAL Upland Management Area	54.90	ACR	1,767,790	353,558	2,121,348	38640
06_03.15	Fresh Water Wetland						
06_03.15. 1	Mob/Demob			140,338	28,068	168,406	
06_03.15.01	Clearing & Grubbing	9.28	ACR	43,579	8,716	52,295	5635.21
06_03.15.02	New Culverts	950.00	LF	99,609	19,922	119,531	125.82
06_03.15.03	Inlet Connection plus flow	5.00	EA	645	129	774	154.75
06_03.15.04	Flow Dissapator	5.00	EA	1,934	387	2,321	464.24
06_03.15.05	Timber Mats	0.24	ARC	309	62	371	1547.16
06_03.15.06	Erosion and Sediment Control			87,698	17,540	105,237	
06_03.15.08	Earthwork-dry	18402	BCY	210,119	42,024	252,143	13.70
06_03.15.09	Dewatering	90.00	DAY	172,565	34,513	207,078	2300.87
06_03.15.10	Fine Grading of Wetland	7.73	ACR	88,917	17,783	106,701	13803
06_03.15.11	Tree	50.00	EA	16,255	3,251	19,506	390.11
06_03.15.12	Shrubs	1.28	ACR	120,508	24,102	144,610	112977
06_03.15.13	Grassland/Herbaceous	25.65	MSF	15,225	3,045	18,270	712.29
06_03.15.14	Wildflowers	25.65	MSF	2,008	402	2,409	93.92
06_03.15.15	Bird Control -Plant Protection	11.75	ACR	79,937	15,987	95,925	8163.83
06_03.15.16	Monitoring			12,896	2,579	15,475	
06_03.15.17	Clean fill - Cohesive Material	5751.00	CY	96,701	19,340	116,041	20.18
06_03.15.18	Subgrade Preparation to Lower	7.73	ACR	22,548	4,510	27,058	3500.37
06_03.15.19	Stone Weir	3.00	EA	619	124	743	247.60
06_03.15.20	Log Weirs	11.00	EA	6,639	1,328	7,966	724.22
06_03.15.21	Access Road	2100.00	LF	62,745	12,549	75,295	35.85
06_03.15.22	Raptor Perches	1.00	EA	97	19	116	116.06
06_03.15.24	Raised Walks	200.00	LF	11,606	2,321	13,927	69.64
06_03.15.26	Obervation Decks	2.00	EA	32,990	6,598	39,588	19794
06_03.15.27	Earthwork-wet	4600.00	BCY	67,053	13,411	80,464	17.49

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
TOTAL Fresh Water Wetland		1,393,541	278,708	1,672,250	
TOTAL Wildlife Facilities & Sanctuary		22,804,056	4,560,811	27,364,867	
TOTAL Fish and Wildlife Facilities		22,804,056	4,560,811	27,364,867	
30 Planning, Engineering and Design		1,820,000	182,000	2,002,000	
31 Construction Management		1,790,000	358,000	2,148,000	
TOTAL Liberty State Park Ecosystem		26,456,056	5,109,211	31,565,267	

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
01 Lands and Damages		42,000	0	0	0	0	42,000	
06 Fish and Wildlife Facilities		17,683,629	1,768,363	972,600	2,042,459	337,006	22,804,056	
30 Planning, Engineering and Design		1,820,000	0	0	0	0	1,820,000	
31 Construction Management		1,790,000	0	0	0	0	1,790,000	
TOTAL Liberty State Park Ecosystem		21,335,629	1,768,363	972,600	2,042,459	337,006	26,456,056	
Contingency	19.31 %						5,109,211	
TOTAL INCL OWNER COSTS							31,565,267	

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
01 Lands and Damages								
01_05 Administration		42,000	0	0	0	0	42,000	
TOTAL Lands and Damages		42,000	0	0	0	0	42,000	
06 Fish and Wildlife Facilities								
06_03 Wildlife Facilities & Sanctuary								
06_03.03 Sand Placement In North Cove								
06_03.03.20 Mob/Demob		21,510	2,151	1,183	2,484	410	27,738	
06_03.03.37 Sand Placement in the North Cove	14455 CY	421,967	42,197	23,208	48,737	8,042	544,151	37.64
TOTAL Sand Placement In North Cove	54.90 ACR	443,477	44,348	24,391	51,222	8,452	571,889	10417
06_03.04 Tidal Wetland & Disposal Area								
06_03.04.1 Disposal Area Berm		2,284,493	228,449	125,647	263,859	43,537	2,945,985	
06_03.04.01 Tidal Wetland		12,396,473	1,239,647	681,806	1,431,793	236,246	15,985,965	
06_03.04.03 Mob/Demob		107,700	10,770	5,924	12,439	2,052	138,886	
TOTAL Tidal Wetland & Disposal Area		14,788,666	1,478,867	813,377	1,708,091	281,835	19,070,836	
06_03.05 Upland Management Area								
06_03.05.01 Clearing & Grubbing	131.80 ACR	479,950	47,995	26,397	55,434	9,147	618,923	4695.93
06_03.05.02 Site Access	131.80 ACR	843,693	84,369	46,403	97,447	16,079	1,087,990	8254.86
06_03.05.07 Monitoring		13,236	1,324	728	1,529	252	17,069	
06_03.05.10 Mob & Demob		33,971	3,397	1,868	3,924	647	43,808	
TOTAL Upland Management Area	54.90 ACR	1,370,850	137,085	75,397	158,333	26,125	1,767,790	32200
06_03.15 Fresh Water Wetland								
06_03.15.1 Mob/Demob		108,827	10,883	5,985	12,569	2,074	140,338	
06_03.15.01 Clearing & Grubbing	9.28 ACR	33,794	3,379	1,859	3,903	644	43,579	4696.01
06_03.15.02 New Culverts	950.00 LF	77,243	7,724	4,248	8,922	1,472	99,609	104.85
06_03.15.03 Inlet Connection plus flow	5.00 EA	500	50	28	58	10	645	128.96
06_03.15.04 Flow Dissapator	5.00 EA	1,500	150	83	173	29	1,934	386.87
06_03.15.05 Timber Mats	0.24 ARC	240	24	13	28	5	309	1289.30
06_03.15.06 Erosion and Sediment Control		68,006	6,801	3,740	7,855	1,296	87,698	
06_03.15.08 Earthwork-dry	18402 BCY	162,939	16,294	8,962	18,819	3,105	210,119	11.42
06_03.15.09 Dewatering	90.00 DAY	133,817	13,382	7,360	15,456	2,550	172,565	1917.39
06_03.15.10 Fine Grading of Wetland	7.73 ACR	68,952	6,895	3,792	7,964	1,314	88,917	11503

		QUANTY	UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
06_03.15.11	Tree	50.00	EA	12,605	1,260	693	1,456	240	16,255	325.09
06_03.15.12	Shrubs	1.28	ACR	93,449	9,345	5,140	10,793	1,781	120,508	94147
06_03.15.13	Grassland/Herbaceous	25.65	MSF	11,807	1,181	649	1,364	225	15,225	593.58
06_03.15.14	Wildflowers	25.65	MSF	1,557	156	86	180	30	2,008	78.27
06_03.15.15	Bird Control -Plant Protection	11.75	ACR	61,988	6,199	3,409	7,160	1,181	79,937	6803.19
06_03.15.16	Monitoring			10,000	1,000	550	1,155	191	12,896	
06_03.15.17	Clean fill - Cohesive Material	5751.00	CY	74,987	7,499	4,124	8,661	1,429	96,701	16.81
06_03.15.18	Subgrade Preparation to Lower	7.73	ACR	17,485	1,749	962	2,020	333	22,548	2916.98
06_03.15.19	Stone Weir	3.00	EA	480	48	26	55	9	619	206.33
06_03.15.20	Log Weirs	11.00	EA	5,148	515	283	595	98	6,639	603.51
06_03.15.21	Access Road	2100.00	LF	48,657	4,866	2,676	5,620	927	62,745	29.88
06_03.15.22	Raptor Perches	1.00	EA	75	8	4	9	1	97	96.72
06_03.15.24	Raised Walks	200.00	LF	9,000	900	495	1,040	172	11,606	58.03
06_03.15.26	Obervation Decks	2.00	EA	25,582	2,558	1,407	2,955	488	32,990	16495
06_03.15.27	Earthwork-wet	4600.00	BCY	51,997	5,200	2,860	6,006	991	67,053	14.58
	TOTAL Fresh Water Wetland			1,080,635	108,064	59,435	124,813	20,594	1,393,541	
	TOTAL Wildlife Facilities & Sanctuary			17,683,629	1,768,363	972,600	2,042,459	337,006	22,804,056	
	TOTAL Fish and Wildlife Facilities			17,683,629	1,768,363	972,600	2,042,459	337,006	22,804,056	
30	Planning, Engineering and Design			1,820,000	0	0	0	0	1,820,000	
31	Construction Management			1,790,000	0	0	0	0	1,790,000	
	TOTAL Liberty State Park Ecosystem			21,335,629	1,768,363	972,600	2,042,459	337,006	26,456,056	
	Contingency	19.31	%						5,109,211	
	TOTAL INCL OWNER COSTS								31,565,267	

	QUANTY	UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
01 Lands and Damages									
01_05 Administration			42,000	0	0	0	0	42,000	
TOTAL Lands and Damages			42,000	0	0	0	0	42,000	
06 Fish and Wildlife Facilities									
06_03 Wildlife Facilities & Sanctuary									
06_03.03 Sand Placement In North Cove									
06_03.03.20 Mob/Demob			21,510	2,151	1,183	2,484	410	27,738	
06_03.03.37 Sand Placement in the North Cove	14455	CY	421,967	42,197	23,208	48,737	8,042	544,151	37.64
TOTAL Sand Placement In North Cove	54.90	ACR	443,477	44,348	24,391	51,222	8,452	571,889	10417
06_03.04 Tidal Wetland & Disposal Area									
06_03.04. 1 Disposal Area Berm									
06_03.04. 1_ 01 Clearing and Grubbing	38.95	ACR	141,839	14,184	7,801	16,382	2,703	182,910	4696.01
06_03.04. 1_ 02 Site Access	38.95	ACR	255,887	25,589	14,074	29,555	4,877	329,980	8471.90
06_03.04. 1_ 05 Seeding-Upland Fill	38.95	ACR	105,351	10,535	5,794	12,168	2,008	135,856	3487.96
06_03.04. 1_ 08 Top Soil /Sand Treatment	38.95	AC	1,561,876	156,188	85,903	180,397	29,765	2,014,129	51711
06_03.04. 1_ 10 Erosion and Sediment Control	38.95	ACR	196,541	19,654	10,810	22,700	3,746	253,451	6507.08
06_03.04. 1_ 12 Monitoring			23,000	2,300	1,265	2,657	438	29,660	
TOTAL Disposal Area Berm			2,284,493	228,449	125,647	263,859	43,537	2,945,985	
06_03.04.01 Tidal Wetland									
06_03.04.01_ 1 Bridge Construction	3600.00	SF	533,204	53,320	29,326	61,585	10,162	687,597	191.00
06_03.04.01_ 2 Relocate Statue			25,941	2,594	1,427	2,996	494	33,453	
06_03.04.01_ 3 Erosion and Sediment Control	36.14	ACR	182,362	18,236	10,030	21,063	3,475	235,166	6507.08
06_03.04.01_ 4 Clearing & Grubbing	36.14	ACR	131,606	13,161	7,238	15,201	2,508	169,714	4696.01
06_03.04.01_ 01 Staging Area	2500.00	SF	12,849	1,285	707	1,484	245	16,570	6.63
06_03.04.01_ 03 Site Access	36.14	ACR	237,858	23,786	13,082	27,473	4,533	306,731	8487.30
06_03.04.01_ 04 Cofferdam at Inlets	6500.00	SF	215,575	21,557	11,857	24,899	4,108	277,996	42.77
06_03.04.01_ 06 Dewatering	365.00	DAY	541,549	54,155	29,785	62,549	10,321	698,359	1913.31
06_03.04.01_ 07 Earthwork-Dry	456427	BCY	3,993,805	399,381	219,659	461,285	76,112	5,150,242	11.28
06_03.04.01_ 08 Earthwork-Wet	304285	BCY	3,246,587	324,659	178,562	374,981	61,872	4,186,660	13.76
06_03.04.01_ 09 Clean Sand -Wetland	58306	CY	760,253	76,025	41,814	87,809	14,489	980,391	16.81
06_03.04.01_ 11 Clean fill -Cohesive Material	58306	CY	760,253	76,025	41,814	87,809	14,489	980,391	16.81
06_03.04.01_ 12 Rip-Rap at Inlet	452.00	CY	29,891	2,989	1,644	3,452	570	38,546	85.28
06_03.04.01_ 13 Filter Fabric	678.00	SY	6,862	686	377	793	131	8,849	13.05
06_03.04.01_ 16 Subgrade Preparation to Lower	36.14	AC	104,806	10,481	5,764	12,105	1,997	135,153	3739.72

		QUANTY	UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
06_03.04.01_ 17	Fine Grading of Wetland	36.14	ACR	322,369	32,237	17,730	37,234	6,144	415,714	11503
06_03.04.01_ 21	Bird Control-Plant Protection	36.14	AC	190,660	19,066	10,486	22,021	3,634	245,867	6803.19
06_03.04.01_ 23	Monitoring-Project Site			110,000	11,000	6,050	12,705	2,096	141,851	
06_03.04.01_ 28	Low Marsh Plants	15.21	ACR	458,841	45,884	25,236	52,996	8,744	591,701	38902
06_03.04.01_ 33	High Marsh Plants	16.43	ACR	531,202	53,120	29,216	61,354	10,123	685,015	41693
TOTAL Tidal Wetland				12,396,473	1,239,647	681,806	1,431,793	236,246	15,985,965	
06_03.04.03	Mob/Demob			107,700	10,770	5,924	12,439	2,052	138,886	
TOTAL Tidal Wetland & Disposal Area				14,788,666	1,478,867	813,377	1,708,091	281,835	19,070,836	
06_03.05	Upland Management Area									
06_03.05.01	Clearing & Grubbing	131.80	ACR	479,950	47,995	26,397	55,434	9,147	618,923	4695.93
06_03.05.02	Site Access	131.80	ACR	843,693	84,369	46,403	97,447	16,079	1,087,990	8254.86
06_03.05.07	Monitoring			13,236	1,324	728	1,529	252	17,069	
06_03.05.10	Mob & Demob			33,971	3,397	1,868	3,924	647	43,808	
TOTAL Upland Management Area		54.90	ACR	1,370,850	137,085	75,397	158,333	26,125	1,767,790	32200
06_03.15	Fresh Water Wetland									
06_03.15. 1	Mob/Demob			108,827	10,883	5,985	12,569	2,074	140,338	
06_03.15.01	Clearing & Grubbing	9.28	ACR	33,794	3,379	1,859	3,903	644	43,579	4696.01
06_03.15.02	New Culverts	950.00	LF	77,243	7,724	4,248	8,922	1,472	99,609	104.85
06_03.15.03	Inlet Connection plus flow	5.00	EA	500	50	28	58	10	645	128.96
06_03.15.04	Flow Dissapator	5.00	EA	1,500	150	83	173	29	1,934	386.87
06_03.15.05	Timber Mats	0.24	ARC	240	24	13	28	5	309	1289.30
06_03.15.06	Erosion and Sediment Control			68,006	6,801	3,740	7,855	1,296	87,698	
06_03.15.08	Earthwork-dry	18402	BCY	162,939	16,294	8,962	18,819	3,105	210,119	11.42
06_03.15.09	Dewatering	90.00	DAY	133,817	13,382	7,360	15,456	2,550	172,565	1917.39
06_03.15.10	Fine Grading of Wetland	7.73	ACR	68,952	6,895	3,792	7,964	1,314	88,917	11503
06_03.15.11	Tree	50.00	EA	12,605	1,260	693	1,456	240	16,255	325.09
06_03.15.12	Shrubs	1.28	ACR	93,449	9,345	5,140	10,793	1,781	120,508	94147
06_03.15.13	Grassland/Herbaceous	25.65	MSF	11,807	1,181	649	1,364	225	15,225	593.58
06_03.15.14	Wildflowers	25.65	MSF	1,557	156	86	180	30	2,008	78.27
06_03.15.15	Bird Control -Plant Protection	11.75	ACR	61,988	6,199	3,409	7,160	1,181	79,937	6803.19
06_03.15.16	Monitoring			10,000	1,000	550	1,155	191	12,896	
06_03.15.17	Clean fill - Cohesive Material	5751.00	CY	74,987	7,499	4,124	8,661	1,429	96,701	16.81
06_03.15.18	Subgrade Preparation to Lower	7.73	ACR	17,485	1,749	962	2,020	333	22,548	2916.98
06_03.15.19	Stone Weir	3.00	EA	480	48	26	55	9	619	206.33
06_03.15.20	Log Weirs	11.00	EA	5,148	515	283	595	98	6,639	603.51
06_03.15.21	Access Road	2100.00	LF	48,657	4,866	2,676	5,620	927	62,745	29.88
06_03.15.22	Raptor Perches	1.00	EA	75	8	4	9	1	97	96.72
06_03.15.24	Raised Walks	200.00	LF	9,000	900	495	1,040	172	11,606	58.03
06_03.15.26	Obervation Decks	2.00	EA	25,582	2,558	1,407	2,955	488	32,990	16495
06_03.15.27	Earthwork-wet	4600.00	BCY	51,997	5,200	2,860	6,006	991	67,053	14.58

	QUANTY	UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
TOTAL Fresh Water Wetland			1,080,635	108,064	59,435	124,813	20,594	1,393,541	
TOTAL Wildlife Facilities & Sanctuary			17,683,629	1,768,363	972,600	2,042,459	337,006	22,804,056	
TOTAL Fish and Wildlife Facilities			17,683,629	1,768,363	972,600	2,042,459	337,006	22,804,056	
30 Planning, Engineering and Design			1,820,000	0	0	0	0	1,820,000	
31 Construction Management			1,790,000	0	0	0	0	1,790,000	
TOTAL Liberty State Park Ecosystem			21,335,629	1,768,363	972,600	2,042,459	337,006	26,456,056	
Contingency	19.31	%						5,109,211	
TOTAL INCL OWNER COSTS								31,565,267	

01_05. Administration		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
01. Lands and Damages												
	TOTAL Administration					0	0	0	0	42,000	42,000	
	TOTAL Lands and Damages					0	0	0	0	42,000	42,000	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06. Fish and Wildlife Facilities											
06_03. Wildlife Facilities & Sanctuary											
06_03.03. Sand Placement In North Cove											
06_03.03.20. Mob/Demob											
Assume all equipment moved to the jobsite at 2 days stand by time and 1 day to move equipment off-site or total of 24 hours											
Assume 16 hrs round trip for mobilized each equipment, 16 hrs round trip for demobilized each equipment											
MIL AA < > Outside Truck Drivers, Heavy					1.00	27.99	0.00	0.00	0.00	27.99	
	64.00	HR	X-TRKDVRHV	1.00	64	1,791	0	0	0	1,791	27.99
MIL AA < > Outside Equip. Oilers					1.00	29.93	0.00	0.00	0.00	29.93	
	64.00	HR	X-EQOPROIL	1.00	64	1,916	0	0	0	1,916	29.93
EP AA < > Move Equipments to Job Site & Off-Site TRLR,LOWBOY, 60T, 3 AXLE (ADD TOWING TRUCK)					0.00	0.00	10.15	0.00	0.00	10.15	
	64.00	HR	T45XX017	1.00	0	0	649	0	0	649	10.15
EP AA < > Move Equipment to Job Site& Off-Site TRK,HWY, 46,000 GVW, 6X4, 3 AXLE					0.00	0.00	42.25	0.00	0.00	42.25	
	64.00	HR	T50F0018	1.00	0	0	2,704	0	0	2,704	42.25
USR AA < > 110hp tug w/crew 01509-700-800					0.00	0.00	0.00	0.00	59.45	59.45	
	40.00	HR		0.00	0	0	0	0	2,378	2,378	59.45
Rent/day: $168 Crew Equipment Cost/day :$236.6											
MAP AA < > Standby Cost, HYD EXCAV BKT, 3.25CY, W/TIPS					0.00	0.00	3.71	0.00	0.00	3.71	
	24.00	HR	H25BS005	1.00	0	0	89	0	0	89	3.71
MAP AA < > Standby Cost, HYD EXCAV, CRWLR,110,880 LBS, 3.50 CY BKT,MASS BOOM					0.00	0.00	90.06	0.00	0.00	90.06	
	24.00	HR	H25CA029	1.00	0	0	2,161	0	0	2,161	90.06
USR AA < > Standy Cost, Deck Cargo Barge,800 ton					0.00	0.00	75.41	0.00	0.00	75.41	
	24.00	HR	ZRI001	1.00	0	0	1,810	0	0	1,810	75.41
USR AA < > Tug Captain					1.00	125.86	0.00	0.00	0.00	125.86	
	40.00	HR	X-TUG0001	1.00	40	5,034	0	0	0	5,034	125.86
USR AA < > Tug Mate					1.00	74.41	0.00	0.00	0.00	74.41	
	40.00	HR	X-TUG0002	1.00	40	2,976	0	0	0	2,976	74.41
TOTAL Mob/Demob					208	11,718	7,414	0	2,378	21,510	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.03.37. Sand Placement in the North Cove Production rate calculation: 02315-424-0300 = 160cy/hr Assume differing site condition (deduct 50%) therefore production is 80 cy/hr											
MAP SC < > HYD EXCAV BKT, 3.25CY, W/TIPS					0.00	0.00	3.71	0.00	0.00	3.71	
	180.69	HR	H25BS005	1.00	0	0	811	0	0	811	4.49
USR SC < > Import Sand					0.00	0.00	0.00	16.00	0.00	16.00	
	14455	CY		0.00	0	0	0	279,849	0	279,849	19.36
USR SC < > 110hp tug					0.00	0.00	44.40	0.00	0.00	44.40	
01590-700-2000	180.69	HR		0.00	0	0	9,708	0	0	9,708	53.73
Crew Equipment Cost/day :$236.6											
USR SC < > Deck Cargo Barge,800 ton					0.00	0.00	75.41	0.00	0.00	75.41	
	180.69	HR	ZRI001	1.00	0	0	16,486	0	0	16,486	91.24
USR SC < > Loading Ramps					0.00	0.00	75.41	0.00	5.25	80.66	
RRBB, volume 1 pg.14-1	180.69	HR	ZRI001	1.00	0	0	16,486	0	1,148	17,634	97.59
MIL SC < > Equip. Operators					1.00	63.30	0.00	0.00	0.00	63.30	
	180.69	HR	B-EQOPRCRN	1.00	181	13,838	0	0	0	13,838	76.59
MIL SC < > Equip. Operators, Oilers					1.00	54.33	0.00	0.00	0.00	54.33	
	180.69	HR	B-EQOPROIL	1.00	181	11,878	0	0	0	11,878	65.74
MIL SC < > Laborers, (Semi-Skilled)					1.00	37.90	0.00	0.00	0.00	37.90	
	180.69	HR	B-LABORER	1.00	181	8,287	0	0	0	8,287	45.86
MAP SC < > HYD EXCAV, CRWLR,110,880 LBS,					0.00	0.00	90.06	0.00	0.00	90.06	
3.50 CY BKT,MASS BOOM	180.69	HR	H25CA029	1.00	0	0	19,690	0	0	19,690	108.97
USR SC < > Tug Captain					1.00	125.86	0.00	0.00	0.00	125.86	
	180.69	HR	X-TUG0001	1.00	181	27,516	0	0	0	27,516	152.29
USR SC < > Tug Mate					1.00	74.41	0.00	0.00	0.00	74.41	
	180.69	HR	X-TUG0002	1.00	181	16,269	0	0	0	16,269	90.04
TOTAL Sand Placement in the North Cove	14455	CY			903	77,789	63,182	279,849	1,148	421,967	29.19
TOTAL Sand Placement In North Cove	54.90	ACR			1,111	89,506	70,596	279,849	3,526	443,477	8077.90

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.04. Tidal Wetland & Disposal Area Berm											
06_03.04. 1. Disposal Area Berm											
06_03.04. 1_ 01. Clearing and Grubbing											
USR SC < > Herbicide Treatment					0.04	2.19	1.03	0.26	0.00	3.48	
Spreader	1696.66	MSF	ZA-2LAND01	25.87	66	4,496	2,114	534	0	7,144	4.21
02935-100-0120											
Weed Control											
02935-100-0190											
L AF SC <02110 0550 > Phragmitles cutting					1.50	70.95	48.89	0.00	827.00	946.84	
	38.95	ACR	CODTB11A	1.33	58	3,344	2,304	0	38,976	44,624	1145.68
Brush mowing, dozer tractor											
02230-200-0300											
L MIL SC <02234 2200 > Hauling, off hwy haulers,22 CY,					0.04	1.51	2.08	0.00	0.00	3.59	
rear/bottom dump, 1 mile	20737	CY	CTDHB34F	27.63	751	37,818	52,253	0	0	90,071	4.34
round trip, incl. loading onto trucks											
Assuming 4" thick phrag											
02315-490-2030											
02315-462-9024											
TOTAL Clearing and Grubbing	38.95	ACR			875	45,658	56,671	534	38,976	141,839	3641.57
06_03.04. 1_ 02. Site Access											
B MIL AA <02244 0080 > New Acess Road, Base course,					0.01	0.48	0.39	9.05	0.00	9.93	
crushed 3/4" stone,	19903	SY	COFGB36C	517.97	193	9,625	7,855	180,126	0	197,606	9.93
compacted, 4"D, large areas											
Assume 230 lf/acr of road x20'											
wide =511 sy/acr											
USR AA < > Timber Mats					0.07	2.82	0.23	3.62	0.00	6.67	
assume each mat is 10' x 10'	5842.50	LF	ZA-2LAND02	85.71	409	16,465	1,327	21,150	0	38,942	6.67
per acre											
Each timber tie is 8" x 10'											
10' / 8/12 = 15ea x 10' =											
150'/acr											
Labor&Material											
05655-700-1600											

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
USR AA < > Temp Tidal Crossing					0.00	0.00	0.00	0.00	3000.00	3000.00	
Qty assumed.	3.00	EA		0.00	0	0	0	0	9,000	9,000	3000.00
15' wide.											
Use 6 timber mats, 2 as a base, 4 on top.											
L USR AA <02512 0011 > Access Road Fine Grade					0.01	0.38	0.14	0.00	0.00	0.52	
	19903	SY	COFGD11L	250.00	159	7,527	2,811	0	0	10,338	0.52
TOTAL Site Access	38.95	ACR			761	33,618	11,993	201,276	9,000	255,887	6569.62
06_03.04. 1_ 05. Seeding-Upland Fill											
B MIL AA <02932 0320 > Hypo Seeding					0.00	0.25	0.08	0.16	0.00	0.49	
Incl Seed & fertilizer	188516	SY	COELB66	221.57	848	46,224	15,881	30,163	0	92,267	0.49
04-02920-310-1000											
L AF AA <02976 4930 > Watering, water by truck					0.04	1.67	2.17	0.02	0.00	3.86	
1 ac =43.56 msfx2pass=87.12 msf/ac	3393.32	MSF	COFWB59	25.00	136	5,652	7,364	68	0	13,083	3.86
TOTAL Seeding-Upland Fill	38.95	ACR			984	51,876	23,245	30,230	0	105,351	2704.77
06_03.04. 1_ 08. Top Soil /Sand Treatment											
B MIL AA <02241 0705 > Loam or topsoil, furnish & place, imported					0.05	2.49	0.95	18.10	0.00	21.54	
	62839	CY	CODFB10S	30.34	3,104	156,621	59,487	1,137,392	0	1,353,499	21.54
02055-150-0800											
43560sf/ac x 2' thick / 27 = CY/ACR											
L USR AA < > Add for hauling additional 5 mile					0.04	1.67	1.65	0.00	0.00	3.32	
	62839	CY	COETH	25.00	2,514	104,659	103,718	0	0	208,376	3.32
TOTAL Top Soil /Sand Treatment	38.95	AC			5,618	261,280	163,204	1,137,392	0	1,561,876	40100
06_03.04. 1_ 10. Erosion and Sediment Control											
USR SC < > Maintenance					78.00	2916.38	0.00	0.00	0.00	2916.38	
Assume 2 laborer 80hrs per acre to maintain erosion control measures	38.95	LS	XLABB	0.03	3,038	137,448	0	0	0	137,448	3528.82
L USR SC < > Sediment Trap with filter					0.00	0.00	0.00	0.00	200.00	200.00	
assume $200/acre	38.95	ACR		0.00	0	0	0	0	9,426	9,426	242.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
USR SC < > Straw Bales					0.00	0.35	0.06	1.93	0.00	2.34	
02370-700-1250	7790.00	LF		0.00	0	3,299	551	18,192	0	22,042	2.83
MIL SC <02228 1625 > Excavate trench, normal soil, by					0.71	27.22	0.00	0.00	0.00	27.22	
hand, piled only, to 2' deep	288.23	CY	ULABB2	7.00	206	9,492	0	0	0	9,492	32.93
excavate 12" deep x 12" wide x 200' = CY/Acr											
MIL SC <02215 0010 > Backfill, by hand, no					0.57	21.66	0.00	0.00	0.00	21.66	
compaction, light soil	288.23	CY	ALABCLAB1	1.75	165	7,554	0	0	0	7,554	26.21
B MIL SC <02266 1110 > Silt fence, 3' high,					0.02	0.84	0.00	0.28	0.00	1.12	
polypropylene	7790.00	LF	ALABCLAB2	90.00	173	7,939	0	2,639	0	10,579	1.36
02370-700-1100											
TOTAL Erosion and Sediment Control	38.95	ACR			3,582	165,732	551	20,831	9,426	196,541	5045.98
06_03.04. I_ 12. Monitoring											
USR AA < > Monitoring					0.00	0.00	0.00	0.00	23000.00	23000.00	
Assume 1% of $2.3million	1.00	LS		0.00	0	0	0	0	23,000	23,000	23000
TOTAL Monitoring					0	0	0	0	23,000	23,000	
TOTAL Disposal Area Berm					11,820	558,163	255,664	1,390,263	80,402	2,284,493	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.04.01. Tidal Wetland											
06_03.04.01_ 1. Bridge Construction											
USR SC < > CON/SPAN Bridge System					0.00	0.00	0.00	251000.00	0.00	251000.00	
Material quote from BridgeTek Orchard Park, NY. not incl. markup	1.00	EA		0.00	0	0	0	303,710	0	303,710	303710
equipment=$1416*1.05*2=2974											
USR SC < > CON/SPAN Bridge System Install					0.26	11.21	4.58	0.00	0.00	15.78	
Material quote from BridgeTek Orchard Park, NY. not incl. markup	3600.00	SF	ZA-2LAND04	26.92	936	48,812	19,936	0	0	68,748	19.10
BCCD04-02850-210-0050											
L USR SC < > Excavate & load, hydr excavator,					0.07	4.11	5.15	0.00	0.00	9.26	
02315-424-1800	1156.00	CY	CODEB12D	28.61	81	5,751	7,201	0	0	12,952	11.20
AF SC <02234 4000 > Hauling, w/loading, 12 CY truck,					0.03	1.61	1.76	0.00	0.00	3.36	
5 mile haul, soil Swell at 20%	204.00	CY	CODEB30	87.00	7	397	433	0	0	830	4.07
M RSM SC <03326 0400 > Concrete ready mix, regular					0.00	0.00	0.00	95.00	0.00	95.00	
weight, 5000 psi	167.00	CY	N/A	0.00	0	0	0	19,197	0	19,197	114.95
footing =3'*10'*75'*2 =167CY											
MIL SC <03372 2700 > Placing conc, footings, spread,					0.64	27.26	8.33	0.00	0.00	35.59	
over 5 CY, w/crane & bucket	167.00	CY	ULABC7	12.50	107	5,509	1,683	0	0	7,192	43.07
MIL SC <03158 0010 > Forms in place, footing,					0.09	3.10	0.00	2.40	0.00	5.50	
continuous wall, plywood, 1 use	1020.00	SF	ACARC1	46.88	87	3,828	0	2,962	0	6,790	6.66
3'*10'*4+75'*3'*4=1020 SF											
M MIL SC <03217 0550 > Reinforcing in place, footings,					8.89	577.96	0.00	590.00	0.00	1167.96	
#6 @ 8"	7.60	TON	SIWRRODM4	0.45	68	5,315	0	5,426	0	10,741	1413.23
101251f*1.5002lb/lf=15208 lb=7.6 ton (short)											

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
MIL SC <02216 5530 > Backfill, strl, 6" lifts,					0.02	1.08	0.56	0.00	0.00	1.64	
w/loader, no compaction, around foundation	986.00	CY	CODFB10N	70.00	21	1,289	665	0	0	1,954	1.98
USR SC < > Road Way					0.00	91.46	0.00	102.38	0.00	193.84	
Assemblies Cost Data 2004 G2010 210 2420	431.00	LF		0.00	0	47,697	0	53,392	0	101,089	234.55
Assuming 5" Thick Bituminous, paving, wearing course											
TOTAL Bridge Construction	3600.00	SF			1,306	118,599	29,918	384,687	0	533,204	148.11
06_03.04.01_ 2. Relocate Statue											
USR AA <02124 0040 > Relocate and Install Statue					83.25	3946.19	995.05	0.00	21000.00	25941.24	
USMA, Thomas J. Hall	1.00	EA	CLABB42	0.10	83	3,946	995	0	21,000	25,941	25941
TOTAL Relocate Statue					83	3,946	995	0	21,000	25,941	
06_03.04.01_ 3. Erosion and Sediment Control											
USR SC < > Maintenance					78.00	2916.38	0.00	0.00	0.00	2916.38	
Assume 2 laborer 80hrs per acre to maintain erosion control measures	36.14	LS	XLABB	0.03	2,819	127,532	0	0	0	127,532	3528.82
L USR SC < > Sediment Trap with filter					0.00	0.00	0.00	0.00	200.00	200.00	
assume $200/acre	36.14	ACR		0.00	0	0	0	0	8,746	8,746	242.00
USR SC < > Straw Bales					0.00	0.35	0.06	1.93	0.00	2.34	
02370-700-1250	7228.00	LF		0.00	0	3,061	512	16,880	0	20,452	2.83
MIL SC <02228 1625 > Excavate trench, normal soil, by					0.71	27.22	0.00	0.00	0.00	27.22	
hand, piled only, to 2' deep	267.44	CY	ULABB2	7.00	191	8,807	0	0	0	8,807	32.93
excavate 12" deep x 12" wide x 200' = CY/Acr											
MIL SC <02215 0010 > Backfill, by hand, no					0.57	21.66	0.00	0.00	0.00	21.66	
compaction, light soil	267.44	CY	ALABCLAB1	1.75	153	7,009	0	0	0	7,009	26.21
B MIL SC <02266 1110 > Silt fence, 3' high,					0.02	0.84	0.00	0.28	0.00	1.12	
polypropylene	7228.00	LF	ALABCLAB2	90.00	160	7,367	0	2,449	0	9,816	1.36
02370-700-1100											

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
TOTAL Erosion and Sediment Control	36.14	ACR			3,323	153,776	512	19,328	8,746	182,362	5045.98
06_03.04.01_ 4. Clearing & Grubbing Includes phragmities removal, haul to on-site disposal											
USR SC < > Herbicide Treatment					0.04	2.19	1.03	0.26	0.00	3.48	
Spreader 02935-100-0120	1574.26	MSF	ZA-2LAND01	25.87	61	4,171	1,961	495	0	6,628	4.21
Weed Control 02935-100-0190											
L AF SC <02110 0550 > Phragmities cutting					1.50	70.95	48.89	0.00	827.00	946.84	
Brush mowing, dozer tractor 02230-200-0300	36.14	ACR	CODTB11A	1.33	54	3,103	2,138	0	36,164	41,405	1145.68
L MIL SC <02234 2200 > Hauling, off hwy haulers,22 CY,					0.04	1.51	2.08	0.00	0.00	3.59	
rear/bottom dump, 1 mile round trip, incl. loading onto trucks Assuming 4" thick phrag	19241	CY	CTDHB34F	27.63	697	35,090	48,483	0	0	83,573	4.34
02315-490-2030 02315-462-9024											
TOTAL Clearing & Grubbing	36.14	ACR			812	42,364	52,583	495	36,164	131,606	3641.57
06_03.04.01_ 01. Staging Area											
USR AA < > Grading					0.02	1.22	0.68	0.00	0.00	1.90	
small areas to 2500 SY	278.00	SY	COFGB32A	123.78	7	340	189	0	0	528	1.90
MHCCD004-02720-200-7000											
USR AA < > Filter Fabric					0.00	0.10	0.03	0.87	0.00	1.00	
MHCCD04-02720-200-6000/6900	278.00	SY	COELB66	561.67	1	27	9	242	0	278	1.00
USR AA < > 12" Aggregate, 3/4" Compacted					0.02	0.83	0.68	10.45	0.00	11.96	
compacted, 4"D, large areas MHCCD04-02720-200-0399	278.00	SY	COFGB36C	300.30	5	232	189	2,905	0	3,326	11.96
USR AA < > Remove Aggregate & Load					0.04	2.02	1.04	0.00	0.00	3.06	
MHCCD04-02315-442-0012	93.00	CY	CODFB10N	37.50	4	188	97	0	0	284	3.06
USR AA < > Haul Aggregate					0.12	5.47	5.97	1.71	0.00	13.14	
10mil rnd trp. Dispose offsite.	93.00	CY	CODEB30	25.60	11	508	555	159	0	1,222	13.14

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
MSWCD04-02325-490-1120&1300 462-9024											
M USR AA <02831 6560 > Fence, CL, 6' H, galv line post @ 10' OC, 9g mesh, 1-5/8" top rail MSWCD04-02820-130-0200M	250.00	LF	CLABB80	19.00	0.21 53	9.08 2,269	3.74 935	9.27 2,318	3.68 920	25.77 6,441	25.77
L MIL AA <02046 0752 > Site dml, chain link fence, remove & salvage for reuse MSWCD04-02220-220-1755	250.00	LF	ALABCLAB2	24.66	0.08 20	3.07 769	0.00 0	0.00 0	0.00 0	3.07 769	3.07
TOTAL Staging Area	2500.00	SF			99	4,332	1,974	5,623	920	12,849	5.14
06_03.04.01_ 03. Site Access											
B AA <02244 0300 > New Access Road 3/4" Crushed Stone 12" thk Assume 230 lf/acr of road x 20'wide = 511sy/acr	18468	SY	COFGB36C	525.00	0.01 175	0.48 8,813	0.39 7,189	9.05 167,131	0.00 0	9.92 183,133	9.92
USR AA < > Timber Mats assume each mat is 10' x 10' per acre Each timber tie is 8" x 10' 10' / 8/12 = 15ea x 10' = 150'/acr Labor&Material 05655-700-1600	5421.00	LF	ZA-2LAND02	85.71	0.07 379	2.82 15,277	0.23 1,232	3.62 19,624	0.00 0	6.67 36,133	6.67
USR AA < > Temp Tidal Crossing Qty assumed. 15' wide. Use 6 timber mats, 2 as a base, 4 on top.	3.00	EA		0.00	0.00 0	0.00 0	0.00 0	0.00 0	3000.00 9,000	3000.00 9,000	3000.00
L USR AA <02512 0011 > Access Road Fine Grade	18468	SY	COFGB11L	250.00	0.01 148	0.38 6,984	0.14 2,608	0.00 0	0.00 0	0.52 9,592	0.52
TOTAL Site Access	36.14	ACR			703	31,074	11,028	186,755	9,000	237,858	6581.56

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.04.01_ 04. Cofferdam at Inlets											
USR SC < > Cofferdams					0.28	14.06	2.80	10.55	0.00	27.41	
incl.mob/demob, temp sheeting 02260-200-0020	6500.00	SF	CLADB49	39.35	1,817	110,571	22,028	82,976	0	215,575	33.17
Assumes 250 ft lone, in 5 ft deep MLW, 5 ft tide +3 ft freeboard-13 ft high, driven 13 ft deep- LPW											
TOTAL Cofferdam at Inlets	6500.00	SF			1,817	110,571	22,028	82,976	0	215,575	33.17
06_03.04.01_ 06. Dewatering Assuming take 12 months to dewater 36.14	ac.	area									
B USR AA < > Dewater/Pump					20.00	990.42	265.41	0.00	0.00	1255.84	
02240-500-1100x1ea -1120x3ea	365.00	DAY	COFWD	0.08	7,300	361,505	96,875	0	0	458,380	1255.84
Assume 4 dewatering system and operating for 12 Months.											
B USR AA < > Generators					96.90	6329.84	600.90	0.00	0.00	6930.74	
Diesel engine, 100kw 01590-400-2700x2ea	12.00	MON	EELER3	0.03	1,163	75,958	7,211	0	0	83,169	6930.74
$720x2ea=$1440/mon											
crew equipment cost/day=$180/day											
ttl =1440+180*30=$6840/mon											
TOTAL Dewatering	365.00	DAY			8,463	437,463	104,086	0	0	541,549	1483.70
06_03.04.01_ 07. Earthwork-Dry											
L MIL AA <02232 0140 > Excavation work (dry area)					0.05	3.18	1.98	0.00	0.00	5.16	
Excavate & load, hydr excavator, 2 CY, medium matl	456427	BCY	CODEB12C	36.99	14,110	829,393	515,619	0	0	2,353,771	5.16
MSWCD04-02315-424-0260,0020,4100											
<*Mod* > Add for loading on trucks					2,117	124,409	77,343				
<*Mod* > Add for heavy soil					8,466	497,636	309,371				

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
L CIV AA <02234 2300 > Haul 1/2 mile					0.01	0.59	1.93	0.00	0.00	2.52	
Hauling, Off hwy haulers, 40 CY 1/2 mile rt. MSWCD04-02315-490-2100	524891	LCY	CTDHB34H	70.94	7,401	308,059	1,013,364	0	0	1,321,422	2.52
USR AA < > Survey Crew					0.00	1011.00	68.47	32.65	0.00	1112.12	
MSWCD04-01107-700-0010/0100 Project site.	36.14	AC		0.00	0	36,538	2,474	1,180	0	40,192	1112.12
USR AA < > Productivity Loss-Level 'D'					0.00	0.61	0.00	0.00	0.00	0.61	
MERCD00,pg1-11	456427	BCY		0.00	0	278,420	0	0	0	278,420	0.61
Productivity = 82% at Level 'D' 100-82=18% loss.											
$1,551,852x18%=$279,333/456,427 c y = $.61 per cy.											
TOTAL Earthwork-Dry	456427	BCY			32,094	2,074,454	1,918,171	1,180	0	3,993,805	8.75
06_03.04.01_ 08. Earthwork-Wet											
L MIL AA <02232 0140 > Excavation work (wet area)					0.07	4.25	2.64	0.00	0.00	6.89	
Excavate & load, hydr excavator, 2 CY, medium matl	304285	BCY	CODEB12C	27.68	10,232	601,494	373,963	0	0	2,097,232	6.89
Bccd-02315-424-0250 ,0020,410 0											
<*Mod* > Add for loading onto trucks					1,535	90,224	56,094				
<*Mod* > Add for wet excavation					10,232	601,494	373,963				
L CIV AA <02234 2300 > Haul 1/2 mile					0.01	0.59	1.93	0.00	0.00	2.52	
Hauling, Off hwy haulers, 40 CY 1/2 mile rt. MSWCD04-02315-490-2100	349928	LCY	CTDHB34H	70.94	4,934	205,373	675,576	0	0	880,949	2.52
USR AA < > Survey Crew					0.00	1011.00	68.47	32.65	0.00	1112.12	
MSWCD04-01107-700-0010/0100 Project site.	36.14	AC		0.00	0	36,538	2,474	1,180	0	40,192	1112.12
USR AA < > Productivity Loss-Level 'D'					0.00	0.75	0.00	0.00	0.00	0.75	
MERCD00,pg1-11	304285	BCY		0.00	0	228,214	0	0	0	228,214	0.75
Productivity = 82% at Level 'D' 100-82=18% loss.											
$1272155 x 18%=$228988/304285cy $.75 per cy.											

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
TOTAL Earthwork-Wet	304285	BCY			26,934	1,763,335	1,482,072	1,180	0	3,246,587	10.67
06_03.04.01_ 09. Clean Sand -Wetland											
B AF SC <02234 4100 > Hauling, w/loading, 12 CY truck, 5 mile haul, sand	58306	CY	CODEB30	63.00	0.05 2,775	2.22 156,706	2.42 171,039	3.65 257,508	0.00 0	8.30 585,254	10.04
L MIL SC <02216 5520 > Backfill, strl, 6" lifts, w/dozer, no compaction, around foundation	58306	CY	CODTB11R	137.50	0.01 636	0.55 38,796	0.47 33,438	0.00 0	0.00 0	1.02 72,234	1.24
RSM SC <02220 5600 > Compaction, riding, 6" lifts, 2 passes, sheepsfoot/wobbly wheel roller	58306	CY	COFCB10G	300.00	0.01 292	0.25 17,779	0.18 12,951	0.00 0	0.00 0	0.44 30,730	0.53
MIL SC <02220 9000 > Compaction, water, truck, 3000 gal, 3 mile haul	58306	CY	COKBB45	236.00	0.01 496	0.42 29,384	0.25 17,945	0.20 14,110	0.00 0	0.87 61,439	1.05
USR SC < > Finishing Grading MSWCD03-02310-440-3310	58306	SY		0.00	0.00 0	0.08 5,644	0.07 4,953	0.00 0	0.00 0	0.15 10,597	0.18
TOTAL Clean Sand -Wetland	58306	CY			4,198	248,309	240,326	271,619	0	760,253	13.04
06_03.04.01_ 11. Clean fill -Cohesive Material											
B AF SC <02234 4100 > Hauling, w/loading, 12 CY truck, 5 mile haul, sand	58306	CY	CODEB30	63.00	0.05 2,775	2.22 156,706	2.42 171,039	3.65 257,508	0.00 0	8.30 585,254	10.04
L MIL SC <02216 5520 > Backfill, strl, 6" lifts, w/dozer, no compaction, around foundation	58306	CY	CODTB11R	137.50	0.01 636	0.55 38,796	0.47 33,438	0.00 0	0.00 0	1.02 72,234	1.24
RSM SC <02220 5600 > Compaction, riding, 6" lifts, 2 passes, sheepsfoot/wobbly wheel roller	58306	CY	COFCB10G	300.00	0.01 292	0.25 17,779	0.18 12,951	0.00 0	0.00 0	0.44 30,730	0.53
MIL SC <02220 9000 > Compaction, water, truck, 3000 gal, 3 mile haul	58306	CY	COKBB45	236.00	0.01 496	0.42 29,384	0.25 17,945	0.20 14,110	0.00 0	0.87 61,439	1.05
USR SC < > Finishing Grading MSWCD03-02310-440-3310	58306	SY		0.00	0.00 0	0.08 5,644	0.07 4,953	0.00 0	0.00 0	0.15 10,597	0.18
TOTAL Clean fill -Cohesive Material	58306	CY			4,198	248,309	240,326	271,619	0	760,253	13.04

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.04.01_ 12. Rip-Rap at Inlet											
USR AA <02270 1000 > Rip-rap, random pieces, dumped from truck, 3/8 - 1/4 CY addt'l cost = mats, etc., wet placement.	452.00	CY	CODEB3A	8.35	0.60	25.87	7.17	33.09	0.00	66.13	
					271	11,691	3,243	14,957	0	29,891	66.13
TOTAL Rip-Rap at Inlet	452.00	CY			271	11,691	3,243	14,957	0	29,891	66.13
06_03.04.01_ 13. Filter Fabric											
USR AA < > Filter Fabric - at Tidal Channel Entrance	678.00	SY	ULABA2	16.20	0.19	7.23	1.10	1.79	0.00	10.12	
					126	4,902	747	1,214	0	6,862	10.12
02340-500-1500+50% work wet area at river											
TOTAL Filter Fabric	678.00	SY			126	4,902	747	1,214	0	6,862	10.12
06_03.04.01_ 16. Subgrade Preparation to Lower											
USR AA < > Subgrade Preparation to Lower Porosity	36.14	ACR		0.00	0.00	0.00	0.00	0.00	2900.00	2900.00	
					0	0	0	0	104,806	104,806	2900.00
Green Brook Flood Control Finderne MItigation Site Feasibility Report dated 8/03 The price is adjusted to scalated to PL 2004 $2500*1.16=$2900											
TOTAL Subgrade Preparation to Lower	36.14	AC			0	0	0	0	104,806	104,806	2900.00
06_03.04.01_ 17. Fine Grading of Wetland											
USR AA <02226 > Fine grade, 3 passes w/grader, irregular area	174918	SY	ZA-2LAND05	250.00	0.02	1.13	0.71	0.00	0.00	1.84	
					4,198	197,797	124,573	0	0	322,369	1.84
02310-100-1050											
TOTAL Fine Grading of Wetland	36.14	ACR			4,198	197,797	124,573	0	0	322,369	8920.02

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.04.01_ 21. Bird Control-Plant Protection											
USR AA < > Protect Planting from Water Fowl					0.00	0.00	0.00	1.09	0.00	1.09	
Item assumed, based on NYC eco. project spec & bid award price, incl. labor & material complete. Price is escalated to 2004 from2003 $1.56/1.65*1.04=$.98 (FY03 Cost)*1.11=$1.09 (FY 04 Cost)	174918	SY		0.00	0	0	0	190,660	0	190,660	1.09
TOTAL Bird Control-Plant Protection	36.14	AC			0	0	0	190,660	0	190,660	5275.60
06_03.04.01_ 23. Monitoring-Project Site											
USR AA < > Monitoring					0.00	0.00	0.00	0.00	110000	110000.00	
Assuming 1% of $11 mil	1.00	LS		0.00	0	0	0	0	110,000	110,000	110000
TOTAL Monitoring-Project Site					0	0	0	0	110,000	110,000	
06_03.04.01_ 28. Low Marsh Plants											
B USR AA < > Low Marsh Plants					0.01	0.46	0.16	0.94	0.00	1.56	
Spartina Alterniflora Cost from bid abstract NYC prject. Cost escalating to 2004 from 2003 Spacing 1.5 ft on center. Includes fertilizer, seeding, restoration specialist, vector, and pest control, weeding Calc: 43560 sf/acr/1.5'/1.5' factor=19360	294466	EA	COEIB17	377.52	3,121	133,982	48,061	276,798	0	458,841	1.56
TOTAL Low Marsh Plants	15.21	ACR			3,121	133,982	48,061	276,798	0	458,841	30167
06_03.04.01_ 33. High Marsh Plants											
USR AA < > Spartina Patens					0.00	0.00	0.00	0.00	1.67	1.67	
Cost from bid abstract-NYC project. Cost escalating to 2004 from 2003	318085	EA		0.00	0	0	0	0	531,202	531,202	1.67

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
Calc: 43560 sf/acr/1.5'/1.5'=19360 each/acr											
TOTAL High Marah Plants	16.43	ACR			0	0	0	0	531,202	531,202	32331
TOTAL Tidal Wetland					91,745	5,584,903	4,280,643	1,709,090	821,838	12,396,473	

06_03. Wildlife Facilities & Sanctuary			QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.04.03. Mob/Demob													
Assume all equipment moved to the jobsite at 2 days standy time 1 day to move equipment off-site or total of 24 hrs.													
Assume 16 hrs RT. for mobilized each equipment, and 16 hrs RT. for demobilized each equipment													
EP	AA <	> Move Equipments to Job Site & off- Site, TRLR,LOWBOY, 60T, 3 AXLE (ADD TOWING TRUCK)	736.00	HR	T45XX017	1.00	0.00 0	0.00 0	10.15 7,468	0.00 0	0.00 0	10.15 7,468	10.15
EP	AA <	> Move Equipment to Job Site & Off Job Site, TRK,HWY, 46,000 GVW, 6X4, 3 AXLE	736.00	HR	T50FO018	1.00	0.00 0	0.00 0	42.25 31,099	0.00 0	0.00 0	42.25 31,099	42.25
MIL	AA <	> Outside Truck Drivers, Heavy	736.00	HR	X-TRKDVRHV	1.00	1.00 736	27.99 20,601	0.00 0	0.00 0	0.00 0	27.99 20,601	27.99
MIL	AA <	> Outside Equip. Oilers	736.00	HR	X-EQOPROIL	1.00	1.00 736	29.93 22,029	0.00 0	0.00 0	0.00 0	29.93 22,029	29.93
GEN	AA <	> Standy Cost, CRANE, HYD, 126' BOOM (59.0MT, 38.4M), 8X4	48.00	HR	C80Z2280	1.00	0.00 0	0.00 0	94.92 4,556	0.00 0	0.00 0	94.92 4,556	94.92
		Assume 2 Crane on site											
EP	AA <	> Standy Cost, CR,ME,CWLR,LIFTING, 85T/160'BOOM	24.00	HR	C85AM010	1.00	0.00 0	0.00 0	107.45 2,579	0.00 0	0.00 0	107.45 2,579	107.45
MAP	AA <	> Standy Cost, GRADER,MOTOR, ARTIC, CAT 14-H	48.00	HR	G15CA005	1.00	0.00 0	0.00 0	57.45 2,758	0.00 0	0.00 0	57.45 2,758	57.45
		Assume 2 graders on site											
EP	AA <	> Standy Cost, HYD EXCAV, CRWLR, 55,660 LBS, 1.36 CY BKT	48.00	HR	H25KC010	1.00	0.00 0	0.00 0	48.43 2,325	0.00 0	0.00 0	48.43 2,325	48.43
		Assume 2 HYD EXCAV on site											
GEN	AA <	> Standy Cost, LOADER, F/E, CRWLR, 1.50CY (1.2M3)	48.00	HR	L35Z4240	1.00	0.00 0	0.00 0	39.02 1,873	0.00 0	0.00 0	39.02 1,873	39.02
		Assume 2 Loaders on site											
EP	AA <	> Standy Cost, LDR,BH,WH, 1.50CY FE BKT, 36"DIP 4X4	48.00	HR	L50JC006	1.00	0.00 0	0.00 0	26.64 1,279	0.00 0	0.00 0	26.64 1,279	26.64
		Assume 2 backhoes on site											

06_03. Wildlife Facilities & Sanctuary		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
GEN AA <	> Standy Cost, PUMP, CENTRF,					0.00	0.00	19.91	0.00	0.00	19.91	
	DEWATER, 6" DIA 1825GPM(152MM, 6908LPM)@40'HEAD	72.00	HR	F60Z5410	1.00	0	0	1,433	0	0	1,433	19.91
	Assume 4 pumps on site											
GEN AA <	> Standby Cost,ROLLER, VIB, SD, SP					0.00	0.00	55.09	0.00	0.00	55.09	
	13.0T (11.8MT), 84"(2.1M)W,SHEEPS FOOT	48.00	HR	R45Z5580	1.00	0	0	2,644	0	0	2,644	55.09
	Assume 2 Rollers on the site											
MAP AA <	> Standy Cost, DOZER,CWLR, D-10R					0.00	0.00	120.60	0.00	0.00	120.60	
	PS,W/BLADE (ADD ATTACHMENTS)	48.00	HR	T15CA018	1.00	0	0	5,789	0	0	5,789	120.60
	Assume 2 dozers on the site											
GEN AA <	> DRILL, AUGER, FENCE POST, TM					0.00	0.00	52.83	0.00	0.00	52.83	
	550 DIG-R-MOBILE - GENERAL EQUIP	24.00	HR	XMEZ9300	1.00	0	0	1,268	0	0	1,268	52.83
	TOTAL Mob/Demob					1,472	42,630	65,070	0	0	107,700	
	TOTAL Tidal Wetland & Disposal Area					105,037	6,185,696	4,601,377	3,099,353	902,240	14,788,666	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.05. Upland Management Area											
06_03.05.01. Clearing & Grubbing											
Includes phragmities removal, haul to on-site disposal Due to the possibility that the area may have oil contaminants, the productivity loss will be decreased by about 15% and is reflected in the individual line items.											
L AF SC <02110 0550 > Phragmities cutting					1.50	70.92	48.87	0.00	827.00	946.79	
	131.80	ACR	CODTB11A	1.33	198	11,310	7,794	0	131,888	150,992	1145.61
Brush mowing, dozer tractor 02230-200-0300											
L MIL SC <02234 2200 > Hauling, off hwy haulers,22 CY, rear/bottom dump, 1 mile round trip, incl. loading onto trucks					0.04	1.51	2.08	0.00	0.00	3.59	
	70170	CY	CTDHB34F	27.63	2,540	127,970	176,815	0	0	304,786	4.34
02315-490-2030											
02315-462-9024											
USR SC < > Herbicide Treatment					0.04	2.19	1.03	0.26	0.00	3.48	
Spreader	5741.21	MSF	ZA-2LAND01	25.87	222	15,213	7,153	1,806	0	24,172	4.21
02935-100-0120											
Weed Control 02935-100-0190											
TOTAL Clearing & Grubbing	131.80	ACR			2,960	154,493	191,762	1,806	131,888	479,950	3641.50

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.05.02. Site Access											
B AA <02244 0300 > New Access Road 3/4" Crushed					0.01	0.48	0.39	9.05	0.00	9.92	
Stone 4" thk	67350	SY	COFGB36C	524.45	640	32,173	26,248	609,516	0	667,937	9.92
Assume 230 lf/acr of road x 20'wide = 511sy/acr											
USR AA < > Timber Mats					0.07	2.82	0.23	3.62	0.00	6.67	
assume each mat is 10' x 10' per acre	19770	LF	ZA-2LAND02	85.71	1,384	55,714	4,492	71,567	0	131,773	6.67
Each timber tie is 8" x 10' 10' / 8/12 = 15ea x 10' = 150'/acr											
Labor&Material 05655-700-1600											
USR AA < > Temp Tidal Crossing					0.00	0.00	0.00	0.00	3000.00	3000.00	
Qty assumed. 15' wide. Use 6 timber mats, 2 as a base, 4 on top.	3.00	EA		0.00	0	0	0	0	9,000	9,000	3000.00
L USR AA <02512 0011 > Access Road Fine Grade					0.01	0.38	0.14	0.00	0.00	0.52	
	67350	SY	COFGB11L	250.00	539	25,472	9,511	0	0	34,983	0.52
TOTAL Site Access	131.60	ACR			2,563	113,359	40,251	681,083	9,000	843,693	6401.31

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.05.07. Monitoring											
USR AA < > Monitoring					0.00	0.00	0.00	0.00	13236.00	13236.00	
Assume 1% of $1.3millions	1.00	LS		0.00	0	0	0	0	13,236	13,236	13236
TOTAL Monitoring					0	0	0	0	13,236	13,236	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.05.10. Mob & Demob											
Assume all equipment move to the jobsite at 2 days standy time and 1 day to move equipment off-ste or total of 24 hours											
Assume 16 hours round trip for mobilized each equipment, and 16 hours round trip for demobilizea each equipment											
EP SC < > Move Equipments to Job Site &					0.00	0.00	10.15	0.00	0.00	10.15	
off- Site, TRLR,LOWBOY, 60T, 3 AXLE (ADD TOWING TRUCK)	192.00	HR	T45XX017	1.00	0	0	2,357	0	0	2,357	12.28
EP SC < > Move Equipments to					0.00	0.00	42.25	0.00	0.00	42.25	
Job Site & Off Job Site, TRK,HWY, 46,000 GVW, 6X4, 3 AXLE	192.00	HR	T50F0018	1.00	0	0	9,817	0	0	9,817	51.13
MIL SC < > Outside Truck Drivers, Heavy					1.00	27.99	0.00	0.00	0.00	27.99	
	192.00	HR	X-TRKDVRHV	1.00	192	6,503	0	0	0	6,503	33.87
MIL SC < > Outside Equip. Oilers					1.00	29.93	0.00	0.00	0.00	29.93	
	192.00	HR	X-EQOPROIL	1.00	192	6,953	0	0	0	6,953	36.22
EP SC < > Standy Cost, LDR,BH,WH, 1.50CY					0.00	0.00	26.64	0.00	0.00	26.64	
FE BKT, 36"DIP 4X4	48.00	HR	L50JC006	1.00	0	0	1,547	0	0	1,547	32.24
GEN SC < > Standby Cost, GRADER, MOTOR,					0.00	0.00	35.30	0.00	0.00	35.30	
135 HP (101KW) 12'(3.6M)BLADE WIDTH, SP, ARTIC	48.00	HR	G15Z3080	1.00	0	0	2,050	0	0	2,050	42.72
GEN SC < > Standt Cost, DOZER, CRAWLER,					0.00	0.00	81.68	0.00	0.00	81.68	
300-340HP (224-254KW), PS, (W/ U BLADE)	48.00	HR	T1526570	1.00	0	0	4,744	0	0	4,744	98.83
TOTAL Mob & Demob					384	13,456	20,515	0	0	33,971	
TOTAL Upland Management Area	54.90	ACR			5,907	281,308	252,529	682,889	154,124	1,370,850	24970

06_03. Wildlife Facilities & Sanctuary		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15. Fresh Water Wetland												
06_03.15. 1. Mob/Demob												
Assume all equipments moved to the jobsite at 2 days standy time and 1 day to move equipment off-site or total of 24 hours.												
Assume 16 hrs round trip for mobilized each equipment, and 16 hrs round trip for demobilized each equipment.												
EP SC <	> Move Equipments to Job Site & off- Site, TRLR,LOWBOY, 60T, 3 AXLE (ADD TOWING TRUCK)	609.00	HR	T45XX017	1.00	0.00 0	0.00 0	10.15 7,477	0.00 0	0.00 0	10.15 7,477	12.28
EP SC <	> Move Equipments to Job Site & Off Job Site, TRK,HWY, 46,000 GVW, 6X4, 3 AXLE	609.00	HR	T50F0018	1.00	0.00 0	0.00 0	42.25 31,137	0.00 0	0.00 0	42.25 31,137	51.13
MIL SC <	> Outside Truck Drivers, Heavy	609.00	HR	X-TRKDVRHV	1.00	1.00 609	27.99 20,626	0.00 0	0.00 0	0.00 0	27.99 20,626	33.87
MIL SC <	> Outside Equip. Oilers	609.00	HR	X-EQOPROIL	1.00	1.00 609	29.93 22,056	0.00 0	0.00 0	0.00 0	29.93 22,056	36.22
GEN SC <	> Standt Cost, CRANE, HYD,	48.00	HR	C80Z2260	1.00	0.00 0	0.00 0	58.44 3,394	0.00 0	0.00 0	58.44 3,394	70.71
MAP SC <	> Standby Cost, GRADER,MOTOR, ARTIC, CAT 14-H	24.00	HR	G15CA005	1.00	0.00 0	0.00 0	57.45 1,668	0.00 0	0.00 0	57.45 1,668	69.52
GEN SC <	> Standy Costk, HYD EXCV, CRAWLER, 55,000LBS, (24,948KG) 1.50CY, (1.2M3) BKT	48.00	HR	H25Z3185	1.00	0.00 0	0.00 0	59.89 3,478	0.00 0	0.00 0	59.89 3,478	72.46
GEN SC <	> Standby Cost, HYD EXCV, CRAWLER, 70,000LBS, (31,751KG) 2.00CY, (1.5M3) BKT	48.00	HR	H25Z3190	1.00	0.00 0	0.00 0	73.13 4,247	0.00 0	0.00 0	73.13 4,247	88.48
GEN SC <	> Standy Cost, LOADER, F/E, WHEEL, 2.75CY (2.1M3), 4WD	48.00	HR	L40Z4395	1.00	0.00 0	0.00 0	39.24 2,279	0.00 0	0.00 0	39.24 2,279	47.48
EP SC <	> Standy Cost, LDR,BH,WH, 1.50CY FE BKT, 36"DIP 4X4	48.00	HR	L50JC006	1.00	0.00 0	0.00 0	26.64 1,547	0.00 0	0.00 0	26.64 1,547	32.24
GEN SC <	> Standy Cost, PUMP, CENTRF, DEWATER, 6" DIA 1825GPM(152MM, 6908LPM)@40'HEAD	96.00	HR	P60Z5410	1.00	0.00 0	0.00 0	19.91 2,312	0.00 0	0.00 0	19.91 2,312	24.09
GEN SC <	> Standby Cost, ROLLER, VIB, SD, SP 13.0T (11.8MT), 84"(2.1M)W,SHEEPS FOOT	24.00	HR	R45Z5580	1.00	0.00 0	0.00 0	55.09 1,600	0.00 0	0.00 0	55.09 1,600	66.66

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
MAP SC < > Standy Cost, DOZER,CWLR, D-10R					0.00	0.00	120.60	0.00	0.00	120.60	
PS,W/BLADE (ADD ATTACHMENTS)	48.00	HR	T15CA018	1.00	0	0	7,005	0	0	7,005	145.93
TOTAL Mob/Demob					1,218	42,682	66,145	0	0	108,827	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.01. Clearing & Grubbing Includes phragmities removal, haul to on-site disposal											
USR SC < > Herbicide Treatment					0.04	2.19	1.03	0.26	0.00	3.48	
Spreader 02935-100-0120	404.24	MSF	ZA-2LAND01	25.87	16	1,071	504	127	0	1,702	4.21
Weed Control 02935-100-0190											
L AF SC <02110 0550 > Phragmities cutting					1.50	70.95	48.89	0.00	827.00	946.84	
	9.28	ACR	CODTB11A	1.33	14	797	549	0	9,286	10,632	1145.68
Brush mowing, dozer tractor 02230-200-0300											
L MIL SC <02234 2200 > Hauling, off hwy haulers,22 CY, rear/bottom dump, 1 mile round trip, incl. loading onto trucks Assuming 4" thick phrag					0.04	1.51	2.08	0.00	0.00	3.59	
	4940.67	CY	CTDHB34F	27.63	179	9,010	12,450	0	0	21,460	4.34
02315-490-2030 02315-462-9024											
TOTAL Clearing & Grubbing	9.28	ACR			208	10,878	13,502	127	9,286	33,794	3641.57

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.02. New Culverts											
B USR AA < > Ex/Bi/Comp/Bed					0.21	11.01	7.53	1.53	0.00	20.07	
MSWCD04-G1030-805-3830 815-2680	950.00	LF	COETR23	17.32	196	10,455	7,155	1,454	0	19,063	20.07
MIL AA <02762 2050 > Piping, drainage & sewage, 30"					0.64	28.01	8.63	24.60	0.00	61.24	
dia, RCP, class 3, no gaskets	950.00	LF	CLABB13	11.00	605	26,613	8,198	23,370	0	58,180	61.24
TOTAL New Culverts	950.00	LF			801	37,067	15,352	24,824	0	77,243	81.31

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.03. Inlet Connection plus flow											
USR AA < > Log Weir					0.00	0.00	0.00	0.00	100.00	100.00	
Assume log Weir	5.00	EA		0.00	0	0	0	0	500	500	100.00
Cost obtained from Kerry Ann's cost spread sheet which is AE'estimated in 2004											
TOTAL Inlet Connection plus flow	5.00	EA			0	0	0	0	500	500	100.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.04. Flow Dissapator											
USR AA < > Flow Dissapator					0.00	0.00	0.00	0.00	300.00	300.00	
Cost from Kerry Ann's cost & qty spread sheet	5.00	EA		0.00	0	0	0	0	1,500	1,500	300.00
TOTAL Flow Dissapator	5.00	EA			0	0	0	0	1,500	1,500	300.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.05. Timber Mats											
USR AA < > Timber Mats					0.07	2.82	0.23	3.62	0.00	6.67	
assume each mat is 10' x 10' per acre	36.00	LF	ZA-2LAND02	85.71	3	101	8	130	0	240	6.67
Each timber tie is 8" x 10' 10' / 8/12 = 15ea x 10' = 150'/acr											
Labor&Material 05655-700-1600											
TOTAL Timber Mats	0.24	ARC			3	101	8	130	0	240	999.80

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.06. Erosion and Sediment Control											
USR SC < > Maintenance					78.00	2916.38	0.00	0.00	0.00	2916.38	
Assume 2 laborer 80hrs per acre to maintain erosion control measures	3.14	ACR	XLABB	0.03	245	11,080	0	0	0	11,080	3528.82
L USR SC < > Sediment Trap with filter					0.00	0.00	0.00	0.00	200.00	200.00	
assume $200/acre	1.00	ACR		0.00	0	0	0	0	242	242	242.00
USR SC < > Straw Bales					0.00	0.96	0.06	1.93	0.00	2.95	
02370-700-1250	7968.00	LF		0.00	0	9,256	564	18,608	0	28,427	3.57
B MIL SC <02266 1110 > Silt fence, 3' high,					0.02	0.84	0.00	0.28	0.00	1.12	
polypropylene	7968.00	LF	ALABCLAB2	90.00	177	8,121	0	2,700	0	10,820	1.36
02370-700-1100											
MIL SC <02228 1625 > Excavate trench, normal soil, by					0.71	27.22	0.00	0.00	0.00	27.22	
hand, piled only, to 2' deep	294.82	CY	ULABB2	7.00	211	9,709	0	0	0	9,709	32.93
excavate 12" deep x 12" wide x 1 = CY/LF											
MIL SC <02215 0010 > Backfill, by hand, no					0.57	21.66	0.00	0.00	0.00	21.66	
compaction, light soil	294.82	CY	ALABCLAB1	1.75	168	7,727	0	0	0	7,727	26.21
TOTAL Erosion and Sediment Control					801	45,893	564	21,307	242	68,006	

06_03. Wildlife Facilities & Sanctuary	QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.08. Earthwork-dry									
L MIL AA <02232 0140 > Excavation work (dry area)			0.05	3.18	1.98	0.00	0.00	5.16	
Excavate & load, hydr excavator, 2 CY, medium matl	18402 BCY CODEB12C	36.98	569	33,443	20,792	0	0	94,912	5.16
MSWCD04-2315-424-0260,0020,410 0									
<*Mod* > Add for loading on trucks			85	5,016	3,119				
<*Mod* > Add for heavy soil			341	20,066	12,475				
L CIV AA <02234 2300 > Haul 1/2 mile			0.01	0.59	1.93	0.00	0.00	2.52	
Hauling, Off hwy haulers, 40 CY 1/2 mile rt. MSWCD04-02315-490-2100	21162 LCY CTDHB34H	70.94	298	12,420	40,856	0	0	53,276	2.52
USR AA < > Survey Crew			0.00	1011.00	68.47	32.65	0.00	1112.12	
MSWCD04-01107-700-0010/0100 Project site.	3.17 AC	0.00	0	3,205	217	104	0	3,525	1112.12
USR AA < > Productivity Loss-Level 'D'			0.00	0.61	0.00	0.00	0.00	0.61	
MERCD00,pg1-11	18402 LCY	0.00	0	11,225	0	0	0	11,225	0.61
Productivity = 82% at Level 'D' 100-82=18% loss.									
$62527 x 18%=$11254/18402cy = $.61 per cy.									
TOTAL Earthwork-dry	18402 BCY		1,294	85,376	77,460	104	0	162,939	8.85

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.09. Dewatering Assuming take 3 months to dewater 8 ac area											
B USR AA < > Dewater/Pump					20.00	990.42	265.41	0.00	0.00	1255.84	
02240-500-1100x1ea -1120x3ea Assume total 4 dewatering system will operate for 3 months	90.00	DAY	COFWD	0.08	1,800	89,138	23,887	0	0	113,025	1255.84
B USR AA < > Generators					96.90	6329.84	600.90	0.00	0.00	6930.74	
Diesel engine, 100kw 01590-400-2700x2ea	3.00	MON	EELER3	0.03	291	18,990	1,803	0	0	20,792	6930.74
$720x2ea=$1440/mon											
crew equipment cost/day=$180/day											
ttl =1440+180*30=$6840/mon											
TOTAL Dewatering	90.00	DAY			2,091	108,128	25,690	0	0	133,817	1486.86

06_03. Wildlife Facilities & Sanctuary		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.10. Fine Grading of Wetland												
USR AA <02226	> Fine grade, 3 passes w/grader, irregular area					0.02	1.13	0.71	0.00	0.00	1.84	
		37413	SY	ZA-2LAND05	250.00	898	42,307	26,645	0	0	68,952	1.84
	02310-100-1050											
	TOTAL Fine Grading of Wetland	7.73	ACR			898	42,307	26,645	0	0	68,952	8920.02

06_03. Wildlife Facilities & Sanctuary		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.11. Tree												
L USR AA <02957	> Trees, 2-1/2" caliper, in beds, B&B	50.00	EA	COEIB17	10.20	0.39	16.85	6.04	202.00	0.00	224.89	
						20	842	302	10,100	0	11,245	224.89
	02915-400-0400 02930-430-6440											
8 MIL AA <02922 5000	> Plant bed preparation, 18" deep, by machine	157.00	SF	CLABB62	29.64	0.10	4.39	0.27	0.00	0.00	4.66	
						16	689	43	0	0	732	4.66
	02910-720-1200											
	Assuming the Pit/bed 2'dia=3.14 Sf for each plant											
USR AA <	> Backfill Planting Pit by machine, on site topsoil	235.50	CY	CLABB62	87.54	0.03	1.49	0.09	1.09	0.00	2.67	
						8	350	22	257	0	628	2.67
	02910-720-0300											
	factor=1.5'*1'*1'*3.14=4.71 cy/tree											
TOTAL Tree		50.00	EA			44	1,882	366	10,357	0	12,605	252.10

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.12. Shrubs											
MIL AA <02954 0480 > Shrubs, 3 gal cont, in place,					0.24	9.32	0.00	9.55	0.00	18.87	
creeping gardenia, broadleaf evergreen	2231.04	EA	ULABD1	12.31	544	20,790	0	21,306	0	42,097	18.87
5'O.C.											
43560 sf/acr / (5)^2 = 1743 plants per acre											
B MIL AA <02922 5000 > Plant bed preparation, 18" deep,					0.10	4.39	0.27	0.00	0.00	4.66	
by machine	7005.44	SF	CLABB62	29.64	709	30,760	1,900	0	0	32,660	4.66
02910-720-1200											
Assuming the hole/bed 2'dia=3.14 Sf for each plant 1743 plants/ac *3.14 =5473 sf/ac											
USR AA < > Backfill Planting Pit					0.03	1.49	0.09	1.09	0.00	2.67	
by machine, on site topsoil 02910-720-0300	7005.00	CY	CLABB62	87.54	240	10,414	643	7,635	0	18,692	2.67
TOTAL Shrubs	1.28	ACR			1,493	61,964	2,543	28,942	0	93,449	73007

06_03. Wildlife Facilities & Sanctuary	QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.13. Grassland/Herbaceous									
AF AA <02932 7010 > Seeding, apply fertilizer,			0.03	1.45	0.50	2.00	0.00	3.95	
35#/MSF	25.65 MSF COELB66	37.50	1	37	13	51	0	101	3.95
M MIL AA <02922 5000 > Grass bed preparation, assum 5"			6.00	260.28	16.07	180.00	0.00	456.35	
deep by machine	25.65 MSF CLABB62	0.50	154	6,676	412	4,617	0	11,705	456.35
TOTAL Grassland/Herbaceous	25.65 MSF		155	6,713	425	4,668	0	11,807	460.30

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.14. Wildflowers											
B USR AA < > Site Preperation					1.10	47.80	2.95	0.00	0.00	50.75	
by machine	25.65	MSF	CLABB62	2.72	28	1,226	76	0	0	1,302	50.75
Assume $2000 per acres site preparation, Rototill-2 year -LMS											
L AF AA <02932 7020 > Seeding					0.08	3.17	4.13	2.64	0.00	9.95	
	25.65	MSF	COFWB59	13.13	2	81	106	68	0	255	9.95
Assume $2000 per acre seed cost; Prairie Nursery; Wet/dry seed mix -LMS											
TOTAL Wildflowers	25.65	MSF			30	1,307	182	68	0	1,557	60.70

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.15. Bird Control -Plant Protection											
USR AA < > Protect Planting from Water Fowl					0.00	0.00	0.00	1.09	0.00	1.09	
Item assumed, based on NYC eco. project spec & bid award price, incl. labor & material complete. $1.56/1.65*1.04=$.98 (2003 P.L) cost)* 1.11=1.09 (2004 P.L)Project site only. 11.75ac=56870sy	56870	SY		0.00	0	0	0	61,988	0	61,988	1.09
TOTAL Bird Control -Plant Protection	11.75	ACR			0	0	0	61,988	0	61,988	5275.60

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.16. Monitoring											
USR AA < > Monitoring					0.00	0.00	0.00	0.00	10000.00	10000.00	
Assuming 1% of Construction	1.00	LS		0.00	0	0	0	0	10,000	10,000	10000
TOTAL Monitoring					0	0	0	0	10,000	10,000	

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.17. Clean fill - Cohesive Material											
B AF SC <02234 4100 > Hauling, w/loading, 12 CY truck, 5 mile haul, sand	5751.00	CY	CODEB30	63.00	0.05 274	2.22 15,457	2.42 16,870	3.65 25,399	0.00 0	8.30 57,726	10.04
L MIL SC <02216 5520 > Backfill, strl, 6" lifts, w/dozer, no compaction, around foundation	5751.00	CY	CODTB11R	137.50	0.01 63	0.55 3,827	0.47 3,298	0.00 0	0.00 0	1.02 7,125	1.24
RSM SC <02220 5600 > Compaction, riding, 6" lifts, 2 passes, sheepsfoot/wobbly wheel roller	5751.00	CY	COFCB10G	300.00	0.01 29	0.25 1,754	0.18 1,277	0.00 0	0.00 0	0.44 3,031	0.53
MIL SC <02220 9000 > Compaction, water, truck, 3000 gal, 3 mile haul	5751.00	CY	COKBB45	236.00	0.01 49	0.42 2,898	0.25 1,770	0.20 1,392	0.00 0	0.87 6,060	1.05
USR SC < > Finishing Grading MSWCD03-02310-440-3310	5751.00	SY		0.00	0.00 0	0.08 557	0.07 489	0.00 0	0.00 0	0.15 1,045	0.18
TOTAL Clean fill - Cohesive Material	5751.00	CY			414	24,492	23,705	26,791	0	74,987	13.04

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.18. Subgrade Preparation to Lower Porosity											
					0.00	0.00	0.00	0.00	2262.00	2262.00	
USR AA < > Subgrade Preparation to Lower Porosity Bare Unit cost based on Green Brook Flood Control Finderne MItigation Site Feasibility Report dated 8/03 price is escalted to 2004 from 2003 $1950*1.16=$2262	7.73	ACR		0.00	0	0	0	0	17,485	17,485	2262.00
TOTAL Subgrade Preparation to Lower	7.73	ACR			0	0	0	0	17,485	17,485	2262.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.19. Stone Weir											
USR AA < > Stone Weir					0.00	0.00	0.00	0.00	160.00	160.00	
Bare UC based on Kerry Ann's spread sheet which is AE's estiated in 2004	3.00	EA		0.00	0	0	0	0	480	480	160.00
TOTAL Stone Weir	3.00	EA			0	0	0	0	480	480	160.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.20. Log Weirs											
USR AA < > Log Weirs					0.00	0.00	0.00	0.00	468.00	468.00	
A/E's cost at $600 each in 2004	11.00	EA		0.00	0	0	0	0	5,148	5,148	468.00
TOTAL Log Weirs	11.00	EA			0	0	0	0	5,148	5,148	468.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.21. Access Road Assumes Installed 2100 LF in place											
B AA <02244 0300 > Access Road 3/4" Crushed Stone 4" thk					0.01	0.48	0.39	9.05	0.00	9.92	
	4662.00	SY	COFGB36C	524.45	44	2,227	1,817	42,191	0	46,235	9.92
Assume 20' wide road factor=1 ft x20'wide /9 sy/sf = 2.22 sy/lf											
L USR AA <02512 0011 > Access Road Fine Grade					0.01	0.38	0.14	0.00	0.00	0.52	
	4662.00	SY	COFGB11L	250.00	37	1,763	658	0	0	2,422	0.52
TOTAL Access Road	2100.00	LF			82	3,990	2,475	42,191	0	48,657	23.17

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.22. Raptor Perches											
USR AA < > Rapton Perches					0.00	0.00	0.00	0.00	75.00	75.00	
Bare cost based on AE'estimate	1.00	EA		0.00	0	0	0	0	75	75	75.00
TOTAL Raptor Perches	1.00	EA			0	0	0	0	75	75	75.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.24. Raised Walks											
USR AA < > Raised Walks					0.00	0.00	0.00	0.00	45.00	45.00	
Bare unit cost obtained from the spread sheet provied by Kerry Ann	200.00	LF		0.00	0	0	0	0	9,000	9,000	45.00
TOTAL Raised Walks	200.00	LF			0	0	0	0	9,000	9,000	45.00

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.26. Obervation Decks											
USR AA < > Observations Deck					0.00	10.00	3.85	43.00	0.00	56.85	
Assuming 15'* 15'=225 sf for each deck. total qty=225*2 =450 sf 02850-210-1600	450.00	SF		0.00	0	4,500	1,732	19,350	0	25,582	56.85
TOTAL Obervation Decks	2.00	EA			0	4,500	1,732	19,350	0	25,582	12791

06_03. Wildlife Facilities & Sanctuary	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
06_03.15.27. Earthwork-wet											
L MIL AA <02232 0140 > Excavation work (wet area)					0.07	4.25	2.64	0.00	0.00	6.89	
Excavate & load, hydr excavator, 2 CY, medium matl	4600.00	BCY	CODEB12C	27.68	155	9,093	5,653	0	0	31,704	6.89
MSWCD03-02315-424-0260,0020,4100											
<*Mod* > Add for loading onto trucks					23	1,364	848				
<*Mod* > Add for wet excavation					155	9,093	5,653				
L CIV AA <02234 2300 > Haul 1/2 mile					0.01	0.59	1.93	0.00	0.00	2.52	
Hauling, Off hwy haulers, 40 CY 1/2 mile rt.	5290.00	LCY	CTDHB34H	70.94	75	3,105	10,213	0	0	13,318	2.52
MSWCD04-02315-490-2100											
USR AA < > Survey Crew					0.00	1011.00	68.47	32.65	0.00	1112.12	
MSWCD04-01107-700-0010/0100 Project site.	3.17	AC		0.00	0	3,205	217	104	0	3,525	1112.12
USR AA < > Productivity Loss-Level 'D'					0.00	0.75	0.00	0.00	0.00	0.75	
MERCD00,pg1-11	4600.00	BCY		0.00	0	3,450	0	0	0	3,450	0.75
Productivity = 82% at Level 'D' 100-82=18% loss.											
$19232 x 18%=$3462/4600cy = $.75 per cy.											
TOTAL Earthwork-wet	4600.00	BCY			407	29,310	22,584	104	0	51,997	11.30
TOTAL Fresh Water Wetland					9,937	506,590	279,379	240,950	53,716	1,080,635	
TOTAL Wildlife Facilities & Sanctuary					121,992	7,063,100	5,203,880	4,303,042	1113606	17,683,629	
TOTAL Fish and Wildlife Facilities					121,992	7,063,100	5,203,880	4,303,042	1113606	17,683,629	

	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
30. Planning, Engineering and Design											
USR <01000 0000 > P & S - Engr Div Cost Only, 10%					0.00	0.00	0.00	0.00	1820000	1820000.00	
	1.00	LS		0.00	0	0	0	0	1820000	1,820,000	1820000
TOTAL Planning, Engineering and Design					0	0	0	0	1820000	1,820,000	

	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
31. Construction Management											
USR <01000 0000 > SIOH (S&A) -					0.00	0.00	0.00	0.00	1790000	1790000.00	
	1.00	LS		0.00	0	0	0	0	1790000	1,790,000	1790000
TOTAL Construction Management					0	0	0	0	1790000	1,790,000	
TOTAL Liberty State Park Ecosystem					121,992	7,063,100	5,203,880	4,303,042	4765606	21,335,629	

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-CARPNTER	Carpenters	21.49	0.0%	36.4%	6.52	0.00	35.83	HR	01/01/01	35.83	65
MIL	B-CEMTFINR	Cement Finishers	31.37	0.0%	28.0%	15.55	0.00	55.70	HR	05/14/04	32.29	13
MIL	B-ELECTRN	Electricians	38.77	0.0%	23.5%	17.45	0.00	65.33	HR	05/14/04	40.18	1181
MIL	B-EQOPRCRN	Equip. Operators, Crane/Shovel	34.50	0.0%	27.9%	19.17	0.00	63.30	HR	05/14/04	37.44	24991
MIL	B-EQOPRLT	Equip. Operators, Light	27.49	0.0%	27.9%	19.17	0.00	54.33	HR	05/14/04	33.66	8267
MIL	B-EQOPRMED	Equip. Operators, Medium	29.31	0.0%	27.9%	19.17	0.00	56.66	HR	05/14/04	35.24	7233
MIL	B-EQOPROIL	Equip. Operators, Oilers	27.49	0.0%	27.9%	19.17	0.00	54.33	HR	05/14/04	29.93	24646
MIL	B-LABORER	Laborers, (Semi-Skilled)	19.16	0.0%	36.4%	11.77	0.00	37.90	HR	05/14/04	27.04	11806
MIL	B-PILEDRVR	Pile Drivers	26.92	0.0%	46.4%	16.12	0.00	55.53	HR	05/14/04	38.32	330
MIL	B-RODMAN	Rodmen, (Reinforcing)	27.63	0.0%	48.1%	24.10	0.00	65.02	HR	05/14/04	44.04	68
MIL	B-TRKDVRHV	Truck Drivers, Heavy	24.70	0.0%	32.1%	9.01	0.00	41.64	HR	05/14/04	27.99	24933
MIL	B-TRKDVRLT	Truck Drivers, Light	24.45	0.0%	32.1%	9.01	0.00	41.31	HR	05/14/04	26.74	110
MIL	B-WELDERS	Welders, Structural Steel	29.53	0.0%	59.1%	24.10	0.00	71.08	HR	05/14/04	46.21	10
MIL	X-EQOPRHVY	Outside Equip. Operators, Heavy	23.24	0.0%	27.9%	7.72	0.00	37.44	HR	01/01/01	37.44	134
MIL	X-EQOPRLT	Outside Equip. Operators, Light	27.49	0.0%	27.9%	19.17	0.00	54.33	HR	05/14/04	33.66	362
MIL	X-EQOPRMED	Outside Equip. Operators, Medium	29.31	0.0%	27.9%	19.17	0.00	56.66	HR	05/14/04	35.24	2912
MIL	X-EQOPROIL	Outside Equip. Oilers	17.78	0.0%	27.9%	7.19	0.00	29.93	HR	01/01/01	29.93	1735
MIL	X-LABORER	Outside Laborers, (Semi-Skilled)	19.16	0.0%	36.4%	11.11	0.00	37.24	HR	05/14/04	27.04	10462
MIL	X-STRSTEEL	Outside Steel Workers	22.68	0.0%	59.1%	10.58	0.00	46.66	HR	01/01/01	46.66	669
MIL	X-TRKDVRHV	Outside Truck Drivers, Heavy	16.98	0.0%	32.1%	5.56	0.00	27.99	HR	01/01/01	27.99	1601
USR	X-TUG0001	Tug Captain	69.19	0.0%	66.0%	11.00	0.00	125.86	HR	07/01/04	0.00	221
USR	X-TUG0002	Tug Mate	38.20	0.0%	66.0%	11.00	0.00	74.41	HR	07/01/04	0.00	221

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
GEN	A25Z0580	ASPHALT DISTR, 3,000GAL (11355L)	5.58	1.10		1.80			7.38	15.86 HR	518
GEN	B30Z1050	BUCKET, CONCRETE, 1.0CY (0.8M3)	0.20	0.05					0.21	0.46 HR	13
GEN	C75Z2080	CRANE, HYD, R/T, 9T, 44' BOOM	5.74	1.73	8.73	3.41	0.21	0.04	6.64	26.50 HR	291
GEN	C80Z2260	CRANE, HYD, TRUCK MTD, 25T	18.75	5.67	5.96	2.60	0.61	0.11	16.25	49.95 HR	224
GEN	C80Z2280	CRANE, HYD, TRUCK MTD, 65T	28.44	9.73	9.93	3.20	0.92	0.16	28.76	81.13 HR	148
EP	C85AM010	CR,ME,CWLR,LIFTING, 85T/160'BOOM	33.40	12.63	3.85	1.02			40.94	91.84 HR	158
GEN	D15Z2720	DRILL, HORZ BORING, 48" DIA, 30'	8.15	1.96	3.88	1.34			11.12	26.45 HR	176
MAP	G15CA005	GRADER,MOTOR, ARTIC, CAT 14-H	15.61	5.82	5.73	2.37	1.26	0.22	18.09	49.10 HR	921
GEN	G15Z3080	GRADER, MOTOR, 135 HP (101KW)	9.72	3.59	3.60	1.49	0.47	0.08	11.23	30.17 HR	704
MAP	H25BS005	HYD EXCAV BKT, 3.25CY, W/TIPS	1.34	0.20					1.63	3.17 HR	205
MAP	H25CA029	HYD EXCAV, CRWLR,110,880 LBS,	22.50	8.51	8.12	2.15			35.70	76.98 HR	205
EP	H25KC010	HYD EXCAV, CRWLR, 55,660 LBS,	13.60	3.87	4.97	2.28			16.67	41.39 HR	48
GEN	H25Z3175	HYD EXCV, CRAWLER, 40,000LBS,	14.54	4.14	3.77	1.74			17.82	42.01 HR	55
GEN	H25Z3185	HYD EXCV, CRAWLER, 55,000LBS,	17.62	5.02	4.77	2.19			21.59	51.18 HR	2050
GEN	H25Z3190	HYD EXCV, CRAWLER, 70,000LBS,	21.23	6.05	6.30	2.90			26.03	62.50 HR	24046
GEN	H25Z3210	HYD EXCV, CRAWLER, 140,000LBS,	37.57	14.21	11.47	3.03			59.60	125.88 HR	40
GEN	L15Z4040	SPREADER, DRY CHEMICAL 85CF	1.40	0.14			0.03	0.00	1.41	2.98 HR	852
GEN	L35Z4240	LOADER, F/E, CRWLR, 1.50CY	9.02	1.77	2.79	1.28			18.48	33.35 HR	65
GEN	L40Z4390	LOADER, F/E, WHEEL, 1.75CY	7.88	2.15	2.98	1.54	0.90	0.16	8.93	24.55 HR	2071
GEN	L40Z4395	LOADER, F/E, WHEEL, 2.75CY	10.36	2.88	4.12	2.13	1.92	0.33	11.80	33.54 HR	103
GEN	L40Z4610	LOADER, SKIDSTEER, 13CWT (590KG)	2.02	0.37	1.35	0.70	0.12	0.02	2.30	6.87 HR	385
EP	L50CA001	LDR,BH,WH, 1.00CY FE BKT, 24"DIP	5.12	1.39	2.21	0.87	0.36	0.06	6.63	16.64 HR	362
EP	L50JC006	LDR,BH,WH, 1.50CY FE BKT, 36"DIP	7.15	1.96	2.61	1.02	0.64	0.11	9.28	22.77 HR	508
GEN	L50Z4640	LOADER/BCK-HOE,WH, 0.80CY(0.6M3)	3.78	1.06	1.70	0.67	0.72	0.12	4.93	12.98 HR	1637
GEN	P50Z5095	HOSE, SUCTION/DISCH,6"(153MM)D X	0.13	0.01					0.26	0.40 HR	330
GEN	P60Z5410	PUMP, CENTRF, DEWATER, 6" DIA	1.59	0.34	9.18	3.59			2.32	17.01 HR	6400
GEN	R45Z5580	ROLLER, VIB, SD, SP 13.0T	13.50	2.70	5.74	2.24	0.48	0.08	22.35	47.08 HR	480
GEN	R45Z5690	ROLLER, VIB, DD, SP 12.0T	12.55	2.47	3.96	1.55			20.72	41.24 HR	212
GEN	R50Z5810	ROLLER, VIB, SD, SP 12.0T	12.22	2.45	5.74	2.24	0.48	0.08	18.41	41.62 HR	2
MAP	T15CA018	DOZER,CWLR, D-10R PS,W/BLADE	26.53	12.14	17.65	5.07			41.68	103.08 HR	945
GEN	T15Z6520	DOZER, CRAWLER, 181-250HP	15.57	6.50	7.43	2.56			23.63	55.69 HR	1052
GEN	T15Z6570	DOZER, CRAWLER, 300-340HP	19.25	8.03	9.91	3.42			29.21	69.81 HR	260
GEN	T40Z6960	TRK FLATBED, 8'X 12'(2.4MX 3.7M)	0.35	0.07					0.32	0.73 HR	42
GEN	T40Z7000	TRK FLATBED, 8'X 20'(2.4MX 6.1M)	0.50	0.10					0.45	1.05 HR	13
GEN	T40Z7080	REAR DUMP BODY, 10.3CY	0.65	0.13					0.69	1.46 HR	55
GEN	T40Z7090	REAR DUMP BODY, 12CY (9.2M3)	0.73	0.14					0.78	1.65 HR	4681
EP	T45XX017	TRLR,LOWBOY, 60T, 3 AXLE	3.12	1.04		0.50	1.02	0.18	2.82	8.67 HR	1601
GEN	T45Z7280	TRAILER, WATER TANKER, 5000GAL	2.96	0.92	1.79	0.51	0.45	0.08	3.15	9.86 HR	138
EP	T50FO018	TRK,HWY, 46,000 GVW, 6X4, 3 AXLE	11.07	2.27	8.11	2.80	1.49	0.26	10.11	36.11 HR	1601
GEN	T50Z7400	TRUCK, HWY 25,000 (11,340KG)GVW	3.49	0.80	4.54	1.46	0.70	0.12	3.42	14.53 HR	55
GEN	T50Z7420	TRUCK, HWY 45,000 (20,412KG)GVW	10.91	2.20	10.30	3.55	0.97	0.17	9.93	38.03 HR	4681
GEN	T50Z7480	TRUCK, HWY 35,000 (15,876KG)GVW	9.46	1.89	10.30	3.55	0.56	0.10	8.60	34.47 HR	55
GEN	T50Z7520	TRUCK, HWY 55,000 (24,948KG)GVW	10.18	2.06	10.30	3.55	0.97	0.17	9.27	36.51 HR	138
GEN	T50Z7580	TRUCK, HWY 45,000 (20,412KG)GVW	10.80	2.21	8.11	2.80	1.43	0.25	9.86	35.46 HR	518
GEN	T55Z7680	TRUCK, OFF-HWY, REAR-DUMP, 25T	8.73	4.83	4.33	1.79	6.77	1.17	7.64	35.27 HR	2514
GEN	T55Z7720	TRUCK, OFF-HWY, REAR-DUMP, 36T	13.17	7.12	6.77	2.80	6.67	1.15	11.49	49.17 HR	4166
GEN	T55Z7800	TRUCK, OFF-HWY, REAR-DUMP, 85T	31.16	17.00	15.71	6.50	16.60	2.86	27.22	117.06 HR	12704
GEN	T60Z7910	TRUCK, OFF-HWY, WATER, 5000GAL	10.22	3.09	4.97	1.94	1.82	0.31	11.12	33.47 HR	212
GEN	W35Z8640	WELDER, 300AMP, TRAILER MTD	0.81	0.20	2.50	0.72	0.03	0.01	1.07	5.33 HR	10
GEN	XMEZ9300	DRILL, AUGER, FENCE POST, TM	43.96	0.13	0.67	0.25		0.12	0.02	45.15 HR	37
GEN	XMEZ9520	CONC VIBRATOR, 2.5" (63.5MM) DIA	1.04	0.16	0.69	0.48			1.33	3.70 HR	27

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
USR	ZR1001	Deck Cargo Barge,800 ton		64.45						64.45 HR	385

No errors detected...

* * * END OF ERROR REPORT * * *